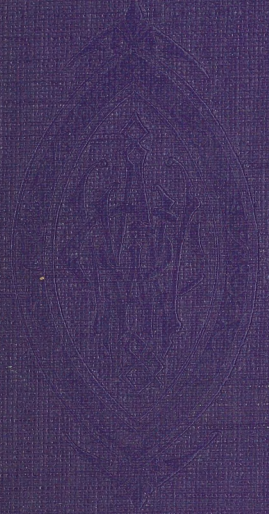


ULTRA-VIOLET RADIATION-RUSSELL



ULTRA-VIOLET RADIATION
AND ACTINOTHERAPY

ULTRA-VIOLET RADIATION AND ACTINOTHERAPY

BY

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WITH FOREWORDS BY

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AND

SYDNEY WALTON, C.B.E., M.A., B.Litt.

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MCMXXVIII.

FOREWORD

By Sir OLIVER LODGE, F.R.S., D.Sc., LL.D.

THE interaction of ether and matter is attracting more attention to-day than ever before. The quiver of the ether that we call radiation has the remarkable property of ejecting electrons from atoms, and thereby of exciting not only vision and photographic action, but of effecting a variety of other chemical changes. It is by this means that plants absorb radiant energy and grow ; it is thus that trees are enabled to form their woody fibre from constituents of the air and moisture. Solar energy, received through the ether and transmuted on arrival into various forms, is responsible for all our activities. What the effect of radiation on human bodies may be, we are only beginning to find out. Pigmentation produced in the skin shows that the effect is by no means negligible ; and now clinical work on the effect of radiation, both natural and artificial—especially radiation of frequency too high to affect, except prejudicially, the retina of the eye—is leading to results of obviously great interest even to a layman. Such rays are found to be conducive to health : the deprivation of such rays, by the unthinking pollution of town atmosphere, must have seriously impaired the health and well-being of the urban community. We are waking up to large possibilities of improvement in these directions.

FOREWORD

Naturally, I express no opinion on purely medical matters ; but a book dealing with this comparatively new and highly promising subject, by people with medical training, physical knowledge, and extensive and rapidly growing experience, should be welcome. I judge that this is such a book, and commend it accordingly.

Oliver Lodge

FOREWORD

By SYDNEY WALTON, C.B.E., M.A., B.Litt.

I AM the merest layman and very shyly take my stand at the threshold of this book which tells of learning linked to life. But, on second and braver thoughts, why should a layman be hushed and dumb ? It is his duty to rejoice when the light of healing comes. He gives thanks to see the shadows of disease grow less and praises all who sincerely seek to do battle with the mysteries of suffering.

Perhaps the authors of this volume, their diary, so to speak, of experiment and research, asked me to write a Foreword because they honour me with their friendship and all true friendship is as sunshine to the soul. I have known Dr Kerr Russell for many years, but it is of his father I would relate a memory or two—his father, to whom this book must be a joy in his eventide.

Dr Russell's father became an intimate friend of mine, and at his hospitable fireside I have many times listened to him on subjects touching the health of the people. He spoke with the eloquence which comes from compassionate contact with life. He turned my thoughts in the direction of preventive medicine which, in my layman's way, I translated : " The doctor as lighthouse rather than lifeboat."

It was he who introduced me to the late Sir Napier Burnett, who was then in Newcastle-on-Tyne, and I

was able at a later stage, through the noble generosity of Mr L. G. Sloan and Sir Harold Bowden, Bart., to assist in making it possible for Sir Napier to come to London and devote himself to his heart's desire, which was the evangel of health. Great and splendid work he did until he was stricken untimely down.

The meaning of this most personal Foreword is that Dr Russell's father sent out his inspirations far and wide, and as the nation was debtor to Sir Napier Burnett, so it was to him, in that he was the cause of the other's apostleship. And now the son and his accomplished wife continue the discipleship which the father adorned. Most sincerely do I give welcome to this book. May it be, as it intends, a lamp of knowledge to shine among the shadows!

Sydney Walton

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We also wish to express our thanks to Dr A. Reyn, Dr Rollier, and Sir Henry Gauvain, for the kindness shown to us when visiting the Finsen Institute, Copenhagen, Leysin, and the Lord Mayor Treloar Cripples' Hospital, Alton, and for the help so readily given.

We should also like to acknowledge the courtesy shown by Professor Leopold Freund, Professor Volk, Dr Cemach, and Dr Ostermann, during a recent visit to Vienna; and the kindness of Dr Saidman and Dr Dufestel in Paris.

We should also like to acknowledge our indebtedness to Thomas Carter, M.Inst.C.E., M.I.E.E., Fel.A.I.E.E., who has specially written for us the chapter of this book dealing with "The Production of Direct Current from an Alternating-Current Supply;" and whose help in correcting the proofs has been invaluable.

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Our thanks are also due to Dr Stanley Banks for his kindness in allowing us to read and quote from his thesis on *Rickets, Active and Latent, and its Treatment by Ultra-Violet Light*, and to Professor Burns, Professor Todd, Professor Firth, Dr Birkett Wylam, Mr A. Albrecht, Mr D. MacFarlane, and Mr T. Bambridge; and to Dr R. L. Bell for help in reading the proofs.

We also desire to acknowledge the kindness of the many firms who have so willingly lent blocks for illustrations, and the unfailing courtesy and help of our publishers, Messrs E. & S. Livingstone.

ELEANOR H. RUSSELL.
W. KERR RUSSELL.

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INTRODUCTION

THIS treatise is submitted with the modesty that best becomes those who realize that we probably stand at the dawn of a new era in medical practice. The science of medicine is constantly changing. Theories which have been accepted for years as being scientifically sound are in a moment supplanted by new discoveries. The liver treatment of pernicious anæmia is an outstanding example; how rarely one now hears of hæmolytic streptococci. The discovery of radio-activity caused great changes in physical and chemical theory, but it is only now beginning to influence our ideas in regard to the theory and practice of medicine.

A review in a recent number of *The British Medical Journal* has truly said: "Important modifications in the basal conceptions of the mechanism of life and disease must be imminent in the light of the advances in connexion with the constitution of the atom and the electron."

Until recent years the establishment of a correct diagnosis was all that was considered necessary. Treatment was often looked on as of secondary importance. The work of Pasteur and Lister enabled surgery to achieve many unanticipated successes. Medicine, however, remained content to make use of drugs which had been employed for generations and whose value was in many cases extremely doubtful.

Then followed the discovery of many so-called specific remedies, and finally an awakening interest in physical methods of treatment.

In a leading article in *The Times* of 15th October 1927, on Actinotherapy, it is stated that "There are few more remarkable movements in the history of medicine than the development which has been witnessed recently in the use, for therapeutic purposes, of rays of various kinds. So great, indeed, and so rapid has this development been, and so wide are the horizons which extend before the science of actinotherapy, that already a kind of bewilderment exists about it in the professional mind. What is the truth about sunlight and artificial sunlight? How far are these natural agencies of healing likely to take the place of existing methods? . . . There can no longer be any dispute about the importance of radiological methods in the treatment of disease. Those who are aware of the revolution which is now being accomplished in the handling of cases of so-called surgical tuberculosis realize that the methods which twenty years ago were universally employed in the treatment of these severe ailments are applicable no longer. The work of the London Hospital in curing lupus is a triumph of the use of light as a therapeutic agent, and not less triumphant in its results is the work now being carried on in the treatment of surgical tuberculosis at the Lord Mayor Treloar Hospital at Alton and at other places. Light in all these instances has taken the place, to a great extent, of the surgeon's knife. It has achieved benefits for the patient which no other agency has ever provided."

Surgical treatment is tending to give way to more conservative measures in certain inflammatory diseases, particularly of the female genitalia.

There is no doubt that a great change is taking place. Preventive treatment is, at last, beginning to take its rightful place in medicine.

As a result of the war, when hundreds of thousands of wounded men were treated by physiotherapy, great interest is now being displayed in new healing agencies, and there is a definite tendency to consider the substitution of physical methods of cure for medicinal in an increasing number of diseases.

H.R.H. the Prince of Wales in his Presidential Address to the 1926 meeting of the British Association, at Oxford, cleverly epitomized the value of ultra-violet radiation. "Closely linked," he said, "with the discovery of vitamins has been the more recent development of knowledge concerning the need of sunlight for health, in man and his fellow-animals as in plants. We know now that crippling deformity appears in the growing child unless he receives his proper share of the vitalizing rays of the sun, either directly or through the presence in natural foods of vitamins which these rays have produced. Sunlight, or its artificial equivalents, has some importance already in the treatment of disease; but a realization of its significance for health has a much greater importance in preventive hygiene. There can surely be no plainer duty for a State charged with the health of an industrial civilization than to promote with all its resources the search for such knowledge as this, as well as to provide for its application when obtained."

Major-General Seely, speaking at a recent hospital meeting in London, said: "Nearly every disease can be cured by fresh air and sunshine. A distinguished scientific friend of mine said to me recently: 'In twenty years' time there will be only three means of treating the human body—surgery, bacteriology, and heliotherapy. The third of these three will be the most important, and all kinds of treatment now regarded as essential will disappear.'"

This may prove to be an exaggeration, but it shows, at least, the trend of contemporary scientific thought.

In the *Eighth Annual Report of the Scottish Board of Health* it is stated that the clinical results of ultra-violet irradiation have been sufficiently numerous and striking to justify the conclusion that this particular form of treatment has come to stay.

It is certainly not claimed or suggested that ultra-violet radiation is the only, or for that matter the best, method of curing some of the diseases mentioned in this book, but undoubtedly in a few conditions its action is specific, and it is able to effect cure, where other remedies have been unavailing, and in many other diseases it acts as a valuable adjunct to older methods of treatment.

We shall be well content if we have been able to make a few suggestive hints, and we can at least claim that our study of this subject has been that of enthusiasm tempered only by the obligation to be painstaking.

We have had personal experience with a large number of different models of ultra-violet lamps, and we have therefore described every well-known type of

arc lamp and quartz mercury vapour lamp, since we feel that it is unwise to limit one's interest to one type of lamp, just as it would be equally illogical, for instance, to prescribe laudanum every time one wished to administer a sedative.

We have found many different types of lamp generally satisfactory, and the air-cooled mercury vapour lamp particularly so; the difficulty is not any inability to get sufficient ultra-violet radiation but trouble in gauging the precise amount required by the patient.

The tungsten arc lamp gives off a large amount of ultra-violet radiation, but it has some disadvantages. Its initial cost, it is true, is less than that of the mercury vapour lamp, but its upkeep, owing to the high price of the tungsten electrodes, is greater. Moreover, it produces unpleasant fumes, and, being hand-regulated, it needs constant attention.

The carbon arc lamp is mostly used in hospitals where several patients are being treated at the same time.

As a means of producing ultra-violet rays any one of these types can be recommended, but each type has its own advantages and disadvantages.

The chief defect of the mercury vapour lamp is its fragility and its comparatively short life; that of the tungsten arc the fumes it produces and the cost of running it; and that of the carbon arc the great cost of the current and of the carbons used.

This book describes principally the use of ultra-violet radiation in our own practice, and we trust that our experience may be helpful to other practitioners who are contemplating the use of this form of treatment.

Over three years ago we endeavoured to encourage the more general use of ultra-violet radiation by doctors in general practice. We did this because we realized actinotherapy would suffer a severe set-back if it were indiscriminately exploited by the unqualified, and that the greatest opportunity of real progress lay in its adoption by the general practitioner, who, after all, inevitably sees the beginnings of disease and is in touch with conditions when they are most amenable to treatment.

There are many persons, who are not wholly cured by medicinal or surgical treatment, who drift from one member of the profession to another, until they eventually reach the quack, who has probably adopted some form of physical treatment and is, in consequence, often able to give them relief. Financial reward is generally gained freely by the unqualified practitioner.

But as *The Times* says in its *Sunlight Supplement* of 22nd May 1928 there is no justification for the rashness which causes many people to place themselves "for sunlight treatment" in the hands of inexperienced and unqualified individuals. Sunlight treatment is medical treatment in the strictest sense of that term, and ought to be given only by physicians who have devoted special study to it.

Unfortunately qualified physiotherapists are often looked upon with suspicion by the other members of the medical profession, and are considered to be practising very near the border-line between reputable medicine and quackery.

Alas, the years 1926 and 1927 have seen many lay

attempts to commercialize actinotherapy, regardless of the fact that its uncritical employment is both dangerous and futile and that correct diagnosis is imperative.

A gigantic wave of quackery has swept the country, and moreover, as *The Times* says in its leading article on Actinotherapy to which reference has already been made: "At the present time great numbers of lamps constructed to emit ultra-violet rays are on sale to the public, and are being purchased by people who hope, by means of them, to enjoy 'sunlight baths' and 'artificial sunlight' illumination. Such enterprises are almost certainly premature and may very well be fraught with danger, for the ultra-violet lamp is a highly complicated scientific instrument, the evolution of which is still in its earliest stages."

It is almost as perilous for anyone to use ultra-violet radiation without skilled knowledge and training as it is for a layman to prescribe and administer some virulent poison or to endeavour to perform a surgical operation.

It is of supreme importance that this valuable remedial agent shall not be carelessly allowed to pass wholly into unqualified hands; if it does doctors will be deprived of a wonderful opportunity of securing additional scientific knowledge of one of the most potent instruments of healing.

Luckily, the medical profession itself can obviate the danger in a very simple way.

When medicinal treatment alone has been disappointing in such conditions as lupus, *Alopecia areata*, hay fever, rickets, spasmodophilia, tetany, or

Parkinsonism following *Encephalitis lethargica* (to mention only a few conditions at random), it is surely unwise for the sufferer to be told that nothing more can be done; this advice generally results in his rushing to the nearest unqualified practitioner.

In suitable cases it is certainly the duty of medical men to advise their patients to have appropriate physical treatment. It is also very unwise and absolutely unprofessional for doctors to send their patients to the unqualified when they desire them to undergo a course of ultra-violet radiotherapy, because, through lack of competent knowledge, the results are naturally often mediocre, and, moreover, disaster sometimes occurs.

Fortunately a change now seems imminent, and the following findings, which have been endorsed by the Council of the British Medical Association, and which were published in a supplement to the *British Medical Journal* of the 28th of April 1928, are not without interest:

TREATMENT BY RADIATION AND ELECTRICITY

81. The attention of the Council has been drawn to the risks to the public involved in the use of ultra-violet light apparatus by untrained persons, and the matter was considered by the Science Committee after report from a special Sub-Committee.

The Council endorses the following findings of the Science Committee:—

(a) Treatment by electro-therapeutic and radiation methods has much increased in recent years and it is probable that some members of

the profession have not kept themselves abreast of the more modern procedure and forms of apparatus. Hence treatment of this kind is sometimes prescribed in general terms rather than with specific directions.

(b) On the other hand these methods of treatment are being cultivated largely by persons who have had no medical education and no adequate practical training, and there is thus risk to the public.

(c) The law puts no restriction on the use by any person of such powerful agencies as electricity, radium, X-rays, diathermy and ultra-violet light.

(d) With all of these there is the risk of serious mischief and here in particular must be noted that the recent development of ultra-violet light apparatus and its sale for amateur and domestic use is not without its dangers. While allowing that these dangers have been overstated in some quarters, they undoubtedly exist, and it is admitted that the apparatus in individual cases has made active a quiescent phthisis pulmonalis and has caused serious damage to the eyesight. Other risks apart, here is good reason why this form of treatment should be confined to properly trained persons.

(e) Similarly diathermy from faulty application may produce burns which are very slow to heal, and applied in the region of the brain may cause giddiness and inco-ordination.

(f) Electricity therefore in its various forms and the several methods of radiation are, in

unskilful hands, agencies which may adversely affect existing diseased conditions, may make active quiescent disease and may inflict positive damage on various organs; even cases of death have been traced to these methods.

(g) Immediate steps should be taken to confine the use of these therapeutic activities to persons who have been adequately trained under medical direction.

(h) Opportunities for technical instruction already exist, at least in part, but it is necessary to establish a public opinion, both professional and lay, against the use of powerful remedial agencies by ignorant and untrained persons.

(i) The medical schools are not unaware of the therapeutic values here considered and are arranging corresponding courses of instruction for medical students.

The Council recommends:—

Recommendation: That the Representative Body express the following opinion, namely, that in view of the risks to the public involved in the use of electricity and radiation as methods of treatment by untrained and unqualified persons it is to be desired (1) that suitable courses of training should be organized under medical direction for persons who wish to administer this form of treatment; (2) that persons who have satisfactorily followed such a course should be entitled to have their names entered on an approved Roll; (3) that one of the conditions attached to admission to, and maintenance on,

the approved Roll should be abstention from the treatment of any patient except on the responsibility and under the general supervision of a registered medical practitioner; and (4) that patients who require electrical or radiation treatment should be referred only to those persons whose names are on the approved Roll.

Another recent development is also full of promise for the future. We refer to the organization of special physical treatment institutions, where teams of qualified practitioners, who are experienced physiotherapists, can treat large numbers of patients at the same time, with privacy, and at a very moderate charge.

Some medical men imply that the good results that follow actinotherapy are entirely due to suggestion. Even if they were (which certainly they are not), does not the patient most of all desire the cure of the condition?

Has a bottle of medicine no psychical effect? Many may remember a recently deceased patent medicine with an intriguing smell which did not seem to be entirely lacking in this respect.

Is not the wholesome mental stimulation of ultra-violet radiation superior to the unpalatable Freudian theories?

Nagelschmidt—determined to meet this criticism—specially treated two hundred cases of *Alopecia*, with success, because he said that the suggestion of psychical effect could hardly be advanced in this disease, which is so often resistant to medicinal treatment.

Many criticize the large number of diseases that workers claim they have cured or benefited by ultra-violet radiation; but are not most diseases benefited by the raising of the natural resistance of the body? After all, actinotherapy, like surgery, is a speciality of method. No comment is made when the surgeon causes such dissimilar conditions as tubercular glands in the neck or exophthalmic goitre to disappear by means of his scalpel. In each case the method is fundamentally the same: something is removed with a knife; but incredulity and severe criticism are often aroused when it is suggested that the radio-therapist can permanently cure the same conditions with some form of invisible radiation, such as X-rays or ultra-violet radiation; or that actinotherapy is valuable in such diverse diseases as *Alopecia areata* and tuberculosis of the hip joint, trachoma and hay fever, lupus and rickets, acidosis and Vincent's angina.

Another frequent criticism is that the estimation of the real value of ultra-violet radiation in medicine is made difficult because both drugs and actinotherapy are used in the same case. This stricture is rather extraordinary when one considers how rarely a bottle of medicine contains one ingredient alone. Does any doctor hesitate to give mercurial injections in a case of syphilis because the patient has had salvarsan administered? Is it clouding the issue to use an antiseptic spray in a case of follicular tonsillitis, because the patient is being given salicylates internally?

The important fact, and one that cannot be effectively gainsaid, is that it has been discovered that in many diseases more rapid improvement is obtained

by combining ultra-violet radiation with the administration of internal remedies than by using either alone.

Solar radiation is essential to all forms of life. Is it, therefore, unreasonable to make use of the various rays in the treatment of disease? At the same time it is essential to recognize the limitations of physiotherapy.

We are still convinced that there is a vast and beneficent field for part of this work in the hands of the general practitioner, and that the necessity by no means exists for curative work of this nature to be relegated wholly to the specialist, though there are some forms of treatment that are best left in his hands.

To-day we have an almost complete realization of the fact that, just as the sun gives light, so, too, sunlight has a curative influence upon disease. The trouble is that we do not get enough sunlight. Happily, however, we know how to produce it artificially. In our War Pensions Hospital experience we observed that patients who had languished in the wards responded at once when put outside on the open-air balconies. Foul discharging wounds which had persistently resisted treatment immediately began to improve; the men's pale cheeks began to colour; their appetites returned; and, generally, their condition became better. We never met a patient who, having once been put outside, wanted to come in again. Later, in general practice, we have seen the same wonderful change.

One case comes particularly to mind—that of a

man suffering from pernicious anæmia. We persuaded him to stay out-of-doors in the sun for gradually lengthening periods. He had a revolving hut placed in his allotment, and here he was able to undress, to don a small bathing suit, and to have his graduated sun bath. He improved wonderfully; but bad weather came, his treatment became very spasmodic, and he seemed to slip back a little each time he was unable to get outside. So we resorted to artificial sunlight on sunless days. We obtained a quartz mercury vapour lamp and began systematic treatment with graduated exposures, until finally the patient was having a total daily treatment of forty minutes' duration.

The effect was most inspiring. The periods of relapse, so characteristic of pernicious anæmia, ceased; he was able to attend his work for several hours daily; the number of his red corpuscles increased; and the improvement continued for several months. Unfortunately a sudden attack of influenza took him away after only one day's illness. He lived for five and a half years from the time the disease was definitely diagnosed from the blood examination.

This, it should be said, occurred before the institution of the successful method of treating pernicious anæmia by means of a diet rich in liver.

Having the lamp, we began using it for the treatment of other conditions in which we thought improvement could be expected—especially those cases in which open-air treatment had been of help, and also in certain skin conditions. Patients convalescing after acute illnesses did particularly well, and equal

success was observed in cases of rickets which had not responded satisfactorily to cod-liver-oil treatment. Cases of hyperpiesis that had remained stationary with medicinal treatment improved greatly with ultra-violet radiation. Very soon the lamp became indispensable.

No single therapeutic agent can be a "cure-all." Each has its place in medicine, and a new method of treatment is brought into disrepute only when extravagant and unsubstantiated claims are made for it. Medicinal treatment, physiotherapy, dietetics, climatology—all have their appropriate uses. It cannot be denied that at present we are experiencing a boom in ultra-violet treatment in the lay Press, and it is certainly deplorable that, in this country, persons without any qualification whatsoever are allowed blatantly to advertise the administration of ultra-violet treatment. At the same time we do not consider that the statement so frequently made by certain members of the medical profession is correct—namely, that ultra-violet treatment at present occupies an unreasonably exalted position in medical treatment and that it will rapidly sink to a much lower level than it at present occupies.

We most profoundly disagree with this suggestion. Visits to hospitals in different parts of the country have shown us how utterly inadequate, in the great majority of cases, are the facilities for the administration of this treatment, which is as yet in its infancy.

Improvements in ultra-violet apparatus comparable with those which have taken place in Röntgen therapy are inevitable. Increasing knowledge of how to prepare

selective filters will make their use more frequent in the future. We realize only too well that treatment with natural sunlight is the ideal method in many forms of disease. But in spite of Willett's wonderful daylight-saving measure it is an ideal often difficult to attain, particularly among the urban working-class population. In industrial towns suitable open spaces are often entirely absent, or difficult of access, and a working-class mother, especially if she has several small children, finds difficulty in taking these children out of doors for a sufficient length of time. Slums and smoke pollution aggravate the problem. The present state of affairs has been tolerated too long. Enlightened town-planning will avoid these grave defects in the future, and the promiscuous creation of slums will no longer be allowed.

Even now it is insufficiently realized how deleterious the effects of smoke are; how it shuts off the beneficial rays in sunlight, and what a tremendous amount of extra work it causes in the home, especially in cleaning and washing. Household hangings, which remain clean in the country for a year, have to be washed every two or three weeks in an industrial town.

It has been found that, normally, the country districts surrounding Newcastle-on-Tyne enjoy twice as much sunshine as the city itself: 841 tons of impurity per square mile have been found to fall in one year at a recording station situated in a manufacturing district of Newcastle, 413 at another in a crowded residential area, and only 263 tons at the smallpox isolation hospital on the Town Moor, which is less than two miles from the first-mentioned station.

It may be mentioned that the 841 tons just referred to is the heaviest recorded deposit in the United Kingdom.

Food must not be adulterated, water must not be



Photo]

[James Bacon & Son

FIG. 1.—Newcastle-on-Tyne and its Smoky Pall. (Reproduced from *The Newcastle Daily Journal*.)

contaminated, yet anyone may pollute the air we breathe practically without hindrance.

The air we inhale in twenty-four hours is six times heavier than the food we eat in the same period. If unpalatable food has been taken we can rid the system of it, but it is not possible to do this with the air we breathe.

During recent coal strikes, with the accompanying

closing-down of factories, the increase in visibility was most noticeable, and one realized then how great is the pollution of the atmosphere by smoke.

Hundreds of thousands of pounds sterling are being spent annually in this country in renewing stonework that has been destroyed by the sulphuric acid formed from smoke.

The erection of factories on the leeward side of towns is helpful in new town-planning proposals. But the total abolition of smoke is really of much more importance, and one way in which this could be achieved is by lowering the cost of electricity. It is its present dearness that hinders its more universal adoption. Of course the use of coke, coalite, and other smokeless fuels, aids smoke abolition, but the cheapening of the cost of electricity is the crux of the matter. A more general electrification of railways and factories would play its part too.

Our hospitals for in-patients should, if possible, be in the country, away from the smoke of towns, and the facilities for putting patients outside on verandas or balconies should be greatly increased. Again, indirectly, the health of the community suffers by the consumption of milk from cows grazing in fields adjacent to towns, and of market produce grown under similar conditions.

We would urge the more general use of either natural or artificial sunlight in the treatment of disease. As we have said, we think general practitioners, after suitable instruction, should use this method of treatment themselves in a great number of cases, so as to make it available for every class in the community.



FIG. 2.—An Express Train passing through Newcastle-on-Tyne.

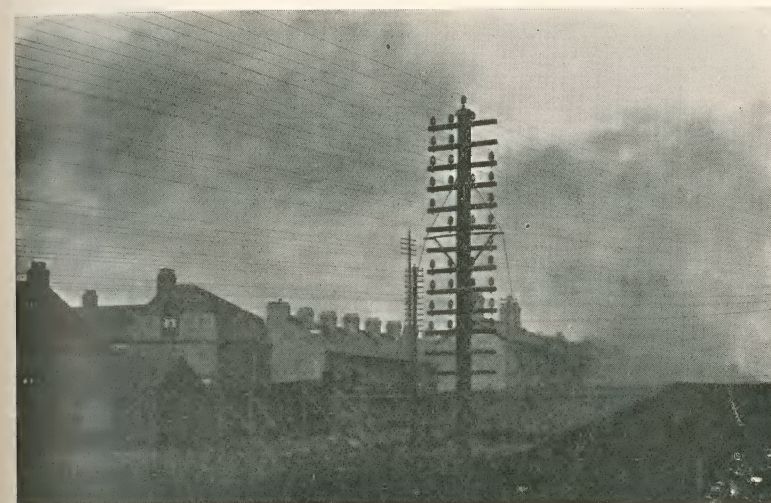


FIG. 3.—The Smoky Aftermath.

The cost is not too great to make its universal adoption possible.

Ultra-violet radiation is certain to be employed



FIG. 4.—A Steamboat on the River Tyne emitting dense clouds of smoke which are obscuring the sun. (Copyright photograph by A. L. Hitchin, F.R.P.S.)

increasingly in the future. "Sun ray" lamps will have to be installed in all hospitals, especially in those for diseases of the skin, throat, nose and

ear, and eye. Ante-natal clinics, tuberculosis clinics and sanatoria, and mental hospitals will also require ultra-violet equipment.

The value of ultra-violet radiation in surgical practice, particularly in the operating theatre, is just beginning to be realized, and the results of the pioneer work at the famous Necker Hospital, Paris, will soon be known all over the world.

Special ultra-violet clinics will undoubtedly have to be established in the centre of our densely populated urban districts, so as to be able to cope satisfactorily with the need for preventive and curative treatment of this nature.

General hospitals alone will never themselves be able to satisfy the ever-increasing demand for ultra-violet radiation, more especially where (as so often happens) X-ray diagnosis, electrical treatment, and ultra-violet radiotherapy are all crowded into one department, and where X-ray diagnosis alone often absorbs the greater part of the time of the honorary medical officer.

We consider that the special ultra-violet clinics to which we have referred are destined to play a very important part in the fight against disease and to give a fairer chance at last to preventive treatment, which is naturally the ideal form of procedure.

ULTRA-VIOLET RADIATION AND ACTINOTHERAPY

CHAPTER I

HISTORICAL

Sun Worship among Primitive Races, and the Greeks and Romans—The Industrial Revolution—The Discovery of the Spectrum and of Invisible Radiation—Pioneer Discoveries in Light and Electricity—The Pioneers of Actinotherapy—A Short Account of Finsen's Life

IN the beginning God said : " Let there be light." The sun was worshipped as the source of both life and light in very early times. Light was recognized as the bringer of health and happiness, as the power that overcomes the dread darkness associated with death and destruction.

The pastoral Aryans worshipped the sun, the great Lord of all, to whom they gave the name Dyaus, from which is derived the Latin *deus* and our own word Deity. The Persians were sun worshippers too, and gave the name Mithra to their god ; in Egypt the sun-god was called Ra ; in Greece, Helios ; and he was known by the Romans as Sol. The temple at Heliopolis was a centre for sun worship.

Hippocrates, the father of medicine, who lived on the little Greek island of Cos about 460-370 B.C., practised heliotherapy at the temple named after Æsculapius, the son of Phœbus Apollo ; Cornelius

Celsus and Galen, who lived about A.D. 130-200, also used sun treatment. Covering the head and exposing the rest of the body to the sun was a favourite practice among the Greeks and Romans.

Cicero describes the solaria that wealthy Roman citizens often had constructed at their country villas,



By the courtesy of]

[The Wellcome Historical Medical Museum

FIG. 5.—Is this the earliest record of the Irradiation of the Body and of Foodstuffs? (From *The Rock Tombs of El Marua*.)

the solarium generally being a terrace on the flat roof of a house.

In Peru the Incas were looked upon as gods, being considered children of the sun; they treated syphilis by heliotherapy. In our own country the Druids deified the sun, Stonehenge being associated with this worship; and is not our Sabbath still called Sunday? With the advent of Christianity there was a revulsion against all pagan practices, and, during the Dark Ages, heliotherapy fell entirely into oblivion, and there was

no appreciable revival until the end of the eighteenth century.

Even to-day fire worship plays an important part in two great religions: the Parsees worship fire as the visible symbol of Ahura-Mazda, the eternal principle of light, and the Brahmans consider light divine.

In Southern Bolivia the Chiriguanos Indians often pray to the sun, using these words: "Thou art born and disappearest every day, only to revive always young; cause that it may be so with me."

This country has been too apt to overlook the vital importance of sunlight to the human race, especially since the beginning of the industrial revolution, that was ushered in with the first use of coal for producing power. New towns rapidly sprang up, badly laid out, and with no attempt at town-planning. Factories were hurriedly built, and were allowed to use coal very wastefully, with the consequent production of large quantities of smoke, which cut off most of the valuable rays of sunlight.

The taxes that had been levied on windows were repealed only in 1851; and even now bricked-up windows can be seen, showing where steps had been taken to lighten the burden of the tax.

Narrow streets were built, into which the sun could rarely shine.

Sir Oliver Lodge explains the problem simply in the following words: "When the most efficient parts of sunlight are excluded, the organisms which flourish are of the lowest kind; and the higher organisms are apt to succumb to their ravages when unaided by the beneficial influence of sunlight."

It is too often forgotten that sunlight contains, besides light and heat, other forms of radiant energy very helpful to the most wholesome forms of growth.

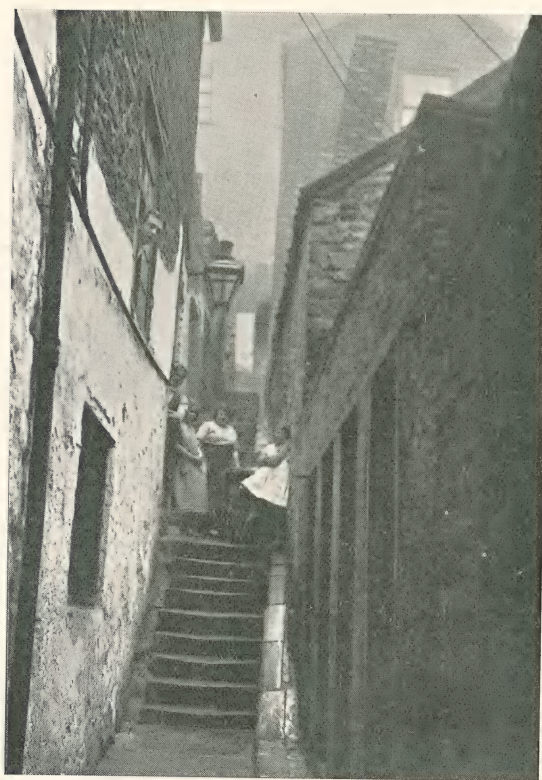


FIG. 6.—The Old Style. Slum Property in Newcastle-on-Tyne.

The centuries-old saying, "Light is the life of man," is only now beginning to be realized in its whole significance.

Heliotherapy is therefore not a new form of

treatment, but a very old practice revived. It teaches only what Hippocrates, Celsus, and Galen preached hundreds of years ago.

In 1666, Sir Isaac Newton discovered that white sunlight is composed of many different colours—red,



FIG. 7.—The New Style. Council Houses on the Pendower Estate, Newcastle-on-Tyne.

orange, yellow, green, blue, indigo, and violet—and he opened up the path to the various fields of invisible radiant energy and to the production of artificial therapeutic rays by this discovery of the spectrum. Even Newton was aware of only the spectrum of visible light, and he also thought that luminous bodies actually shot out small particles or corpuscles with tremendous velocity, the corpuscles being able to pass only through transparent bodies.

In 1678, Christiaan Huygens formulated the wave theory of light, which assumes that there is a univers-



FIG. 8.—Oscar Bernhard, M.D., St Moritz.

ally diffused medium that undergoes some form of regularly repeated physical change.

In 1733, Dufay discovered that there are two kinds of electricity.

In 1774, Faure treated ulcers with solar rays, and,

soon after, other workers used lenses to focus the rays of the sun on open wounds.

In 1777, Scheele described the action of light on certain silver salts.

In 1779, Ingenhouse showed that it is the light of the sun and not its heat that enables the chlorophyll of the green leaf to dissociate carbon dioxide.

In 1779, Bertrand published essays on *The Influence of Light on Living Organisms*.

In 1799, Volta announced the discovery of the voltaic battery.

In 1800, Sir William Herschel, repeating Newton's experiment, placed a clinical thermometer before each colour of the spectrum, and noticed that when it was placed beyond the limit of the visible red rays it continued to rise, which proved the existence of invisible radiant energy. These rays, owing to their position in the spectrum, were named "infra-red" rays, and because of their properties they are known as heat rays.

In 1801, Ritter, noticing that silver chloride was blackened by invisible rays situated beyond the limit of the visible violet rays, rightly concluded that other radiant energy, invisible to the eye, is present in the ether. These rays, owing to their position in the spectrum, he termed "ultra-violet" rays, and it is these rays, of all those in the solar spectrum, that have been proved to exert the greatest therapeutic influence.

In 1802, Sir Humphry Davy first produced the electric arc. This epoch-making discovery made artificial radiotherapy possible.

In 1815, Fraunhofer discovered the dark lines in the solar spectrum.

In 1820, Grotthus formulated the photochemical absorption law.

In 1820, Hans Christian Oersted discovered that a magnetic field is created round a wire connecting the two terminals of a voltaic battery.

In 1831, Faraday made the fundamental discovery that an electric current is induced when a conductor cuts across lines of magnetic force; this made the construction of the dynamo and other electrical apparatus possible. He found that an electric current is created in a wire loop by simply moving a magnet towards or away from it.

In 1835, Daguerre took the first photographs.

In 1845, Bonnet drew attention to the great value of heliotherapy in the treatment of tuberculous osteoarthritis, advising both local and general application.

In 1854, Bunsen perfected the spectroscope.

In 1862, J. B. F. Foucault and A. H. L. Fizeau devised an experimental method of determining the velocity of light.

In 1865, Clerk Maxwell demonstrated that light is due to electro-magnetic vibrations in the ether, and that the vibrations all travel through space at the same speed.

In 1876, Professor A. H. Rowland discovered that if an electrified body is moved a magnetic field is created round it.

In 1877, Downes and Blunt proved the bactericidal properties of light.

In 1879, Sir William Crookes, while experimenting

with a vacuum tube excited by a high-tension source of electricity, discovered cathode rays; later, in 1897, Sir J. J. Thomson showed that these rays consist of particles of negative electricity called electrons.

In 1885, A. A. Michelson determined the velocity of light to be 186,326 miles per second.

In 1886, Heinrich Hertz discovered by means of his oscillator that electro-magnetic waves can be produced in the ether with all the fundamental properties of light waves, but differing from them in wave-length, frequency, and penetrating power.

In 1889, Widmark showed that it is the ultra-violet rays in sunlight that cause erythema and pigmentation.

In 1893, Finsen published his early experiments on the physiological action of solar radiation and the rays from arc lamps, and announced the results of his treatment of tuberculosis of the skin by means of the "Finsen Light."

In 1895, William Conrad Röntgen discovered X-rays.

In 1896, Becquerel discovered the radiation given off by uranium.

In 1897, Sir J. J. Thomson demonstrated the existence of electrons.

In 1898, the Curies discovered radium and other radio-active substances.

In 1900, on the first day of May, Finsen's light treatment was introduced into England.

In 1902, Bernhard of Samaden treated wounds and tuberculous lesions with sunlight.

In 1903, Dr Rollier opened his first clinic at Leysin, in the Vaudois Alps, where he obtained excellent



FIG. 9.—Auguste Rollier, M.D., Leysin.

results in the treatment of tuberculosis, especially of the surgical type, by insolation in the brilliant Alpine sunshine.

In 1904, Kromayer designed the water-cooled quartz mercury vapour lamp for local treatment.

In 1908, Sir Henry Gauvain introduced heliotherapy at Hayling Island and at Alton.



FIG. 10.—Franz Nagelschmidt, M.D., Berlin.

In the same year Nagelschmidt used the air-cooled quartz mercury vapour lamp for general irradiation of the body.

In 1913, Reyn commenced general carbon-arc-bath treatment. It is, however, very interesting to remember that as long ago as 1895 Finsen wrote: "I believe

implicitly that, in the future, use will be made of this new therapeutic agent and it will be easy to carry it out practically under the form of light baths . . . that is, the exposure of the whole body to the chemical rays of light."

In 1918, Huldchinsky first showed the value of ultra-violet rays in the cure of rickets.

In 1924, in December, the Sunlight League was formed, with the late Queen Alexandra as its patron. The League has for its objects the abolition of smoke, dirt, and slums; and the education of the people in regard to the hygienic value of sunlight as a means of health, teaching that it is a stimulant, a tonic, and nature's universal disinfectant.

In 1926, in March, the monthly magazine, *The British Journal of Actinotherapy*, first appeared.

In 1927, The Society of Actinology and Actinotherapy was formed, with Sir Henry Gauvain as its first President, and Professor Leonard Hill as its Vice-President.

A SHORT ACCOUNT OF FINSEN'S LIFE

Niels Ryberg Finsen, the founder of modern actinotherapy, was born on the 15th of December 1861, at Thorshavn, in the Faroe Islands, where his father was chief magistrate. The Finsens are, however, an old Icelandic family. Finsen's father was married twice, Niels Ryberg Finsen being one of the four children of the first marriage. One of his brothers was Postmaster-General in Copenhagen. As a boy, Finsen was very fond of an outdoor life, climbing, fishing and

shooting, and he did not relish the restriction of his personal liberty when he was sent to a boarding school



FIG. 11.—Professor Niels Ryberg Finsen.

Born 1861, in the Faroe Islands. Died 24th September 1904, at Copenhagen.

in Denmark. At school he was a rather backward pupil, one of his reports reading: "Niels Finsen is a thoroughly good boy, but his abilities are small, and he is rather lacking in energy."

When Finsen was fifteen years of age his father took him from the Danish boarding school and sent him to continue his education at Reyjavik, the capital of Iceland, where he remained for six years.

The drawback of this change was that everything had to be learned in a new language—and by no means an easy one. The severe climate of Iceland, with its cold sunless winters, did not help Finsen physically, and he soon began to feel that something was amiss. Although he was intensely fond of climbing, he found that he had to give up this strenuous form of sport, and content himself with yachting and shooting—he was an excellent shot and won many medals.

In 1882, he became a medical student at Copenhagen, where he boarded with a hundred others at Regensen's. While there he found that he could work better in his chum's room, which was sunny, than in his own less cheerful room; and later, realizing the stimulating effect that sunshine had on him, he spent a part of each day walking up and down the sunny pavement at St Anneplads, where he had come to lodge.

Finsen now began to wonder why sunshine had this wonderful effect on him, but on consulting his copy of Hermann's *Physiology* he was unable to find any reference to light in it except in connexion with sight.

A little incident that occurred about this time greatly interested Finsen. He saw a cat lying contentedly sunning itself on a flat roof just below his window. After a short while the shadow reached it and the cat moved into the sunshine again; this little

action was repeated several times, and Finsen realized that by instinct the cat sought the sunshine. This was the genesis in Finsen's mind of the sun or light bath, and later he read about the Greek and Roman solaria.

In 1889, Finsen became engaged to Ingeborg, daughter of Bishop Balslev.

In 1890, when Finsen had finished his medical course, he was appointed demonstrator of anatomy. He had always shone in this subject, because he was particularly clever with his hands. He continued his anatomical work for three years, but suffered from ill health during the whole of the period.

While on holiday at his father-in-law's house at Ribe, in 1892, Finsen first began experimenting with sunlight. He tried the effect of it on his own skin. First he painted a two-inch strip on his forearm (which was usually covered by his coat-sleeve) with Indian ink, and exposed the arm to strong sunlight for nearly three hours. Some hours later he washed off the ink and found that the skin underneath was quite white, whereas the surrounding skin was intensely red, there being a very marked contrast between the two. Two days later he noticed that the redness had disappeared but the arm was pigmented, except in the white area, which was unchanged. Once more he exposed his arm to the sun, but this time without painting it, and later he found that the white area now turned red, while the surrounding skin was scarcely affected.

This phenomenon answered a riddle over which he had often pondered: why negroes have the warmest-coloured skins and people living in northern countries

the coldest, the property of black objects being to absorb visible rays and convert them into heat, whereas white objects remain cold because they reflect visible radiation.

Finsen then began to wonder, seeing the effect of sunlight was so strongly marked on normal skin, what the effect would be if the resistance of the body were lowered by disease, and he later evolved the "Red Room" treatment of smallpox, having noticed that in this disease the scars are usually most marked on the parts of the body usually exposed to light. He made the suggestion that smallpox patients should be treated in rooms with red windows similar to those used in the photographic dark-room. There was no smallpox in Copenhagen at the time, but in the summer of 1893 an epidemic broke out in Bergen, and Finsen's suggestions were followed out with great success.

In November 1893, Finsen wrote an article on "The Harmful Influence of Chemical Rays on the Animal Organism," and in this he showed that bacteria thrive best in darkness and can be killed by exposure to light.

Finsen's first work aimed at the exclusion of the blue-violet rays of light; now he began to study their effect on organisms. He differentiated certain animals into those which seek the light and those which prefer darkness.

First he made a box, the lid of which was made of strips of different coloured glass—red, yellow, green, and blue. He put some earthworms into the box and found that in a very short time they were all lying

under the red strip of glass. Certain beetles, earwigs, and wood-lice acted in precisely the same way.

Butterflies were next tried, and soon most of them were moving about under the blue glass. A few settled under the red glass, but these were all in a resting condition with folded wings.

Ripe salamander eggs, with the embryos plainly visible in the shells, were also placed under these same coloured glasses, and the number of movements were counted. Forty-six movements were noticed under blue light, eight under green, none at all under yellow, and six under red.

Finsen came to the conclusion that light, besides having illuminating and heat-producing properties, has also a chemical effect, which can be destructive to life (as is seen in the case of bacteria), or can be stimulating, producing development and movement. Chemical rays bring energy, transformed in different ways, to the body that absorbs them.

Finsen then began to advocate the use of "light baths" as distinct from radiant-heat baths, making use of the cold, so-called chemical rays.

He wrote: "My electric light bath consists of a circular room in the middle of which are two gigantic arc lights of 100 amperes suspended about 6 ft. from the floor, and by numerous radiating partitions bath chambers are formed in which the patients lie naked on couches."

Finsen next began to experiment with concentrated light, passing the sun's rays through lenses, made in the first instance of glass, and finally of quartz, and cutting out the heat rays by passing the radiation

through clear water; it was, however, found necessary to absorb the red and yellow rays too, and so he coloured the water with methylene blue.

He performed some experiments on his wife's ear, and found that there was much greater penetration of the rays if the blood was pressed out of the tissues. He was able to show that no darkening of photographic paper took place, unless it was held behind the lobe of an ear that was compressed.

Soon Finsen found that it was impossible to rely on sunlight in northern latitudes, and he therefore began to experiment with arc lamps.

In November 1895, Finsen was allowed by the manager of the Copenhagen central electric power station to experiment in his laboratory. It had been noticed that cases of lupus of the face were invariably a little better during the summer months than in the winter. Finsen therefore decided to test his theory of positive light treatment by applying it to this disease. The treatment of lupus at this time, by scraping, by the application of caustics, by excision with skin grafts, etc., was very unsatisfactory. It generally had to go on for years, and even if healing were effected, unsightly scars were left.

Mr Hansen, the manager of the Corporation Electricity Works, was a little doubtful about the propriety of allowing Finsen to treat patients actually at the works; but it happened that a friend of his, a Mr Mogensen, was suffering from lupus of the face, and had had the disease for eight years; and he became Finsen's first lupus patient. Treatment was given from November 1895 until March 1896,

when the lupus was entirely cured. A very primitive form of arc lamp was used.

About this time some friends were able to get Finsen a small money grant of £65 to help with his work. He began to feel at this period that he had not very long to live, and he made superhuman efforts to ensure that his ideas should be adopted and put into practical use.

At the time that Engineer Mogensen was receiving arc-light treatment Finsen had a very severe attack of pneumonia, and this made him all the more anxious to develop his light treatment quickly. He luckily managed to interest several influential men, foremost among them being Mr Hageman and Mr Gorgensen. The help of these two men proved invaluable, so that in October 1896, with the mayor, Mr Borup, as chairman, "Finsen's Medical Light Institute" was formed "to make and support scientific research concerning the action of light upon living organisms, and especially to apply the results to the service of practical medicine."

At first a small building in the Municipal Hospital garden was used. In return for free electric current Finsen promised to give treatment to those patients in the municipal hospital who required it. Only fifteen patients were treated in the first five months that the Institute was open. In 1897 the total reached seventy-three. Now more than two hundred patients are treated every day.

Finsen published a short paper in December 1896 on "The Use of Concentrated Chemical Light Rays in Medicine." Knowledge of the results that were

being obtained by the new cure for lupus soon spread abroad, and in a very short time there were a hundred names on the waiting-list. Queen Alexandra was a very warm supporter of Finsen from the beginning, and she persuaded King Edward and other royalties to visit the Light Institute. As a result, Light Treatment Centres were opened in most countries.

Soon the little building in the Municipal Hospital grounds became quite inadequate for the work, and on the 12th August 1901 the present Institute was opened, a Government grant of £12,000 having been obtained. The work rapidly progressed.

On 10th December 1903, Finsen was awarded the Nobel Prize. He spent most of the summer of 1904 in the country: he was very ill, ascites and a very troublesome cough causing him a great deal of distress. He was unable to walk, and had to be wheeled about in an invalid-chair by his wife. In September he moved back to Copenhagen and spent a considerable time in discussing the affairs of the Institute. On the 24th September he died peacefully, shortly after having said good-bye to his assistants. Thus he passed at the early age of forty-three; but his spirit still lives.

Reyn says that Finsen left at his death the complete designs of a clinic in which investigations were to be undertaken for the purpose of ascertaining more exactly what affections would lend themselves to treatment by general light baths, and among the diseases for which this treatment was to be used he expressly mentioned tuberculosis.

Quite recently large new hospital buildings have

been erected, having nearly two hundred beds for in-patients. The present Finsen Institute buildings are situated on the wide Strand Boulevard, within a stone's-throw of the sea, the new in-patient hospital facing the boulevard. In the grounds are the Radium Institute, the older building for the Finsen local treatment, the Light Baths building, and the hospital for the treatment of internal diseases by actinotherapy.

In spite of all his sufferings, Finsen had a strong sense of humour. In writing about an American, General Pleasanton, who had written a book on "The influence of the blue ray of the sunlight and of the blue colour of the sky in developing animal and vegetable life, in arresting disease, and in restoring health in acute and chronic disorders to human and domestic animals," he says: "The General's book, printed on blue paper, and bound in blue, makes one think, however favourably disposed one might be, that its contents could hardly fail to be coloured also!"

CHAPTER II

RADIANT ENERGY

The Ether—The Theory of Light—Waves—Sources of Light—Rate of Transmission of Radiant Energy—The Electro-Magnetic Spectrum—Properties of Different Forms of Radiation—Luminescence—Prismatic Analysis—The Solar Spectrum—Recent Discoveries in the Electro-Magnetic Spectrum—Divisions of the Ultra-Violet Region

RADIATION is thought to consist of waves in an all-pervading medium, which we know is not air, because the atmosphere extends for a very small distance indeed. The name "ether" has been applied to this elusive something, which cannot be described, because the ether is not perceptible by any of our senses. It, however, must possess some form of elasticity and resist changes in itself, because these properties are essential for wave-motion; it must also have inertia or mass, so that it persists in motion. It has always been realized that it is inconceivable that any action could take place through space between two widely separated bodies unless there were some medium of communication between them. There must be something in space that vibrates, and that "something" must extend to the farthest object we can see, and far beyond, to the most distant star.

The Theory of Light.—The undulatory theory supposes that light is propagated as a succession of waves in the ether, much as waves in water are propagated;

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light is thus defined as an electro-magnetic disturbance of the ether.

We know that water always finds a level, and resists anything that tries to disturb its level. If we depress the surface of the water at one place it becomes heaped up at another and waves are formed. A floating object at sea does not actually move forward with the waves; it is only raised up, pushed forward a little, then let down and pulled back again. The actual particles of water in the wave change from moment to moment. Wave-motion occurs when particles of any material move so that they successively start from and come back again to a given point.

Waves have certain properties in common, and these can be most easily realized by considering waves on the surface of water.

Wave-length is obtained by measuring the distance between the crests of two waves; amplitude is half the perpendicular distance between the crest and trough of a wave; the frequency is the number of times a second the cycle of movements is repeated at one point. Wave-velocity is obtained by multiplying the wave-length by the wave-frequency.

When light is transmitted through the ether, just as when waves are transmitted over the surface of water, the oscillations are transverse to the direction of the motion. The rate of propagation through the ether is the same for all the oscillations, but they vary over a long range in their number of vibrations per second and, consequently, in their wave-length.

It seems to be generally agreed now that light is

the result of waves of energy caused by the vibrations of electrons and transmitted through the ether.

Bohr found that the hydrogen atom consists of a nucleus or proton with a negative electron revolving round it, like a planet round the sun, in one of several possible orbits, and that every spectral line emitted by a substance can be accounted for by the dropping of an electron from one alternative orbit to another.

Electrons taken collectively constitute negative electricity.

Sir Oliver Lodge considers that the physical universe consists of :

- (1) Positive electric charges ;
- (2) Negative electric charges ;
- (3) The radiation due to sudden movements and rearrangements of these charges.

Electrons and protons arranged in various ways form the atoms of all the different elements, of which there are probably ninety-two in all, though one or two are as yet undiscovered. Radiation is always emitted in jerks, and is started whenever an electron drops nearer to the nucleus of an atom.

It has been found that each element has its own characteristic spectrum at a given temperature. If it be visible, the wave-lengths determine its colour, and their amplitude its brightness, and so from the colour of the light the rate of vibration of the atom can be ascertained.

Prismatic analysis proves definitely that every atom of matter has its own definite rate of vibration, just as a bell has. It may emit several colours, or only one, and the number it emits may depend on the extent to

which it is heated. In fact it is now thought that the only way in which light can be produced is by the vibration of electrons. For instance, every free atom of sodium vibrates in the same way, whatever other element it may be combined with, and whether it exists in the earth, in the sun, or in the most distant star. When a metal is heated to incandescence it sets up waves of energy: the waves differ in their frequency of vibration and in their wave-length, and the frequency increases proportionately with the decrease in wave-length. A poker can be heated in the fire, first, to redness, and then, at a higher temperature, to white heat.

Sources of Light.—The natural sources of light are the sun and the stars, these being bodies undergoing combustion, and therefore self-luminous. The sun is giving off vibrations of the most varied nature and wonderful complexity, all these varying vibrations occurring in the ubiquitous ether. Sir Robert Ball, in his book on the sun, marvels at the wonders of the sun's radiations. To quote his own words :

“ When we think that the sun pours forth its radiations with such prodigality that our Earth is only able to intercept the two-thousand-millionth part of the whole ; when we think that the other suns in space, to the number of many millions, are each of them simultaneously filling the ether with their orchestra of vibrations ; when we think of the marvellous delicacy with which that medium transmits all these vibrations, we begin to realize the majesty of the words, ‘ Let there be Light.’ ”

Rate of Transmission of Radiant Energy.—It has

been found experimentally that light, in common with other radiant energy, is transmitted through space at approximately 186,326 miles (300,000 kilometres) per second, the velocity being independent of the frequency and of the wave-length. The sun's rays reach the earth in eight minutes. All electro-magnetic waves can travel a distance equal to eight times the circumference of the earth in a second.

Astronomers use the term "light-year" to describe the distance travelled by a ray of light in a year, and this is equal to almost six million million miles. Alpha Centauri, the nearest star to the earth, is at a distance of four light-years from us, the pole-star is forty-four light-years away, and the five middle stars of the Plough are one hundred and eighty light-years away.

Recently a star cloud has been found which is 700,000 light-years away, and in which some of the brightest stars are about 30,000 times as luminous as our sun.

It has been noted that only a very short range of radiant energy is perceptible to the human eye, which is excited by only an octave of light—that is, the waves at the violet end of the spectrum are pulsating at twice the rate of the waves at the red end. The spectrum extends for many octaves beyond its visible limits.

The Electro-Magnetic Spectrum.—The part of the spectrum that lies beyond the visible violet can be directly observed by the aid of photography, or by means of special fluorescent screens. It is necessary, therefore, to think of a greatly enlarged spectrum—the electro-magnetic spectrum—consisting at one

extremity of the series of Hertzian or wireless waves, the length of which is measured in miles, and then including successively several octaves of infra-red rays, the single octave of the visible spectrum, the ultra-violet region, X or Röntgen rays, the gamma rays given off by radium, with a wave-length of $1.4 \text{ \AA}$ downwards ($\text{\AA}$ or an Ångström unit being equal to one ten-millionth part of a millimetre), and finally the "ultra-gamma" or "cosmic" rays, to which Professor R. A. Millikan has recently drawn attention, and which have been found to have most remarkable properties of penetration; and who can say whether even these form the other extremity of the electro-magnetic spectrum?

Luckiesh says: "If a normal spectrum of this entire range of wave-lengths of radiant energy could be produced and the portion of it due to visible radiation—light—were one foot long, the entire spectrum would be several million miles in length."

It has been proved that the velocity of the propagation of electro-magnetic induction through space is the same as that of light.

Hertz produced waves from the oscillatory discharge of a Leyden jar, and showed that these waves, which have very long wave-lengths, follow the same rules of reflection, refraction, and polarization, as light waves. They also travel at the same velocity. It is thus considered that radiation is caused by the rapid vibration or oscillation of electric charges within the atomic or molecular structure, the oscillations being continuously maintained at the definite frequency corresponding to the wave-length emitted.

X-rays, like light, are considered to be ether waves, but their length is very much shorter than that of visible light waves.

Infra-red rays behave in the same way generally as light. They are reflected and refracted, and the law of inverse squares also applies. By means of ebonite, which is transparent to all waves longer than the visible, it is possible to isolate the infra-red rays by absorbing the visible radiations. In a uniform medium light travels in straight lines. When an eclipse occurs light and heat are cut off at the same time; hence both must travel at the same enormous speed.

The ultra-violet spectrum is found to be continuous with the visible spectrum. Ultra-violet radiations are capable of being reflected and refracted according to the usual laws. They can be caused to interfere, and can be polarized by crystals—for instance, tourmaline—in exactly the same way as ordinary light.

When waves are absorbed by a blackened surface their energy is converted into molecular energy or heat. The molecules of the absorbing substance, being set in motion, in their turn become sources of disturbance in the ether, and generate waves in it. Lord Kelvin estimated that every square foot of the sun's surface radiates energy at the rate of 7000 horse-power.

Luminescence.—Generally, when light is absorbed by a substance it is converted into heat, but sometimes luminescence results—that is, there is an emission of light from the absorbing body. Luminescence includes photoluminescence, which can again be divided into

fluorescence and phosphorescence, in both of which light of a certain wave-length falling on a substance results in the emission of light of a longer wave-length. If the luminescence exists only when the exciting rays are acting it is called fluorescence. If it continues after the stimulus has ceased it is called phosphorescence. These phenomena are probably due to the motions of electrons separating from and recombining with their parent atoms. Janet Clark clearly describes the reaction as follows:

“In true photo-electric effect the electrons are lost from the substance; in fluorescence they return to their original atom; in photo-chemical reactions they attach themselves to some other atom or group of atoms.”

X-rays and ultra-violet radiations passing through the air cause it to conduct electricity, the ionizing effect of X-rays, however, being much greater than that of ultra-violet rays.

Prismatic Analysis.—In 1801, Ritter and Wollaston showed that when sunlight is passed through a prism the dark area beyond the violet of the resultant spectrum contains rays capable of blackening silver chloride.

Prisms in general have the effect of breaking up or dispersing a beam of rays projected on them. There is comparatively slight refraction in the visible spectrum, but it is considerable in the ultra-violet portion. In the region 2000 Å the separation corresponding to a given difference of wave-length is ten times as great as in the region 4000 Å. This renders the study of ultra-violet radiation a matter of greater

ease than that of the regions of longer wave-lengths. A point, however, is reached when the material of the prism, even though it may be of quartz or fluorite, absorbs the radiation projected on it. Another means of studying the shorter rays has to be adopted, and the diffraction grating is made use of. This consists essentially of a thin sheet of glass or metal on

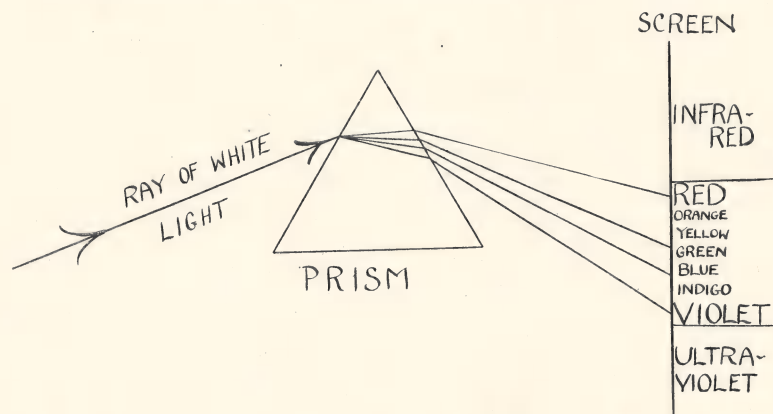


FIG. 12.—Diagram showing a Prism splitting up Radiation into its Component Parts, the Violet and Ultra-Violet Rays being more refrangible than the Red and Infra-Red.

which a large number of fine lines have been ruled very close together, the lines being parallel and equidistant.

Obviously there is a limit to the closeness of lines ruled mechanically, but nature has provided a finer separation in certain crystals (consisting of layers arranged one behind the other and containing regular assemblages). By means of these the wave-lengths of X-rays have been measured and found to vary from 1019 Å to 0.06 Å in length. The shorter

the wave-length the greater its penetrative power or hardness.

The Solar Spectrum can be divided roughly into visible and invisible portions. The visible spectrum is composed of the seven well-known colours—red, orange, yellow, green, blue, indigo, and violet—one colour merging gradually into the next. Each of the colours represents a movement of the ether, with its own average wave-length—namely,

Colour	Wave-Lengths Å	Average Frequency Million Millions per sec.
Red	7700–6200	375
Orange	6200–5900	541
Yellow	5900–5500	571
Green	5500–4900	595
Blue and indigo	4900–4300	645
Violet	4300–3900	750

These frequencies are, however, only approximately correct, and should be looked on as rough averages of the wave-lengths given.

The visible spectrum thus extends from 7700 Å to 3900 Å.

In the solar spectrum Fraunhofer's lines are present. These correspond to radiations emanating from the central mass of the sun, but absorbed by its cooler periphery. In the case of light it is known that many of the dark lines in the absorption spectrum of a body are in the same position as the bright lines in its emission spectrum; in other words, a body under suitable conditions—*e.g.* when cooling—is capable of absorbing strongly its characteristic light radiations.

With X-rays the contrary is the case, an element being especially transparent to its characteristic X-radiations. "The sodium atom contains systems of electrons which, when suitably excited, give out light of the frequency corresponding to the sodium lines. To use an analogy from sound, or from wireless telegraphy, the sodium atom is tuned to this frequency. It will, therefore, begin to vibrate violently if oscillations of this period fall upon it—in doing so it abstracts the energy of the radiation in tune with itself, so that the latter is very rapidly absorbed, while light with frequency remote from this passes on almost unaffected. Thus after passing through a very small thickness of material the light is robbed of all the constituents which have frequencies corresponding to those of the radiating systems within it. Hence all the electronic systems which have natural periods falling within the limits of the visible spectrum must produce a dark band when white light is passed through." Thus does Crowther describe the phenomenon in his recent book on *Molecular Physics*.

Experiments have shown that for an atom to emit its characteristic spectrum it is necessary that it should be in a region of intense ionization or recombination. It seems that nothing short of driving an electron into or out of the atom will suffice to set in vibration the light-emitting systems of electrons. In 1800, Herschel repeated Newton's classical experiment of passing a beam of light through a prism and thus breaking it up into its component parts. He placed a thermometer with a blackened bulb in various parts of the spectrum, and found that beyond the red

it showed a rise of several degrees when the eye could see nothing. He thus demonstrated the presence of infra-red rays. Recently the area has been extended some nine and a half octaves by the use of rock salt and sylvine prisms—that is, up to the Hertzian system.

The solar spectrum, extending from 2900 Å to $20\ \mu$ (one μ being the one-thousandth part of a millimetre), contains about six octaves of infra-red rays, one octave of luminous rays, and about half-an-octave of ultra-violet rays. The spectrum of the infra-red region has been mapped out by Professor Langley with his bolometer—an extremely sensitive instrument capable of showing a rise in temperature amounting to no more than one-hundred-millionth part of a degree centigrade. What would be a dark band in the spectrum, could we but see it with our eyes, would fail to heat the sensitive platinum strip of the bolometer, and the galvano-metric deflection would be correspondingly diminished or reduced to zero. A bright band in the spectrum would, of course, have exactly the opposite effect.

Ultra-violet radiation can be considered as formed of invisible rays whose frequencies are greater than those of the visible spectrum. By means of quartz prisms and lenses the region between 3900 Å and 1850 Å has been photographically recorded. Schumann mapped out the area from 1850 Å to 1230 Å by using lenses and prisms made of fluorite instead of quartz (which absorbs practically all radiations having wave-lengths less than 1850 Å), and also by using a vacuum spectroscope to prevent air absorption, the

TABLE SHOWING THE PROPERTIES OF THE VARIOUS RAYS OF THE
ELECTRO-MAGNETIC SPECTRUM

	HERTZIAN WAVES	INFRA-RED RAYS	VISIBLE RAYS	ULTRA-VIOLET RAYS	X-RAYS	GAMMA RAYS
GENERATION	Oscillating discharge of condensers, resonators, etc.	Heat radiations from hot bodies	Radiated from hot bodies and emitted by ionized gases	Emitted from very hot bodies, and also by ionized gases	Emitted by sudden stoppage of fast-moving electrons	Emitted when atomic nuclei disintegrate
GENERATION IN MEDICINE	Discharge of condensers with spark gap, etc.	Electric radiator; carbon filament lamp; arc	Carbon filament lamp; arc	Mercury vapor lamp; arc	Spark coil or transformer	Radium with thick filter
DETECTION	Cocher	Bolometer; rise in temperature of receiving body	Photography; produce sensation of light; certain chemical actions; photo-electric effect	Photography; phosphorescent effects; chemical effects; ionization; photo-electric effect	Photography; phosphorescence; chemical action; ionization	No effect with fluorescent screen; phosphorescence; chemical action; very vigorous; discharge of gold-leaf electroscope
REFLECTION	By sheets of metal	By polished metallic surfaces	By ordinary mirror, etc.	Especially by silicon, nickel, and magnesium	No ordinary reflection	?
REFRACTION	By large prisms of pitch	By rock-salt prisms	By glass prisms, etc.	By quartz or fluorite prisms	No ordinary refraction	?
DIFFRACTION	Yes	With coarsely ruled grating	With ruled grating on glass or metal	With finely ruled grating	By crystals	?
PENETRATION	Penetrating	Slight penetration rapidly absorbed by water	Slight penetration of body; more than infra-red; red rays most	Very slight penetration of most substances except air, quartz, fluorite, and water	Penetrates all matter to a greater or less extent	More penetrating than even X-rays

SELECTIVE ABSORPTION	Metals containing free electrons	Water	Hemoglobin	Albuminous substances, particularly tyrosin and phenylalanin	Molecules of heavy atomic weight	Molecules of heavy atomic weight
WAVE-LENGTH	Several kilometres to 1,000,000 Å	4,000,000 Å to 7700 Å	7700 Å to 3900 Å	3900 Å to 136 Å	1019 Å to 0.06 Å	1.4 Å downwards
VELOCITY	←	←	←	←	←	←
MEDICAL APPLICATIONS	High frequency; diathermy	Thermotherapy; calorotherapy	Phototherapy	Actinotherapy	Röntgen therapy	Radium therapy
ACTION ON SKIN, ETC.	Immediate hyperemia	Immediate hyperemia	No hyperemia if infra-red rays are removed	Hyperemia after a latent period of a few hours	Hyperemia after a latent period of many days	Very lasting hyperemia after latent period
EFFECT WITH OVERDOSAGE	Destruction of tissue	Destruction of tissue with charring	Superficial effect; no destruction of tissue	Superficial effect only	Destruction of tissue	Destruction of tissue
RATE OF ORDINARY REACTION	Immediate	Immediate and soon fading	Immediate and soon fading	After latent period of several hours	After latent period of 8-21 days	After latent period of about a month, reaction very lasting
ACTION ON BODY	Vaso-dilatation and heating	Hyperemia; elevation of temperature and congestive effect	Increases haemoglobin	General tonic effect, improved nervous tone, and calcium and phosphorus absorption, etc.	Local action: destruction of young active cells	
EFFECT ON BACTERIA	?	Abiotic above certain temperatures	None, unless certain sensitizers are added, such as eosin, erythrosin	Abiotic, also destroying most toxins and antitoxins	None	Has much slower action than U.V.R.

atmosphere being strongly absorbent of wave-lengths less than 1700 Å. Lyman, in fact, states that absorption of the air begins to manifest itself in the near ultra-violet, but becomes critical only at a wave-length of about 2000 Å.

Recent Discoveries in the Electro-Magnetic Spectrum.—Recently Lyman, by using powerful electric discharges in a helium vacuum, has been able to reach a wave-length of 510 Å. Millikan, by using electrodes of



Fig. 13.—Spectrogram showing part of Visible and Ultra-Violet Regions.

non-fusible material, separated by a very small space, and employing a potential difference of 100,000 volts, has reached a wave-length of 202 Å. Holweck, with slow cathode rays, has produced X-rays having a wave-length of 500 Å, so that the gap which formerly separated X-rays from ultra-violet has now been bridged.

The doctor using ultra-violet radiations therapeutically is concerned, however, only with the area between 3900 Å and 1850 Å. Browning and Russ have shown that from the clinical point of view there are two distinct regions of ultra-violet radiation—the first, extending from 3800 Å to 2960 Å, being rays capable of penetrating a considerable depth of human skin, but having no bactericidal effect; and the second, extending from 2960 Å to 2100 Å, having

a strong germicidal effect, but not capable of penetrating more than one-tenth mm. of skin. The maximum abiotic effect is produced by rays between 2800 Å and 2540 Å.

The following table gives the different wave-lengths of the complete spectrum :

Gamma rays of radium	up to 1.4 Å
X-rays	0.06 Å to 1019 Å
(Those generally used for medical purposes have a wave-length varying between 0.06 and 0.5)	
Ultra-violet	136 Å to 3900 Å
Visible spectrum	3900 Å to 7700 Å
Infra-red	7700 Å to 4,000,000 Å
Hertzian oscillations : 1,000,000 Å to several kilometres	

It will be noticed that in several cases the wave-lengths given in the above table overlap.

Laue has proved that crystals will produce interference effects with X-rays similar to those produced with diffraction gratings in the case of light waves; and Professor Bragg has been able to focus X-rays with bent sheets of mica. Curiously, Röntgen rays have little or no effect on bacteria, and in this respect show a marked contrast to ultra-violet rays, certain wave-lengths of which, as already stated, have a most marked bactericidal action.

CHAPTER III

NATURAL ULTRA-VIOLET RADIATION

Comparison of Natural and Artificial Radiation—The Solar Spectrum—Influence of Altitude, Time of Day, and Season—The Technique of Heliotherapy—Dosage—Local Heliotherapy

THE natural source of ultra-violet radiation is sunlight, which is the most powerful form of radiation known. It is very difficult to realize that of the total solar radiation only the two-thousand-millionth part is intercepted by the earth, and that only 60 per cent. of this amount passes through the earth's atmosphere.

The intrinsic brilliancy of the sun's surface has been calculated to be 1000 candles per square millimetre, while an arc lamp has a brilliancy of only 170 candles for the same area. Solar rays are parallel, while artificially produced rays always diverge from their source unless they are passed through special lenses.

Visible light can cause three different results: heating, illuminating, and so-called chemical effects. The red and orange rays have the greatest heating effect, the yellow rays are the most luminous, and the blue, indigo, and violet have the most marked chemical effects. Thus in sunlight there are some heat rays that are visible, and some—the infra-red—that are invisible; and there are also some chemical rays that are visible

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and others—the ultra-violet—that are invisible. We have then

1. Invisible heat rays (infra-red)

2. Light rays $\left\{ \begin{array}{l} \text{red} \\ \text{orange} \\ \text{yellow} \end{array} \right\}$ producing heat

$\left\{ \begin{array}{l} \text{green} \\ \text{blue} \\ \text{indigo} \\ \text{violet} \end{array} \right\}$ producing chemical effects

3. Invisible chemical rays (ultra-violet)

The same three kinds of rays are given off by all arc lamps, but in varying proportions, as the following table shows:

TABLE SHOWING PERCENTAGE OF RADIATIONS GIVEN OFF BY VARIOUS SOURCES

Source	Infra-Red	Light	Ultra-Violet
1. Mercury vapour . . .	52%	20%	28%
2. Sunlight . . .	80%	13%	7%
3. Arc lamps (such as Carbon)	85%	10%	5%
4. Incandescent lamps .	93%	6%	1%

Though the infra-red and visible rays can be successfully used, either separately or together, in a very large number of conditions, in this book they will be considered not individually, but only as a part of the radiation given off by one or other of the ultra-violet lamps that are mentioned.

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It is almost wholly the therapeutic action of the chemical, or more correctly the ultra-violet, rays that will be considered in the succeeding pages. As

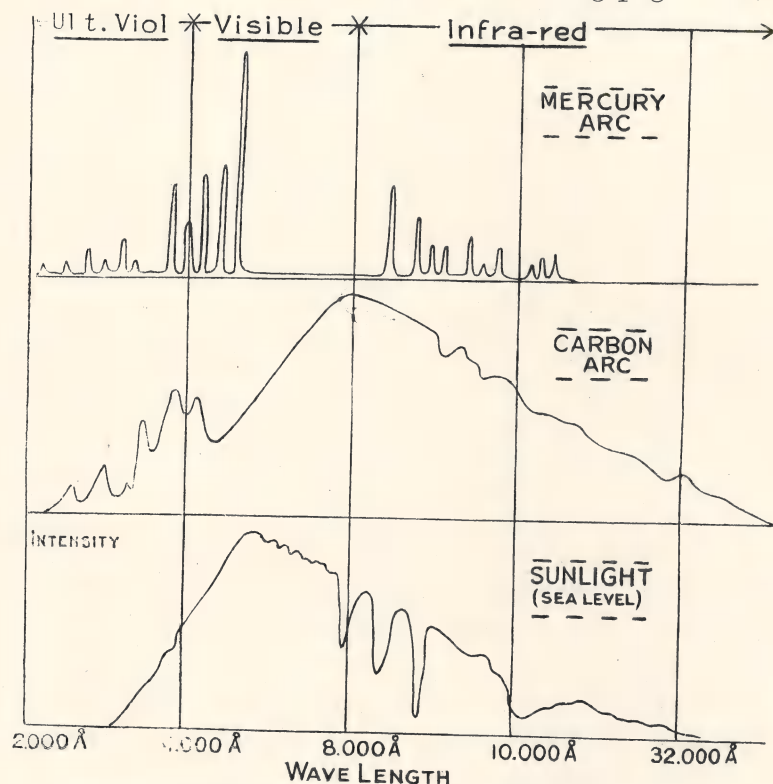


FIG. 14.—Spectra of Common Sources: Distribution of Intensity.
(After Griffith and Taylor.)

Finsen said: "It is to the most refrangible rays that we owe the special influence of light. The influence of light as a bactericide, its power to cause inflammation and pigmentation of the skin, as well as its stimulating action, are connected with the chemical rays."

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There is great diversity of opinion as to whether natural sunlight or artificially produced rays are of the greater therapeutic value. Dr Rollier is strongly in favour of the former, and we all realize that sunlight, together with pure, fresh, dry air, free from



FIG. 15.—Children Patients at Dr Rollier's Clinic, Leysin, playing in the Snow.

dirt and smoke, such as can be obtained at Alpine resorts, is better for general treatment than doses of artificially produced rays administered in hot rooms in the centre of our smoky cities. In Switzerland at altitudes over 5000 feet the supply of sunlight is very constant, whereas in England the sun appears very erratically, and when it does its actinic value varies

almost from minute to minute, making dosage difficult and regular courses impossible, and so one must often fall back on "artificial sunshine."

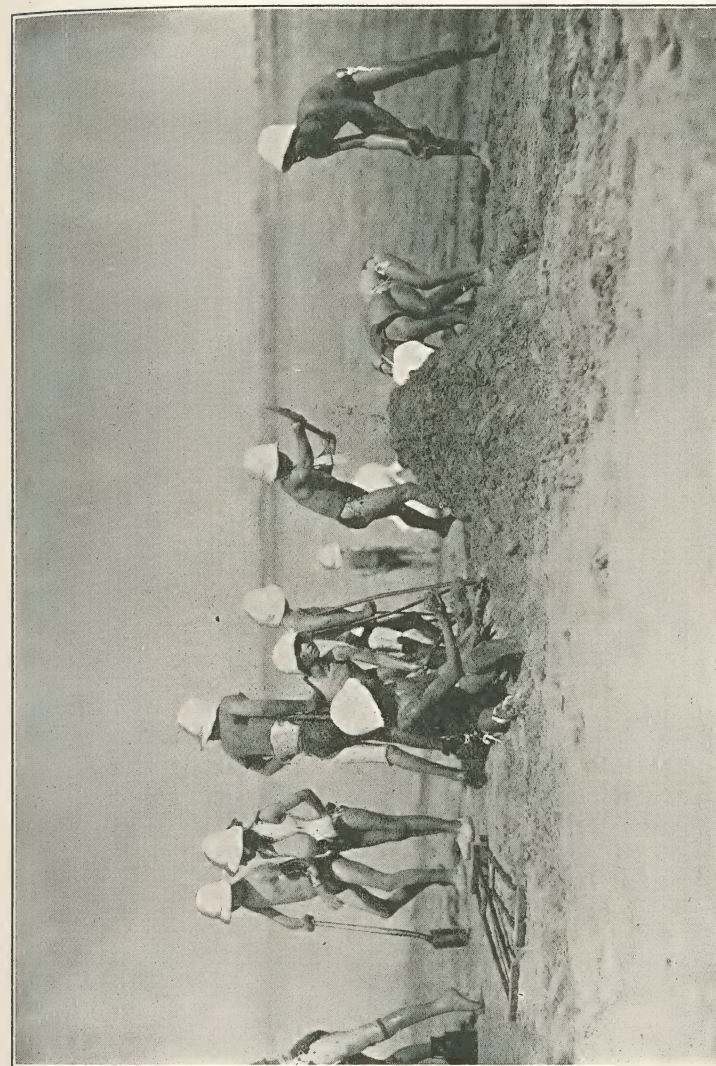
As someone has said: "The sun is the greatest physician in the world; the only trouble is to get an appointment with him."

Some phototherapists hold that certain rays from the sun are unnecessary, and even harmful, for therapeutic purposes, and these are not present in artificial actinotherapy.

"Sun and ultra-violet rays bear much the same relation to one another as crude drugs do to their synthetically prepared chemical substitutes" is a quotation from Rollier's book on heliotherapy.

An examination of statistics of various cases of tuberculosis treated by heliotherapy at Leysin, and by carbon arc radiation at the Finsen Institute, Copenhagen, reveals the surprising fact that the results obtained by the two forms of treatment are almost identical, and in some cases the Finsen results are even better than those obtained under the ideal conditions of the Alps. This is even more wonderful when one realizes that the patients at the Finsen Institute are out-patients, who return to their none too healthy homes after treatment, and who obtain a minimum of fresh air or sunshine.

The limits of the solar spectrum are influenced by the seasons, by the clearness of the atmosphere, by the height of the sun above the horizon—*i.e.* the time of day—and by altitude. It has been found that the last-mentioned has very little effect; but the spectral range decreases very considerably the lower the sun is in



[Sir Henry Gauvain

FIG. 16.—Sun Treatment on the Beach at Hayling Island.

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the heavens—that is, the longer the path through the earth's atmosphere that the radiation has to traverse. Red skies at sunrise and sunset prove that the atmosphere absorbs rays of short wave-length—the colour showing that the red rays alone reach the observer's eye when the sunlight has to pass through the maximum thickness of the atmosphere, and that the other rays of shorter wave-lengths are all absorbed. In foggy weather the sun, if it can be seen at all, appears as a red disc.

The sun's rays reach their maximum intensity at about 1 P.M., and not at noon, as might have been expected; the greatest intensity of rays of short wave-lengths occurs at the same time.

Seasonal influences affect both the sun's spectral range and the intensity of the solar radiation.

It is in the month of July that the maximum range of the spectrum is usually found, while in winter the smallest amount of ultra-violet radiation is present. In winter the intensity of ultra-violet radiation at high altitudes varies considerably from that found at low altitudes, the greatest amount of both ultra-violet and calorific radiation being found at high altitudes; in summer there is no great difference between high and low altitudes.

From May to September the intensity of the ultra-violet radiation remains fairly constant, but from October to April sudden variations of considerable extent are commonly found, although these are often rather inexplicable. Except during one month (July), the intensity of the calorific radiations is always greater than that of the ultra-violet.

Diffuse light also plays its part in heliotherapy, and contains a larger proportion of ultra-violet rays than one would imagine, because rays of short wave-length are more easily diffused than rays of longer wave-length.

Small particles of dust, water-vapour, etc., are responsible for the diffusion of light; and it is therefore obvious that the greater the thickness of atmosphere the rays have to traverse the greater will be the resulting diffusion. Hence the diffusion of light is greater at low levels than at high, and increases during those parts of the day when the sun is lowest in the heavens. It is also greater in winter than in summer.

It must be remembered, however, that impurities in the atmosphere, such as smoke and dust, even though they may scarcely affect the amount of visible radiation, generally absorb practically all the ultra-violet rays.

As one would expect, reflection increases the diffusion of light, and it is found to be greatest near large expanses of water or above stretches of snow.

Heliotherapy is the graduated exposure of the whole or part of the body to the sun's rays.

The practice, as we have already stated, is by no means new, the Greeks and Romans knowing and making good use of the salutary effects of solar radiation.

We have described how Finsen first of all used the sun lens for the treatment of lupus. The lens consists of two pieces of glass, one flat and the other convex. These are fixed into a brass ring, the space between them being filled with a blue solution of either

copper sulphate and ammonia or methylene blue water.

The ring is fixed into an adjustable stand so that the sun's rays can be kept in focus on the affected part.

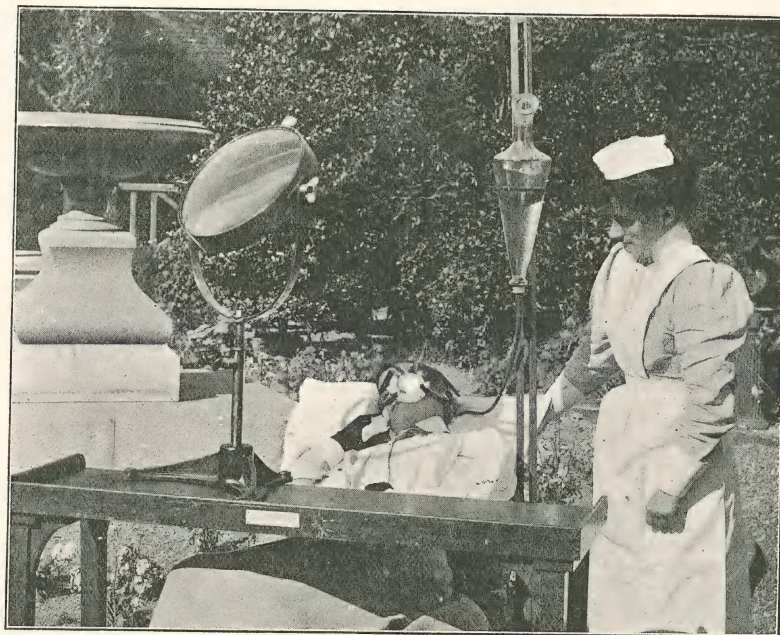


FIG. 17.—The Finsen Sun Lens in use at the Royal Sea-Bathing Hospital at Margate in 1899. (From *The British Journal of Actinotherapy*.)

A water-cooled compressor must be used also to cool and compress the tissues.

Finsen gave up this method because he found it too uncertain.

Dr Sörgo has designed a simple apparatus for direct insolation of the larynx, which will be described later.

For general treatment, when possible, the whole

body, with the exception of the head, should be exposed to sunlight, preferably out of doors, but if this is not feasible the patient should be placed in front of an open window, or a closed window glazed with "Vitaglass," which allows the free passage of all the natural ultra-violet rays.

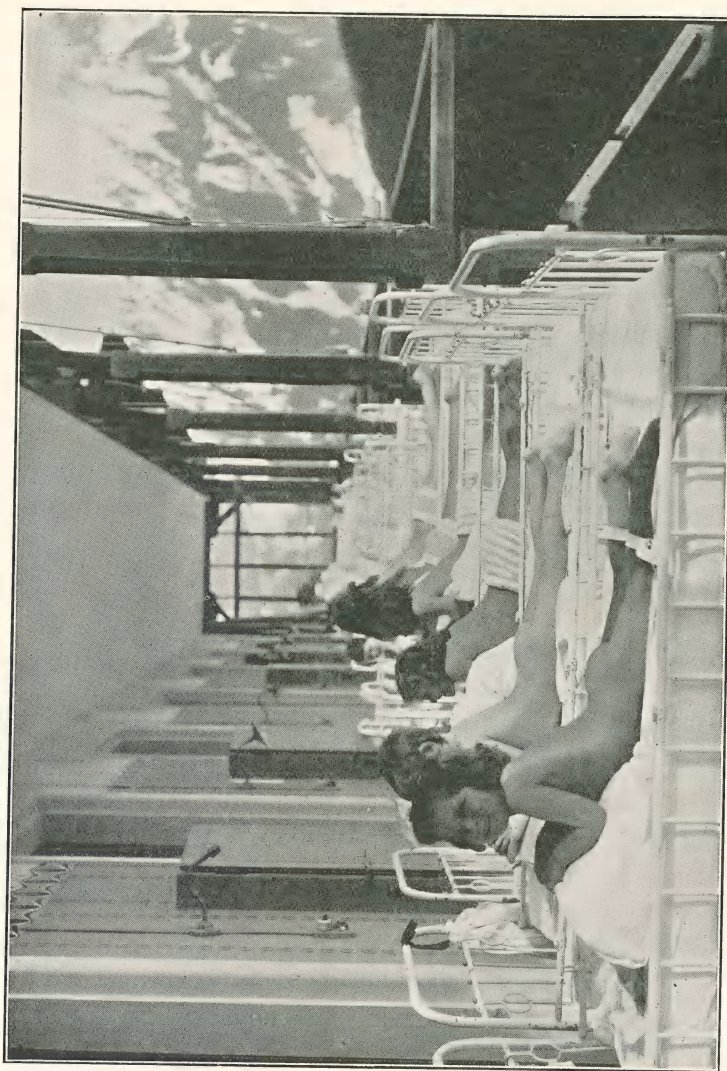
The best time of day for sun baths varies with the season, and should be chosen when the temperature of the surrounding air is favourable—that is, when the temperature taken in the shade is about 46° F. In winter some time between 10 A.M. and 3 P.M. will generally suffice, and in summer between 6 A.M. and 11 A.M. and between 3 P.M. and 5 P.M.

The temperature of the surrounding air found comfortable by the patient varies greatly for different persons; the greatest heat can be tolerated by those who are used to the treatment, and also by those who are young and fairly strong.

The same methods can be used for the measurement of the intensity of the solar rays as are used for the measurement of radiation from artificial sources. These will be described later.

Great care must be taken, especially at the beginning of treatment, to avoid over-exposure of delicate patients and those suffering from tuberculous lesions: any rise in temperature or pulse rate, or sign of nervous irritation after exposure, indicates that the exposure should be decreased, or the treatment discontinued, according to the severity of the symptoms.

It is not customary to expose the whole body at the beginning of treatment: only a small surface is



[Dr. A. Rollier

FIG. 18.—A Sun Gallery at Leysin for the Treatment of Pott's Disease.

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uncovered on the first day, and this area is increased daily until the whole body is being irradiated.

The head should always be shaded, and dark glasses should be worn to protect the eyes.

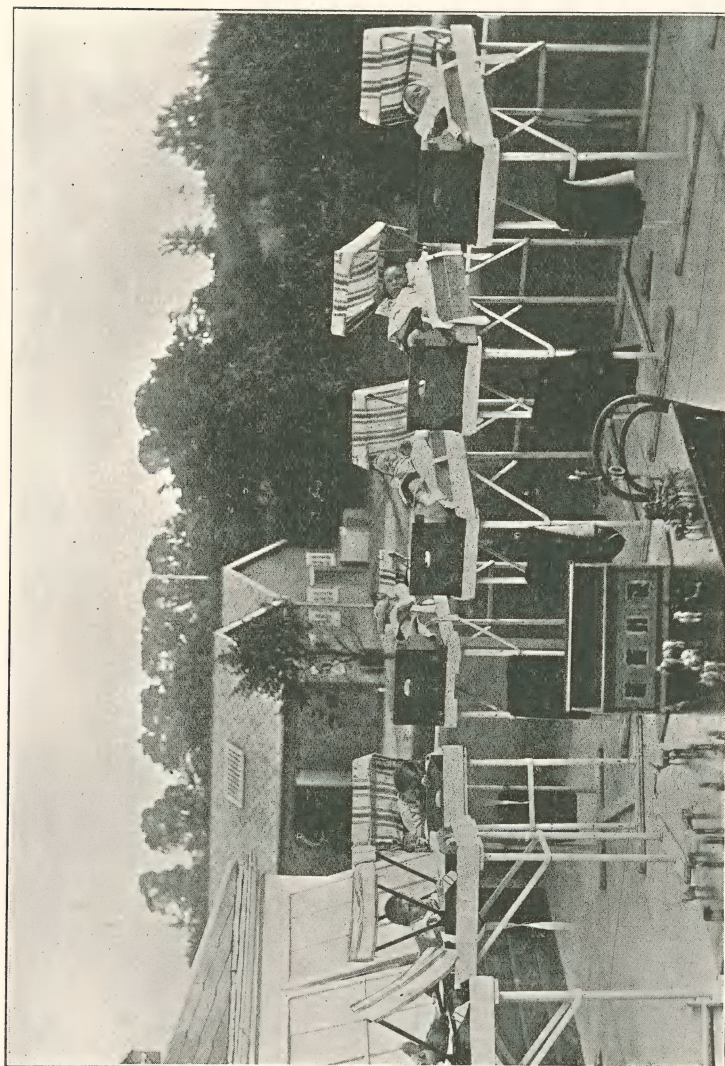
If the patient is very weak or sensitive, eight to ten days are allowed to elapse before the whole body is exposed, and great care is taken to record the temperature and pulse. If, on the other hand, the patient tolerates irradiation well, pigments quickly, and is fairly strong, the process may be accelerated, and the whole body exposed after three or four days.

Dr Rollier's method of fractional exposure is very advantageous and is widely used.

At the first application the feet alone are exposed, on three separate occasions during the day, for five minutes. At the second treatment the feet and legs are exposed for five minutes, then the legs are covered and the feet exposed for another five minutes. On the following day, in the same way, the feet are exposed for fifteen minutes, the legs for ten minutes, and the thighs for five minutes. On the fourth day the exposure of the feet is increased to twenty minutes, that of the legs to fifteen minutes, and that of the thighs to ten minutes, and the abdomen is exposed for five minutes; and in the same way the thorax is included on the fifth day, unless the patient is suffering from phthisis or heart trouble, when it is unwise to expose the chest for about a month.

The exposure of the body is then increased gradually, by five minutes per day, until a maximum of three to four hours is reached.

As has been already mentioned, this procedure may



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FIG. 19.—A Solarium at Lord Mayor Treloar's Cripples' Hospital, Alton.

[Sir Henry Gourevin

be modified according to the susceptibility of the patient, but when marked pigmentation is established there is no further fear of over-exposure.

Patients tolerate two or three short exposures with rest-intervals much better than a single long exposure.

Where practicable, a tepid bath or douche is beneficial after insolation, especially if there has been profuse sweating, but if this is not possible the patient should rest for some minutes.

A patient should be immediately covered with rugs if he feels too cold during treatment.

Any ulcers or sinuses should be left exposed.

It should be remembered that brilliant sunshine is not essential for heliotherapy, and that diffused rays play an important part, especially near the sea, or near snow, where reflection increases their effect.

If treatment is interrupted by bad weather, or from some other cause, it should be recommenced with a smaller dose.

Patients who are sent to high Alpine sanatoria should not be insolated until they have become accustomed to the altitude and the air. Marked disturbances are often noticed, and, although these generally pass off in two or three days, their occurrence means that exposure to the powerful sunlight must be undertaken only with great caution.

The effects of exposure to sunlight are the same as those of exposure to rays from artificial sources. During insolation the pulse and respirations are slightly increased. After a long exposure the temperature of the body may be slightly raised, but it returns



FIG. 20.—Some of Dr Rollier's Patients undergoing the Natural Sunshine Cure at Leysin, in the Vaudois Alps. (From *Modern Science*.)

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to normal half-an-hour to one hour after the cessation of treatment.

Perspiration is profuse if the rays are very hot, particularly if the temperature of the surrounding air is high and the exposure is long.

The patient experiences a feeling of well-being after a sun bath unless it has been too prolonged. After a latent period of several hours erythema becomes marked, and blisters may form if the patient is too sensitive or the exposure has been too long. This condition lasts for two or three days, and is followed by pigmentation, which, when it is well established, protects against excessive reaction.

The various general changes that accompany insolation are identical with those occurring in artificial irradiation, and will be more fully discussed in the chapter dealing with biological changes.

Clothes made of cellulose acetate are partly permeable to ultra-violet rays, and their use offers some advantages for this reason.

CHAPTER IV

CARBON, TUNGSTEN, AND IRON ARC LAMPS

Incandescent Lamps and Light Baths—Classification of Arc Lamps—The Arc—Short-Flame and Long-Flame Arcs—Regulation of an Arc—Carbons—Open Arc Lamps—The “Finsen” and “Finsen-Reyn” Lamps—Enclosed Arc Lamps—Special Types of Arc Lamp—Tungsten Arc Lamps—The Iron Arc Lamp

As has been previously mentioned, it is almost impossible to practise heliotherapy regularly in this country, owing to its low altitudes and its climatic conditions. The moisture-laden atmosphere and the smoky air filter out the majority of the therapeutic rays of the sun, particularly in our large cities, and especially in winter, so that the sunlight we get is very often lacking in these vitally important wavelengths. Consequently we must generally rely on artificial light for our phototherapy, some form of electric arc or incandescent lamp being customarily used.

Incandescent Lamps and Light Baths.—The incandescent electric lamp is very rich in visible and heat rays, but the ultra-violet rays are almost completely cut off by the glass bulb.

The light of incandescent lamps, however, applied either locally or to the whole body, is of great value in many disorders, amongst which are neuritis,

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rheumatic conditions such as lumbago, fibrositis, myalgia, torticollis, gout, rheumatoid arthritis, chronic nephritis, and early arterio-sclerosis.

By means of such light baths the temperature of the skin can be raised to a very high point without

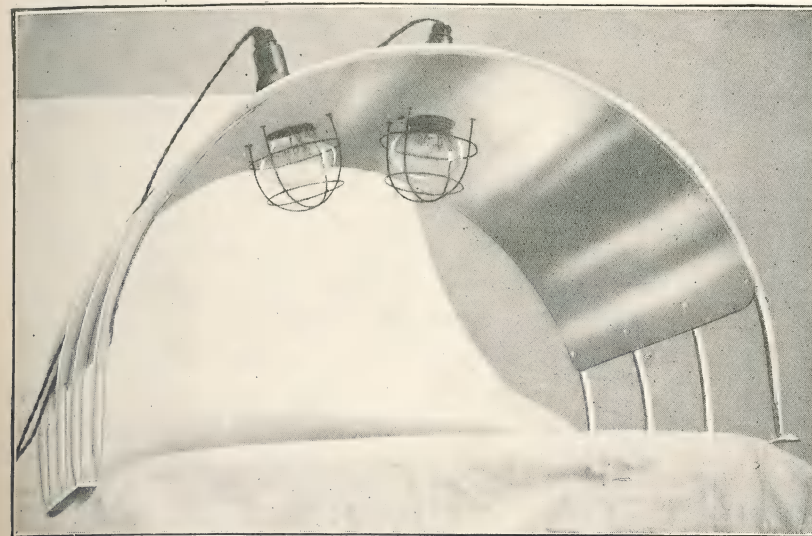


FIG. 21.—The “Ulvira” Apparatus, showing the two Quartz Globes fitted with Tungsten Filaments, which form a weak source of Ultra-Violet Radiation. (Siebe, Gorman & Co.)

danger. This results in dilatation of the cutaneous arterioles, and stimulation of the sweat glands. Internal congestion is relieved, pain is lessened, and a feeling of well-being and comfort results. An increase in metabolism and in the hæmoglobin content of the blood can also be shown to occur. If, however, incandescent lamps are provided with bulbs of quartz instead of ordinary glass, they form a weak source of ultra-violet rays, which may be beneficial in some

cases if several lamps are burned continuously as near to the naked body of the patient as comfort allows.

The "Ulvira" apparatus manufactured by Siebe, Gorman & Co. is of this type.

Some form of electric arc lamp is generally used to produce ultra-violet rays. They may also be generated by the spark discharge of Leyden jars or spark coils, but not in sufficient volume for therapeutic purposes.

If the reader finds the chapters describing apparatus rather tedious he is advised to pass them over. The authors, however, feel that it is very desirable that at least one typical example of each of the many types of apparatus should be described. A great variety of lamps is being used to-day, and it is reasonable that each reader should expect to find his own type of lamp at least mentioned, which is not possible when the products of only one particular firm are discussed.

Arc lamps may be divided into two main groups :

1. Open arcs.
2. Enclosed arcs.

Arcs may be :

1. Hand-fed.
2. Automatically regulated.

They may also be :

1. Air-cooled { non-mechanically.
mechanically.
2. Water-cooled.

Open arc lamps usually have their electrodes made of carbon, pure or modified ; but various metals may be used, such as tungsten, iron, aluminium, cadmium, silicon.

Carbon arc lamps are generally of the open type, but the "Quain Quartz Arc" and the "Heliol" lamp are two examples of enclosed carbon arcs. Quartz mercury vapour lamps are, however, the commonest type of enclosed arc.

Most carbon arcs are automatically fed, while hand-feeding is the rule with tungsten lamps. General treatment lamps are usually air-cooled, but it is customary to use water-cooled lamps for local treatment.

THE ARC

A space containing air or some other gas can be bridged by an electric discharge in one of three ways :

1. By a glow discharge, as in the "Neon" lamp.
2. By an electric spark : the induction coil furnishes a familiar example.
3. By an electric arc.

When two carbon electrodes with a sufficient difference of potential between them are brought together, the points in contact immediately become extremely hot, and some of the carbon is volatilized ; if the electrodes are then slightly separated, the carbon vapour conducts the current from one electrode to the other, an intense illumination results, and an arc is formed.

Sir Humphry Davy discovered this phenomenon in 1801, and in 1808 he exhibited an electric arc

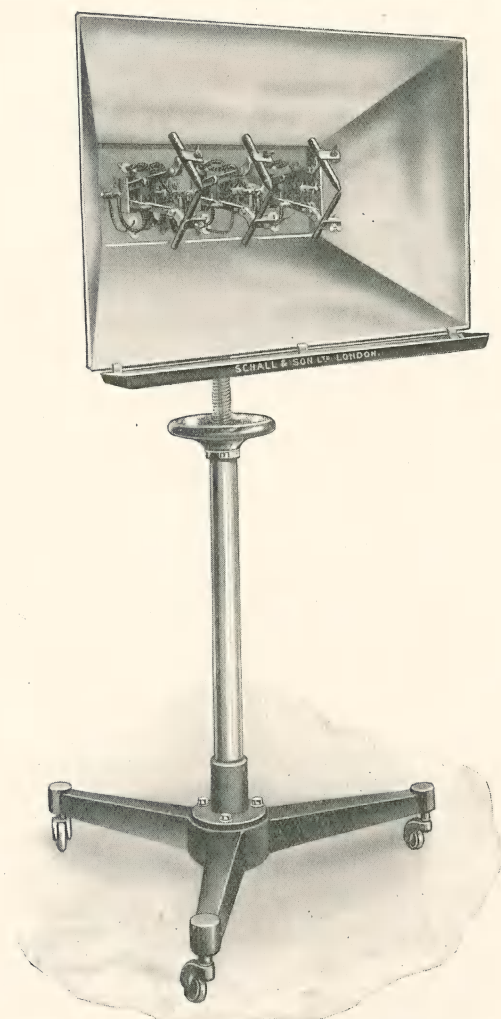


FIG. 22.—Triple Arc Lamp, automatically fed.
20 amperes A.C. or D.C.

produced by a battery of 2000 cells at the Royal Institution.

In the electric arc the ends of the electrodes become incandescent, and a flame of luminous vapour fills the space between them. When the electrodes are in a horizontal position the flame is arch-shaped, and the name "arc" was given to it on this account.

The colour of the arc flame depends entirely on the electrodes; pure carbons generally give a white flame, and metals, according to their nature, produce green, blue, or violet-coloured flames. In the direct-current arc the tip of the positive carbon becomes extremely hot, and may reach a temperature of 3500°C .

A cup-shaped depression, known as the crater, forms at its extremity, whereas the negative carbon becomes sharply pointed.

The positive carbon is generally made thicker than the negative, because in the open arc it burns away almost twice as quickly as the negative, and the difference in size keeps the position of the arc constant.

In the direct-current short-flame open arc 85 per cent. of the radiation is from the brightly incandescent positive crater, 10 per cent. from the negative carbon, and only 5 per cent. from the flame of the arc itself.

The carbon arc flame consists of an inner violet band of carbon vapour surrounded by an outer yellow aureole.

The maximum radiation is given off from the positive crater at an angle of forty to fifty degrees from the axis of the carbon.

The two carbons are generally arranged co-axially

in the vertical position, with the positive uppermost, when direct current is used. Angus, however, has recently advocated putting the positive carbon below and the negative above, and claims that by this means 50 per cent. more ultra-violet radiation is emitted for the same consumption of power. He has also found that the carbons burn more slowly. This alteration may, however, necessitate a readjustment of the mechanism of the lamp, because it has been found that the resistance of the arc is increased by putting the positive electrode underneath. A thin negative carbon offers less obstruction to the radiation, but if it is made too thin the incandescent area is not confined to the end of the carbon, but spreads along it; and we have noticed that when this happens very fine flakes of carbon are gradually cast off from the body of the negative electrode, which eventually becomes completely disintegrated and has to be replaced. At the same time the arc becomes unstable and begins to hiss. This is probably due to the crater overlapping the end of the carbon and thus allowing free access of air to the crater. When hissing occurs the arc voltage suddenly falls.

In some lamps the carbons are inclined at an angle to each other, and sometimes they are set with their axes parallel, as in the "Jupiter" lamp.

The alternating-current arc is not so satisfactory for medical purposes as the direct-current arc, because the emission of radiation is so different. In the alternating-current arc the polarity of the two carbons varies very rapidly, so that each in turn becomes the crater. Further, the output of radiation,

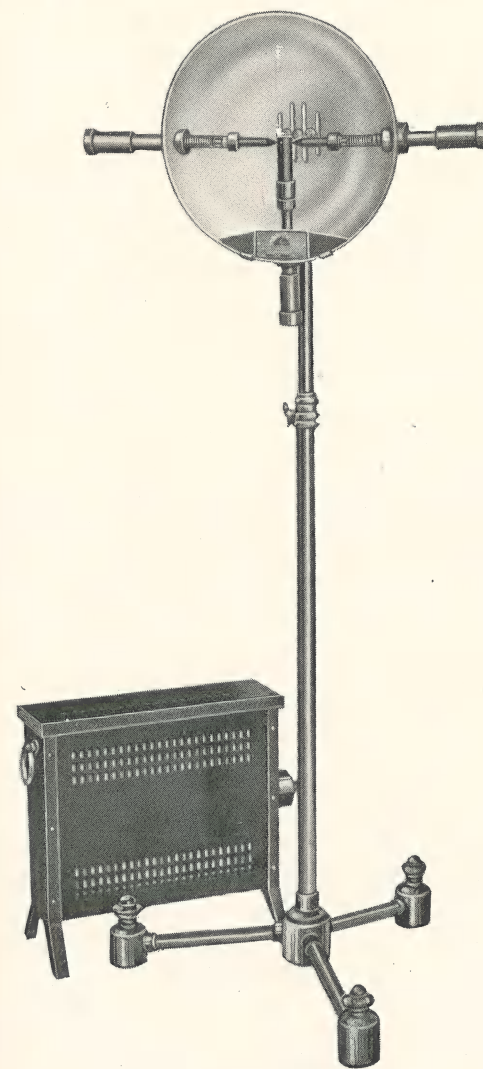


FIG. 23.—The "Quain" Twin Arc.

especially in the near ultra-violet region, is much greater with direct than with alternating current.

When the carbons in an alternating-current arc are in the co-axial position, and vertical, as much radiation is given off above a horizontal line drawn through the centre of the arc as below it. Both the carbons are of the same thickness, because they burn away each at the same rate.

The carbons of open arcs burn comparatively rapidly owing to the free access of oxygen. This is not the case with enclosed arcs, in which the air has only a limited access to the carbons.

The encircling tubes or globes are generally made of "Uviol" glass, of "Vitreosil," or of clear quartz, but "Vitaglass" globes are now available also.

If the air has no access at all to an arc the globe soon becomes blackened by a deposit of carbon, but the admission of a regulated amount of air to an enclosed arc ensures perfect combustion: the carbons burn with flat ends, and no crater or point is formed.

The advantages of the enclosed arc are that:

- (1) The carbons last for a much longer time than in the open arc; and
- (2) If special carbons are used no unpleasant fumes are given off, such as are emitted by the same carbons in the open arc.

The rays of greatest power are emitted from a vertical enclosed arc in a horizontal direction. The principal disadvantage of this type is that a certain amount of the radiation is cut off by the globe, and the globe gradually becomes covered with a fine deposit of carbon on its inner surface.

Short-Flame and Long-Flame Arcs.—These terms are relative; there is no definite point at which a short-flame arc becomes a long-flame one. The longer the arc the shallower the crater, and if the length of the flame is greater than the diameter of the positive carbon there is practically no depression at all.

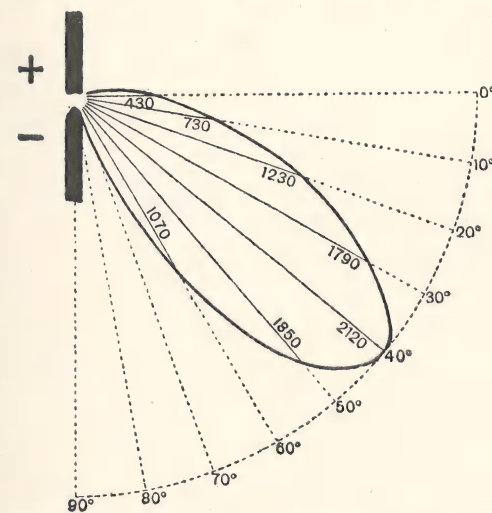


FIG. 24.—Curve showing the distribution of radiation from a Direct-Current Short-Flame Arc. The figures printed on the radial lines represent the candle-power in different directions, but the curve of ultra-violet emission is not shaped exactly like that of visible light. (Fleming.)

Special impregnated or chemical carbons are necessary for the production of the long-flame arc. The white-flame arc is produced by carbons impregnated with barium salts; strontium colours the arc flame red, and calcium fluoride makes it yellow. Sixty-five per cent. of the radiation from the flame arc comes from the flame itself: the radiation is directed

horizontally outwards, but the greatest intensity is just below the crater.

An increase in voltage allows a lengthening of the arc. Taylor and Griffith have found that when the arc-length does not exceed twelve millimetres, and when similar electrodes and the same number of watts

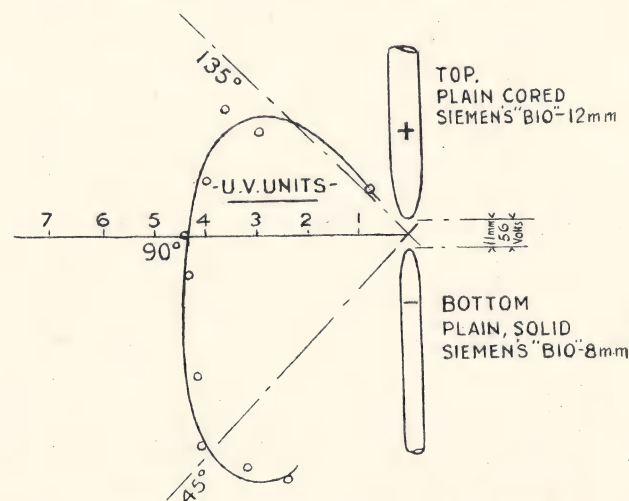


FIG. 25.—Distribution of Ultra-Violet Radiation from the Short-Flame Arc. (After Angus.)

(volts $\times$ amperes) are used, more ultra-violet rays are given off by the long flame than by the short, and under similar conditions the long-flame-arc ultra-violet emission is greater than that of a group of several arcs in series; but the total radiation (infra-red, visible, and ultra-violet rays) is greater in the composite arc, and the heating effect is therefore more intense.

When the length of the arc is greater than twelve millimetres Angus's law holds good, and for the same

amount of power consumed the short-flame arc and the long give off an equal amount of ultra-violet rays. Thus when the lamps are used from the main without a motor-transformer it is more economical to use long-flame arcs, because less current is wasted in the resistance.

The ultra-violet emission of an arc is markedly influenced by variations in both the voltage and the amperage. Griffith and Taylor found that an arc taking 15 amperes at a certain voltage emitted 12 photo-electric units, whereas when the amperage was raised to 75 at the same voltage 156 photo-electric units were registered. In other words, an increase of the amperage to five times the original amount resulted in an ultra-violet emission thirteen times as great.

Raising the voltage from 70 to 95 increased the ultra-violet emission from 70 to 253 units.

Similarly Coblenz found that when the amperage was increased 5.6 times there was often a fifty-fold increase in ultra-violet radiation.

We have often noticed, when visiting different clinics, that there is a great deal of carelessness shown in regard to the number of volts and amperes supplied to the arcs. This is most unfortunate, because it is a matter of fundamental importance.

The carbons of the long-flame arc can be arranged co-axially, or else inclined at such an angle as to be almost parallel, as in the "Jupiter" lamp.

Regulation of an Arc.—Arcs may be (a) hand-fed or (b) automatically regulated.

(a) Hand-fed arcs are satisfactory only when very

short exposures are given; an automatic feed is necessary for long exposures.

(b) Automatic feeding of an arc requires two essential factors:

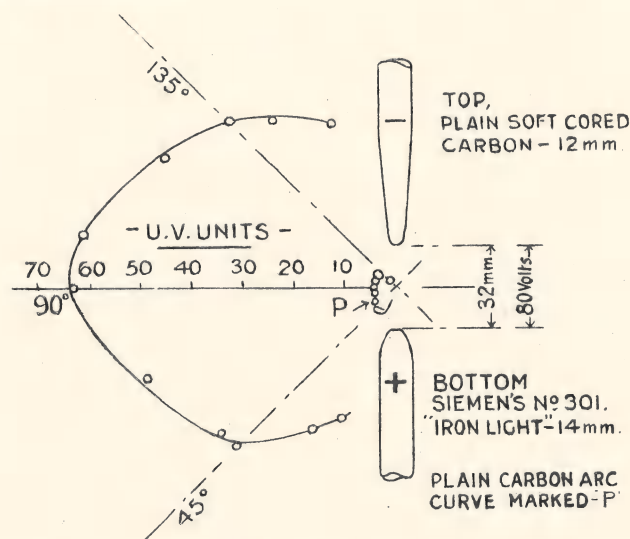


FIG. 26.—Distribution of Ultra-Violet Radiation from the Long-Flame Arc. The Radiation from the Short-Flame Arc is plotted to the same scale at P. (After Angus.)

- (1) When the current is switched on, the carbons must be brought momentarily together, and then automatically drawn apart until they are separated by a predetermined distance; and
- (2) This distance must be maintained as the carbons burn away.

In the simplest form of automatically regulated arc the positive carbon is attached to a T-shaped iron rod, the two free limbs of which are inserted into two hollow cylinders. One cylinder has a winding of thick

insulated wire round it and the other has one of thin wire. The coil of thick wire is called the series coil, and is connected in the line carrying the current to the positive carbon. The coil of thin wire is called the shunt coil, and is coupled between the positive and negative wires. When the current is switched on,

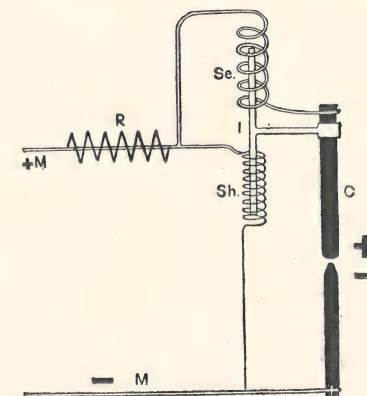


FIG. 27.—Diagram of Shunt and Series Coil Arc Mechanism. (After Fleming.)
MM are the two Electric Supply Mains; Se., the Series Coil; Sh., the Shunt Coil; I, the Iron Core; C, the Carbons; and R, the Resistance.

the carbons, which had previously been in contact, are separated by the attraction the series coil exercises on the iron rod, and the arc is struck. As the carbons burn away the length of the arc flame increases, and the current in the arc becomes less, so that fewer volts are dropped in the resistance and there are more volts across the shunt coil, which then acts on the iron rod and draws the carbons nearer together. The distance between the carbons is therefore automatically regulated and kept reasonably constant.

Carbons.—In arc lamps the carbons are of great importance, and special care is needed in their manufacture. Unless particular attention is paid to their composition, their density, and their electrical resistance, the efficiency of the arc may be impaired.

Carbons are usually made by mixing ground coke and lampblack with coal-tar or syrup to form a stiff paste, which is then submitted to hydraulic pressure. Rods are formed in this way, and these are afterwards baked in a special furnace.

Carbon is particularly well adapted for use as an electrode because its oxide is a gas, and therefore does not form a deposit round the arc; it is a relatively poor conductor of heat and electricity, and therefore the crater is raised to a high temperature; and, compared with metals, carbon is easily disintegrated, and gives a longer arc for a given difference in potential between the two poles.

To start a true electric arc, carbon requires a pressure of thirty-five volts or more; iron, twenty-five volts; and copper, twenty-three volts. The more infusible the material an electrode is made of, the greater is the difference between the temperatures of the two poles.

Carbons may be (*a*) cored, or (*b*) non-cored.

The central core may be made of a less dense form of carbon, so that the crater tends to keep to the easily volatilized central area. If the negative carbon is a plain one and the positive is cored, the arc shows much less tendency to splutter. Metallic cores, such as iron, aluminium, molybdenum, or tungsten, may, however, be used, and the polymetallic carbons are

cored with a mixture of several metallic salts, principally those of magnesium, aluminium, and calcium.

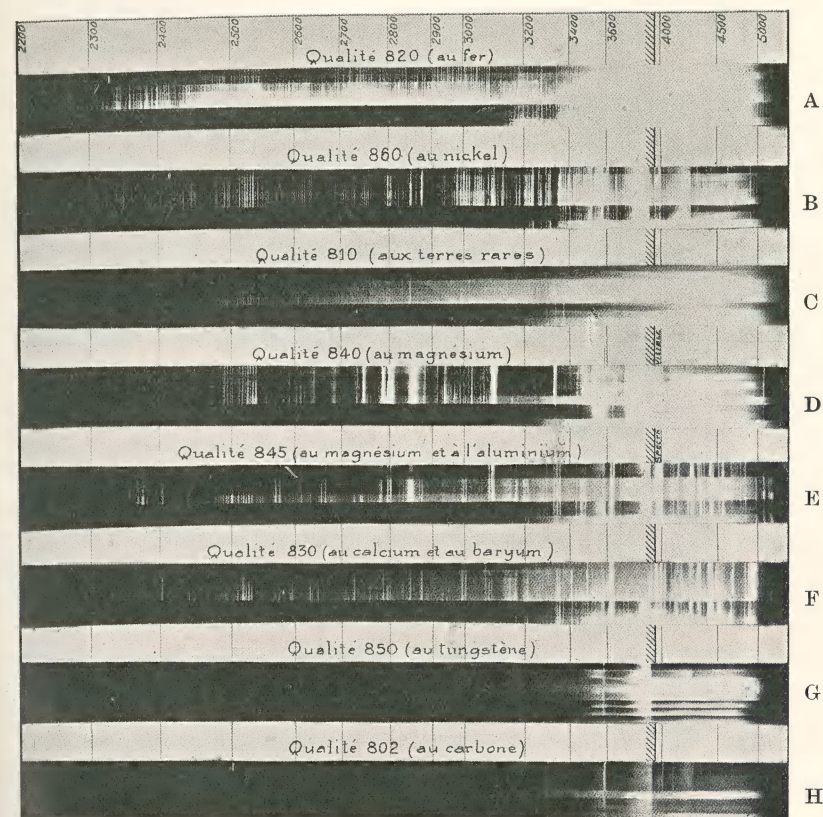


FIG. 28.—Spectrographs of Different-cored Carbons. (Oswald.)

A, Cored with Iron; B, Cored with Nickel; C, Cored with Rarer Alkaline Earths; D, Cored with Magnesium; E, Cored with Magnesium and Aluminium; F, Cored with Calcium and Barium; G, Cored with Tungsten; H, Plain Carbon.

Oswald has shown that when large cores are used there is a bigger proportion of the total radiation in the

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ultra-violet region, because the incandescent area of pure carbon then becomes smaller and less infra-red rays are given off. Carbons may also be impregnated with various salts of the alkalies and alkaline earths, such as fluorides, silicates, borates, and phosphates.

It is possible to modify the radiation given off by using a different type of carbon for each of the electrodes.

The composition of the positive carbon, however, almost entirely determines the wave-lengths of the radiation emitted—that is, the character of the rays.

When a fresh type of carbon is used with a particular lamp, it may be necessary to readjust the lamp mechanism.

Although not so rich as the pure tungsten and mercury vapour arcs in far ultra-violet rays, the light from a carbon arc has great penetrating power. Intense radiations are emitted in the near ultra-violet region, and by using different cored carbons the quality and the quantity of the rays can be greatly modified. Direct current is always preferable for use with carbon arc lamps.

A comparison of the spectrum of the sun and that of an arc lamp shows that the differences between them are very slight. The spectrum of the carbon arc extends farther towards the red end, making water-cooling necessary in local treatment.

CARBONS USED FOR ULTRA-VIOLET RADIOTHERAPY

It may be useful to mention briefly some of the better-known varieties and brands of carbons used for therapeutic purposes.

CARBON, TUNGSTEN AND IRON LAMPS 113

Sunic Standard Medical Carbons (made in England):
The erythema times given are those for normal skin at 2 ft. 6 in. distance when a direct current of 30 amperes at 65-70 volts is used:

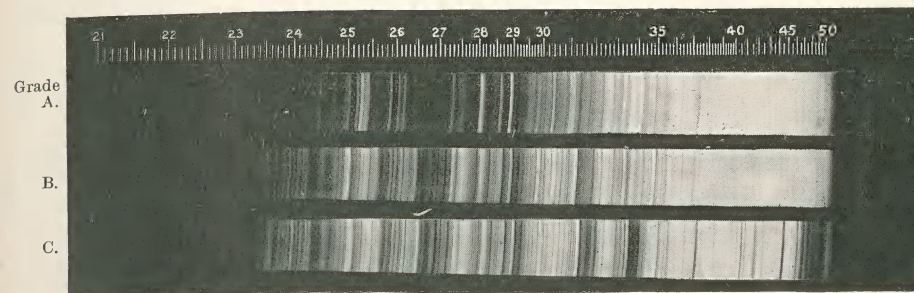


FIG. 29.—Spectra of "Sunic" Carbons.

Grade A have a cerium core, the erythema time is 8 minutes, and the principal wave-lengths are 3100-2950 Å.

Grade B have a cerium and iron core, the erythema time is 4 minutes, and the principal wave-lengths are 3500-2900 Å.

Grade C have an iron core, the erythema time is 3 minutes, and the principal wave-lengths are 3575-2400 Å.

Conradty's Carbons (made in Germany):
Noris-Chromo brilliant white is barium-cored.
Noris-Chromo No. 3349 has an iron or tungsten core.
Noris-Chromo No. 3774 has a nickel core.

Henrion Carbons (made in France):
No. 820 has an iron core.
„ 810 has a core of rare earths.

Henrion Carbons—*continued*

No. 860 has a nickel core.

„ 840 has a magnesium core.

„ 845 has a magnesium and aluminium core.

„ 830 has a calcium and barium core.

„ 850 has a tungsten core.

„ 802 has a plain carbon core.

Siemen's Therapeutical Carbons (made in Germany) have, among others, the following cores: aluminium, copper, iron, iron B, iron W.B., magnesium, nickel, thorium B, tungsten B, and zinc. Plain carbons are A, E, and B10.

National Carbon Co.'s Carbons (made in U.S.A.):

Therapeutic A is cored with rare earth compounds and gives a large amount of energy down to 2900 Å.

Therapeutic B has an iron core and has a strong emission between 3000 Å and 2300 Å.

Therapeutic C has a polymetallic core of iron, nickel, aluminium, and silicon, and gives an even distribution of radiation through the spectral range.

Therapeutic D has an alkaline silicate core and emits mostly in the region 3900 to 3500 Å.

Therapeutic E has a strontium core and gives off relatively very little ultra-violet radiation.

Therapeutic F has a tungsten core.

Therapeutic G has a nickel core and shows a strong line at 2295 and a strong band between 2900 and 3500 Å.

Therapeutic H has a calcium compound core and gives off very little ultra-violet radiation.

Therapeutic K has a cobalt core and has very strong emission in the region 3500 to 3100 Å. It is also very rich in ultra-violet radiation below 2500 Å.

All these carbons can, of course, be obtained in different lengths and of different thicknesses.

Carbons intended for carrying small currents are naturally smaller in diameter than those for use with large currents.

The following table gives the sizes generally employed, though the sizes used at the Finsen Institute are a little different.

<i>Amperes</i>	<i>For A.C. Carbons and Positive Carbons for D.C.</i>	<i>For Negative Carbons for D.C.</i>
	Diameter of Carbon in Millimetres	Diameter of Carbon in Millimetres
4-6	5	5
6-10	6	5
10-15	8	6
15-20	10	8
20-35	13	10
35-50	16	13
50-90	16 copper-coated	13

The rate at which carbons burn naturally varies, but an average-cored carbon burns away at the rate of about an inch an hour, and, roughly, carbons cost about 1½d. per inch, so that the expenditure on carbons for a single arc lamp averages 3d. an hour.

OPEN ARC LAMPS

The "Finsen" and "Finsen-Reyn" Lamps.—The first artificial source of ultra-violet light was the carbon arc lamp introduced by Professor Finsen for the treatment of lupus so long ago as 1893—the world-renowned "Finsen Light." It has :

- (1) A source of radiation.
- (2) An apparatus for the concentration of the rays on the area to be treated.
- (3) A means of removing the heat rays so as to prevent burning.
- (4) A means of compressing and squeezing out the blood from the tissues.

It consists of an automatically regulated 50-ampere arc lamp burning at 50 volts, having the carbons arranged in the vertical position, one above the other, the larger, positive carbon being uppermost. Four metal tubes shaped like telescopes are suspended obliquely to collect and concentrate the rays.

These collecting tubes, which are a yard long, are each fitted with one plain quartz window and four convex quartz lenses. Some of the spaces between the lenses are filled with distilled water, while tap water runs through the metal casing that encloses the collecting tube.

Various types of compression apparatus are used for different parts of the body : they generally consist of a metal ring, 4.5 cm. in diameter, holding a quartz lens and a plain quartz window with a space between of 5 mm. Water circulates through this space, and has the effect of absorbing any remaining heat rays.

This compression apparatus is held by its four handles and firmly pressed on the part under treat-

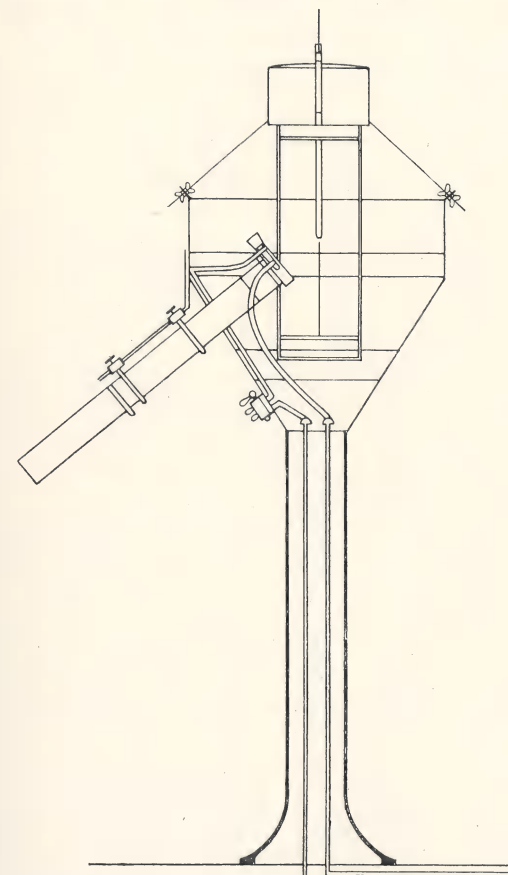


FIG. 30.—Diagram of the "Finsen" Lamp. (Reyn.)

ment, thus driving the blood from the tissues and allowing greater penetration by the ultra-violet rays.

An area having a diameter of half-an-inch can be treated at one time with the "Finsen" lamp.

Four patients are treated simultaneously with each "Finsen" lamp, and at the Light Institute at Copenhagen seven such lamps are in continuous use.

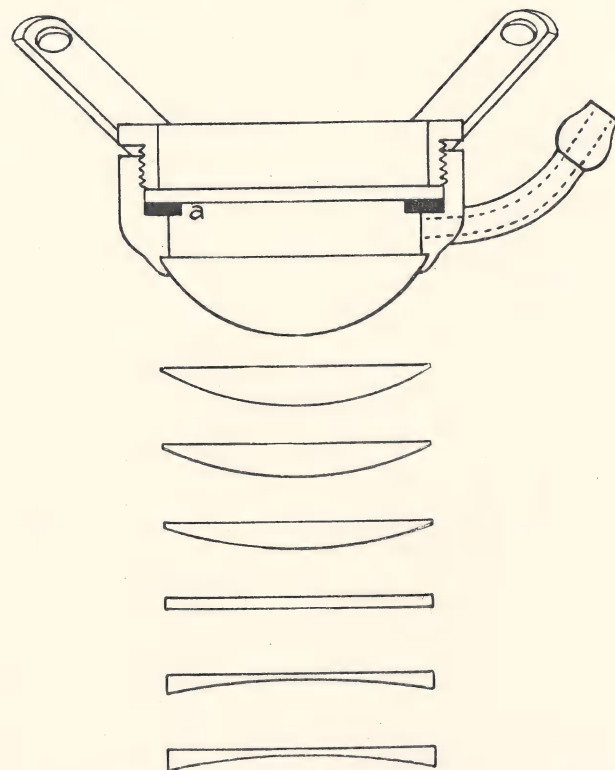


FIG. 31.—Diagram of Different Compression Lenses used with the "Finsen" and "Finsen-Reyn" Lamps. (Reyn.)

For the treatment of patients singly the "Finsen-Reyn" lamp was designed. It is an automatic scissor arc, taking 20 amperes at 50 volts. As in the "Finsen" lamp there is a cylindrical metal collecting tube fitted with a quartz window and four quartz lenses. The

heat rays are eliminated by filling the tube with distilled water and also by surrounding it with circulating tap water.

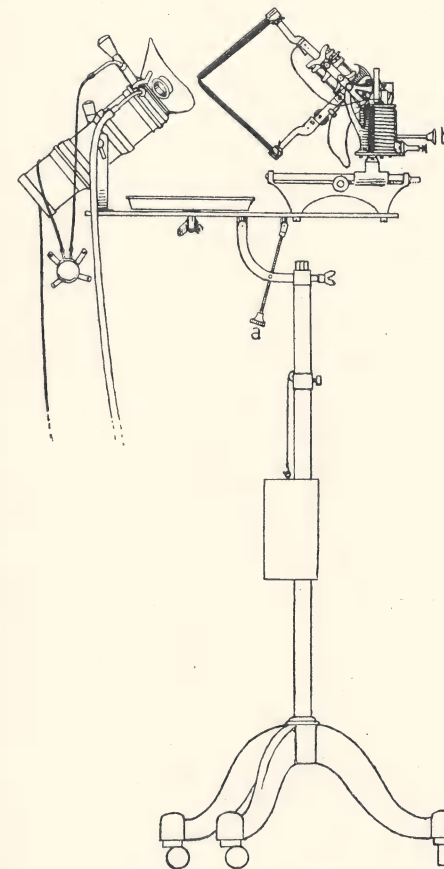


FIG. 32.—The "Finsen-Reyn" Lamp. (Reyn.)

Quartz compressors are used in the same way as with the "Finsen" lamp. Special prisms of quartz have been made for use in the nose and ear, where

it would be impossible to use the ordinary type of compressor.

Professor Reyn has also devised powerful carbon short-flame arc lamps for general irradiation of the body.

As units he uses (a) two 75-ampere arcs in parallel

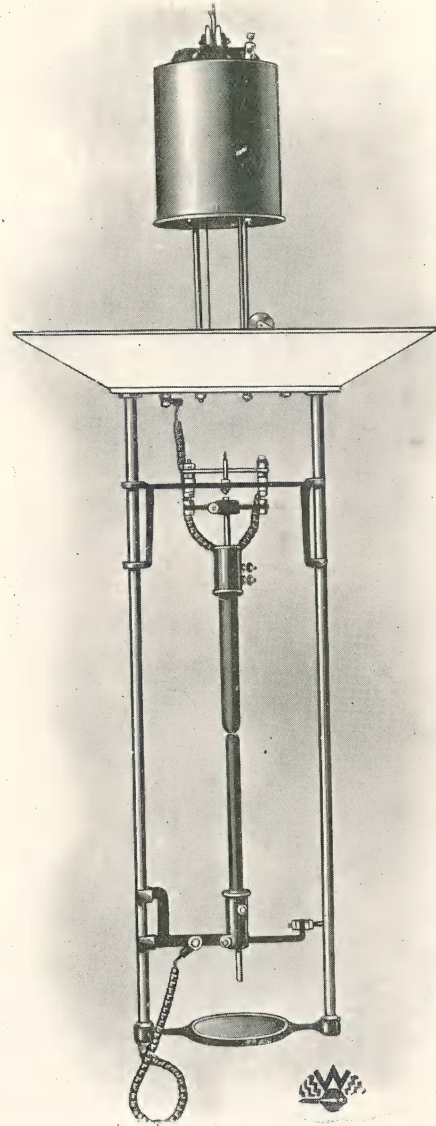


FIG. 33.—Carbon Arc Lamp, after Reyn (75 amperes). Capable of treating eight ambulant patients simultaneously. (Watson & Sons.)

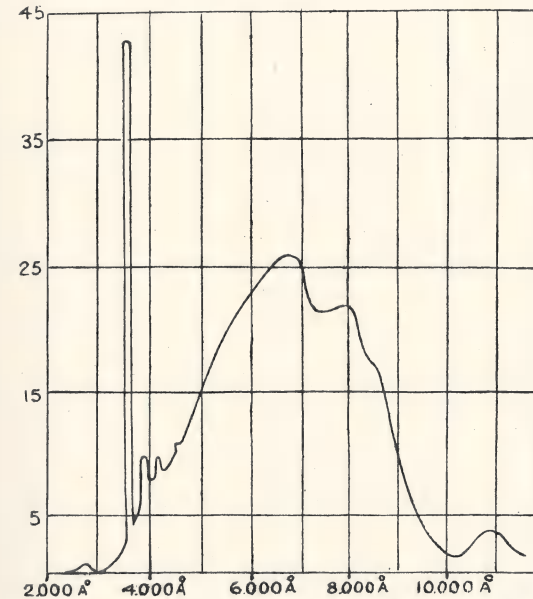


FIG. 34.—Intensity of the Spectrum of the "Finsen-Reyn" Lamp. (After Johansen.)

at 55 volts ; and (b) three 20-ampere arcs, which can be used in series if the main supply current is used, and if the voltage is 220 or over.

The larger lamps are used for the treatment of six to eight ambulant patients simultaneously. The 20-ampere lamps are used for the treatment of two recumbent patients. They are economical when only

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one or two patients have to be treated, because two couches can be placed close together with the lamps between; they are therefore very useful in a small hospital.

To secure the greatest emission of ultra-violet rays the thinnest possible carbons are used consistent with carrying the large current. The most satisfactory sizes have been found to be :

For 75-ampere lamps :

Positive	. 31 × 300 mm.	} plain-cored carbons
Negative	. 22 × 300 mm.	

For 20-ampere lamps :

Positive	. 12 × 300 mm., plain-cored carbon
Negative	. 8 × 300 mm., solid carbon

The distance between the 75-ampere lamps measured from arc to arc is 60 cm., and the distance from the floor to the positive carbon crater is 1 metre. The 20-ampere lamps are placed 55 cm. apart (carbon to carbon), 1 m. 20 cm. from the floor, and about 35 cm. from the patient's couch.

We have mounted our 20-ampere arcs on a specially made wooden trolley, which runs on four rubber-covered wheels. The switch and variable resistance are attached to one end of the trolley, and there are stout, horizontal handles to facilitate moving the apparatus, which can be used in several rooms. Aluminium pans collect any falling pieces of carbon.

Long-Flame Arcs.—This type of lamp was originally designed for photographic purposes, and was first used for medical treatment in the Light Department of the London Hospital. There are two well-known British

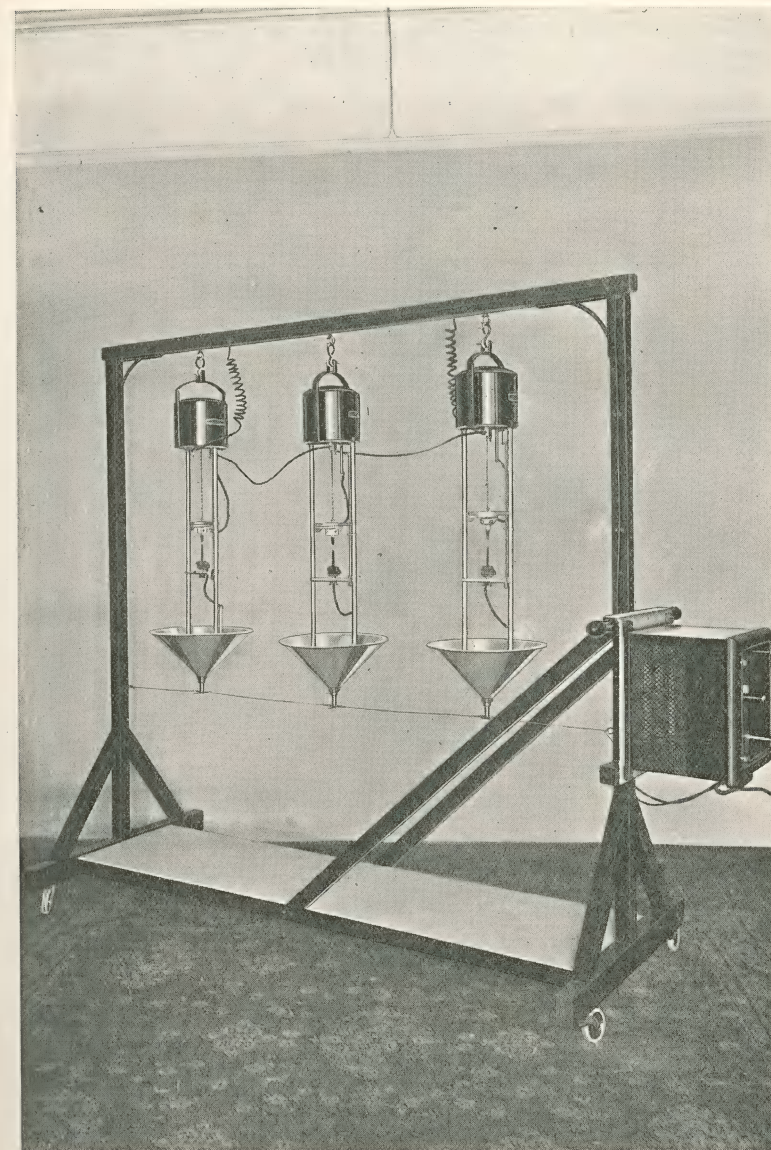


FIG. 35.—Our method of mounting three 20-ampere Short-Flame Carbon Arc Lamps, such as are used at the Finsen Institute.

makes—the “Sunrae” long-flame arc and the “Westminster” long-flame arc.

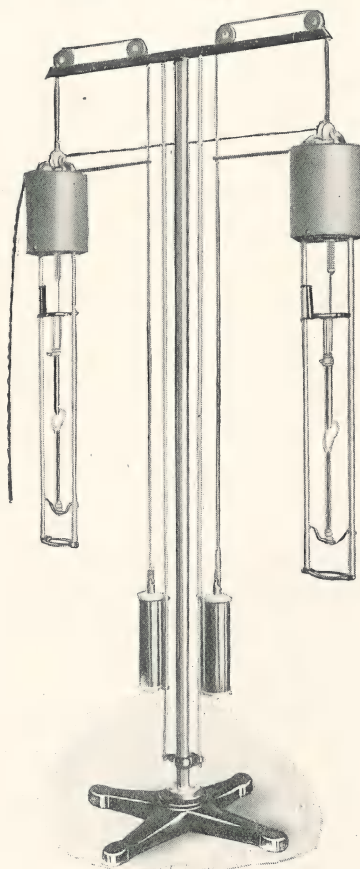


FIG. 36.—Two Carbon Arcs in Series, mounted on Floor-stand with Adjustable Counterweights; they can be used on D.C. or A.C., taking 32 amperes (average), and Arc Voltages of 50 to 120 volts. (X-rays Ltd.)

The “Westminster” lamp is an automatically regulated long-flame arc taking a standard current

of 30 amperes. Two lamps can be used in series or in parallel, depending on the voltage of the circuit.

The “Sunrae” lamp is another automatic-feed lamp, and takes 30 amperes at 120 volts.

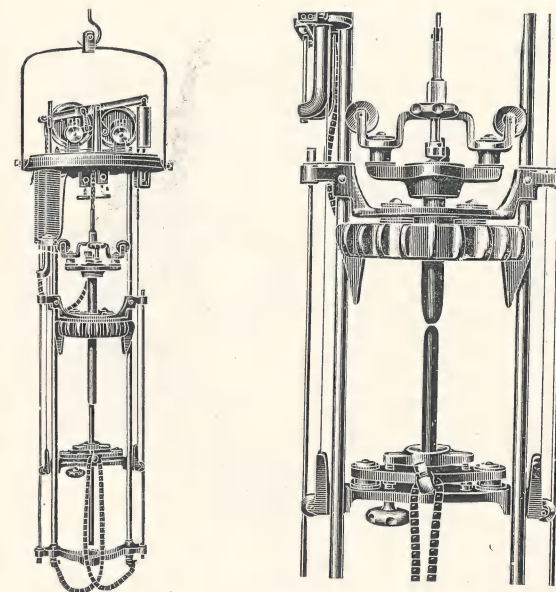


FIG. 37.—The Open “Flaming” Carbon Arc Lamp for Alternating Current or Direct Current. Automatic Feed (30 amperes). (Cox-Cavendish Electrical Co. Ltd.)

Recent work at the National Institute for Medical Research has led to the adoption of several improvements in the design of the “Sunrae” lamp.

X-rays Ltd. make an apparatus consisting of two lamps in series mounted on a floor-stand: the lamps carry 30 amperes and are counterweighted; and they may be used with either short or long flame arcs, the

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voltage being variable between 50 and 120. They may be operated with either A.C. or D.C.

There are other lamps that have their carbons

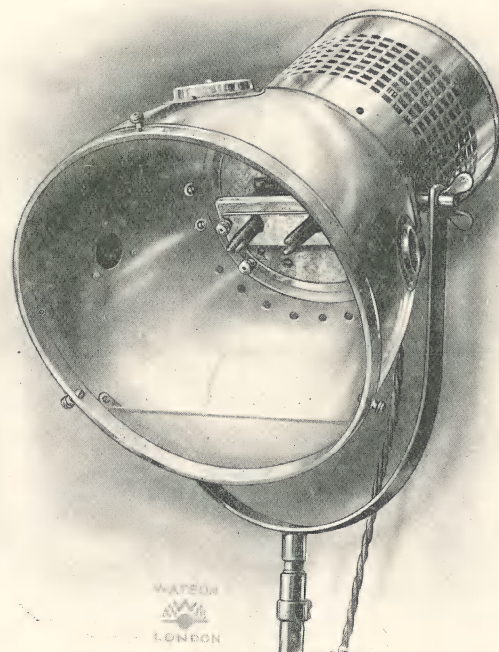


FIG. 38.—Detail of "Sunic" Parallel Carbon Arc Lamp.

arranged in the vertical co-axial position, and probably the best known of these are the "Arnold" lamp, models 2, 3, 4, and 5 of the "Marion" lamp, the hospital type of "Saidman" lamp, and the "Sunstar" lamp.

The "Arnold" lamp is a hand-fed carbon arc lamp, and has four flames on high voltages. The

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arcs burn in series, on either A.C. or D.C., at 15 to 25 amperes, and various types of carbons can be used. In the "radial" type there are four arcs, which are automatically controlled and grouped round a central nickelled reflector; this type is useful for

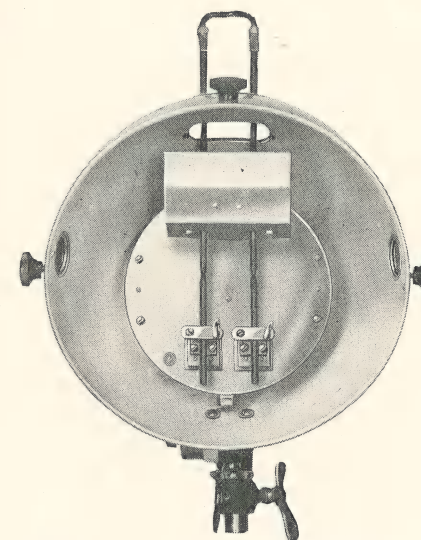


FIG. 39.—The "Spectro-Sun" Double-Flame Carbon Arc Lamp. (Paul E. Johnson, Chicago.)

hospital work, but it is not so efficient as one suitable long-flame carbon arc if the voltage supply is 110 volts, or two in series if the voltage supply is 220.

No. 5 model "Marion" lamp is almost exactly the same as the "Arnold" lamp.

No. 2 model has been specially designed for group treatment, and is arranged in such a way that very few shadows are formed by the lamp itself.

No. 4 model consists of two lamps, which are

arranged in series, and allow the simultaneous irradiation of both the back and the front of a patient.

The hospital type of "Saidman" lamp has three automatically regulated vertical arcs. The lamp uses 10-15 amperes at 220 volts.

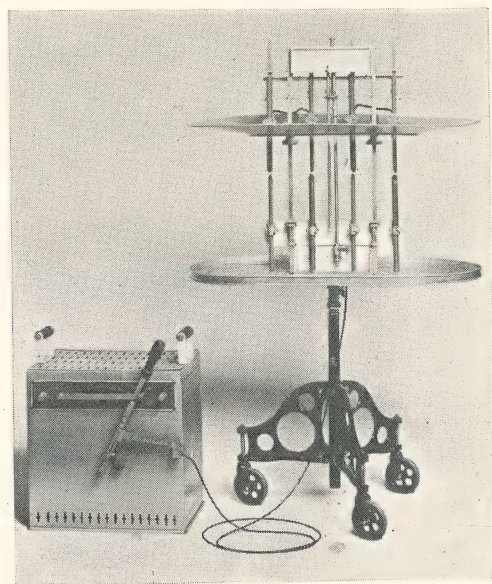


FIG. 40.—"Marion" Group Type Carbon Arc Lamp with hand regulation.

The "Sunstar" arc lamp is a portable carbon arc, burning most satisfactorily with a current of 12 amperes; it has a Bowden wire control and can be used with either direct or alternating current.

All the carbon arc lamps that have already been mentioned have their carbons arranged in the vertical co-axial position, but there are a considerable number

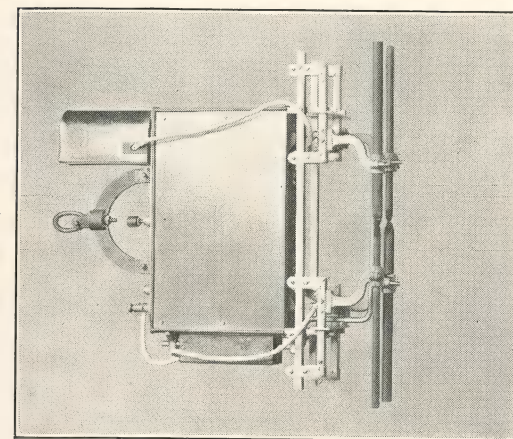


FIG. 42.—"Marion" Horizontal Carbon Arc Lamp for overhead use, with Shield and Reflector removed.

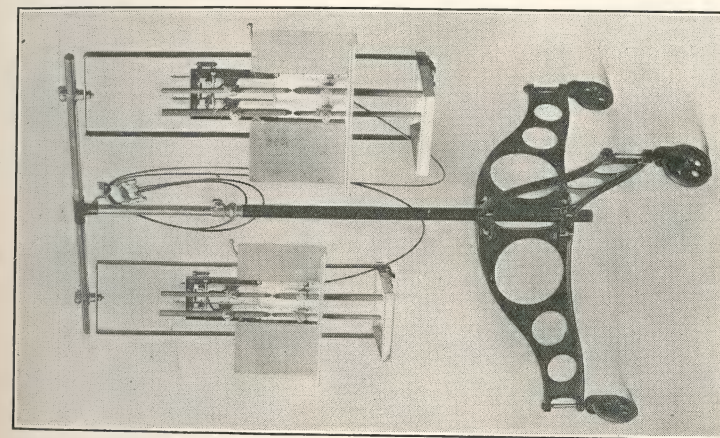


FIG. 41.—"Marion" Twin Duplex Type of Hand-regulated Carbon Arc Lamp.

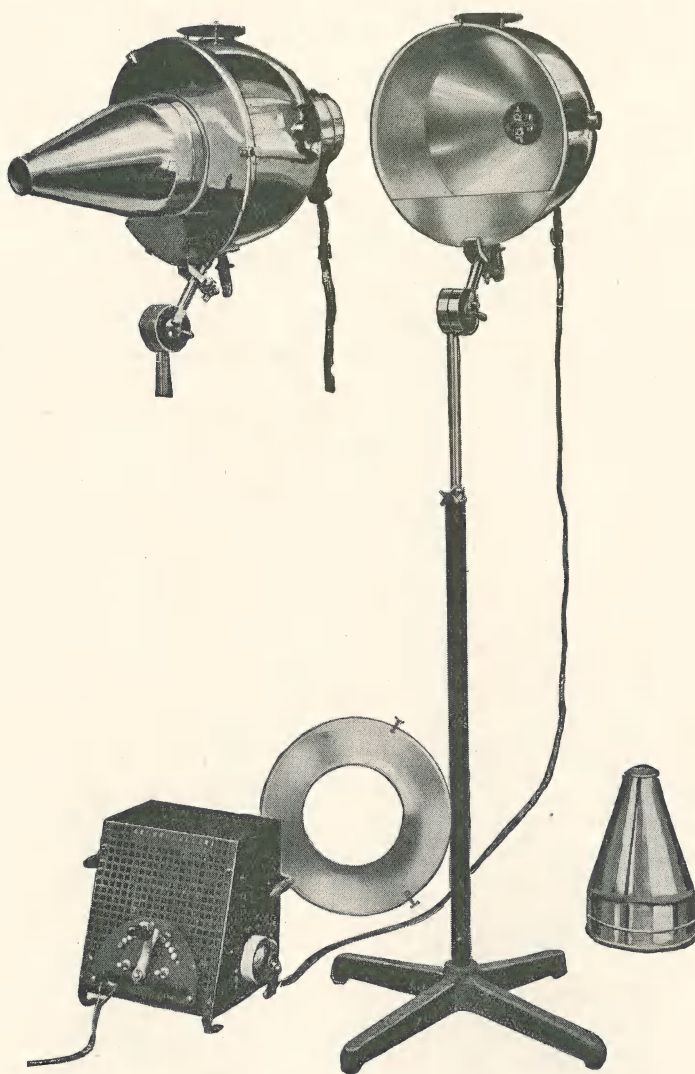


FIG. 43.—The "Solart" Carbon Arc Lamp, 100 to 250 volts, D.C. or A.C., automatically regulated, taking about 9 amperes.

of other positions in which the carbons can be mounted. For instance, the "Marion" horizontal-type carbon arc lamp is a suspension lamp in which two pairs of carbons are arranged in the horizontal co-axial plane, and a small quartz tray, which is suspended below the arc, prevents any hot fragments from falling on the patient, who lies directly under the lamp during

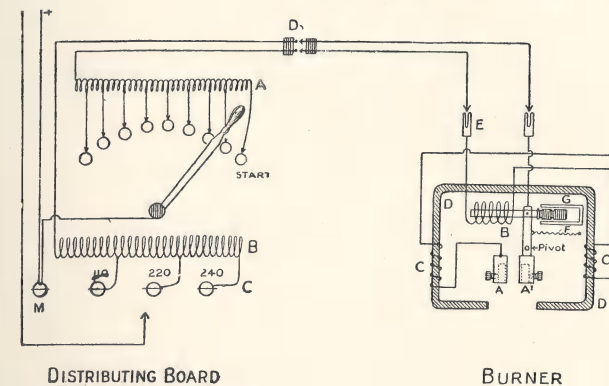


FIG. 44.—Diagram of the Mechanism of the "Solart" Carbon Arc Lamp.

treatment. This lamp takes 30 amperes at 100-250 volts.

Lamps with Carbons arranged in the same Parallel Horizontal Plane.—The "Solart" carbon arc lamp is automatically regulated and takes about 9 amperes at 100-250 volts; it can be operated with A.C. or D.C.

The "Jupiter" stand model is an automatically regulated two-flame lamp, with two pairs of parallel electrodes. It has an aluminium parabolic reflector and can be used with A.C. or D.C., taking 25 amperes at 110-220 volts.

The "Sonic" parallel carbon arc lamp is similar.

Lamps with their Carbons inclined at an Angle.—
The "Ultra Sonne" lamps, of Dr Landeker-Steinberg's

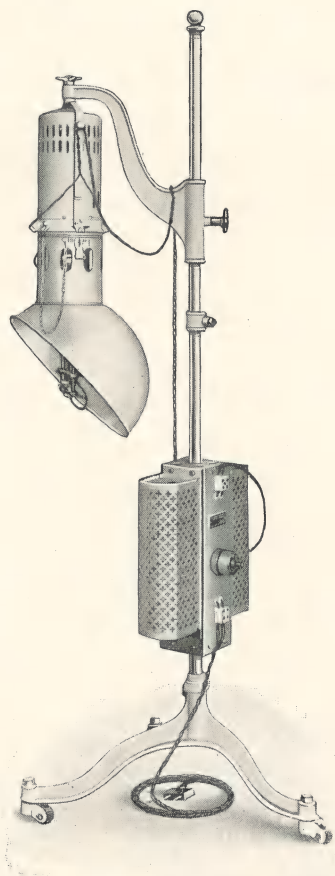
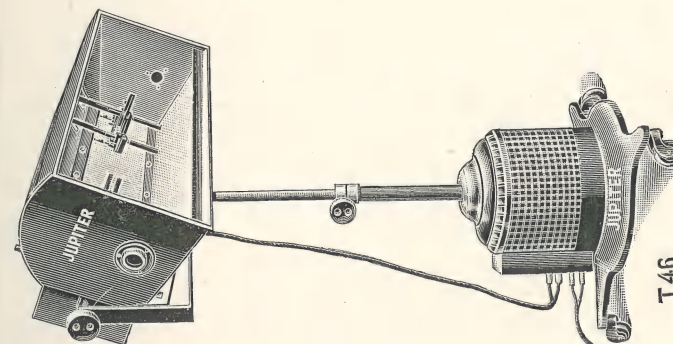


FIG. 45.—The Stand Model of the
"Heliol" Enclosed Carbon Arc.

design, are scissor carbon arcs, with the carbons inclined to one another almost at a right angle; one



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FIG. 47.—"Jupiter" Carbon Arc Lamp,
with Four Arcs, which are automatic-
ally regulated. 12 amperes, 200 to
250 volts.

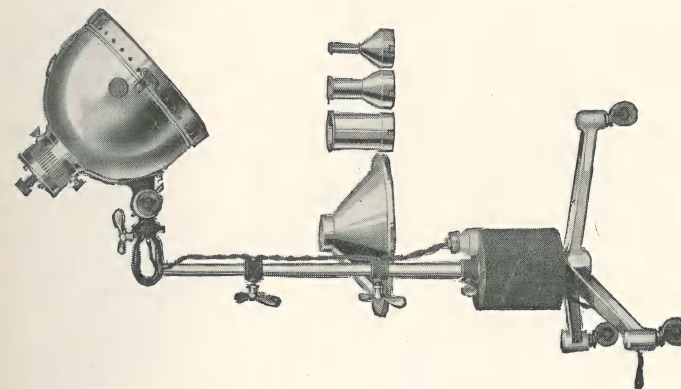


FIG. 46.—The "Spectro-Sun" Carbon Arc
Lamp. (Paul E. Johnson, Chicago.)

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is a hand-fed model, and the others are automatically regulated. They work at 6 amperes at 110-220 volts,

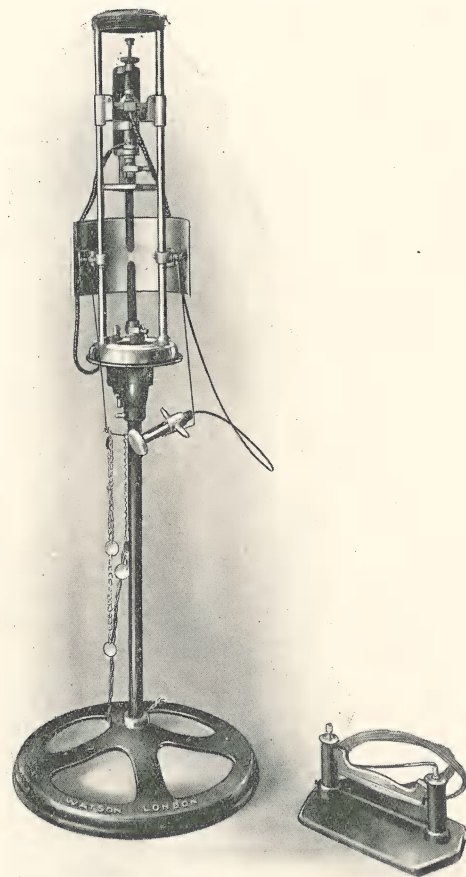


FIG. 48.—The "Sunstar" Portable Hand-regulated Carbon Arc Lamp, taking 12 amperes at 100 volts.

and are used a great deal for irradiation of the body cavities.

The hanging type of "Jupiter" lamp is for collective

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overhead treatment; it has two arcs at low voltages and three at 220 volts, and it works at 60 amperes.

The portable type of "Saidman" lamp, which weighs only 14 lb., works at 4-8 amperes; the

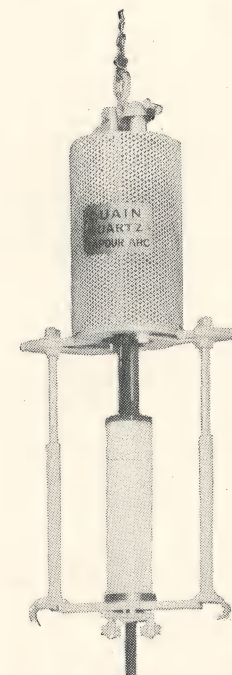


FIG. 49.—The "Quain" Quartz Arc.

carbons are inclined almost at a right angle and there is a magnetic blow-out, which, if desired, can be used to increase the size of the arc flame.

The cabinet type is entirely enclosed in a metallic case; this allows the use of quartz lenses for local treatment.

The "Radosol" lamp is a carbon arc with

automatic control, working at 15 amperes. For direct current it has horizontal electrodes, and for alternating current the carbons are inclined at a right angle.

The "Arnone" lamp is a small scissors arc, hand controlled, working at about 5 amperes, and used on

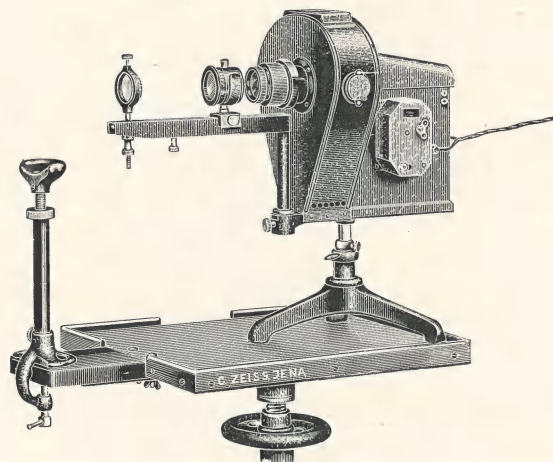


FIG. 50.—Birch-Hirschfeld's Large Eye Radiation Lamp, showing the adjustable stand and chin rest.

either A.C. or D.C. The carbons are inclined at an angle of less than 90° . There are both table and tripod models.

Enclosed Arcs.—The "Quain Quartz Arc" lamp has its arc enclosed in a "Vitreosil" quartz tube.

The "Heliol" lamp has the arc enclosed in a "Heliol" glass tube.

The violet-blue colour seen when this lamp is burning is due to the cyanogen and carbon monoxide that are formed. It is possible to obtain an arc length of 50 mm. with this lamp.

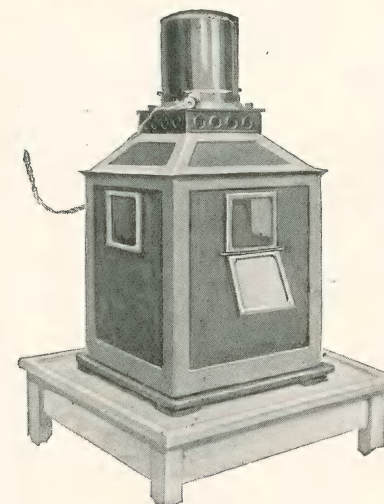


FIG. 51.—"Schanz's" Special Carbon Arc Lamp for the Treatment of Diseases of the Eye. (Kohl, Leipzig.)

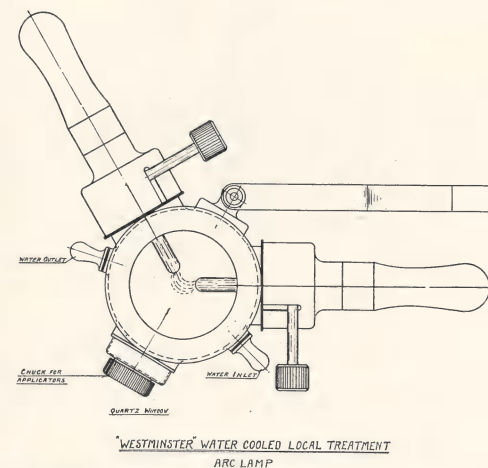


FIG. 52.—Water-cooled Carbon Arc Lamp designed for Local Treatment.

The Westminster Engineering Company have recently introduced a water-cooled carbon arc lamp for local treatment, which has the advantage that it

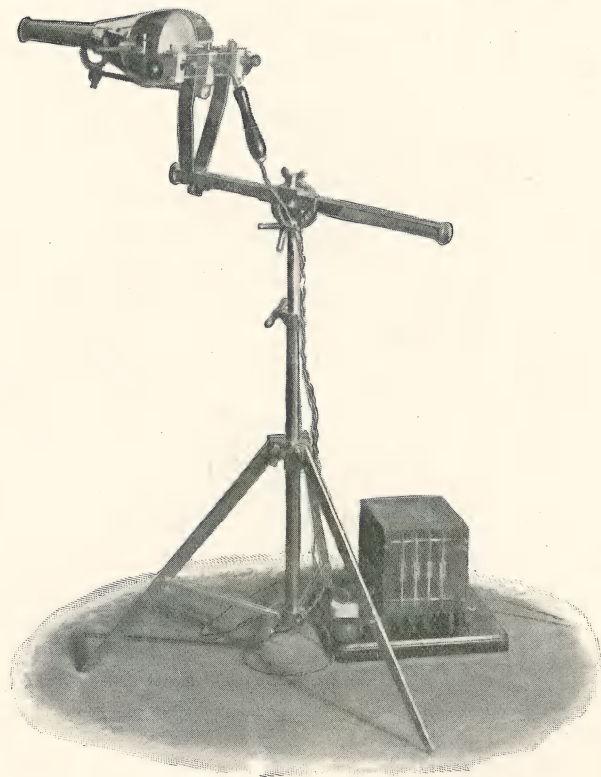


FIG. 53.—Portable Tungsten Arc for Local Treatment.
(Arnold & Sons.)

is possible to bring the arc itself within 2 in. of the skin. It is designed to take 5-10 amperes.

Special Types of Arc Lamp.—The Zeiss “Redfree” lamp is a small encased light-proof carbon arc lamp taking 5-10 amperes. One of the models has clock

work regulation of the carbons. The lamp is used for ultra-violet treatment of eye diseases.

“Schanz’s Eye Radiation” lamp consists of a special 12-ampere arc lamp inserted into a light-proof casing having four windows made of blue Uviol glass, which allows only rays of 4000 Å to 2650 Å to pass. Four patients can be treated simultaneously.

Tungsten Arc Lamps.—In 1916, an engineer named Simpson used therapeutically an arc lamp with electrodes of a secret composition. Professor Sydney Russ proved that they were made of wolfram, a tungstate of iron and magnesium. The “Simpson” arc burns very irregularly; it takes 5-7 amperes at about 70 volts, and is provided with reflectors.

About the same time, Dr W. J. Turrell, of Oxford, made use of pure compressed tungsten electrodes, and found that they burned very evenly, with but little spluttering, and gave a spectrum richer in ultra-violet radiation than the wolfram electrodes.

Various modifications have been used—*e.g.* carbons impregnated with sodium tungstate, uranium nitrate, ammonium molybdate, and titanous chloride, and carbons cored with uranium oxide, wolfram, pure molybdenum, and tungsten in the form of powder. Schunk found that the richest and most intense source of ultra-violet radiations was tungsten metallic electrodes with lines in the spectrum extending to 2000 Å. He found that the molybdenum spectrum was very similar to that of tungsten, but with much weaker lines below 2300 Å. Carbons cored with tungsten metallic powder gave almost the same result as when metallic tungsten alone was used. These carbons are

much less costly than pure tungsten electrodes, but the current must be slightly increased.

There are also electrodes made of tungsten and chrome steel; these give off brownish fumes of iron oxide, and a bulbous crater forms, which has to be broken off before the electrodes are used again.

A common type of tungsten lamp is one in which the electrodes are in the horizontal position; the arc is hand-fed, and usually consumes about 5 amperes at 60 to 100 volts. It has a copper reflector, which absorbs fewer rays than an ordinary mirror. When local application is required, the rays may be concentrated by means of a quartz lens, 2 in. in diameter, with a focal length of 4 in. The surrounding parts must be protected, and the exposed area should be placed at a distance of 12 in. from the lamp.

The vertical arc is, however, much more stable than the horizontal, because, when the electrodes are in the horizontal position, the arc assumes the form of an arch and most of the radiation is directed upwards. To procure the same ultra-violet emission as can be obtained with the vertical arc, less voltage and more current are required. Automatic regulation should be provided for tungsten arcs, because otherwise great variations in ray emission are inevitable.

T. Clark makes a tungsten lamp in which three arcs are mounted on a movable iron base; the arcs are fitted with detachable aluminium hoods, and each arc consumes 5 amperes. He has also made a tungsten arc bath in the style of a radiant-heat cabinet.

The "Arnold" tungsten arc hand-lamp is a 5-ampere lamp, with a quartz lens for local treatment.

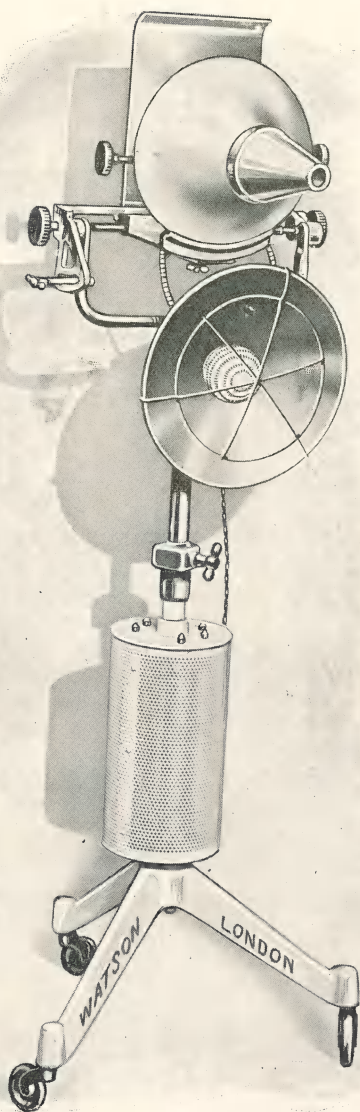


FIG. 54.—The "Sunic" Tungsten Arc fitted with Special Heater.

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The "Densolarc" is a 6-ampere, self-regulating, dental lamp fitted with a quartz concentrator.

The Ediswan Company has designed a closed tungsten arc, the "Pointolite." The arc is formed

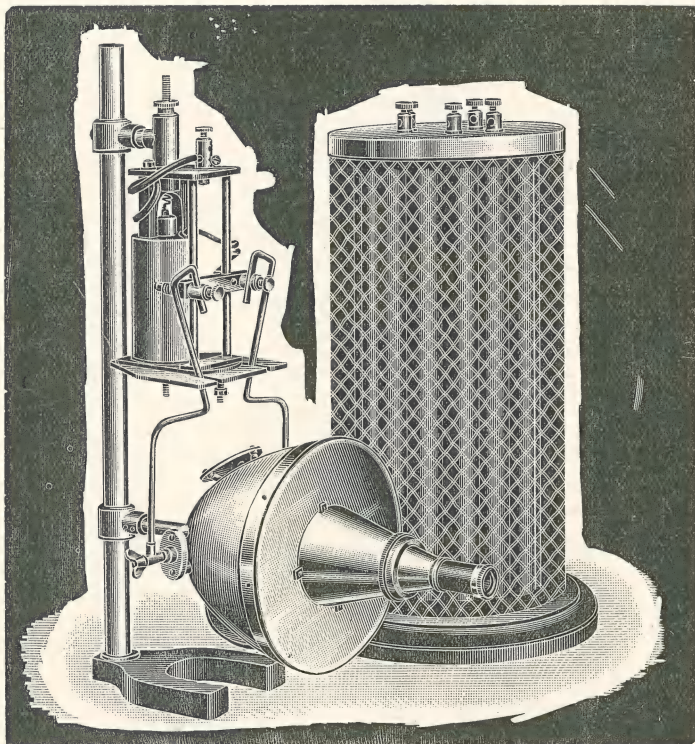


FIG. 55.—A Dental Tungsten Arc Lamp with Automatic Regulation, designed by Norman Black. Direct current, 6 amperes. (Medical Supply Association.)

between a special filament and a small ball of tungsten, and is enclosed in a quartz bulb. It forms a weak source of ultra-violet radiation, but is deficient in the rays of greatest therapeutic effect.

Luckiesh says an arc between tungsten electrodes

CARBON, TUNGSTEN AND IRON LAMPS 143

operated in an atmosphere of hydrogen and nitrogen is a source of intense ultra-violet radiation.

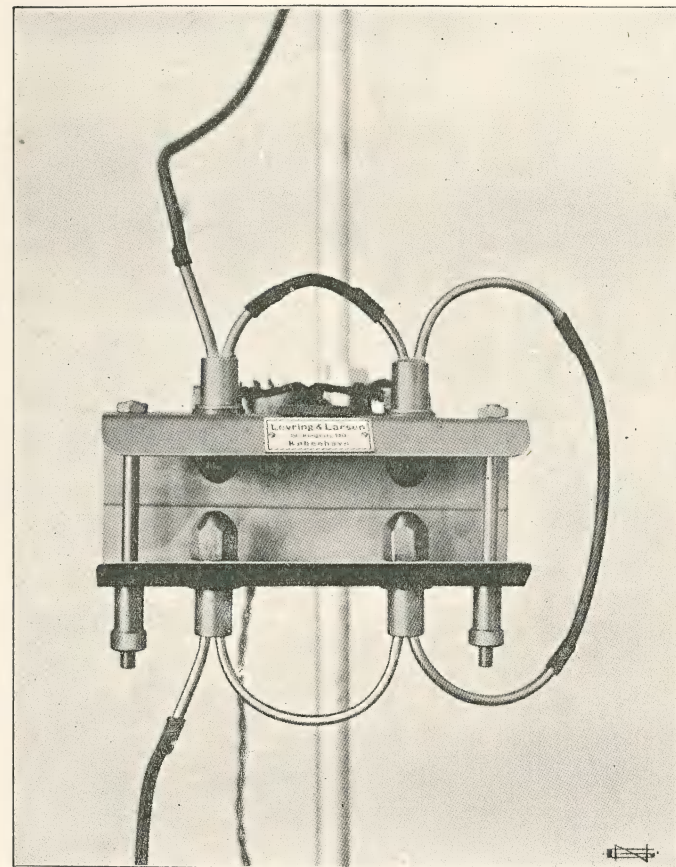


FIG. 56.—Details of Professor Bang's Iron Arc Lamp. (Levring & Larsen, Copenhagen.)

The Iron Arc Lamp.—Professor Bang has designed a water-cooled iron arc lamp. The electrodes have hollow centres and are cooled by running water.

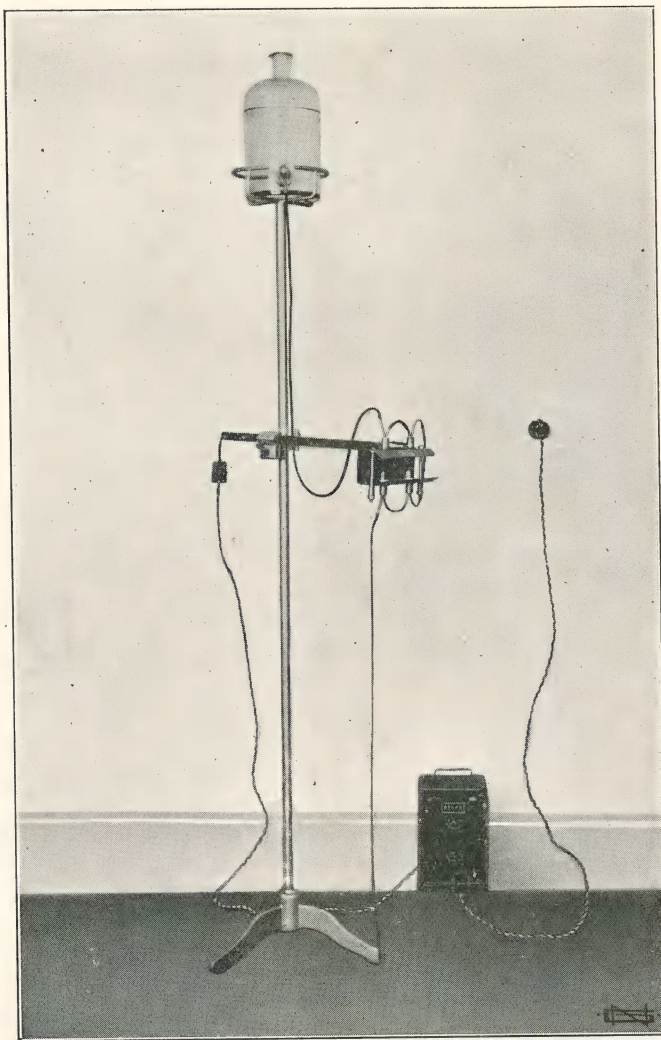


FIG. 57.—Professor Bang's Water-cooled Iron Arc Lamp.
(Levring & Larsen, Copenhagen.)

We saw one of these working in Copenhagen, and one in the Light Department at Alton. The spectrum of the iron arc is less continuous than that of tungsten, and extends only to 2250 Å; but the cost of iron electrodes is insignificant compared with that of tungsten, and this makes the lamp very cheap to use. Sir Henry Gauvain has found it very useful in the treatment of local superficial lesions.

Arcs struck between copper electrodes and silicon electrodes have been used successfully, the latter emitting intense ultra-violet radiation, with very little accompanying visible light.*

Zinc, cadmium, and aluminium have also been used satisfactorily.

CHAPTER V

QUARTZ MERCURY VAPOUR LAMPS

The Mercury Vapour Lamp in Industry—The Essentials of the Mercury Vapour Lamp—Classification of Mercury Vapour Lamps—Different Types of Air-cooled Vacuum Burners—The Functioning of the Mercury Vapour Burner—Quartz, its Properties and Manufacture—Care of the Burner—The Non-Vacuum Burner—Alternating-Current Burners—Burners and Electrodes activated by High-Frequency Current—The Water-cooled Mercury Vapour Lamp—The "Kromayer" Lamp—The "Victor" Water-cooled Burner—The Spectrum of the Mercury Vapour Lamp—Methods of Supporting the Burner

THE first mercury vapour lamp was probably made in London by Way as long ago as in 1860, but it was not used for any practical purpose or developed commercially. In 1892 Arons constructed a lamp, but its use was confined to the laboratory. An American engineer, Peter Cooper Hewitt, took out a patent for a mercury vapour lamp in 1890, but it was not until 1901 that he exhibited to the American Institute of Engineers the actual lamp which bears his name, and which is in common use in industry to-day.

This lamp consists of an evacuated glass tube, 1 in. in diameter and $4\frac{1}{2}$ ft. long, and has a positive electrode made of iron and a negative electrode of mercury.

It can be used with direct current only, and takes about 3 amperes at an E.M.F. of 65 volts.

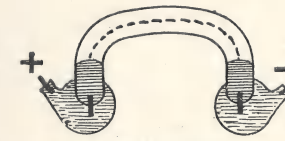
QUARTZ MERCURY VAPOUR LAMPS 147

Apart from medical purposes the mercury vapour lamp is used principally in photographing cinematograph films, in drawing offices, and in newspaper printing, where it is advantageous because it gives a visual acuity fifty per cent. greater than that given by white light.

Kuch and Heraeus were the first to replace the glass of the Cooper Hewitt tube by quartz, which allowed higher temperatures and voltages to be used.



WAY (1860)
FIG. 58.



ARONS (1892)
FIG. 59.

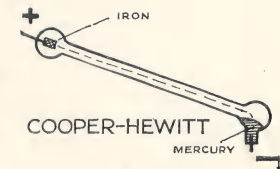


FIG. 60.

The mercury vapour lamp consists of several essential parts, the burner being the principal, but it is also necessary to have a means of lighting the arc and a support for the burner, and a reflector of some pattern is generally used. A rheostat is needed to control the current required for the proper functioning of the lamp under the varying conditions that occur at different times after its ignition.

The burner of the mercury vapour lamp consists primarily of a tube of clear quartz containing some mercury.

When an electric current is passed through the

tube there is a temporary short circuit, heat is generated, causing some of the mercury to volatilize, and an intense illumination results.

The spectrum from the arc is very rich in ultra-violet radiation and extends far beyond the limits of the solar spectrum.

Kromayer, in 1905, designed the lamp known by his name. It is an interesting fact that the rather complicated "Kromayer" lamp was the earliest to

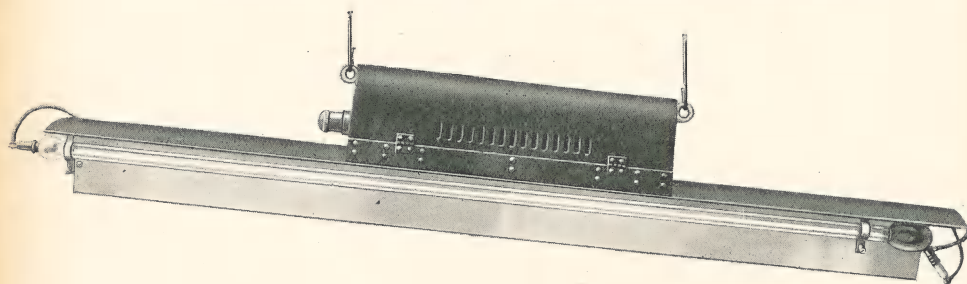


FIG. 61.—Glass "Cooper Hewitt" Mercury Vapour Lamp used for Lighting Purposes.

be used, but at first ultra-violet treatment was restricted to local applications; and it was only when Bernhard and Rollier's work became better known that the air-cooled lamp was invented, to allow general irradiation of the whole body.

Dr Schott's "Uviol" lamp consists of a tube of Uviol glass about 60 cm. long, containing some mercury. Carbon terminals inside the tube are connected to platinum wires, which are fused into the extremities of the glass.

Rays down to $2530 \text{ \AA}$ are allowed to pass, but for medical purposes the lamp has been superseded by the quartz lamp.

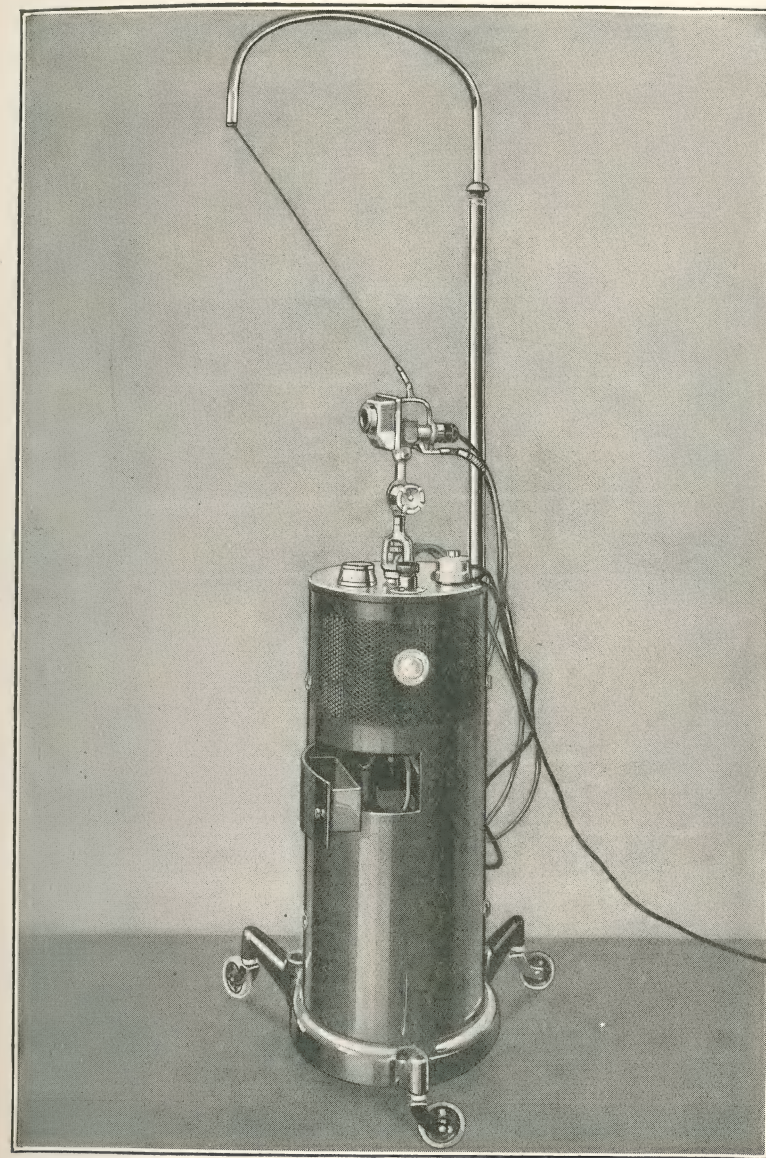


FIG. 62.—The Self-Contained "Kromayer" Lamp.

Mercury vapour lamps can be divided into :

- (1) Air-cooled.
- (2) Water-cooled.

In air-cooled lamps, the cooling can be effected by
(a) radiation from metal coolers, or (b) a mechanically produced air blast.

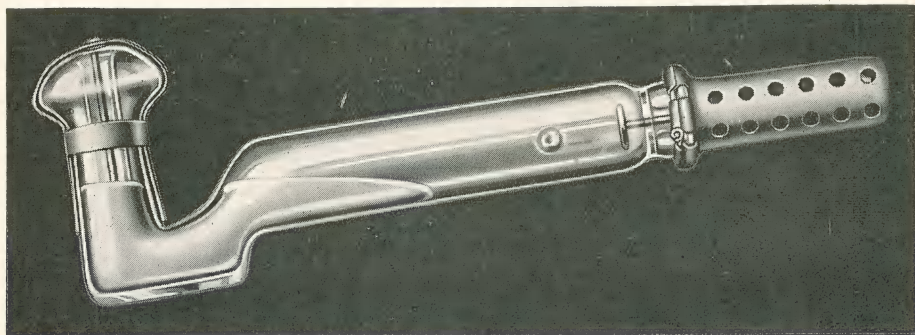


FIG 63.—Air-cooled Type "Uviarc" Quartz Tube. (Victor X-ray Corporation, Chicago.)

There are three common types of air-cooled mercury vapour lamp :

- (1) The vacuum burner.
- (2) The gas-filled burner.
- (3) The atmospheric burner.

Air-cooled lamps can also be subdivided into :

- (1) Those which have to be tilted to produce the arc. (The tilting may be (a) performed by hand, or (b) magnetic.)
- (2) Those which start automatically :
 - (a) By means of an auxiliary heating system
 - (1) outside the burner, or (2) inside the cavity of the burner ; or
 - (b) By an initial high-tension discharge.

The commonest types of vacuum mercury vapour lamps are :

- (1) The original "Hanau" and "British Hanovia" lamp.
- (2) The "Hewittic" lamp.
- (3) The "Medical Supply Association" lamp.

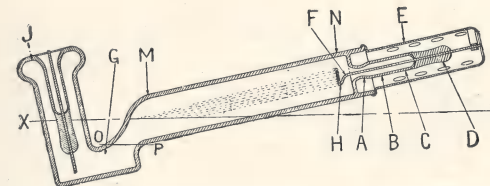


FIG. 64.—Diagram of "Uviarc" Air-cooled Quartz Mercury Vapour Burner.

A, Quartz Stem of Seal Structure ; B, Connexion of Quartz Stem and Seal Grading ; C, Connexion of Seal Grading and Seal Coating ; D, Tip of Seal Coating ; E, Anode Seal Guard ; F, Tungsten Electrode ; G, Cathode Mercury Pool ; H, Anode Target ; J, Cathode Chamber ; M-N, Luminous Portion ; X-Y, Level of Mercury when cold ; O-P, Level of Mercury during operation.

- (4) The "Uviarc" lamp, made by the Victor Company (Chicago) and by the Cooper Hewitt Company.
- (5) The "Quartz Transparent" lamp, Paris.
- (6) The "Silectra" lamp, Leipzig.
- (7) The "Vignard" lamp, made by Gallois et Cie, Lyons.
- (8) The "W. Ulbrich" lamp, Jena.
- (9) "Le Quartz Dimant," Paris.
- (10) The "Lasem" lamp, Paris.
- (11) The "Belleaud and Barrolier" lamp, Paris.
- (12) The "Quartz Français" lamp, Paris.

(1) The "Hanau" lamp is manufactured in the small town of Hanau, near Frankfort, Germany. The quartz of this and of the "British Hanovia" lamp is considered particularly transparent, great skill having

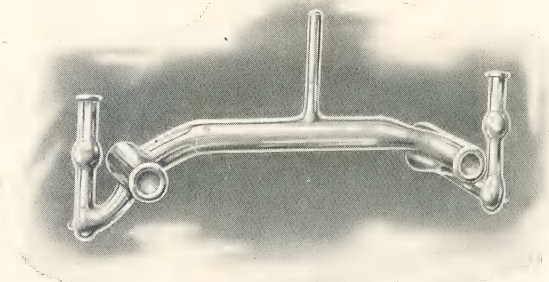


FIG. 65.—The Hewittic "Ulviarc" Quartz Burner before assembly.

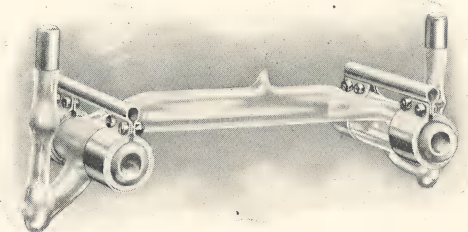
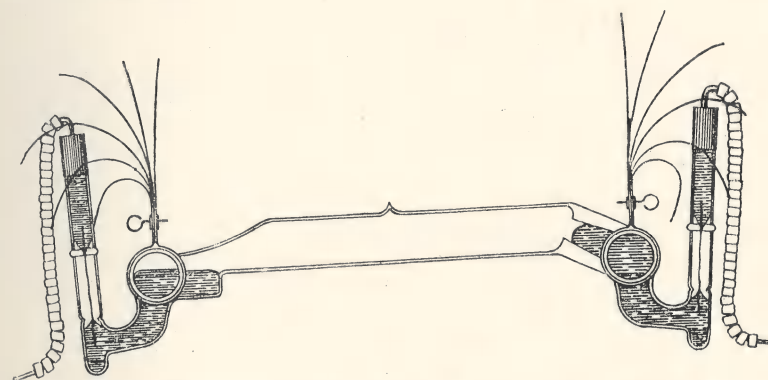
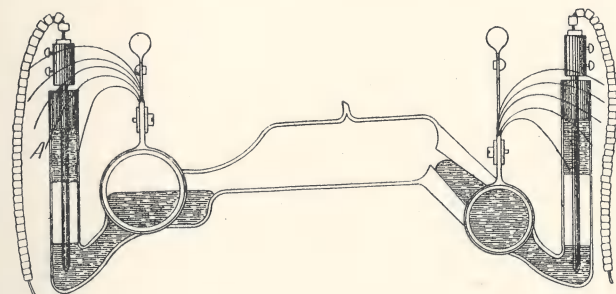


FIG. 66.—The Hewittic "Ulviarc" Quartz Mercury Burner completed. Note the absence of Aluminium Cooling Vanes.

been acquired in working the material since W. C. Heraeus, of Hanau, first devised an improved method of fusing quartz crystal. The "British Hanovia" lamps are made in England, at Slough.

(2) The "Hewittic" lamp, which is made in England, is so similar in construction to the "Hanau" and "British Hanovia" lamps that one description of

the three will suffice. The new "Hewittic" burner has, however, no cooling vanes.



FIGS. 67 and 68.—Diagrams of two Quartz Mercury Vapour Burners (Vacuum Type) manufactured by the Hewittic Co. In each burner the anode is on the left and the cone and negative terminal are on the right. To strike the arc the anodal end must first be tilted, so that the mercury in the anodal chamber comes momentarily into contact with the mercury in the cone, and then lowered. The upper diagram illustrates a Burner for 110 volts, and the lower—for 220 volts—shows the much longer Arc Tube. The Aluminium Cooling Vanes attached to the polar vessels can be seen.

A Common Description of the Burners of Lamps (1) and (2).—The direct-current burner consists of a transparent quartz tube, the arc tube, $1\frac{1}{2}$ to 2 millimetres thick, varying in length from three to five

inches according to the voltage, and having at each end transverse polar vessels also made of quartz; these contain a fixed bundle of quartz rods to lessen the amount of mercury required. When in position the burner is slightly out of the horizontal plane, the anode, generally on the left-hand side when the burner

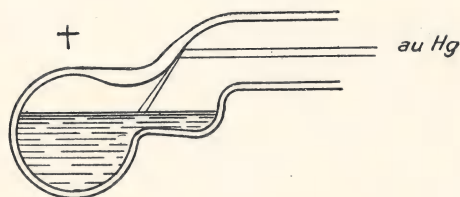


FIG. 69.—Showing the Thickened Projection on the upper part of the Burner at the junction of the Arc Tube and the Anodal Reservoir. This diverts the Luminous Arc Stream on to the surface of the Liquid Mercury. (Saidman.)

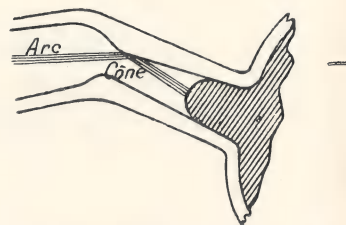


FIG. 70.—Illustrating the Cone, which is situated at the junction of the Arc Tube and the Cathodal Polar Vessel. The Quartz Walls of the Burner are considerably thickened at this point. The Cone plays an important part in regulating the surface area of mercury in contact with the luminous arc, and thus maintains equilibrium in the burner. (Saidman.)

is viewed from the front, being a little lower than the cathode.

At the cathode, where the arc tube joins the polar vessel, the quartz is very much thickened, the internal narrowed portion being cone-shaped, for which reason this portion of the burner is known as "the cone." The cone plays an important part in regulating the even working of the burner.

The cathode is cooler than the anode, and consequently liquid mercury tends to be deposited at the cathode. The more mercury there is deposited at the

cathode, the higher is its level in the cone, with the result that a smaller surface of mercury is in contact with the luminous arc, a greater amount of heat is developed, and consequently more mercury is volatilized. In this way the amount of mercury vapour in the burner is regulated and kept fairly constant. When the lamp has reached its normal output, and the

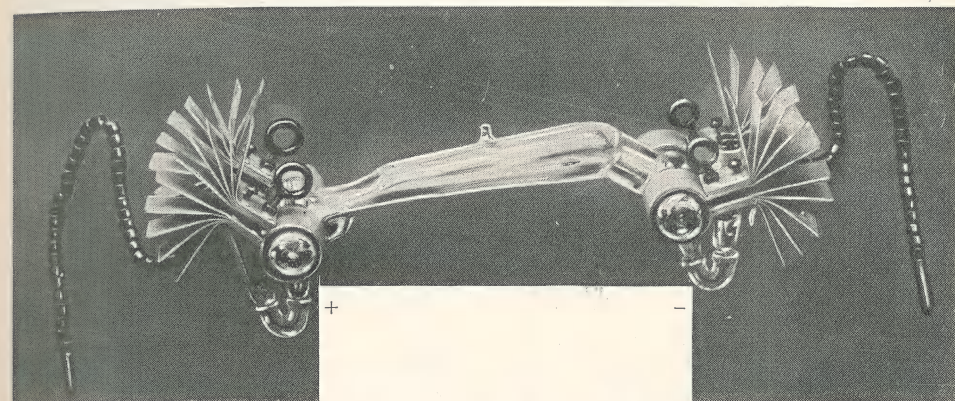


FIG. 71.—Direct-Current Type of Air-cooled Quartz Mercury Vapour Burner, for use on 220 to 240 volts. The Anode is seen on the left and the Cone and Cathode on the right. (Ajax Ltd.)

electrical energy input is equal to the radiation from the burner, the luminous column occupies only the centre of the arc tube. A special projection at the cathode end deflects the arc stream on to the relatively small cathode surface almost at right angles to it.

On the upper surface of the anodal end of the arc tube the quartz is thickened to form a slight protuberance into the lumen of the burner.

On the lower surface below this the anodal mercury reservoir is continued into the arc tube. The thickened projection of quartz on the upper internal

surface of the arc tube deflects the arc stream almost at right angles on to the surface of the mercury.

The terminal vessels are surrounded by metallic coolers and contain the mercury poles. The coolers control the mercury distribution in the lamp by heat regulation. Conductors are ground or sealed into the quartz, enabling the external current to enter the polar vessels between the coolers. Inside the vacuum

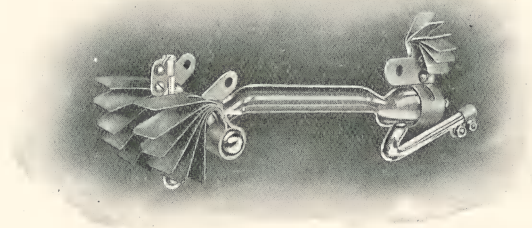


FIG. 72.—The "Medical Supply Association" Direct-Current Quartz Mercury Vapour Burner.

of the tube the mercury vapour carries the current from one inside terminal to the other. Two sockets, which enable the burner to be held in place, are fastened to the coolers. The tube was originally made of quartz because of its very high melting-point of about 1700°C ., which made it possible to use lamps at a much higher temperature than when they were made of glass. Another advantage is that the coefficient of expansion and contraction of quartz is only $\cdot 00000059$ inches per inch per degree centigrade. Again, about a thousand times more ultra-violet radiation is allowed to pass through quartz than through glass.

(4) The "Uviarc" lamp consists of a cylindrical pipe-shaped quartz tube, the cathodal chamber corresponding to the bowl of the pipe, and containing mercury. The tungsten electrode wires are fused into glass, which is in turn connected to the quartz of the tube through intermediate steps of glasses of decreasing coefficients of expansion; this has made it possible to use a solid tungsten anode, and, as a result, to work the burner at high temperatures, without the use of metal cooling-fins. The lamp is lit by tilting the cathodal end so that metallic contact is made by the mercury from the cathode momentarily touching the tungsten anode. During operation the mercury is entirely confined to the cathodal chamber, partly by mercury vapour pressure and also because the cathode lies at a lower level than the anode.

Quartz is a mineral commonly found on the earth's surface, where it forms 60 per cent. of the outer crust of the earth. It is found in its free state in sand, sandstone, and rock-crystal, and in combination generally as silicates in clay. It rarely occurs in its pure, colourless, crystalline form; usually it is tinted yellow, violet, blue, or brown. Quartz crystals are rhombohedral, and, chemically, quartz is silicon dioxide (SiO_2).

Fused quartz occurs in nature only as fulgurites, which are formed by lightning discharging in a bed of sand.

The introduction of the oxy-hydrogen blow-pipe made it possible to fuse silica successfully, and Gaudin exhibited some small pieces of fused quartz before the Academy of Science in Paris in 1839.

Quartz requires a very high temperature to melt it, and it never becomes really fluid, because volatilization takes place at a temperature very little above that at which it becomes soft.

In 1888 Sir Charles Parsons, in a communication to the Royal Society, said he had fused silica sand by means of an electrically heated carbon rod embedded in it.

In 1889 Boys exhibited thin quartz threads, and in 1901 Shenstone exhibited a fused silica tube at the Royal Institution.

In 1903 Heraeus exhibited some small quartz vessels that he had made, and at the beginning of the same year work was commenced at the Thermal Syndicate, Wallsend-on-Tyne, to whom we are indebted for most of our information about the manufacture of quartz. Originally, small pieces of rock-crystal were fused in the oxy-hydrogen blow-pipe and either joined to one another, piece by piece, until a rough tube was built up, or else drawn out into threads and wound round a platinum core.

Crystalline quartz cracks when heated in a flame, it is therefore necessary to heat very small fragments to about 1000° and then throw them into cold water. The material is fairly easy to work afterwards. Once a tube of silica has been made it is possible to work it in the flame without excessive difficulty.

Heraeus improved on this method: he heated the pieces of quartz crystal slowly to a red heat, so that they did not splinter during the process, and then placed them while still hot in an iridium crucible,

in which they were brought up to the softening temperature.

The great difficulty experienced with fused silica is that the temperature at which it can be worked is about the melting temperature of platinum. Fused silica never becomes really liquid, but only plastic, like warm toffee. Fused silica is harder than glass and about as brittle; it has great resistance to sudden and extreme changes of temperature, so that small articles can be heated to softening temperature and plunged into cold water without cracking. There are only two acids that attack fused silica—namely, hydrofluoric acid and phosphoric acid. Its working temperature is about 1750° C., but it cannot be used above a maximum of 1450° C. because it slowly deforms, and if it is kept above a temperature of about 1100° C. it slowly devitrifies. Silica is a remarkable electrical insulator at high temperatures. Fused silica transmits many invisible rays as well as all the visible rays, and is probably the most perfectly transparent known solid.

In the process of manufacture of quartz mercury vapour burners, all gases are removed by a temporary opening in the middle of the upper surface of the arc tube, and a vacuum is formed. When the lamp is in use a direct-current arc is formed between the positive electrode of iron, carbon, or tungsten, and the mercury cathode; the tube then contains many free electrons, molecules, and ions of mercury, and there is a constant movement of electrons from the cathode to the anode and vice versa.

This type of burner must be operated by direct

current, and mercury must form the cathode, because the substance used as a cathode must be capable of being easily maintained at a sufficiently high temperature to emit electrons, and, as Fleming explains, mercury has a relatively low boiling-point, a small latent heat of vaporization, a low specific heat, and a low ionization potential.

Striking the arc generates intense heat on the comparatively small surface of the mercury cathode. Electrons are freely formed, and a high cathodal temperature at one spot is maintained by ionic bombardment, the ions being derived from the mercury vapour between the electrodes.

On the other hand, it is difficult to maintain local heating of iron or tungsten at a high temperature; if alternating current were used the iron and mercury would alternately become negative; and, as has already been indicated, iron is not a suitable cathode. The mercury arc is therefore a unidirectional conductor, the maintenance of the small cathodal hot area being essential.

There is a variation in the arc temperature of the tube from the centre to the surface of from 1400° to 450° C., and the vapour pressure is usually a little over an atmosphere.

To ensure steadiness in the arc stream the lamp is operated out of the horizontal plane, the anode generally being at a lower level than the cathode. To strike the arc after current is switched on, the mercury cathode is first brought into contact with the anode by tilting the lamp and so causing the mercury to flow across the burner, and then the stream is broken,

and the arc established, by lowering the anode to its original position. Compared with a filament incandescent lamp the mercury vapour lamp is relatively cold. The luminescent vapour is at a temperature



FIG. 73.—Diagram of the Correct Burning Position of the Vacuum Type Quartz Mercury Vapour Burner.

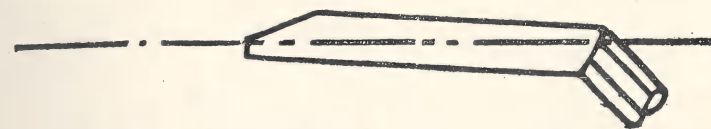


FIG. 74.—Diagram of the Incorrect Burning Position of the Vacuum Type Quartz Mercury Vapour Burner, which will cause Failure of the Burner.

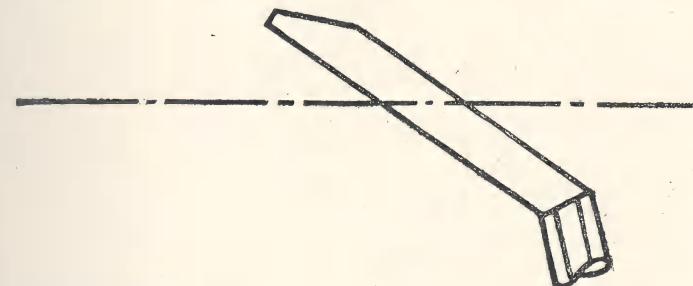


FIG. 75.—Diagram of the Position of the Vacuum Type Quartz Mercury Vapour Burner when tilted to start. The Anode has been raised.

of 200° to 500° C., whereas the filament of the incandescent lamp usually has a temperature of 2800° C. Quartz will stand very high temperatures, but it is fragile and has to be handled carefully. It must also be kept scrupulously clean and free from grease and dust; the tube must not be fingered, because imprints become etched into the quartz and

cannot be removed. It is best to clean it with a piece of silk soaked in rectified spirit.

The characteristic odour near an active mercury vapour lamp is due to the formation in the air of hydrogen peroxide, ozone, and nitrous acid. Ozone is produced in considerable quantities, especially soon after the lamp has been lit. The smell is not unpleasant, and the ozone does not seem to have any bad effects.

Some time ago we had experience of the variation in intensity of lamps. A "Hewittic" lamp was broken because the resistance was inadvertently cut out, and the application of the full pressure of 240 volts to the lamp led to results which cracked the quartz. On the arrival of a new lamp slight overdoses occurred when the same exposures were given.

Gradually, in the course of the life of a lamp, some air leaks into the vacuum, causing a change in the composition of the gas in the tube, and a brownish grey stain appears on the inside of the quartz, decreasing the emission of rays. The evacuated type of burner has generally to be overhauled after it has been in use for 800 hours (longer exposures are generally required after 400 hours). The burner should be returned to the makers, who usually treat the interior with nitric acid, re-evacuate it, and seal it. Sometimes, however, it is necessary to replace the arc tube of the burner by a new tube. Taylor and Griffith found that some mercury vapour lamps, when they were new, gave off nearly eight times as much ultra-violet radiation as when they had been used for 800 hours.

It has also been found that when deterioration with age occurs in a quartz mercury vapour lamp

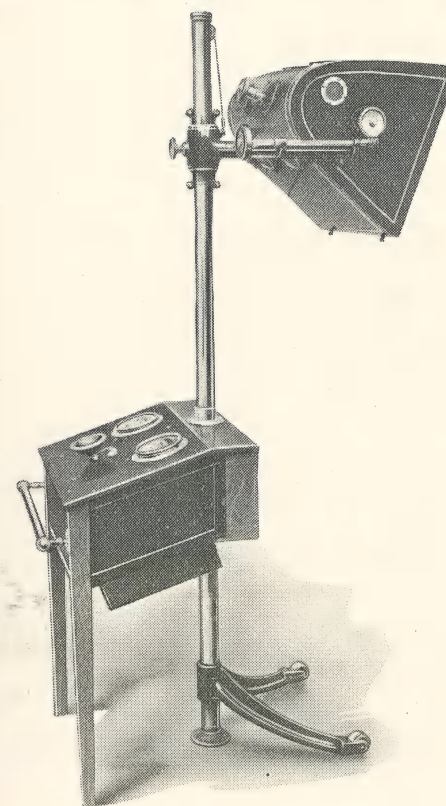


FIG. 76.—The "Helios" Quartz Mercury Vapour Lamp made by Quartz Français.

it is particularly the rays below $2540 \text{ \AA}$ that are cut off.

All the lamps already described must be tilted to strike the arc. Care must be exercised not to reverse the polarity of the terminals, either at the switchboard

or at the lamp ends, or the lamp will be destroyed. It is customary to make the wall plugs with pins of

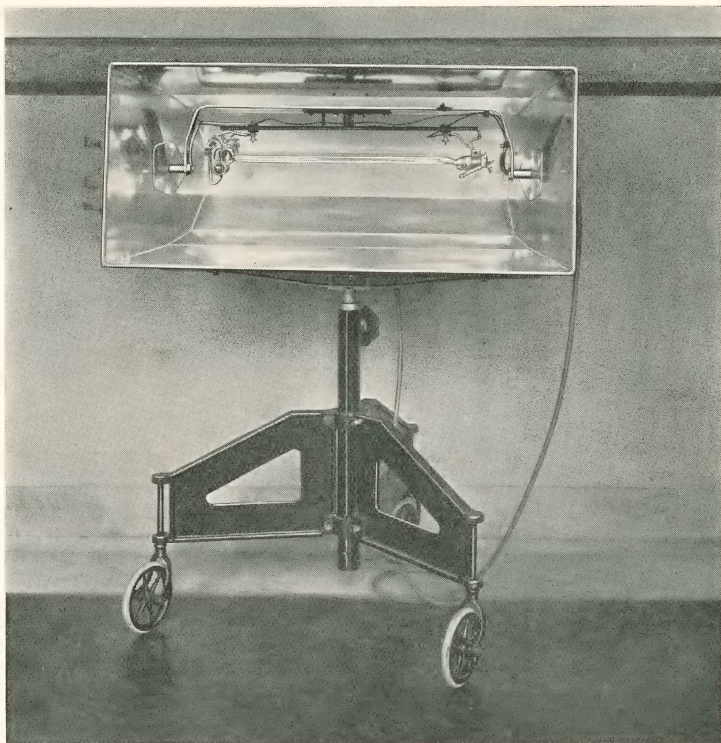


FIG. 77.—One of the Special Lamps used at the "Sun-Ray" Clinic, Newcastle-on-Tyne, which are fitted with Vacuum Type Quartz Mercury Vapour Burners whose arc tubes are eighteen inches long.

different sizes, or in some other way to ensure their non-reversibility, to avoid mistakes.

The direct-current "Quartz Transparent," "Silectra," and "Lasem" burners are very similar to the "Hanau-Hanovia."

The "Ulbrich" burner has a special mercury seal, which obviates the need for aluminium cooling fins. The hood also contains the resistance specially mounted above the middle of the quartz burner, so as to provide the maximum emission of infra-red radiation. The lamp is lit by tilting the whole reflector hood. The cathode is on the left-hand side.

Recently an evacuated burner of the classical type has been made with milky coloured translucent quartz. The radiation which this burner emits is, naturally, much weaker than that obtained from one of clear quartz.

The Thermal Syndicate have recently made some very long evacuated quartz burners, having an arc tube eighteen inches in length. More even distribution of radiation is obtained with them than with the more usual type, on account of the length of the arc tube, and they have a longer effective life than burners of smaller size, because devitrification of the quartz takes place more slowly. They are, however, more easily broken than the ordinary, shorter type.

The "Henri George" burner has at each end two terminal reservoirs filled with mercury. The anodal reservoir, which lies on the left, has two auxiliary chambers attached to it: one, the heating chamber, contains a laminated nickel chrome wire; the other is the balancing chamber, which acts as a receptacle for the mercury displaced when the lamp is in use. It has at its base a constriction with a passage only one millimetre wide for the purpose of steadying the mercury. When the current is switched on, the

laminated nickel chrome wire (12) quickly becomes red-hot, and causes the inert gas, argon, which at first fills the chamber 8, and in fact the whole burner above the level 14—14, to expand rapidly and press

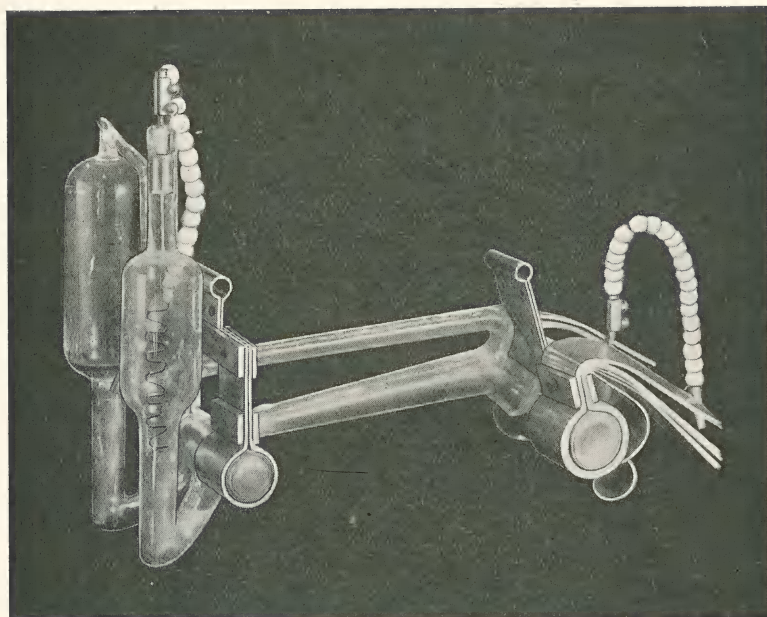


FIG. 78.—The "Henri George" Quartz Mercury Vapour Burner for use at 240 volts D.C. This burner, which contains Argon, lights automatically without tilting.

the mercury downwards in the tube 15 and at the junction of the tubes 1 and 9. Most of the displaced mercury passes through the narrow opening at 13 and collects in the balancing chamber (7), where it remains the whole time the lamp is burning. The expanding gas in this manner breaks the continuity of the mercury column in the uppermost part of the

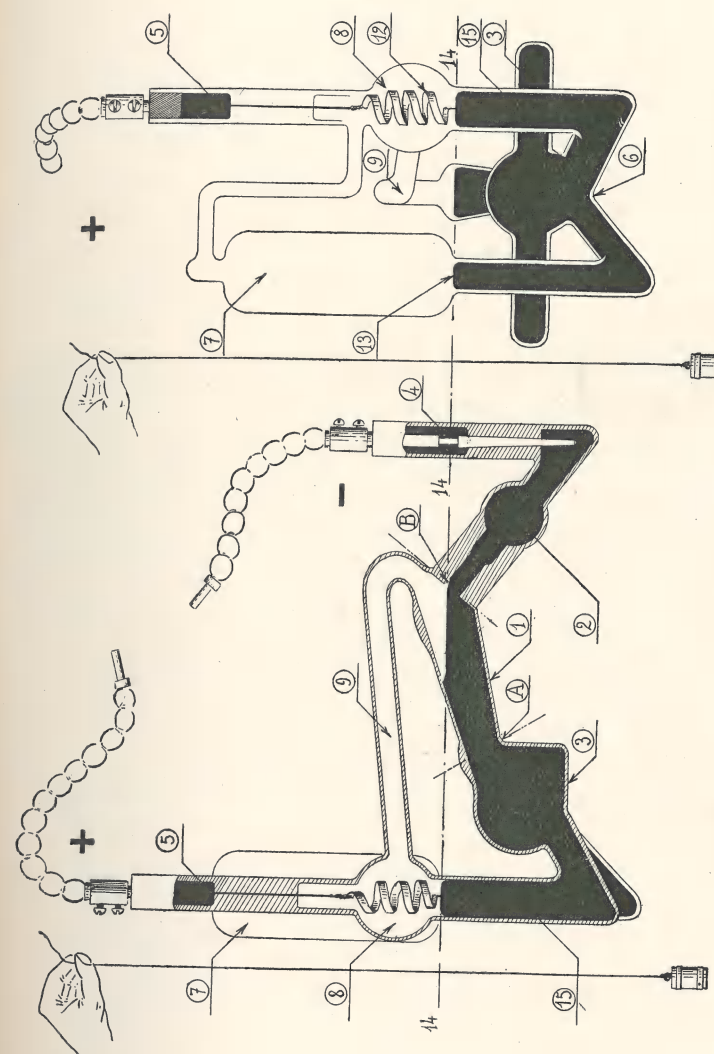


FIG. 79.—Diagram of the "Henri George" Quartz Mercury Vapour Burner.

- 1, Arc Tube; 2, Cathodal Mercury Reservoir; 3, Anodal Mercury Reservoir; 4, Negative Terminal; 5, Positive Terminal; 6, Tube connecting Chambers 7 and 8; 7, Hollow Chamber with constricted neck, 13, at its base, pierced by a small opening only 1 mm. across; 8, Hollow Oval Chamber containing laminated Nickel Chrome Wire, 12; 9, Tube connecting 8 with the Upper Part of the Arc Tube, 1; 14—14, Level of Mercury when Lamp is not lit; 15, Tube connecting Anodal Reservoir, 3, and Chamber, 8.

A to B, Arc assumes this position in 5 to 10 seconds after the switch has been closed.

arc tube and the arc is then struck, the arc stream rapidly lengthening until it occupies the position A—B. The whole process takes only a few seconds.

Lamp in which the Arc is struck at Atmospheric Pressure.—The burner of this lamp, the "K.B.B.," is manufactured at Wallsend-on-Tyne by the Thermal Syndicate Co. for Messrs Kelvin, Bottomley & Baird. It has a quartz body and is self-starting. The "K.B.B." quartz mercury vapour lamp differs from those made

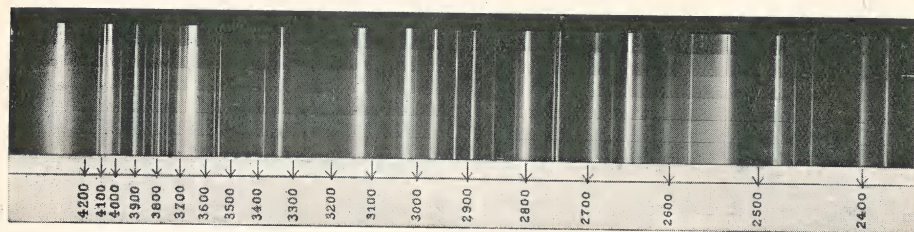


FIG. 80.—Spectrogram of "Henri George" Quartz Mercury Vapour Burner.

previously inasmuch as it is open to the atmosphere instead of being sealed in a vacuum. The result is a lamp having some advantages over the vacuum type. The atmospheric type of lamp has greater mechanical strength, because it is completely sealed with mercury when it is not in operation and it is not therefore possible for any mercury hammer to take place in the lamp when it is transported from place to place. This may easily happen in lamps of the vacuum type, which contain a quantity of free mercury in the exhausted envelope.

Since there is no vacuum inside the lamp, no air-tight seals are required between the quartz envelope and the leading-in conducting wires, and loss of vacuum

due to leakage is entirely eliminated. Staining is also avoided, and the inside of the tube may be cleaned, when a mercury film has formed, by treating it with pure nitric acid, and then washing it out freely first with distilled water and then with absolute alcohol.

With continued use, however, all lamps, whether of the atmospheric or of the vacuum type, give off

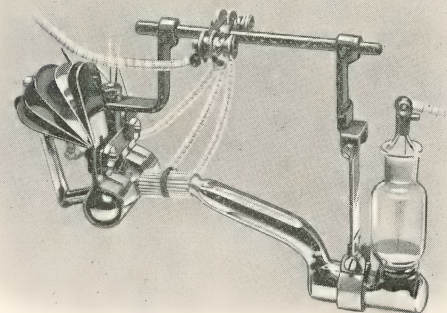


FIG. 81.—The new pattern of Atmospheric Quartz Mercury Vapour Burner. (Kelvin, Bottomley & Baird.)

less ultra-violet radiation owing to the occurrence of a chemical change, and some of the quartz is converted into tridymite, a substance less transparent than quartz to the rays. This change takes place more rapidly in air-cooled lamps than in water-cooled.

Tridymite and quartz are probably polymers of the molecule SiO_2 ; but tridymite, being the less complex polymer, is more stable at high temperatures. It has a specific gravity of 2.3, whereas that of quartz is 2.65.

It has been found experimentally that if quartz

glass is devitrified at 1200°C ., homogeneous tridymite is formed.

Two of these burners, which were put on a life test in 1922, burned continuously night and day, except for one short period in the summer of 1924, when the

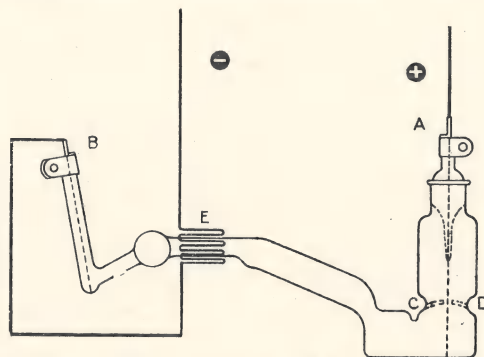


FIG. 82.—Diagram of the "K.B.B." Atmospheric Burner.

When the current is switched on it flows along the positive terminal, passes through the constriction at C—D and through the mercury in the arc tube to the negative terminal, B, and then through the heating coil, E, causing it to become hot. The mercury contained in the constricted portion of the burner, which is encircled by the coil, becomes hot also, and vaporizes, causing the mercury column in the arc tube to break at this point; the arc is thus struck.

lamps were taken down during cleaning operations. They were only turned off at the end of 1926, when the building in which they were installed was demolished. Their ultra-violet emission, of course, became progressively weaker.

The above diagram illustrates the new type of atmospheric burner. The whole burner is filled with mercury to a level about a quarter of an inch above

C—D. The negative electrode, which is a tungsten wire, projects into the mercury at B; this electrode is also connected with the heating coil which encircles the cone at the junction of the arc tube and the cathodal polar vessel like a collar. The heating coil consists of a fine wire which passes through a series of thin cylindrical quartz rods, which are arranged horizontally, with their long axes parallel to one another around the narrow cone. The positive electrode is also made of tungsten wire, and this projects through a small circular aperture in the quartz partition which separates the vertical from the horizontal portion of the anodal chamber. When the current is switched on and the heating coil becomes red-hot the mercury enclosed in the cone at E also becomes very hot, and is eventually vaporized.

The vapour causes the mass of mercury to break in two at the constriction, and the arc is thus struck. The liquid mercury on the left is forced back by the mercury vapour and passes through the small aperture in the dividing partition in the anodal chamber and reaches a much higher level; when the current is turned off it slowly returns to its original level. Should the current be interrupted, and the arc broken, the heating coil will heat up automatically and restore the light as soon as the current is again switched on.

These lamps can be supplied to operate on any direct-current supply at from 95 to 500 volts. They take about 4 amperes when starting and about 2.25 amperes when running under normal conditions. If only alternating current is available a rectifier will be required.

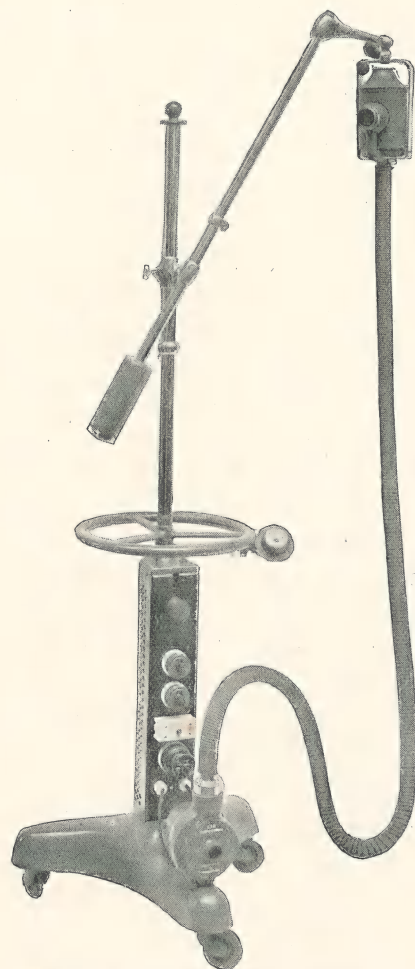


FIG. 83. — Atmospheric Type Mercury Vapour Lamp cooled by Forced Air Draught, with Stand. (Kelvin, Bottomley & Baird.)

Recently the "atmospheric" burner has been modified to make it possible to cool the lamp by a forced air draught. A motor-fan is attached to the lamp-stand and the air current passes up the hollow lamp handle. When the lamp is used for local work

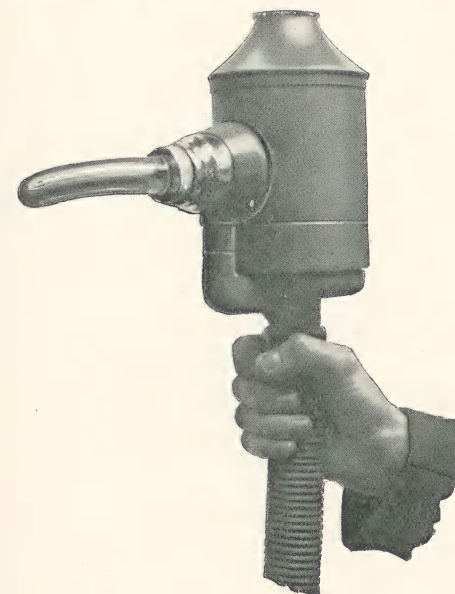


FIG. 84.—The Housing of the "Uviator" Mercury Vapour Lamp, cooled by Forced Air Draught.

it is enclosed in a hood and the air current is directed on to the quartz applicator, so that it is kept cool. This lamp is very convenient when no running water is available, but it is apt to be a little noisy.

This principle has also been utilized in a lamp made by "Ajax Ltd," where the heated air is drawn off by a motor-fan, allowing the lamp to be used with the hood closed for prolonged periods without overheating.

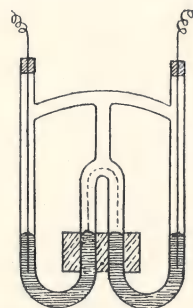


FIG. 85.—Diagram of the Belleaud and Barrolier Burner.

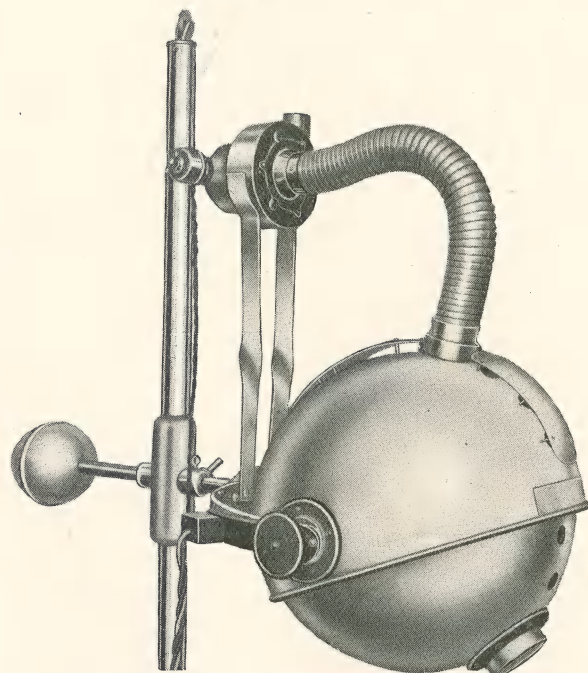


FIG. 86.—“ Ajax ” Quartz Mercury Vapour Lamp fitted with Suction Exhaust Fan to ensure effective cooling when the Lamp is used for Local Treatment with the hood closed.

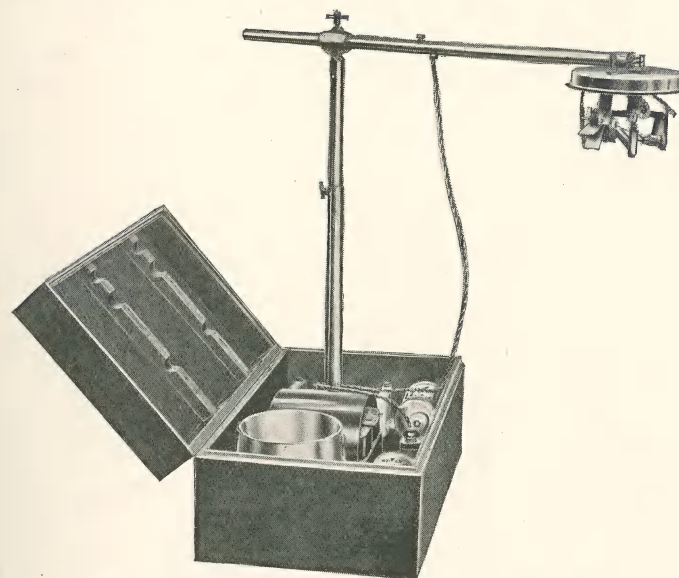


FIG. 87.—Portable Mercury Vapour Lamp ready for use. (Gallois et Cie.)

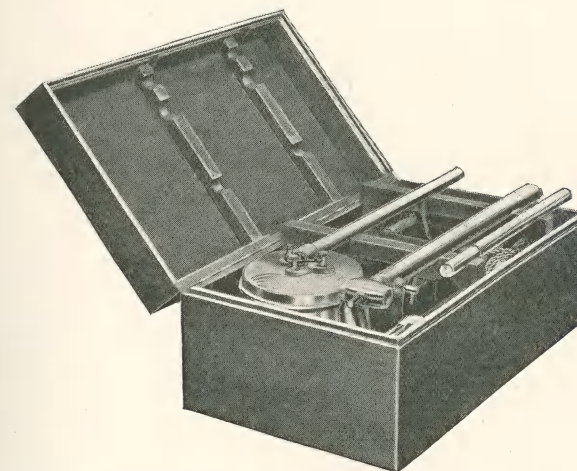


FIG. 88.—Portable Mercury Vapour Lamp packed in case.

Belleaud and Barrolier have invented several new types of mercury vapour burner. The simplest

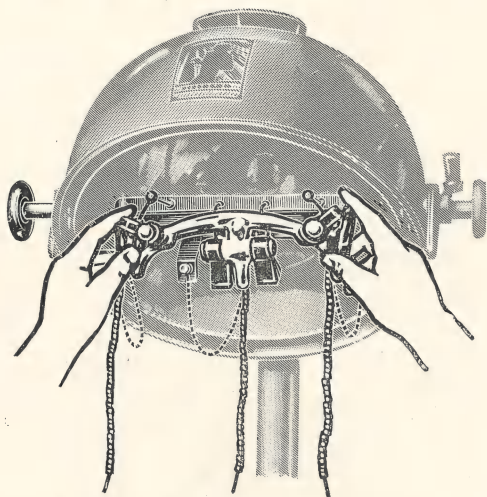


FIG. 89.—Method of inserting the "Silectra" Alternating-Current Quartz Mercury Vapour Burner into its Housing.

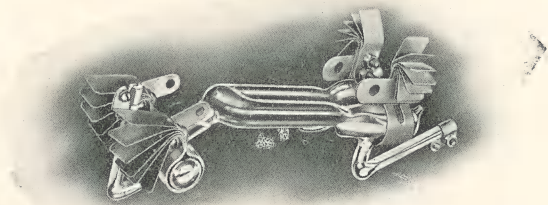


FIG. 90.—The "Medical Supply Association" Alternating-Current Quartz Mercury Vapour Burner.

consists of an inverted Π -shaped quartz tube, with the electrodes sealed into the two limbs. A substance that conducts heat well forms a bridge across the gap

between the limbs, and tends to keep the temperature at both poles equal. Since both electrodes have the same cross-section, the polarity does not matter.

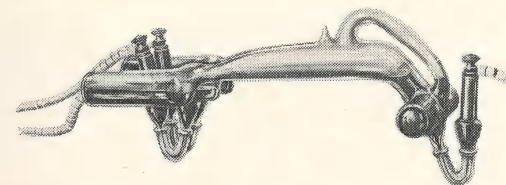


FIG. 91.—The "Quartz Français" Alternating-Current Quartz Mercury Vapour Burner.

Another type of burner designed by Belleaud and Barrolier has three parallel limbs, which are joined together at their upper extremity. The negative

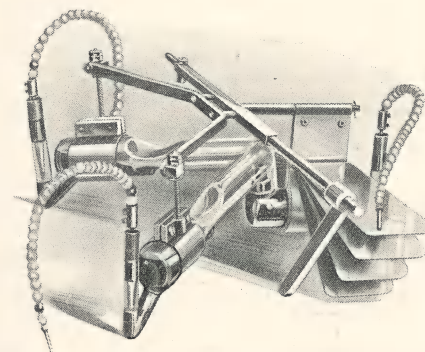


FIG. 92.—The "Gallois" Alternating-Current Quartz Mercury Vapour Burner.

terminal is attached to the central limb and the two outer ones are positive. This burner can be used with either direct or alternating current.

Alternating-Current Burners.—Direct current is

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always preferable for use in mercury vapour burners, but there are several burners made that can be worked from an alternating-current supply.

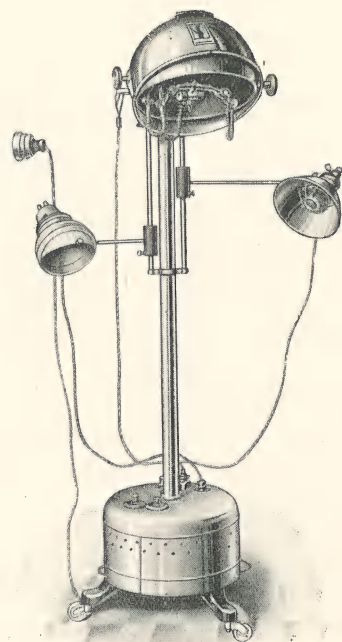


FIG. 93.—“Silectra” Quartz Mercury Vapour Lamp with Infra-Red and Luminous Radiators attached.

These burners all have two electrodes of the type used for the positive pole in direct-current burners:

(1) The “Hanau-Hanovia” is similar to the direct-current burner, but the anodal half of the arc tube is split into two parallel anodal chambers, which are on the left-hand side of the burner.

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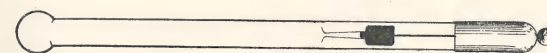
(2) The “Medical Supply Association” alternating-current burner is very similar.

(3 and 4) The “Quartz Transparent” and “Quartz Français” are similar to the “Hanau-Hanovia.”

(3) The “Gallois” burner is V-shaped, the anodal limbs being at the front of the burner and widely



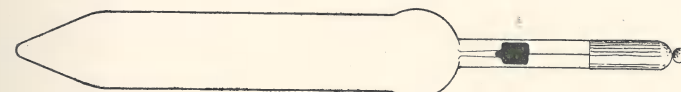
Convex Surface Electrode.



Surface Electrode with globular end.



Long Haemorrhoidal Electrode.



Rectal Electrode.

FIGS. 94, 95, 96, and 97.—“Gallois” Quartz High-Frequency Electrodes.

divergent; the cathode is at the back, nearest the reflector.

(4 and 5) The “Silectra” and “Ulbrich” burners are very similar. The anodes form the extremities of an almost straight tube, and the cathode, which lies behind and at a lower level, is attached to the middle of the tube. The burner has to be tilted upwards, in the horizontal plane, to light it, and this is sometimes a little difficult.

Burners and Electrodes for use with High-Frequency Current.—Some burners are made for use with a high-frequency current. The best known of these are the following :

(1) The "Quartz Dimant" is a compact, portable apparatus, having a special quartz mercury burner which is automatically lighted by means of the high-frequency current. The apparatus can be used for

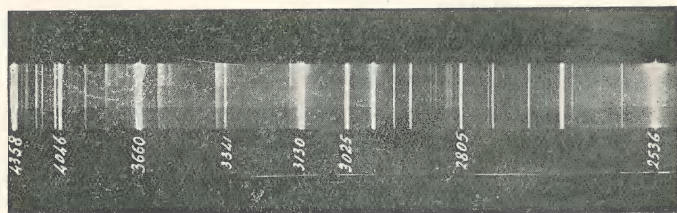


FIG. 98.—Spectrogram of "Gallois" Quartz High-Frequency Electrode.

either ultra-violet or high-frequency work, and is very convenient for local applications.

(2) The "Gallois" high-frequency burner is shaped like an inverted $\mathbf{u}$ and is very compact.

(3) Recently, M. Gallois has made some very interesting high-frequency electrodes of clear quartz. They are evacuated, and contain argon and a small quantity of mercury. They are very similar in principle to the quartz mercury vapour burner and, like it, emit ultra-violet radiation, but they also emit a high-frequency discharge and thus allow the simultaneous administration of ultra-violet radiation and high-frequency. A tungsten wire is fused into the base of the electrode, and projects through the quartz, making contact with the mercury.

WATER-COOLED MERCURY VAPOUR LAMPS

Of this type of lamp, that designed in 1906 by Professor Kromayer, a Berlin dermatologist, is perhaps the best known ; it is manufactured in this country by the British Hanovia Company. Different types of lamps have to be used for direct and for alternating current. The lamp for direct current consists of an inverted $\mathbf{n}$ -shaped arc tube made of fused quartz,

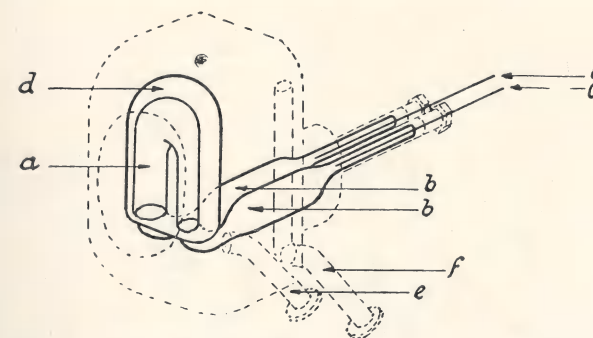


FIG. 99.—Diagram of the "Kromayer" Direct-Current Burner. *a*, Arc Tube—Cathode on the right; *b b*, Electrode Vessels containing Mercury; *c c*, Electrodes conveying Current; *d*, Evacuated Quartz Jacket surrounding Arc Tube; *e*, Inlet Water Tube; *f*, Outlet Water Tube.

having two horizontal polar vessels attached to the lower end of each limb. The alternating-current burner is $\mathbf{M}$ -shaped, and has three terminal vessels.

The cavity of the right-hand cathodal limb of the D.C. arc tube is considerably narrowed, and when the arc is first struck the mercury boils at this point.

The arc tube itself is surrounded by a quartz jacket, and this in turn is encased in a watertight metal case fitted in front with a quartz window. Inlet

and outlet openings are situated at the back part of the case.

The quartz window itself may be applied directly to the part to be treated, or special quartz applicators may be interposed.

The lamp is lighted by gently tilting it slightly forwards and then bringing it back to its former vertical

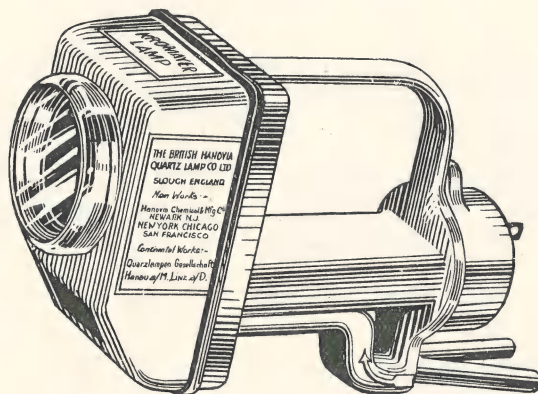


FIG. 100.—Burner Casing of Water-cooled "Kromayer" Lamp.

position: the tilting brings the mercury in the two limbs together, and the backward movement separates it again, causing the arc to be struck. Shortly after ignition "Kromayer" lamps consume three times their normal running current. The water circulating through the chamber in which the lamp is contained must be clear and pure. This lamp provides a source of the shortest wave-lengths procurable from arc lamps, because the water in the cooling chamber condenses the mercury vapour in the quartz tube, so that the ultra-violet rays are not filtered through mercury vapour, as they are in the air-cooled lamp.

This lamp is essentially for local irradiations and is used mostly in the treatment of skin conditions. It is therefore more likely to be useful to specialists than to general practitioners.

Kelvin, Bottomley & Baird, the Hewittic Co., and the Quartz Transparent Co. all manufacture a water-

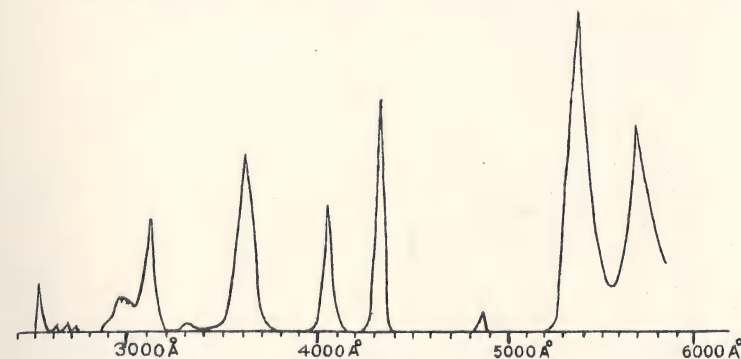


FIG. 101.—The Intensity of the Spectrum of the Quartz Mercury Vapour Lamp. (After Ladenburg.)

cooled mercury vapour lamp very similar to the "Kromayer."

The "Victor" water-cooled burner is a vertical quartz tube with the cathode containing the mercury at the bottom and the tungsten anode at the top.

The shortest wave-length available from the quartz mercury vapour lamp is 1849 Å, owing to the absorption of shorter lengths by the quartz. McLennan and Lang, investigating and photographing spark spectra produced at a potential difference of several hundred volts in a very high vacuum, found that the mercury, iron, and copper spectra extended to 1435, 1427 and 1925, Å respectively.

The spectrum of the mercury arc is dominated by

a broad line at 1849 Å. It is this line that is most powerful in producing abiotic effects. According to Lyman, fused quartz is often sufficiently transparent



FIG. 102.—Water-cooled Type "Uviarc" Quartz Tube. (Victor X-ray Corporation, Chicago.)

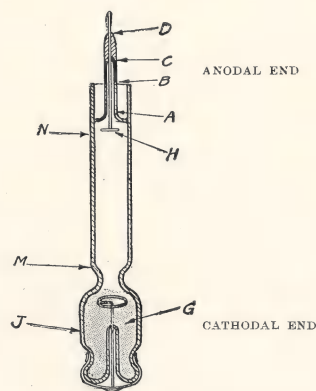


FIG. 103.—The Water-cooled "Uviarc" Quartz Burner.

A, Quartz Stem of Seal Structure; *B*, Connexion of Quartz Stem and Seal Grading; *C*, Connexion of Seal Grading and Seal Coating; *D*, Tip of Seal Coating; *G*, Cathodal Mercury Pool; *H*, Anode Target; *J*, Cathodal Chamber; *M—N*, Luminous Portion.

to transmit this radiation strongly. Other lines present in the spectrum are 5790 Å and 5770 Å in the yellow, a very brilliant green line 5461 Å, and a faint line 4358 Å in the violet. The resulting illumination is

almost entirely due to the green line, and is the nearest approach to monochromatic light that can be obtained.

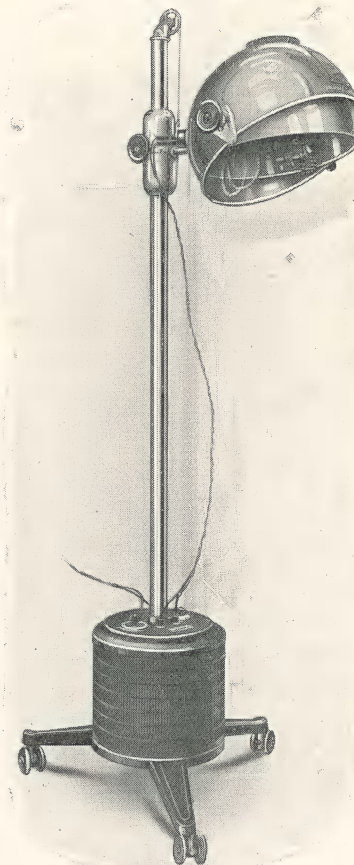


FIG. 104.—"British Hanovia" Air-cooled Quartz Mercury Vapour Lamp—Alternating-Current Model.

The mercury vapour lamp gives off practically no red or yellow rays, so that red objects appear almost

black when they are illuminated by it, and the hands and face assume a deathlike, livid, blue appearance. Attempts have been made to remedy the deficiency of red rays by using amalgams of mercury and cadmium, but the results have not been very successful. "Neon" lamps are sometimes used with mercury vapour lamps.

It has been found that the line $2536.7 \text{ \AA}$ in the mercury vapour lamp is remarkable for its effectiveness in exciting "resonance," and is particularly potent in producing photo-electric action; and it has also been found that it is in this neighbourhood that the greatest therapeutic effect is experienced.

Hallwach gives the following table showing relative energy at different wave-lengths:

<i>Wave-Length</i>	<i>Relative Energy</i>
5780 $\text{\AA}$	116
5460 "	169
4360 "	100
4060 "	61
3650 "	119
3130 "	90
2540 "	38
2170 "	55

It has previously been mentioned that it is essential to provide some means of support for the burner, either a stand or some method of suspension from the wall or ceiling. The stand generally consists of a steel column inserted into a heavy base provided with castors; the resistance is often placed at the top of the base; and a bracket arm attaches the hood to the upright column. The hood is usually counterweighted.

We have designed a special treatment couch,

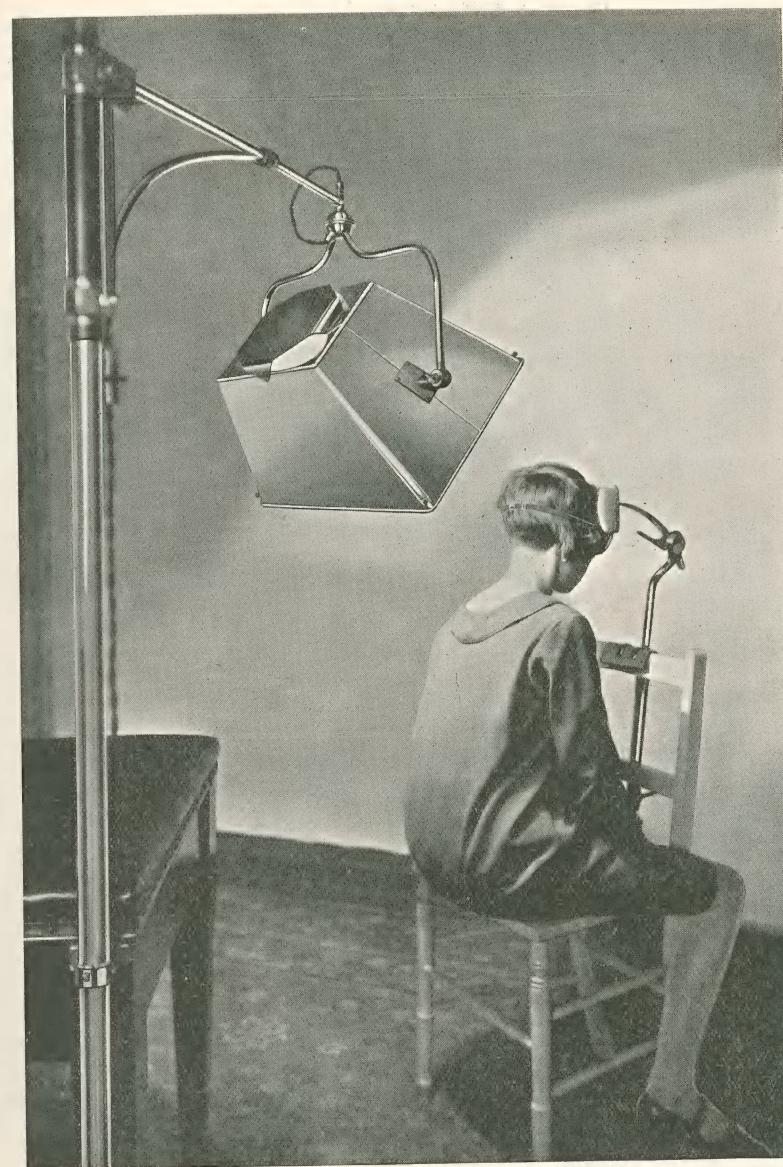


FIG. 105.—One of the Lamps of our Treatment Couch being used for Irradiation of the Scalp. Each lamp is fitted with a Kelvin, Bottomley & Baird "Atmospheric" Burner.

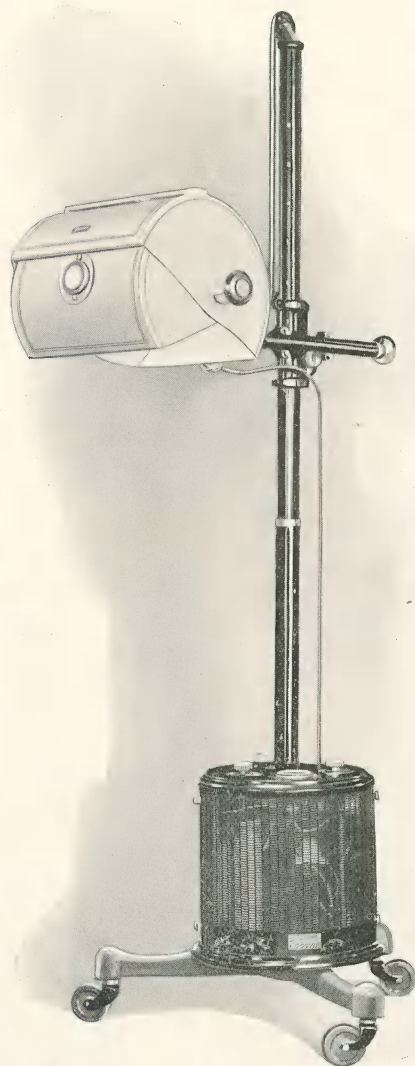


FIG. 106.—The Standard Air-cooled Quartz Lamp.
(The Burdick Corporation, Milton, Wisconsin.)

consisting of a couch with two resistances mounted underneath it and with two lamp brackets fixed to it. The two lamp housings, which are adjustable in every direction, are supported by the brackets and are counterweighted. For general treatment the range of movement is from three feet away from the patient as a maximum, down to any required smaller distance. As shown in the illustration (Fig. 105), either lamp can be used for local treatment.

The design obviates the need of an independent stand for each of the two lamps without any loss of stability. This is an advantage, because the stands and their bases are generally rather cumbersome, which makes cleaning operations difficult. Very uniform distribution of the radiation can be obtained with this model. If the couch is needed for other purposes the lamps can be readily swung out of the way.

The reflecting hoods are of various shapes—hemispherical, cylindrical, parabolic, or rectangular—and are generally made of aluminium, which is, however, not a good reflector of ultra-violet rays; but this is not of great consequence, since it is the direct rays that are most important. It is impossible to get quite uniform distribution of radiation, the area nearest the arc tube always receiving the greatest amount.

It has been explained already that it is necessary to have some means of lighting the lamp; this, as has been indicated, is generally done by tilting, but there are several automatic burners, such as the "Atmospheric," the "Henri George D.C." burner, and the two

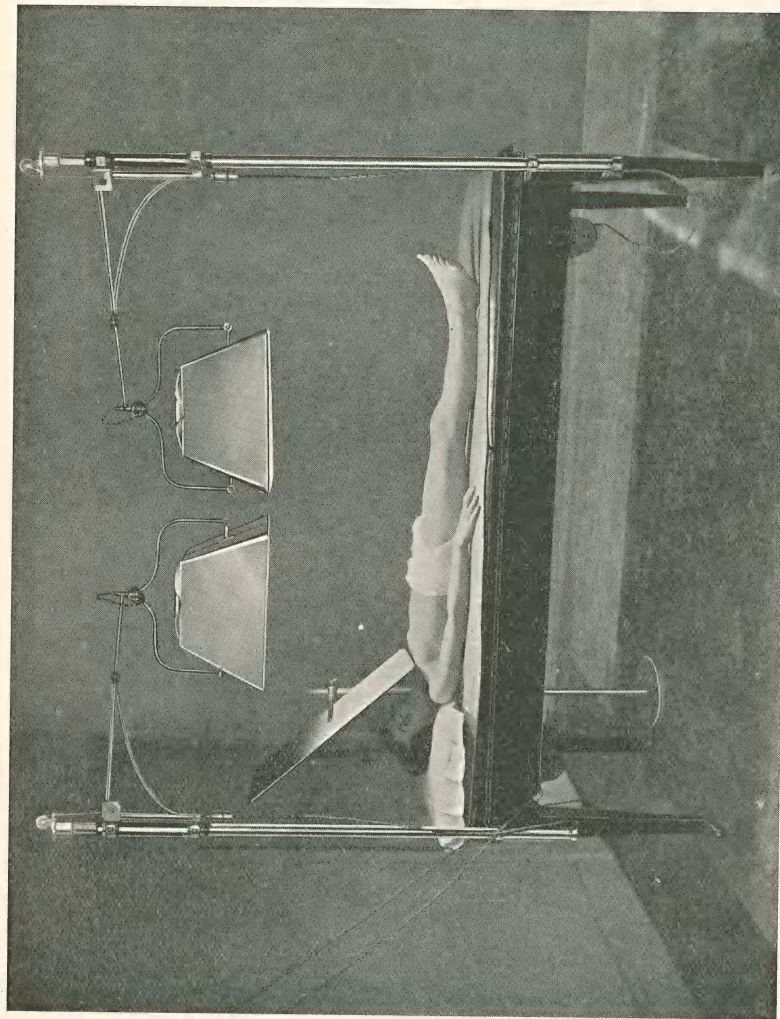


FIG. 107.—Our Treatment Couch, with two Lamps supported by Adjustable Bracket Arms. This method ensures almost uniform distribution of the Rays. The Lamps, which have a wide range of movement, can of course be used singly or together. The Burners, which are of the Kelvin, Bottomley & Baird "Atmospheric" type, can be placed at any distance between 3 feet and 6 inches from the Patient. The Lamp Resistances are mounted under the Couch, and help to keep it warm. The Screen is being used instead of Spectacles.

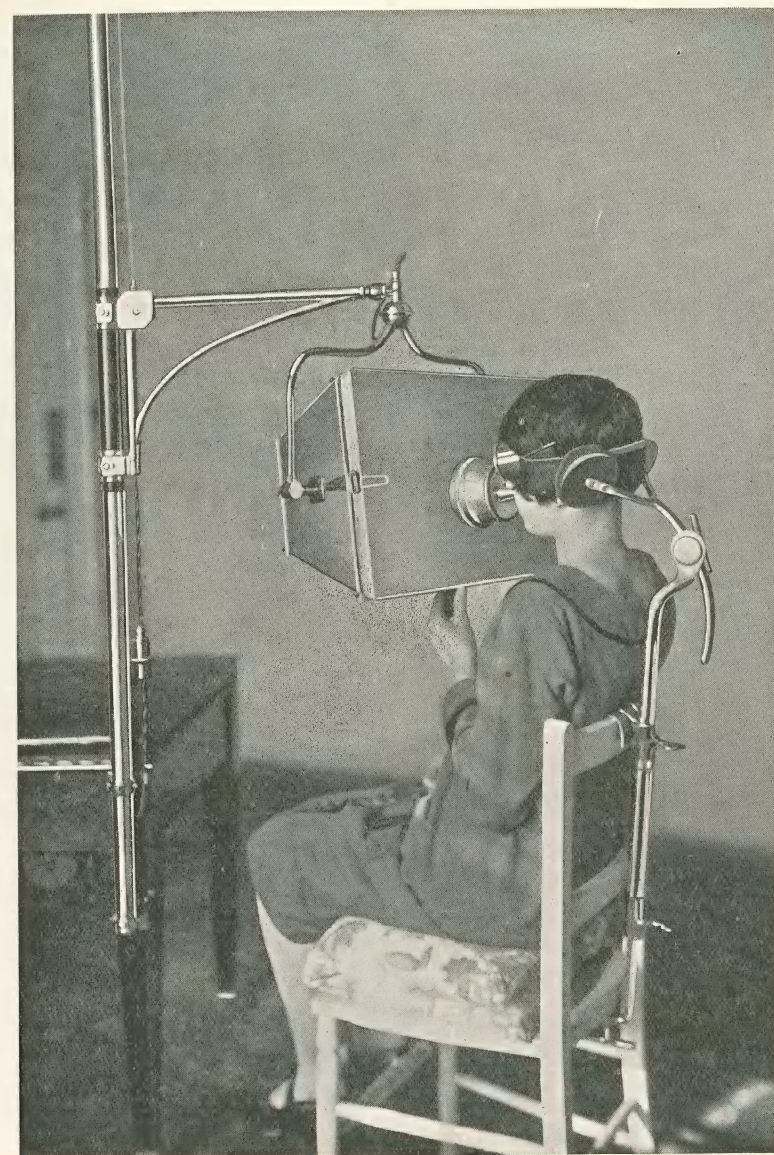


FIG. 108.—The same Lamp as illustrated in Fig. 105 being used for Irradiation of the Nose in a case of Hay Fever. The Bracket Arm has been shortened, and the Shield and Nasal Applicators are attached to the Housing. A Special Head-Rest, which can rapidly be detached from the chair, is in use.

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high-frequency current burners; and one type of "Hewittic" lamp has magnetic tilting. Usually the

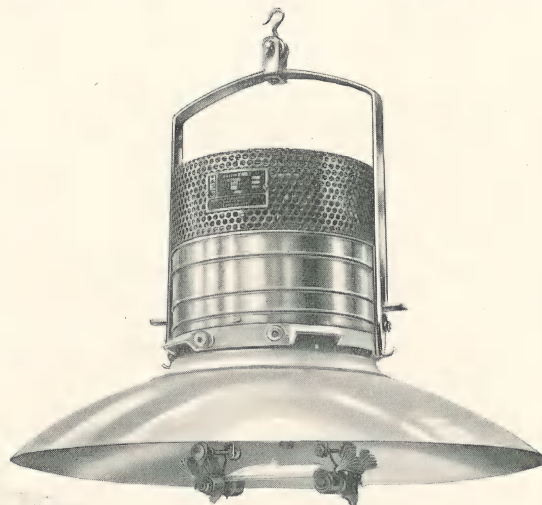


FIG. 109.—Suspension Type of "Hewittic" Air-cooled Quartz Mercury Vapour Lamp, fitted with Automatic Tilting Device.

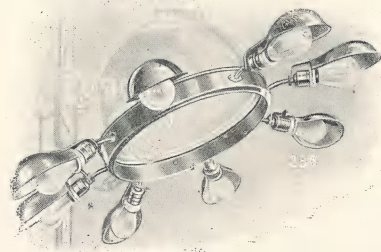


FIG. 110.—The "Hagemann" Lamp Ring, consisting of 8 Carbon Filament Lamps which can be attached to any of the "British Hanovia" Air-cooled Lamps.

burner is tilted by a special lever, but in some patterns the whole hood tilts. It is generally the anode that

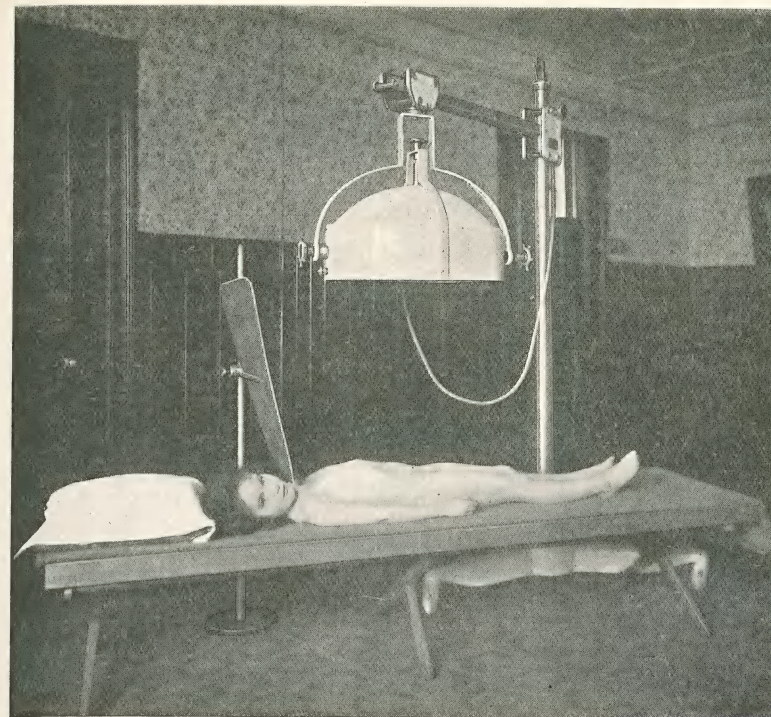


FIG. 111.—The Hewittic "Ulvic" Air-cooled Mercury Vapour Lamp in use. This Lamp is fitted with an Adjustable Parabolic Reflector.

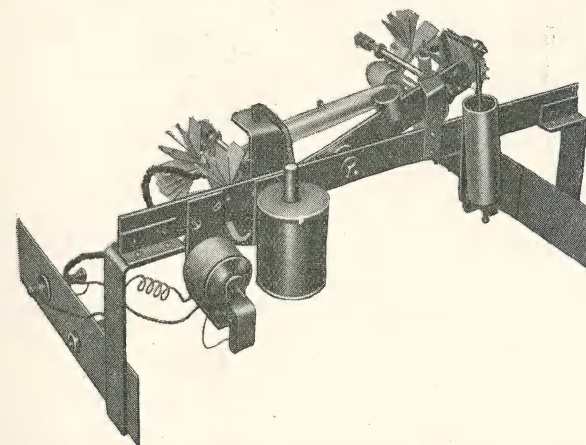


FIG. 112.—"Ajax" Electrically-controlled Tilting Apparatus for Automatic Lighting of Quartz Mercury Vapour Lamps.

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is raised to obtain metallic connexion between the two poles. The anode is generally on the left-hand

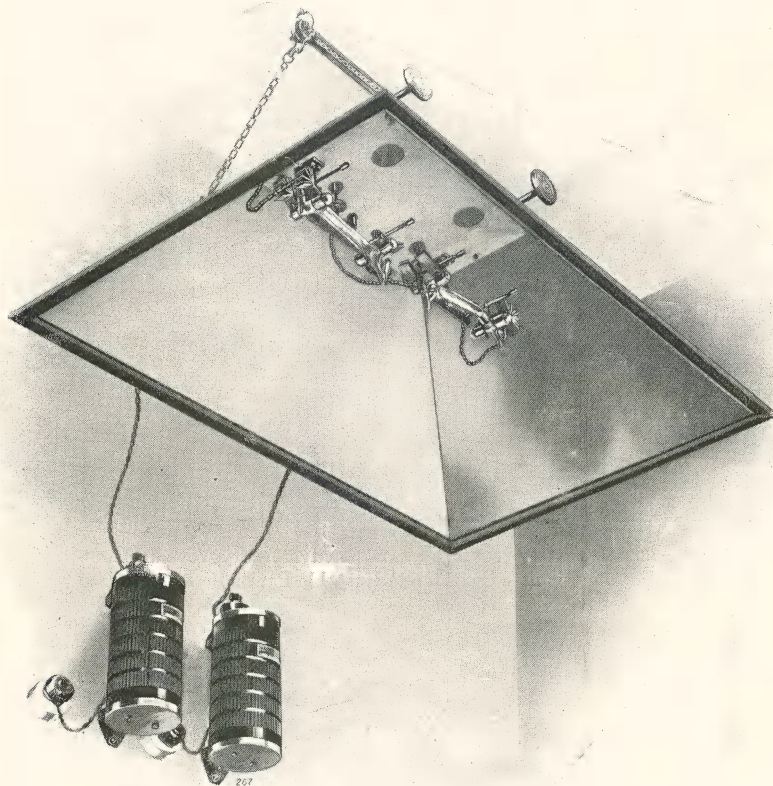


FIG. 113.—Suspension Type of "Jesionek" Lamp fitted with Two Burners.
(British Hanovia Co.)

side of the lamp, and the cathode can usually be identified by means of the "cone."

The "Jesionek" stand type of lamp is ordinarily used for collective treatment, the maximum radiation

being horizontal. Recently a suspension model fitted with two burners has been designed, in this case the maximum radiation is projected vertically downwards. The "K.B.B." type "E" lamp is provided with four quartz radiant heaters.

The "Hewittic-Levick" lamp has an adjustable parabolic reflector.

CHAPTER VI

THE PRODUCTION OF DIRECT CURRENT FROM AN ALTERNATING-CURRENT SUPPLY

Electric Generating Plants—Motor Generators—Motor Converters and Rotary Converters—Mercury Arc Rectifiers—Thermionic Valve Rectification—Electrolytic Rectifiers.

FOR many years the common practice in electric supply was to deliver the energy in the form of direct current, and this had the great advantage, from the point of view of the actinotherapist, that direct current is the type most suited for operating many of the devices that produce ultra-violet radiation. It is true, as has been shown, that mercury vapour burners have been designed for working on an alternating-current supply, and that it is possible to use alternating current in some types of arc lamps; but there is no doubt that, in the present state of the art, direct current is much more suitable than alternating current for most, if not all, of the apparatus. From this rather narrow standpoint, therefore, it appears to be a disadvantage that the general tendency of electric supply undertakings is to change over from direct current, where they used it previously, to alternating current as the standard type of supply. It is, consequently, becoming more and more difficult to obtain a public supply of direct current; and since, for the reasons stated, direct current is requisite, it is appropriate to

say something, at least in outline, about how it may be obtained by some method of transformation from an alternating-current supply, or otherwise. There is no need here to go into the details of the reasons that have led to the adoption of alternating current for the public supply of electricity; it is enough to say that it has many technical advantages over direct current, both in its generation and in its transmission. The tendency already begun will be accentuated by the national scheme of supply from the "grid," which will carry the possibility of an alternating-current supply to every likely part of the country within the next few years.

The following brief summary will indicate some of the ways in which direct current may be obtained. It is possible that a public supply of it may be available in isolated cases; but even then it will be well to inquire whether it is likely to be changed over to alternating current in the not very remote future. If the answer is yes, it will obviously be necessary to make provision for the housing and operation of transforming apparatus when it becomes essential at the time of the change-over; for otherwise the design of an equipment may have to be considerably altered, and it will probably be cheaper to provide for the addition in anticipation than to have to find space for it later, possibly by curtailing the space already devoted to therapeutic apparatus.

Electrical Generating Plants.—In some cases there may not be even an alternating-current supply available; or the available supply may be very costly. In the first alternative it is necessary, and in

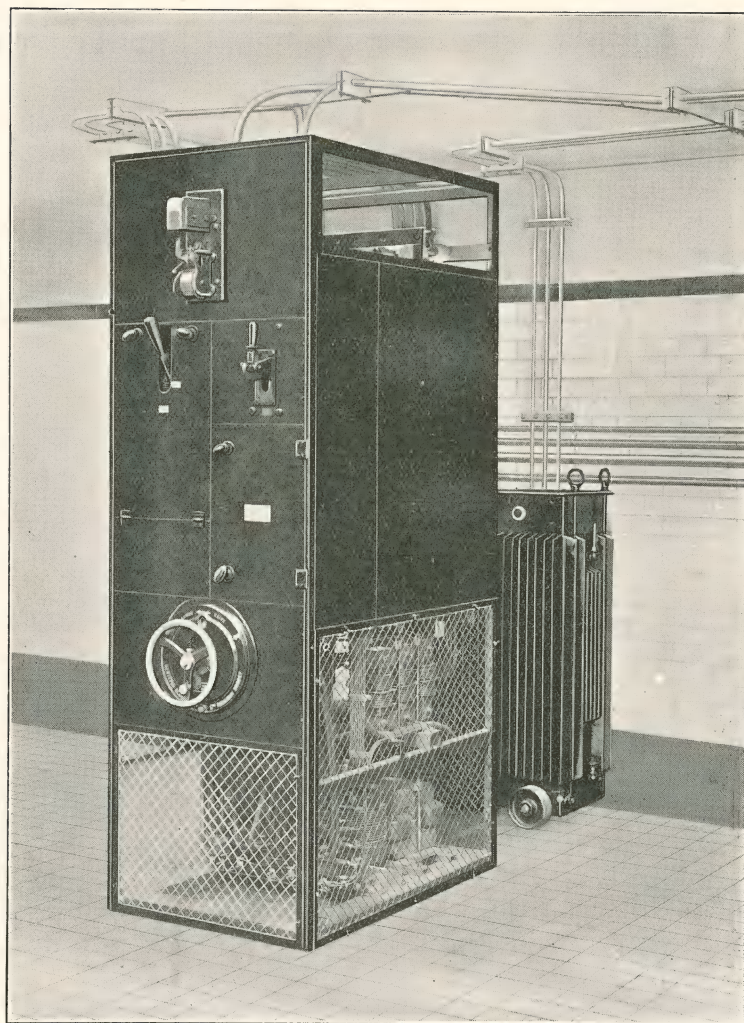


FIG. 114.—50 kw. "Hewittic" Rectifier Equipment.

the second it may be advisable, to consider the installation of an independent generating plant, consisting, say, of a direct-current dynamo driven by a steam or gas or oil or water engine of some suitable type. The obvious disadvantage of this is that a good deal

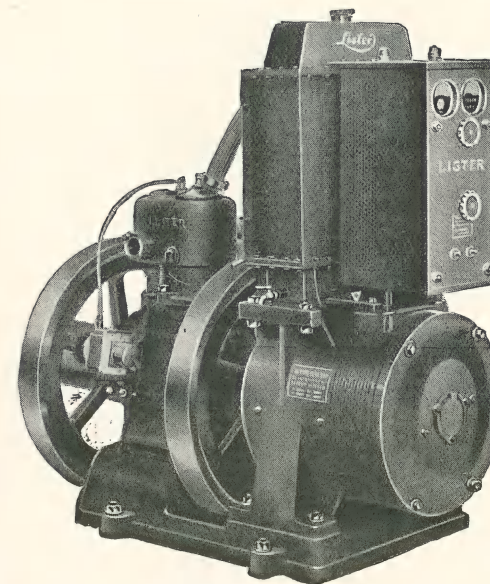


FIG. 115.—The "Lister" 1.5 kw. Generating Plant.

of really skilled attention is necessary to keep the engine in first-class condition. The disadvantage is not, however, insuperable: the private practitioner, with a comparatively small equipment, could probably use one of the many automatic or semi-automatic generating sets now on the market; and a large public institution would be more than likely in any event to have at hand, for other purposes, skilled attendants who could give the necessary care to the

generating equipment. The capital cost of a set of this kind may be comparatively large, but its maintenance and running costs are usually low, and thus the total cost of current is not excessive.

Motor Generators.—The much more usual condition

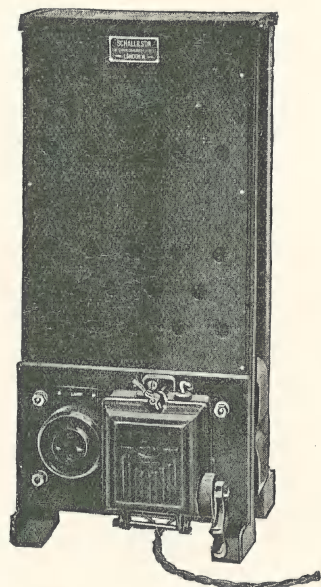


FIG. 116.—Transformer for economizing Current.

of things is that an alternating-current supply is available, and it becomes then merely a matter of choosing which of the several possible types of transforming apparatus will suit the working conditions best. Perhaps the simplest of all is the motor generator, which consists of two electrical machines coupled together and mounted on a common bed-plate. One of the machines is an alternating-current motor, and

the other, driven by the first, is a direct-current generator. In other words, the motor acts as an electric engine, taking the place of the steam or gas or other mechanical engine already referred to as part of an independent generating set. The motor generator is easily started up from the always available public supply, and the advantages it has over other types of rotating transformers are (1) that the supply can be applied direct to the motor through a starting device of some kind, and (2) that the voltage of the generator can be independently regulated through a large range, if necessary, to suit various kinds of ultra-violet-radiation apparatus. A comparatively small set will do all that the individual practitioner requires; and if standard machines can be used for larger sets, the cost will not be excessive for an equipment suitable for a large institution. It must be remembered that considerable currents are required when arc lamps are in use, and when large numbers of patients are being treated simultaneously it will be easy to run up to a demand for powers possibly of the order of fifty to one hundred horsepower.

Motor Converters and Rotary Converters.—Other types of rotating machinery for changing alternating current into direct current are motor converters and rotary converters. A motor converter consists, like the motor generator, of two separate machines, but some of the power is transformed electrically instead of altogether mechanically, and the losses associated with the transformation (which, of course, have to be paid for) are smaller. The rotary converter is a single

machine, the revolving part of which takes in alternating current at one end and delivers direct current from the other end. This seems, and actually is, very simple; but in practically every case the voltage of the alternating current is not of the correct numerical

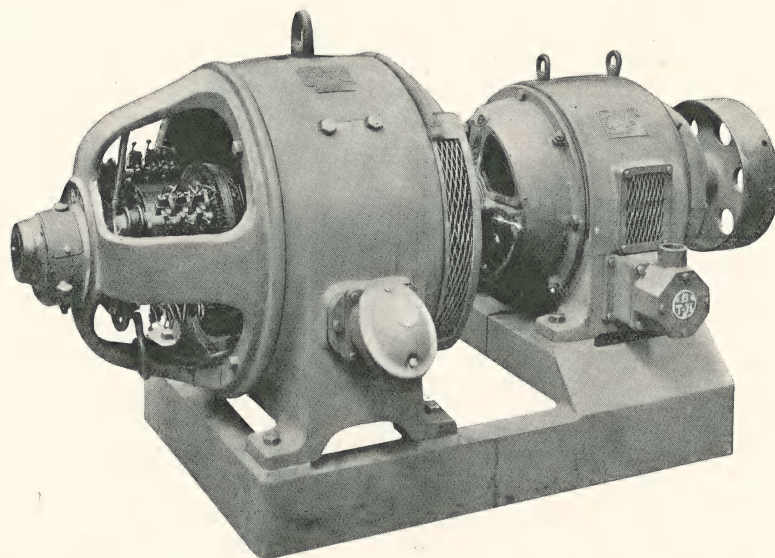


FIG. 117.—Motor Converter installed at the "Sun-Ray" Clinic, Newcastle-on-Tyne.

value to give the voltage at the direct-current end requisite for the ultra-violet-radiation apparatus, and, consequently, a preliminary piece of alternating-current-transforming apparatus is necessary to modify the supply suitably. This adds to the cost, and when it is also remembered that the voltage at the direct-current end of a rotary converter is fairly definitely bound up with the voltage at the alternating-current end, and that its regulation through even a compara-

tively small range is obtained only by the use of additional apparatus of not negligible cost, it will be seen that the rotary converter, though in many respects a very convenient type of transformer, is not so completely superior to the motor generator as might at first sight appear. Motor converters and rotary converters are usually made in standard sizes for outputs of several hundred horse-power, and for that reason also they are rather out of court for the much smaller powers required for actinotherapy; but it will, nevertheless, be useful to bear them in mind when inquiries are being made as a preliminary to the purchase of transforming machinery and apparatus. A rotary converter transforms all the energy it deals with electrically, and not partly mechanically and partly electrically as the motor converter does; and its efficiency—that is, the ratio of its output to its input—is very high, higher than that of any of the other types of rotating transformers. Its losses being low, its running cost tends to be low also.

The great drawback to all rotating machinery is that because it rotates it has parts that tend to wear out, and bearings that need fairly constant attention to their lubrication if they are to run well. Clearly, then, a stationary transformer is desirable; but, although such transformers for changing alternating current at one voltage into alternating current at another voltage are quite common and highly developed and efficient pieces of apparatus, there are unfortunately, no correspondingly adequate stationary transformers of alternating current into direct current. It is much too early to say that there never will

be transformers of this type; for indeed there are several kinds on the market already, and some of

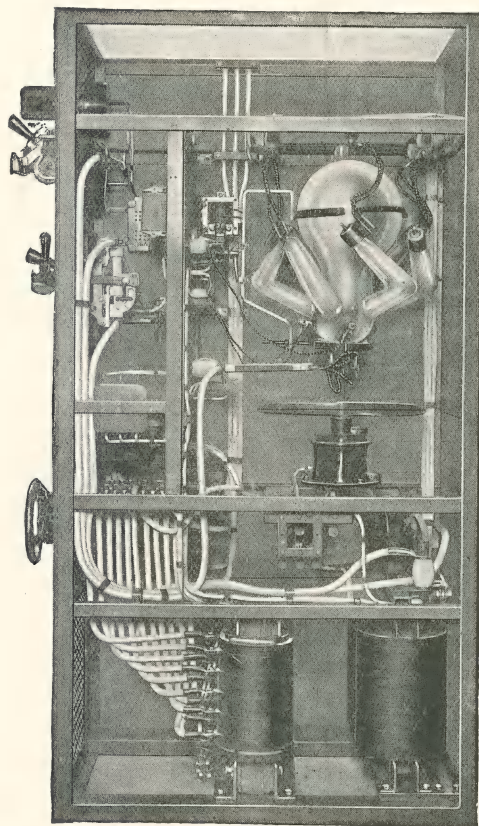


FIG. 118.—Side View of "Hewittie" Rectifier Cubicle.

them have very useful and interesting characteristics. An alternating current, as is well known, consists of waves of current flowing first in one direction and then in another; a direct current flows always in the same direction, and the principle on which the station-

ary alternating to direct current transformers work is that they allow current to pass through them in one direction only. Thus the backward half of the alternating-current wave is cut off and prevented from passing into the direct-current part of the circuit; and if, at the same time, the connections can be so

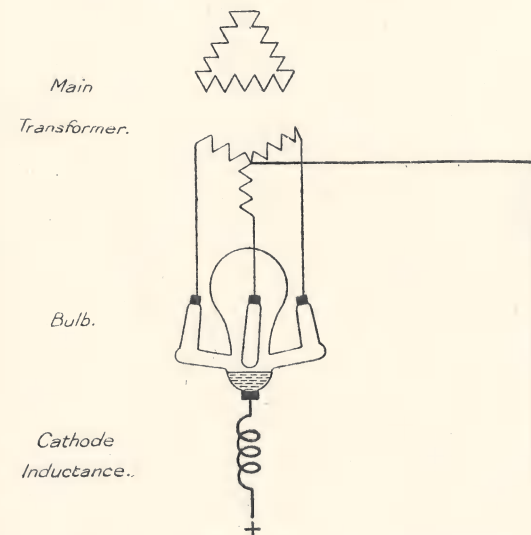
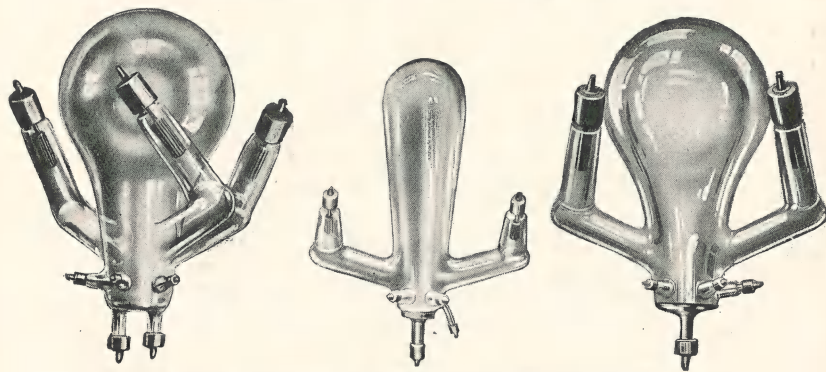


FIG. 119.—Main Connections of a Three-Phase Rectifier Equipment.

arranged that the backward half of the alternating-current wave is, as it were, turned upside down and then allowed to pass into the direct-current part of the circuit, both halves of the alternating-current wave become available in the same direction, and the current flowing through the ultra-violet-radiation apparatus, though not constant, but pulsating, in magnitude, is always in the same direction, and thus never reverses its polarity. That is the essential

point. Apparatus for transforming in this way is called rectifying apparatus, because it corrects the unsuitable direction of one half of the alternating current.

Mercury Arc Rectifiers.—Probably the best-known apparatus of this type is the mercury arc rectifier. It consists of a container, exhausted of air and other gases, with a quantity of mercury in it, so that the



FIGS. 120, 121, and 122.—Typical Rectifier Bulbs.

space not filled with liquid mercury is saturated with mercury vapour. The alternating current passes in the form of an arc between terminals mounted in and projecting into the container on the one hand, and the mercury on the other, and is led away from the mercury by means of suitable connections through the container. The mercury arc is the rectifier, because it has the characteristic that it allows current to flow in one direction and not in the other. The use of two terminals at the entry side enables both halves of the alternating-current wave to be used, in the manner already outlined. The smaller sizes of mercury

arc rectifiers have glass containers, and the larger have steel containers; on the whole, at their present stage of development, their cost, together with that of the other apparatus necessary for their successful working, is rather high; and the data available in respect of their maintenance and running costs when they are used for actinotherapeutic purposes are too meagre as yet to be very instructive or conclusive. The apparatus may, however, be precisely of the right kind to suit some particular circumstances, and should therefore be borne in mind as a quite possible type.

Thermionic Valve Rectification.—Other apparatus in use on a small scale, and possibly on the eve of developments on a larger scale, is of the same type as the thermionic valves used in wireless work. A heated filament mounted at one end of a vacuum tube, with a plate called an anode at the other end of the tube, sends out a stream of negative electricity, or electrons; and if the anode is positive and the filament negative the electrons pass over to the anode as an actual electric current. If, however, the reverse polarity obtains, the electrons are repelled from the anode, and prevented from leaving the heated filament, and the current is quenched. So, if the vacuum tube is connected in the alternating-current circuit, the half-wave consisting of current from the filament to the anode is allowed to pass, and the other half-wave is not; and thus current impulses all in one direction come through the apparatus. The development of valves of this type is very interesting from the point of view now under consideration; but the

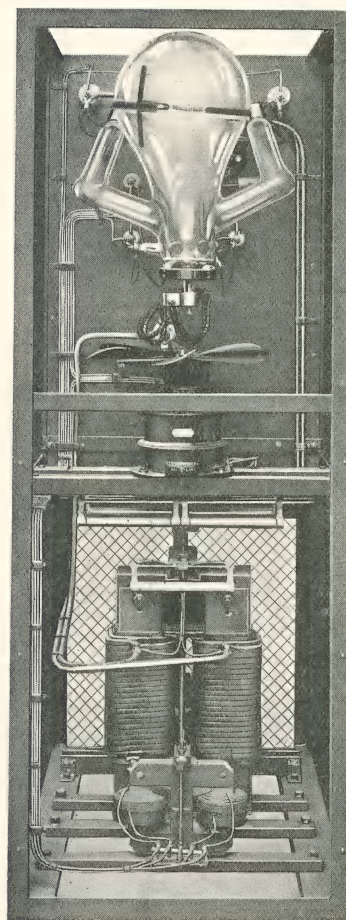


FIG. 123 —Rear View (with back plates off) of Typical "Hewitt" Rectifier Cubicle.

whole matter is too new to allow anything very definite to be said about it.

Electrolytic Rectifiers.—Another type is the electrolytic rectifier, the principle of which depends on the fact that, when some combinations of metals are immersed in appropriate chemical solutions, the apparatus acts like a non-return valve, and allows current to pass through it in one direction only, because a high-resistance chemical film forms on one of

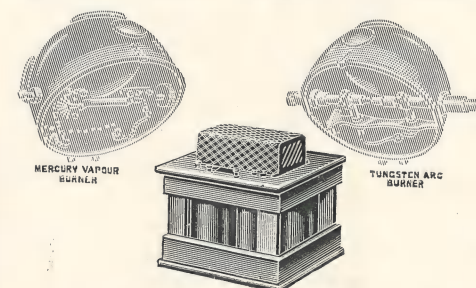


FIG. 124.—The Electrolytic Arc Lamp Rectifier. (M.S.A.)

the metal plates, with the curious property that it is effective only when the current tries to pass in one definite direction and not in the other direction. This is the basis of several recent types of comparatively small rectifiers, and they are mentioned here, not because they are of any great practical interest at present, but rather because some early development may make this account incomplete without at any rate a passing reference to them.

In brief summary, then, it may be said that the most usual alternating-to-direct-current transformer at present is of one of the rotating types, but that the stationary types, though not greatly used at present

in actinotherapy, should not be refused consideration in comparison with the commoner types.

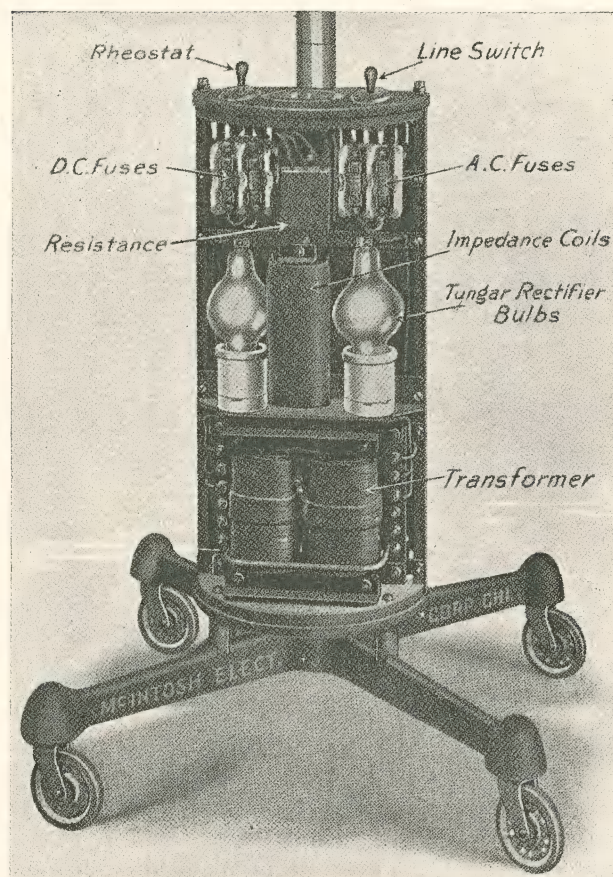


FIG. 125.—The "McIntosh" Tungar Rectifier, which is mounted at the base of the Lamp.

It is perhaps well to add that in some special cases a secondary battery may be a useful adjunct to the

generating or transforming or rectifying plant, any type of which may be used to charge a battery. It is certainly not often that the need for considerable outlay on a battery will be required; but if emergency cases are to be treated, or if skilled attention to running

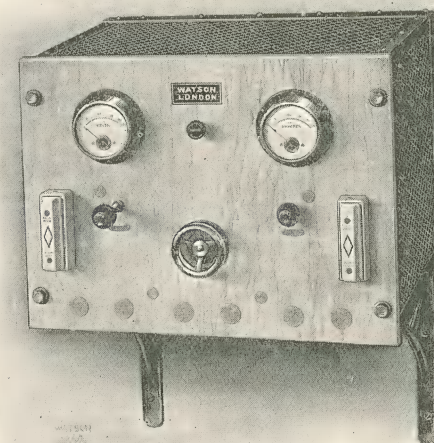


FIG. 126.—"Safety First" Switchboard.

machinery is available at very restricted times only, it might be worth its cost.

The requirements of an installation in switch-gear are variable, and depend so much on the particular circumstances prevailing in each case, that no general rules can be laid down. But, obviously, when transforming plant is used, just as when it is not, some main control for cutting off the supply of current will be

required, with, in addition, sectional control for power and lighting, subdivided as may be most convenient. There should, of course, be means for switching on and off each individual piece of actinotherapeutic

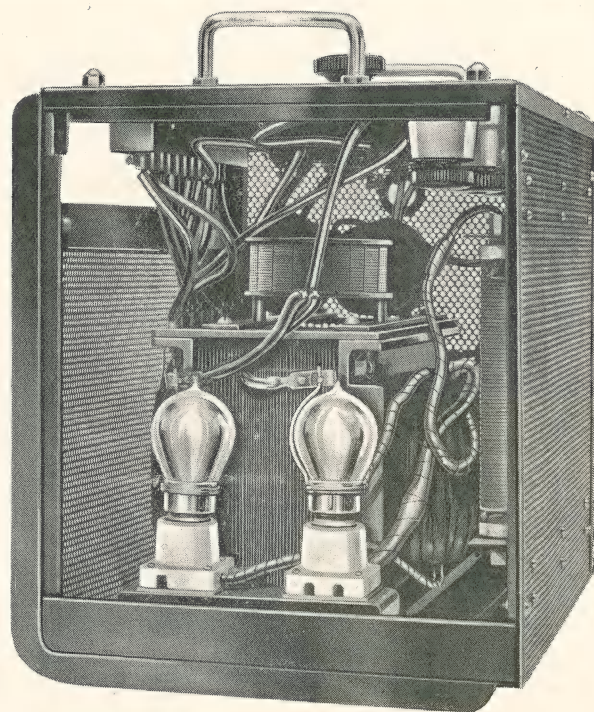


FIG. 127.—“B.T.H.” Tungar Rectifier. For use with Quartz Mercury Vapour Arc. Universal voltage, 50 cycles; D.C. output, 120-150 volts, 4 amperes.

apparatus, conveniently placed near the position of the person using the apparatus; and one important thing is to see that all metal cases and frameworks are connected to earth through a special earth connection, so that they may be at a safe potential, and

no shock may come from touching them. Should any fault occur in the way of leakage from a live part to the case or frame of the apparatus, the appropriate fuse will blow and danger will be avoided. It is to be noted in this connection that if the installation is a large one, with the possibility of considerable leakage current in the event of a fault, a water pipe is not necessarily a good thing to use as an earth connection, because the leakage current could conceivably melt it, with disastrous results in the way of flooding. In such circumstances a special earthing circuit connected to a specially buried earthing plate is advisable.

Measuring instruments are useful to show the amount of current passing in individual pieces of apparatus, and, since much of the apparatus depends for its working on the application of correct polarity to it, it is essential that a polarized voltmeter should be available on the terminals of the general direct-current supply, from whatever source it is obtained, so that it may always be seen at a glance that the polarity is correct. Some types of transforming apparatus are not definite in their polarity, and special care must then be taken to see that the excitation is in the right direction. Finally, it is to be urged that in so specialized and technical a matter as the selection of transforming apparatus, with its accessory switch-gear and other appliances, the detailed advice of manufacturers and of first-class electrical contractors should be sought. The subject has been treated here merely in outline, and only for the purpose of giving a general idea of some of the problems associated with it.

CHAPTER VII

CHEMICAL PROPERTIES OF ULTRA-VIOLET RADIATION

Reactions of Degradation—Reactions of Synthesis—Chemical Methods of Testing the Intensity of Ultra-Violet Radiation—Grotthus's Law—Photosensitization and Inhibition—Photochemistry in Nature—Technical Applications

THE existence of invisible radiation, beyond the limit of the visible spectrum, having the power of converting silver chloride into metallic silver, was noticed by Scheele as long ago as 1777.

These rays came to be termed "actinic" or "chemical" rays, because they were supposed to be necessary before chemical reactions could take place. This has been proved to be erroneous, however, and it is now known that chemical changes can take place in the presence of all rays of the spectrum, but some so-called photochemical reactions have velocities inversely proportionate to the wave-length of the rays present.

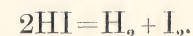
Baly has said that, in general, no substance can take part in a chemical reaction or undergo chemical change unless previously a certain amount of energy has been supplied to it. One of the most familiar methods of giving this necessary quantity of energy is by heating the substance; photochemical processes occur only when the energy is supplied in the form of visible or ultra-violet rays.

Photochemical reactions may be divided broadly

CHEMICAL PROPERTIES

into reactions of degradation—where the original product is broken down—and synthetic reactions—where two or more substances unite to produce a more complex product. Reactions of double decomposition may conveniently be included in the last-named group.

Reactions of Degradation.—The splitting up of hydroiodic acid into its two elements may be taken as a typical example of the degrading effect of light:



Because of this, hydroiodic acid is always stored in the dark, or in dark-coloured bottles. If it is kept exposed to light the colourless liquid soon turns to a dark brown hue, owing to the liberation of iodine.

Many other chemical compounds are decomposed by light, even water, but in this case the action is a slow one. Hydrogen peroxide is decomposed much more readily.

Photochemical decomposition of many substances takes place in aqueous solution or in solution in organic solvents.

Rays of wave-length 3330 Å or shorter have been shown by Anderson to convert an aqueous solution of potassium nitrate into nitrite with the liberation of oxygen.

Marmier irradiated sodium sulphate and identified sodium hydrosulphite and sulphur in the degradation products.

Jacquier has found that sunlight or the radiation from a mercury vapour lamp will precipitate metals from solutions of their salts when aluminium plates are suspended in the solutions.

If plates of silver, copper, tin, or lead, are suspended in water and exposed to ultra-violet radiation, colloidal solutions are formed. A large number of organic compounds are decomposed by radiation. Acetone is broken up into carbon monoxide, ethane, and methane.

In the presence of light, chloroform is converted into carbonyl chloride (phosgene) and hydrochloric acid; because of this, chloroform used for anæsthetic purposes should always be kept in the dark, and, as far as possible, the bottle should be full.

Many workers have investigated the effect of light on aqueous solutions of sucrose and other sugars. Sucrose is first converted into glucose and fructose, which are in turn decomposed into aldehydes, ketones, and alcohols, and, finally, after prolonged irradiation, into carbon dioxide, carbon monoxide, and hydrogen.

Euler and Euler and Ryd have shown that under the influence of ultra-violet rays aqueous solutions of lactic acid are decomposed into alcohol and carbon dioxide.

Baudisch states that solid calcium lactate is degraded into carbon monoxide, ethane, methane, and hydrogen.

The fact that exposure to ultra-violet radiation accelerates the spontaneous decomposition of many commercial explosives has been utilized by Berthelot and Gaudechon as a basis for stability tests.

Reactions of Synthesis.—The formation of hydrochloric acid by the photochemical combination of hydrogen and chlorine is a typical example of a synthetic reaction; an equimolecular mixture of dry chlorine and hydrogen may be kept in a sealed tube in darkness for several weeks without appreciable

combination taking place. On exposure to diffuse daylight complete conversion takes place in a few hours, whilst direct sunlight causes the reaction to take place with explosive violence. The light given out by burning magnesium (photographic "flash powder") also causes explosive combination, because this light is very rich in actinic or short-wave rays. A similar effect is produced by a mercury vapour lamp.

Oxygen is partly converted into ozone (O_3) under the influence of ultra-violet radiation. It has been suggested that ozone is produced in the upper regions of the atmosphere by the action of the sun's rays on the oxygen of the air, and that rain and wind bring this ozone to the earth's surface.

Many organic compounds undergo polymerization when subjected to actinic radiation, two or more molecules uniting to form a larger molecule of the same empirical composition, but having greatly modified chemical and physical properties.

An interesting application of the production of polymers by ultra-violet light is described by Klatte and Tollet, who submitted vinyl chloresters to the action of heat and ultra-violet rays. A solid substance resembling celluloid was obtained from vinyl chloracetate, and a solution which could be used as a lacquer was formed when this was dissolved in a suitable solvent.

According to Plotnikow, vinyl chloride polymerizes under ultra-violet rays of very short wave-length, a substance resembling rubber being formed.

Halogenation, or the introduction of halogens into organic chain compounds, is probably the most

valuable technical application of ultra-violet rays to induce or assist chemical reaction. Methane may be chlorinated to give successively methyl chloride (CH_3Cl), methylene chloride (CH_2Cl_2), chloroform (CHCl_3), and, finally, carbon tetrachloride (CCl_4). Radiation has been extensively used for this reaction on a commercial scale in the halogenation of natural gases and liquid hydrocarbons.

Chemical Methods of Testing the Intensity of Ultra-Violet Radiation.—This phenomenon of photochemical reaction suggested chemical means by which the intensity of ultra-violet radiations might be determined. The intensity of the radiation may be measured by weighing the quantity of metallic silver produced in a given time from a given amount of silver chloride after a certain length of irradiation. This method may be modified into measuring the amount of blackening of standard photographic paper in a given time.

In Bunsen and Roscoe's actinometer the intensity of ultra-violet radiation is measured by the quantity of hydrochloric acid formed in a given time when the rays are allowed to act on a mixture of hydrogen and chlorine.

King has elaborated a method of estimating the intensity of radiation below $2650 \text{ \AA}$ by means of carbon tetrachloride, which liberates free chlorine during irradiation. The addition of a potassium iodide solution replaces the chlorine in solution by iodine, which colours the carbon tetrachloride a reddish violet, and the amount of radiation can be estimated from the depth of the coloration.

Moss and Knapp have devised a method which they

call the "uroxameter" test, in which they employ aqueous solutions of oxalic acid and uranium acetate and then ascertain the amount of undecomposed oxalic acid by titration with a potassium permanganate solution.

Recent research by these two workers has confirmed the fact that the ultra-violet output of quartz mercury

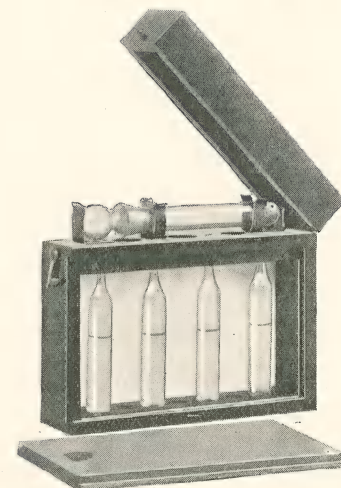


FIG. 128.—The "K.B.B." Uviometer.

vapour lamps decreases considerably with continued use. Three lamps were tested, but divergent results were obtained, showing the necessity of controlling photochemical work by actinometric tests.

Janet Clark uses the darkening of lithopone paint as a means of estimating the intensity of ultra-violet radiation, lithopone being insensitive to rays above $3200 \text{ \AA}$ and uniformly affected by rays between $3000 \text{ \AA}$ and $2300 \text{ \AA}$.

Grotthus's Law.—More than a hundred years ago

Grotthus propounded the photochemical absorption law, in which he stated that only the rays absorbed are effective in producing chemical change. The law of Ritter, Herschel, and Becquerel, states that rays of long wave-length exert an oxidizing action as opposed to the reducing action of rays of short wave-length. Rays of wave-lengths shorter than 3022 Å decompose diastase in solution.

We have repeated Schanz's experiment and exposed a dilute solution of egg albumin in a quartz tube for an hour at a distance of 5 cm. from a lamp, and have been able to demonstrate that the albumin reacted like globulin with ammonium sulphate, showing that proteins are rendered less soluble when exposed to ultra-violet radiation under suitable conditions. These rays also partially change chlorophyll dissolved in aqueous alcohol into urobilogen.

Amylase and invertase, the enzymes of malt and yeast, are destroyed by ultra-violet rays, the former more readily than the latter. The rays also destroy the toxicity of strophanthus compounds, and quickly render harmless the venom of the cobra, but have much less effect on antivenomous serum.

The antitryptic effect of human blood is nullified by ultra-violet radiations.

Photosensitization and Inhibition.—Certain bodies may act as sensitizers in a large number of photochemical reactions, promoting reaction or increasing its velocity. Other substances act as inhibitors or decelerators.

The ordinary photographic plate is much more sensitive to light of short wave-length than to light

at the red end of the spectrum. This causes a bright red object to appear much darker in a photograph than a dark blue object, and gives a false impression of the respective colours. Colour-sensitive plates, which are equally susceptible to both the red and the blue ends of the spectrum, are made by the addition of certain compounds.

Vogel observed, as long ago as 1873, that photographic plates could be made sensitive to other colours besides blue and violet by the incorporation of certain colouring matters, and Waterhouse, in 1875, showed that eosin rendered a plate sensitive to yellow and green.

In 1856 Greville Williams prepared the blue colouring matter cyanine, and in 1875 Vogel discovered that this compound acted as a photographic sensitizer for the red.

In 1903 Miethe first used the isocyanine colouring matters as sensitizers and obtained much better results than with cyanines, which are inclined to give irregular results.

Pope and his contemporaries have introduced many new photographic sensitizers within recent years, and plates can now be obtained which are sensitive to the whole range of the solar spectrum.

In some photochemical reactions the presence of water or water vapour acts as a sensitizer, but in other cases it partly or entirely inhibits the reaction.

The halogens, mercury and zinc oxide, often act as sensitizers.

It has been found that hydrogen and oxygen alone do not react at ordinary temperatures in the presence

of ultra-violet rays, but the addition of mercury causes immediate combination.

The photochemical decomposition of carbon dioxide is inhibited by the presence of even a trace of water vapour, and water is essential for the combination of hydrogen and chlorine under the influence of visible light. The decomposition of potassium nitrate in aqueous solution is auto-inhibited by the nitrite liberated in the reaction.

Much work has been done recently on the effect of mercury vapour on photochemical decomposition. Taylor and Bates have carried out many experiments on the decomposition of such substances as water, ammonia, methane, alcohols, and organic acids, in the presence of mercury vapour, and have shown the enormous effectiveness of the excited mercury atom in disrupting the linkages C·H., N·H. and O·H.

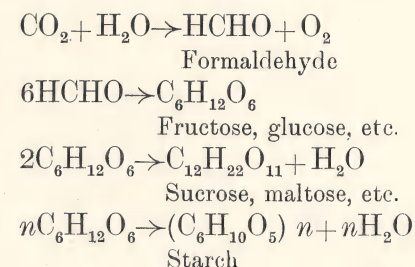
Photochemistry in Nature.—Photochemical reactions play an important part in plant metabolism. The living plant inhales carbon dioxide from the air, and under the influence of sunlight this reacts with water to form formaldehyde, which is subsequently polymerized to carbohydrates. This theory was first postulated by Bayer, in 1870. The chlorophyll of the leaf and inorganic bodies derived from the soil probably act as photocatalysts.

Baly and his co-workers have repeated the photosynthesis of formaldehyde in the laboratory.

These investigators have submitted water, with a stream of carbon dioxide passing through it, to ultra-violet radiation, and have detected formaldehyde in the resultant solution. Rays of 2000 Å cause the

production of formaldehyde and those of 2900 Å polymerize the aldehyde to reducing sugars.

Ferric hydroxide, malachite green, and chlorophyll, all catalyze the formation of formaldehyde, and calcium carbonate assists in the polymerization of formaldehyde to form sugars.



The natural synthesis of proteins by the living cell has attracted much attention among biologists and biochemists.

Fischer, in his epoch-making researches on the synthesis of proteins, succeeded in building up many polypeptides closely related to proteins from amino-acids, and has indicated the possibility of synthesizing proteins by a similar method.

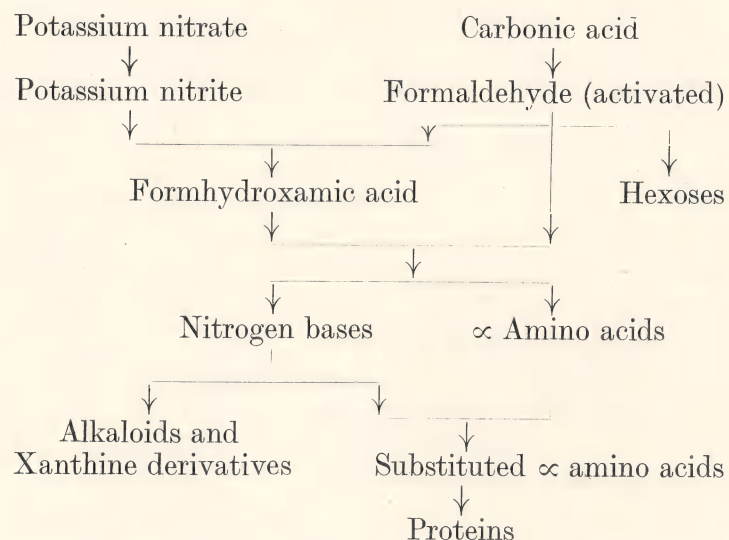
Plants obtain their supply of nitrogen from the nitrates and nitrites of the soil, but many of them are also able to assimilate nitrogen and oxides of nitrogen from the air.

According to Baly, Heilbron, and Stern, free ammonia plays an important part in plant metabolism; they identified methylamine and nitrous and nitric acid in the products obtained after irradiating solutions of ammonia and carbon dioxide with a quartz mercury vapour lamp.

The photochemical reaction between "activated" formaldehyde and potassium nitrite produces the potassium salt of formhydroxamic acid HCOH
 NOK , and this is probably the first step in the production of nitrogen compounds in the plant.

From this substance amino-acids and proteins are most probably synthesized.

Baly, Heilbron, and Hudson have obtained definite evidence of the formation of amino-acids from formaldehyde and nitrate; they have also isolated alkaloidal bases, and have identified pyridine, piperidine, and methylamine in the products of the photochemical reaction between ammoniacal cupric carbonate and carbon dioxide. They suggest the following scheme as an indication of what probably occurs in the plant:



As a result of their latest investigations, these workers suggest that the primary product in photochemical synthesis from carbon dioxide and water is not formaldehyde, but other more complex bodies. The formaldehyde is formed by the degradation of the latter under the influence of radiation. They have been able to induce synthesis by means of visible instead of ultra-violet rays. This makes it possible to compare the laboratory experiments directly with plant metabolism, and the use of visible light has the advantage that photochemical decomposition is avoided.

Photosynthesis has been effected by means of carbon dioxide absorbed on the surface of nickel or cobalt carbonate suspended in water and exposed to visible light. Complex organic compounds are formed, and in the presence of ammonium bicarbonate in solution nitrogen derivatives are produced.

In a living leaf, too intense or too lengthy exposure to light gives rise to a marked fatigue effect, and in the laboratory a similar effect is noticed. This is due to the poisoning of the surface of the nickel or the cobalt carbonate with oxygen. In both cases there is a slow recovery reaction, and it appears that photosynthesis in both cases, natural and artificial, must not be more rapid than this recovery reaction.

Technical Applications.—One interesting use of ultra-violet radiation is for testing the fastness of various dyestuffs. Previously when it was desired to make experiments in this connection it was customary to send fabrics for exposure for one or two years to the tropics, or to attach them to the masts of ships. With

ultra-violet radiation, after very short exposures, their fastness or their want of it can be demonstrated.

We found on exposing cotton fabrics dyed with direct cotton colours that fading commenced very rapidly indeed, and that considerable bleaching had occurred after exposures varying from sixty to ninety minutes.

The "Fadometer" can also be used for testing the permanency of inks, paints, and enamels.

Some leather manufacturers found that "patent leather" exposed in the process of manufacture to sunlight was greatly improved in quality. This process was by no means easy to arrange, because the leather had to be protected from the slightest shower of rain, but now mercury vapour lamps are used without difficulty, and very successfully, to illuminate special airtight chambers where the leather is dried in a few hours.

At a local tannery it has also been found that patent leather exposed to ultra-violet radiation becomes more deeply coloured and glossy.

CHAPTER VIII

PHYSICAL PROPERTIES OF ULTRA-VIOLET RAYS

Detection of Ultra-Violet Radiation—Spectroscopic Examination of Radiation—Methods of Determining the Intensity of Radiation (Chemical, Thermal, Photometric, Electrical)
—Photo-electric Effect—Absorption of Ultra-Violet Rays—Glasses—Reflection of Ultra-Violet Rays—Fluorescence

THE presence of ultra-violet rays can always be proved by their property of blackening silver chloride, and by their action on photographic plates and paper. In their presence willemite gives out a brilliant green fluorescence. We found that this green fluorescence immediately disappeared when a thick sheet of plate glass was placed between the willemite and the source of the rays, which proved that the visible rays were not responsible for the phenomenon. We also noticed that when rays of long wave-length from an electric torch were directed on to the willemite the fluorescence was again not excited; but it is produced by the invisible ultra-violet rays passing through a special filter of oxide of nickel.

To study ultra-violet radiations it is necessary to make use of a spectroscope in which the prisms and lenses are of fluorite or quartz, since ordinary glass prisms and lenses absorb all the waves of short length. Photographs of emission and absorption spectra can

be made with this instrument. Air absorbs rays of lower wave-length than $1700 \text{ \AA}$, and therefore spectrographs of the extreme ultra-violet region must be taken in vacuo. In studying spectra it is advantageous when possible to make use of a diffraction grating, because then not only a pure spectrum, but a uniformly disposed one (*i.e.* one in which all wave-lengths are equally separated), is obtained.

Methods of Determining the Intensity of Radiation :

1. *Chemical*—

- (a) The effect of rays on silver chloride or sensitized paper.

Erythema Dosimeter.—This apparatus has been devised by Dr Keller to measure the amount of radiation active in producing erythema given off from any source. Different portions of a single strip of special photographic paper are simultaneously exposed to the rays at the distance at which it is desired to expose the patient: (1) without any cover; (2) under Uviol glass; (3) under special glass that completely absorbs the erythema-producing rays.

The uncovered portion of the paper is allowed to become as dark as a special blackened test surface, and the number of seconds required for this is noted. The paper is then removed, and the shades of the portions (2) and (3) are compared with specially prepared tables. From these the ultra-violet intensity is obtained.

- (b) Saidman has designed a sensitometer with which it is possible to test the intensity of various sources of ultra-violet radiation as well as the

sensitivity of the patient's skin. The property of a colourless solution of paraphenylenediamine, that it darkens on exposure to ultra-violet rays, is made use of for the first-mentioned purpose. The apparatus is more fully described on page 375.

- (c) *Actinometers.*—Bunsen and Roscoe's actinometer is based on the amount of HCl formed

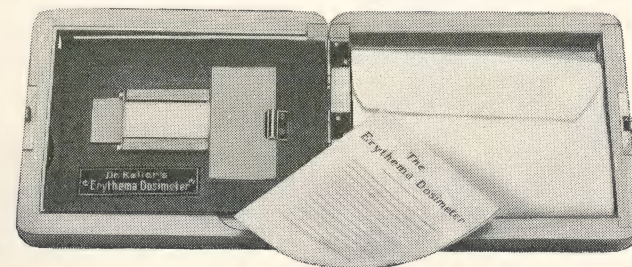


FIG. 129.—Dr Keller's Erythema Dosimeter.

on irradiating a mixture of hydrogen and chlorine.

- (d) The bleaching power of radiations on acetone methylene blue solution (Webster, Eidinow, and Hill).
- (e), (f), and (g) The Carbon tetrachloride, Uroxameter, and Lithopone tests, mentioned in Chapter VII.
- (h) Bordier's chromoactinometer consists of paper tinted yellow with a 20 per cent. solution of potassium ferrocyanide, and a graduated series of permanent tints of known value. When the test paper is exposed to ultra-violet radiation it acquires a yellow-ochre colour, and this is compared with the standard tints.

- (i) Filter paper soaked in a solution of paraphenylenediamine nitrate turns violet when exposed to ultra-violet rays.
- (j) The new "Levy-West" ultra-violet pastilles consist of small discs of thin cardboard, having the white side coated with a material sensitive only to ultra-violet rays between 2300 and 3800 Å, and responsive equally to these rays. On the reverse side the discs are dark grey in

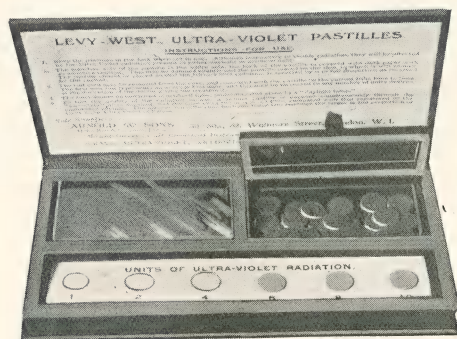


FIG. 130.—Case containing "Levy-West" Ultra-Violet Pastilles, "Vitaglass" Filter and Tint Cards giving Units of Dosage.

colour and are covered with an adhesive which can be made to stick by damping it.

The white side of the disc turns varying shades of light yellow, corresponding to the length of exposure. A tint card is provided, showing average tints expressed in units of 1, 2, 4, 6, 8, 12—tint 1 being an average first dose.

The proportion of radiation having a wavelength shorter than 2900 Å can be determined by exposing two pastilles simultaneously, one

unscreened, and the other covered by the "Vitaglass" slide provided for this purpose.

2. Thermal—

- (a) Various types of pyrheliometers or actinometers can be used. Perhaps the best known are those which have been devised by Violle, Pouillet, Ångström, Abbot, Michelson, and Callendar.

Pouillet's Pyrheliometer.—A surface of known size is exposed to the radiation, and the amount of heat imparted by it to a given quantity of mercury in a given length of time is noted. After allowance has been made for loss due to radiation, the quantity of heat received in the given time is obtained by multiplying the specific heat of the body by its mass and by the rise of temperature.

Crookes' Radiometer.—This little apparatus, so often seen in opticians' windows, can be used for the measurement of the intensity of incident radiations, because a relation exists between this and the revolutions per second of the vanes of the radiometer.

Ångström's Pyrheliometer.—Two identical strips of thin metal are used, one kept screened, and the other exposed to radiation. The strips are connected by a galvanometer, the needle of which is deflected. The deflection is reduced to zero by passing an electric current through the shaded metal strip; this current is a measure of the intensity of the radiation falling on the exposed strip.

- (b) *Rubens' Thermopile*.—An electric current is produced when metal couples such as iron or copper and constantin are heated by being exposed to radiation. A galvanometer records the current, and from this indication the intensity of the radiation can be deduced.



FIG. 131.—The "Fürstenau" Actinometer.

- (c) *Langley's Bolometer*.—The rays are directed on to a thin strip of blackened metal; radiant energy is absorbed, so raising the temperature of the strip. This alters its electrical resistance, and thus the intensity of the incident radiation can be measured.
- (d) *Fürstenau's Actinometer*.—This consists of two parts: a selenium cell fitted with a spring shutter, and an instrument for registering the intensity of the radiation. The electrical

resistance of the cell is modified when ultra-violet rays fall upon it; but heat rays also influence it. There is a graduated scale marked from 0 to 50. The point marked 40 on the scale corresponds to an erythema dose.

3. *Photometric*.—In this method the spectrum of the radiation under examination is compared with one of known source and strength.

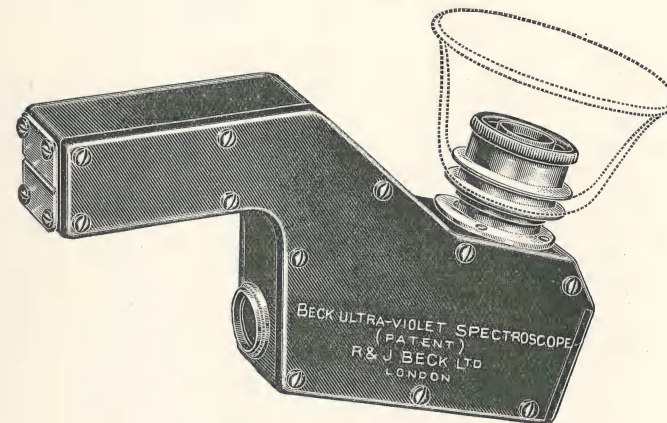
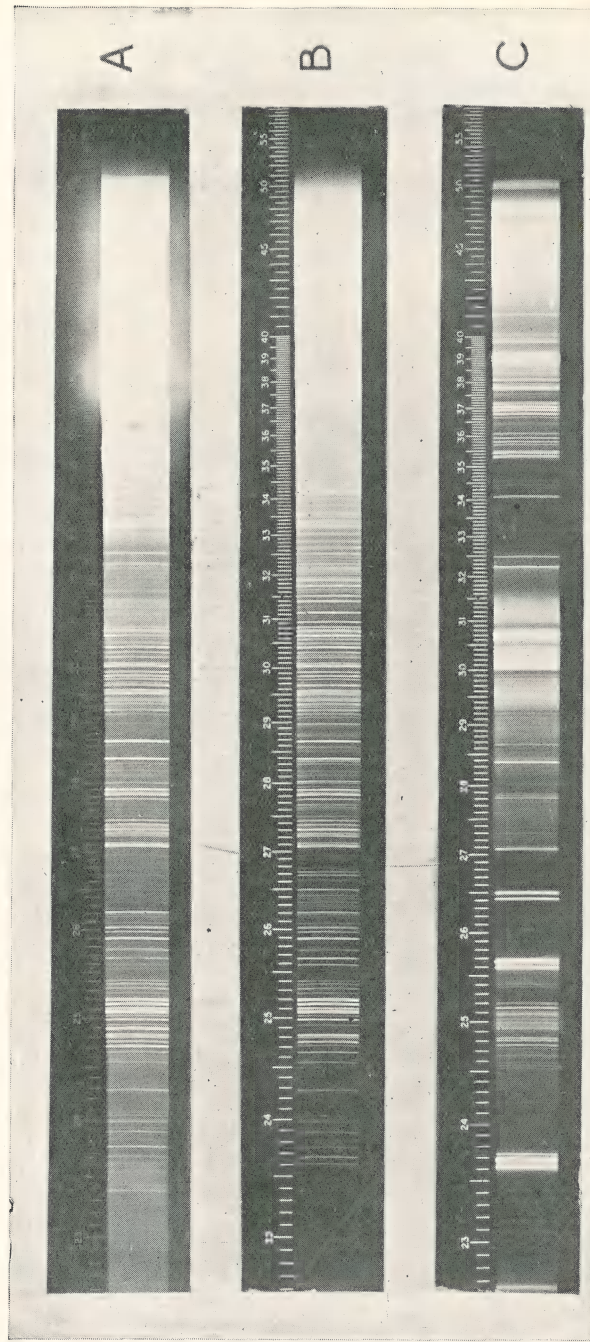


FIG. 132.—The "Beck" Ultra-Violet Spectroscope.

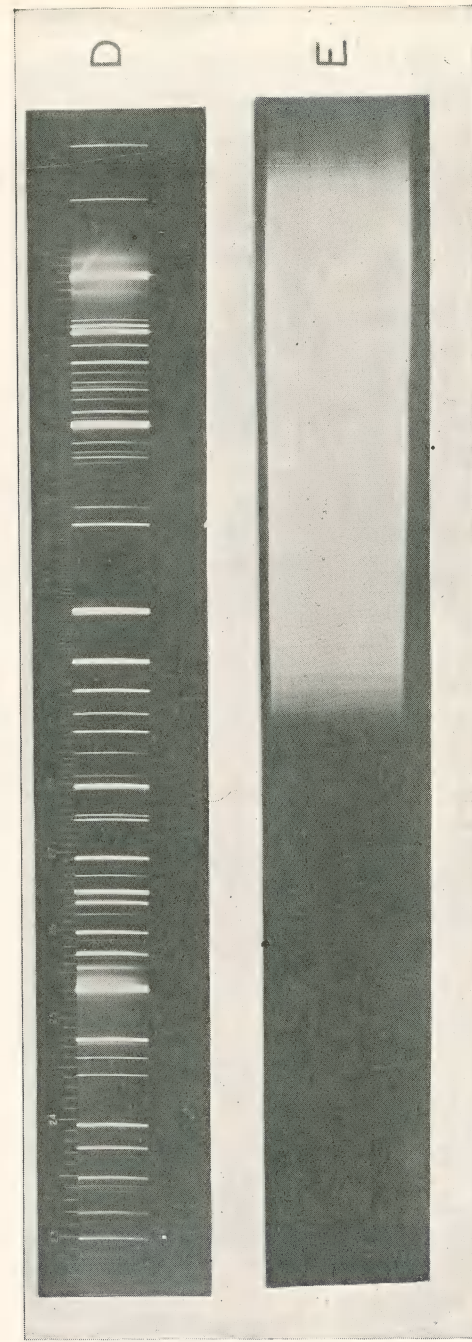
A spectroscope enables a detailed examination to be made of the radiation given off by a substance in the incandescent state. For use with ultra-violet rays it consists of four essential parts:

- (a) A narrow slit through which the radiation passes;
- (b) A small telescope, called a collimator, which makes the rays parallel;
- (c) A quartz prism to produce dispersion of the rays; and
- (d) A fluorescent screen, which transforms the invisible ultra-violet radiation into visible light.



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FIG. 133.—Spectrographs.
A, Of the Carbon Arc ; B, Of an Arc with Carbons cored with Molybdenum and Tungsten ; C, Of an Arc with Aluminium Electrodes.
(From *Modern Science*.)



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FIG. 134.—Spectrographs.
D, Of the Quartz Mercury Vapour Lamp ; E, The Solar Spectrum. (From *Modern Science*.)

Photographs of the spectrum may be taken by substituting suitably screened photographic plates for the fluorescent screen.

Another method of determining the relative intensity of ultra-violet rays consists in passing the

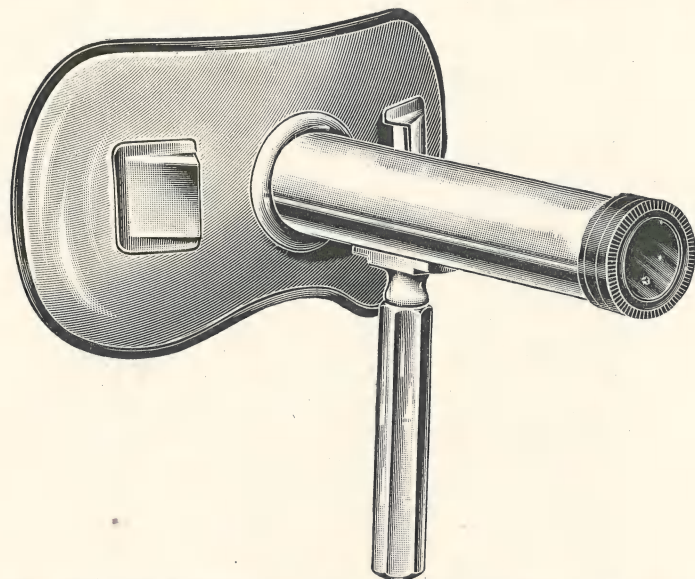


FIG. 135.—The Actinoscope, with which it is possible to make rough comparisons of the Ultra-Violet Radiation of various types of Lamps.

radiation through a Chance's ultra-violet filter and then through a piece of uranium glass, which fluoresces when actinic rays are present.

4. *Electrical*.—This method is based on the phenomenon that if metals are exposed to rays of certain wave-lengths negative electrons are emitted. If the metal is charged positively before irradiation it remains charged indefinitely. A metal plate tends to become positive on irradiation, since it is giving off

negative electrons. After a while it would become so strongly positive that it would tend to attract back the negative electrons. If ultra-violet rays fall on the polished surface of a zinc plate negative electrons are shot off. If a fine metallic gauze, positively charged and connected to a gold-leaf electroscope, is placed in front of this plate the electrons will be caught and measured, and the intensity of the radiation may be determined.

Dr Rosselet, who is at present in charge of the electro-therapeutic department of the Cantonal Hospital, Lausanne, recently explained to us the apparatus with which he made most of his observations on the intensity of natural ultra-violet radiation. The apparatus consists of a zinc sphere, 2 cm. in diameter, which has been dipped into hydrochloric acid, and then amalgamated by immersion in mercury. The sphere is situated in the long axis of a cylinder of brass blackened on its inner surface, and is kept in position by a wire, which is attached to it at one end, and to an Elster and Geitel's electroscope at the other. The wire passes through an amber button in the centre of the closed end of the cylinder. The sphere is first charged with negative electricity, and is then discharged under the action of ultra-violet radiation. The rate of discharge is proportional to the intensity of the incident radiation.

We made an electroscope of English gold-leaf attached to a copper wire passing through an insulated cork and attached to a polished zinc plate, which was negatively charged from ebonite. On irradiation with the mercury vapour burner the

leaves, which were separated when charged negatively, gradually came together again, proving the discharge of the negative electricity from the zinc plate. This phenomenon is known as the photo-electric effect of radiant energy.

Griffith and Taylor have recently devised a photometer for measuring the intensity of ultra-violet radiation. It consists of a photo-electric cell and a gold-leaf electroscope. The cell is made of glass, except at one end, where there is a flat quartz window. The cell is evacuated of air and then filled with argon or hydrogen at a pressure of 3 mm. of mercury.

The cathode consists of a thin disc of cadmium attached to a copper support, which is carefully insulated, and is attached to the terminal of the electroscope. A short distance in front of the cathode there is a fine wire grid, the anode, which is earthed. The electroscope is charged negatively to a potential of about 200 volts, which causes the leaves of the electroscope to separate.

When in use, ultra-violet rays enter the quartz window, pass through the wire grid, and act on the cadmium plate, causing it to give off negative electrons, so that the electroscope which is attached to the cathode is gradually discharged. The intensity of the ultra-violet rays is directly proportional to the rate of discharge. In making measurements the exact distance of the photometer from the source of radiation has of course to be taken into account. Wave-lengths greater than $3500 \text{ \AA}$ do not influence cadmium photo-electrically, and the quartz window is opaque to most wave-lengths below $2000 \text{ \AA}$, so that the

photometer is sensitive only to ultra-violet rays between these two wave-lengths.

Every substance has a critical or threshold wave-

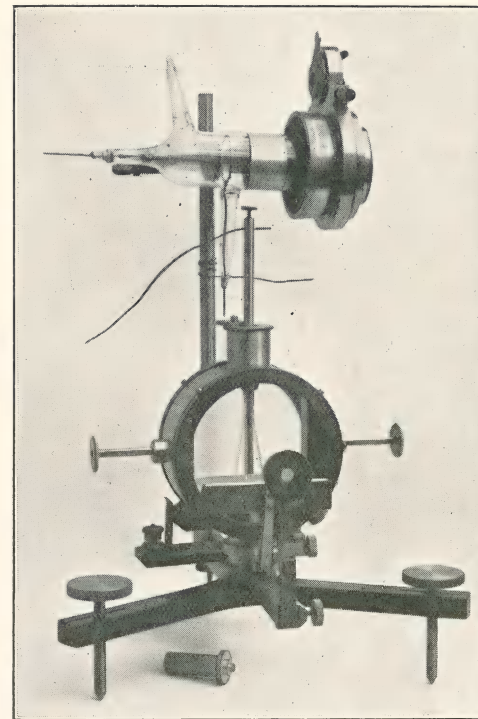


FIG. 136.—General view of Griffith and Taylor's Apparatus for measuring the Intensity of Ultra-Violet Radiation.

length, below which, even down to the shortest wave-lengths, electrons are given off. Above this critical wave-length no electrons are given off. Wave-lengths below $3000 \text{ \AA}$ generally bring about this effect. In some metals the critical wave-length is very large,

and even visible light will cause the emission of electrons. For example, the critical wave-length of sodium is $3400 \text{ \AA}$, of potassium, $4400 \text{ \AA}$, and of rubidium, $4800 \text{ \AA}$. A piece of heated glass-tubing will

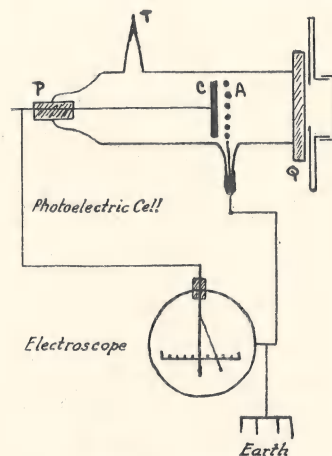


FIG. 137.—Diagram of Griffith and Taylor's Cadmium Photo-Electric Cell.

A represents the Anode, consisting of a Wide-Mesh Grid of fine Wire about 3 mm. from the Cathode; C, Cadmium Electrode attached to Copper Support; P, Quartz Bush through which the Copper Wire passes; Q, Flat Quartz Plate screened by Adjustable Diaphragm; T, Point for Evacuation, Introduction of Argon and, finally, Sealing of Cell.

cause the last-named to give off electrons. If the substance is in chemical combination it is still possessed of this property, and the critical wave-length remains unchanged.

Unattached and wandering electrons are supposed to exist in solids, interspersed between the molecules. These can be ejected by heat. They are the important

agents in thermo-electricity, and in the conduction of electricity and heat. A good conductor is one which contains many such free electrons. Metals are of this class. Non-metals, such as glass, paraffin-wax, porcelain, ebonite, etc., have very few free electrons, and are insulators.

Electrons are very small particles of electricity, each equal in mass to one two-thousandth part, approximately, of the mass of the hydrogen atom. They can be weighed and measured. They all have the same mass, diameter and electric charge, and are composed wholly of negative electricity. They rotate round the proton, or positive nucleus, much in the same way as planets round their sun, and by their varying numbers and arrangement give rise to atoms of different elements.

When a metal is acted upon by rays smaller than its critical wave-length, electrons are emitted not only from the surface of the metal, but also through its substance, and even from the opposite side if the metal is not too thick. There is a diversity of opinion whether the emission of electrons is evenly distributed in all directions, or whether they are given off in exactly the same direction as the incident rays.

The number of electrons given off is in direct proportion to the intensity of the light. The velocity of the electrons is affected only by the wave-length of the rays, being greater the shorter the wave-length. There is a uniform velocity of the emitted rays for any given wave-length.

On comparing the intensity of the incident and

emergent electrons given off by films of varying thicknesses under ultra-violet irradiation, Stulmann found that the maximum emission energy of the photo-electrons was about 40 per cent. greater when they left the emergence side than when they left the incidence side of very thin films. In thick films the reverse effect was obtained.

Since the photo-electric effect takes place when substances are in chemical combination, it follows that if certain salts (for example, zinc salts) are applied to the skin, electrons will be given off, some of which will penetrate the skin. It would be interesting to know whether the absorption of the ultra-violet rays themselves or the actual electrons given off have most influence in the biological effect.

All metallic substances are photo-electric, and many non-metallic substances also, such as sulphur, paraffin, and aniline dyes.

Drina investigated the photo-electric effect of numerous inorganic compounds, and found that when a metal can combine with another element in two ways that compound in which the metal has the lower valency has the greater photo-electric effect, and also, in the case of halogens, that the photo-electric effect increases as a heavier halogen atom is substituted for a lighter.

Gases also have the same property, and this is the explanation of Hertz's discovery, in 1887, that if the two pole-plates of a spark coil are so adjusted that a spark will just not pass between them under ordinary conditions, there will immediately be a spark of ultra-violet rays directed on to the gap, owing to the

emission of electrons from the metal spheres of the pole plates, and also to the ionization of the intervening

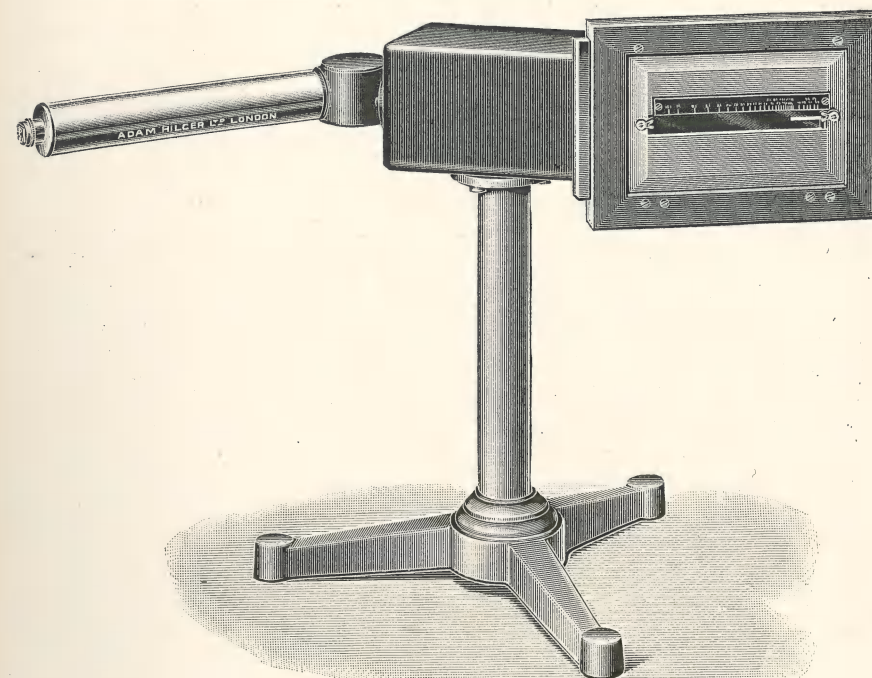


FIG. 138.—The "Hilger" Ultra-Violet Spectroscope.

air gap. Heat, X-rays and radium emanations have the same effect.

Hughes found that the critical wave-length for air is 1350 Å.

It is interesting to note that ions from ionized gases can be filtered out of the gas by passing it through cotton-wool. In liquids, where the penetration is deeper, the electrons do not escape so easily, and thus,

in addition to emission of electrons there is an increase in the conductivity of the solution.

Temperature has no influence on the photo-electric effect. In the alkali metals polarization of the rays increases the effect, because the photo-electric current is at a maximum when the plane of polarization is perpendicular to the plane of incidence, and at a minimum when these planes are parallel. When the angle of incidence is zero, the two currents have the same value. The photo-electric effect is probably directly proportional to the amount of ultra-violet rays absorbed (Grotthus's law). The phenomenon of photo-electric fatigue is interesting. After radiation has been allowed to fall on a substance for some time the number of electrons emitted by the substance gradually decreases. If the substance is then given a rest and radiation is resumed the original number of electrons will again be given off. This fact can be proved by means of the gold-leaf electroscope.

Absorption.—When light rays are incident on the surface of a medium some are reflected and some are absorbed :

Absorption = the ratio of the amount absorbed to the amount incident.

Reflection = the ratio of the amount reflected to the amount incident.

The sum of these is unity.

Unit increase in the thickness of a medium reduces the intensity of a radiation by a constant ratio.

Most substances become increasingly opaque to ultra-violet radiation as the wave-length decreases, and this absorption of the shorter rays makes their

study particularly difficult. It is thought that oxygen causes air to be opaque to wave-lengths shorter than 1850 Å. Nitrogen, on the other hand, is quite transparent to ultra-violet rays, and so also is hydrogen. Ozone absorbs the rays strongly. It is present in very high atmospheric regions where it helps to shield the world from excessive ultra-violet radiation. Water vapour, dust particles and smoke all absorb the rays, and this is the reason why the sun's rays in our large cities are so weak in the ultra-violet portion of the spectrum. In winter these rays are often entirely absent after the sunlight has been filtered through a layer of water vapour and smoke. Leonard Hill says that "on a clear day 75 per cent. of the sun's energy which reaches the earth's atmosphere arrives at an altitude of 18,000 feet, and only 50 per cent. at sea-level. Of course the amount is still further reduced by absorption of particles of dust and water vapour which surround large cities."

When ultra-violet radiation is transmitted through clear tap water a fair amount of radiation is absorbed, but this is not so with distilled water. Ordinary tap water 10 cm. in depth absorbs all rays shorter than 2350 Å; but bacteria can be killed in water at as great a depth as 30 cm.; water, however, strongly absorbs the infra-red rays.

Absalom concluded that transparency to ultra-violet rays associated with colour is more commonly found in the colloidal metals than in ordinary coloured salts or aniline dyes. Generally, fluorescent solutions and solids are opaque to the rays. By using ultra-violet radiation it has been found possible by means

of absorption spectra to detect quantities of cocaine as small as 1 in 200,000, and atropine at a strength of 1 in 2000.

Solutions of peptone, amino-benzoic acid, tyrosin, leucin, and phenylalanin are not penetrable by ultra-violet rays at all. Blood absorbs all rays shorter than 4500 Å, and has absorption bands at 5400 Å and 5750 Å.

Fluorite is the most transparent solid to the actinic rays that has been found, and transmits them as far down as 1250 Å.

Quartz comes next to fluorite in transparency. There is, however, a great difference between fused and crystalline quartz, the latter being much more transparent. Quartz absorbs in the region of 1850 Å, but there are considerable differences between various specimens. Celluloid and gelatin are transparent to near and middle ultra-violet radiations, but mica absorbs all wave-lengths below 3100 Å.

Cellophane .25 mm. thick absorbs all ultra-violet rays below 2800 Å. It is very easy to sterilize if it is made with 45-50 per cent. of glycerine. It has proved a very convenient dressing for wounds when it is desired to irradiate them.

"Windolite" consists of acetocellulose spread in a thin film on a fine wire mesh; it transmits to 2320 Å.

For any substance to be transparent to any radiation it must be an insulator of that radiation.

Glasses.—The transparency of glasses to the rays differs considerably: most clear glasses transmit wave-lengths of 3500 Å, but transmission below this level is very variable. The thickness of the glass and its

chemical composition are both important factors. The most absorbent glasses are those containing metals of large atomic weight.

It is not correct to say that glass does not transmit ultra-violet rays. It is, however, not transparent to the rays of the greatest value. A quartz spectrograph is the simplest means of studying the transparency of glasses.

The permeability of window glasses is interesting. Luckiesh gives the following table for different glasses 2 mm. in thickness:

<i>Type of Glass</i>	<i>Absorption Limit</i>
Common Glass . . .	2950 Å
Light Crown . . .	2950 „
Extra Light Flint. . .	2980 „
Medium Crown . . .	3000 „
Light Flint . . .	3050 „
Medium Flint . . .	3150 „
Extra Dense Flint . . .	3350 „
Schotts' Heavy Flint . . .	3400 „

Ordinary window glass absorbs rays below 3300 Å, and therefore pigmentation does not occur under glass, since rays about 3000 Å are the most active in producing it.

Best Crown Glass absorbs very strongly from 3100 Å.

A great deal of research has been applied, in recent years, to the production of a glass transparent to ultra-violet rays. Such transparency depends, of course, on the chemical constitution of the glass. Glass of the constitution 1.0 Na₂O, 1.4 CaO, 6 SiO₂, transmits rays to 2370 Å for a thickness of 1.5 mm., and similar glass containing 1.5 parts of CaO, instead of 1.4,

transmits down to 2790 Å for the same thickness. The presence of oxides of antimony, iron, magnesium or aluminium in glass tends to decrease the penetrability, whereas those of either cobalt or nickel increase

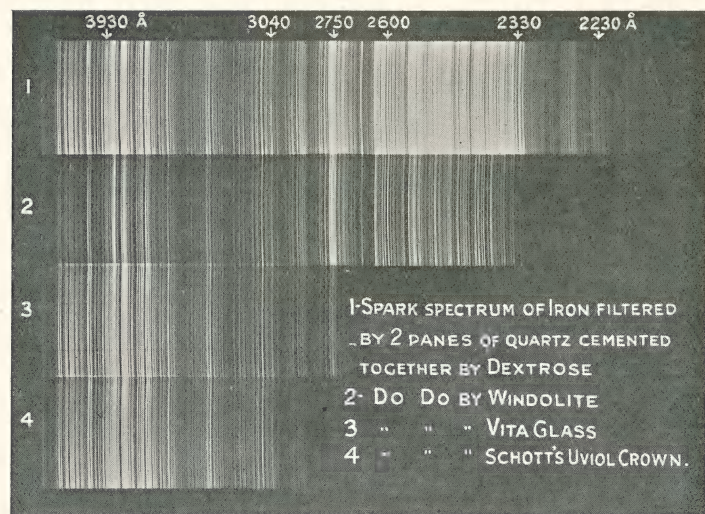


FIG. 139.—Spectrogram taken by Colonel J. William Gifford showing the Permeability of "Windolite" and various Glasses.

it; but when the latter are present together they absorb both ultra-violet and infra-red radiations.

Recently F. E. Lamplough, M.A., has succeeded in making a new glass called "Vitaglass." This special glass, which contains a large proportion of quartz, and other ingredients not present in ordinary glass, has the property of transmitting rays up to 2750 Å; it is thus freely transparent to all the ultra-violet rays which occur in sunlight. This discovery of a comparatively cheap material which transmits all the

natural ultra-violet radiation is of outstanding importance: "Vitaglass," when bought in quantity, is less expensive than even the cheapest varieties of plate glass. When the sun is shining all the beneficial effects of natural sunlight can now be easily

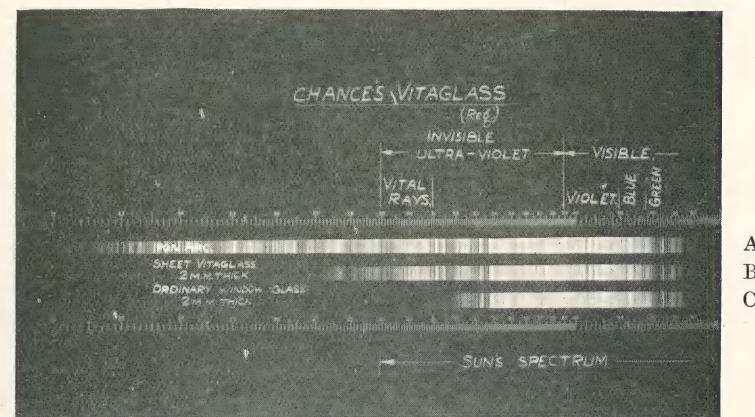


FIG. 140.—Illustration showing the Transmission of Ultra-Violet Rays by "Vitaglass."

A, Spectrograph of the Iron Arc without filtration; B, Shows that "Vitaglass" transmits the Vital Ultra-Violet Rays to the extreme limit (wave-length 2900 Å) of the Sun's Spectrum; C, Shows that the Vital Rays are completely obstructed by ordinary Window Glass.

enjoyed in warmth and in privacy, in a room having windows or roofs glazed with "Vitaglass."

This makes its use in hospitals, sanatoria, convalescent homes, schools, nurseries, and the like, especially important. It has recently been proved that the lethal effect on infusoria is exactly the same when sunlight is transmitted either through quartz or through "Vitaglass." Dr Leonard Hill has recently confirmed, in his Royal Institution lectures, the transparency of "Vitaglass" to 2750 Å.

"Vitaglass" of 15 oz. weight transmits approximately 65 per cent. of the incident radiation with wave-lengths between 3100 and 2900 Å.

"Vitaglass" is transparent to nine-tenths of the rays with wave-lengths longer than 3300 Å, and to three-quarters of the rays between 3300 Å and 3000 Å.

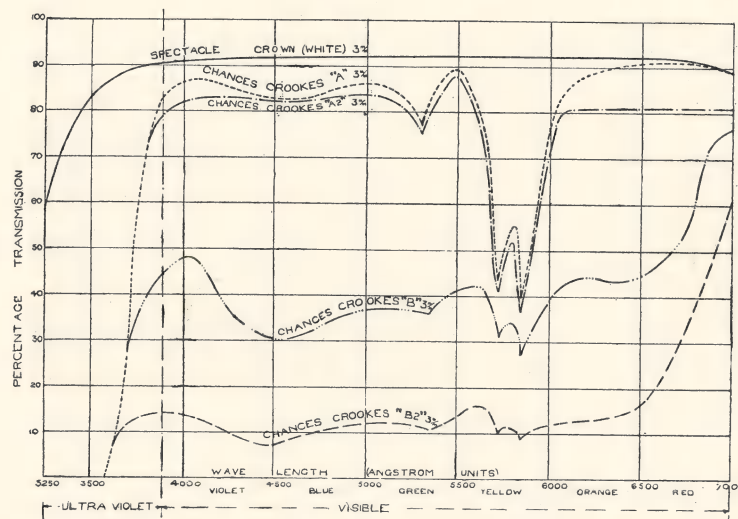


FIG. 141.—Graphs showing the Transmission of Chance's Spectacle Glasses.

In actinotherapy and arc welding, glasses which cut off the ultra-violet rays are very important. Well-known varieties are :

- (1) Euphos Glass, and
- (2) Fieuzal Glass No. 5.

Other glasses absorb the ultra-violet rays and most of the infra-red. The best-known are :

- (3) Chance's Crookes' A Glass, which is of a faint neutral shade, almost colourless, and transmits 86 per cent. of daylight.

- (4) Chance's Crookes' A₂ Glass, which transmits 78 per cent. of daylight.
- (5) Chance's Crookes' B Glass, which is of a stronger neutral colour and transmits 46 per cent. of daylight.
- (6) Chance's Crookes' B₂ Glass, which transmits only 20 per cent. of daylight.
- (7) Saniweld Glass.
- (8) Noviweld Glass, which transmits less than 1 per cent. of ultra-violet rays and 1 to 3 per cent. of infra-red.
- (9) Pfund lenses, which consist of Noviweld Glass gold-plated and covered with a transparent cover-glass ; their properties are due to reflection of the infra-red and ultra-violet rays rather than to absorption. They appear like a gold mirror, but their transparency for luminous rays is exceedingly good, because, owing to their property of reflection, a light-tinted Noviweld Glass can be used.

Glasses which transmit only ultra-violet rays are :

- (1) Wood's Filter.
- (2) Chance's Ultra-Violet Glass, which transmits only rays between 2870 and 4270 Å, with the maximum transmission between 3300 and 3900 Å.
- (3) Oxide of Nickel Glass.
- (4) Wratten Filter No. 18.

Other glasses, permeable only to the near ultra-violet rays, are :

- (1) Gallois Special T.O. Glass, which is transparent as far as 2900 Å.

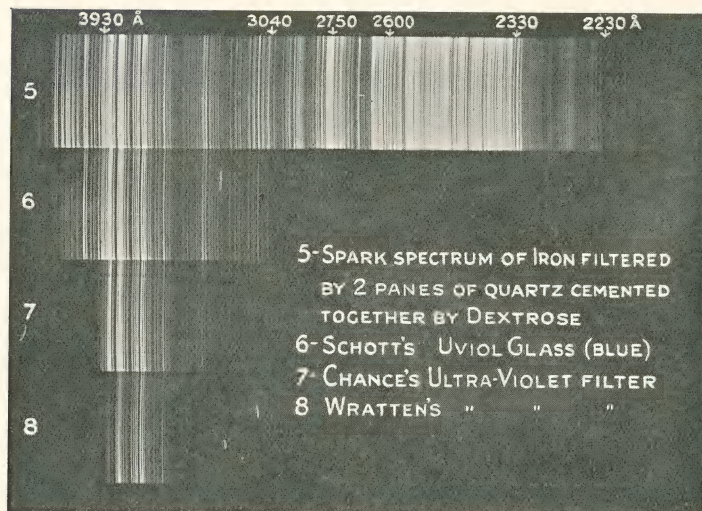


FIG. 142.—Spectrogram showing the Transmission of Schott's Blue Uviol Glass, and Chance's and Wratten's Ultra-Violet Filters. (By Colonel J. William Gifford.)

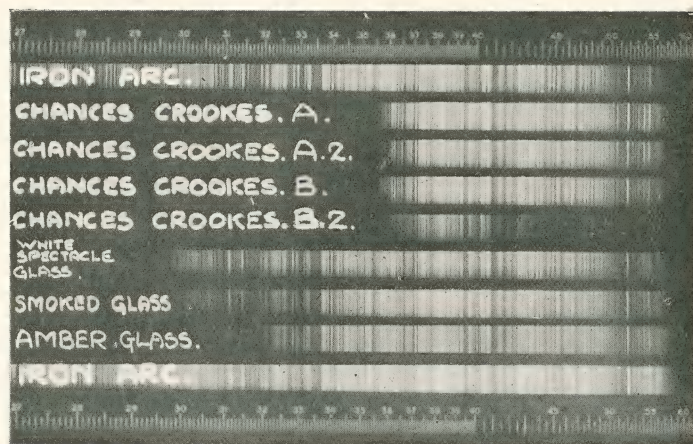


FIG. 143.—Spectrographs showing the Transmission of Chance's Crookes' Spectacle Glasses. They transmit very little of the Spectrum below 3900 Å.

- (2) Clear "Uviol" Glass (Schott), which, when 1 cm. thick, transmits 50 per cent. of wave-length 3050 Å, and when 1 mm. thick 50 per cent. of wave-length 2800 Å.
- (3) Blue "Uviol" Glass, which, when 2 mm. thick, transmits as far as 2850 Å.

Fluorescent screens are made generally of barium platinocyanide or uranium glass.

Pyrex Glass a few millimetres thick transmits to 2900 Å.

Crookes' A Glass 1.79 mm. thick absorbs all rays below 3450 Å.

Crookes' B Glass 1.93 mm. thick absorbs all rays below 3500 Å.

Euphos Glass 1.95 mm. thick absorbs all rays below 4000 Å.

Fieuzal Glass 2.13 mm. thick absorbs all rays below 3500 Å.

Saniweld Glass 1.82 mm. thick absorbs all rays below 5000 Å.

One mm. thickness of skin absorbs rays shorter than 3600 Å; 2.5 mm. are opaque to indigo and violet 4358 Å.

Lenku, Ganni, and Busk showed that light filtered through potassium bichromate solution, transmitting only red, orange, and yellow rays, caused an impression on an isochromatic plate after traversing the hand. This did not take place when blue and violet rays were used, an ammoniacal solution of copper oxide being used as a filter. Most protoplasmic substances which are colourless in ordinary light show marked absorption to ultra-violet rays, and this is made use of in microscopy to obtain contrasts.

If a paint made of Chinese white (zinc oxide), either used alone, or, better, mixed with a little lamp-black to form a light grey, is applied to form a flat and not a glossy surface, it will absorb all ultra-violet radiation, not allowing any to be reflected. This is of importance when the wall-covering of a treatment-room is being considered.

Reflection of Ultra-Violet Radiation.—"Ultra-violet

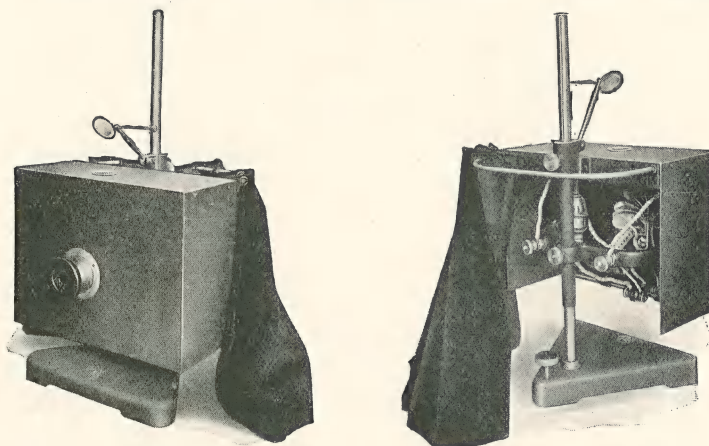


FIG. 144.—The "K.B.B." Microscope Illuminant Lamp.

radiation often undergoes considerable absorption by reflection. Many substances reflect the near ultra-violet fairly well, but the middle and extreme ultra-violet are generally absorbed to a considerable degree. Much of the ultra-violet energy is absorbed by some substances in excitation of fluorescence" (Luckiesh).

Snow reflects ultra-violet rays extremely well, as it does visible light, and this accounts for the development of snow-blindness under certain conditions, ultra-violet rays down to 2950 Å being reflected to the

extent of from 80 to 90 per cent. The limit of the transparency of the cornea to short wave-lengths is about the same as the short-wave limit of the solar spectrum. "Partial eclipse blindness" falls into the

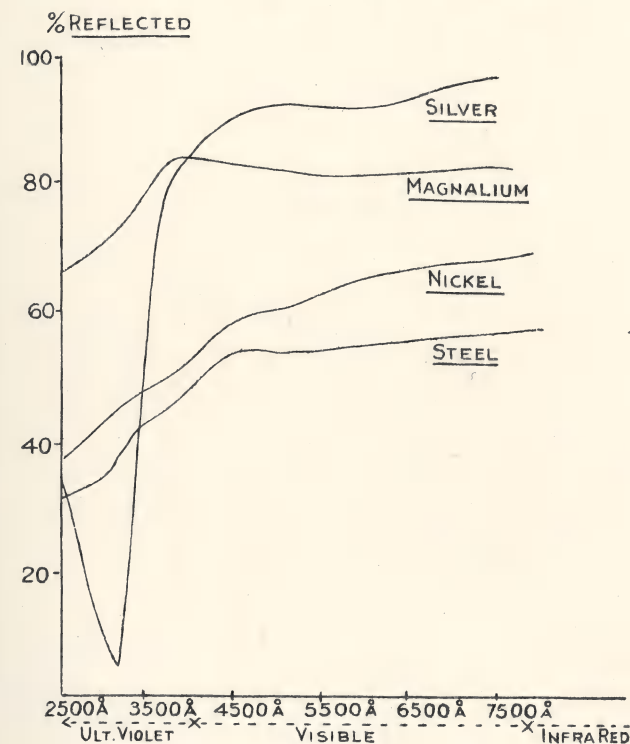


FIG. 145.—Diagram of the Reflecting Power of Metals.
(After Griffith and Taylor.)

same category as snow-blindness, being due to the short wave-lengths present. In arc welding and allied trades it is now customary to wear special darkened glasses to protect the eyes from the ultra-violet rays generated and to prevent the occurrence of conjunctivitis.

An ordinary mirror, which reflects excellently in the visible range, reflects only to about 4 per cent. at 3160 Å, but this rises to 34.1 per cent. at 2510 Å. Silicon is the most efficient reflector: it reflects 75 per cent. of the rays, and an average of 60 per cent. for the whole range from 3800 Å to 1800 Å. Copper

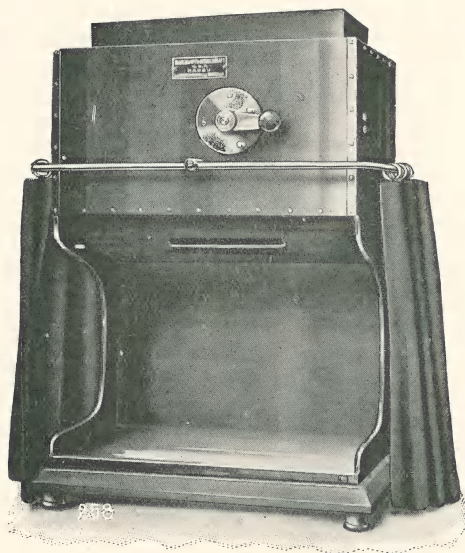


FIG. 146.—The "Hanovia" Analytic Quartz Lamp.

and gold reach their minimum between 3500 Å and 4000 Å, but reflect 38.8 per cent. at 2810 Å. Nickel reflects 40 per cent., whereas silver reflects only 6 per cent.

Magnalium—an alloy consisting of 69 parts of aluminium and 31 parts of magnesium—reflects 80 per cent. of visible light, dropping to 67 per cent. at a wave-length of 2500 Å; and it is stated that this reflective power does not diminish with age. But

polished nickel is generally considered to be the most practical reflecting medium for ultra-violet rays.

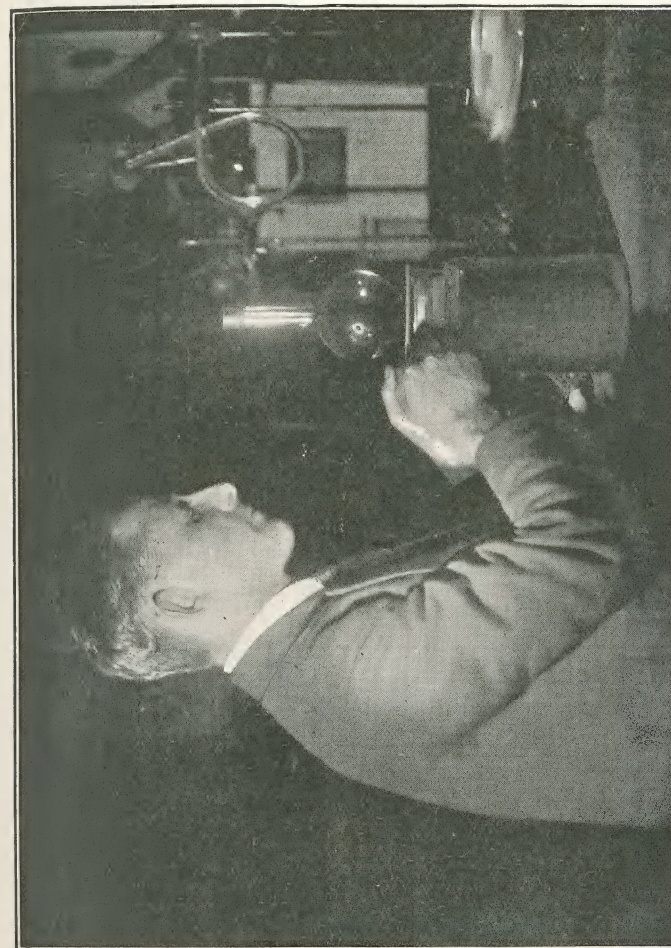


FIG. 147.—A Photograph taken in a room, in Total Darkness, by means of Invisible Ultra-Violet Rays from a "K.B.B." Mercury Vapour Lamp filtered through a "Chance" Ultra-Violet Filter. It demonstrates the great actinic effect that these invisible rays have on a photographic plate.

Ultra-violet rays were successfully used for signalling in the late war, all the visible light being cut off

from the source of radiation by an arrangement of special glasses. Small barium platinocyanide screens, which fluoresced in the presence of ultra-violet radiation, were used to receive the signals. Generally these screens were attached to telescopes and field-glasses.

Fluorescence.—A large number of substances are fluorescent, but the phenomenon is not ordinarily noticeable, because the brightness of the source of light overshadows the much fainter fluorescence. If, however, nickel oxide glass is used with the mercury vapour lamp, practically all the visible rays are cut off and only the invisible ultra-violet rays allowed to pass. The sun appears as an orange-red disc when looked at through this filter, and the metal filament of a gas-filled lamp looks merely red.

Many substances show very beautiful fluorescence under the influence of ultra-violet rays, particularly if the room is in darkness. A tallow candle glows a bright blue, and many boiled sweets coloured with aniline dyes reveal unexpected fluorescent effects. Sodium salicylate exhibits a strong violet fluorescence, quinine sulphate a light blue, the dye rhodamine a bright orange-yellow, fluorescein a yellow, a solution of chlorophyll a red, fluorspar a blue, and unirradiated ergosterol a blue and ultra-violet, but vitamin D or irradiated ergosterol shows no fluorescence.

All animal tissues are capable of producing fluorescence. The liver shows an intense yellowish-green fluorescence, the suprarenals an orange-red, and the cerebral cortex a yellow.

The finger-nails fluoresce much more markedly than the fingers themselves.

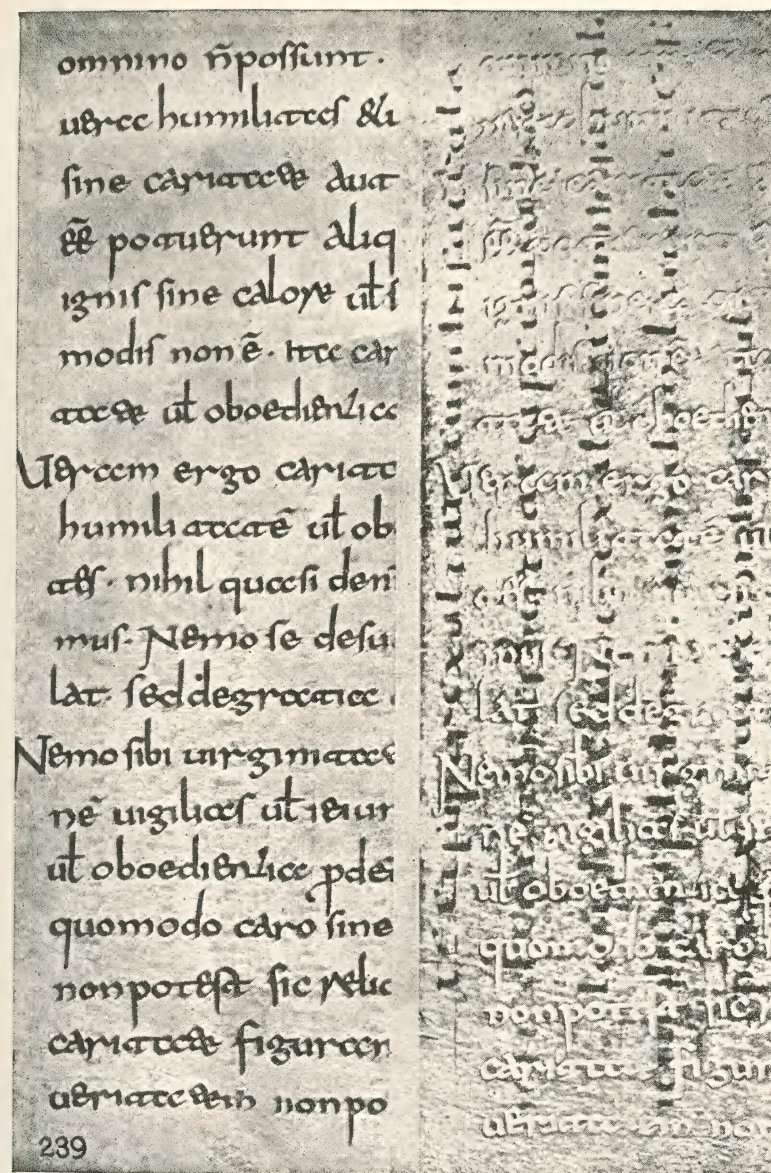


FIG. 148.—Illustrating the use of Ultra-Violet Rays filtered through an Oxide-of-Nickel Filter for the examination of Old Parchments. Early erased writings are revealed by fluorescence.

Ultra-violet rays passed through the oxide-of-nickel filter have proved an invaluable means of diagnosing small-spored ringworm of the scalp, and of accurately determining the extent of the scalp infection. This technique is also very useful for the examination of contacts. The spores on the infected hairs fluoresce vividly and look like minute bluish-green strings of beads.

With this filter it is an easy matter to distinguish natural Oriental pearls from Japanese cultivated pearls. Under the rays, we have noticed, the natural pearls have a bluish fluorescence and the Japanese a yellowish green. Artificial pearls appear quite dead and show no fluorescence at all.

In industry an increasing use for ultra-violet radiation is being found, particularly in the cotton and woollen trades, where, with its aid, it is possible to detect incipient mildew in raw or worked wool, as well as iron spots and early fading of dyed materials such as it is difficult to detect in ordinary light.

Fresh eggs show a reddish fluorescence, stale eggs a dirty-violet.

The rays can also be used for examining old parchments which, owing to their cost in olden days, were often written over several times. When ultra-violet rays fall on them the old erased characters become apparent; and this is important because they are often of greater archaeological interest than the superimposed visible writing.

Recently the filtered rays have been used for the examination of fossil remains and, as all organic substances fluoresce, much greater detail has been revealed.

CHAPTER IX

BIOLOGICAL EFFECTS OF ULTRA-VIOLET RADIATION

Absorption by Protoplasm—Effect on *Cyclops quadricornis*—
Effect on Growing Seedlings—Sensitization of Cells to Light
—Effect of Rays on the Skin—Erythema—Pigmentation—
Effects on Bacteria—On Cardio-Vascular System—On Blood
—On Metabolism—Calcium Metabolism—On Endocrine
Glands—On the Eye—On the Alimentary System—On the
Nervous System

THE physiological effect of light is probably mostly due to the photochemical reactions that result when rays are absorbed. We know that the chemical rays bring energy to the body that absorbs them, and that this energy is transformed in various ways.

Of the many theories advanced to explain the mode of action of ultra-violet radiation, the three principal are these:

(1) That the autonomic nervous system is directly influenced by the stimulation of the nerve endings in the skin, the nerves being stimulated by the oscillations of cells. There may also be a direct photo-electric action on nerve endings. Dixon, however, thinks that this nerve stimulation is due to fluorescent substances, such as quinioidine, that occur in the skin.

(2) That the rays are able to penetrate as far as the capillaries of the corium, and that they are absorbed by the blood, where changes occur leading to widespread systemic reactions.

(3) That some substance formed in the epidermis acts as a hormone.

Harthausen considers that the skin fat is rendered photo-active by irradiation; the body certainly has a curious characteristic smell, rather like that of burnt horn, after exposure to ultra-violet rays, as if some chemical reaction had taken place on the surface of the skin.

Pincusson considers that ferments are formed by the destruction of some of the superficial cells, and others think that some substance is formed from the breaking up of the chromatin bands of the cell nuclei, or again that the electrical state of protein is altered by ultra-violet irradiation, there being a change in hydrogen-ion concentration.

It is probable that the three theories are all partly correct, and that the reactions following irradiation actually occur in the different ways suggested by them.

Most of the constituents of living cells are colourless, since they do not absorb visible rays; but the great majority of them absorb ultra-violet rays strongly, so that ultra-violet radiation has a marked effect on living cells, as could be expected from Grotthus's law. This fact is made use of in taking microphotographs of living tissues.

It has been found that the various constituents of protoplasm begin to absorb light markedly in the region of 3000 Å. The whole protoplasm of minute organisms is affected when they are exposed to ultra-violet radiation, and the laws of simple photochemical reaction govern the change. We ourselves repeated some experiments showing the effect of ultra-violet

radiation on the small pond crustacean *Cyclops quadricornis*. They were exposed in a Petri dish containing tap water at a uniform distance of ten inches from a "Hewittic" burner. In one series of experiments we placed two cyclops in Petri dishes. These were exposed to ultra-violet rays until all movement had ceased. At first mobility was greatly increased, the cyclops going round in small circles at a very rapid rate, but movement gradually slowed down until it finally ceased. This time was noted with a stop-watch:

Uncovered Petri dish	All movement of cyclops ceased in	{ 1 min. 15 sec. 1 min. 40 sec.
Petri dish covered with thin celluloid	" " "	{ 3 min. 50 sec. 3 min. 50 sec.
Petri dish covered with 15 oz. glass	" " "	{ 5 min. 30 sec. 6 min. 30 sec.
Petri dish covered with 21 oz. glass	" " "	{ 5 min. 30 sec. 5 min. 30 sec.
Petri dish covered with 26 oz. glass	" " "	{ 8 min. 10 sec. 8 min. 20 sec.

These results show that glass cuts off most of the abiotic radiations. Next, pairs of cyclops were placed in watery solutions of two fluorescent dyes, aurantine O and fluorescein, for twelve hours, and then removed and placed in tap water in Petri dishes as before, with the following results:—

Cyclops which had been in aurantine O solution	All movement ceased in	{ 6 min. 45 sec. 8 min. 30 sec.
Cyclops which had been in fluorescein solution	" " "	{ 8 min. 38 sec. 8 min. 30 sec.
Control with untreated cyclops in Petri dish	" " "	{ 3 min. 0 sec. 3 min. 45 sec.
Control covered with 15 oz. glass	" " "	{ 8 min. 15 sec. 8 min. 45 sec.

These experiments show that previous immersion of the cyclops in a fluorescent solution has the effect of protecting it from subsequent exposure to ultra-violet rays, the fluorescent matter present converting the ultra-violet rays into visible rays, which are not generally harmful to protoplasm. If, however, the size of the organism is greater, the effect is more on the surface, owing to the small penetrative power of ultra-violet rays; but there is a partial diffusion of the reaction throughout the organism. The exact effect of ultra-violet radiation on protoplasm is unknown, but definite alteration in its chemical composition occurs.

Experiments to show the Effect of Ultra-Violet Radiation on Seedlings.—In 1925 we carried out some simple experiments with seedlings, comparing the growth under identical conditions of seedlings screened by Vitaglass with that of others under ordinary glass. The Vitaglass seedlings germinated before the others and showed a much taller, sturdier growth.

I. Cress seeds were sown in four small jars covered with muslin, kept moist with water and fairly warm (about 60° F. on the average).

No. 1 was grown in total darkness.

No. 2 was grown mostly in darkness, but was exposed daily to radiation from a mercury vapour lamp at a distance of 24 in. for thirty minutes.

No. 3 was also grown mostly in darkness, but was exposed, in the same way as No. 2, for sixty minutes daily.

No. 4 was grown in daylight.

Results :

No. 1 showed typical etiolated growth. The seedlings were very tall and delicate and showed no sign of chlorophyll formation.

No. 2.—The seedlings were very short and shrivelled-looking. Some of the seeds did not germinate. There were slight signs of chlorophyll formation.

No. 3.—Several of the seeds did not germinate. Growth was very short and the plants looked burnt-up. Chlorophyll was present in the small wizened leaflets.

No. 4 showed normal sturdy growth, with abundant chlorophyll. This shows that unfiltered radiation from a mercury vapour lamp is inimical to plant growth, but aids chlorophyll formation, owing, no doubt, to the visible light emitted by the mercury vapour lamp.

II. Mustard seeds were sown as above in seven jars covered with muslin and kept warm and moist.

No. 5 was grown in total darkness.

No. 6 was exposed for five minutes daily to ultra-violet radiation, and then left in darkness.

No. 7 was exposed for ten minutes daily, and then left in darkness.

No. 8 was exposed for fifteen minutes daily, and then left in darkness.

No. 9 was exposed for twenty minutes daily, and then left in darkness.

No. 10 was grown in daylight.

No. 11 was grown in daylight, but was exposed in addition for five minutes daily to ultra-violet radiations from a mercury vapour lamp.

Results :

No. 5 seedlings showed etiolation—no chlorophyll formation.

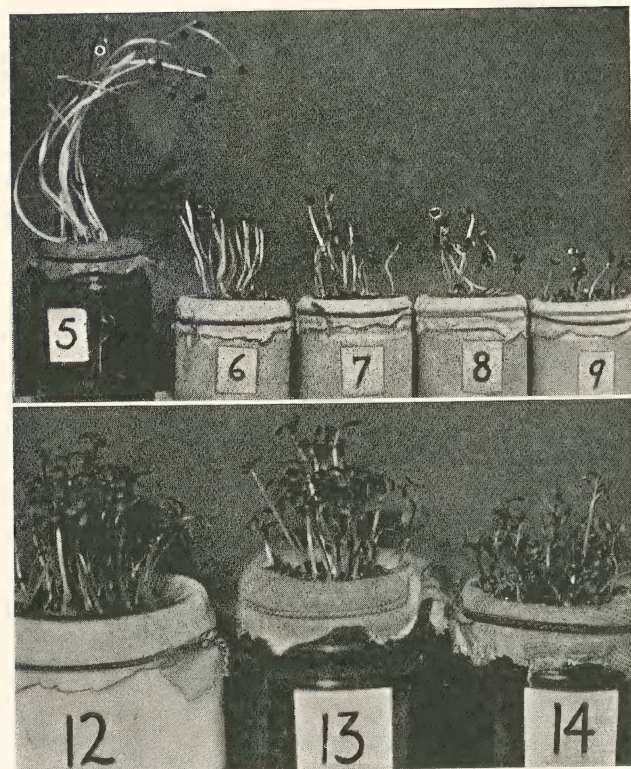


FIG. 149.—Illustrating the Effect of Ultra-Violet Rays on Seedlings.

Jars 5-9 : Effect on Mustard Seedlings. Jar 12 : Cress Seedlings grown in Daylight. Jar 13 : Grown in Daylight, but covered with glass and exposed to U.V.R. for thirty minutes daily. Jar 14 : Grown in Daylight, but exposed to unfiltered U.V.R. for thirty minutes daily.

No. 6.—Inhibition of growth—slight chlorophyll formation.

No. 7.—Greater inhibition of growth—some chlorophyll formation.

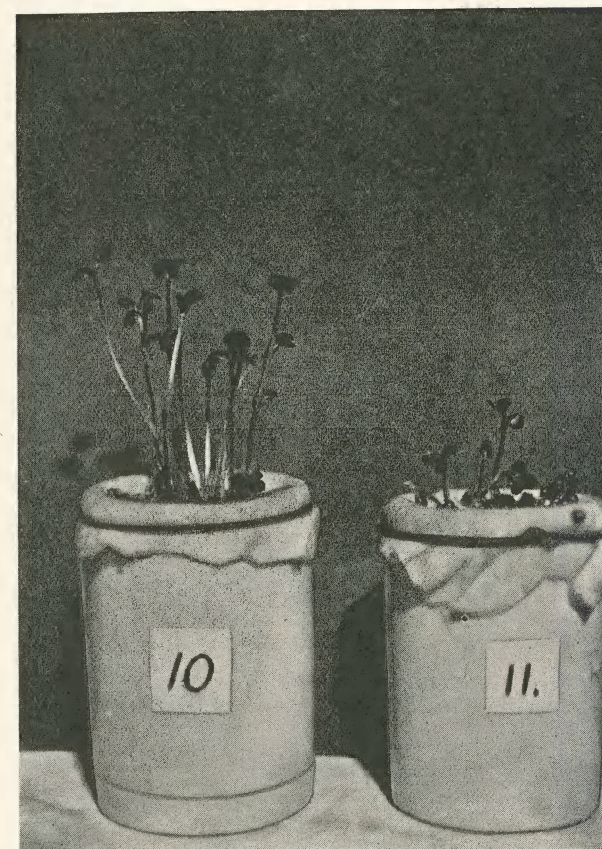


FIG. 150.—Showing the Effect of Ultra-Violet Radiation on Mustard Seedlings.

No. 8.—Greater inhibition of growth—some chlorophyll formation.

No. 9.—Same wizened appearance of seedlings as before—some chlorophyll present.

No. 10.—Normal healthy growth—normal amount of chlorophyll present.

No. 11.—Same inhibition of growth as in seedlings 6, 7, 8, and 9, grown in darkness—normal amount of chlorophyll present.

It is seen that exposures as short as five minutes daily to the unscreened radiations of a mercury vapour lamp are detrimental to growth in light or in darkness, although some chlorophyll formation may occur in etiolated plants. Recent work on *Voandzeia* and other plants shows that daily irradiation with a similar type of lamp at a distance of three feet for two minutes—or even for only a minute—causes definite structural changes and more or less retardation of growth (Delf, Ritson, and Westbrook, 1927). In further experiments, the results of which have not hitherto been published, a screen of Vitaglass was employed, cutting off all radiation of wave-length less than about 2700 Å, and approximately 70 per cent. of the rays 2900 Å. The time of exposure was increased, and the distance reduced to two feet to compensate for the absorption of part of the transmitted light, but no stunting effect resulted, nor was any other structural change found. The changes previously observed were, therefore, presumably due to the rays of short wave-length. It is possible that, with still further reduction of effective radiation, a harmless or even beneficial result might be seen. In this connexion it is of interest to note that the time of year, the length of day, the temperature, and other factors, certainly influence the reaction of plants to ultra-violet radiation.

Experiments by the same authors are in progress on the effects of ultra-violet rays on the epidermis of plants. This is shown in many genera by the appearance of a yellow or brown colour, and, as in the case of irradiated human skin, there is a definite latent period before the reaction becomes evident, unless, of course, an excessive exposure has been given.

This effect on plant life is different from that which is found on exposure of seedlings to radium emanations, for, although large doses of these inhibit growth, small doses stimulate it.

It is possible, by the use of eosin, chlorophyll, some derivatives of hæmoglobin (hæmatoporphyrin), and certain aniline dyes, to sensitize living cells and to cause, by the action of visible light, abnormal conditions such as are otherwise produced only by means of ultra-violet radiation. For example, if a mouse is sensitized by the injection of eosin, no change takes place in darkness, but the animal dies within a few hours when exposed to daylight.

Finsen drew attention to the fact—which he found from his experiments on animals—that the excitation produced by the actinic rays reveals itself only after a definite time has elapsed, and that the greatest effect may occur even after the cessation of the radiation which has been the cause of the excitation.

Perhaps the most noticeable biological effect of ultra-violet radiation is the effect it has on the skin. At the time of radiation nothing is felt by the patient excepting perhaps a faint sensation of warmth due to the incandescence of the quartz. No reddening is noticed at the time, but after a latent period, which

varies with almost every patient, and is generally from four to eight hours, a feeling of heat is experienced in the part exposed. According to the period of irradiation this feeling may increase and lead to great irritation, and even to pain. The part becomes red, hot, and slightly swollen, and exhibits all the signs of mild inflammation, varying in severity according to the dose and the sensitiveness of the patient. This erythema gradually fades and is followed by desquamation. We have noticed that if a second exposure is made on the same part within ten days of the first this erythema is not repeated, but if a larger area is exposed the part that is freshly irradiated undergoes similar changes to the first; and when a patient is irradiated with the arms and neck bare, and the shirt-front open, and at the next exposure the whole chest is exposed, the neck and V appear pale when contrasted with the intense erythema of the surrounding skin. Desquamation occurs about four or five days after exposure, though the hyperæmia may last for several weeks, or only for two or three days. After continued irradiation, pigmentation of the skin results.

Probably because of the vasodilatation which accompanies the erythema, or because of sympathetic paresis, there is almost invariably a fall in the arterial blood pressure. In one case in particular we found there was a fall of 20 mm. of mercury after five minutes' irradiation by the mercury vapour lamp at thirty-six inches distance. This fall occurred before erythema appeared.

The whole metabolism of the body is quickened, and the general health and vitality are benefited.

Ultra-violet rays assist in the formation of antibodies in the blood, and so the immunizing power of the body is raised.

The general action of the rays is proved by the effects they have on lesions far distant from the part irradiated.

An indirect effect that can be claimed for ultra-violet radiation is that it counteracts the diarrhoea and bronchitis so often found in rickets. We have noticed this in those of our own patients whom we are treating for rickets. Another important action of ultra-violet rays is their analgesic effect. It is thought that the rays exert some biologic action on the irradiated interepithelial nerve fibrils. We have noticed this effect chiefly in cases of *Herpes zoster*: the acute pain is relieved even after the first exposure.

Deeper visceral pain also is often allayed. This may be because of the erythema and consequent lessening of internal congestion, or because of the effect on the peripheral area, according to the view that there is a reflex relationship existing between many superficial areas and internal organs.

The Effect of Ultra-Violet Rays on the Skin.—The skin itself has an important protective function, and it is aided in this by the sebaceous matter it contains. It is also an insulator with a high electrical resistance, as everyone who has practised electrotherapy knows. It is an important regulator of the heating mechanism of the body through the medium of the sweat glands. It is also a valuable excretory organ, assisting in the elimination of such waste matters as lactic acid, urea, and carbon dioxide.

It is the site of the formation of antibodies and is an important endocrine organ. It can play its part in the nutrition of the body, such substances as olive oil being absorbed by it. It is an expansion of the arterial and nervous systems, containing the receptors of such stimuli as discrimination of peripheral heat and cold, pain, and tactile sensations. It is a protector of the body against excessive exposure to ultra-violet radiation. It is the site of the activation of hormones and vitamins. Sequeira has said that it is the most extensive sensory organ of the body, and its condition may most profoundly influence the nervous system: an example of this is the severe shock that follows an extensive burn. The skin responds to changes of environment, and also to internal conditions, these responses being manifested by alterations in colour, in temperature, and in moisture.

Hasselbalch gives the following table showing the amount of ultra-violet radiation transmitted through epidermis 0.1 mm. and 1 mm. thick; the figures are given as percentages of the incident radiation:

Wave-Length	4360	4050	3660	3540	3130	3020	2970	2890
0.1 mm. .	59	55	49	42	30	8	2	0.01
1 mm. .	0.5	0.3	0.08	0.02	..	..	..	..

The absorption by the skin of ultra-violet rays, especially the rays of very short wave-length, is very great, all rays shorter than 3000 Å being absorbed by a layer of

epidermis 0.1 mm. in thickness. The shorter the wave-length the thinner the layer that will completely absorb it: 2.5 mm. of skin are opaque to indigo and violet rays (4358 Å). Long wave-lengths are absorbed to a smaller extent. This is easily demonstrated by noting the sensation of red experienced when the eyes are closed and a source of light is placed in front of them, or when the facial sinuses are illuminated. We have noticed that if the eyes are closed when one is standing close to the quartz mercury vapour burner a sensation of green is apparent: this shows that red rays are absent from mercury vapour radiation, and also that green rays are capable of penetrating the eyelids.

Macht found that ultra-violet rays could penetrate to the capillaries when he experimented with a spectroscope inserted beneath living skin.

Blood serum absorbs all rays below 3000 Å, and normal blood not only absorbs all rays with wave-lengths less than 4500 Å, but also has two absorption bands—one at 5400 Å, and the second at 5750 Å.

As a result of the absorption of the ultra-violet rays by the skin certain changes take place. It is thought that the rays convert the cholesterol in the skin into vitamin D, which stimulates calcium and phosphorus absorption. Pacini mentions that there is at first a period of vasodilatation, which is followed by vasoconstriction if irradiation is continued. This he proves by eliciting the "adrenal reflex" by stroking the skin, when it will immediately blanch and then appear red. If this is repeated while the part is being irradiated with the quartz mercury vapour lamp, it is

found at first that the reaction time between the initial blanching (vasoconstriction) and the ultimate reddening is markedly lessened; this is the period of vasodilatation. If the exposure is continued, the reddening disappears, and is again succeeded by



FIG. 151.—Specimen of Cholesterol crystallized from Solution in Alcohol. (Photograph by Mr Spencer Breslin.)

blanching (vasoconstriction). It must therefore be concluded that short exposures to the rays cause vasodilatation, and longer exposures cause vasoconstriction. A healthy non-pigmented skin takes on the appearance of "goose flesh" when exposed to cold; but this rapidly disappears under the ultra-violet rays.

Erythema.—Erythema is undoubtedly one of the

most important phenomena occurring in actinotherapy. Erythema from sunlight most often occurs in spring, when the previous summer's pigment



FIG. 152.—Pigmentation due to the action of Heat Rays.

has disappeared. It has been found that erythema causes an immediate rise in the amount of calcium in the blood, and that this decreases as the erythema fades.

Actinic erythema must be clearly distinguished

from erythema caused by infra-red rays, which appears actually during irradiation and soon disappears afterwards, whereas actinic erythema appears only after a latent period of from four to twelve hours. This latent period is very variable. The erythema produced by ultra-violet radiation also differs from other inflammations in that it is nearly always followed by pigmentation.

The erythema varies in severity, according to the length of exposure and the sensitiveness of the patient, from a faint reddening to necrosis of the epidermis with the formation of blisters containing serous fluid.

Saidman mentions two cases where ultra-violet irradiation was followed immediately by the appearance of erythema—one of these patients was pregnant and the other was suffering from asthenia associated with endocrine disturbance. He also describes a case of carcinoma which had a hæmorrhagic type of erythema.

Fair people react more strongly than dark, and the "red" type is more sensitive than either. It is often difficult to produce erythema in infants, and for this reason great care should be exercised in irradiating them, for fear of giving an overdose. Signs of overdose are loss of weight, insomnia, and increased irritability. We have also found that normal skin is more sensitive to irradiation than morbid skin, and also that parts generally covered by clothing are especially liable to the subsequent development of erythema. It is difficult to produce erythema on the palms of the hands or on the soles of the feet.

The duration of the erythema also depends upon its severity and the reactivity of the patient, and varies between two days and several weeks.

Erythema is sometimes preceded by an abnormal sensitiveness of the skin; and the colour of the erythema disappears on pressure.

Erythema is accentuated when ultra-violet rays are applied conjointly with luminous and infra-red rays. If drugs such as iron or arsenic are taken internally, erythema may be intensified, but resorcin ($C_6H_4(OH)_2$), on the other hand, decreases it. The whole range of rays between 3130 and 2530 Å can cause erythema, but the maximum effect is produced by rays of 2970 Å, which provoke almost one-third of the total erythema.

Hausser and Vahle give the following table :

Wave-length	3130	3020	2970	2890	2800	2650	2530 Å
Activity	45	58	100	30	28	19	16

Angus found that the relative powers of the following sources of radiation to produce erythema were in the order given below :

- (1) New mercury vapour lamp.
- (2) Carbons with pulverized iron cores.
- (3) Tungsten arc.
- (4) Cerium-cored carbons.

Chemical changes occur in the stratum corneum, where the ultra-violet rays of short wave-length are absorbed; but the maximum vital response takes place in the cells of the basal layer of the *Rete mucosum*. This important layer of cells has for its function the reproduction of destroyed skin, keratinization, and

the formation of pigment. The capillaries in the dermis are influenced by the absorption of substances formed in the irradiated epithelial cells.

The phenomenon is probably partly photochemical and partly photo-electric, arising from the actual penetration of electrons.

It has been found experimentally that there is a more rapid onset of actinic erythema in an area if the sympathetic nerve controlling it has been cut, and that the redness also subsides more quickly than usual.

We have often noticed that when a small area is strongly irradiated the resulting erythema is most marked around its periphery, though little dark red spots appear dotted over the whole area.

The irradiated skin is more sensitive than normal skin to painful stimuli, and feels hotter and rougher to the touch.

Microscopic examination of the skin reveals serous swelling in the deeper layers of the epidermis, the cell nuclei of the granular and Malpighian layers being especially affected. Vesicles form, and there is a migration of leucocytes into these two layers.

The diameter of the capillaries increases to from two to four times their normal size. The blood stream slows down till it comes to a standstill in the affected area.

Twenty-four hours later there is active diapedesis from the non-thrombosed vessels, with marked oedema, and the reaction is at its height about thirty hours after exposure.

When the exudation is sufficiently great to break

continuity between the stratum corneum and the stratum granulosum, blisters occur. The thrombi in the superficial vessels are removed by phagocytes. Some days later, if the exposure has been sufficiently powerful to cause necrosis of the epidermal cells, desquamation results.

Fauré-Fermiet, experimenting on the eggs of a certain ascaris, found that fragmentation of the chromosomes occurred. This probably takes place in the human epidermal cells on irradiation, and the subsequent erythema that occurs after several hours may be due to some substance formed from the broken-up chromatin.

Pigmentation.—Pigmentation can occur only if there has been a preceding erythema. The phenomenon is due to the deposition of the pigment melanin as granules round the nuclei of the basal cells of the epidermis. These granules form a screen round the nuclei and protect them from an overdose of ultra-violet rays, and when pigmentation has once taken place there is much less danger of excessive actinic erythema. At the same time it is unlikely that the pigment granules, which are situated in the basal layer, can protect the stratum corneum. In therapeutics the appearance of pigmentation necessitates the administration of longer exposures.

The rays that are most potent in producing pigmentation are those between 2900 Å and 3300 Å, which are the shortest wave-lengths of the solar spectrum. Waves shorter than 3300 Å are absorbed by glass, and since it is known that pigmentation does not take place if sunlight first passes through glass,

INFRA-RED | VISIBLE | ULTRA-VIOLET RAYS

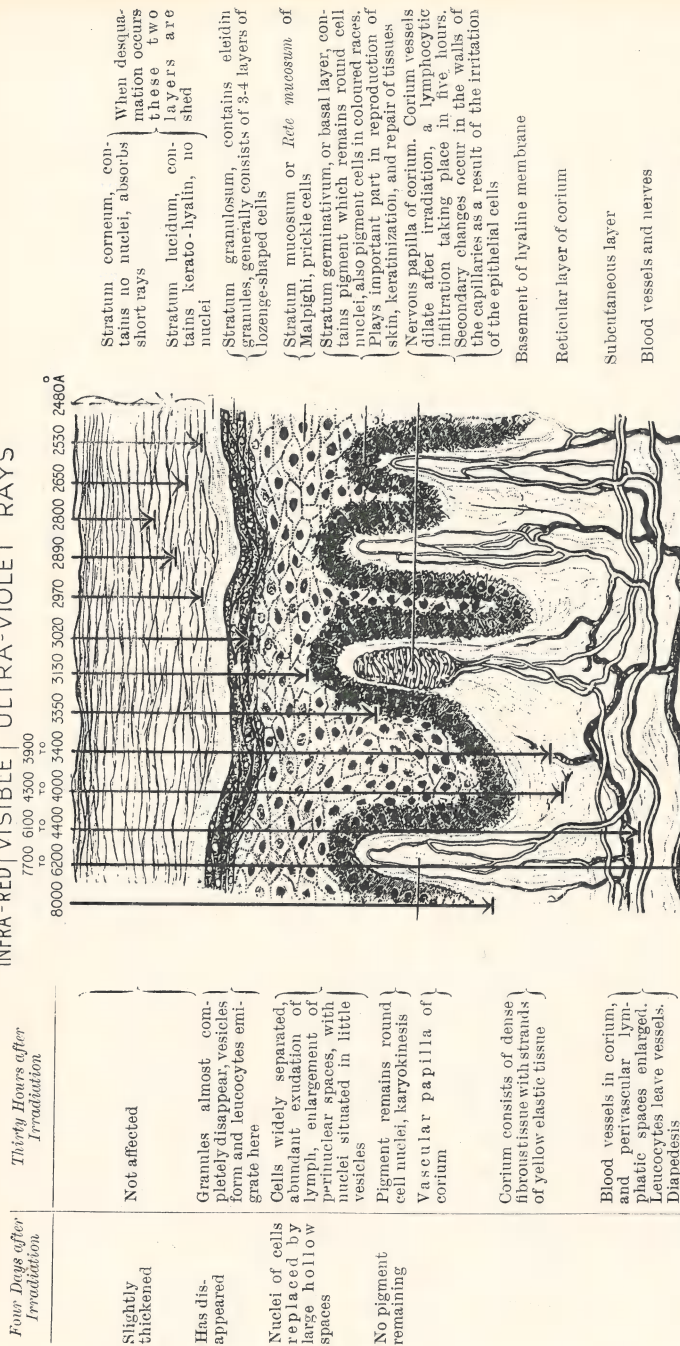


Fig. 153.—Vertical Section of the Epidermis and Papillae of Corium, showing diagrammatically the Penetration of different Wave-lengths. After Irradiation of the Skin the primary changes occur in the Epidermal Cells, which absorb the Ultra-Violet Rays, the Stratum Germinativum or Basal Layer being especially affected. The cells of this layer produce horny substance and pigment, and are also constantly forming new cells. They also secrete a substance which is absorbed by the blood vessels of the corium, and thus circulates throughout the body. The termination of the medullated nerve fibres is in the touch corpuscles at the apex of the papillae, but non-medullated fibres pass through the corium and appear to end in the stratum mucosum.

BIOLOGICAL EFFECTS

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it is clear that the longer waves do not cause this effect. Again, rays shorter than 2900 Å produce a strong erythema, which is not followed by any marked pigmentation.

The screen formed by the pigmentation is thought to convert light into heat. Its use as a screen is evident if some melanin, obtained from the eye of an ox, is mixed with water and placed in a quartz tube, which is held in the palms of the hands while the sun's rays are focused on it by means of a burning-glass. The skin underneath the tube is unharmed, but the water in the tube is evaporated because the pigment absorbs the rays and converts them into heat. In the same way the deeper structures of the skin are protected and profuse sweating is promoted.

Pigmentation also ensures the maximum amount of absorption of ultra-violet radiation, and therefore an increased therapeutic reaction. Rollier observed close parallelism between the amount of pigmentation and the beneficial therapeutic results, and he considers that the possible effect of the pigment is to transform rays of short wave-length into longer and more penetrating rays. This theory was based on the fact that in some places where the amount of sunlight, and hence of pigmentation, is small, better results were obtained when fluorescent substances were painted on or injected under the skin.

Rollier is inclined to think that if pigment is important in this way in phototherapy, it may be that the fall of potential observed in photochemical reactions takes place because of it; but under Wood's monochromatic light, which produces fluorescence

in all substances possessing that property, freckles and pigmented areas are found to be entirely non-fluorescent. Reyn, however, disagrees with Rollier and says that non-pigmenters often show excellent therapeutic results.

Gordon Pugh, at Carshalton, has investigated 232 cases of tuberculosis of the spine and of the hip and knee joints, and has carefully noted the degree of pigmentation in each case. Three and a half years later the mortality was found to have been 16 per cent. among the very good pigmenters; 15 per cent. among the good pigmenters; 10 per cent. among the slight pigmenters; and only 9 per cent. among the non-pigmenters.

Melanin itself is supposed to be the end product of oxidation of tyrosin, probably through the agency of an oxidizing ferment such as tyrosinase. Tyrosin, which is colourless, and a vaso-constrictor, circulates in the blood, and is also present in the basal epidermal cells. Rothman has shown that there is a fall in the amount of blood tyrosin when pigment is deposited.

Bloch proved the presence of an enzyme in the production of melanin, which he termed "dopa oxydase." He made use of dioxyphenylalanin, which he brought into contact with skin. A brown coloration resulted, which was granular and appeared in the basal cells of the epidermis. This reaction did not take place in an albino skin, and was activated by all agents causing pigmentation, especially light.

Variations in the colour of the pigmentation obtained from different sources of radiation have been noticed, the carbon arc producing a reddish brown

hue and the mercury vapour lamp a more greyish coloration.

Sequeira has found that he is able to produce pigmentation more rapidly with the carbon arc than with the mercury vapour lamp. Pigmentation is rare in infants.

The degree of pigmentation has no direct relationship to the intensity of the preceding erythema.

Pigmentation is also associated with the resistance of the skin to infection. It has been found that in specific infections the rash did not appear on the pigmented parts of the body, but was present on any white skin that had been kept covered. Dr Leuba noticed in the Swiss army that men who had been used to working in the fields, stripped to the waist, and had become pigmented, would not respond to vaccination until the skin was actually cut through instead of being merely subjected to the usual scarification.

Skin infections such as acne and boils are almost unknown among black tribes. Artificial ultra-violet rays confer a similar immunity, making it practically impossible for skin infection to exist or occur.

The skin plays an important part in the activation of hormones and vitamins, and many avitaminic conditions are caused by the lack of ultra-violet irradiation.

The temperature of the skin, the underlying tissues, and the blood, is raised owing to the absorption of the rays and the conversion of the radiant energy of shorter wave-length into heat. This results in a stimulation of the sweat glands, either locally over the part

irradiated, or generally, owing to the raising of the general temperature by the circulation of the warmed blood. The pigmented skin is effective in protecting patients against changes in temperature and exposure to dampness, and its insulating properties are enhanced by the increased deposition of subcutaneous fat.

Pigmentation may persist for a considerable time. Three years ago one of us exposed several small areas on both forearms to ultra-violet radiation for the purpose of preparing an illustration showing the use of the test-dosage armlet. Several of these areas can still be clearly distinguished.

The protective effect of pigmentation, however, lasts only for a short time, and may wear off in from six to eight weeks.

Dufestel considers that rapid depigmentation is much more important than the speedy appearance of pigment in the first place.

Pigmentation plays an important part in animal life, especially in that of polar animals, whose coats are generally dark in summer and white in winter.

Effects on Bacteria.—In 1877 Downes and Blunt proved the bactericidal action of light. Two series of culture tubes were submitted to irradiation. One set of tubes was surrounded by lead-foil, which prevented the action of light, but not that of heat. The other tubes were left uncovered, and it was found that it was only in the former that the organisms grew. The media in which the bacteria were killed were again inoculated with organisms, which developed normally, and thus proved that the light

acted on the organisms themselves and not on the media, and that heat alone had no bactericidal effect.

In 1890 Robert Koch showed that tubercle bacilli were killed by light. Sputum bacilli spread in a thin film on glass slides and exposed to direct sunlight are killed in ten minutes.

In 1917 Browning and Russ produced the spectrum of a tungsten arc by means of a quartz spectroscopie on a gelatin plate inoculated with micro-organisms.

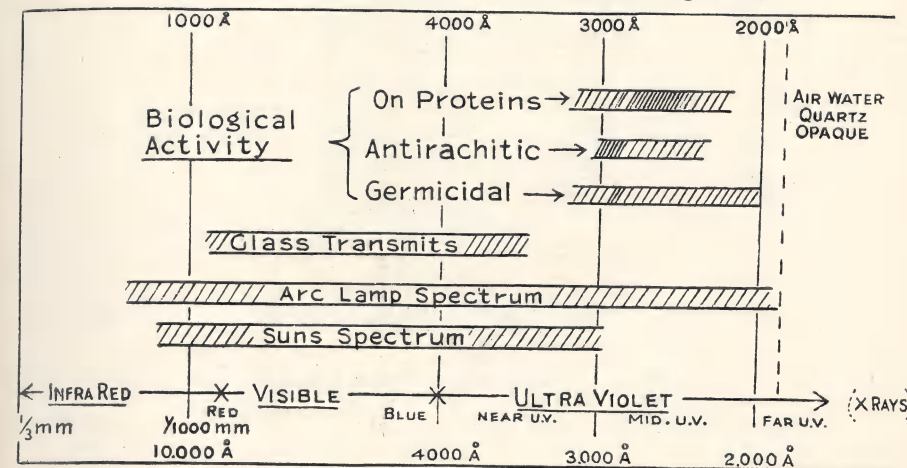


FIG. 154.—Diagram of Wave-Length Ranges. (After Griffith and Taylor.)

Sharply defined vertical areas resulted, some showing growth, others showing none. The region shown to be most actively bactericidal lay between the rays of 2960 Å and 2100 Å. Wave-lengths slightly longer than 2960 Å were lethal after much longer exposures, or at a higher temperature. The sharp lines of demarcation suggested selective absorption, and this was proved by examining absorption spectra of suspensions of organisms used in the former experiments.

The absorption of ultra-violet rays by bacteria is principally due to the large amount of tyrosin and phenylalanin that they contain, and epithelial cells

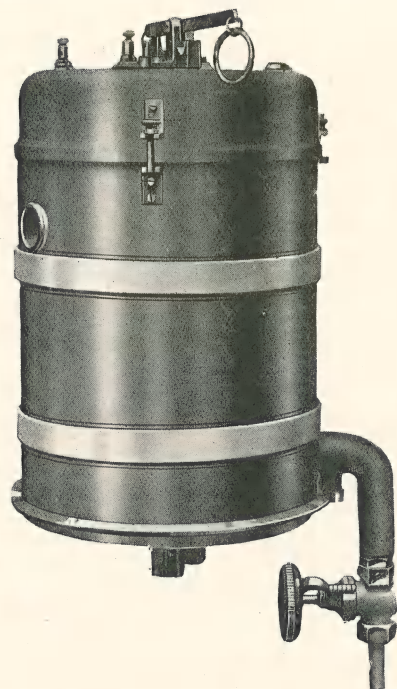


FIG. 155.—“Hewittic” Water Sterilizer.

may often be stimulated by rays that are markedly bactericidal.

The region of the rays absorbed by the bacterial emulsion corresponded almost exactly to the portion of the spectrum of most marked bactericidal power. Browning and Russ divided the ultra-violet region into two parts—namely, the region between 3800 Å and 2960 Å, where there is the greatest penetrative

power, but no marked bactericidal effect, and the region between 2960 Å and 2100 Å, where there is marked bactericidal effect, but no power of penetrating even one-tenth mm. thickness of skin.

Opinions on the action of the rays of longer wavelengths are diverse. Some scientists consider that these rays favour the growth of bacilli; but all are agreed in recognizing the powerful germicidal action of the shorter ultra-violet rays. It has been suggested that this is due to the formation of ozone and hydrogen peroxide in the medium, which would kill the organisms; but the short length of time necessary (fifteen to sixty seconds) for the lethal effect proves this theory to be incorrect, because it takes a much longer time for even the slightest trace of these substances to be formed; and, further, if the medium is inoculated after the irradiation there is no effect on the organisms.

Water, which is probably more transparent to ultra-violet rays than any other liquid we know, can be sterilized by ultra-violet radiation if it is passed through an apparatus where it must come into contact with a quartz plate separating it from a mercury vapour lamp.

Ultra-violet radiation destroys the secretions and toxins of organisms, but only after a longer period than is necessary to kill the organisms themselves. The resistance of bacteria to ultra-violet radiation does not vary in the same way as their resistance to antiseptics and to heat.

Young cultures are more sensitive than old ones. Spores are often twenty times more resistant to certain

chemicals than bacteria are, but this does not apply to their resistance to ultra-violet radiation, for which the figure is only 1.5 to 5 times. The abiotic effect is independent of temperature. It can take place just as easily in clear ice as in water.

Ultra-violet rays are absorbed by the protoplasm

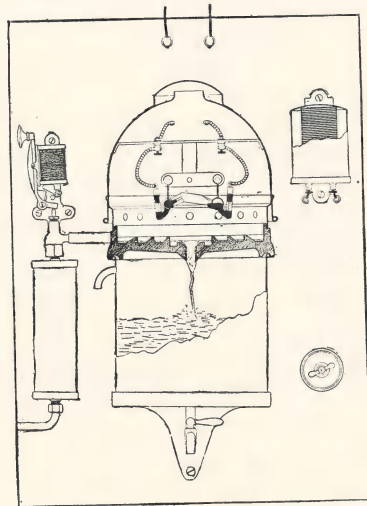


FIG. 156.—Diagram of "Gallois" Water Steriliser.

of the organism, and in a culture, or on the surface of a wound, one bacterium will protect a second lying under it ; so in a lesion such as lupus very little beneficial therapeutic effect can be considered to be due to the bactericidal effect of the rays. It is due rather to an increased bactericidal property of the blood itself, increased lymphocytosis in the part, and stimulation of cicatrization.

The destructive effect on bacteria is apparently due to coagulation, one view being that ultra-violet

radiation kills living cells and tissues by affecting their protoplasm in such a way that it is made possible for certain salts to combine with the protein of the protoplasm and form insoluble compounds. The colloids of the cell, particularly of the nucleus, are modified. Another theory is that the cause of death of the bacteria is the heat coagulation that follows sensitization by ultra-violet radiation.

Wishing to prove the bactericidal action of ultra-violet radiation for ourselves, we exposed Petri dishes containing agar sown with fresh cultures of *staphylococcus aureus* and *bacillus coli* to the radiations from a mercury vapour lamp at a distance of ten inches. We found that all the organisms were killed after five seconds' exposure. We repeated the experiment, but placed screens of various materials between the lamp and the organisms, and found that no inhibition of growth took place when the rays passed through glass, only very slight inhibition when they passed through celluloid, and marked inhibition with gelatin. This shows that glass cuts off rays having wave-lengths shorter than 2960 Å, whereas celluloid allows some bactericidal rays to pass through, and gelatin is even more permeable to these rays.

The agar plates on which the growth of bacteria had been killed were again inoculated for twenty-four hours at 37° C., and normal growth was found, showing that the rays act on the bacteria themselves, and not on the medium on which they are grown.

Angus, using the following sources of radiation, and experimenting with hay infusoria, has found that

the relative power required to produce equal lethal effects is as follows :

Source	Relative Watts
1. Mercury vapour lamp . . .	1.0
2. Tungsten arc . . .	1.1
3. Carbon with pulverized iron core . . .	2.2
4. Carbon with cerium and iron core (1) . . .	2.2
5. Hollow plain carbon . . .	2.7
6. Carbon with cerium and iron core (2) . . .	2.8
7. Carbon with cerium core . . .	3.6

Cardio-Vascular Effects.—When the body is exposed to ultra-violet radiation, dilatation of the surface capillaries results in disengorgement of internal viscera and vessels. The blood pressure in cases of hyperpiesis is thus reduced and the patients are greatly relieved.

Several eminent phototherapists have proved this phenomenon, and Bach found that a fall of blood pressure followed irradiation in 105 cases out of 109. We ourselves have had very satisfactory results in cases of hyperpiesis in practice, especially where the systolic blood pressure exceeded 200 mm. of mercury.

The general health of the patient improves, headache is relieved, and the "weighted" feeling of the limbs disappears. In cases of heart lesions the dilatation of cutaneous vessels and lowering of blood pressure lessens the work of the heart, and dyspnoea is often relieved.

Chilblains have been successfully treated by actinotherapy; and so also have cases of Raynaud's disease.

Effects of Ultra-Violet Radiations on the Blood.—

It is an interesting fact that although ultra-violet rays have so little penetrating power they are still capable of producing profound blood changes.

Normal blood absorbs all rays with wave-lengths less than 4500 Å, and has two other absorption bands, one at 5400 Å and the other at 5750 Å. Exactly how the rays of energy are stored and carried is as yet unknown, but it has been discovered that a photochemical product, vitamin D, is formed at the surface and conveyed to the internal organs by the blood stream.

Finsen found that there was a definite seasonal variation in the number of red blood corpuscles, the maximum occurring at the end of summer, and the minimum at the beginning of spring.

It is generally agreed that exposure to ultra-violet rays increases the number of red blood corpuscles.

Rollier finds that there is a constant increase in the amount of hæmoglobin and the number of red corpuscles in patients undergoing heliotherapy, but altitude may play a part in these cases.

In a series of blood estimations which were made in the case of a large number of soldiers, first in a temperate climate and then after their transfer to the tropics, it was found that the red blood corpuscles and lymphocytes were considerably increased in number and the polymorphs decreased, and the blood pressure was also lowered.

It seems certain that ultra-violet rays stimulate the hæmopoietic system.

We ourselves found that an increase in the number

of erythrocytes from 4,300,000 to 5,725,000 occurred in one case in three weeks. The hæmoglobin increased from 70 to 90 per cent. in the same length of time.

Sunlight, ultra-violet rays, and heat, all produce an increase in the lymphocyte count.

The lymphocytosis caused by ultra-violet radiations has been found to be almost entirely due to rays shorter than 3300 Å. Rays longer than 3300 Å cause leucopenia. Bunting and Huston have shown that more lymphocytes can enter the blood stream from the thoracic duct during twenty-four hours than are present in the blood stream at any time. The excess of cells migrates from the blood vessels into the mucous membranes, chiefly those of the gastro-intestinal tract. If small animals are killed after irradiation by the mercury vapour lamp, the lungs, liver, and spleen are found to be greatly engorged with blood, especially the spleen. It is therefore sometimes supposed that the increase in white cells is due to stimulation of the lymphocytic organs.

This engorgement of the viscera cannot of course be proved in human beings, and an opposite action is thought to take place because of the cutaneous erythema and lowered arterial blood pressure.

Some observers have noticed a slight increase in eosinophilic leucocytes after irradiation. We ourselves found on making differential counts in one case that these cells increased from $3\frac{5}{8}$ to 6 per cent. in a fortnight, this being a relative increase of 69 per cent. The number of blood platelets in the blood is also increased. If an animal is kept in darkness and fed on a diet deficient in fat soluble A vitamin the number

of blood platelets is reduced, but they are rapidly increased to normal after irradiation with the quartz mercury vapour lamp. Cramer and Drew consider that blood platelets are part of the defensive mechanism against infection by bacteria.

By testing the effect of blood after irradiation on typhoid agglutinins, and by drawing conclusions from its increased resistance to diphtheria toxin, Sonne proved that irradiation causes a rise in its antigenic properties.

Red corpuscles in the blood are protected from hæmolysis by the absorption of the ultra-violet rays by the serum. This protective action is supposed to be due to the absorptive power of the amino-acids tryptophan and tyrosin contained in the serum. Red corpuscles suspended in saline are readily hæmolysed by ultra-violet rays, probably because of the absorption of the rays in a similar way by tyrosin and phenylalanin, which are also present in the protein of living cells, with the result that the chemical composition of the cells is changed and cellular death occurs.

Ultra-violet radiation increases the amount of calcium, phosphorus, and iron in the blood, and the tyrosin increases and reaches its maximum during the presence of erythema, falling to normal again when pigmentation occurs. Hyperglycæmia decreases, but irradiation augments the iodine content of the thyroid gland, and raises the temperature of the blood. A basic hydrogen-ion concentration in the blood is produced by ultra-violet irradiation; and hence its value in diabetes, acidosis, and rickets.

Reed, experimenting with animals, inserted a quartz tube into the severed ends of one of the carotid arteries, after having injected heparin to prevent the blood from clotting. He then irradiated the quartz tube, and found that there was a small but definite reduction in the negative electrophoretic potential of the red blood cells.

Experiments on Human Blood.—Owing to the kindness of Professor Burns (Professor of Physiology at Durham University) we were able to carry out some experiments on the effect on the human body of irradiation with ultra-violet rays. The lamp used was of the "K.B.B." pattern, and irradiation was carried out at thirty inches from the lamp in a dark room. At first short doses were given, and these were gradually increased to thirty minutes' exposure of the back and front of the whole body daily. The irradiation was continued for twenty-three consecutive days, except on Sundays, and frequent notes were made of the pulse, the systolic blood pressure, the number of red and white cells per cubic millimetre, and the percentage of the various types of leucocytes. The pulse rate remained practically unchanged; the systolic blood pressure tended to drop slightly; the hæmoglobin percentage rose regularly from 70 to 90 per cent.; and the red blood corpuscles also increased from 4,300,000 to 5,725,000. The total number of white cells varied a little, the first and last figures being 10,500 and 11,926 per cubic millimetre respectively. By far the most interesting changes were those that occurred in the relative numbers of the white blood corpuscles—*i.e.* the differential counts.

The initial figures were: polymorphs, $70\frac{1}{2}$ per cent.; large mononuclears, $5\frac{7}{8}$ per cent.; small mononuclears, $20\frac{3}{8}$ per cent.; eosinophils, $3\frac{5}{8}$ per cent. The final figures were: polymorphs, $56\frac{3}{8}$ per cent.; large mononuclears, $6\frac{1}{2}$ per cent.; small mononuclears, $31\frac{1}{2}$ per cent.; eosinophils, 6 per cent. The polymorphs decreased progressively, though the greatest drop was early. The total fall was 20 per cent. The large and small mononuclears, or lymphocytes, on the other hand, taken together, showed an increase (most marked in the small lymphocytes) of 45 per cent., and the eosinophils increased 69 per cent.

The effect of ultra-violet radiation, therefore, on the blood is to cause a slight increase in the red and white corpuscles, and in hæmoglobin; a diminution in the polymorphonuclear leucocytes; and an increase in the lymphocytes and, most markedly of all, in the eosinophilic cells.

It is also known experimentally that the immunizing and bactericidal properties of the blood are increased, but the connection between these and the changes in the differential white count is not obvious, because it has always been thought that the polymorphs had the greatest bactericidal effect, and yet they are both actually and relatively decreased.

According to four authorities, the average number of white blood corpuscles per cubic millimetre is as follows:

Howell	5000 to 7,000
Gray's <i>Anatomy</i>	7000 to 12,000
Schafer	8000 to 10,000
Halliburton	8000 to 10,000

The percentage of the several kinds of white cells is as follows :

Polymorphs	.	60 to 70 per cent.
Eosinophils	.	1 to 4 „
Small lymphocytes	.	20 to 25 „
Large lymphocytes	.	1 „
Mast cells	.	0.5 to 1 „

Clinically, an increase of polymorphs is seen in inflammatory and allied cases ; of lymphocytes in whooping cough, rickets, and congenital syphilis ; and of eosinophils in certain parasitic diseases and in many skin conditions.

Effects on Metabolism.—The exact way in which ultra-violet radiation affects metabolism has not yet been explained, but exposure to it deeply influences carbohydrate, fat, protein, and mineral metabolism.

Rothman found that actinic erythema reduces pathological blood sugar ; glucose disappears from the urine. The rays appear to have a regulating effect on carbohydrate metabolism, but normal blood sugar is not affected. Ultra-violet radiation should, however, never be combined with the internal administration of insulin, because in this case the amount of blood sugar is increased.

Ultra-violet radiation increases the oxidation of fats.

The amount of carbon dioxide expired is increased, and there is an increase of growth in daylight as compared with darkness. The appetite improves. Inspirations are deeper and slower.

The increased temperature of the blood probably

influences the rate of metabolism, since biochemical reactions may be greatly accelerated by even slight rises in temperature. Ultra-violet radiation has the effect of activating vitamins in the body.

Rollier quotes an interesting case of a man aged forty-five with benign *Diabetes mellitus* of several years' standing, glycosuria twenty grams per litre, easily controlled by dieting. Under heliotherapy the glycosuria practically disappeared on ordinary hotel diet. This was maintained during the whole period of treatment, but after twenty-four hours without a sun bath the sugar appeared again.

Effect on the Muscular and Skeletal Systems and on Growth.—Rollier says "Sunlight is the best masseur," and it will be found that the texture of the skin rapidly improves under irradiation. The condition of the underlying muscles also improves, and flabby wasted limbs soon become strong and firm. Tubercular children whose limbs are being treated by complete immobilization do not get muscle-wasting and loss of tone when exposed to sunlight. Sunlight undoubtedly stimulates symmetrical muscular development.

Experimentally it has been found that contraction occurs when the uterus or the involuntary muscle of the viscera is exposed to ultra-violet radiation.

Calcium Metabolism.—Another phenomenon following exposure to ultra-violet rays is an increase in the calcium content of the blood, and also an increase in the concentration of inorganic phosphorus ; and it is probably due to these changes that actinic-ray therapy is so invaluable in the treatment of rickets. One cause of the beneficial effect is thought to be the decrease of

micro-organisms in the intestine, which allows greater absorption of calcium and phosphorus. Two minutes' irradiation daily with the mercury vapour lamp at a distance of three feet prevents rats, kept in darkness, and fed on a ricket-producing diet, from developing rickets; and a similar dose of rays administered to a baby will double the amount of inorganic phosphorus in its blood in a fortnight.

Very interesting observations were made by Eleanor Mary Hume and Hannah Henderson Smith, of the Lister Institute. Rats were placed in glass jars containing some sawdust and kept in darkness except for ten minutes daily, when they were irradiated by means of a quartz mercury vapour lamp through the tops of the jars with the lids removed. Controls were kept in total darkness. After irradiation the rats were removed, and fresh animals placed in the jars, which were then placed in darkness. It was noticed that the animals that were irradiated grew most quickly. Those that were placed in the irradiated jars grew more quickly than the controls, but not so quickly as the animals that were themselves exposed.

At first it was thought that the air in the jars was affected, but it was later found that if the sawdust was removed from the jar no change took place. A deal board was then substituted for the sawdust, and was also irradiated for ten minutes daily. The result was that the animals that were then placed in the jars on the deal boards grew slightly more quickly than the controls, but not so quickly as when irradiated sawdust was used. It must be con-

cluded, therefore, that in some way sawdust is able to absorb ultra-violet rays and to emit them again afterwards.

It used to be suggested that the reason why cod-liver oil is beneficial in rickets is that the oil itself emits ultra-violet rays when oxidized, but it is now known that this action is due to the presence of vitamin D. Some samples of cod-liver oil prove to be therapeutically inert, and this is because a new method of preparing the oil has been introduced. The oil is expressed by machinery, and the process is such that it becomes highly coloured. To clarify it, an absorbent mineral earth is often used; but this, unfortunately, absorbs the vitamin and removes it from the oil, so rendering it ineffective.

Interesting experiments have been made recently by Ethel Marjorie Luce, in which some cows were kept in dark byres and others in sunlit fields, and the results of feeding animals on the respective milks were noticed. It was found that the growth of the animals was the same in each case, but those fed on the milk from cows kept in the open were less liable to rickets.

Calcium salts play an important part in many body processes. Blair Bell has stated that lime salts are among the most important physiological agents in resisting infections and in repairing the local ravages of disease. They have a tonic action on the heart, and an increase in the amount of blood calcium has been found to have a stimulating effect. This is very important in tuberculosis, where the heart muscle is often relaxed. Calcium salts also stimulate the peripheral circulation, being largely responsible for

vasomotor stability, and because of this they are valuable in the treatment of chilblains, and erythematous rashes are also relieved.

Calcium salts diminish the permeability of the lymph and blood vessels, and their presence in adequate amounts in cases of bleeding is absolutely essential to ensure clotting of the blood. They therefore lessen the possibility of hæmoptysis and epistaxis. They also reduce the amount of secretions and ameliorate catarrhs; they stimulate the phagocytic action of the leucocytes and aid the absorption of exudates; and they also stimulate the sebaceous glands.

Calcium salts reduce anaphylactic reactions. They improve the emotional tone, and play an important part in the control of nervous and muscular irritability. Fatigue easily occurs when there is hypocalcæmia, and there is a diminished power for work and a lessened resistance to disease. There is a considerable strain on calcium and phosphorus metabolism during growth, pregnancy and lactation.

Most of the endocrine glands influence calcium metabolism, and stimulation of the sympathetic system increases the cellular intake of calcium. Calcium and phosphorus are influenced chiefly by rays of 3022 Å to 2600 Å. Shorter wave-lengths are antagonistic to an increase of these salts, so that, in certain cases, irradiation should not be given with the patient a shorter distance than thirty-six inches from the lamp.

Endocrine Glands.—The principal action of ultra-violet radiation on the endocrine glands is a marked

depressor effect on the suprarenals. There is a rapid fall of blood pressure, which precedes the appearance of erythema, and if hyperglycæmia is present the blood sugar falls. There also appears to be some action on the thymus gland and the sexual glands; and the hæmopoietic system and the thyroid are stimulated. Some recent experiments performed on rabbits showed that the weight of the parathyroid glands increased by from 14.1 to 51.1 per cent. after irradiation.

Effects of Ultra-Violet Rays on the Eye.—Only visible rays—i.e. rays between 7600 Å and 3800 Å—are capable of penetrating the crystalline lens of the eye. These rays effect chemical changes in the visual cells, and the new substances formed act as stimulants. That this is so was deduced from the discovery of the presence in the rods of a purplish pigment—rhodopsin or visual purple, which is bleached on exposure to light. The layer of pigment cells that lies in apposition to the rods and cones acts as a medium for the regeneration of the visual purple.

The limit of visibility varies from 4100 Å to 3800 Å. Rays from 3800 Å to 2950 Å are absorbed by the lens and cause it to fluoresce. This acts as a protection to the retina. If an eye in which the lens has been enucleated is irradiated, the retina loses chromatin in the ganglionic cells, and the development of vacuoles takes place in the protoplasm of these cells. The nuclei of the same cells are large and clearly defined, and have a vacuolar appearance, with a very distinct nucleolus. Every other part of the retina is affected to some extent. These changes may

become apparent at once, or they may take several hours to develop, but recovery is complete in a few days. Visible rays, chiefly the red rays, antagonize this fluorescence in the lens, but it is not influenced by infra-red rays, nor do the latter diminish the intensity of kerato-conjunctival lesions caused by ultra-violet radiation. Thus it is the red and not the infra-red rays which antagonize ultra-violet rays. Ultra-violet rays cause contraction of the pupil, either directly by their action on the muscle fibres of the iris or reflexly by their harmful action on the conjunctiva. Toulant considers this phenomenon due to the stimulation of the retina by visible rays caused by the fluorescence in the crystalline lens, as the pupillary contraction due to ultra-violet rays is identical in character and rhythm with that due to visible light. The cornea is most sensitive to ultra-violet rays, all rays below 2950 Å being absorbed by it. Cloudiness of the cornea results from exposure to these rays, followed by desquamation of the epithelium. Similar lesions occur in the conjunctiva and even in the sclerotic. The lesions are usually superficial and clear up without permanent damage to the transparency of the cornea. Acute lesions of the parenchyma are rare and result only from excessive doses, which are never applied therapeutically. Cataract has been proved to be caused by rays of longer wave-lengths—namely, red and near infra-red—and ultra-violet rays are not responsible for this condition as they are absorbed by the more superficial structures.

Effect on the Respiratory System.—Irradiation and,

more especially, the production of erythema cause respiration to be slower and deeper.

Effect on the Alimentary System.—Pacini has observed that gastric juice removed from the stomach during ultra-violet radiation shows a diminution in the acid content, and this may explain the beneficial effects that so often follow irradiation for the vomiting of pregnancy, and in young children when the condition is due to pylorospasm. Pacini also holds that irradiation of the referred cutaneous sensitive areas will relieve the pain of most gastric lesions.

Reflex contraction of involuntary muscle occurs when it is irradiated, and this may be the reason why constipation is often relieved by irradiation, probably through the medium of the sympathetic system.

Loss of appetite is nearly always remedied by ultra-violet irradiation, probably because the digestive glands are stimulated, particularly the pancreas, but also the liver.

The erythema produced after exposure is sometimes useful in relieving congestion in cirrhosis of the liver. Microbic infection of the bowel is decreased, and thus diarrhoea is checked, and substances are more easily absorbed from the alimentary tract.

Effect on the Genito-Urinary System.—The kidneys themselves are very little affected by irradiation of the body, except that diuresis sometimes occurs, but there is a marked depressor effect on the supra-renal glands. The secretions of the ovaries and testicles are stimulated. Some cases of incontinence of urine are benefited by actinotherapy.

Effect on the Nervous System.—Ultra-violet radiation acts on the central nervous system and produces a marked mental stimulation; it also acts on the peripheral nervous system and has an analgesic effect, and on the sympathetic or vegetative nervous system, influencing the action of the endocrine glands. It has the same action as natural sunlight in producing a feeling of vigour and of mental exhilaration and cheerfulness, and a sense of well-being. Nervousness disappears and insomnia is benefited; fatigue is lessened. As Finsen said: "When the sun suddenly comes out, it is as if nature had been brought to life. The insects fly and hum gaily, the reptiles bask in the bright sunlight; the birds chirp and we ourselves get a feeling of well-being and fullness of life."

Dr Wilcken has told us that "on Disco Island, Greenland, it is a well-known fact that people quarrel in the winter, the continued darkness 'getting on their nerves.' Disco Island is a Danish botanical and meteorological station, with a more or less constant population." He also says: "Antarctic explorers visiting the Meteorological Institute in Buenos Aires have often told me how the winter's darkness affected their mental condition; and the expeditions sent out annually from the Argentine Meteorological Institute to Laurie Island, South Orkneys (about 61°5' latitude), frequently had trouble amongst the personnel owing to the depressing effect of the long winter."

The whole disposition of children is often altered by ultra-violet irradiation; there is an increased mental alertness, and this has been conclusively proved by a recent series of intelligence tests. Children at the

Treloar Cripples' Hospital at Alton were found to be mentally a year in advance of crippled London children of the same age.

The mental outlook of the patient is of supreme importance in many diseases.

The analgesic effect of ultra-violet irradiation, which is most pronounced with the carbon arc, can readily be seen when cases of herpes, lumbago, or neuralgia are treated.

Rothman considers that ultra-violet radiation temporarily paralyses the sympathetic nerve endings in the skin, which causes tonic depression of the whole sympathetic system. This results in an inability of the suprarenal glands to convert tyrosin into adrenalin, and it is converted instead into melanin pigment in the skin.

In Addison's disease, which we know is due to disease of the suprarenal glands, there is also a hypotonicity of the sympathetic system, with excessive pigmentation and a low blood pressure.

Finsen's experiments showing the stimulating effect of actinic rays on butterflies have already been referred to in Chapter I.

When the vasomotor reflexes become sluggish for want of use, as they do, for example, when clothing is habitually worn, great susceptibility to variations in heat and cold exists. Exposure to ultra-violet rays improves the regulation of body temperature, which is a very important function of the skin.

CHAPTER X

THE PATHOLOGY OF SOLAR AND ULTRA-VIOLET RADIATION

Heat Exhaustion and Sunstroke—Actinic Erythema or Sunburn—Are Ultra-Violet Rays Dangerous?—Harmful Effects of Ultra-Violet Rays on the Eyes—*Xeroderma pigmentosum*—*Hydroa aestivale*—Hutchinson's Summer Prurigo—Pellagra—Buckwheat Disease—Symptoms which may follow Irradiation—A Case of Over-Exposure—Contra-Indications to Actinic Treatment

It has been found that, besides the well-known beneficial results which follow exposure to various radiations, certain ill effects may occur.

In the case of over-exposure to the sun's rays, the different effects of both the heat and the chemical rays must be taken into consideration. Heat rays are responsible chiefly for two conditions: heat exhaustion and sunstroke.

Heat Exhaustion is a condition occurring frequently in the engine-rooms of large steamships sailing in the tropics. The patient becomes pallid, and there is nausea and vertigo and a small pulse, owing to the weak action of the heart. The temperature is generally subnormal, and in fatal cases patients often remain conscious to the end. Recovery usually occurs if stimulants are given and the patient is immediately brought to a cooler place.

Sunstroke, or Thermic Fever, often occurs in the

tropics when troops are on the march. It is characterized by headache, dizziness and a feeling of oppression. There is very high fever, and vomiting and nausea sometimes occur. The patient quickly loses consciousness and the muscles become relaxed. The exciting cause is probably the action of the infra-red rays on the head in causing a disturbance of the heat-regulating mechanism of the body. Cold baths or ice-packs are the most satisfactory form of treatment. Loss of memory sometimes supervenes in cases which recover.

Actinic Erythema, or Sunburn.—The chemical rays of the sun act on the exposed parts of the body only, and in excess may cause intense redness of the unprotected skin, with swelling and considerable pain, and even blisters may form. Later, when the erythema passes off, the skin cracks and peels. A few years ago one of us had a very painful arm from this cause, following excessive exposure to the sun's rays during a visit to the Grand St Bernard Monastery. Skins which contain very little pigment, such as those of blondes and, particularly, of persons with red hair, are most sensitive to the ultra-violet rays.

Actinic erythema or sunburn is often experienced in mountainous regions, especially where there is much snow lying. The chemical rays are reflected by snow and ice, and this causes the under side of the nose and chin to be affected—this condition being known as "glacier burn." Climbers always freely smear their faces with some protective substance, such as "Antilux," to avoid the occurrence of this painful condition.

Are Ultra-violet Rays Dangerous?—The burning of the skin felt in “glacier burn” entirely clears up, and causes no permanent ill effects, although there are some dermatologists who consider that prolonged exposure to bright sunlight will cause carcinoma. But this is extremely doubtful, and quite contrary to authoritative opinion. It is true that carcinoma may develop on the faces of some old seafaring men, but the effect of wind and salt water cannot be overlooked in such cases. *Xeroderma senilis* of the peasants is a condition in which the skin becomes dry, brown and withered, and seems to be associated with long-continued exposure to sun and air; but without doubt lack of cleanliness is a factor to be considered, as the condition is by no means universal among outdoor workers.

Bernhard says: “I have never seen carcinoma of the skin of the face or hands in our road makers, road repairers, postillions or post conductors on the Alpine passes, who are exposed to every inclemency of the weather, and in winter months to the most intense solar radiation, with its reflection from snow and ice, which in spring gives them the appearance of bronze figures. I believe, on the contrary, that they are, if anything, more proof against carcinoma. In negroes carcinoma of the skin is extremely rare, and, in general, the frequency of carcinoma in all countries, however caused, is in inverse proportion to the intensity of light.”

Recently fears have been expressed that the continued exposure of the operator to artificially produced ultra-violet radiation might cause conditions

similar to those produced by continued exposure to X-rays.

Dr Axel Reyn, head physician at the Finsen Institute, Copenhagen, writes, however, as follows:

“I read with the greatest interest Sir G. Lenthal Cheatle’s letter in the *B.M.J.* of 28th March, in which he states that, together with Dr Arthur Whitfield, he has examined skin that has been ‘bronzed’ by therapeutic exposure to sunlight and has found mitosis occurring in the epithelial cells situated above the basal layer, from which he seems to conclude that there may be some risk of inducing epithelioma by exposure to sunlight or artificial irradiation. It is true that atrophic changes are sometimes observed in the skin of persons whose hands and faces are habitually exposed to strong light and air, and that in such cases epithelioma is sometimes seen to develop on the exposed parts. But up to the present nothing whatsoever has been brought forward to prove that it is the light particularly that produces these changes. From all indications the lesions are much more likely caused by such influences as wind and rain and all the various assaults to which the constantly uncovered and unprotected skin of these persons is daily exposed. Do we not see epithelioma of the skin develop in almost any site exposed to constant mechanical influences? We need only think of cancer of the lips, chimney-sweeps’ cancer, tar cancer, and many others besides.

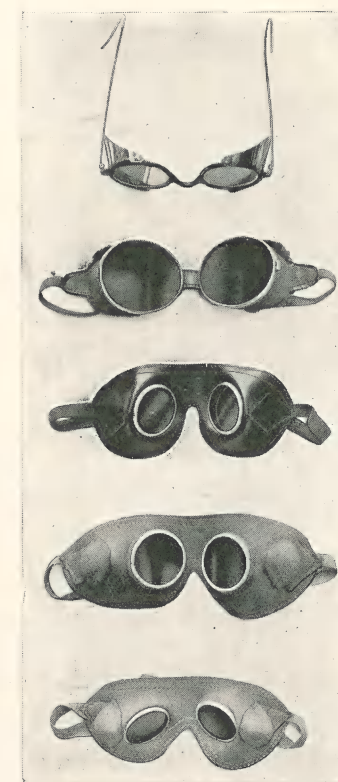
“That the therapeutical application of light should produce epithelioma is in the highest degree unlikely. Nothing argues more strongly against this suggestion

than the fact that up to this day not one single case of cancer of the skin has been reported as caused by the light bath, among the hundreds and thousands of persons who take either sun or artificial baths of this kind. I may state, furthermore, that among the thousands of patients who have received local phototherapeutic treatment for lupus at the Finsen Institute we have not observed one case of lupus carcinoma resulting from this treatment. On the contrary, the percentage of lupus carcinoma shown by our records is the lowest existing; a fact which must be ascribed exclusively to the phototherapeutic treatment, which cures the patients so that they do *not* get carcinoma, while, if the light were particularly provocative in this respect, we should, of course—on the contrary—see a great many cases of this complication.

“I see yet another proof in the conclusions arrived at by Dr K. A. Heiberg, the histologist at the Finsen Institute, as the result of microscopical examinations made of the skin of twenty-five patients who had been under treatment with carbon arc light baths for a considerable period. Not in a single instance did Dr Heiberg observe any change involving risk of epithelioma; on the contrary, he proved that a vigorous regeneration of healthy skin takes place which greatly assists in improving the functioning of the latter. I therefore urgently recommend the use of light baths, sunlight or artificial, in all diseases in which this treatment is suitable. It is a therapy which has already proved so rich in beneficial results that it should be used, also, in the future, to an ever-increasing extent; and we certainly must not allow

ourselves to become frightened of dangers that are non-existent.”

Harmful Effects of Ultra-Violet Rays on the Eyes.—Snow blindness is another evidence of the local effect



Glasses fitted with Crookes' B.B. Glass and protected at sides.

Patient's Goggles.

Goggles fitted with Arkos Glass.

Rubber Goggles fitted with Arkos Glass which can readily be sterilized.

FIG. 157.—Protective Goggles.

of the actinic rays of the sun. The conjunctiva becomes very injected, marked photophobia and lachrymation are present and the pain is intense. The damage, however, is not permanent and the condition

clears up in a few days. Exactly the same effect can be produced by direct irradiation with the sun or any of the ultra-violet-producing lamps. It is, therefore, a very wise precaution always to warn patients against looking at the arc with the naked eyes.

We specially mention this because recently two



FIG. 158.—The "Wellsworth" Face Mask in position.

adult patients of ours did this out of curiosity; one felt no ill effects until he was awakened from his sleep the same night with intense pain in his eyes; he was unable to see, and was confined to his house for three days before the reaction subsided. The other had a somewhat similar experience, and was attended by his own doctor's locum, who was newly qualified, and could not make up his mind definitely whether the intense inflammation of the face was

due to erysipelas or whether it was a case of scarlet fever.

Numerous cases are on record where men engaged in arc welding have suffered from severe conjunctivitis following exposure to ultra-violet radiation. The symptoms usually are photophobia, excessive



FIG. 159.—The "Wellsworth" Face Mask in the inoperative position.

lachrymation, and intense smarting of the lids, with contraction of the pupil. Sometimes swelling of the lids, with the formation of corneal ulcers, iritis and retinitis, may result.

If this condition ever should occur after exposure to ultra-violet rays, ice-packs should be placed over the patient's eyes three or four times a day for periods of fifteen to sixty minutes, and the eyes irrigated with a saturated solution of boric acid several times daily.

If pus is present, argyrol or protargol may be used. The patient should be confined to a darkened room, and if there is intense pain morphine may be administered.

There are certain congenital diseases which are brought on by exposure to sunlight, but in all these cases there is a hypersensitiveness, dating from birth, on the part of the individual to normal sunlight. The most important of these conditions are :

- (a) *Xeroderma pigmentosum*.
- (b) *Hydroa aestivale*.
- (c) Hutchinson's summer prurigo.

(a) *Xeroderma pigmentosum* is a very rare skin condition, which generally commences in infancy. Several cases often occur in one family. The skin on the exposed parts of the child's body has a dry and rough appearance. An abnormal sensitivity to ultra-violet radiation exists and these rays appear to stimulate small, warty excrescences to abnormal growth. Abnormally pigmented areas appear dotted over the skin, and there are, also, white atropic patches where nodules have dropped off. The keratoses rapidly increase in number, become deeply pigmented and take on a malignant character, becoming melanotic sarcomata. These cases generally succumb owing to the formation of metastases before adolescence is reached.

(b) *Hydroa aestivale*, or *Summer Rash*.—This condition is also most common in children, especially of a fair type. It is generally first noticed when the child is three or four years old. At first, twelve to twenty-four hours after exposure, small red papules appear over the uncovered parts of the skin. These gradually

increase in size and become vesicular, and central depressions appear on the vesicles, for which reason Bazin named the condition *Hydroa vacciniformis*. Blebs are sometimes formed by the coalescence of several vesicles. The vesicles dry up in a few days, forming scabs, and where these have fallen off there remain depressed, white scars. The condition is cured in a week or two if the patient is kept in semi-darkness, or is otherwise protected, but it may continue for months if special precautions are not taken. The lesions clear up in winter and recur again with the advent of spring, but generally disappear at puberty. Very probably some sensitizing agent is at work, and a number of these cases have hæmatoporphyrinuria; in fact, a disease having all the appearances of *Hydroa aestivale* has been produced experimentally in rabbits by the injection of fluorescent colouring matter which had been irradiated with ultra-violet rays. The bones are often stained a pink colour.

Meyer Betz injected a small quantity of hæmatoporphyrin into himself, and developed alarming symptoms when he exposed himself to light, his face and hands becoming intensely swollen. He remained in this light-sensitive condition for several weeks.

A similar condition, *Conjunctivitis vernale*, attacks the eyes of certain people. The conjunctiva is injected and small, hard nodules appear on the tarsi. As in *Hydroa aestivale*, the condition is alleviated in winter and returns each spring until adolescence, when it spontaneously disappears.

Protective glasses, especially if fitted with airtight

sides, prove effective in this affection, both in treatment and prophylaxis.

Eclipse blindness is a condition caused by looking at a partial eclipse with the unprotected eyes. It can be very painful and troublesome.

(c) *Hutchinson's Summer Prurigo* is an irritating, discrete papulo-vesicular eruption which occurs in infancy and childhood, and affects the face, neck and hands. Pustulation sometimes occurs. It usually disappears entirely in winter, but reappears in the summer months.

In all these various diseases some sensitizing agent is probably present, such as one of the porphyrins or aromatic amino-acids, and it has even been suggested that bacterial toxins might have the same effect.

Pellagra, which is characterized by marked nerve and psychical disturbances, is a disease in which there is also a skin eruption appearing only in summer and affecting only the parts of the body exposed to light. It is thought that it is caused by the introduction into the body of certain photodynamic substances found in imperfect maize, which cause the typical nerve and skin lesions to develop when the body is exposed to ultra-violet radiation.

Buckwheat Disease.—In domestic animals a condition known as Buckwheat disease, or fagopyrism, sometimes occurs, but it affects only light-coloured animals which have been fed on buckwheat. The animals fall sick when exposed to strong sunlight, but remain unaffected when kept indoors in badly lighted byres.

Finsen commented on the similarity of the action of light in fagopyrism and in smallpox.

Symptoms which may follow Irradiation.—If insomnia should occur after treatment it is almost always due to pruritus, associated with erythema. A few patients have their nervousness aggravated by irradiation, and headache sometimes occurs after exposure. In very rare cases anaphylactic symptoms may be manifested.

Occasionally tachycardia and vertigo may appear if ultra-violet treatment is given during menstruation. A feeling of tiredness, anorexia, and a rise of temperature, are other symptoms which sometimes, though very rarely, follow irradiation, and they are probably due to overdosage.

Severe burns, such as sometimes unfortunately occur as a result of galvanic, faradic or diathermy treatment, are unknown with ultra-violet radiation. The word "burn" is not a strictly correct one to use when describing the skin reaction caused by ultra-violet rays. The term "actinic erythema" is much more appropriate.

If, however, the red-hot mercury arc tube is touched, burning may occur. Quartz is so good an insulator that there is no danger of electric shock.

A Case of Over-Exposure.—Great care should be taken to prevent patients from administering ultra-violet treatment to themselves. Dr MacCormac and Dr McCrea describe in *The British Medical Journal* of 11th April 1925 an instructive case, which came to their notice, of the very serious consequences that resulted from excessive exposure in a patient who

was taking light baths without medical advice. This patient was accustomed to have a daily artificial sun bath of ten minutes' duration, usually taken while he was lying on his back in bed. One day while having his light bath he fell asleep, and the lamp continued



FIG. 160.—A case of Exfoliative Dermatitis, caused by Combined Irradiation with Ultra-Violet and X Rays, which ended fatally.

to play on him for an hour and ten minutes. Severe erythema and desquamation followed.

Twelve days later a general erythema of the trunk and extremities was noted. Urticaria developed, the irritation of which kept the patient awake. Five days later he became restless and disturbed; cardiac extra-systoles developed, and the patient continued to be gravely ill for four days and then rallied. The skin, however, continued to be affected, desquamation went on, and a fortnight later an extensive purpuric eruption developed on the legs. After this the patient's convalescence was uninterrupted.

This accident happened in an extremely simple way, since the rays are very soothing and conducive

to sleep. It emphasizes the necessity that ultra-violet radiation shall be applied solely under the personal supervision of qualified medical practitioners.

In properly supervised ultra-violet irradiation the greatest harm that can result is the formation of a blister. Only the superficial layers of the epidermis are shed, and the true skin is never destroyed.

We have recently seen a fatal case of exfoliative dermatitis caused by the conjoint administration of X-rays and ultra-violet rays. This case also demonstrates the great dangers associated with the unskilled administration of these powerful remedial agents.

Contra-Indications to Actinic Treatment.—From a consideration of the pathology of ultra-violet radiation it is obvious that the following diseases should not be treated by actinotherapy:

- (1) *Xeroderma senilis.*
 - (2) *Xeroderma pigmentosum.*
 - (3) *Hydroa aestivale.*
 - (4) Hutchinson's summer prurigo.
 - (5) *Conjunctivitis vernalis.*
- Other conditions which should not be irradiated are:
- (6) Addison's disease.
 - (7) Variola.
 - (8) Grave heart disease where compensation has broken down.
 - (9) Acute nephritis.
 - (10) Severe cases of arterio-sclerosis.
 - (11) Cases of very acute eczema, or where bullæ are present.

New growths should never be locally irradiated, nor should ultra-violet treatment be given when the

temperature is high, when insulin is being administered, or when sulphonal, trional or veronal is being taken internally.

The Treatment should be discontinued if:

- (1) The temperature is raised after irradiation for more than 24 hours.
- (2) The patient is regularly losing a large amount of weight (except in obesity cases).
- (3) The patient is excessively nervous after the first two applications, or there is insomnia or increased irritability.
- (4) The treatment is followed by severe depression or weakness.
- (5) In psoriasis or in lupus erythematosus an acute eruption develops.
- (6) Menstruation is present. (This is customary, but not essential.)
- (7) Marked pigmentation associated with weakness suddenly develops in a tubercular patient.

Great care should be taken when the following cases are irradiated :

- (1) Patients who have previously had hæmoptysis.
- (2) Where amyloid degeneration is present.
- (3) Patients who are also having, or have recently had, X-ray treatment.
- (4) Where quinine has been administered for a considerable time.
- (5) Where injections of metallic salts are being given.
- (6) Where a mercurial dermatitis is present.
- (7) Where crude coal tar has been applied to the skin.

- (8) Where sensitizing substances, such as eosin, phylloporphyrin, iodine, erythrosin, gentian violet, brilliant-green, or crystal violet, are being used.

Whenever there is any doubt whether it is wise or not to give ultra-violet treatment, small doses should be the rule, and careful records of the pulse, temperature, and weight should be taken.

CHAPTER XI

TECHNIQUE

Arrangement of Surgery—Planning an Ultra-Violet Clinic—
The Choice of Lamps—Mercury Vapour Lamps—Position
of Lamps—Air-cooled Mercury Vapour Lamp—Method of
lighting Lamps—Administration of Treatment—Raying
Children—Position of Patient during General Treatment—
Use of Ultra-Violet Rays in the Operating Theatre—Dosage
—Cosine Law—Intervals between Applications of Treat-
ment—Duration of Treatment—Local Treatment with
Water-cooled Mercury Vapour Lamp—Lighting the
“Kromayer” Lamp—Applicators and Compressors—Dosage
with the “Kromayer” Lamp—The Carbon Arc Lamp—Trim-
ming an Arc Lamp—Hissing—The Tungsten Arc Lamp
—Combined Treatment—Remedies for Faults—Conjoint
Internal Medication and Actinotherapy

MANY practitioners are greatly hampered in practising physiotherapy because they have not sufficient space at their disposal, especially if only one room is available. This makes it difficult for them to utilize these new methods of treatment satisfactorily. It is a great advantage for a practitioner to have several rooms which he can use: for example, a waiting-room, a dispensary, two consulting-rooms and a small dressing-room, the last-named having a door into one of the consulting-rooms if possible. Each room should be well lighted, and have a satisfactory method of heating; and particular attention should be paid to the matter of ventilation, especially when it is proposed to use

TECHNIQUE

open arc lamps, because pungent fumes are often given off when carbons cored with metallic centres are used.

It is most satisfactory to maintain the room at a temperature of about 70° F. Electric fans may be used, or the windows may be widely opened, if the room becomes too hot when mercury vapour lamps are burning.

We find hot-water pipes and radiators fed from a small coke boiler most useful. They are clean and effective, and are not costly to work when once fitted. The room in which the ultra-violet apparatus is installed should be especially well heated, to avoid the possibility of patients feeling cold when they have to undress. Screens should be provided, so that patients may undress in privacy. The walls should be treated if possible with a light grey paint made from Chinese white and lamp-black, and applied with a matt surface. This paint has the property of not reflecting ultra-violet radiation.

In a clinic, conditions are quite different, and reflection from the walls may be desired, particularly if “Jesionek” lamps are being used. In this case the walls should be whitewashed. At the Institute of Actinology, Paris, some of the treatment-room walls are covered with aluminium-leaf, which reflects well, and which also increases the photo-electric effect of the rays. A small, portable couch is necessary in the room; we find a folding camp-bed very useful. It should have a pillow, and either a separate length of white linen huckaback towelling, 6 ft. by 2 ft. 3 in., or a sheet of crêpe paper should be provided for each

patient who is having general treatment, and used to cover the couch. The use of paper effects a considerable saving in laundry costs, and good paper will serve a patient for several irradiations. The couch should, if possible, be placed near the radiator of the heating installation.

The resistances of some lamps are utilized to provide infra-red rays; they have reflectors and are mounted on stands. It is often convenient to place the patient between the sources of ultra-violet and infra-red rays.

The windows of the treatment-rooms should be provided with blinds. Saidman suggests that the furniture should be painted black. A mirror should be provided for the convenience of patients when they are dressing after treatment.

There are several accessories that we have found very useful. Black cotton gloves may often be worn with benefit by the actinotherapist when the "Kromayer" lamp is being used.

Non-inflammable celluloid combs are helpful when treating scalp lesions. An adjustable head-rest, which can be fixed to a chair, is invaluable in local treatment of the head.

Adhesive plaster, or "Antilux," can be used for protecting the area surrounding the lesion, and tie-clips are useful for fixing towels in position during local irradiation. A small brush is useful for cleaning the carbons of arc lamps.

A plentiful supply of drinking water should be available for patients during irradiation with the carbon arc.

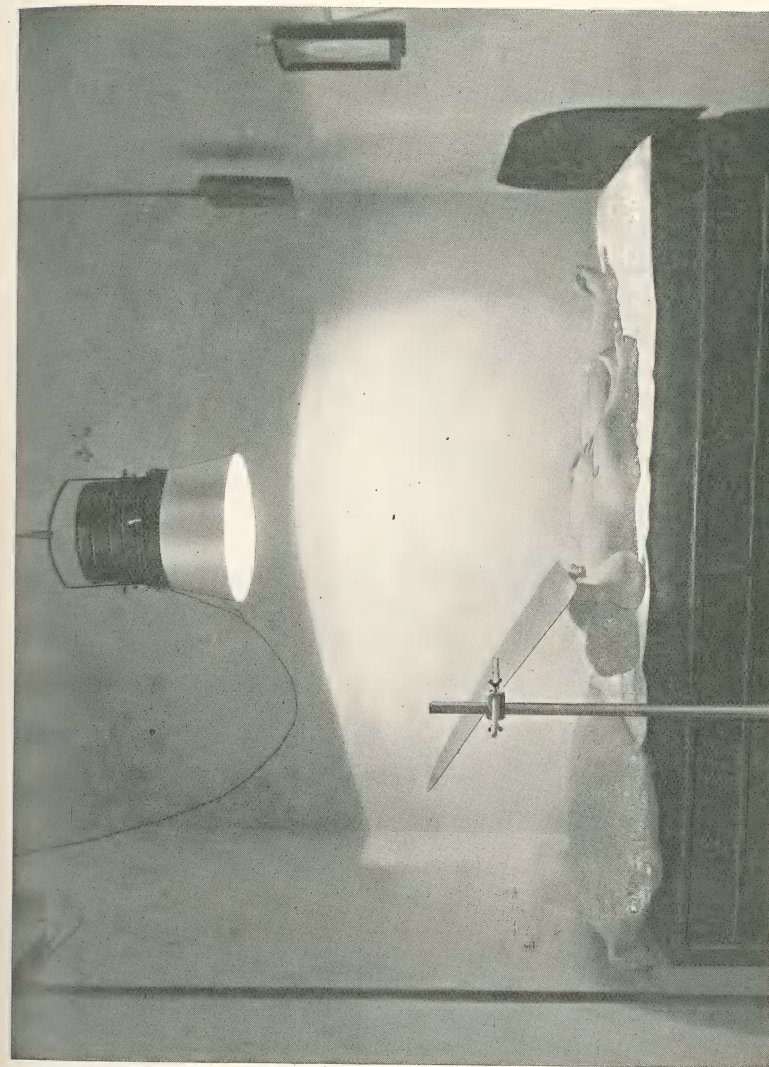


FIG. 161.—Our "Hewittic" Air-cooled Mercury Vapour Lamp with Magnetic Tilting Device, suspended from the ceiling by a Counterweighted Chain passing over two Cog-Wheel Pulleys. This illustration shows how a small room 6 ft. by 11 ft. can be used conveniently for Ultra-Violet Treatment. A large roof-window ensures efficient ventilation, and the room is heated by a hot-water radiator supplied from a small coke-fired boiler.

After carbon arc treatment a shower bath is generally necessary.

A spatula, nasal and aural specula and a thermometer should be available.

Some 1:1000 solution of corrosive sublimate is necessary for sterilizing rock-crystal applicators.

Ether and benzene are useful for cleaning local areas of the skin before treatment.

It is very advantageous to have a record-card system, with individual cards for each patient.

The Planning of an Ultra-Violet Clinic.—The number of nursing staff available is of great importance. If there are several nurses, small treatment-rooms may be used, so that both men and women may be treated during the same session; otherwise, one large treatment-room is more economical.

The following rooms are necessary: treatment-room, dressing-, bath-, and waiting-rooms, nurses', medical officer's and store-room; an isolation-room, rest-room and surgical-dressing-room are also very convenient.

The size of the treatment-room naturally depends on the number of patients likely to be treated, but a convenient size is about 40 ft. by 20 ft. The ceiling should be high, to make cross-ceiling ventilation possible by means of hopper windows. Special ventilators may also be fitted behind the central-heating radiators, to allow air to enter the room and be deflected upwards without causing draughts. It is very necessary to avoid draughts, because open arcs are very sensitive to air currents: to obtain steady burning the air must be still.

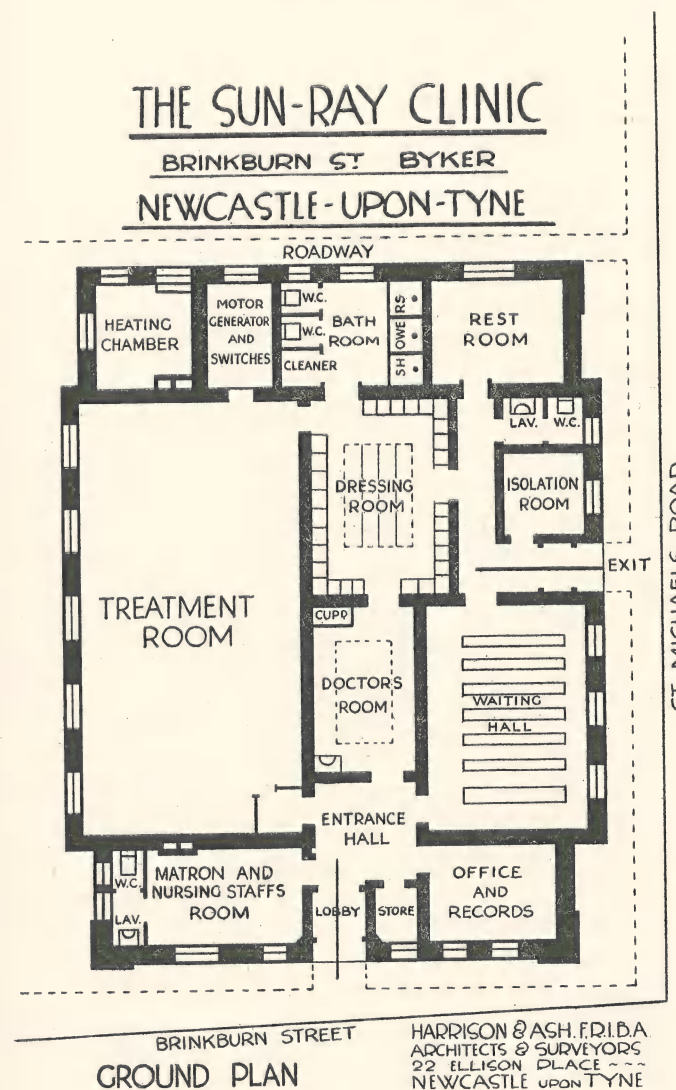


FIG. 162.—Ground Plan of the "Sun-Ray Clinic," Newcastle-on-Tyne.

The floor of the treatment-room may very conveniently be paved with "Granwood" blocks. These are of a patent composition, which is durable, a good non-conductor, warm, non-inflammable and water-

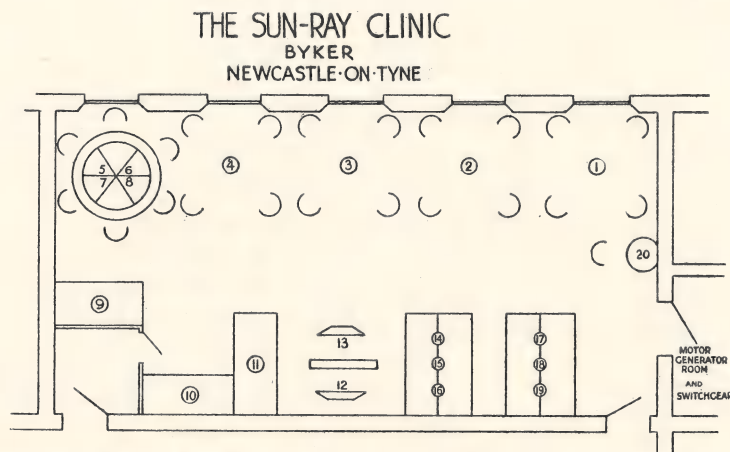


FIG. 163.—Plan of the Treatment-Room of the "Sun-Ray" Clinic, Newcastle-on-Tyne, showing the position of the various lamps

1, 2, 3 and 4, "Westminster" Long-Flame Arcs; 5, 6, 7 and 8, Special Couch fitted with four burners; 9, "Hewittic" M.V. Lamp; 10, "K.B.B." Lamp; 11, "British Hanovia" Lamp; 12 and 13, Special Q.M.V. Lamps with 18-in. burners; 14, 15, 16, 17, 18, 19, "Finsen" 20-ampere Short-Flame Arc Lamps; 20, "Kromayer" Lamp. Chairs, Couches and Form are represented diagrammatically.

resisting. Linoleum is not satisfactory, both because it is cold to the touch and because it is inflammable, though the latter defect could be rendered harmless by placing an asbestos or uralite tray under the lamps; concrete and terrazzo are too cold unless the patients wear wooden clogs; and wood flooring is not satisfactory. Carpets, or rugs, or cork lino, may be quite suitably used if precautions are taken

against their being set on fire: they are all comfortable and warm to the touch.

The walls may be tiled for four or five feet up from the floor, or made of terrazzo; or the plaster, which should be of a specially hard variety, may simply be painted some sombre colour, which does not reflect the rays of visible light. A matt surface is preferable.

A sufficiently large waiting-room—about 20 ft. by 20 ft.—should be provided, and there should be easy access from it to the medical officer's room, as well as to the dressing-room and wash-room. The treatment-room, dressing-room and rest-room must, of course, be adjacent to one another and on the same floor.

In the dressing-room a separate peg and locker should be provided for each patient. The usual sanitary conveniences are also essential. In the wash-room there should be several shower-baths, with hot and cold water laid on, because in some cases a shower, both before and after treatment, is invaluable. A shallow teak trough, about 2 ft. 9 in. high, should be fitted under one of the showers, so that small children can be sprayed without difficulty. It is economical to use paper towels; soiled towels may be burned in one of the boiler-house fires.

The building should be heated by a low-pressure hot-water system, and it should be possible to regulate the temperature in the treatment-room. Independent boilers should be provided for heating the water for the showers, etc., and for the central-heating system.

A small store-room for keeping towels, carbons, etc., is very useful.

The chairs used by the patients during the treatment

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should be of unpainted, hard wood, held together with brass screws, no glue being used. We have had special chairs made for use at the "Sun-Ray" Clinic, Newcastle-on-Tyne; these are illustrated on opposite page.

The couches can be satisfactorily cleaned if covered with oilcloth. To avoid chill, a crêpe-paper sheet, as already described, may be placed on the couch. One or two stretchers should be available, and couches should be provided in the rest-room.

A reliable alarm system should be installed to give both an audible and a visible warning. This necessitates the installation of a separate clockwork timing mechanism for each lamp. The lighting of a red lamp placed near each ultra-violet lamp provides a suitable visual signal. A buzzer alarm is preferable as an audible signal to the ringing of a bell. The noise made by a number of bells would be very unpleasant.

Convenient control-boards for the lamps should be placed on the walls at such a height that they are not within easy reach of the children.

Brown-paper shades, which can be made easily and destroyed after use, should be provided for the protection of the patients' eyes. Special protective glasses should be worn by the staff; these should have adequate side protection and yet be ventilated to avoid steaming. Cloth or rubber rims are much preferable to metal rims. We have known a case of acne of the face where burning of the eyebrows occurred when the patient was wearing goggles with metal rims during irradiation with a powerful carbon arc lamp. In the

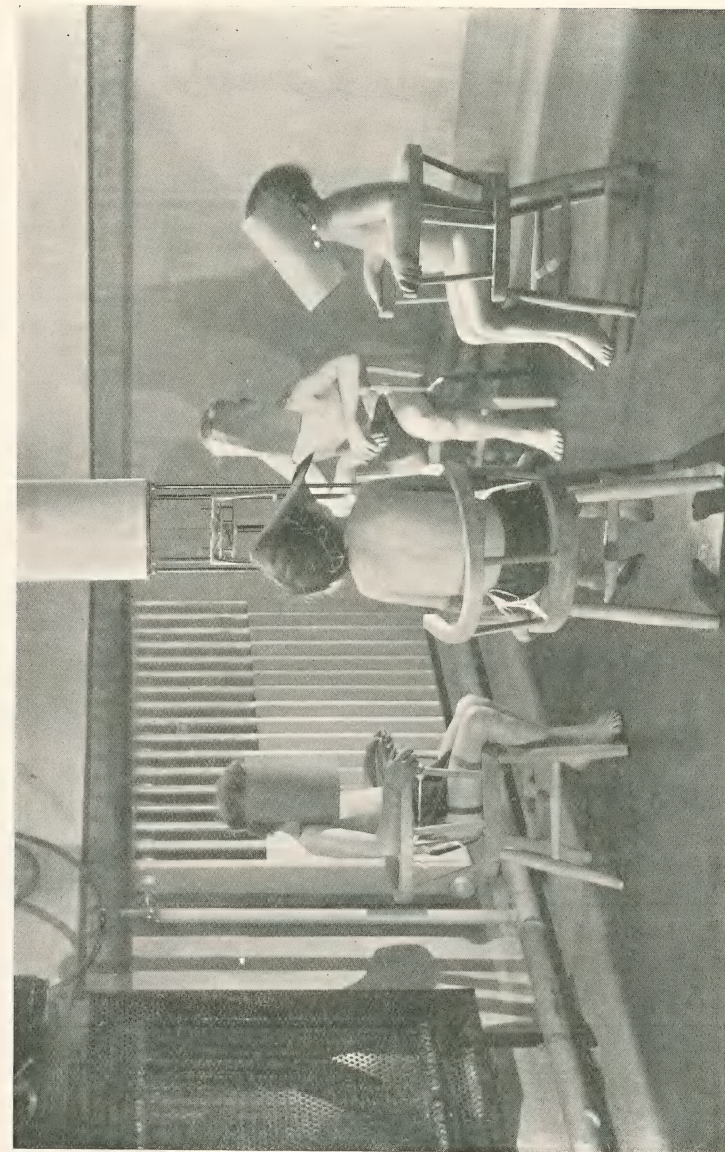


FIG. 164.—Irradiation of Children at the "Sun-Ray" Clinic, Newcastle-on-Tyne, with a "Westminster" Long-Flame Arc Lamp. (The Chairs were specially made by the North of England School Furnishing Company, Darlington.)

medical-dressing-room a few surgical instruments will be required, including probes, stylets, dressing

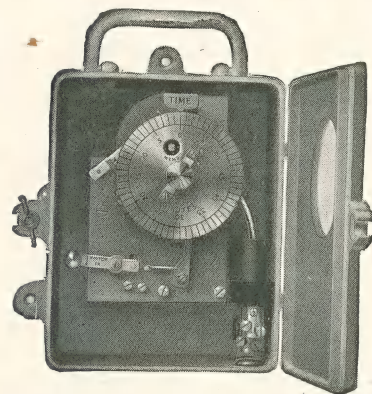


FIG. 165.—The “Venoff” Time Switch can switch off the current automatically provided the D.C. amperage does not exceed 10 amperes, and the A.C. 20 amperes.

scissors, etc., and syringes; and a plentiful supply of dressings is essential.

There should be a reliable weighing machine, as it

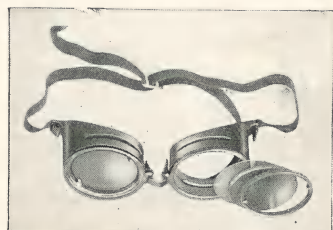


FIG. 166.—Pfund Goggles, which are opaque to Ultra-Violet and Infra-Red Rays.

is very important to record the patients' weights at regular intervals during treatment.

An efficient card-index system with medical-history

[illegible]

FIG. 167.—The Front of the "History" Cards which are used at the "Sun-Ray Clinic," Newcastle-on-Tyne. The actual size of the cards is $4\frac{1}{2} \times 7$ in. (Library Bureau Ltd.)

treatment are tabulated vertically, and the lamps horizontally. When four patients can be treated simultaneously from one lamp, such as the long-flame arc, four horizontal spaces are provided for the insertion of their names or numbers. Account is also taken of the fact that the average irradiation with a quartz mercury vapour lamp does not exceed thirty minutes in duration, whereas the time allowed for treatment with the long-flame arc must be one hour, and with the short-flame arc two hours and a half. A small appointment card bearing the patient's name and number is given to everyone attending for treatment. These cards state the exact time and day each patient must come, and also the date on which he must be examined again by the medical officer on duty.

Fire extinguishers should be provided and kept readily available.

The Choice of Lamps.—If in private practice it is desired to have only one lamp, a mercury vapour lamp will probably prove most satisfactory. If the lamp is required for local treatment a "Kromayer" water-cooled lamp should be chosen; if it is for general work, it should be an air-cooled lamp.

In clinics and hospitals the carbon arc lamp is most often used, because it allows several patients to be treated simultaneously.

If direct current is available it should always be used, and preferably at a voltage of 200 to 250 volts.

A comparison can be made between the carbon arc and mercury vapour lamps:

Carbon Arcs

It is simple to obtain a constant output, and similar lamps are interchangeable, but the ultra-violet emission can be varied by using different types of cored carbon.

A large amount of current is required.

The carbons have to be constantly renewed; the changing of the carbons takes time and soils the hands.

The construction is robust.

Fumes are given off.

Small, red-hot particles are often thrown off.

Draughts have a considerable effect.

Great heat is developed.

A long exposure is needed, and therefore overdosage rarely occurs.

Several patients may be treated together.

These lamps are especially useful for general treatment.

Mercury Vapour Lamps

The emission of the mercury vapour lamp decreases with use, and therefore lamps are not interchangeable, and the radiation can be altered only by the use of special screens.

Only a small amount of current is required.

Burners have to be replaced on an average only after about 800 hours' use.

The quartz burner is rather fragile.

There are no fumes.

There is no spluttering, and the burning is steady.

Draughts have no effect.

Not much heat is given off.

The exposure is short, and must therefore be nicely judged.

Patients are most conveniently treated singly.

Either general or local treatment can be given.

Carbon Arcs

These lamps are most valuable in the treatment of deep-seated tuberculosis, asthma, and rheumatism, and for prophylaxis.

Adults can best be treated with these lamps.

Mercury Vapour Lamps

These lamps are very useful in the treatment of rickets, spasmophilia, and tetany.

Children can best be treated with these lamps.

Tungsten Arcs are very costly to burn, because of the high price of the tungsten electrodes, and, being hand-regulated, they can never be left unattended while they are burning. Further, they burn unevenly, and cannot be used except on D.C.; but they have only a small current consumption.

Carbon Arcs.—If the long exposure required is no objection, short-flame arcs can be used; but equally good results can be obtained with shorter exposures, using long-flame arcs.

There is no particular advantage in using lamps with several arcs burning in series, because the ultra-violet emission is exactly the same as with one arc taking the same number of watts; and, though more heat is given off, the cost of carbons is naturally greater.

Enclosed carbon arcs are often useful for treating children. Suitably impregnated carbons are preferred to plain carbons, because they give off more ultra-violet rays, and the time required for irradiation is therefore much shorter.

The "Ajax" portable carbon arc lamp is useful for treating patients in their own homes, but no portable

lamp is so reliable in operation as the more robust fixed type of lamp, which is too heavy to move about conveniently from place to place.

Mercury Vapour Lamps.—Burners that light automatically are generally more convenient than those that have to be tilted, but, being a little more elaborately constructed, they have a greater tendency to develop faults. The "Henri George" burner can be used immediately after lighting. Care should be taken to see that the alignment of the arc tube is correct, since otherwise the laminated nickel chrome wire may overheat and eventually burn through. We experienced this accident with one of our burners and incurred considerable expense, because it was necessary to have the burner dismantled and exhausted again. The "Henri George," like other quartz mercury vapour burners, often goes out if localizing diaphragms, which impede ventilation and cooling, are used for too long a period; when this happens the diaphragm should be removed and the lamp should be allowed to cool before an attempt is made to relight it. Excessive vibration may also extinguish the lamp, and we ourselves had to discontinue the running of a large diathermy motor convertor in the room where we were using a "Henri George" burner.

The ultra-violet emission from the "Atmospheric" burner is more constant than from the evacuated type, but not quite so powerful.

The number of watts used by a burner is some index of its ultra-violet-ray emission.

Most firms make burners which work at different

voltages (with corresponding differences in the currents), and this should be remembered when a burner is being purchased.

There are two types of portable mercury vapour lamps that a doctor can conveniently use in the house of a patient who is unable to attend at his consulting-rooms. One of these is illustrated on page 175.

Choice of Lamp Housing.—Several of the existing types of lamp-housing are unsatisfactory, because they are made irrespective of the fact that the arc tube of the mercury vapour lamp is often six inches or more in length, and therefore a rectangular or a parabolic housing is required rather than a spherical.

Cost of running Different Types of Lamp :

Volts multiplied by amperes = watts.

1000 watts = 1 kilowatt.

1000 watts used for one hour = 1 kilowatt-hour.

1 kilowatt-hour = 1 Board of Trade Unit.

The price of the unit of electricity varies according to the purpose for which it is used. There are usually several rates of charge for current from the same supply.

In Newcastle, for instance, there are three rates: a lighting rate of 6d. per unit; a power rate of 3d. per unit; and a heating rate of 2½d. per unit. Current for ultra-violet lamps is supplied at the power rate.

A mercury vapour lamp consuming 3 amperes at 240 volts uses 720 watts or 0.72 kilowatts, at a cost of about 2½d. an hour.

A carbon arc lamp consuming 30 amperes at 240



FIG. 170—Our Suspension Housing, which is manufactured by Kelvin, Bottomley & Baird, being used for the Simultaneous Irradiation of both Nostrils. A cord fastened round the Patient's neck, and attached to the Lamp at each end by clips, maintains the Housing in position.

volts would use 7.2 units in an hour, at a cost of 1s. 9³/₄d.

The current consumption of carbon arc lamps is considerable, being generally between 20 and 75 amperes, though some small lamps made for local use take less current. Carbons cost approximately 1¹/₂d. per inch, and cored carbons usually burn away at the rate of one inch an hour. A single-flame lamp, when in use, therefore, costs about 3d. per hour for the two electrodes.

Air-cooled mercury vapour lamps for use with direct current cost from £8 to £10, whereas the alternating-current models cost about £14.

The quartz mercury vapour burner can be used for approximately 800 hours before it needs reconditioning. This costs about £3, and therefore the depreciation in value of a quartz mercury vapour burner is less than a penny an hour of actual use.

Position of the Lamps.—We have found that the most satisfactory method of installing our lamps is to have them suspended from the ceiling and counter-weighted over pulleys, so that they can be raised or lowered easily, and may be lifted out of the way when not in use. This leads to a great saving of space, and, in addition, facilitates the cleaning of the room. It is an advantage if the lamp can be lowered as far as the floor, and if there is sufficient room to move the couch so that various parts of it can be placed under the lamp. This does away with the necessity of having a swinging arm. The lamp should also be placed far enough from the wall to allow it to be brought over the centre of the couch.

We have designed a simple type of suspension

housing that allows the radiation to be directed vertically downwards or horizontally outwards as may be desired. This housing can be used also for local treatment, with special applicators. We generally find it more satisfactory, however, to use the lamp without diaphragms and to cover the area it is not desired to expose. Two overhead lamps give a more even distribution of the radiation than one. Our treatment couch, illustrated on page 190, is very convenient when it is desired to use two lamps together. The switch and resistance can be conveniently placed on the wall, so as to be easily accessible.

A protected quick-break two-pole switch is safest, and also most convenient, and the fuses should be of the replaceable type, which consists of a porcelain plug or handle containing the fuse, and capable of being readily withdrawn and inspected, and, if necessary, of having the fuse wire replaced, without any necessity for turning off the current at the main. A supply of proper 15-ampere fuse wire is also desirable for 240-volt lamps, and of 20-ampere wire for 110-volt lamps.

There seems to be no particular time most suitable for administering ultra-violet radiation, and there is no danger in giving it after a heavy meal, because the erythema does not show itself until from four to eight hours after exposure. During and after irradiation with the quartz mercury vapour lamp the patients feel comfortably warm, but are not overheated, since the source of irradiation is relatively cold, and there is therefore no risk in going out of doors soon after

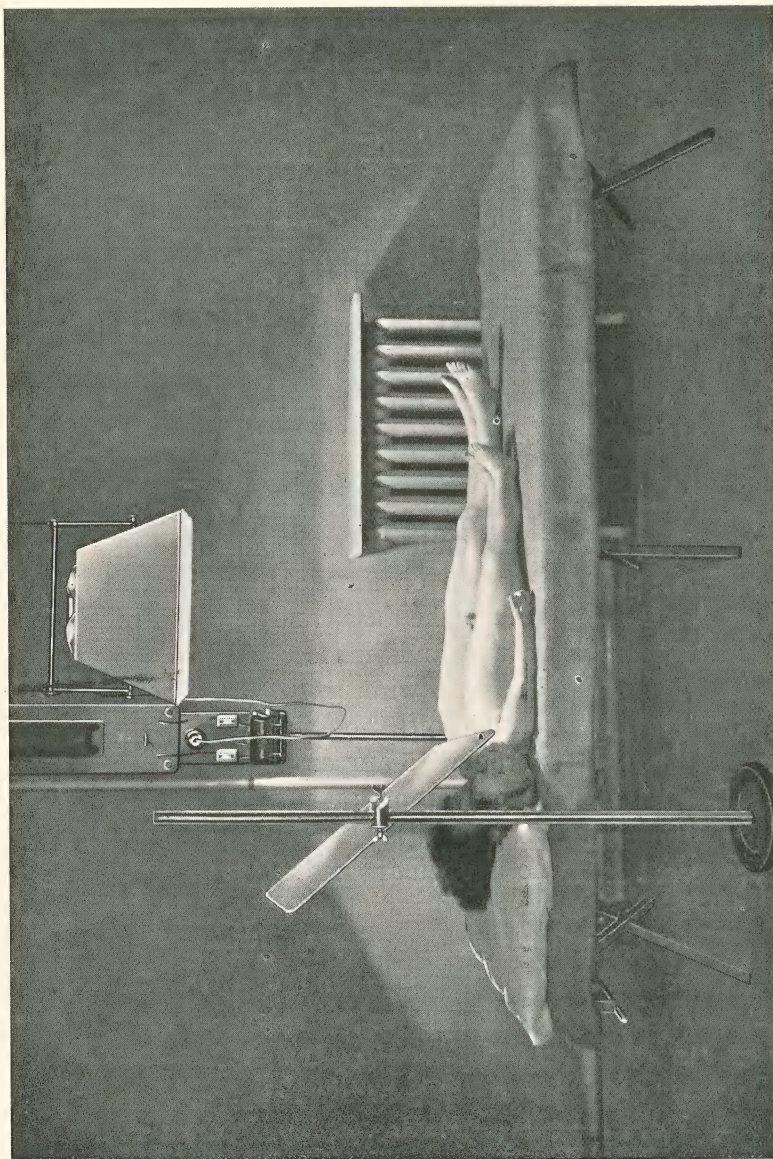


FIG. 171.—Our Suspension Housing being used for General Irradiation. The Patients are lying on a Folding Camp Bed, which is placed near the hot-water radiator for warmth. The Adjustable Screen dispenses with the need for Goggles. The Lamp Resistance, a Protected Quick-Break type of Two-Pole Switch, and the Fuses, are fixed at a convenient height on the Wall near the Couch.

treatment. This, of course, does not apply to the carbon arc.

Air-cooled Mercury Vapour Lamp.—To obtain good results it is necessary that the lamp should be kept scrupulously clean. The quartz tube, as has already been said, should never be touched with the fingers, because imprints become etched into the quartz and can never be removed. Cleanliness is best achieved by gently rubbing the lamp with an old silk handkerchief moistened with alcohol. If direct current is available, it is preferable to use it with the mercury vapour lamp. With alternating current a rectifier or rotary convertor has to be used; this does not however apply to the special type of burners made for use with alternating current by the Hanau and British Hanovia, "Quartz Transparent," "Silectra," Ulbrich and Gallois companies. With both types of current, resistance is necessary to cut down the current to about 15 amperes.

Great care must be taken to ensure that the polarity of the electrodes of a burner always remains constant, otherwise the burner would be rapidly destroyed. To avoid this danger, plugs for use with ultra-violet lamps should invariably be non-reversible, one pin being larger than the other, or some other means be adopted of making it impossible to insert the plug in the wrong way.

Method of lighting Lamps.—Burners unprovided with an automatic method of ignition must be tilted, when all connections are secure, by raising the positive end so as to cover the negative electrode with mercury, and must then be lowered. The

current is then switched on and the lamp is once more raised as before. As soon as the mercury touches the negative electrode again the arc is struck and a brilliant illumination results. The burner is now lowered to its original position. At first the light is rather dull, but after a few minutes it reaches its maximum intensity. The current falls while the burner is heating up, and consequently the voltage across the lamp rises. A very small fall in voltage may result in a large drop in the intensity of the ultra-violet emission.

By exposing strips of printing-out paper for one, two, three, and up to ten, minutes respectively, and comparing the different tints, we noticed that the radiation from the "Hewittic" lamp attains its maximum intensity five minutes after lighting, and remains constant thereafter. The lamp should therefore be allowed to burn for five minutes before treatment is begun. On exposing a strip of printing-out paper of the same length as the burner, parallel with it and directly below it at a distance of about three inches, we found that the greatest amount of ultra-violet rays was given off from the centre.

It has already been said that it is unnecessary to tilt the "K.B.B." quartz mercury vapour lamp to start it. Like the "Hewittic" lamp, five minutes elapse before the constant maximum irradiation is obtained, but the "George" and high-frequency burners are ready for use in a few seconds.

It is undesirable ever to alter the lamp housing, since the adjustment of the temperature of the mercury in the lamp is critical, and the housings provided have

been specially designed to keep the temperature of the mercury below boiling-point.

It has been shown that external cooling plays an important part in the character of the arc, and this fact explains why mercury vapour lamps fitted with unsuitable housings sometimes become overheated and go out. When overheating occurs, the resistance of the mercury vapour column is greatly increased, and a higher voltage is needed to maintain the arc; if this is not available the lamp is extinguished, and will not start again until it is cooler. A similar effect occurs with the carbon arc lamp when the arc has become too long. A relatively large amount of current is needed to ignite the mercury vapour lamp when it is cold; and the low vapour pressure in the tube requires only a low voltage.

The vapour pressure and the volts rise with rise of temperature, but the amount of current passing decreases. A uniform intensity of radiation is obtained when the vapour pressure remains constant, and the electrical expenditure balances the heat radiation from the burner; but the ventilation of the burner and the temperature of the room both affect the radiation.

"Violet" and Ultra-Violet Rays.—At present there is great confusion in the public mind between the two terms "violet rays" and "ultra-violet rays," and they are continually being confounded. "Violet rays" is the popular name given to the vacuum electrode discharge from small monopolar high-frequency sets often used by hairdressers and "beauty specialists." Even when used in this sense the expression is an

unfortunate one, because the colour of a vacuum tube when carrying current depends entirely on its degree of exhaustion, and it must never be forgotten that ultra-violet rays are themselves invisible, and that, moreover, glass absorbs all of them that are of importance therapeutically.

Administration of Treatment.—Many patients are apprehensive at the thought of undergoing any new form of treatment, especially if they think it is to be electrical treatment, because this often means only one thing to them—namely, the small faradic coil. It is always advisable, therefore, to stay with a patient during the first application, and with nervous people during each treatment. It is a good thing to tell the patients that all they will feel during the treatment is a sensation of warmth accompanied by slight tingling, and a feeling of freshness very similar to the effect of sunshine, except that the heat is less.

Before commencing treatment it is always wise to ask patients if they are unduly sensitive to sunshine, and also to test the urine for albumin, sugar, or hæmatoporphyrin.

Saidman finds that rheumatic and arthritic patients are usually most sensitive to skin sensations.

A clock with a loud alarm is a great boon, since it allows other duties to be attended to while the patient is being irradiated. Clocks can be obtained capable of being set for any length of time between fifteen seconds and an hour. We have found the wall type the most reliable.

More robustly made time-switches can also be obtained, which will automatically switch off the

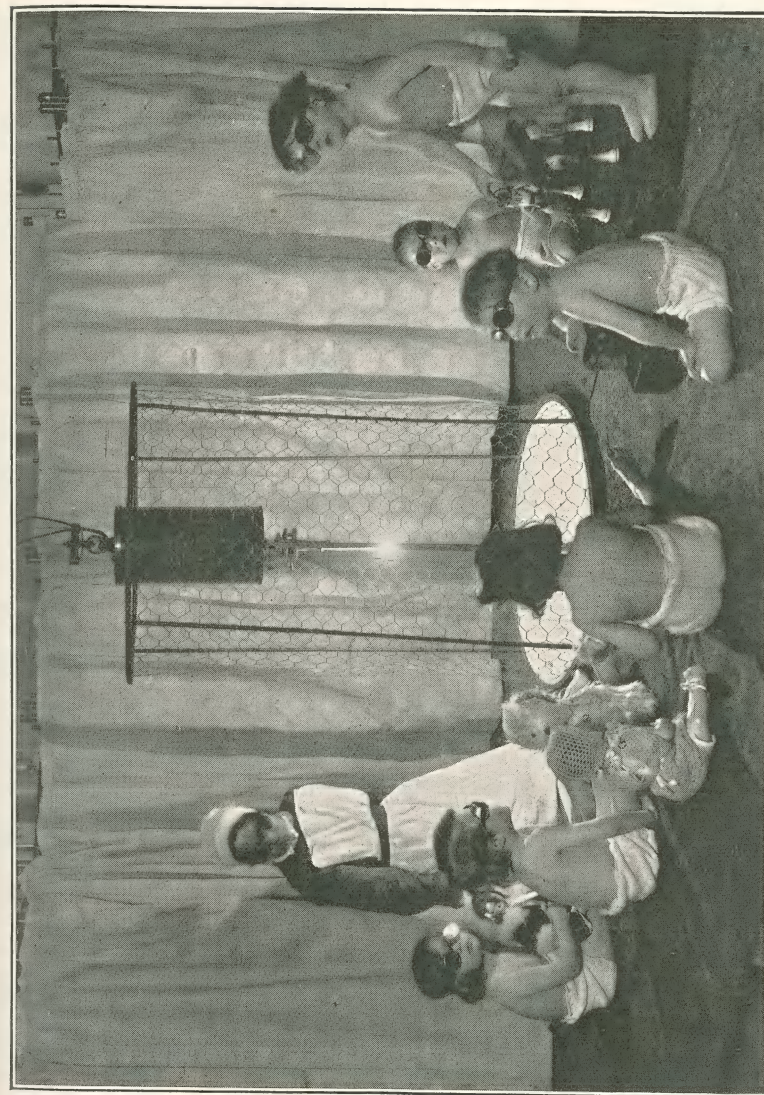


FIG. 172.—Children being irradiated with the "Westminster" Long-Flame Carbon Arc Lamp at a London Hospital.

current at the end of the required period, and at the same time, if specially desired, will ring an alarm bell.

These devices are the means of saving a great deal of time, but extreme care must be taken to see that the alarm is properly set and free to ring at the desired time, otherwise overdosage may result. The alarm clock is not, of course, absolutely necessary,

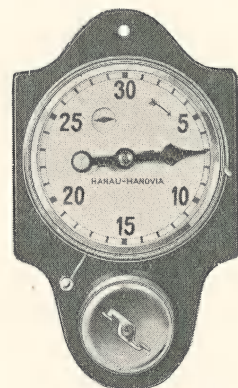


FIG. 173.—Exposure Meter with Alarm Bell. (Wall Type.)

but we find that it obviates the constant looking at a watch that would otherwise be unavoidable.

It is advisable to warn patients, or mothers whose children are having treatment, that the skin will assume a purplish colour in the light, and that the mucous membranes will appear black, because the light of the mercury vapour lamp is deficient in red rays.

Every patient should be warned of the probable appearance of erythema in a few hours, and should be told of simple remedial measures, such as applying

olive oil, lanoline, or calamine lotion, if the reaction is sufficiently intense to cause discomfort and tenderness. It should be made clear, however, that it is much better not to apply anything unless it is absolutely necessary, because this tends to prevent the penetration of the radiation at subsequent exposures. It is not advisable to bathe the irradiated part for about twenty-four hours after exposure.

It is of great importance that both the patient and the operator should have their eyes adequately protected, since even a few seconds' direct exposure will cause severe conjunctivitis, which, although it may pass off after a few days, is extremely painful while it lasts.

Patients should be particularly warned never to look at the lighted lamp while they are undressing preparatory to treatment.

Crookes's or some similar glasses should preferably always be worn. The patient's face may be covered, as an alternative, with an oblong piece of cardboard, having elastic or tapes fastened to its two upper angles, or an opaque fan or similar object may be held by the patient over the face; but glasses are generally used. It has already been stated that the operator's goggles should be provided with efficient side-ventilation to avoid steaming, which soon results if this precaution is neglected. Glasses used for electric arc welding are suitable, and can easily be obtained.

If the air-cooled lamp is being used in local applications, the normal skin surrounding the lesion and other exposed parts must be protected. This protection

of the surrounding parts may be effected by smearing over them some absorbent ointment. There are several preparations: "Antilux," which contains two per cent. of Beta-naphthol in a lanoline base; an ointment made with *æsculin*, a glucoside found in the bark of the chestnut-tree; an ointment made of paraffin molle, lanoline, and finely powdered wood-charcoal; a pomade containing collargol; or paraffin

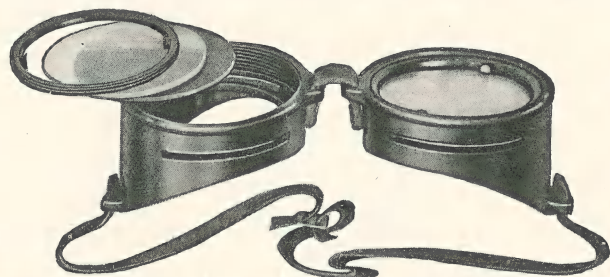


FIG. 174.—The "Wellsworth" Hardy Goggles, which can be fitted with Saniweld, Noviweld or Pfund Lenses. The frame is made of Condensite, which is a non-conductor of heat and electricity, and ventilation is arranged so that no side-light can reach the eye.

molle and tannic acid. Or, again, the skin may be painted with some dark pigment mixed with soft soap, which can be washed off easily after treatment.

Black or red paper, cardboard, adhesive plaster, or thin lead-foil, which is very malleable, and can easily be obtained from any tea-dealer whose tea-chests are lined with this material, may be used.

We have found it convenient to outline the area to be irradiated rather strongly with a skin pencil, and to stick a piece of adhesive plaster firmly over the whole area. If the plaster is removed, then the outline will be found to be imprinted on the adhesive side of

the plaster, and it is quite easy to cut out this outlined area accurately with a pair of scissors. The blue skin-marking can afterwards be readily removed with a little oil of sesame.

It must be remembered in this connection that clothing materials that are partly transparent to ordinary light are also penetrable by ultra-violet rays. This is of importance when children or women are being treated, since exposure of surfaces not intended to be irradiated might easily result in the occurrence of erythema in undesired places. The hoods of most lamps are, however, provided with diaphragms that allow the rays to be localized.

During treatment, women generally use loin slips; these can easily be made. Care should be taken to ensure that the same area of skin is always covered. Some "Antilux" or vaseline should be applied to the nipples before irradiation.

To avoid the discomfort of recurring erythema and consequent desquamation, if the operator's skin be at all sensitive, it is wise to wear a hood and gloves to protect the exposed parts. The hood can conveniently be made of some thin material and have apertures for the eyes, which should be covered by protective goggles.

Before irradiation the skin should be thoroughly cleaned, and all greasy matter or powder must be removed. Scales and crusts must also be dislodged, and if the application is to the scalp the hair must be kept as short as possible, since each hair may cast a shadow over the affected part. It must always be remembered that practically all substances have great

power of absorbing ultra-violet rays, and particularly the short, bactericidal rays.

In deep-seated skin lesions, and especially in cases of lupus, where the maximum amount of rays is required to penetrate the tissues, it is advisable to use a quartz compressor to make the part anæmic, and thus prevent the absorption of the rays by the blood.



FIG. 175.—Protective Face Mask made of thin tissue paper.

During winter it is sometimes desirable to apply a hot-water bottle, or, better still, an electric heating pad, to the patient's feet.

It is advantageous not to relight the lamp for each new patient. It is much better to allow it to burn continuously, so that it is available for immediate use. Incidentally, damage is most likely to be done to a lamp by repeated relighting at short intervals. On the other hand, lamps should not be left burning



FIG. 176.—“Westminster” Long-Flame Arc Lamp used for the Irradiation of Small Children at the “Sun-Ray” Clinic, Newcastle-on-Tyne.

unnecessarily, since the burners have a definitely restricted life.

For general treatment, it is best to expose a comparatively small area at the first application, but afterwards to irradiate as large an area of the body as possible—the whole of the back and the whole of the front on the same day—since there is no doubt that the effect obtained in most cases is increased by exposing the maximum skin area to the irradiation. Recently it has been suggested that better results follow the production of erythema on an area roughly equal to a quarter of the surface of the body. Another quarter is irradiated at the next application, and so on. Sequeira however states that some of his cases have been treated in this piecemeal way and he has been so disappointed with the clinical results that he has been forced, by the opinion of the workers in his department, to put the patients on to more general and larger exposures. The results in limited exposures are not, in his opinion, worth the trouble taken, and not as good as those from general-bath exposures.

Another method of general irradiation frequently used is one in which the first exposure is given to the feet, the second to the feet and calves, the third to the feet, calves, and thighs, and so on, the longest exposures always being given to the parts that have been exposed oftenest, until the whole body is exposed. The term "fractional irradiation" is applied to this method.

It is thought by some authorities that irradiation of the extremities leads to decongestion of the viscera, and similarly that irradiation of the trunk leads to

congestion; and therefore in such cases as phthisis, where visceral congestion is contra-indicated, the extremities only are exposed to the rays.

When giving general treatment it is usually wise to cover the back of the patient's head with a light towel when he is lying prone, especially if he suffers from headaches.

The ozone generated by the mercury vapour lamp can be used for inhalation; large amounts are formed particularly when the lamp has just been lighted. When desired, the ozone should be inhaled for about a quarter of an hour at a distance of about twenty-four inches from the lamp.

A special attachment is available for fitting to "British Hanovia" lamps, to enable the inhalation treatment to be carried out conveniently.

Irradiation of Children.—The first application of the rays to a child should be given when it is in its mother's arms, so that its confidence may be gained, and there may be no difficulty in getting it to lie on the couch afterwards. Small infants can easily be irradiated on the mother's knee. Great care must be taken to shield their eyes and to prevent them from taking off the protective glasses.

We have designed a simple but quite invaluable appliance, which consists of a weighted stand with an adjustable screen of three-ply wood. In general treatment it entirely obviates the necessity of wearing goggles, and it also prevents erythema or pigmentation from changing the normal appearance of the face.

Recently we have designed a special circular couch

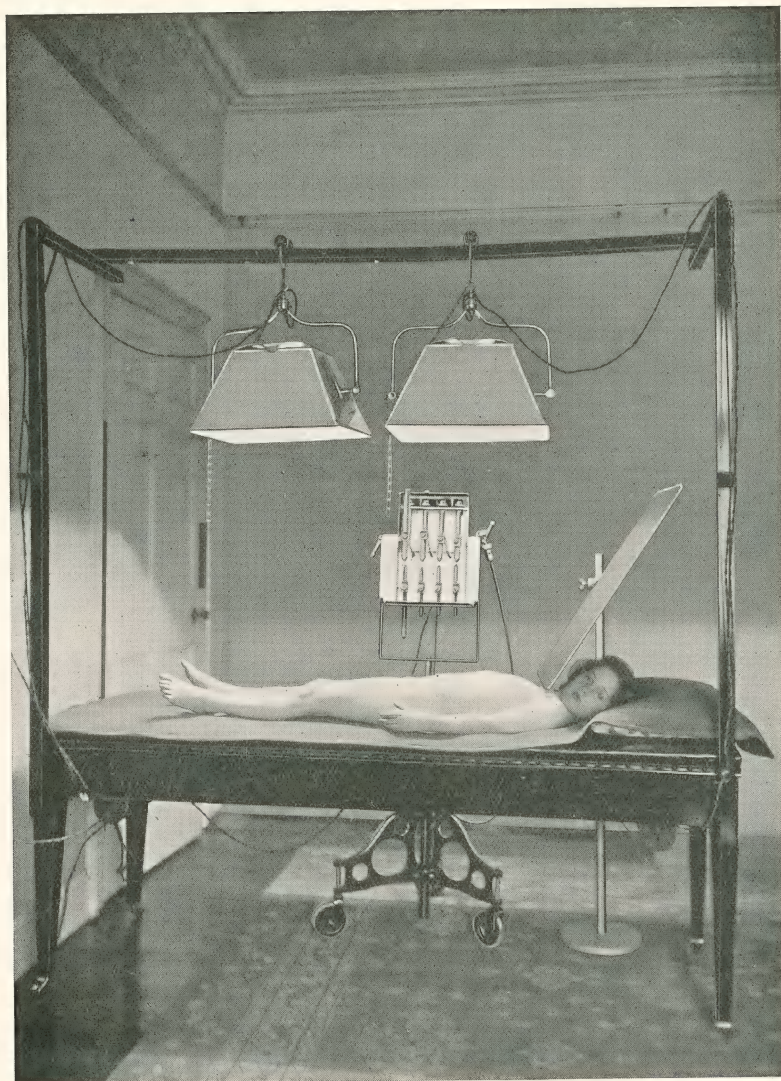


FIG. 177.—A type of Treatment Couch used by us some time ago, but now replaced by the type illustrated in Fig. 107. The photograph illustrates the simultaneous use of two Mercury Vapour Lamps and a Multiple Carbon Arc Lamp. The Mercury Vapour Lamps are suspended by hooks from a ladder chain, which allows them to be lowered when required. The chains are attached to wooden rollers, which can move along the horizontal wooden rail. Our Screen is seen in use instead of goggles. The disadvantage of this type of couch is that it is difficult to use for local treatment.

for use in infants' hospitals and welfare centres, to allow the simultaneous irradiation of six small children. The children lie on their backs on the couch, with their feet pointing to the centre and their heads outwards. A cylindrical curtain suspended over the couch screens the infants' faces from the rays, and allows their mothers to look after them conveniently during treatment. The top of the couch is divided into six segments, and the inner part of each segment is formed of netting. Two lamps are suspended above and two below the level of the couch. These lamps are slowly rotated by means of a small motor, thus ensuring even distribution of the radiation. The lamps can be automatically screened when desired, so that it is possible to arrange the children in position on the couch without having to switch the lamps off. The distance between the lamps and the couch can be varied between three feet and one foot.

The simultaneous irradiation of the front and back of the patient's body halves the time needed for treatment.

In hospitals, where a large number of children have to be irradiated daily, it is a great convenience to have several lamps installed in one room, with reflectors arranged to direct the rays into the centre of the room. Children of a similar height are treated together, and the lamps are adjusted so that the rays are directed towards the centres of their bodies.

Concentric circles of measured radii are permanently marked on the floor, and the lamps are placed on the outermost of these. During treatment the children walk round on a definite circle corresponding to the

dose required at that application, and thus the whole body is irradiated at once.

The walls of the treatment-room should be white-

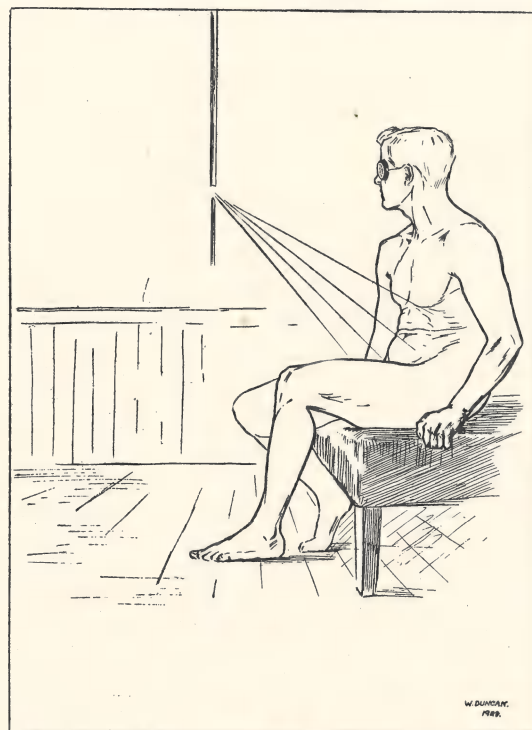


FIG. 178.—Diagram showing the correct position for the Irradiation of a Sitting Patient with the Short-Flame Carbon Arc.

washed so as to get as much reflection of the ultra-violet rays as possible.

The Position of the Patient during General Treatment.

—The patient may stand, or sit, or lie down, for treatment; but if the exposure is to be a long one the standing position will naturally not be satisfactory.

When a carbon arc lamp is used, patients generally sit on chairs with seats about seventeen inches from the ground; they sit as close together as possible, and as near the lamps as the heat allows, but it is

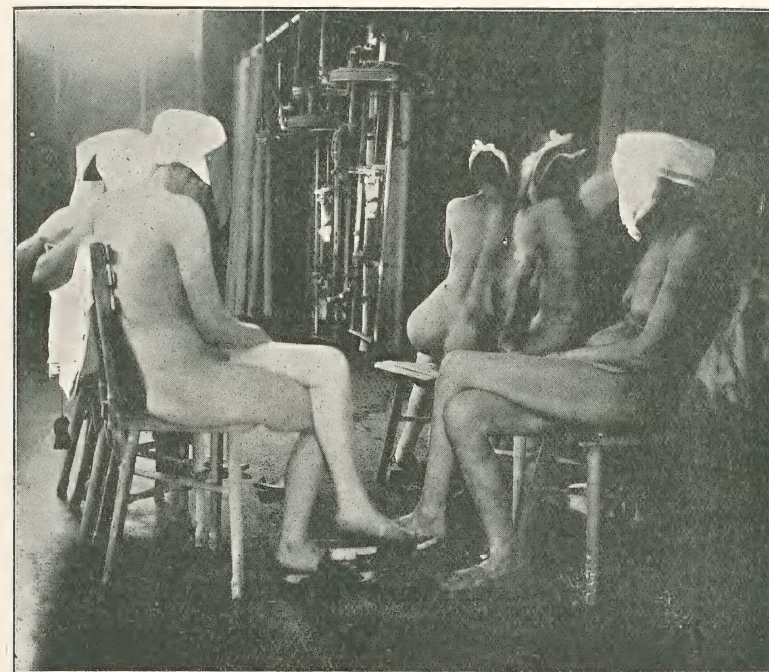


FIG. 179.—General Treatment at the Finsen Institute, Copenhagen, for Sitting Patients, with two 75-ampere Carbon Arcs in parallel.

generally impossible to make the distance between the positive crater and the middle of the patient's back less than eighteen inches. The whole body is exposed to the rays, and the greatest intensity of radiation is allowed to fall on the trunk, which presents the largest surface area. The most intense

radiation is given off from the positive crater of the short-flame arc at an angle of about forty-five degrees to the axis of the negative carbon, and these rays should fall on the patient's body at the subcostal

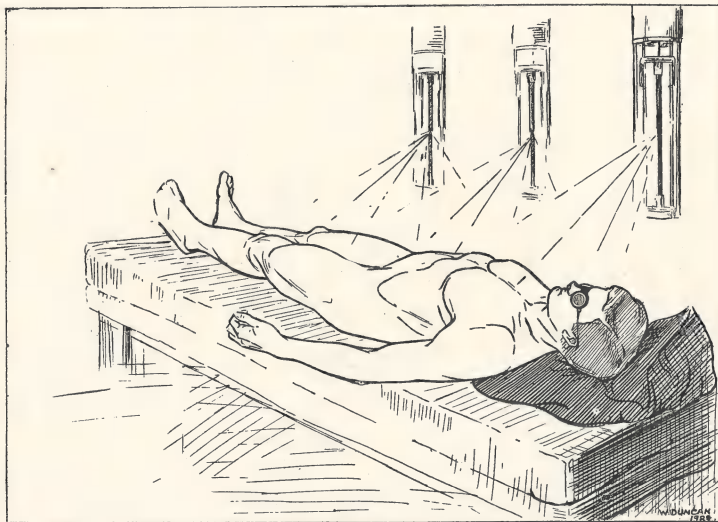


FIG. 180.—Diagram showing the correct position for the Irradiation of a Lying Patient with three Short-Flame Carbon Arc Lamps mounted in series.

margin. Six to eight patients can be treated at one time with two 75-ampere lamps.

The middle patient on each side receives the greatest intensity of radiation, and it is therefore customary for them to change places from time to time. During treatment, the back, sides, and front of the body are all exposed in turn.

Couches should be provided for those patients who are unable to sit comfortably, and in this case it is customary to use three 20-ampere arc lamps in series arranged in a straight line between two couches, so

that two lying patients can receive treatment at the same time.

The amount of heat given off by these lamps is not great, and it is therefore possible to use them

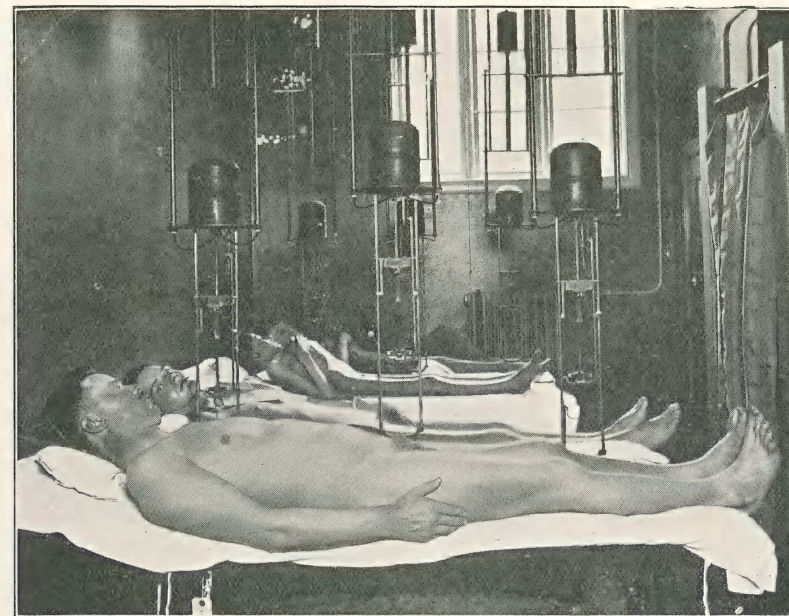


FIG. 181.—Patients at the Finsen Institute, Copenhagen, receiving General Treatment with the 20-ampere Carbon Arc Lamps.

comparatively close to the patients, who lie first on their backs and then prone.

In the long-flame arc the greatest ultra-violet emission takes place from the flame itself, and therefore when a sitting patient is being treated with this type of lamp the arc should be at the same level as the patient's trunk. A recumbent patient should lie on his side during treatment with this lamp, first

facing the lamp and later with his back to it, the arc being just above the level of the couch top.

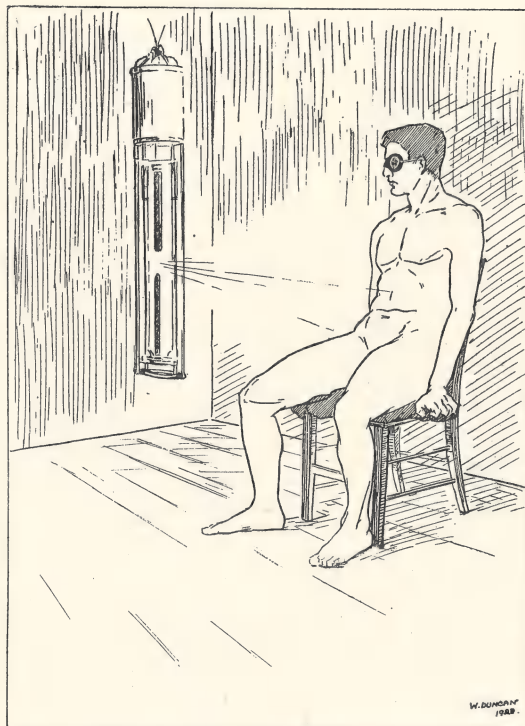


FIG. 182.—Irradiation of the Front of the Body with the Long-Flame Carbon Arc.

With the mercury vapour lamp it is quite true that it would ensure even distribution of radiation if the patient, during the first six applications, assumed a curved position approximating to part of the circumference of a circle with a radius of three feet; but later, when the distance between the patient and the burner had been decreased to one foot, the assumption

of the hypothetical curved position required would naturally be quite impossible.

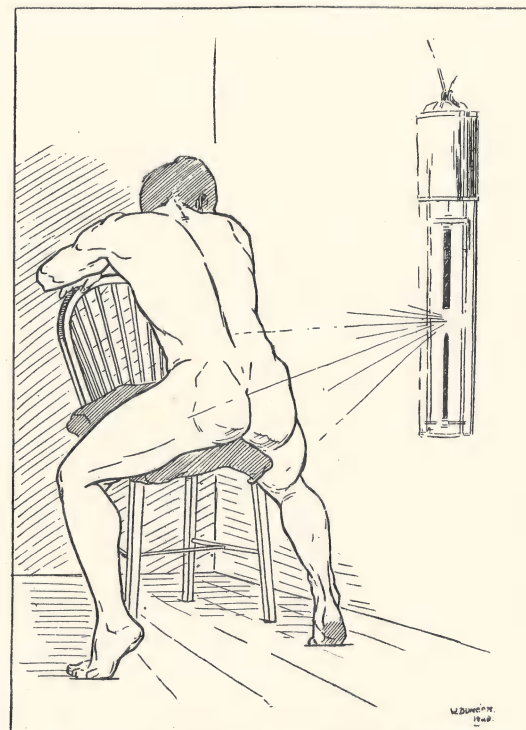


FIG. 183.—Irradiation of a Sitting Patient's Back with the Long-Flame Carbon Arc Lamp.

The satisfactory solution is undoubtedly the utilization of two mercury vapour lamps simultaneously for each patient. We prefer to have the patients lying on couches, with the lamps suspended above them, their arc tubes being parallel to the patients, who lie first in the supine and then in the prone position.

Taylor and Griffith found that when the radiation of a particular lamp was measured by means of a cadmium photo-electric cell on a level with and exactly opposite the centre of the arc tube of the lamp the intensity was 21 units; but when the cell

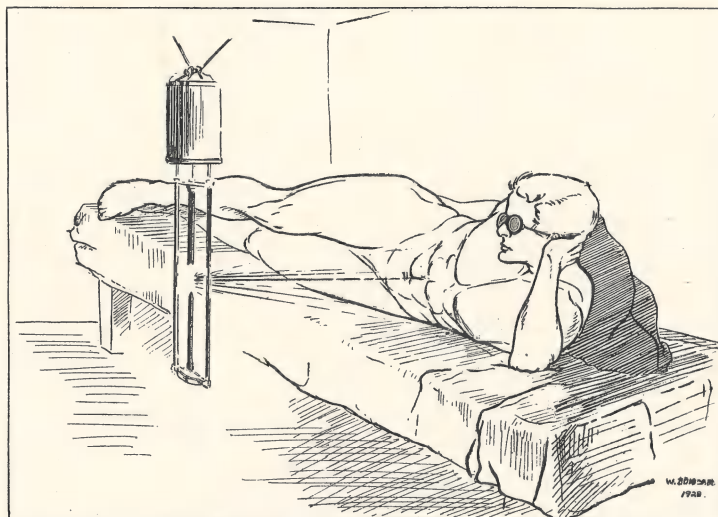


FIG. 184.—The correct position for a Lying Patient to assume during Irradiation with the Long-Flame Arc.

was placed at exactly the same distance directly underneath the lamp the intensity was 32 units.

It is extremely rare for a quartz burner to burst while it is in use, and even if it did, all that would result would probably be some slight burns caused by hot pieces of quartz falling on the skin.

We have known fracture to occur on six different occasions with one particular type of burner, which is now no longer made; but in each case the breakage occurred at identically the same spot on the burner,

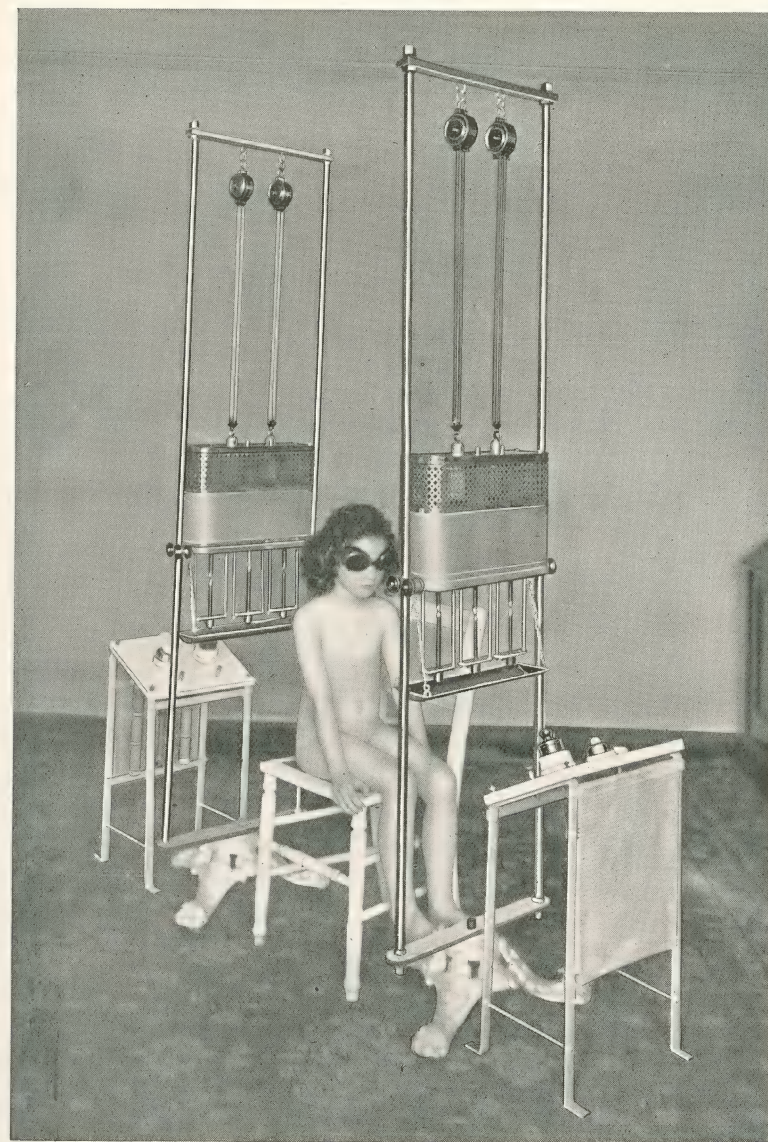


FIG. 185.—Simultaneous Irradiation of the Front and Back of the Body with two "Hospital Type" Saidman Carbon Arc Lamps.

and always took place in the five minutes immediately following the lighting of the burner, and therefore before the lamp was being used for treatment. Incidentally, we have proved to our own satisfaction that boiling mercury poured on the skin rolls off without causing a burn, and therefore no burning will come from the mercury unless the couch on which the patient is lying sags and causes it to remain in contact with the skin.

If a burner should break, the windows of the treatment-room should be opened immediately, because mercury vapour is very poisonous.

If the "Jesionek" type of lamp is used the patient can lie on his side, first facing the lamp and then with his back to it.

Some enclosed carbon arcs with inclined carbons can be suspended directly above the patient.

In the "Arnold" lamp the effective rays are given off obliquely in exactly the same way as in the short-flame arc. This, we know, is contrary to what is frequently stated; but it was proved to our satisfaction when we noted the level at which erythema, and later pigmentation, occurred on the back of a patient who was treated in the upright position.

Treatment may be applied simultaneously to both sides of the body by means of two carbon or "Jesionek" lamps, the patient either lying on his side on a couch or sitting on a small stool with his face towards one lamp and his back towards the other. This enables treatment to be given in half the usual time.

For *Local Treatment* it is generally easy to arrange the patient in a convenient position; a head-rest and sandbags are very useful.

The lithotomy position is very convenient for irradiating the vaginal and pubic regions, and either this or the knee-elbow position may be used for anal affections. We have found the greatest difficulty in treating eczema affecting the inter-natal area, and have had a small instrument made to secure mechanical separation of the cheeks of the buttocks.

In treating scalp conditions the back of the neck and ears of the patient must be carefully protected by a towel held in position with clips.

In all local treatment the areas surrounding the part to be treated must be adequately protected.

The Use of Ultra-Violet Rays in the Operating Theatre.—The authors recently saw at the Hospital Necker (Paris) a special ultra-violet lamp, suspended over the operating-table, which Professor Leguen and Dr Saidman have been using during the performance of operations. The rays fall directly on the wound, and have been found to be a help rather than a hindrance to the surgeon during the time of exposure, because of the good illumination they give.

Dosage.—Dosage is dependent on so many different factors that it is very difficult to formulate definite rules for the length of exposure. When radiation falls on the body:

- (a) Some may pass through; for example, red rays can pass through the fingers or cheeks.
- (b) Some is absorbed and (1) is converted into heat (a radiant-heat bath can raise the body temperature), or (2) produces luminescence, which takes place in all animal tissue.
- (c) Some is reflected.

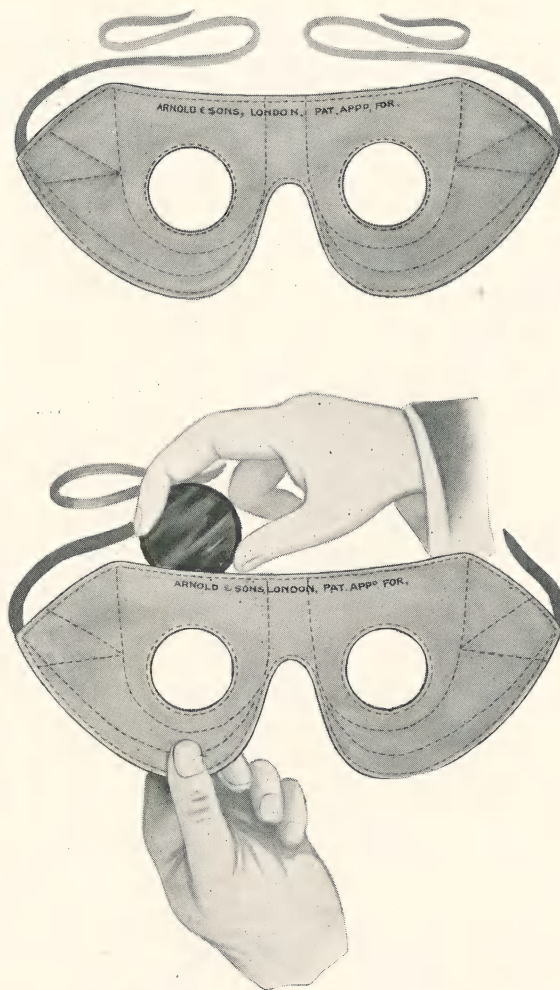


FIG. 186.—Protective Goggles with Removable Glasses easily sterilized by boiling.

This can readily be proved by projecting ultra-violet radiation on the skin after filtering it through an oxide-of-nickel filter, and then holding a fluorescent screen in a position facing the skin and with its back to the filter. The screen will fluoresce brightly.

The radiation from the lamp depends upon :

- (a) The primary source of illumination.
- (b) The different media through which the rays have to pass.
- (c) Whether a special filter is being used.

Lamps operating at from 240 to 480 volts are much more powerful than those designed for 110 volts. One type of "George" burner is seven times as powerful as another. The intensity of the radiation also depends on the age of the burner. A new burner is more brilliant than one that has been in use for some time. The reason for this has been explained in Chapter V. The number of lamps employed is also of consequence, because naturally two lamps give off twice as much radiation as one.

Another important factor in dosage is the sensitiveness of the patient. No two patients are alike. One would have a severe reaction with an exposure that causes only the slightest reddening in another person. Generally speaking, dark types can stand a longer dosage than fair, and the reddish type is the most sensitive.

Women are as a rule more sensitive than men, and sensitiveness decreases as age increases. The parts of the body ordinarily exposed to light—the face and, particularly, the hands—are much less sensitive than the regions covered by clothing.

TABLE SHOWING THE RELATIVE SENSITIVITY OF
DIFFERENT PARTS OF THE BODY

<i>Part</i>	<i>Relative Sensitivity</i>
Chest	1
Abdomen	1
Back	1
Groin	1
Anterior arm	$1\frac{1}{2}$
Posterior arm	$1\frac{3}{4}$
Posterior leg	$1\frac{3}{4}$
Anterior leg	2
Dorsum of hands	5
Palms of hands	15
Soles of feet	25

Another important point is whether the epidermis is thick or thin, and whether it perspires easily or not. Thin, dry, pale skin reacts more readily than fat, moist, pigmented skin.

Children seem to respond more readily to ultra-violet radiation than adults, and this is probably partly because the horny layer of the skin is not so thick as it is in the case of adults. It is, however, a curious fact that erythema is not so readily produced in an infant as in children above the age of four, and in adults. Special care is therefore necessary when small children are being irradiated, because then the absence or the appearance of erythema is not a reliable guide, and, naturally, infants are unable to describe any symptoms they may experience.

This phenomenon has been attributed to the imperfect development of the central nervous system in very young children.

In practice we have generally found that an initial dose of two minutes and a half at a distance of thirty-six inches is safe, whether the patient is a child or an adult.

The strength of a lamp can be standardized either by its power to darken photographic paper in comparison with a standard shade, or by its power of bleaching a solution of acetone methylene blue. In the latter method a little of the solution is placed in a

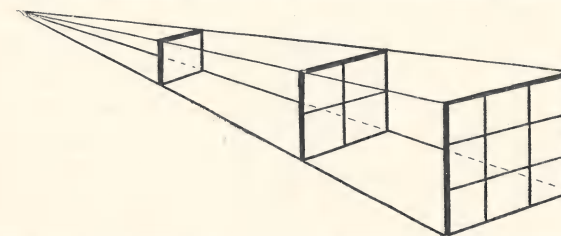


FIG. 187.—Diagram illustrating the Law of Inverse Squares.

small quartz tube and exposed to the rays from the lamp at a definite distance for a definite length of time. The shade of the solution is then matched with a series of eight solutions of successively paler shades contained in small glass tubes, and the number of tubes between the original shade and the faded shade is noted. In practice elaborate tests are unnecessary.

The intensity of ultra-violet radiation varies with distance in the same way as ordinary light—*i.e.* the intensity varies inversely as the square of the distance from the lamp. Thus, if the radiation falling on a given area at a distance of one foot from the source is taken to be unity, the amount falling on an equal area at a distance of two feet will be only a quarter, at three feet a ninth, at four feet a sixteenth, and so

on. This shows the imperative necessity of always carefully measuring the distance of the patient from the burner of the lamp. Some lamps are conveniently provided with a fixed steel-spring tape-measure, but

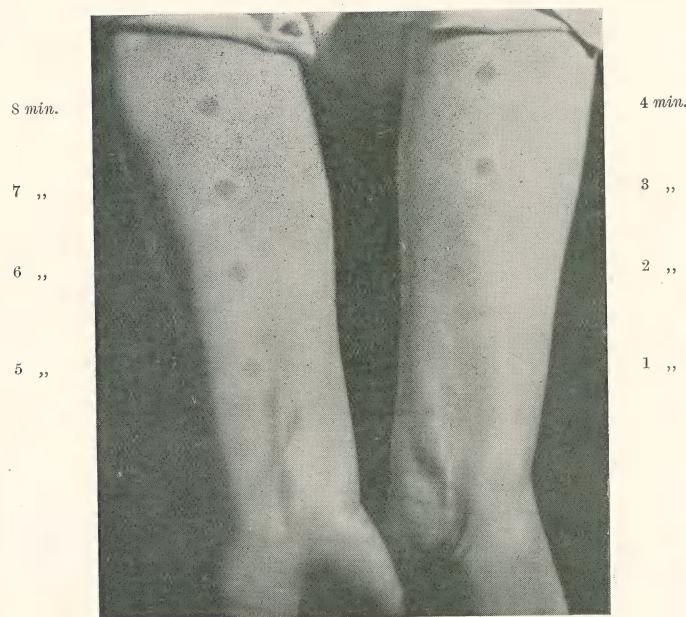


FIG. 188.—Photograph showing varying degrees of Erythema produced by Graduated Exposure of different areas on the forearms to Ultra-Violet Rays.

an ordinary tape-measure or a wooden yard-stick does almost as well.

A new burner is exceptionally powerful for the first twenty-four hours of use, and great care should therefore be taken in treating with it during this period.

The cases of over-exposure that sometimes occur are generally due not to the actual length of the

exposure in seconds but to failure to measure the distance of the patient from the lamp. This measurement should invariably be made before commencing treatment. Especial care should be taken in the first treatment, in case the patient should be one of those susceptible people who have an idiosyncrasy to ultra-violet radiation.

If over-exposure should occur, smaller subsequent doses should be given. Olive oil, vaseline, or zinc-oxide ointment, may be applied, and blisters may be treated with a .5 per cent. solution of resorcin.

One point that deserves notice in regard to the length of exposure is that if for any reason a patient has missed treatment for a period of ten days it is safest to recommence with half the last exposure; if, however, three weeks or more have elapsed it is as well to begin again with the initial dosage.

The sensitiveness of the patient may be judged by covering the forearm with a piece of material in which there are several holes that can be covered after exposure. The first hole is exposed for one minute at a definite distance (thirty-six inches for an air-cooled lamp), the second for two minutes, and so on, up to five minutes. The following day the degree of erythema is noticed, and therapeutic exposures are given accordingly.

A Test-Dosage Armlet is useful and convenient for making these tests.

Saidman has invented an automatic "sensitometric" test. The apparatus consists of a flat aluminium plate, about 7 in. square, with eighteen different-shaped holes punched in it. Numbers are

also stencilled in the plate, which supports a clockwork mechanism. A small movable screen automatically covers the different apertures in rotation, the first after one minute, the second after two, and so on up to the last, which is covered when a period of eighteen minutes has elapsed.

Some filter paper soaked in a colourless solution of paraphenylenediamine is exposed to the rays from the ultra-violet lamp, and the distance is determined at which the filter paper is darkened to a standard tint in ten minutes.

The "sensitometer" is now firmly applied to the bare skin of the patient, usually in the region of the loin, and the patient is irradiated at the predetermined distance from the lamp for eighteen minutes, the surrounding skin being carefully covered. The next day the patient's reaction can be quickly seen, since the outline of some of the numbers will be stencilled on the skin. The production of a faint erythema in five minutes is taken as normal. If erythema occurs, say, after one minute, then only one-fifth of the normal dose should be given; if only after ten minutes, twice the normal dose; and so on. It is of course necessary to vary this dosage in treating different diseases, some conditions requiring a mild reaction and others a strong one.

The erythema varies, and may be classed in four degrees of severity; the doses mentioned refer only to an average air-cooled mercury vapour lamp:

- (1) A very slight degree of reddening, not followed by desquamation of the skin, obtained on an average after one or two minutes at

36 in. from the lamp, increasing one minute daily.

- (2) Slightly more reaction, accompanied by mild irritation, and followed by fine desquamation, obtained after two and a half to three minutes at 36 in., and increasing as shown on the scale.
- (3) A more severe reaction, accompanied by itching and burning, and later by free peeling of the skin, obtained after five minutes at 18 to 20 in.
- (4) A destructive reaction, in which there is swelling and blister formation, obtained after seven or eight minutes at 12 to 18 in.

These dosages are average and must be modified as previously explained. It is obviously important to consider whether stimulation or irritation of the part treated is desired.

Degrees (1) and (2) are used in cases where general irradiation is required for constitutional conditions. A first-degree reaction is aimed at in such conditions as rickets, tetany, debility, and pulmonary tuberculosis, and a second-degree in extra-pulmonary tuberculosis, rheumatism, and asthma. The length of exposure may be gradually increased during the whole course of treatment as the skin pigments, even to half-an-hour back and front, or longer, care being taken that the increase is gradual. Degrees (3) and (4) are used for local conditions, such as lupus and nævus, where destruction of abnormal tissue is desired.

SUGGESTED DOSAGE-SCALE FOR USE WITH AN AVERAGE
AIR-COOLED MERCURY VAPOUR LAMP (220-240
VOLTS) FOR GENERAL ULTRA-VIOLET IRRADIATION

<i>No. of Application</i>	<i>Duration of Exposure of each Side of Body</i>	<i>Distance from Source of Radiation</i>	<i>Relative Strength of Dose</i>
1st	2½ min.	36 in.	1
2nd	3½ „	36 „	1.4
3rd	5 „	36 „	2
4th	6½ „	36 „	2.6
5th	8 „	36 „	3.2
6th	10 „	36 „	4
7th	10 „	30 „	5.76
8th	10 „	24 „	9
9th	10 „	18 „	16
10th	10 „	12 „	36

For a first-degree reaction slightly smaller doses should be given, and for a second-degree slightly larger.

The makers of the “Henri George” burner suggest the following dosage-scale :

	110 volts	220 volts	
1st application	4 min.	2½ min.	} To each side of the body at a distance of 3 ft. from the burner
2nd „	6 „	4 „	
3rd „	8 „	6 „	
Never exceed	45 „	30 „	

Augment the dose by two minutes at each application.

At a first glance this dosage seems stronger than

ours given on page 378, but this is not actually so, because the final dose is only twelve times as powerful as the initial one, whereas on our dosage-scale it is thirty-six times as strong, which incidentally saves a great deal of valuable time. The great intensity of radiation from the 220-volt burner must, however, be remembered.

Our experience with a 220-volt “Henri George” burner is that this suggested dosage is rather strong, and that an initial dose of one minute, very gradually increased, is ample.

The skin is more susceptible than mucous surfaces to ultra-violet radiation.

Cosine Law.—It has already been mentioned that there is a considerable amount of reflection of both visible and ultra-violet rays from the surface of the skin, and the patient should be placed, whenever possible, so that the rays from the lamp strike the part being irradiated at right angles, because the amount of reflection increases if the incident angle is less than a right angle. The law governing this loss of intensity is known as the “Cosine Law,” and in accordance with it the period of exposure must be proportioned in a definite relation to the size of the angle of incidence. An unequal effect is produced by radiation of convex surfaces such as the shoulder, the action of the rays, as has already been indicated, being strongest where they strike the surface at right angles. When a large area is being irradiated an attempt should always be made to cause an equal distribution of effect, and the simultaneous use of two lamps is advantageous in this respect.

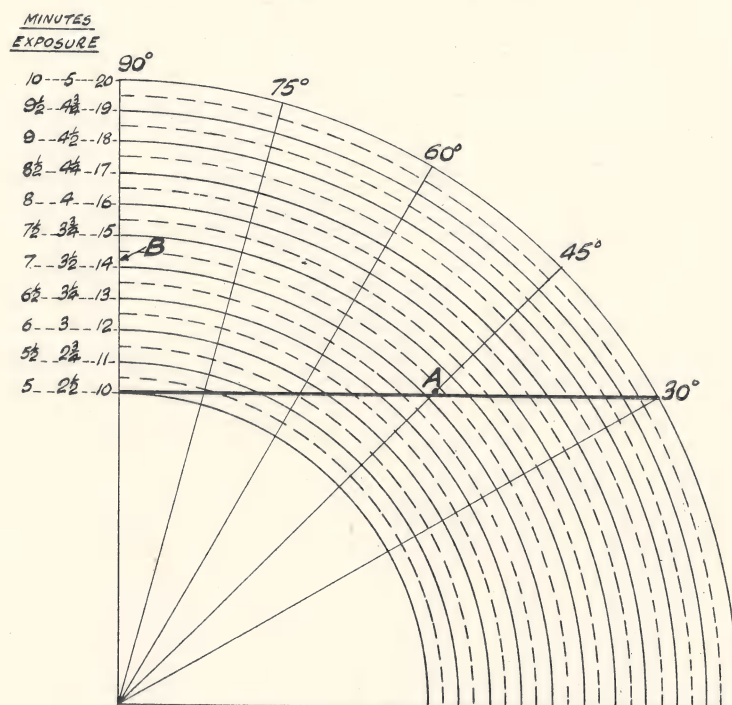


FIG. 189.—Chart showing Dosage required for Irradiation at Different Angles of Incidence.

Example.—Assuming that the lamp is to be used at an angle of 45° to the patient, follow down the 45° line until the point A is reached, corresponding to the exposure at 90°, and then follow round the curved line to the point B, and read the figures there—viz., approximately, 7, 3½, and 14 minutes. This means that, assuming the exposure to be 2½ minutes when the lamp is directly over the patient (or at 90°), the time required to produce a similar effect at 45° would be just over 3½ minutes, and similarly an exposure of 10 minutes at 90° would imply one of 14½ minutes at 45°, the point B being away from 14 by about an eighth of the distance between the figures 14 and 15 on the scale. In the same way the proportionate exposure required at any angle can be found on this chart.

Intervals between Applications of Treatment.—First-degree erythema doses can, if desired, be given every day; second-degree doses are usually applied either every other day or twice a week. Some cases do well with weekly doses, particularly chronic cases, such as hyperpiesis.

In general treatment it should be a rule never to apply radiation when the reaction from the previous treatment is still present.

After twelve to twenty applications some actinotherapists prefer to make a rest interval of three to four weeks, but this is quite contrary to the opinion of the Finsen Institute authorities, as well as to that of Rollier in regard to exposure to the sun—and, after all, these experts have had unsurpassed experience of actinotherapy and heliotherapy. No unanimous decision, however, has yet been reached on this important point.

Duration of Treatment.—When the rays are applied for their tonic effect twelve applications will sometimes suffice. In other conditions the nature and severity of the disease are important factors in determining the total period of treatment.

In rickets at least twenty-four applications should be given, and in cases of sterility thirty-six applications. Treatment is generally prolonged in cases of surgical tuberculosis.

Treatment with "Gallois" Quartz High-Frequency Electrodes.—These electrodes are very convenient when it is desired to apply ultra-violet radiation and high-frequency current simultaneously. They are very suitable for the application of internal treatment to

the several body cavities, such as the nose, ear, and throat, and the urethra, vagina, and rectum.

Before the electrodes are used, any grease on the outside of them should be removed with a little ether, chloroform, or alcohol, and then the mercury in their interior should be shaken down to the terminal end, just as the mercury is shaken down in a clinical thermometer. They can be sterilized by passing them through a Bunsen flame. Brown stains sometimes appear on the inside of the quartz after it has been used for some time. These will quickly disappear if the electrode is gently warmed in the flame. The eyes and hands should be adequately protected when these electrodes are being used. They are made in a variety of shapes and sizes, and have been found particularly useful in the treatment of many cases of eczema and in tubercular laryngitis.

We found that a first-degree actinic erythema could be obtained on the skin in about five minutes with one of these electrodes, and a second-degree in about ten minutes. As mucous surfaces can tolerate longer exposures than the skin, we suggest that the first application should be of five minutes' duration, the second of seven minutes', and so on.

It is possible to vary the intensity of the ultra-violet and high-frequency emission by regulating the current passing through the electrode.

The Use of the Finsen Lamp.—After all grease and crusts have been removed, with ether or lysol solution, the area to be treated should be carefully outlined with a dermatological pencil. It is necessary to focus the rays correctly when the Finsen lamp is used. It is

provided with a perforated metal cap, and the rays must be made to strike the outlined area as nearly as possible at right angles. The compressor, with water flowing through it, should be firmly pressed on the part to be treated. All uneven adjacent spaces covered by the compressor must be carefully filled with cotton-wool or lint soaked in cold boric lotion, otherwise burning may occur, since any area treated with concentrated radiation will get hot unless it is cooled by firm contact with the compressor. The metal cap should now be removed and the radiation focused so that there is a bright spot on the lesion, surrounded by a red halo. The reason for this is that when the rays from the lamp are passed through the lens the blue rays come to a focus nearer the lens than the red, and hence the blue rays form a bright spot and the unfocused red rays form a halo round it. At a point a little farther away from the lens the red rays focus and the blue rays cross and diverge to form a blue halo. The ultra-violet rays are more refrangible than the blue rays, and therefore have an even shorter focal length. Satisfactory results can be obtained only when every care is taken to obtain accurate focusing.

Local Treatment with the Water-cooled Mercury Vapour Lamp.—The water-cooled lamp is so powerful that it is always wise to become familiar with the air-cooled lamp first.

Moreover the air-cooled lamp is generally much more useful than the "Kromayer," which probably will be required only by a specialist.

The lamp can be removed from its stand and used

to "iron" the affected parts, but this method is not very satisfactory, because it renders exact dosage difficult. The lamp is much more often used in the fixed position, either clamped in its holder or firmly held in the hand. Some soothing ointment should be applied to the affected part when there has been a very strong reaction.

Mild or strong doses may be needed: mild doses for localized cases of eczema and trophic conditions, and strong doses for lupus, port-wine stain, and keloid, or when a counter-irritant effect is desired, as in cases of sciatica and rheumatoid arthritis.

A lamp of the "Kromayer" type is most often employed for local application in the treatment of skin conditions of limited size.

Only areas equal in size to the quartz window of the lamp (*i.e.* 2 in. in diameter) can be treated at one time. If only superficial effect is required the lamp is held about four inches from the lesion. For example, in cases of alopecia, exposures varying from five to fifteen minutes are given. If deeper action is necessary the quartz window is applied directly to the skin and pressure is maintained to cause exsanguination of the part and so to obtain greater penetration of the rays, since otherwise the majority of them would be absorbed by the blood in the capillary vessels. This mode of application is used in cases of lupus, naevus, and the like, and the length of exposure varies from one to forty-five minutes.

Lighting the "Kromayer" Lamp.—Before lighting the lamp it should be seen that the water is running at the rate of about four pints a minute, and that

the water tubes are correctly fitted to the inlet and outlet tubes on the burner casing. The main current should then be switched on, and the regulating lever of the rheostat switch should be brought to the weak "reduced" position.

The burner handle should now be firmly held with

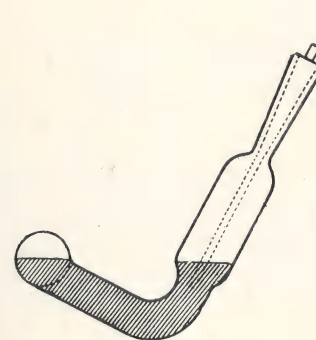


FIG. 190.—Diagram of Method of lighting the "Kromayer" Lamp. When tilting the Burner to strike the Arc, it should not be tilted too far from the Vertical Plane, or the Electrodes will no longer be in contact with the Mercury.

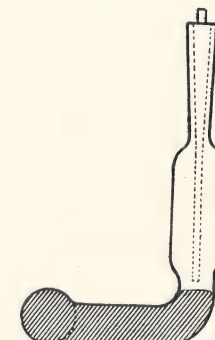
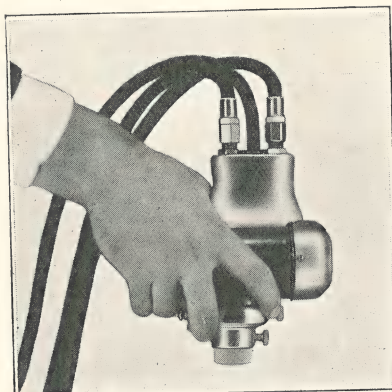
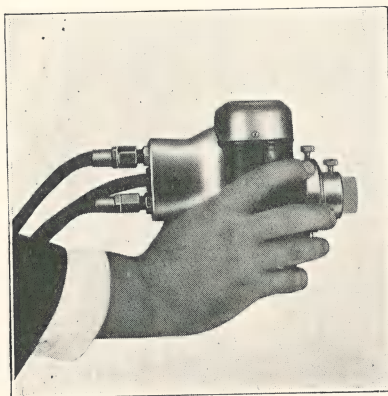


FIG. 191.—Diagram showing how the "Kromayer" Burner can be tilted so far, when attempting to light it, that the Mercury is no longer in contact with the Electrodes.

the right hand, while the hand-wheel, which is directly beneath the spring clamp holding the burner, is loosened with the left. The burner should next be gently and evenly tilted forwards, to an angle that must never exceed ninety degrees, until the two mercury columns in the parallel limbs of the burner arc tube meet and establish metallic connection between the two electrode vessels, the current short-circuiting through the mercury. The burner is then to be brought slowly back to its original vertical

position, so that the mercury column is broken, and the arc struck.

The hand-wheel must finally be tightened and the lamp allowed to burn two minutes before the



FIGS. 192 and 193.—Method of lighting the Water-cooled "Uviarc" Lamp. (As can be seen, this differs from the method employed in lighting the "Kromayer" Lamp.)

Showing the Vertical Position in which the lamp is held before it is tilted to strike the arc.

The burner is tilted to the Horizontal Position shown for a few seconds only, and is then replaced in the vertical position seen in Fig. 192. After five minutes in the vertical position the lamp is ready for use. The tilting causes the mercury from the cathode to come into contact with the anode and so to complete an electrical circuit through the tube.

regulating lever is turned to another stud; after this, the current is gradually increased to its full strength by passing the lever over successive studs at intervals of one minute. When a direct-current lamp is used, the current-direction indicator should always be looked at to see if the polarity is correct (R=right; F=fault). Five minutes after ignition

the lamp can be used by removing the mica protection screen.

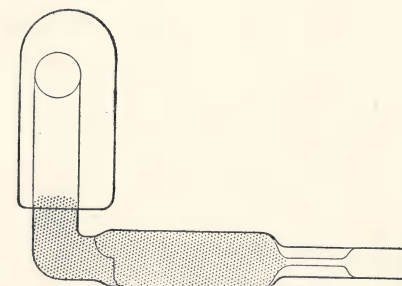


FIG. 194.—Diagram of the "Kromayer" Direct-Current Burner, showing the correct position of the Mercury in the Burner after the Lamp has been burning a few minutes.

The alternating-current lamp often needs repeated tilting. When the arc has been struck, and light is

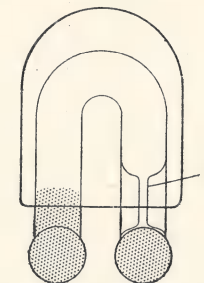


FIG. 195.—Diagram of the "Kromayer" Burner (D.C. Type), showing the correct levels of the Mercury after the Lamp has been lighted for four or five minutes. If there is much mercury in the right-hand limb above the constriction O, the lamp should be extinguished and relighted.

seen, the transformer button should be pushed down, and the lamp should be kept in an inclined position

for a further half-minute, and then brought slowly back to the upright position.

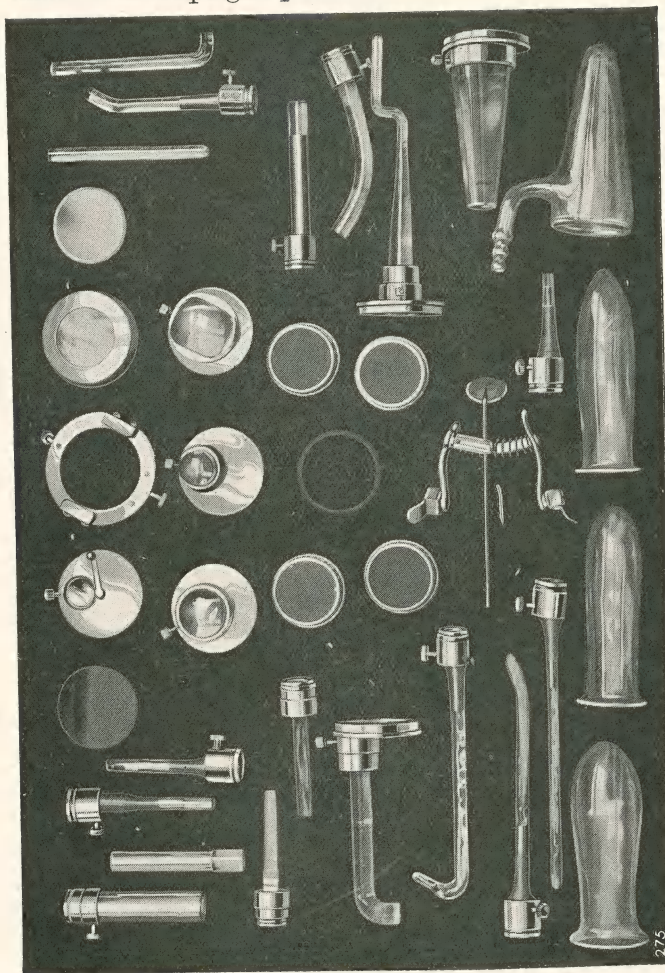


FIG. 196.—Applicators and Holders for use with the "Kromayer" Lamps made by the British Hanovia Co.

Only very slight deviations from the vertical plane are permissible in the "Kromayer" lamp.

A careful watch must be kept to see that an

adequate water circulation is being maintained. Sudden withdrawals of water from neighbouring taps are the commonest cause of trouble.

When the treatment is finished, turn off the current

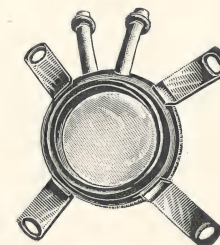


FIG. 197.—Water-cooled Quartz Compressor for use with "Finsen" or "Finsen-Reyn" Lamps. (Sanitas, Berlin.)

first and then the water. It is advisable not to allow the water to flow away, but to keep it in the lamp, so that the quartz cools gradually, and cracking

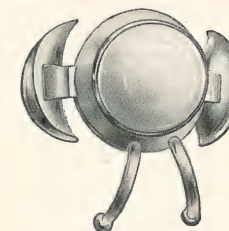
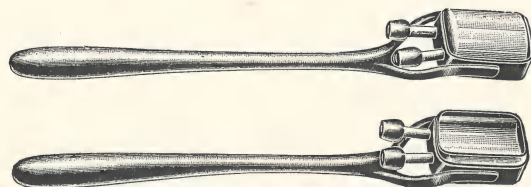


FIG. 198.—"Jungmann" Quartz Compressor for use with the "Finsen-Reyn" Lamp. (G.R.S.A. London.)

is prevented. The metal jacket of the water-cooled burner should never be allowed to get too hot: it should always be possible to hold it comfortably in the hand.

Applicators and Compressors.—Solid quartz applicators can be obtained, of different shapes and sizes,



E.G. SANITAS, BERLIN

FIG. 199.—Quartz Compressors for use in Tubercular Dactylitis in association with "Finsen" or "Finsen-Reyn" Lamps.

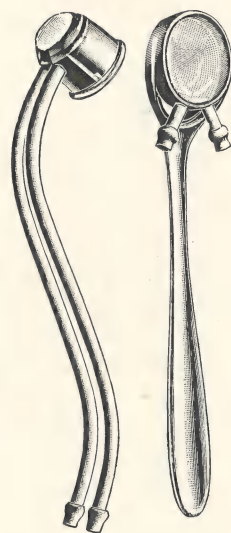


FIG. 200.—Other types of Quartz Compression Apparatus for use with "Finsen" or "Finsen-Reyn" Lamps. (Sanitas, Berlin.)

and can be fixed to the quartz window of the lamp in order to treat parts such as the nose, where, owing

to irregularities of contour, it is difficult to apply the window directly.

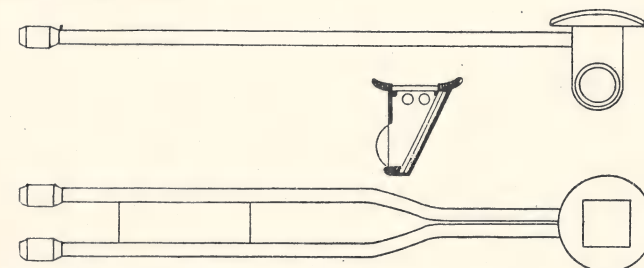


FIG. 201.—Prismatic Quartz Applicators used with "Finsen" or "Finsen-Reyn" Lamps, principally for the Treatment of Lupus affecting the Mucous Membrane of the Nose. The Small Diagram shows where the Radiation leaves the Applicator. (Reyn.)

For the treatment of orifices, solid quartz rods may be used, and hollow cone-shaped applicators of quartz, fitted with water-cooling devices, can be

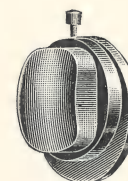


FIG. 202.—Large Square Applicator for Compression of Skin Lesions, for use with a "Kromayer" Lamp.

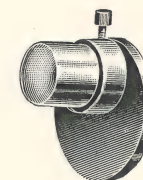


FIG. 203.—Small Round Dermatological Compression Applicator for use with a "Kromayer" Lamp.

obtained for irradiation of the vagina, rectum, mouth, etc. When these applicators are used very little ray intensity is lost by the increase in distance between the burner and the part under treatment, because quartz conducts the rays much more easily than

air, and the law of inverse squares is not applicable in these circumstances.

The Finsen Institute compressors are separate, and

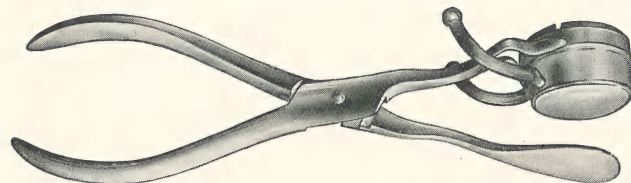


FIG. 204.—Forceps-shaped Quartz Compressor designed by Dr Jungmann for use with the "Finsen-Reyn" Lamp. (G.R.S.A. London.)

are not attached to the lamp itself, but are held in position by a nurse. An independent water supply

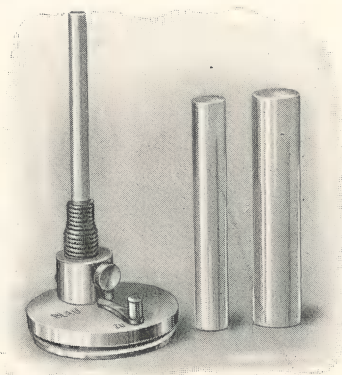


FIG. 205.—Dr Cemach's Quartz Applicators, principally used for Nasal Treatment. A Spiral Spring makes the Rod flexible and less liable to be broken. With this Applicator the Rays can be used without filtration or they can be passed through blue Uviol Glass.

circulates through them to keep them cool. The form most commonly used consists of a plate of rock-quartz

and a plano-convex lens separated by an enclosed space, 5 mm. in thickness, through which the water circulates.

There is also an oval-shaped Finsen compressor, and one with a concave lens specially designed for use in tubercular dactylitis.

Prismatic applicators are used for treating lupus of the nose.

A large range of useful applicators can be employed with the "Kromayer" lamp.

We use two or three plano-convex lenses of different

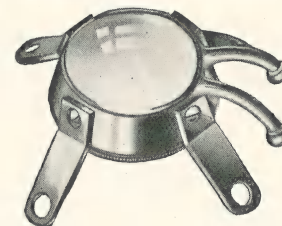


FIG. 206.—Compressor with Convex Quartz Lens for use with the "Finsen-Reyn" Lamp. (G.R.S.A. London.)

sizes for dermatological work, and we find the "Cemach" spring applicator invaluable for nasal work.

There are other special applicators for treating the mouth, the urethra, the posterior nares, etc.

A large number of hollow metal specula have been designed for localizing the rays; these are, of course, of no use in compression work. They are most often used for treating the vagina, the rectum, the ear, the nose, and the mouth.

We have designed an applicator of the speculum type, which can be used for the simultaneous irradiation of both nostrils in such conditions as ozæna or

nasal catarrh, with our own type of housing for an air-cooled lamp or with a "Kromayer" lamp.

Fused quartz applicators can be sterilized by simply passing them through a naked Bunsen or spirit flame. Natural quartz crystal, however, must never even be

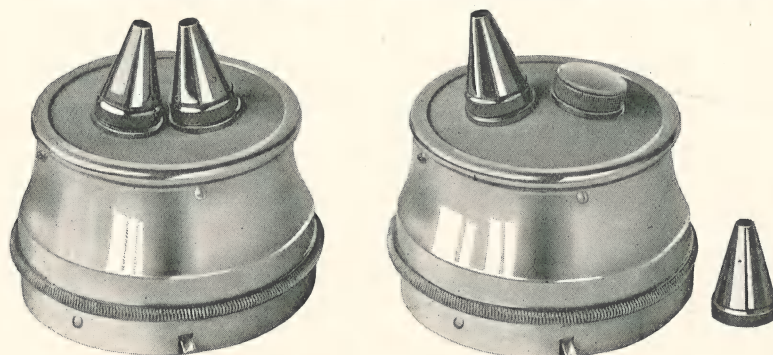


FIG. 207.—Our Nasal Speculum, manufactured by Kelvin, Bottomley & Baird, can be used if desired for the simultaneous Irradiation of both Nostrils. The Nozzles are mounted on a rubber base and readily adapt themselves to the Nostrils. The rubber also prevents the nozzles from becoming hot through heat conduction.

boiled, but can be sterilized by soaking it in a 1 : 1000 solution of corrosive sublimate.

Blue Filters.—Professor Kromayer has devised a method of cutting off the superfluous heat and non-penetrating short-wave ultra-violet rays by interposing screens of varying thicknesses of blue Uviol glass with a perforated metal holder between the quartz window and the cover of the burner—that is, actually in the water bath itself. In this way the blue, the violet, and the long-wave ultra-violet rays are allowed to pass through the screen, while the red rays, the heat rays, and the ultra-violet rays of short wave-length, are absorbed. The amount of

absorption varies with the thickness of the glass screens.

The quartz window of the lamp can also be replaced by a blue Uviol glass filter, but this can be made only of a limited thickness, to prevent the surface not in contact with the circulating water from becoming too hot.

Dosage with the "Finsen" Lamp.—One hour's exposure is usually given to each area with the "Finsen" lamp; this can often be cut down to forty-five minutes when the "Finsen-Reyn" lamp is used.

Dosage with the "Kromayer" Lamp.—Third- or fourth-degree reactions are usually required.

The "Kromayer" lamp produces :

- A first - degree erythema with contact in 10 seconds.
- A second-degree erythema with contact in 25 seconds.
- A third - degree erythema with contact in 40 seconds.
- A fourth-degree erythema with contact in 1 minute.

Compression for a minute with a quartz rod will generally produce a blister.

At four inches distance from the skin :

- 1 minute's exposure generally produces a first-degree or second-degree erythema.
- 2 minutes' exposure generally produces a third-degree erythema.
- 3 minutes' exposure generally produces a fourth-degree erythema.

Doctors are often diffident about giving the necessary doses with the "Kromayer" lamp, but there is practically no difference between the discomfort produced by a blister following three minutes' exposure at

four inches distance and that of one caused by half-an-hour's exposure at the same distance; and more benefit will naturally result from the longer exposure, because the rays have had so much more time to act on the tissues.

There is, however, a great difference between the effect of a blister produced by compression and that of one caused by a long exposure at a distance of, say, three feet, since in the latter case the air filters out the rays of short-wave length.

If a blister forms it should be punctured with a sterile needle, and the lesion should be dressed with a little zinc and lanoline or some boracic ointment spread on white lint. Hamamelidis ointment should never be used for this purpose. These dressings should be applied until the lesion is quite dry. Sometimes when the affected area is near the eye the face becomes very much swollen, but this soon passes off.

Treatment with the "Kromayer" lamp is usually applied to an area at intervals of seven to fourteen days—that is, when the previous reaction has quite subsided.

The Carbon Arc Lamp.—Arc lamps with pure carbons are used at the Finsen Institute, Copenhagen, and Reyn prefers them to those with impregnated carbons, because he considers that, although impregnated carbons give off more ultra-violet rays of short-wave length, there is less penetration, and they also produce pungent fumes.

The general tendency, however, especially in this country, is to use impregnated carbons.

Some workers use plain carbons for the first appli-

cations, and replace them by tungsten-cored carbons later on in the treatment.

Dosage for Carbon Arc Light Baths (Short-Flame Arcs) at the Finsen Institute.—Always at the same distance, begin with 15 to 20 minutes' exposure of each side of the body, as near the lamp as possible; increase this by 5 to $7\frac{1}{2}$ minutes at each application, until a maximum of 75 minutes is reached, thus:

1st application,	15 to 20 minutes to each side of body
2nd	20 to $27\frac{1}{2}$ „ „ „
3rd	25 to 35 „ „ „

For patients with laryngeal or pulmonary tuberculosis the first application should be $7\frac{1}{2}$ to 10 minutes to each side of body. Each exposure is increased by $2\frac{1}{2}$ to 5 minutes, until a total of one hour on each side of the body is reached.

Patients with heart or lung disease are placed at a greater distance from the lamps. The first application should be $7\frac{1}{2}$ to 10 minutes on each side of body, and the time should be increased at each application by $2\frac{1}{2}$ to 5 minutes, until 75 minutes' exposure of each side of the body is reached.

Skin Diseases.—The first exposure should be $7\frac{1}{2}$ to 10 minutes, and the length of each application should be increased by $2\frac{1}{2}$ minutes, up to a maximum of 75 minutes, on each side of the body.

The first application to infants should be 5 minutes, and this should be increased by $2\frac{1}{2}$ minutes at each treatment, up to a maximum of 75 minutes on each side of the body.

Long-Flame Arc Dosage :

The dosage naturally varies considerably according to the carbons that are used. The times given below are average exposures with white-flame carbons (cerium fluoride), and an exposure of five minutes at a distance of four feet generally produces a mild erythema, whereas erythema is generally produced in three minutes by an iron-cored carbon at a distance of 2 ft. 6 in.

Great care must therefore be exercised when different types of carbon are being used, to avoid the occurrence of mistakes.

First application, 5 minutes to each side of the body, as near the arc as possible.

Second application, 10 minutes to each side of the body, as near the arc as possible.

Third application, 15 minutes to each side of the body, as near the arc as possible ; up to a total of 30 minutes.

Treatment should preferably be given every other day.

"Arnold" Arc Lamp.—An exposure of 5 to 7½ minutes should be given on each side of the body, at three feet from the lamp, increasing to 15 to 20 minutes as near the lamp as the heat allows.

Ajax and Saidman Polymetallic Arcs :

First exposure, 5 minutes to each side of the body, as near the arc as possible.

Second exposure, 7 minutes to each side of the body, as near the arc as possible.

Third exposure, 9 minutes to each side of the body, as near the arc as possible.

Fourth exposure, 11 minutes to each side of the body, as near the arc as possible.

Fifth exposure, 13 minutes to each side of the body, as near the arc as possible.

Sixth exposure, 15 minutes to each side of the body, as near the arc as possible.

Dufestel suggests gradually decreasing the distance between the lamp and the patient from 60 to 40 cm.

With children, in whom it is difficult to judge sensitivity to heat, the following data may be of value :

With a 4-ampere Saidman arc the child should be placed 25 cm. away.

With an 8-ampere arc the child should be placed 30 cm. away.

With a 12-ampere arc the child should be placed 35 cm. away.

With an 18-ampere arc the child should be placed 40 cm. away.

When a 4-ampere portable arc is used, the dosage given in the table should be doubled.

From these tables it will be seen that with the carbon arc there is not nearly so great a difference between the length of the first and last applications as there is with the mercury vapour lamp.

When the whole body has to be exposed it is of great advantage to have two lamps in series, so that time may be saved by treating the front and back of the patient simultaneously.

Short-flame arcs consuming 20 amperes are sufficient in general practice, and two patients can be treated together. When one patient only is being

white-hot tip eventually becomes detached, and care must be taken to prevent such a falling fragment from igniting any inflammable material on the treatment-



FIG. 208.—“Sunic” Parallel Carbon Arc Lamp (for Local or General Treatment), fitted with Localizer.

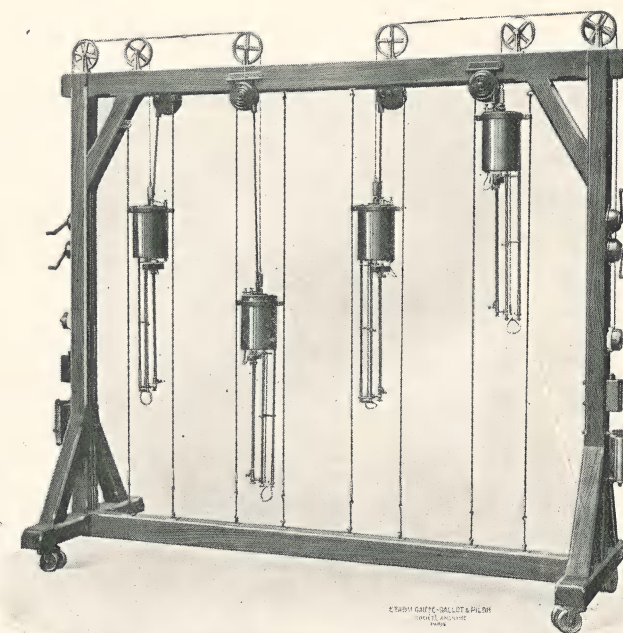


FIG. 209.—Belot's Method of mounting four Carbon Arcs in Series.

room floor. These pieces are most easily caught in flat tin dishes or on asbestos trays.

The Tungsten Arc Lamp.—Tungsten electrodes can be used in any simple hand-fed arc lamp, although the usual practice is to use them in the horizontal co-axial position. If the positive electrode is tungsten, a tungsten-cored carbon will be quite satisfactory for the negative electrode. The tungsten arc lamp works

with direct current only, and a rectifier must therefore be used if the supply is alternating. A resistance capable of varying the current between zero and 15 amperes is an advantage.

A reflector, made of some material that absorbs as



FIG. 210.—A Portable Tungsten Arc Lamp.

few of the rays as possible, should be fitted behind the arc. Silicon is the most useful metal for this purpose, seeing that it reflects 75 per cent. of ultra-violet rays. Nickel reflects 45 per cent., but silver reflects only 6 per cent. In some cases where local lesions are being treated, a concave mirror may be used to focus the rays on the part, and this should have its reflecting surface coated with nickel or silicon. More often the rays are focused by means of a quartz lens two inches in diameter with a focal length of four inches.

This is held in a long-handled circular frame, which should be of sufficient size to protect the area surrounding the part under treatment. A splutter bowl is usually placed under the electrodes to catch any falling fragments.

It must be remembered that, as has been already stated, ultra-violet rays come to a focus at a point nearer to the arc than the focal point of visible rays. This can easily be proved by an experiment with an oxide-of-nickel filter and a piece of uranium glass. On the whole, a reflector is more satisfactory than a lens, because even quartz absorbs some of the radiation that passes through it.

With the ammeter registering 10 amperes, and the rays focused on the part to be treated by means of a quartz lens, the required erythema will generally be caused by an exposure of approximately five minutes. But here again, all the other factors that influence dosage should be taken into account. When the erythema is fading the dose is repeated.

We have had experience with the molybdeno-tungsten arc lamp, in which the larger, positive electrode is of carbon cored with molybdenum and tungsten, and the smaller, negative electrode is of carbon only. The falling red-hot pieces of tungsten are caught in a quartz globe. This lamp is used mainly for local lesions, and is especially effective in superficial tubercular lesions, such as dermatitis, abscesses, or lupus. It is held as close to the lesion as possible for from two to five minutes daily, care being taken to protect the surrounding healthy skin in the way already described.

One disadvantage of the molybdeno-tungsten lamp is that, the tungsten core being directed vertically downwards, beads of red-hot tungsten often fall out

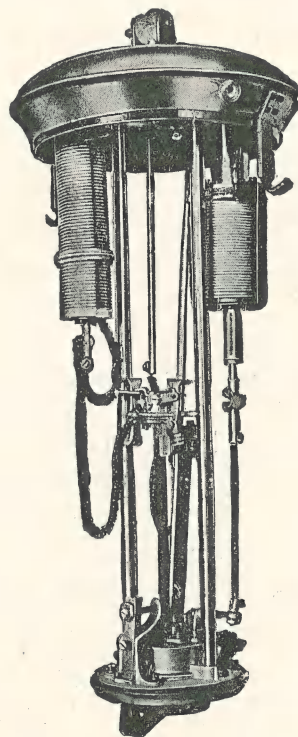


FIG. 211.—The Molybdeno-Tungsten Arc Lamp.

of the encircling carbon sheath. This is naturally a source of alarm to the patient.

Combined Treatment.—In some cases the effect of ultra-violet radiation may be enhanced by using it in conjunction with other forms of electrical treatment, for example, with infra-red rays or with ordinary

carbon filament lamps, usually fitted so as to encircle the ultra-violet radiation lamp. We have used ultra-violet rays conjointly with other methods of electrical treatment in those cases in which the same physiological effect is achieved by the two different types of application. Examples of this are found in the treatment of chilblains, in which the alternate use of ultra-violet radiation and Schnee sinusoidal baths is found to be very advantageous. Likewise, when a tonic effect is desired, high frequency or diathermy with the auto-condensation couch may be administered alternately with ultra-violet radiation, with considerable benefit. The same combination has been used in cases of hyperpiesis, diathermy and ultra-violet radiation being both effective in lowering high blood pressure.

Some varicose ulcers seem to respond better to treatment when zinc ionization is given in conjunction with ultra-violet rays, and we have had successful results in several cases.

Some local skin affections yield satisfactorily to combined ultra-violet radiation and high-frequency discharges from Gallois quartz electrodes.

Another successful combination is that of X-rays with ultra-violet radiation.

Sampson advises an ionizing dose of X-rays of one milliamperere for five minutes at a distance of eight inches between the anti-cathode and the skin, with a five-inch spark gap and a one-millimetre aluminium filter. Three applications can be given at intervals of from three to seven days.

We have used this technique ourselves with success, but great care must be exercised, because fatal cases

of exfoliative dermatitis have followed the unskilled use of these two forms of radiation.

Ultra-violet radiotherapy and heliotherapy can, of course, be combined, and this is the usual practice at many places in this country.

Remedies for Faults in Apparatus.—Occasionally it is difficult to get ultra-violet lamps to work properly. A short description of a few of the commoner causes of trouble may be useful.

The lamp may go out suddenly during a treatment. This may arise from several causes, one of the commonest being an interruption of the current, due to a cutting off of the main supply, either unexpectedly through a failure at the power-house, or purposely to permit of repairs being carried out in the neighbourhood, or as a result of some more local trouble. The other points of supply should therefore be immediately tested. If they are off, too, inquiry should be made to see if adjacent premises are also without current. If the trouble is limited to the one house only, the main fuse will probably be found to have blown.

When only one point of supply is affected the branch fuse should be examined. If the trouble is confined to one plug and its immediate connections a simple test-lamp is of great help in localizing the defect, because the plug, the flexible, and the terminals can all be tested by means of it without difficulty, and it can soon be seen whether they are in good order. When the two terminals of the test lamp are placed on two "live" parts, the filament of the lamp will become luminous only when current at the requisite voltage

is actually flowing through it, and it is therefore easy to localize any fault. The flexible connections can



FIG. 212.—The "Trilite" Lamp makes it possible to use Radiant Heat, and also administer Ultra-Violet Treatment with either the Tungsten, Carbon, or Quartz Mercury Vapour Arc, with the one apparatus.

easily become broken in the plug. The flexible cord itself may be defective, either from a partial break

in the conducting core or from imperfect insulation. Defects should always be looked for first at the most vulnerable point—namely, the junction of the fixed and movable parts. The terminals should be examined to see if they are clean and properly connected.

In the hanging type of mercury vapour lamp it is advisable to see that the alignment is correct, because the lamp may go out if it is not. If the polarity of the terminals has been reversed, the lamp will burn for a time and then fail, owing to the destruction of one of the electrodes.

If the vacuum of the burner is impaired the arc tube becomes discoloured, and black and yellow patches appear. That there is a leakage can be confirmed if the burner is taken out of its housing and moved sharply sideways. If the vacuum is defective the characteristic click is not obtained.

The closing of the hood may overheat a lamp and cause it to go out during operation. If this happens, the lamp should be allowed to cool thoroughly before any attempt is made to relight it.

It can generally be said that if a lamp has been burning satisfactorily for some time, and then goes out suddenly, the fault should not be looked for in the burner, but in the circuit.

We have noticed once or twice that our mercury vapour lamps have gone out when a large arc lamp has been switched on in an adjacent room, causing a momentary local drop in voltage.

There are several causes of trouble in a water-cooled mercury vapour lamp. Briefly, these are as follows.

Overheating of the lamp because of defective water

circulation is the commonest fault. One way in which this may be brought about is by an interchange of the inlet and outlet tubes; another is by the cracking of the quartz jacket of the arc tube; and an interchange of positive and negative poles will also cause the lamp to burn permanently dull.

If the lamp burns only after frequent tilting, a small air bubble usually present in the polar vessels may have found its way into the arc tube, or the mercury may be unevenly distributed in the two limbs of the tube. This can be remedied by tilting the lamp gently forward through an angle of ninety degrees from its original plane and then bringing it gently backwards again. If the lamp should become accidentally extinguished, two minutes should be allowed to elapse before an attempt is made to relight it, and the resistance switch should be moved immediately to "weak." When a leakage of water occurs at the quartz window of the lamp, a new rubber packing ring should be fitted.

If the water used for cooling the lamp contains a great deal of lime, the inside of the burner casing should be cleaned occasionally. It may be necessary to use a five-per-cent. solution of hydrochloric acid to do this effectively.

In carbon or tungsten arc lamps, the carbons should first be touching and should then be quickly separated to the required distance, when the arc has been struck.

A supply of suitable fuse wire, of several thicknesses, should always be kept in a place easily accessible in case of emergency. So also should a candle and matches, or a small flash-lamp—one of the self-

generating type is very handy, since it does not require refill cells. Fuse wire of the correct size only should be used at each point where a fuse is required: a fuse is a safety device and a means of avoiding more serious consequences. Great care should be taken to prevent unauthorized persons from having access to ultra-violet lamps. A little ignorant curiosity may cause great trouble and damage.

AN OUTLINE OF CONJOINT INTERNAL MEDICATION AND ULTRA-VIOLET RADIATION

There are a number of foodstuffs that can act as sensitizers when eaten by certain persons: well-known examples are eggs, lobster, and strawberries. Other patients have an idiosyncrasy to certain drugs, perhaps the best known of which are quinine, potassium bromide, the iodides, copaiba, and iodoform; serum injections may also act in the same way.

It has been found that the administration of mercury, arsenic, quinine, and iodine, slightly increases the intensity of the reaction caused by ultra-violet irradiation, whereas resorcin decreases it. The effect of any vaccine can probably be enhanced if the patient is also irradiated. It is therefore a wise precaution for the actinotherapist to ascertain what, if any, drugs a patient is taking before he begins ultra-violet treatment.

In many cases the beneficial effects produced by ultra-violet irradiation can be greatly enhanced if certain drugs, dyes or vaccines are taken internally, either by the mouth, or injected subcutaneously or intravenously. The following lists of organic or inorganic preparations contain the names of those

substances most commonly used in association with ultra-violet radiation.

Organic Preparations:

Thyroid extract.
Parathyroid extract.
Ovarian extract.
Testicular extract.
Liver extract (but it may act as a sensitizer).
Vaccines (such as tuberculins).
Cod-liver oil (in rickets).
Chlorophyll.
Stercoporphyrin } sensitizers.
Uroporphyrin }

Dufestel advocates an injection of 10-20 minims of 1 in 1000 sol. of adrenalin hydrochloride for patients who have asthenic symptoms after ultra-violet treatment, and also for those in whom there is too rapid pigmentation.

Inorganic Preparations:

Calcium chloride { intravenous in abdominal tuberculosis.
Calcium lactate (and thyroid extract), in asthma and hay fever.
Colloidal calcium.
Arsenic, in tuberculosis.
Gold preparations { in lupus, lupus erythematosus, laryngeal and pulmonary tuberculosis.
Resorcin.
Quinine.
Iodine.
Erythrosin
Gentian violet (1:1000) } sensitizers.
Eosin }

Eosin can be taken by the mouth in the form of $1\frac{1}{2}$ -grain tablets. The usual dose is one tablet three times a day for fourteen days, followed by a rest period of the same length of time.

Ostermann finds that very small quantities of the heavy metals circulating in the blood increase the effect of the ultra-violet rays :

Iron, in anæmia.

Mercury, in syphilis.

Bismuth.

Copper, in surgical tuberculosis.

Silver, argochrome (silver and methylene blue),
used intravenously in influenza and pneumonia.

Gold, in laryngeal tuberculosis and septic processes.

Reactions in Local Treatment are increased by the external application of the following :

Copper ointment, in lupus.

Silver nitrate.

Hydrogen peroxide.

Calcium sulphide, powdered on the skin.

Sodium chloride.

And by these dyes :

Eosin { The usual formula is : eosin, 2 parts ; distilled
water, 50 parts ; 95 per cent. alcohol, 50 parts.

Brilliant-green.

Crystal violet.

Gentian violet.

Fluorescein.

Cyanosin.

Methylene blue.

Acridine.

Sequeira states that he produced ulceration instead of vesication by exposing an area of skin to the concentrated rays of a large carbon arc after the local injection of erythrosin.

CHAPTER XII

ULTRA-VIOLET TREATMENT IN TUBERCULOSIS

Outline of the Biological Effects of Ultra-Violet Radiation—
Mode of Action in Varying Conditions—Comparison of
Results obtained by Natural and Artificial Irradiation—
Tubercular Skin Lesions—Glandular Affections—Bone and
Joint Lesions—Tubercular Peritonitis—Pleurisy—Phthisis
—Tubercular Laryngitis—Genito-Urinary Tuberculosis—A
few Illustrative Cases

It is foolish to suggest that ultra-violet radiation, or for that matter any other remedial agent, is a "cure-all." But it is equally absurd to doubt the favourable results that many workers have claimed as a result of actinic treatment under the most diverse conditions. Are not most diseases benefited by the stimulation of the defensive mechanisms of the body? The argument that the results are due entirely to suggestion is hardly worth serious consideration.

The greatest field of usefulness for ultra-violet radiation lies in the prevention rather than in the cure of disease. It is, however, almost a specific remedy in such dissimilar conditions as rickets, surgical tuberculosis, *Alopecia areata*, spasmophilia, and hay fever; and in a very large number of diseases it is a useful adjuvant, supplementing other necessary remedial measures.

TREATMENT IN TUBERCULOSIS 417

When selecting cases for ultra-violet radiation the biological effects of the rays must be borne in mind. It must be remembered that the rays form some substance in the skin that is absorbed by the blood and thus carried through the whole system. The chief general effect is an increase in the rate of metabolism: the appetite is stimulated and the whole resistance of the body is raised, and hence comes the value of this treatment after acute illnesses and in weakly children and adults. The number of micro-organisms in the intestinal tract is reduced, absorption is facilitated, and catarrh is lessened. The tone of unstriated muscle is increased, and obstinate cases of constipation and auto-intoxication from the bowel are greatly benefited. Anæmias are aided, by stimulation of the hæmopoietic system and increase in hæmoglobin; rickets, from the increase of calcium and phosphorus in the blood; and surgical tuberculosis and many infections, by the increase of the bactericidal power of the blood, lymphocytosis, and increase of general resistance. Ultra-violet radiation also stimulates the endocrine system, especially the thyroid and sexual glands.

Similarly, a consideration of the physiological effects of ultra-violet radiation will suggest many other conditions that might be benefited by it.

The benefits derived from ultra-violet treatment may be due to:

- (1) Psychical effects attributable to:
Suggestion or mental exhilaration.
- (2) Alterative effects:
Stimulation of carbohydrate, protein, fat, and

mineral metabolism (as of calcium, iron, phosphorus, and iodine).

Production of vitamin D from ergosterol.

Action on the sympathetic system and some of the endocrine glands.

Increase of hæmobactericidal and immunizing powers.

Lowering of abnormally high blood pressures.

- (3) The production of a beneficial inflammation, as in indolent ulcers, as well as an eliminative effect that causes dead tissues to be thrown off.
- (4) A local counter-irritant effect, as in certain cases of neuritis. It is sometimes said that a mustard plaster is equally efficacious, but how could a mustard plaster be applied to the inside of the mouth to relieve the pain of an erupting wisdom tooth?
- (5) Direct bactericidal effect.
- (6) Analgesic effect.
- (7) Stimulation of vasomotor reflexes of the skin, lessening the susceptibility of the body to extremes of heat or cold.
- (8) Redistribution of the amount of blood in the different circulatory systems—for example, a lessening of the amount of blood in the portal circulation.

Illustrative cases of a few of the conditions mentioned will be given.

The great benefit derived from fresh air and sunlight in tuberculosis is, fortunately, universally acknowledged at the present time, and every patient, from

whatsoever type of the disease he is suffering, should be sent as soon as possible to the country, where he will get the maximum of these essentials. Undoubtedly the best resorts for patients suffering from early tuberculosis are to be found in the High Alps, but unfortunately, at present, these are within the reach of only a very small proportion of the thousands of sufferers from this disease.

There is surprisingly little difference, if any, among the results obtained at Leysin, Alton, and Copenhagen. At Leysin natural sunlight is used; at Alton this is replaced on sunless days by artificial ultra-violet radiation; and at the Finsen Institute, Copenhagen, only artificial sunlight is used. The following table compares the results obtained by Dr Rollier and those of the Finsen Institute:

<i>Disease</i>	<i>Finsen Institute</i>	<i>Dr Rollier's Clinics</i>
	<i>Cured</i>	<i>Cured</i>
Tuberculosis of hip-joint .	78 per cent.	70 per cent.
Tuberculosis of knee .	70 "	71 "
Tuberculosis of ankle .	93 "	82 "
Tuberculosis of hand and wrist	88 "	55 "
Tuberculosis of elbow .	94 "	93 "
Tuberculosis of shoulder .	93 "	84 "

Seventy per cent. of the patients attending the Finsen Institute are over fifteen years of age, and the great majority are out-patients, often living in none too healthy homes.

Rollier's patients live in hospitals situated in the High Alps, under his personal supervision.

Finsen's brother-in-law, Professor Reyn, says that the results obtained by the application of carbon arc light baths in the treatment of extra-pulmonary tuberculosis are splendid.

Affections of the bones, the joints, the skin, the glands, the peritoneum, and the genito-urinary system, all respond very favourably to ultra-violet irradiation, and the results have been so satisfactory that this should always be the treatment of choice. Operations such as the aspiration of abscesses and removal of sequestra have, of course, to be performed in conjunction with or preparatory to the ultra-violet treatment.

Children naturally respond more quickly to treatment than adults, and Chievitz at the Finsen Institute has not had to operate on a child for tubercular disease for years; recent cases heal in shorter periods than old-standing cases, and lesions of small joints are cured more rapidly than those of large joints, probably because there is a better blood supply to the smaller joints. Cases where abscesses have recently developed and ruptured spontaneously heal more quickly than closed cases where perhaps the tissue reaction to the infection is less marked. It has been found that old fistulous bone conditions of the pelvis, spine, and hip, and uncomplicated teno-synovitis are least responsive to radiotherapy. Those cases where there is but slight impairment in the power of the natural resistance of the body respond most favourably to actinotherapy: when the recuperative powers tend to become exhausted and unable to react ade-

quately to fresh stimuli, irradiation may aggravate the patient's condition.

Cases of phthisis require great care during irradiation, and particular attention must be paid to dosage. Early cases are the most satisfactory, but those in which the condition has become generalized, with nightly rises in temperature, and particularly those in which hæmoptysis is present, are better left unirradiated.

If irradiation in a case of phthisis is followed by the slightest rise in temperature or quickening of pulse rate, it is wisest to discontinue the treatment—at any rate, for a time. General irradiation of the body must always be given in conjunction with local exposures in every case of tuberculosis, whatever the type.

TUBERCULAR SKIN LESIONS

Lupus.—This was the first disease treated by actinotherapy. Professor Finsen no doubt chose it because it was so resistant to all ordinary forms of treatment, and caused so great an amount of suffering. His great lesson in the treatment of lupus was the need for perseverance.

The dry nodular type is probably the most amenable to phototherapy; lesions on the body or limbs are more easily cured than those on the face, and lesions on the ear and mucous membranes are the most difficult to heal. Ultra-violet radiation is unavailing when lupus, affecting the face, is complicated by lymphatic obstruction.

The rays are so easily absorbed by the blood in the capillary network of the skin that it is necessary to

make the affected area anæmic by compression with a quartz lens to ensure the maximum action of the rays during exposure. A strong inflammatory reaction with blister formation should be caused, so as to flood the diseased area with lymph and thus promote the growth of healthy tissue.

The extreme sensitiveness of the tubercle bacillus must be remembered: this, together with the leucocytosis and increased bactericidal property of the blood, is probably responsible for the cure of the condition.

General and local treatment should be given, and great attention should be paid to hygiene and to the provision of plenty of nourishing food. Catarrh of the lesion is soon checked, and the part looks healthier; peripheral spread is rapidly arrested.

Dr Sequeira, of the London Hospital, finds that the combination of general with local treatment increases the cures in cases of lupus from 60 to 90 per cent. In many cases of tubercular lesions general irradiation alone, without local exposures, will clear up the condition, and in lupus the results have occasionally been found to be equally good even if the lesion itself has been covered over during irradiation. General treatment is especially valuable in lupus affecting the mucous membranes. As many as 2863 cases of lupus had been treated at the London Hospital up to July 1927, and 90 per cent. of these were cured, the successful cases including a number in which the mucous membranes were affected.

Sir Norman Walker, in his *Introduction to Dermatology*, 1925, referring to ultra-violet treatment, says:

"For extensive cases of lupus no other method even distantly approaches it in efficiency, and I have little doubt that it will soon be available in all considerable centres." And again: "With a large experience of lupus—more than a thousand cases have passed under my notice—I feel bound to say deliberately that under no other method of treatment have I seen such rapid and satisfactory improvement as in those treated by one or other of the 'sunshine lamps.'"

In cases of lupus, actinotherapy should be advised rather than X-ray treatment, especially in the nodular types, where carcinomatous changes are so apt to occur.

At the Lupus Heilstatte, Vienna, a combination of local with general light baths is used for large lupus lesions on the face, body, and mucous membranes. Short-flame carbon arc baths are given, and the exposures are increased from fifteen minutes initially up to two hours. Light baths are taken two or three times weekly. Local treatment is given with either "Finsen" or "Kromayer" lamps.

Dr Maar, of the Finsen Institute, Copenhagen, says that the "Kromayer" lamp can compete successfully with the "Finsen" lamp; and Dr Neisser, of Breslau, states that in his experience the "Kromayer" lamp has given results that were quite equal to those obtained from the "Finsen-Reyn" lamp. It is interesting and useful to know this, because in private work the use of the "Kromayer" lamp makes it possible to save a great amount of time and expense.

Good results are obtained in old-standing cases, which require skin grafts, if the part is rayed both

before and after operation. First of all the area is rendered sterile, and, later, mild doses are given to stimulate epithelial proliferation.

Lupus cases in hospital are usually treated with



FIG. 213.—Local Treatment of Four Patients with the "Finsen" Lamp (50 amperes) at the Finsen Medical Light Institute, Copenhagen.

the "Finsen" lamp: four cases are dealt with by one lamp. The edges of the lesion should be treated first. In many hospitals automatic compressors are now used, instead of applicators held by specially trained nurses. The initial dose is generally of ten minutes' duration, and this is gradually increased to an hour.

An intense reaction with blister formation follows exposure, and another application is not made until the reaction from the last has subsided.

The "Finsen" lamp is expensive and rather cumbersome, and the "Kromayer" lamp is therefore generally preferred for private practice. Quartz applicators are used, corresponding in size to the lesion to be treated, and a steady pressure is maintained during treatment. An exposure of five minutes is given at first, and the blue Uviol filter is used if the area to be treated is very sensitive; otherwise it is inadvisable to filter the radiation. The exposure may be gradually increased to thirty minutes. These sittings are followed by very intense reaction and are repeated after intervals of two or three weeks.

As many as eight applications to one particular area may be required. After treatment it is customary to apply a soothing ointment. The following prescriptions are very useful:

℞ Paraffin molle, 4 parts.	Or ℞ Zinci oxidi, 2 parts.
Ung. zinci, 1 part.	Amylli. trit., 2 parts.
Adeps lanæ, 5 parts.	Olei olivæ, 1 part.
	Adeps lanæ, 1 part.

Pyrogallic acid dressings may be applied to the part, particularly if it is extensive, a few hours before irradiation. They remove crusts and open the pores. Treatment is then given, without compression, about two inches from the window of the burner. Red rays may be combined with the radiation from the "Kromayer" lamp, and are beneficial.

Excellent results have been obtained at the Lupus

Heilstatte, Vienna, by this mode of treatment. Generally the centre of the affected area heals first and the edges remain active. Small areas of the peripheral nodules should be treated in turn with small lenses, the central area being protected at these times.



FIG. 214.—The "Finsen-Reyn" Lamp in use at the Finsen Institute, Copenhagen.

The treatment is generally most prolonged where there are extensive fibrous scars.

Diathermic cauterization of small resistant nodules is often helpful.

Very refractive cases of lupus are often benefited by injections of some gold preparation in conjunction with general or local actinotherapy.

By treating lupus of the mucous membrane of the throat, nose, and mouth, with general carbon arc baths, Strandberg, at the Finsen Institute, has cured 87.1 per cent. of his cases.

Special prismatic quartz applicators are generally used for the local treatment of lupus affecting the

nose, the eyelids, or the mucous membranes of the mouth.

Before giving local irradiation for lupus the skin should be well cleansed with benzene to remove grease and scales, and half-an-inch of skin surrounding the lesion should be exposed. Dressings should be applied immediately after irradiation and should not be discarded until the reaction has subsided and healing has taken place.

In every case of lupus the mucous membrane of the nose and mouth must be examined. At least two exposures should be given after the lesions have disappeared, and the patients should be examined at intervals of a few months after the termination of the treatment.

Treatment of Eyelids. — Lundsgaard's special apparatus, with a quartz prism, is used with the "Finsen" lamp.

Gronholm's eyelid forceps are useful for everting the lids. Ten to thirty minutes' exposure is given, and is followed by an intense reaction and swelling of the eyelids.

Lundsgaard's applicator is also very useful for treating the nasal vestibule with the "Finsen-Reyn" lamp. Special applicators can also be used with the "Kromayer" lamp.

Scrofuloderma.—Sequeira says that artificial sunlight treatment is often of the greatest value and should be tried before surgical interference is proposed.

Tubercular dermatitis and superficial ulcers also heal very rapidly under ultra-violet radiation—much more quickly than cases of lupus. A third-degree

erythema should be produced at first over the lesions, care being taken to protect the surrounding skin. The ulcer soon becomes clean, and healthy granulations appear. The newly formed epithelium

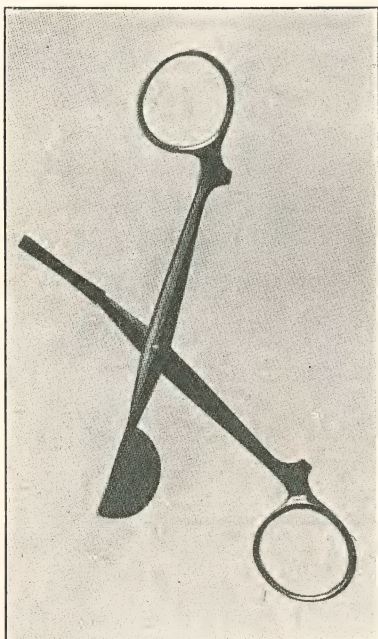


FIG. 215.—Gronholm's Single Eyelid Forceps, for Eversion of the Eyelid. (Reyn.)

that appears round the edges of the lesion should be carefully protected during subsequent irradiations, which should follow as soon as the reaction from the preceding exposure begins to fade.

The fibrotic type of tubercular ulcer does not respond to ultra-violet radiation nearly as well as the ulcerative or fungating type.

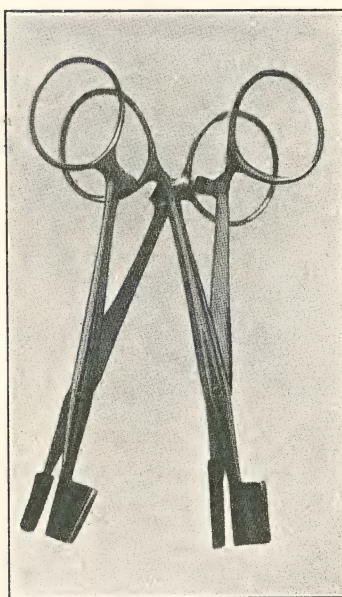


FIG. 216.—Gronholm's Double Forceps, for use during Irradiation of the Eyelids. (Reyn.)

Erythema induratum of Bazin.—Excellent results are obtained with ultra-violet radiation in these cases, which soon heal.

Tubercular Glands.—The glandular enlargement, which is the characteristic feature of tubercular

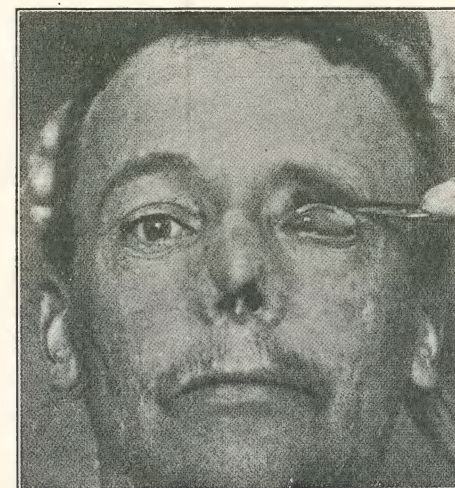


FIG. 217.—The Upper Eyelid everted with Gronholm's Forceps preparatory to Irradiation. (Reyn.)

lymphadenitis, proves that the glands are endeavouring to combat the infection, that the lymphatic system is reacting to the hostile stimulus, and that the patient's power of resistance is not wholly exhausted. Actinotherapy is therefore of great value in these cases and the results with ultra-violet radiation are so brilliant that it is hoped that excision will soon become a thing of the past.

At the Finsen Institute it was found that only 40 per cent. of these cases were cured by X-rays, whereas

98 per cent. of the patients treated with ultra-violet rays were cured, the average time to effect the cure being 4·8 months.

It is generally agreed that the carbon arc lamp is the most efficacious for general treatment in these

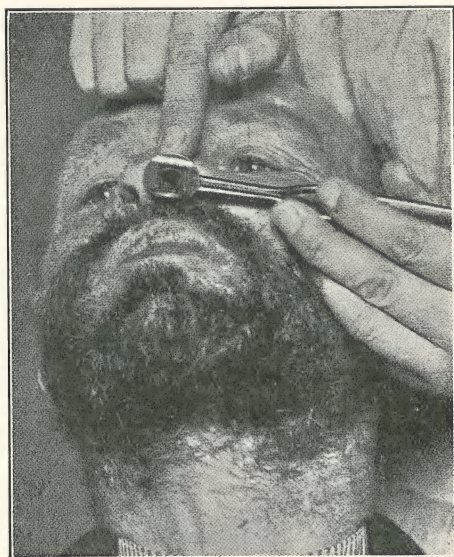


FIG. 218.—Treatment of the Nasal Vestibule with a Prismatic Applicator. (Reyn.)

cases. Our own results, at first, with the mercury vapour lamp were not nearly so good as the Finsen figures.

There are three stages of the disease :

- (1) Where simple hyperplasia of the gland tissue exists.
- (2) Where pus formation has taken place.
- (3) Where the overlying skin has broken down and a fistula has resulted.

In the first stage general sun baths alone will often effect a cure, though local treatment may also be advantageous. It is usually possible to obtain speedy healing if treatment is commenced at an early stage of the disease.

When pus forms it must be evacuated either with a syringe, or after the gland has been punctured with a special diamond-shaped stylet. In stages (2) and (3) resolution will be hastened if local treatment is applied as well as general. The cervical glands are those most commonly treated, but the peritoneal, axillary, inguinal, and tracheo-bronchial glands are often affected. In the case of the last-mentioned, the relief of dyspnoea is one of the first signs of improvement.

Multiple tubercular glands respond to treatment most satisfactorily when there is periadenitis and a fistula, such cases generally healing with an inconspicuous supple scar. Single glands covered with sound tissue are much more refractory. Irradiation soon overcomes the secondary infection nearly always present when the skin is involved.

Enlarged mesenteric glands have been found to yield most quickly to ultra-violet radiation, the mediastinal glands come next, and the peripheral glands yield most slowly. Hilus tuberculosis responds well to irradiation with the quartz mercury vapour lamp.

Taylor found that of one hundred and twenty children suffering from hilus tuberculosis all made the most favourable progress when treated by actinotherapy.

In tubercular adenitis strong local doses with the water-cooled lamp and compressors, combined with general irradiation, often expedite healing, third-degree erythemas being aimed at. If progress is very slow X-ray treatment should also be given. At first weekly doses, and later monthly exposures, are made. General ultra-violet baths are continued twice or thrice weekly throughout the treatment, the Dosage Table on page 397 being followed.

The internal administration of iodine is often helpful during the treatment of tubercular adenitis.

Tubercular Bone and Joint Lesions.—The effects of heliotherapy in this type of the disease are marvellous. Rollier at Leysin and Gauvain at Alton have both obtained wonderful results, in two places very unlike one another in climatic conditions; the most interesting point is the range of movement obtained in old ankylosed joints merely by insolation.

It is an extraordinary fact that the results obtained at the Finsen Institute with carbon arc baths are equally good, as the following list shows:

RECOVERED CASES

		<i>Non-com- plicated</i> Per cent.	<i>Com- plicated</i> Per cent.
Tuberculosis of the wrist .	.	86	90
" elbow .	.	88	96
" shoulder .	.	100	87
" foot .	.	100	87
" knee .	.	71	69
" hip .	.	100	57
" spine .	.	80	61

RECOVERED CASES—*continued*

		<i>Non-com- plicated</i> Per cent.	<i>Com- plicated</i> Per cent.
Tubercular teno-synovitis .	.	12	100
" dactylitis .	.	100	98
" peritonitis .	.	75	57
" disease of the female genito - urinary system .	.	..	66
" disease of the male genito - urinary system .	.	66	85
" caries of ribs and sternum .	.	..	82
" osteitis .	.	..	94
" osteitis of pelvis .	.	..	55
Subcutaneous tuberculosis .	.	..	92

The most striking difference between the results of treatment of tubercular joint disease by surgery and by actinotherapy is the dissimilarity in the amount of movement possible in the healed joint. Ankylosis generally follows excision of the joint; but a wonderful range of movement is usually possible after the more conservative radiotherapy, and naturally this is a most important matter to the patients.

Ernst did some very interesting work at the Finsen Institute on the radiographic appearances of bone tuberculosis. He found that at the commencement of general ultra-violet radiation latent foci often manifested themselves, and that they healed up after this period of reaction. He often found also that before any clinical signs had shown themselves X-rays

would reveal such conditions as tubercular dactylitis, just as pulmonary conditions can often be diagnosed by X-ray examination alone. X-ray photographs taken before, during, and after actinic treatment, often show surprising differences. Complete recalcification of a bone which had apparently disappeared may occur, particularly in the case of small bones like the phalanges, the final appearance being that of normal bone tissue.

Von Pirquet's test is valuable in helping to establish a diagnosis.

General irradiation with the carbon arc lamp is the method of choice in bone and joint tuberculosis, but the authors can also testify to the value of mercury vapour lamps in these cases.

Cases of tuberculosis of the spine and lower limbs are best treated in hospital.

In certain deep-seated cases conjoint Röntgen radiation may also be advisable. Naturally, great attention must be paid to hygiene, to diet, and, particularly, to orthopædic measures to prevent and correct deformity.

In bone lesions, where there is much absorption of osseous tissue, the osteoblastic cells are stimulated, the calcium and phosphorus content of the blood is increased and recalcification takes place, sequestra are often extruded, and new bone formation results.

When ultra-violet radiation is first applied there is usually an increased discharge from ulcers and sinuses, and some shedding of necrotic tissue in the form of sloughs or sequestra. This is soon followed by the formation of healthy granulation tissue and

subsequent healing. Pain is soon relieved except when it is due to the contact of eroded bony surfaces. Cases with superficial fistula heal most quickly; closed cases generally take much longer.

Irradiation plays an important part in getting secondary infection under control. In regard to the difficult question of prognosis the following figures from the Finsen Institute will be of interest:

Tubercular Dactylitis generally requires from two to six months for cure; more rarely, refractory cases may take as long as twelve months.

Tubercular Wrist.—Uncomplicated cases usually heal in six months; for complicated cases the average time is from six to twelve months, and in a few cases this period is exceeded.

Tuberculosis of Elbow.—Of 31 cases: 4 cases recovered in three months; 3 cases recovered in six months; 8 cases recovered in twelve months; and the others took longer.

Tuberculosis of Shoulder.—Healing generally takes place in about six months in uncomplicated cases.

Tuberculosis of Ankle.—The average time for cure is six months.

Tuberculosis of Knee.—Recovery takes place in from nine to twenty-four months.

Tuberculosis of the Hip Joint.—Treatment must generally be given for twelve months or longer.

Tuberculosis of the Sternum and Ribs.—When sinuses are present, six to twelve months, as a rule, are needed for cure; but occasional cases heal in as short a time as three months.

Tubercular Osteitis.—The average time for recovery

is from one to two months; very severe cases may require six months, and cases affecting the trochanter of the femur even longer.

Tubercular Osteitis of the Pelvis.—This generally heals in twelve to twenty-four months.

Tubercular Peritonitis.—Actinotherapy is very useful in this disease and many cases can be cured by it.

With carbon arc treatment it has been found that 75 per cent. of uncomplicated cases and 57 per cent. of complicated cases recover. Confinement to bed is necessary in severe cases, and the usual hygienic and dietetic measures must be strictly carried out. In hospital, patients can be wheeled to the treatment-room in their beds, but for acute cases in general practice a portable lamp is necessary.

In some cases there is an amelioration of both the general and the local symptoms from the commencement of treatment, but in others there is at first a slight aggravation of the symptoms. Usually, however, the general health improves, appetite returns, fever disappears, and weight is gained. Locally, pain and ascites rapidly decrease, and the action of the bowels becomes more normal.

The most satisfactory cases are those where there is localized peritonitis, especially of the cæco-appendicular, hepatic, or splenic regions, and when the disease is of the fibro-adhesive type. Cases with effusion do not generally respond quite so well, and ulcerative caseous forms are least satisfactory. Lesions affecting the female genitalia also do well, healing usually taking place in from two to four months.

Cases of tubercular peritonitis of more severe types,

especially when part of a generalized infection, do not respond so well; but there are some in which great improvement has resulted from actinotherapy. If actinotherapy alone is only partially successful, and a point is reached where the condition remains at a standstill, greater improvement often follows the conjoint use of infra-red, ultra-violet, and X-rays; or if the mercury vapour lamp alone has been used, improvement often results by substituting the carbon arc for it.

Intestinal tuberculosis complicating phthisis is generally of the ulcerative type, and is characterized by pain and constipation, if the small bowel is affected, and by diarrhoea if the large.

Digestive trouble is the first symptom, and was formerly considered to be "the beginning of the end." Actinotherapy now offers some chance of recovery.

Irradiation of the abdomen, limbs, and back, is advisable, preferably with the carbon arc lamp, using special electrodes, such as the polymetallic type.

In advanced cases of phthisis, associated with hæmoptysis, the chest should be protected during treatment. The patient must be watched carefully for any rise in temperature or pulse rate, and small doses at the beginning are safest. Many of these cases do well, especially those with early lung symptoms. Pain and discomfort disappear after the first few applications, and the stools become normal after about three months.

Approximately half of the cases that respond well show signs of definite improvement by the end of

the first month of treatment. Cases that do not improve under irradiation are generally those of very advanced pulmonary disease.

Pleurisy.—The pain of pleurisy is relieved by a second-degree erythema, and pleural effusions are absorbed in the same way as joint effusions and ascites.

Pulmonary Tuberculosis.—On the whole the results following ultra-violet irradiation have been a little disappointing when compared with those obtained in non-pulmonary cases.

Taylor has, however, recently treated one hundred and fifty-six adult cases, 92 per cent. of whom were classified Turban-Gerhart stage 3; 50 per cent. showed improvement after irradiation; 33.3 per cent. remained stationary; 11.6 per cent. retrogressed, and 5.1 per cent. died. He considers that the disappointing results previously experienced in lung tubercle are almost invariably due to the adoption of a too hard-and-fast technique. Ultra-violet rays can be safely used in quiescent cases of pulmonary tuberculosis provided there is no fever, but the treatment should be confined to those cases in which there is no impairment of the patients' power of response to the stimulation of irradiation. The rays generally have a stimulating effect: patients have more energy, their appetite improves and their weight increases, and they have a better mental outlook and feel brighter in spirits. The cough is relieved in the great majority of cases, the sputum is reduced in quantity, and sleep is ameliorated. Treatment should be discontinued if there is any rise in temperature or pulse rate, or if there is anorexia, or any progressive

loss of weight, or an exacerbation of symptoms. These cases must be carefully supervised by a medical officer during the whole of their treatment, and their response to irradiation must be carefully recorded. Temperature, pulse, cough, sputum, pigmentation, etc., should all be noted.

Crocket considers that patients suffering from pulmonary tuberculosis should always lie down during the administration of the treatment so as to avoid the strain of sitting in one position.

Reyn recommends mild doses of from fifteen to twenty minutes' general carbon arc treatment every other day, the exposure being very slowly lengthened.

Oldenburg reports favourable results in pulmonary tuberculosis in fourteen out of thirty-eight children treated. The best method of irradiation for these cases is the fractional system described in the chapter on "Technique." If the case is an advanced one the chest should not be exposed during irradiation.

Murray has noted that the skin of patients suffering from advanced tubercular disease is very sensitive to ultra-violet radiation, and that erythema, which develops very readily, is rarely followed by pigmentation.

Tubercular Laryngitis.—Many cases of this disease will yield to actinotherapy even when they are secondary to pulmonary tuberculosis. Strandberg has published an account of one hundred cases with pulmonary involvement treated with general carbon arc baths, showing 53 per cent. cured; ninety-seven of these patients suffered from hoarseness, and in seventy-eight this symptom entirely disappeared, while in fifteen it was improved. Eight cases had suffered

from hæmoptysis, and only two of these had an attack during treatment. The remaining ninety-two of these patients had no attacks of hæmoptysis. The average number of treatments given was eighty-six. General irradiation with either the mercury vapour or the carbon arc lamp must be given at least thrice weekly.

Ultra-violet irradiation generally relieves any pain that may be present in this condition.

There are several forms of local treatment. Dr Sörgo has evolved a method in which the patient applies the treatment himself. An adjustable head-band is fastened round the patient's head; to this is fixed a jointed wooden rod, which supports a mirror about six inches away from the face and a cardboard screen. The patient pulls the tongue forward with one hand and holds a nickel laryngoscopic mirror in the other. With this he reflects the arc light on to the larynx, an image of which he should be able to see in the mirror. The first exposure of five minutes is gradually increased to one of an hour. The local irradiation can easily be carried out while the patient is having general treatment.

The "Kromayer" lamp can be used in these cases, with a special curved quartz applicator. An exposure of two minutes, increasing to five minutes, is given weekly.

To combat the pain and dysphagia so often present in this condition, Dr Ostermann, of Vienna, uses an inhaler attached to the spherical reflector of his air-cooled lamp. Half-an-hour after taking a draught containing one gramme of potassium iodide, the patient

inhales ozone generated by the lamp through the mouthpiece of the inhaler, which is plugged loosely

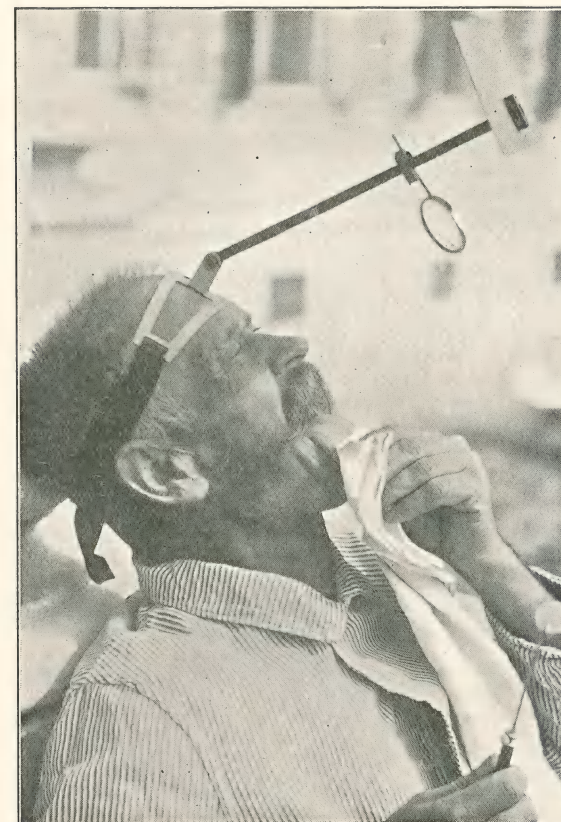


FIG. 219.—Dr Sörgo's Apparatus for Irradiation of the Larynx with Sunlight or with Rays from the Carbon Arc Lamp.

with cotton-wool moistened with a few drops of HCl and turpentine. This technique makes use of the fact that potassium iodide has a great affinity for ozone. The treatment is repeated for twenty to thirty

minutes every other day: the pain and dysphagia are often relieved after the first five or six treatments.

Dr Cemach's Method makes use of his specially designed stand, the "Photostat."

The patient lies on his back on a couch, with his head projecting partly over the end, his mouth open,

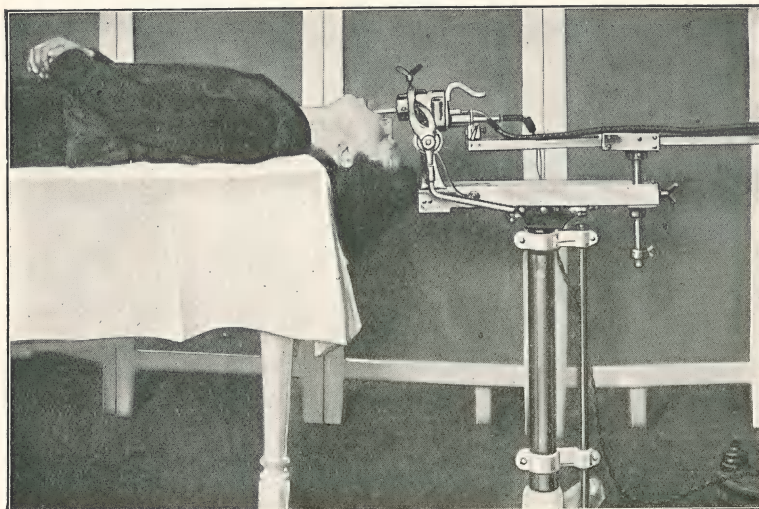


FIG. 220.—Dr Cemach's "Photostat" being used for Direct Irradiation of the Larynx.

and his tongue out. A special hollow metal speculum is introduced into his mouth in the exact middle line. First the uvula is seen, and then the stand is lowered and the speculum is adjusted so that the epiglottis becomes visible. The stand is again lowered until the larynx can be seen. The lamp itself is now simply swung into position and the exposure begins.

The speculum is easily removed at the end of treatment. Two-minute exposures are given, and

the treatment is continued generally for several months.

All early cases can be cured when the general condition is good, and 60 per cent. of advanced cases with good general condition.

The blue Uviol filter should be used for exudative cases of tubercular laryngitis. All cases of tubercular laryngitis should have sanatorium treatment and tuberculin injections.

Renal Tuberculosis.—Ultra-violet radiation is invaluable in bilateral cases. There is often an early disappearance of hæmaturia, a cessation of pain and frequency of micturition, and a diminution of pyuria.

In cases where a sinus remains after nephrectomy radiotherapy will generally cause rapid healing, usually within two months.

Tubercular Cystitis.—General irradiation should be given, and the female bladder can be treated locally by means of a special electrode, similar to McIntyre's, but made of fused quartz, and used with high-frequency current.

In male cases, if there is a cystostomy opening the electrode can be introduced through it. The symptoms of tubercular cystitis are improved in 80 per cent. of the cases treated by ultra-violet radiation.

Tubercular Orchi-epididymitis and Prostatitis.—Two months' ultra-violet treatment produces a great improvement in 75 per cent. of the cases. Secondary infection is rapidly controlled. When hydrocele is present healing is not so rapid. Good results can be obtained especially in fistulous cases; the patients stand near the carbon arc and hold up the scrotum.

Tubercular Salpingitis may be treated by general irradiation.

A FEW ILLUSTRATIVE TUBERCULAR CASES

Case 1. Woman, aged 36, had a large patch of lupus, about the size of a hen's egg, over the right malar region. She was given altogether thirty-one general applications with the mercury vapour and carbon arc lamps, and three local applications with the "Kromayer" lamp. The lesion disappeared completely, leaving a very smooth inconspicuous scar. The last twelve treatments were given after healing had occurred, with the object of preventing any relapse.

Case 2. Girl, aged 7 years, had had a patch of *Lupus vulgaris* on the right cheek for a year when she first came for treatment; it was the size of a shilling. The lesion healed perfectly with six applications of the "Kromayer" lamp, but three further treatments were given as a precautionary measure. Doses of two to ten minutes with a compressor were given. There is a pale scar of a lighter colour than the remainder of the cheek. The patient was seen six months after the termination of treatment, and the cheek was normal, but she was instructed to attend at regular intervals for examination.

Case 3. Woman, aged 32 years, had had a lupus lesion on the right cheek for thirteen years. The patch had been scraped and burned with acid on four occasions: it often healed for nine months after the operation and then broke down again. Eight applications of the "Kromayer" lamp, with doses of two to ten minutes with compression, caused the lesion to heal.

Four further exposures were made. Another patch on the lobe of the right ear healed after four treatments.

Case 4. Male, aged 19 years. When he was seventeen a swelling appeared on the medial surface of the left thigh, about an inch above the knee joint. It was incised in hospital, but a large tubercular ulcer formed, about the size of a bantam's egg, which did not heal. General ultra-violet treatment with the mercury vapour lamp was commenced, and the ulcer, which had been present for two years, healed in six weeks, eighteen treatments being given. It has remained soundly healed now for nearly a year.

Case 5. Boy, aged $3\frac{1}{2}$ years. Two and a half years ago a swelling appeared two inches above the left ankle joint. It was operated on at a hospital, and found to be due to tubercular osteitis of the tibia. After the operation it healed for a short while, and then broke down and formed a discharging sinus. General ultra-violet treatment with the air-cooled mercury vapour lamp was commenced on 28th January 1926, and the wound had healed soundly on 29th June 1926, fifty-two irradiations having been given.

Case 6. Boy, aged $3\frac{1}{2}$ years. Tubercular dactylitis and osteitis. A swelling of the left ring finger was first noticed on 19th December 1924. The bone was scraped in hospital on 13th August 1925, and a few days later the finger was amputated through the centre of the middle phalanx. A lesion that had appeared on the right humerus just below the shoulder joint, and another on the left middle finger, were scraped on 27th October 1925. The surgeon told the mother that the left middle finger and the left great toe

would have to be amputated, and that ultra-violet treatment was of no value at all in a case of this nature.

Actinotherapy was commenced on 22nd December 1925, and general irradiation with the quartz mercury vapour lamp given. The finger healed soundly, and there was no further discharge after May 1926. The toe healed in July 1926. Treatment has, however, been continued since then, and the boy is exceedingly well and is rapidly putting on weight. In all, one hundred and two treatments have been given, which certainly cover a considerable period; but this is well worth while, compared with the mutilating operations still performed, unfortunately, only too frequently. The multiplicity of the lesions in this case is another proof that tuberculosis is a general rather than a local disease.

CHAPTER XIII

ULTRA-VIOLET TREATMENT OF RICKETS
AND NUTRITIONAL DISORDERS

Debility—*Diabetes mellitus*—Acidosis—Gout—Obesity—Acute Muscular Rheumatism—Lumbago—Muscular Torticollis—Fibrositis—Chronic Rheumatism—Rheumatoid Arthritis—Injuries to Muscles, Joints, and Ligaments—Rickets—Historical Considerations—Ætiology—Biochemistry—Diet and Heredity—Cholesterol—Ergosterol—Vitamin D—Treatment—Bone Changes—*Laryngismus stridulus*—Tetany—Fractures—Osteoporosis—Osteomalacia—*Osteogenesis imperfecta*—Osteomyelitis—*Osteitis deformans*—Effect of Ultra-Violet Radiation during Pregnancy and Lactation

Debility.—Actinotherapy is very valuable in the treatment of cases during convalescence after infectious fevers, or after operations, prolonged sepsis, severe hæmorrhage, or bodily exhaustion.

Improved appetite generally follows irradiation, weight is gained, and patients feel stronger, become calmer, and sleep better.

Ultra-violet radiation has a valuable prophylactic action in preventing the development of tuberculosis after such conditions as pleurisy, pneumonia, and repeated attacks of influenza. Twelve to fifteen applications to the whole body generally suffice.

Diabetes mellitus.—Rothman has found that ultra-violet irradiation decreases the percentage of blood sugar in cases of hyperglycæmia, but has no effect

when the blood sugar is normal. He considers that this probably occurs because of a depressor action on the sympathetic nervous system.

Laqueur has found that irradiation of mucous membrane has the same effect, and thinks that ferments may play a part in the reaction, because there is a great decrease in the amount of the enzyme diastase present in the skin after irradiation. Acetone bodies also disappear from the urine.

Saidman also mentions several cases where there was a rapid diminution in the sugar content of the blood and urine following irradiation, and all the patients with glycosuria whom we have irradiated have derived benefit. Weinbren reports that he has treated ninety cases of diabetes by means of actinotherapy and that he did not find a single case in which its use was contra-indicated.

It is advisable to proceed carefully when administering ultra-violet radiation to a diabetic patient: the dosage should be mild at first, and should be very gradually increased.

The subcutaneous injection of insulin is the method generally chosen for the treatment of diabetes. Ultra-violet radiation is also very useful, but the two methods must never on any account be used simultaneously. Irradiation is useful for relieving the circulatory disturbances and neuritis that often occur in the course of the disease.

Acidosis is a condition occurring in young children where there is nausea, uncontrollable vomiting, and great prostration, and where acetone can readily be detected in the breath and in the urine. The attacks

are often cyclical: some disorder of metabolism is probably responsible for the condition, and there is generally a marked alteration in the hydrogen-ion concentration of the blood. Ultra-violet treatment is generally most successful in acidosis; the beneficial effect is probably due to an increased retention of calcium salts in the body, though the action of the ultra-violet rays on the sympathetic and endocrine systems may also play a part. Pacini has published the results of treatment of thirty-four cases of acidosis by means of actinotherapy: all showed improvement, and twenty-eight were cured. We ourselves have had very successful results when actinotherapy has been combined with the administration of a special fat-free diet containing a large amount of glucose.

Gout.—Ultra-violet rays influence purin metabolism and a quickened building up of purin bases follows irradiation. There are many theories regarding the causation of gout: one is that it is caused by a defective functioning of the skin, and another that it is due to a deficiency of enzymes. The ultra-violet rays certainly stimulate the functional activity of the skin and are known to mobilize enzymes, so that the benefit that sufferers from gout experience after irradiation may be due to these causes. Treatment should always be applied generally, but local irradiation can be given also for the purpose of stimulating the absorption of tophi or for the relief of pain in the affected joint during an attack.

Either the mercury vapour lamp or the carbon arc may be used; but the open arc is more useful on

account of its stimulation of the skin and sweat glands. A tepid shower bath after irradiation is beneficial. The usual dietetic and medicinal treatment must not be neglected.

In chronic cases it is well to give an occasional monthly course of general treatment for its prophylactic effect.

Obesity is often due to defective metabolism or glandular insufficiency. The hygiene of the skin also plays an important part, and since ultra-violet rays improve the nutrition of the skin and make it healthier, they are very useful in the treatment of cases of anæmic obesity; but they are a valuable adjunct in all cases, because they stimulate oxidization processes and increase the vitality of the patients, which makes them take more exercise. Bergonie treatment and radiant-heat baths may also be used.

Ultra-violet radiation tends to correct deviations from the normal and to restore the balanced rhythm of health, so that thin people generally increase in weight, owing to the improved muscular development that accompanies irradiation, especially with the carbon arc.

Acute Muscular Rheumatism, Lumbago, Muscular Torticollis, Fibrositis, Chronic Rheumatism, Rheumatoid Arthritis.—These conditions all respond in varying degrees to ultra-violet radiation. Pain is relieved and movement increased, and even in old-standing cases of rheumatoid arthritis some alleviation may be expected.

General irradiation improves the functional activity of the skin, which, as Van Breemen has pointed out,

is generally very sluggish in rheumatic disease; the skin temperature is abnormally low in most of these

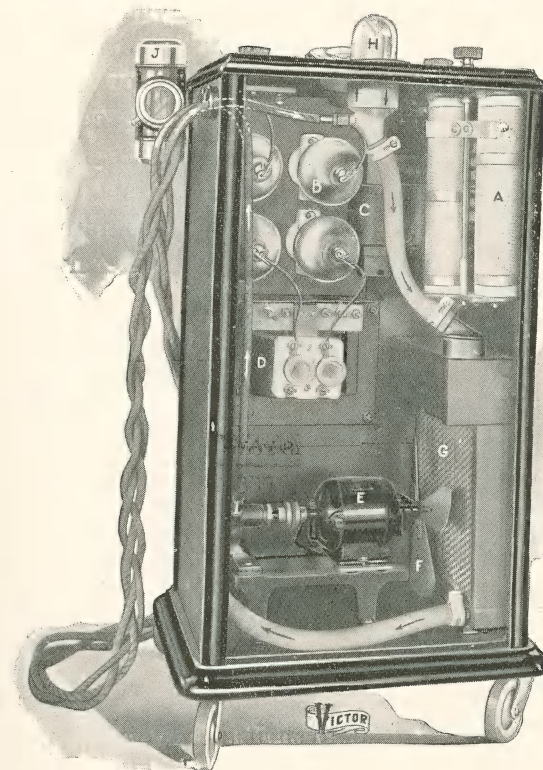


FIG. 221.—A Mobile Water-cooled Mercury Vapour Lamp with Self-contained Water-cooling System. (Victor Corporation, Chicago.)

A, Rheostat Control; B, Tungar Rectifier Bulbs (4 used); C, Choke Coil; D, Transformer for Rectifier; E, Motor for Pump and Fan; F, Fan; G, Radiator, with Water Reservoir above; H, Water Flow Indicator; I, Water Circulation Pump; J, "Uviarc" Casing. Arrows indicate path of flow of water.

cases, but it can be raised for prolonged periods by exposure to ultra-violet rays.

General irradiation is also valuable as an aid to metabolism, and for the purpose of raising the bactericidal properties of the blood. General hygienic measures and dental, vaccine, and medicinal treatment should also be prescribed. Local irradiation of the affected part should be carried out; a third-degree erythema alleviates the pain and arrests the progress of the disease, and if fluid is present it aids its absorption.

The conjoint use, with ultra-violet radiation, of infra-red and luminous rays and diathermy is most valuable in rheumatic conditions.

In many cases of myalgia or muscular rheumatism, the production of a severe third-degree erythema over the affected area by means of one exposure to the rays will often effect a cure. It is rare that more than three or four applications are necessary, even in the most severe cases. Irradiation is very valuable in cases of rheumatism complicated by heart disease where intense heat cannot be tolerated.

Laqueur mentions a case of acute gonococcal arthritis where irradiation was followed immediately by complete cessation of pain.

Chronic rheumatoid arthritis is very resistant to treatment; cure is not expected, but the general health can be greatly improved, and pain can be relieved and movement increased. Naturally, early cases respond better than long-standing cases, and sub-acute better than chronic. Acute cases should always be mildly irradiated in bed, so that all unnecessary movement is avoided. Treatment is best given intermittently over a period of several months.

The carbon arc should be used in all these cases because it has the greatest analgesic effect.

Injuries to Muscles, Joints, and Ligaments.—All cases of contusions, sprains, torn ligaments, after dislocations, and torn articular cartilages, should be

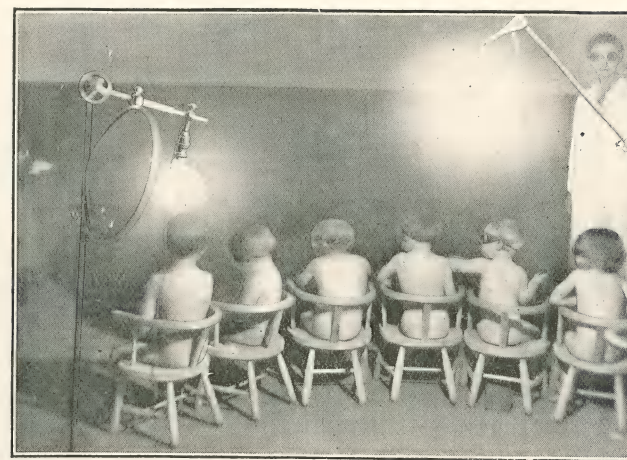


FIG. 222.—Children being irradiated in an East London Clinic with a "K.B.B." Mercury Vapour Lamp.

treated by ultra-violet radiation. A localized third-degree erythema should be produced, and often this speedily relieves all pain. It is an ideal way of producing counter-irritation in synovitis of the knee-joint following a torn semilunar cartilage. It is also extremely useful in cases of coccygodynia, where small areas around the sacro-coccygeal should be strongly irradiated.

Fibrositis.—Case 7, that of a female, is a typical example. She complained of pain over the erector spinæ muscle, which had increased in severity for two months until she was almost unable to walk.

On the first day radiant heat was given, followed by ultra-violet radiation. A smart reaction was set up, and great relief was experienced immediately. After seven subsequent exposures to the rays, given thrice weekly, the pain had disappeared.

We have treated various cases of indefinite pains of a "rheumatic" nature, and these have generally responded to radiation.

Rickets.—Special attention has been devoted in this book to the consideration of the ætiology and treatment of rickets, seeing that it is a brilliant example of a disease in which ultra-violet radiation has a specific action.

Historical Considerations.—Rickets is by no means a modern disease, but it is only in comparatively recent years that it has been recognized as a clinical entity; formerly it was considered merely as a symptom of general weakness arising from some other condition. References have been found in the writings of a Roman physician (Soranus Ephesius, A.D. 98-138) to the prevalence of rickets in Rome and its suburbs, and it is well known that the hygienic conditions of the Roman working and poorer classes were, at that time, very bad.

On the other hand, no signs of rickets have been found in ancient bones disinterred in America, Egypt, and South Africa, but it must be remembered that industrialism did not develop in these countries until a much later date.

Glisson, in 1650, was the first to describe rickets as a separate disease, and much later, towards the end of the nineteenth century, Osler described it as a disease of infants characterized by impaired nutrition of

the whole body, associated with certain alterations in growing bones. Osler, however, considered that the primary lesion was actually in the bone elements themselves. It was the late Dr T. A. Palm who, in 1890, first expressed the opinion that rickets was a "disease of darkness," the lack of sunshine disorganizing the metabolism of the whole body.

In 1922 Lawson Dick said: "Rickets is the commonest disease of children in our large towns and probably the most serious factor interfering with the efficiency of the nation." The distribution of rickets throws a good deal of light on the nature of the disease. It is most common in thickly populated areas, especially in large manufacturing cities where there is much atmospheric pollution by smoke; when it is found in rural districts it is in places where the climate is particularly wet and cloudy. Geographically the whole of Europe, excepting the extreme south, is subject to the disease, and in America it is rife in all densely populated areas. As a rule the abundance of sunlight in the Far East and in the Southern Hemisphere appears to counteract bad hygienic conditions and poor food, and when rickets does occur in these parts it is always of a mild character.

The Ætiology of Rickets.—It is generally recognized at the present time that lack of sunshine is the essential cause of rickets. The disease is most commonly found in dark, squalid slums, but it is sometimes present also among children of the better classes when nurseries are dark and the children remain indoors for the greater part of the day, and when insufficient attention is paid to diet.

The question that now arises is: In what way does the deprivation of sunlight cause rickets? Before answering this question we must first consider the chemical composition of bone and the pathological factors that interfere with its formation. Normal bone contains 11 per cent. of calcium oxide and 8.58 per cent. of phosphorus pentoxide. Brubacher found, in 1890, that the femur of a child of four years suffering from rickets contained only 2.74 per cent. of CaO and 1.97 per cent. of P_2O_5 ; the fat was also reduced, but the water was increased. There is almost always a deficiency in the amount of these minerals present in the bones of patients suffering from rickets; but their ratio to one another remains approximately constant. The essential pathological change in rachitic bones has been found to be a cessation or retardation of the deposition of calcium in newly forming bone or ossifying cartilage. Histologically, the bone is imperfectly calcified in these situations. The greatest amount of osteoid tissue is present in rapidly growing rachitic infants who are active and running about.

Schabad (1910) found, on comparing the intake and output of calcium in the early progressive stage of rickets, that a negative balance was almost invariably the rule; he also noticed that in the later stages, when the condition was marked but the softening of bone had ceased, there was a zero or slightly positive balance, and that during healing there was usually a marked positive balance.

Many workers have detected a negative calcium balance in apparently normal infants; this condition

has been found to be an incipient stage of the disease and the usual rachitic symptoms have invariably followed later.

Schabad and Orgler have remarked that "An increased calcium intake in the diet of rachitic children at the progressive stage does not cause any increased retention of calcium." If rickets were due to calcium starvation—*i.e.* an insufficient intake of calcium—it would be relieved by increasing the amount of calcium taken by the mouth. Telfer showed that the absorption of calcium is dependent on the free acid in the gastric juice, which dissolves the calcium salts that are present in the food. Absorption is normally restricted by the alkaline reaction of the intestinal tract, and the calcium is precipitated as an insoluble calcium phosphate. The fixation of calcium influences the fixation of phosphorus, and if the calcium balance is low the phosphorus balance is low also. In some way ultra-violet irradiation causes an increase in the amount of calcium absorbed from the alimentary tract for a given intake.

The concentration of calcium and phosphorus in the blood has also been studied, and although the evidence indicates that rickets is frequently associated with a lowered inorganic phosphate content in the blood, this is not a specific condition (Hess and Unger). Blood contains, in addition to lipoid phosphorus and inorganic phosphate, a certain amount of combined phosphoric acid, which is readily hydrolysed by boiling with acids. The amount of this phosphoric acid in normal plasma is much higher in very young infants

than in adults. It appears that some ester of phosphoric acid soluble in acids is present in small amounts in the plasma and in relatively large amounts in the corpuscles. Robison and his co-workers have shown that an enzyme present in ossifying cartilage is capable of hydrolyzing the phosphoric ester, which in turn brings about the deposition of sparingly soluble calcium phosphate. This enzyme Robison terms phosphoric esterase, and it is present in ossifying cartilage, in bone, and in the teeth. He suggests that the enzyme present in bone is concerned in the process of ossification by effecting the hydrolysis of the phosphoric esters contained in the blood, thus bringing about a local increase in the concentration of inorganic phosphate ions, so that the product of concentrations of phosphate and calcium ions becomes greater than the soluble product of calcium phosphate, which is therefore deposited in the solid state. Actually, however, the process is not so simple, because the solid deposit is a complex basic phosphate.

It would appear from the results so far obtained that defective calcification is not due to any deficiency of inorganic phosphate, or of the specific phosphoric ester in the blood, or of the enzyme in the bone by which the ester is hydrolyzed.

Considerable research has been carried out and is still in progress on calcium metabolism from the chemical standpoint, but the problem is receiving attention from other aspects with some measure of success.

Experiments show, for example, that a supply of radiant energy facilitates the deposition of the basic

calcium phosphate of bone; of the exact mode of operation nothing definite is known at present, and it is not improbable that both chemical and physical factors will be found to be involved in the solution of the problem of defective calcification.

The application of radiant energy may stimulate chemical processes directly or may produce the conditions necessary for their occurrence. The energy supplied may act as a direct stimulus to the ossifying enzyme, or may increase ionization, or bring about such local changes as will facilitate hydrolysis of the phosphoric ester. Another theory of rickets that has received considerable attention lately is the "acidosis theory," which suggests that lack of sunlight and errors in diet bring about a condition in which the ingested food is insufficiently oxidized and does not produce the normal end-products, carbon dioxide, water, and urea, but gives rise to the creation of large acid molecules in the organism. This results in an acidosis, and is compensated at the expense of the alkaline reserves of the blood—*e.g.* sodium, potassium, ammonia and, later, calcium salts; in this way insufficient calcium is available for bone formation. This is ameliorated by any metabolic stimulus, such as ultra-violet radiation.

Diet and Heredity.—It is well established that diet plays an important part in rickets, and the chief factor has been proved to be vitamin D, which is fat-soluble and is found in butter, milk, egg yolk, cod-liver oil, and the like.

Professor Mellanby, in 1918, produced rickets in puppies by feeding them on a diet deficient in fat-

soluble vitamins, and proved that this disease could be both prevented and cured by the addition of these vitamins to the food.

Cod-liver oil is the most valuable natural source of vitamin D, and it is sometimes asserted that daily administration of it will prevent and cure rickets. This is a debatable point, and the results of cod-liver-oil treatment have in fact proved to be uncertain. May G. Wilson found, when treating forty-seven infants as out-patients, that daily doses of one to three teaspoonfuls of cod-liver oil failed to prevent the development of rickets in 68 per cent. of the cases. We ourselves have often known this method of treatment fail. One reason for the failure may be that in the last few years a new method of preparing the oil has been introduced. The livers are crushed by machinery now and, as a result, the crude oil is very turbid and much discoloured. To clarify it, it is filtered through a special mineral earth, but this, unfortunately, has the effect of removing the vitamin.

Fish obtain vitamins from diatoms and plankton growing on the surface of the sea. These substances probably cause the wonderful phosphorescence that can often be seen on the sea during very dark nights. They have the power of elaborating vitamins from the sun's rays. The cod stores these vitamins in its liver, which thus acquires its value as an anti-rachitic medicament.

It is an interesting fact that although Laplanders live in darkness in the Arctic regions for six months of every year they do not suffer from rickets, because their chief article of diet is pure fish oil.

The vitamin appears to act by causing the mobilization of more calcium in the body. In milk fat a second vitamin (A) is present, which influences the growth of the organism. It is present also in fresh fruit and vegetables, and it comes into milk from the fresh greenstuff contained in the diet of the animals that produce it. If cows are kept in darkness and fed on greenstuff, their milk contains this vitamin, but is deficient in vitamin D. If, on the other hand, the cows are exposed to sunlight, but no green food is given to them, vitamin D will be present in and vitamin A absent from the milk; young animals fed on it would eventually die, but no evidence of rickets would be found.

Ultra-violet radiation has a still more certain prophylactic and curative effect on rickets than the oral administration of substances containing vitamin D, and it is probable that the rays, which have very little power of penetration, act photochemically on the sterols present in the hair and in the superficial layers of the skin, and so produce vitamin D.

Hess and Weinstock irradiated human skin after it had been removed from the body, and added it to the food of rats that were being fed on a rickets-producing diet. These rats did not develop rickets, whereas the controls did. They further found that if the irradiation of the skin is too prolonged a substance is finally produced that has no anti-rachitic properties. The time necessary for the activation of cholesterol is from one-half to three hours, and this period should not be exceeded.

If chemically pure cholesterol ($C_{27}H_{46}O$) is irradiated

it remains quite inactive, and therefore the provitaminic substance must be present in its impurities.

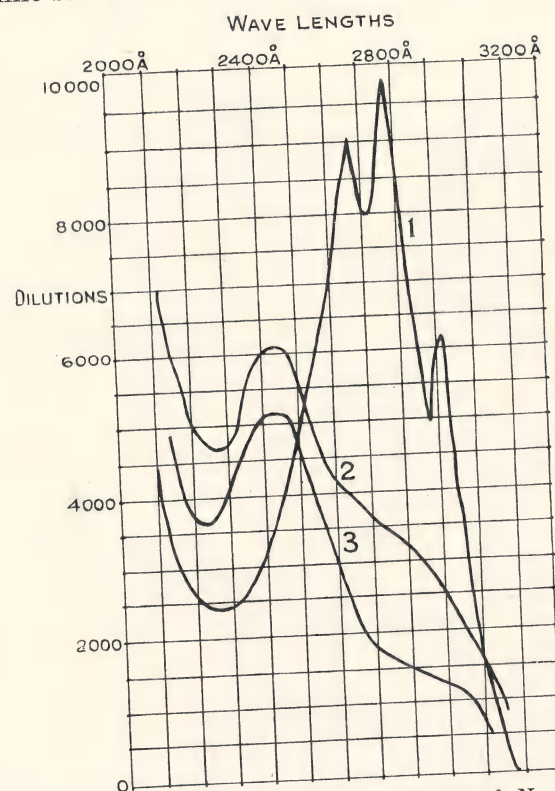


FIG. 223.—Curves of Absorption Spectra of Non-Irradiated and Irradiated Ergosterol.

1, Fresh solution of Non-Irradiated Ergosterol with maximum absorption bands at 2700, 2815 and 2935 Å and minimum at 2300 Å. 2, After Irradiation for 120 minutes with Q.M.V. Lamp, showing band at 2470 Å. 3, After Irradiation for 150 minutes, showing the well-developed band at 2470 Å due to the presence of Vitamin D. (After Morton, Heilbron, and Kamm.)

Rosenheim and Webster have finally proved that the provitamin was contained in the most insoluble

portions of the cholesterol and that it belongs to the group of unsaponifiable sterols. The provitamin is unsaturated, and if cholesterol, which contains the provitamin, is hydrolyzed, it loses its antirachitic power entirely. Cholesterol contains $\frac{1}{100}$ per cent. of the provitamin. When the spectrum of irradiated cholesterol is examined it is found that it differs in some respects from the spectrum of non-irradiated cholesterol. Certain absorption areas have disappeared, proving that irradiation has chemically altered some substance that caused the absorption in the non-irradiated cholesterol. In rachitic rats definite curative effects have followed the daily administration to each of so minute a quantity of irradiated ergosterol as $\frac{1}{100,000}$ of a milligramme. Ergosterol ($C_{27}H_{42}O$), it may be concluded, represents the provitamin and is an isomer of irradiated ergosterol, which is the vitamin. It is an interesting fact that ergosterol fluoresces when exposed to ultra-violet rays passed through an oxide-of-nickel filter, whereas irradiated ergosterol shows no fluorescence. Many substances have been found to contain the provitamin—yeast, linseed oil, and cotton-seed oil being examples; they all become anti-rachitic after irradiation with the quartz mercury vapour arc and this action is not lost by subsequent boiling.

Recently it has been suggested that the oral administration of irradiated oils containing a large percentage of vitamin D should prove much simpler and cheaper than the exposure of the body to ultra-violet radiation. The formation of vitamin D, however, is only one of the beneficial effects following irradiation,

and amongst others that could be mentioned are the powerful bactericidal action of the rays, the production of antibodies, the stimulant effect on the central nervous system, and the tonic and nutritive action on the skin itself. Is it, therefore, reasonable to discard lightly the proved value of direct irradiation and substitute the oral administration of substances containing vitamin D, the production of the vitamin in the human body being only one of the benefits attributable to ultra-violet irradiation?

Steenbock and Black have shown that the exposure of a rat's food ration deficient in fat-soluble vitamin to ultra-violet rays caused it to become activated so that it produced satisfactory growth and calcification of bone.

S. J. Cowell has been able to demonstrate similar effects in children suffering from rickets. Two rachitic children were given milk that had been exposed twice daily to ultra-violet rays in a wide, shallow dish for twenty minutes at a distance of three feet from the lamp. A control case was given untreated milk. X-ray photographs of the wrist were taken before and after one month's treatment. The two radiographs of the control case showed that hardly any difference had taken place during the month, but those of the children fed on irradiated milk indicated a marked improvement in calcification.

Similar results have been obtained by irradiating dried milk for half-an-hour in thin layers one foot from the lamp. Subsequent boiling does not destroy the anti-rachitic property of irradiated foods.

Treatment.—Exposure to some source of ultra-violet

radiation is undoubtedly the most satisfactory method of curing rickets. The quartz mercury vapour arc lamp is certainly the most convenient, especially for the treatment of young children.

Dr Theobald Adrian Palm, in 1890, was the first to recommend natural sunlight in the treatment of rickets, and Huldchinsky's brilliant discovery in 1919 proved beyond all doubt, by means of X-ray photographs taken before and after treatment, that the condition could be cured by approximately twenty-six graduated exposures to the mercury vapour lamp. If the treatment is given thrice weekly this takes only a little over two months.

It has been found experimentally that the rays in natural sunlight that accomplish the cure of rickets are those with wave-lengths between 3022 Å and 2900 Å, and in the mercury vapour lamp those between 3022 Å and 2654 Å.

General irradiation of the whole body gives the best results, beginning with two-minute exposures of the back and front of the body at thirty-six inches from the mercury vapour lamp and gradually increasing the exposure until fifteen minutes of both back and front are given at twenty inches distance, either daily or on alternate days. In rickets or tetany it is not necessary to induce erythema or to bring the lamp very close to the patient.

Huldchinsky advises that the irradiation should be continued for as many months as the child's age in years, and that there should then be a month without treatment, followed by final treatment during another month. Other workers consider that two

months' treatment is sufficient even for the severest case, and we have found this to be so in our own

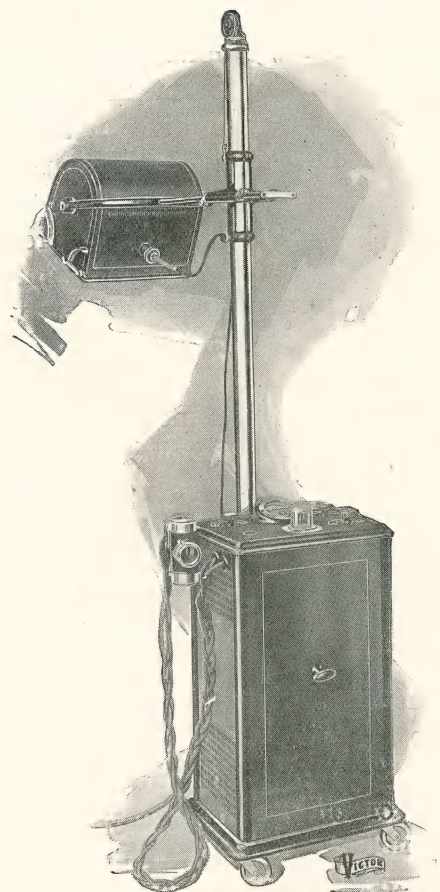


FIG. 224.—“Victor” Combination Air-cooled and Water-cooled Quartz Lamp Outfit. This can be used when no regular water supply is available.

practice. After the course the condition is completely cured, and will never return.

All the symptoms that characterize rickets tend to disappear rapidly. The catarrhal condition of the lungs, the stomach, and the intestines, soon clears up, the appetite improves, and the weight is increased. One of the most obvious changes that occur after the first few irradiations is the alteration in the disposition of the child. A cross, fretful infant becomes happy and playful. In practically every case of rickets there is marked irritability; this is due often to digestive troubles, to tenderness of the limbs, or simply to the general “poorly” condition.

Calcium is a nerve sedative, and if the amount in the body is insufficient fretfulness and irritability develop, often leading to carpopedal spasms, to *Laryngismus stridulus*, and even to convulsions, which are so often seen in ill-nourished, rickety children.

The atonic condition of the muscles found in children suffering from rickets, and associated with tenderness of the limbs, is due partly to low calcium content of the serum and partly to deficiency of phosphorus, leading to diminished conductivity of the nerve fibres supplying the muscles.

Another symptom that responds well, but rather more slowly, to actinotherapy is the anæmia. The red cells and their hæmoglobin content gradually increase, and become normal by the end of two or three months.

Bone Changes.—The epiphyseal enlargements quickly subside, and by the aid of X-ray photographs several changes in the bones themselves may be noticed. The general fluffiness and swelling round the epiphyses disappear, the epiphyses themselves

become clearly defined, lime salts are deposited in the shafts of the long bones, and cupping of the diaphyses disappears. New, yet very distinct, centres of ossification, which were not present before treatment, begin to appear. Children who have been unable to walk soon get the use of their feet and are able to run about quite normally. Bony deformities, such as bow legs, often disappear in children under two and a half years of age. Craniotabes gradually disappears.

Huldschinsky maintains that "the prophylactic treatment of rachitis ought to be introduced as universally as vaccination against smallpox. Every child, whether it shows any symptoms of rickets or not, should during its first year be exposed for at least a month to ultra-violet rays. If this be done there are prospects of seeing rickets as a disease disappear entirely. Cases of rachitis ought not to occur in any well-administered community."

If this were systematically carried out in hospitals and clinics there would be a considerable decrease in infant mortality from pneumonia, diarrhoea, convulsions, and so on. Bow legs, kyphosis, scoliosis, and many other crippling conditions, would be unknown; maternal mortality at childbirth from flat and deformed pelvis would be greatly decreased, and the general health of the race would be improved.

It has been shown by work done at the out-patient department of the Children's Hospital, Boston, U.S.A., that acute rickets can be readily cured by ultra-violet radiation given in an out-patient department thrice weekly for two months. It is not necessary to use any anti-rachitic medication. Drs Wyman and Weymuller

also found that of four hundred babies between the ages of three and eight months who were attending the out-patient department, and who had not had cod-liver oil, 95 per cent. had rickets, and, further, that 100 per cent. of the negro and Italian children were affected before they were eight months old. In this country over 50 per cent. of all cases between the ages of six months and three years attending the Motherwell Child Welfare Centres in 1924-1925 showed some osseous sign of rickets.

The functional nerve disorders, tetanic carpopedal spasms, *Laryngismus stridulus*, and spasmophilia, react quickly and very favourably to ultra-violet radiation. Speaking of spasmophilia, Cameron says that sunlight and the mercury vapour lamp are quickly curative in most cases. In tetany the calcium content of the blood serum is always found to be below the normal.

Convulsions are of reflex origin, and are generally due to such causes as dentition, constipation, or some other form of irritation, which would have no ill effects in a normal child, but which provoke convulsions in rickety children owing to the decrease of calcium in the blood and the increased excitability of the nervous system. Two or three exposures to the mercury vapour lamp are often sufficient to prevent the occurrence of this alarming symptom.

Delayed dentition is another manifestation of rachitis that may be rectified by ultra-violet radiation, and we find that children who have had this treatment for any condition have very little disturbance or pain when cutting teeth. Altogether, the results that can be obtained in treating rickets with

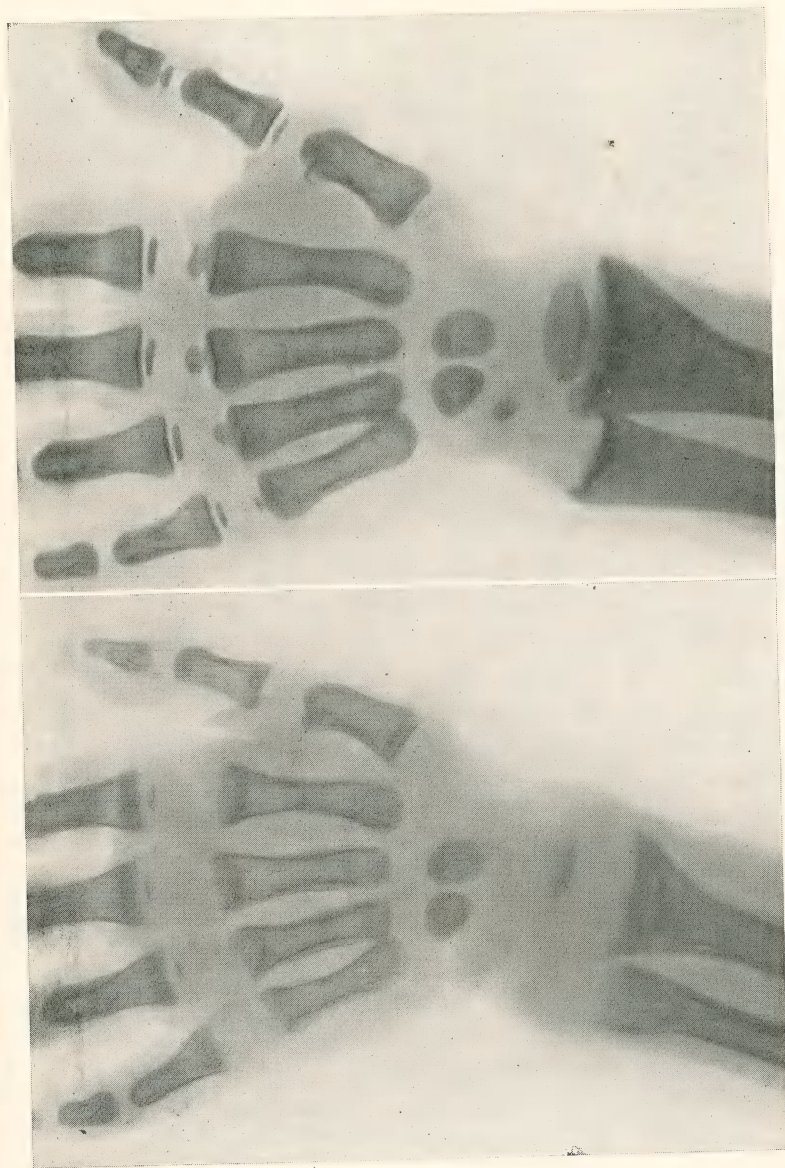


Fig. 225.—A Case of Rickets which prolonged administration of Cod-Liver Oil failed to cure, but which rapidly yielded to Ultra-Violet Radiation. X-Ray Photographs of Boy's Wrist (Case 37).
A, Taken before commencement of Ultra-Violet Treatment, showing typical Florid Rickets; B, Two months later, showing Complete Cure.

ultra-violet radiation are so striking that no difficulty has ever been experienced in getting parents to bring their children for treatment, even though in doing so they have been put to a great deal of trouble and inconvenience.

If rickets is treated early enough no permanent bone deformities need be anticipated. With older children who already have shaft deformity the problem is more difficult, especially because it is almost impossible to get children living at home to wear suitable corrective apparatus. Osteotomy seems the only procedure in these cases. This can be done while irradiation is being carried out. Usually the fractures in the bones are soundly healed in four weeks, allowing the splints to be discarded at the end of this time.

Huldschinsky says that operation should be avoided in *Rachitis florida*, because it may bring on tetany. He advises a thorough examination of the nervous system in all rachitic cases before operation.

We have had an opportunity of treating several cases of rickets, some of which were of the florid type with active joint lesions, accompanied by marked metaphyseal enlargement and deformity of the long bones, and associated with all the usual symptoms of this condition—namely, prominent abdomen, bronchitis, diarrhoea, etc. We took a series of X-ray photographs of the wrist, ankle, knee, and elbow joints, before, during, and at the end of treatment. The radiograms taken before treatment showed the presence of marked florid rickets, characterized by great enlargement of the epiphyseal areas, which were indistinct, and by cupping of the lower ends of the

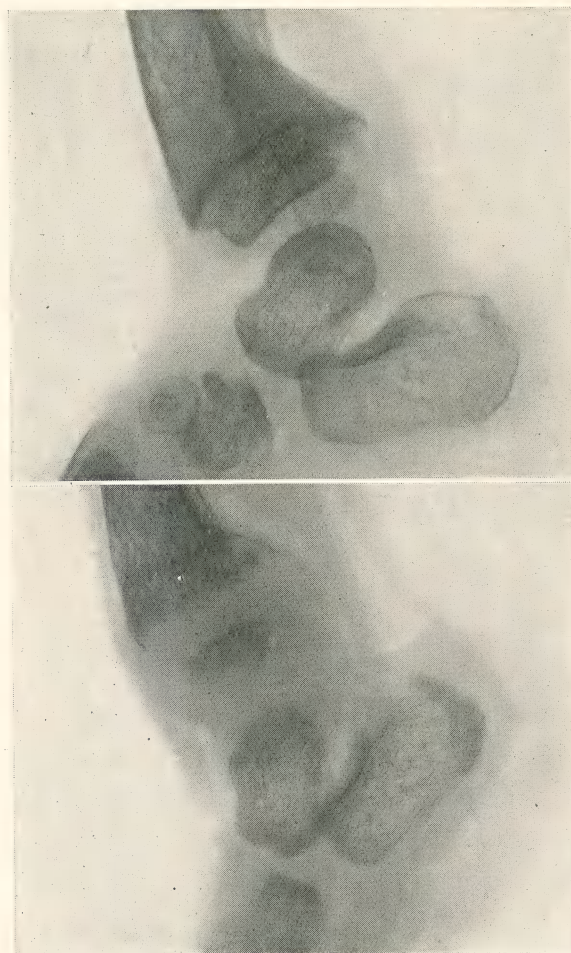


FIG. 226.—X-ray Photographs of Ankle of a Case of Rickets (Case 37), which prolonged administration of Cod-Liver Oil failed to cure, but which rapidly yielded to Ultra-Violet Treatment. Before the commencement of Actinotherapy, the child, though aged $3\frac{1}{2}$ years, had never walked.

A, Taken before commencement of Ultra-Violet Treatment ;
B, Same, two months later.

metaphyses, with irregularity and poor definition. There was also rarefaction of the shafts and slight periosteal thickening. The photographs taken after only five weeks' treatment showed a wonderful difference, with increased metaphyseal definition, clearly marked epiphyses, and the absence of cupping. This proves indeed that rickets is essentially a "disease of darkness." Ultra-violet radiation has won its place in therapeutics, if only for its wonderful power in this disease.

Case 8. A boy, aged $3\frac{1}{2}$ years, was a typical case. He was the second youngest of a family of twelve, six of whom were living, and three of whom were suffering from rickets. At the commencement of treatment he weighed 1 st. 9 lb., had never walked, and talked very badly. He suffered from bronchitis and diarrhoea, and was very fretful. After the first few applications of the rays the bronchitis and diarrhoea cleared up, he ate and slept well, and played about with his toys. Before this he had been given cod-liver oil for several months without any noticeable effect, but the almost immediate improvement with ultra-violet radiation was most marked. The child was breast-fed until six months old, and then had a well-known brand of infants' food until he was a year old, after which he had food with the rest of the family, which would not be very nutritious, seeing that the parents are poor. At sixteen months of age he was beginning to walk, when he developed measles, and made no further attempt to walk. He was treated at a clinic for rickets from that time onward without much benefit, and when we saw him marked deformity was present.

He was wearing splints to counteract this as far as possible and to prevent its increase, but difficulty was experienced in getting him to keep them on at home.

After the first two or three weeks the bronchitis and diarrhoea had completely cleared up, and the child was much brighter.

At the end of treatment he was almost normal, talking well, and playing and running about with other children. Examination of the bones by X-rays proved that the rickets was completely cured. When seen eighteen months later he was strong and well, with no bony deformity.

Banks mentions a very interesting case of a girl eight years of age who was suffering from very severe rickets, with marked deformity of the head, trunk, and limbs, and who had never been able to walk. Three weeks' treatment with ultra-violet irradiation made this child able to rise to her feet; in another three weeks she could walk about without assistance; and at the termination of the treatment she was running about and playing with normal children of her own age.

Bone Lesions.—Ultra-violet radiation is very useful in many bone diseases, because it increases the amount of calcium in the blood and therefore leads to a greater deposition of lime salts in bone.

Fractures.—Actinotherapy is invaluable in the treatment of fractures of bone, caused either surgically or by trauma, especially in compound fractures, which so often become septic. Irradiation aids the extrusion of sequestra and healing of sinuses. At the

Royal Free Hospital, London, there has not been a single failure to secure union in any of the four thousand cases of fracture that have been treated during the last five years.

Osteoporosis, which often occurs after fracture, or during illness, owing to disuse of the bones, can also be prevented.

Osteomalacia is essentially due to a deficiency of calcium in the blood during pregnancy, and results in the falling out of the hair, the loosening of the teeth, and the softening of the bones of the mother, and foetal rickets (achondroplasia) in the child. Both these conditions can be avoided by means of antenatal ultra-violet radiation.

Osteogenesis imperfecta is a disease in which the bones are exceedingly brittle, so that fractures result from the slightest injury. It can be improved by actinotherapy.

Osteomyelitis cases do well with ultra-violet radiation, especially after they have been operated on. Bernhard and Rollier have had exceedingly good results with heliotherapy.

Osteitis deformans (Paget's Disease).—We have had very satisfactory improvement in some recent cases of this rather uncommon disease. The spongy oedematous condition of the tibiae soon show marked amelioration.

In all these cases general irradiation is necessary. Calcium should also be given orally, and small doses of parathyroid gland extract are often beneficial in conjunction with actinotherapy.

Case 9. Male, aged 55 years, suffering from *Osteitis*

deformans. The condition was first diagnosed three years ago, when he was being X-rayed for a fractured clavicle, but undoubtedly it had been going on for some years previous to his accident.

There is two inches shortening in height and consolidation of the lumbar vertebræ into a rigid bony column. There is a curious fold in the skin of the abdomen which passes through the umbilicus.

Before commencing treatment there was wasting of both groups of gluteal muscles, and a boggy swelling of the upper third of the left tibia and the middle of the shaft of the right humerus.

The condition has yielded wonderfully to ultra-violet radiotherapy; the deformity, of course, persists, but the spongy condition of the tibia and the humerus soon disappeared, and it is now impossible to get any pitting on pressure over either of these bones.

General treatment was given for several months with the air-cooled mercury vapour lamp, the ordinary dosage being used.

The Effect of Ultra-Violet Radiation during Pregnancy and Lactation.—Actinotherapy is invaluable during pregnancy. The increasing demands of the growing foetus upset the calcium metabolism of the mother. It is sometimes suggested that this calcium deficiency is responsible for eclampsia, because in this condition the blood calcium is extremely low.

Kehrer has noted a marked fall in the blood calcium during the later part of pregnancy. Pacini has found that ultra-violet radiation dispels the tetanic or convulsive symptoms that sometimes occur towards the end of pregnancy and that he considers to be the

precursors of eclampsia. The general health of the mother is also benefited and metabolism is increased, and thus the risk of constipation and auto-intoxication is diminished.

The value of antenatal irradiation to the foetus is equally important, since even a slight diminution in the blood calcium of the mother may be detrimental to the child, causing the so-called rachitic diathesis. After birth this may lead to various symptoms, such as badly developed bones, irregular eruption of teeth, which rapidly decay, and a tendency to the development of florid rickets, with its attendant symptoms.

Achondroplasia, as already mentioned, is another manifestation of calcium deficiency in the foetus. The condition is due to an abnormal development of the foetal skeleton characterized by undersized limbs, attributable to the premature union of the epiphyses of the long bones.

If the infant is irradiated with the mercury vapour lamp after birth improvement takes place, and the skeleton becomes more normal in appearance.

A case is recorded where the condition was diagnosed at the eighth month of pregnancy by means of X-rays. The mother was irradiated for fourteen days before delivery and the infant was practically normal.

General irradiation should be commenced about the beginning of the third month of pregnancy, and weekly applications should be given at first; later exposures can be made twice or thrice weekly.

An interesting fact, which Professor Mellanby has discovered, is that an excess of certain cereals has the effect of actually causing rickets in borderland cases.

He considers that many cereals contain a rachitic antivitamin, which is present in the saponifiable part of the fat of the cereal. He also says that the ingestion of oatmeal, which is the worst cereal in this respect, during pregnancy and lactation, and by young growing children, is very harmful when other conditions favour rickets. This property of cereals, however, is easily counteracted by the administration of cod-liver oil, egg yolk, or milk fat.

The milk of many mothers of the poorer classes, especially in industrial districts, has very little anti-rachitic value, and this accounts for the number of cases of rickets in breast-fed infants. If the mother is exposed to ultra-violet radiation during lactation the anti-rachitic properties of the milk are greatly increased, and rickets in the child is prevented or cured, as the case may be; incidentally, there is generally an increased yield of milk.

Adolescent Rickets, Tetany, and Amenorrhœa.—

Case 10. Girl, aged 22 years, who had been unable to walk for several years. In 1916, when 11 years of age, she had severe attacks of diarrhœa. A diagnosis of tubercular peritonitis was made, and, later, tetanic contractions added to the sufferings of the patient. The condition became chronic and she was wheeled in a bath-chair for several years. We first saw her in May 1926. She was very badly developed, with marked lordosis, and was unable even to stand. Tetany was very marked and painful. She commenced general ultra-violet radiation on 18th May 1926, and the tetany entirely disappeared after the first six treatments. During Christmas week, 1926,

she was able to walk a few steps without assistance. Her exposures were reduced from three times weekly to once weekly, and she gradually became stronger, so that in the summer of 1927 she was able to take over the management of a poultry farm, which she has been able to look after since without any untoward results.

CHAPTER XIV

ACTINOTHERAPY IN THE TREATMENT OF DISEASES OF THE BLOOD, THE DUCTLESS GLANDS, AND THE CIRCULATORY, NERVOUS, RESPIRATORY, AND ALIMENTARY SYSTEMS

Anæmia—Chlorosis—Leukæmia—Purpura—Hæmophilia—Affections of the Endocrine Glands—Circulatory Disorders—Hyperpiesis—Diseases of the Heart—Angina Pectoris—Peripheral Circulatory Disorders—Raynaud's Disease—Diseases of the Central Nervous System—Ultra-Violet Radiation in Mental Disorders—Neurasthenia—Chorea—Epilepsy—Paralysis agitans—Encephalitis lethargica—Anterior Poliomyelitis—Peripheral Nerve Diseases—Neuritis—Neuralgia—Spasmodic Torticollis. *Respiratory Disorders*: Asthma—Bronchitis—Bronchiectasis—After-effects of Poison Gas—Empyema—Emphysema—Laryngismus stridulus—Pneumonia: Broncho-Lobar—Post-Influenzal—Pleurisy—Pleurodynia—Whooping Cough. *Disorders of the Alimentary System*: Dyspepsia—Gastric Ulcer—Constipation—Diarrhœa—Functional Disorders of the Gastro-Intestinal Tract—Abdominal Adhesions—Cirrhosis of the Liver—Cholecystitis—Jaundice—Hæmorrhoids—Fistulæ—Ultra-Violet Radiation in Infectious Diseases

DISEASES OF THE BLOOD AND DUCTLESS GLANDS

Anæmia (secondary, pernicious); Chlorosis; Leukæmia.—Improvement in cases of anæmia could be expected from actinotherapy when the biological effect of ultra-violet radiation on the blood is

OTHER INTERNAL DISEASES 481

considered. Finsen carried out interesting experiments on the seasonal variation in the number of red blood corpuscles and in their hæmoglobin content. Experimenting with twenty persons, he found that the red blood corpuscles and hæmoglobin increased progressively throughout the summer months and reached a maximum at the beginning of the autumn. From then onwards there was a regular decrease, which continued until the beginning of spring. More recently a valuable experiment has been performed at a home for delicate children at Honley. Thirty-one of these children were given ultra-violet irradiation, and thirty-one others were not. The irradiated children showed an increase in hæmoglobin of 8·2 per cent. compared with an increase of 6·7 per cent. in the non-irradiated children. Again, those receiving ultra-violet radiation showed an increase of nearly 400,000 red blood corpuscles compared with 58,600 in the children not receiving treatment—i.e. the red blood corpuscles of the irradiated children increased nearly seven times as much as those of the non-irradiated. Cases of secondary anæmia, following hæmorrhage, or acute illness, and accompanying rickets, or pretubercular conditions and nephritis, do exceptionally well with general light baths. Chlorosis is now a rare disease, probably on account of the more hygienic and rational clothing worn by the modern girl. Ultra-violet radiation rapidly clears up the chlorotic condition. Splenomedullary leukæmia, and even pernicious anæmia, can, in a certain measure, be benefited by irradiation, but medicinal, hygienic, and dietetic treatment must not be neglected. This applies particularly

to the last-mentioned, and wonderful results have been obtained in pernicious anæmia with the "liver diet" of Minot and Murphy. We have, however, known a case where sensitization apparently occurred when the patient was on the liver dietary, and irradiation was followed by an intense urticarial reaction.

The air-cooled lamp or preferably the carbon arc is used, and general exposures are given to the whole body. The Dosage Tables on pages 378 and 397 should be followed.

The good results obtained in cases of chlorosis are due probably to the indirect disinfection of the alimentary tract, and the aid given to the absorption of iron, which should be given by the mouth during the treatment. There is an increase both in the number of red blood corpuscles and in the amount of hæmoglobin. The general health improves, the colour returns, headache is relieved, the appetite becomes normal, and consequently the weight increases.

Before the introduction of the "liver diet" we treated several cases of pernicious anæmia with ultra-violet radiation and were able to bring about slight progressive increases in the number of red cells. The patients felt much better for the treatment, and in some cases were able to attend work again. They were also relieved of vomiting and other stomach symptoms, and their weight increased. The glossitis so often present can be rapidly remedied by local irradiation of the mouth.

While realizing that pernicious anæmia is a disease characterized by remissions, there is no doubt about the beneficial effect of ultra-violet radiation. The

value of open-air sunlight treatment in these cases has never been disputed. Now, however, the "liver diet" should always be the treatment of choice, but irradiation can play a part too, particularly when the special diet is no longer being taken.

Some cases of leukæmia have been successfully treated with actinic radiation. The administration of X-rays to the spleen, in conjunction with general irradiation with the air-cooled lamp, has been advised.

Murray mentions a case of splenic anæmia that responded very well to ultra-violet treatment; the spleen became much smaller, and the patient increased nine pounds in weight.

Purpura ; Hæmophilia.—Purpura and hæmophilia have both been successfully treated with actinic rays, the beneficial action being probably due to the fact that the rays increase the calcium content of the blood, and calcium is essential for the clotting of the blood.

The Endocrine Glands (affections of).—There is no doubt that ultra-violet radiation has a stimulating effect on the secretion of certain of the endocrine glands. This is thought to be a reflex action due to the stimulation of the nerve endings in the skin.

We have given ultra-violet radiation treatment, with satisfactory and definitely successful results, to a case of hypothyroidism, accompanied by physiological swelling of the gland, and Dufestel has had similar results. The rays undoubtedly stimulate thyroid and pituitary secretion, the activity of the parathyroids appears to be increased, and the sexual glands are also stimulated by irradiation. General

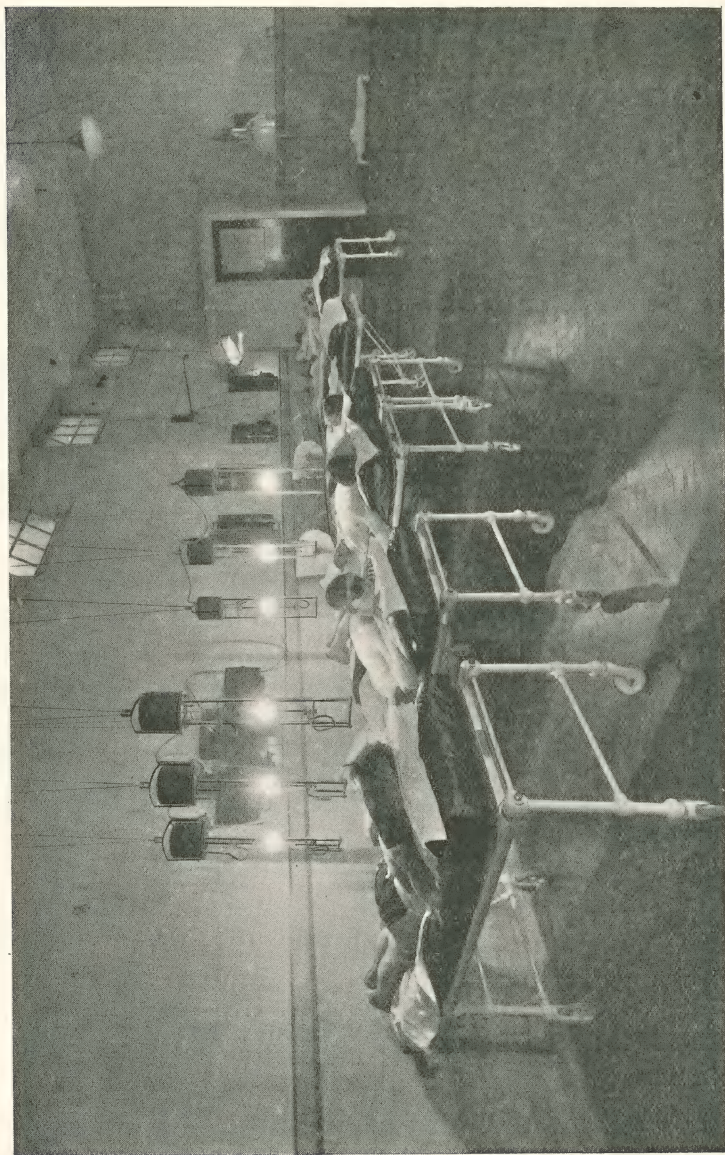


FIG. 227.—Part of the "Sun-Ray" Clinic, Newcastle-on-Tyne, showing 20-ampere Short-Flame Carbon Arcs, "British Hanovia," "K. B. B.," and "Hewittic" Quartz Mercury Vapour Lamps.

ultra-violet radiation is useful in relieving the asphyxial crises that sometimes occur where there is hypertrophy of the thymus gland.

Hypothyroidism.—Case 11. The patient was an unmarried lady, 36 years of age. The condition had begun about twelve months previously, with a feeling of listlessness and exhaustion. There was soreness and tightness over the thyroid area, and some swelling was noticeable. The pulse was 48. Thyroid gland tablets were taken (5 grs. increasing to 30 grs. daily) for several months without result. Mixed-gland tablets were then tried, also without any benefit. Ultra-violet irradiation was commenced, and almost immediate improvement was felt. The swelling disappeared, together with the sore and tight feeling, which was noticed only when the patient was very tired. Six months later she felt better in herself, said she was more lively, and ate and slept well, and all she complained of was that she became easily tired.

CIRCULATORY SYSTEM

Patients suffering from the effects of high blood pressure, whatever be its causes, are greatly assisted by exposure to ultra-violet rays. Hasselbalch and Jacobeus have described the lasting reduction in blood pressure they have found following carbon arc irradiation. They consider that the erythema produced because of the dilatation of the superficial vessels plays a very important part in the phenomenon. We have, however, noticed in almost every case of hyperpiesis we have treated that the fall in

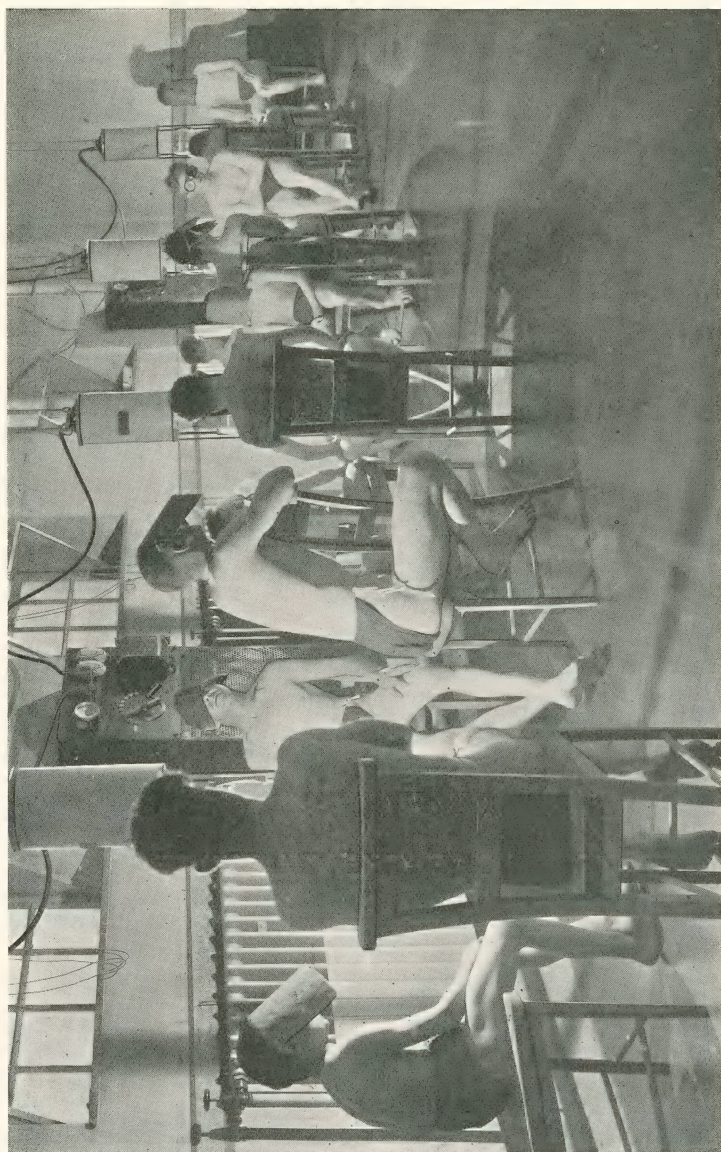


FIG. 228.—Sixteen Patients being treated simultaneously with four Long-Flame Arc Lamps at the "Sun-Ray," Clinic, Newcastle-on-Tyne.

blood pressure is often immediate—that is, before the erythema has developed—and the effect may be due to the hypotonic action of the rays on the sympathetic nervous system. Another theory is that the fall in blood pressure is due to the inhalation of ozone generated by the lamps, but this seems very unlikely. It has been our custom to take blood-pressure readings just before treatment, and again just after. In many cases we have noticed that the pressure fell as much as 20 mm. of mercury after the first irradiation of two or three minutes at a distance of thirty-six inches from the lamp.

Naturally, cases in which the condition is due to functional causes respond best—cases where there have been severe emotional disturbance, mental repression and worry. But cases with definite kidney involvement, and considerable arteriosclerotic changes, do very well also.

We have taken blood-pressure readings some time after ultra-violet treatment has been discontinued, and have found that, although the pressure has generally risen above the pressure registered immediately after treatment was stopped, it is invariably considerably lower than it was previous to the commencement of treatment.

Breathlessness on exertion, headache, vertigo, and irritability, generally disappear. There was no fall in blood pressure in a few of the cases treated, but the patients said they felt wonderfully better for the course of treatment, and several returned again for a further series of applications. General irradiation should invariably be given, with a second-degree dose.

In nine recent cases of hyperpiesis, five of which were arteriosclerotic, one nephritic, and three functional, with no ascertainable organic cause, we have had an average fall of systolic blood pressure of 30 mm. of mercury. Some cases respond much more quickly than others. One patient (Case 12) had twenty-three treatments, extending over three months. The systolic blood pressure was 220 mm. of mercury at the commencement of treatment, and at the end it had dropped to 190 mm. of mercury. Despite this comparatively small drop the patient said she felt immeasurably better. She had lost the languid feeling that generally accompanies this condition, and could get about much more easily; and she eats and sleeps well.

Another patient (No. 13) showed the surprising fall of 54 mm. of mercury, from 186 to 132, after two exposures, totalling eight minutes only.

Case 14. This was a functional case, in which a systolic blood pressure of 162 fell to 119 after four treatments.

The whole subject is of great interest and importance, because cases of this condition have proved so intractable to treatment with such drugs as potassium iodide and the nitrites; and we have personally been unable to obtain with diathermy the results that other workers claim to have secured.

Diseases of the Heart.—The presence of adequate quantities of calcium and potassium salts in a suitable form is essential for the proper functioning of the heart. The calcium plays an important part in the mechanism of contraction, and the potassium is necessary for relaxation. Ultra-violet radiation

has a very marked influence on calcium metabolism, as has already been mentioned.

Functional heart conditions derive great benefit from actinotherapy, improvement occurring in cases of tachycardia and where ventricular extra-systoles are present; heart conditions secondary to anæmia or tuberculosis are also benefited.

We have had good results in cases of myocarditis and valvular disease of the heart, especially in those of recent origin. Irradiation has a favourable influence on cases of aortitis and aortic regurgitation. The heart is generally hypertrophied in these cases in an endeavour to ensure compensation. Patients usually feel much better as a result of the treatment; but whether this is due to the fall in blood pressure is doubtful. The permanent dilatation of the peripheral vessels, however, lessens the amount of blood in the internal organs and so relieves the heart muscle.

Dyspnœa and vertigo often disappear, and insomnia is relieved.

Cases of organic heart disease tolerate heat very badly, so that during irradiation the patient should be placed at a greater distance from the lamp than usual, and short exposures should be given. Reyn prefers the carbon arc for the treatment of cardiac conditions, and considers that the relief of dyspnœa and the lowering of blood pressure depend on the production of erythema. Others prefer the quartz mercury vapour lamp because of the small proportion of heat rays it emits.

Angina Pectoris.—Hasselbalch, at the Finsen Institute, uses general carbon arc baths with exceedingly

good results in cases of angina pectoris. He produces a definite erythema, which relieves internal congestion as well as dyspnoea and cardiac distress. In many cases the dilatation of the heart was reduced. Strikingly favourable and rapid results, which were lasting, were obtained in forty-four cases of true angina pectoris.

We have had experience of the rapid way in which palpitation, dyspnoea, and the oppressive feeling of tightness in the chest, can be relieved; the attacks, too, become much less frequent.

Case 15. Female, aged 63 years, had suffered from valvular disease of the heart, auricular fibrillation, and angina pectoris, for several years. She obtained wonderful relief after eighteen general applications with the quartz mercury vapour lamp. Dyspnoea and pain disappeared, and there were no further attacks in six months following treatment.

Peripheral Circulatory Disorders.—The treatment of chilblains and frost-bite will be discussed in Chapter XVI.

Raynaud's Disease.—Ultra-violet radiation is invaluable in Raynaud's disease.

The history of an interesting case, which we have treated, is as follows:

Case 16. Patient is now 29 years of age. When she was a baby a year old she had to have both little toes amputated for Raynaud's disease. The condition gradually got worse, and when she was nineteen it became necessary to amputate first the great toe and second toe of the left foot, and then the left leg itself below the knee. She now wears an artificial

leg. Four years ago a sinus developed on the sole of the right foot, over the head of the middle metatarsal bone. This was scraped soon afterwards, but continued to discharge; a sequestrum was extruded, but the lesion did not heal. The lesion had the same appearance as a perforating ulcer.

Local ultra-violet treatment with the mercury vapour lamp was commenced on 6th May 1925, and after seventy-four applications the foot was soundly healed on 13th November 1925. The foot has now remained healed for over two years.

The peripheral circulatory disturbances that often occur in diabetes and arterio-sclerosis can also be improved by local irradiation. The pain is often relieved and the local circulation ameliorated.

As soon as there is any evidence of disturbed circulation the air-cooled lamp should be used to produce regenerative erythema, a second- or third-degree dose being necessary. If the skin is broken and the lesion infected the water-cooled lamp should be used; applications of radiant heat can be combined with ultra-violet irradiation, and a blue filter should be used if the lesion is very painful.

NERVOUS SYSTEM

Diseases of the Central Nervous System.—The psychical effect of ultra-violet radiation has already been mentioned, and it is therefore easy to understand why it is useful in many cases of mental disease and in neurasthenia. The general tonic action of ultra-violet radiation also plays an important part in the results it produces.

Nervous symptoms associated with rickets, such as *Laryngismus stridulus*, convulsions, and tetany, are very quickly relieved by a few applications of ultra-violet radiation: this has already been mentioned in the chapter dealing with rickets. These symptoms are all associated with a low blood calcium content and owe their alleviation to its rise following irradiation. The irritability and fretfulness of rickety children are also manifestations of nervous hypersensitiveness, and are the first symptoms to be dispelled by irradiation.

Ultra-Violet Radiation in Mental Diseases.—Dr Dove Cormac, of the Cheshire County Mental Hospital, has kindly given us the following information concerning the use of actinotherapy in mental disorders:

“Actinotherapy in the treatment of mental disorders is now in use in many mental hospitals, and having been in continuous use in this hospital for over three years may be said to have passed the experimental stage here. It is employed as the routine treatment for convalescent cases of all forms of mental disorder and generally hastens their recovery.

“Manic depressive cases and convalescing cases of melancholia respond most readily to the treatment, the period of depression being considerably curtailed, while in cases of agitated melancholia and hyperthyroidism the agitation and restlessness are increased, and the treatment is contra-indicated. In the delusional psychoses, where there is much mental irritability due to the nature of the delusions, and impulsive actions, there is usually a decided change of temperament. The patient becomes more amiable, the delusions are seldom referred to and do not appear

to trouble the patient so much while undergoing treatment.

“In dementia præcox, where there is a lowered metabolic rate, and one would expect some benefit, the results have not been satisfactory, though remissions have occurred in many cases enabling them to return to their homes and normal occupation on discharge. Cases of confusional insanity in convalescence make rapid progress as well as those of anergic stupor. The mental improvement usually accompanies the improvement of the general health, sleep becomes more normal, the appetite increases, and a gain in body weight is usual; two of my cases showed an increase of 23 and 25 lb. respectively after eight weeks' treatment.”

Neurasthenia.—A low calcium content of the blood is one of the causes of neurasthenia in the adult; many cases are also probably due to an imperfect balance of the internal secretions, since impotence and amenorrhoea are common symptoms, and neurasthenia is a frequent occurrence at the menopause. Actinotherapy may therefore be expected to give good results in these cases, and Reyn has said that carbon arc baths often have an excellent effect. Patients who have been depressed and unable to work regain their good humour and strength. This has been our experience with quartz mercury vapour lamps. We have treated many cases of neurasthenia, and all except two have benefited greatly.

The most satisfactory response to ultra-violet irradiation is obtained in cases of the apathetic type, and when the patients are anæmic and emaciated.

The cases that show the least favourable response are those with a marked tremor, exaggerated reflexes, and a hypersensitive condition of the vasomotor system.

Treatment may be given to patients who continue at their work. This is a great advantage, since it is unnecessary for them to take the usual rest away from home, and solitude and its consequent opportunity for introspection are avoided.

Patients invariably remark on the soothing effect of the rays, saying that often when they first lie on the couch they are "on edge," but that this feeling gradually leaves them and they feel composed and inclined to sleep.

One patient who had suffered for some time from neurasthenia, with fits of depression, said shortly after commencing treatment that she was beginning to see the funny side of things again.

The Commissioners of the Board of Control of Lunacy Cases, in their Report for 1925, comment favourably on the results obtained by treating neurasthenic patients with ultra-violet rays.

Chorea.—We have had excellent results in the treatment of chorea by ultra-violet radiation. There is soon a mitigation of the unpleasant symptoms and insomnia is relieved. The time necessary to effect a cure depends on the severity of the condition and the period that has elapsed since its commencement. General irradiation should invariably be given, with first- or second-degree doses.

Epilepsy.—Wagner claims to have had good results in the treatment of epilepsy with ultra-violet rays.

Paralysis agitans.—We have had an opportunity

of treating two cases of *Paralysis agitans* with ultra-violet radiation and diathermy. There has been very marked improvement in one case and slight improvement in the other.

The diathermy is most easily given with the Schittenhelm couch, and the actinic radiation may be applied over the whole body with gradually increasing doses up to fifteen minutes back and front at twenty-four inches distance from the lamp. The exposures should be given twice or thrice weekly and continued for some time.

Encephalitis lethargica (Parkinsonism following).—Cures can hardly be expected, but the improvement in the patient's general health following ultra-violet treatment amply justifies its general use in this distressing malady.

Patients feel stronger and walk better, the appetite improves, and the weight increases. Mentally, they appear brighter and more intelligent, speech becomes clearer, and they rest better at nights.

Even this amount of alleviation means a great deal to the patient, and the treatment is worth a prolonged trial in each individual case.

Locomotor ataxia.—Diathermy and general ultra-violet irradiation are often successful in alleviating the lightning pains that are so often a dreadful feature of this disease. It is difficult to say whether this relief is due to the general tonic effect of the radiation or to some action on the peripheral nervous system.

Some workers have found that co-ordination is improved after prolonged treatment. General ultra-

to those where there is actual shortening of the affected sterno-mastoid muscle.

CASES

Case 17. Female, aged 43 years, had suffered from periodical "nervous breakdowns" since she was twenty-eight years of age. At one time during this period she was an unwilling spectator of some incident in the early stages of the Russian revolution, and the shock which she suffered as a consequence greatly aggravated her condition. Recently she had had a very trying illness, lasting more than twelve months, at the beginning of which she had undergone a severe operation. She was a very highly strung, nervous woman, and since her illness had been unable to leave the house alone. She was afraid to cross the road or enter a tramcar, and said she had lost all confidence in herself, and had a constant dread of falling.

After sixteen exposures, extending over seven weeks, this patient was completely cured of her distressing symptoms, and was once more able to lead a normal life. After even the first few exposures the improvement was remarkable, and she was able to walk to and from the surgery and to find the exercise enjoyable. After two years she continues to be perfectly well.

Case 18. Male, aged 40, a commercial traveller, was troubled with sudden fears while travelling in railway trains, which caused him to get out of the train at some intermediate station without completing his journey; he regained his self-confidence after the

first few applications of ultra-violet radiation, and has remained well ever since.

Case 19. Female, aged 39, was suffering from nervous depression. She felt people were staring at her in the street and, for some months, had entirely lost her nerve at the thought of driving a car, which formerly she had been able to do with ease. After the third application of the rays she was able to drive the car into town. After sixteen exposures, extending over one month, she was feeling quite well and happy, and has remained so for over eighteen months.

Case 20. Female, aged 55 years, was suffering from general weakness and wasting, accompanied by acute brachial neuritis in the right arm, owing to which she was unable to sleep at nights. Movement of the arm was impaired, and she was unable to do her own hair. The neuritis cleared up after a few treatments, but the irradiation was continued for her general condition. In all she had twenty-nine exposures, spread over eleven weeks, and improved wonderfully. The pain completely disappeared, she ate and slept well, and rapidly gained weight. At present she says she feels better than she has done for four years, and is bright and well and never feels tired.

Case 21. Female, aged 35 years, suffering from psychasthenia. In April 1925 she went out for a walk and turned giddy, and afterwards did not care to go out alone. She also suffered from vague fears. Twenty-four general irradiations were made, with both the carbon arc and the quartz mercury vapour lamp, and pigmentation was very marked. She resumed work at the termination of treatment in April 1926, and is

once more perfectly normal, not having missed a single working day since.

Case 22. Female, aged 45, had suffered from *Paralysis agitans* for fifteen years. She improved greatly with diathermy treatment, and, as a result, was able to knit, feed herself, and dress herself for the first time for several years. Latterly, we have used diathermy and ultra-violet radiation in combination, with continued improvement.

Case 23. Boy, aged 13 years, contracted *Encephalitis lethargica* when he was seven years old; this was followed by typical Parkinsonian symptoms. Since having general ultra-violet treatment he has been constitutionally stronger, his appetite has improved, he speaks more clearly, his disposition has become brighter, he sleeps better, and he has progressed mentally.

DISORDERS OF THE RESPIRATORY SYSTEM

Ultra-violet radiation plays an important part in the treatment of respiratory disorders and is particularly useful in acute cases when the febrile symptoms have subsided. It stimulates the absorption of exudates, lessens catarrh and acts as a wonderful tonic in the convalescent stages.

Asthma.—Many cases of asthma respond favourably to ultra-violet treatment, especially when the condition is of recent origin. The ætiology of asthma reveals a number of different causal factors, and this is probably the reason why the results vary. The beneficial action may be due to the improved calcium metabolism which follows ultra-violet irradiation or to a

decreased excitability of the reflexes of the thoracic organs, or possibly the inhalation of ozonized air may be advantageous.

Saidman states that he has had successful results in 74 per cent. of the cases he has treated. He has found that the treatment is only moderately successful in children under three years of age, but is very successful in children from three to fourteen years, especially where the asthma is only a local manifestation of an exudative diathesis and where the thymus gland is enlarged. Relapses frequently occur after treatment of patients aged from fourteen to thirty years, particularly after an attack of nasal catarrh or influenza. In adults and old people chronic bronchitis and emphysema are often present in addition to asthma, and therefore the results are not nearly so favourable. Saidman recently showed us a number of his asthma patients; some said they felt better after the first application, and had no further attacks after the second. Of fifteen recent cases of his, five were cured after the first application.

The best results are obtained by general irradiation of the whole body and by the production of a strong erythema alternately on the front and back of the chest. We have noticed on several occasions that only slight improvement followed irradiation with a quartz mercury vapour lamp, but marked benefit was experienced when the carbon arc was used, and therefore the last-mentioned should always be the method of choice.

In those cases which are only partially benefited the attacks usually become less frequent, and when they

do occur are less severe in character. It is only fair to say that a number of cases show no improvement.

Bronchitis.—Cases of chronic bronchitis show improvement with actinotherapy, because ultra-violet radiation raises the resistance of the body to infection. The cough becomes less troublesome and, consequently, insomnia is often relieved; expectoration decreases. Radiant heat to the front and back of the chest can often be employed advantageously at the same time.

Children who have persistent spasmodic coughs without any physical signs rapidly respond. Coughs that have continued for months, and have been a source of disturbance to a whole household, have been swiftly cured by ultra-violet radiation.

Improvement is usually seen in bronchiectasis.

Pulmonary Conditions due to the Action of Poison Gas.—Ultra-violet radiation has a prophylactic value in preventing the onset of secondary infections, such as tuberculosis.

Empyema.—Ultra-violet radiation is invaluable in treating post-operative cases which have chronic sinuses; rapid healing is the rule.

Emphysema.—Apart from improvement of the general health, actinotherapy has no effect on this condition.

Laryngismus stridulus has been mentioned already in the section dealing with rickets.

Pneumonia, Broncho-Pneumonia, Lobar-Pneumonia, Post-Influenzal Pneumonia.—Diathermy now seems the method of choice in treating lobar-pneumonia, but ultra-violet radiation is exceedingly useful in aiding

the absorption of exudates and clearing up the persistent catarrh which so often follows an attack of influenzal pneumonia, especially in children. Pain and expectoration are relieved; convalescence is materially shortened; and thus the return to normal health is hastened.

Pleurisy can be benefited by ultra-violet radiation.

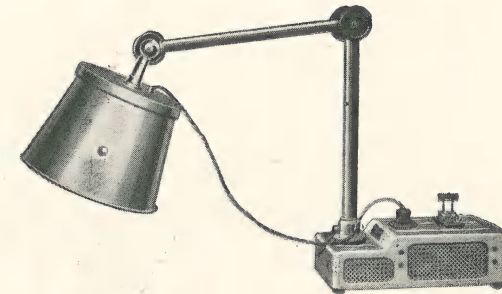


FIG. 229.—The "Lasem" Portable Lamp ready for use.

In afebrile cases third-degree erythema doses should be applied locally to the site of pain; this can easily be done by means of a portable lamp while the patient is lying in bed. Radiant heat is often very useful in these cases too. It has a marked counter-irritant effect, and applications should be given twice weekly.

In pleurisy with effusion the absorption of the fluid is hastened by irradiation. Ultra-violet radiation is also exceedingly useful during convalescence for its tonic effect, and there is no doubt that it has a prophylactic action in preventing the subsequent development of pulmonary tuberculosis.

Pleurodynia.—Ultra-violet radiation and diathermy

given conjointly are very useful in cases of pleurodynia which do not respond to medicinal treatment and where the general state of health is bad. A third-degree erythema should be produced locally at the site of the pain.

Whooping Cough.—We have found that this condition is very amenable to treatment by general

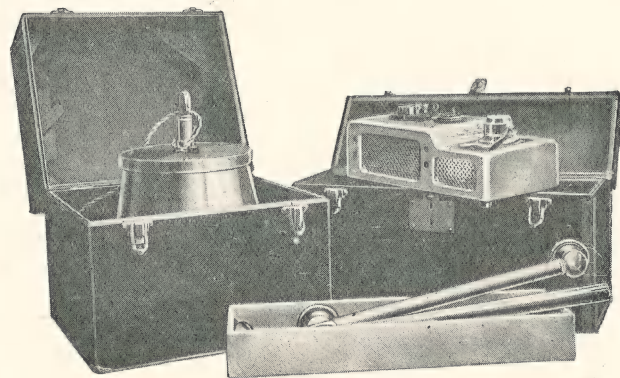


FIG. 230.—The "Lasem" Portable Lamp dismantled.

irradiation with the carbon arc or mercury vapour lamp. The frequency and severity of the attacks of coughing are greatly reduced, vomiting ceases and the general condition of the patient improves. We have treated several children lately suffering from this distressing condition, with very gratifying success. A few days after the commencement of the disease mothers have remarked that their children had not coughed during the twenty-four hours following treatment. The children became much brighter and less fractious after the first few exposures, and played contentedly with their toys. They ate and slept well,

and put on weight. The production of erythema on the front and back of the chest are necessary.

Bru has recently treated thirty-three cases, of which three were total failures, three were partial successes, and twenty-seven were cured. Treatment was given on an average five or six times.

X-rays, applied to the neck and upper part of the chest, can sometimes be usefully combined with ultra-violet radiotherapy.

Case 24. Girl, aged 3 years, a very delicate, frail, weakly child, contracted whooping cough from other children in the same house. For a fortnight she was in bed with a temperature ranging from 100° to 104° . The cough was very troublesome, especially at night; she was very fractious, and the relatives got practically no rest, night or day. As soon as it was possible, the child was wrapped in blankets and brought by car to our consulting-rooms for ultra-violet irradiation. The chest was first exposed for two minutes at thirty-six inches, and the area and dosage were gradually increased, until the whole body was exposed, back and front, each for fifteen minutes daily. The result was surprising. After seven exposures the child was greatly improved, and the attacks of coughing were very much less frequent. The mother stated that she had not coughed for fourteen hours, and was much more lively and played alone with her toys. Four days later she had not coughed from one exposure to the next (twenty-four hours), and this improvement was maintained until the attacks of coughing had practically ceased. She ate and slept well, gained weight, and was soon almost a normal child again.

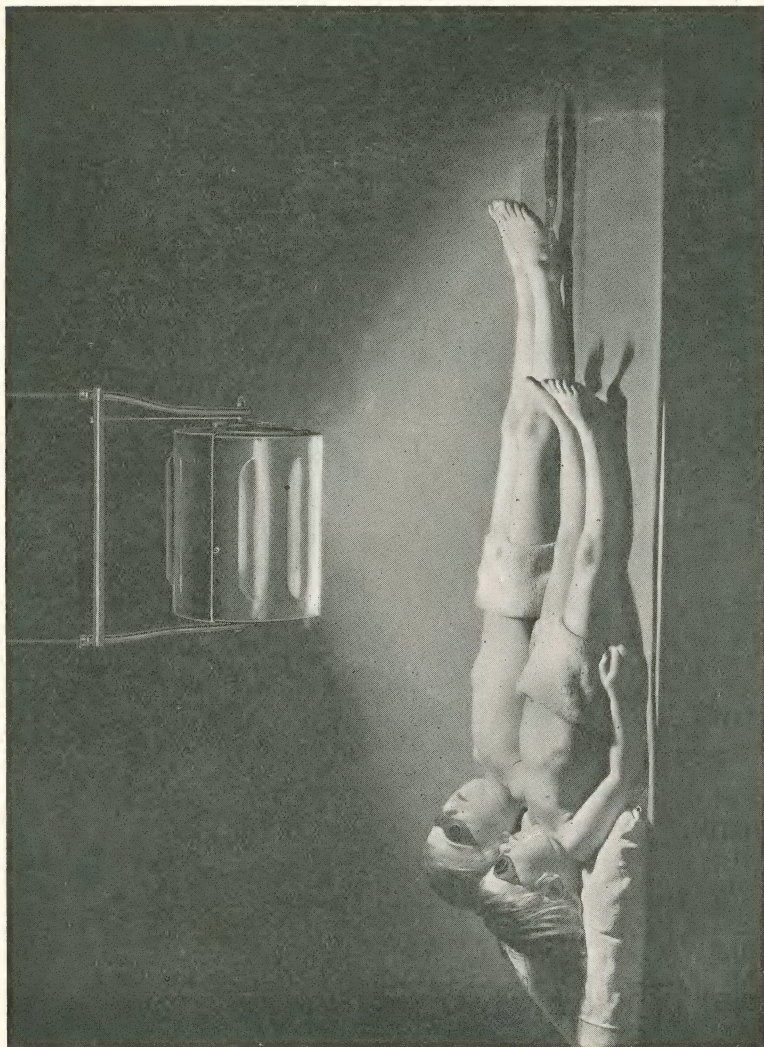


FIG. 231.—Two Children suffering from Whooping Cough being irradiated with one of our Lamps.

Over two years ago this child commenced natural sun baths, out-of-doors when possible, and in a room with windows glazed with "Vitaglass" when outside conditions were not suitable. She is now deeply pigmented, broad and strong and full of mischief, and able to tolerate extreme cold without any discomfort.

Case 25. Girl, aged 6 years. The child had had whooping cough for eight weeks, but was not confined to bed. She had an attack of coughing after each meal, which caused her to bring back her food. After the first treatment, which consisted of three minutes' exposure to an air-cooled mercury vapour lamp at a distance of three feet, and simultaneous irradiation of the front and back of the body with two Saidman polymetallic arcs for five minutes, the child coughed only once in the next forty-eight hours, only once after each of the two succeeding exposures, and not at all for two days after the fourth application. She became much happier, and was able to take her food well and to sleep well. The improvement was maintained, and after seven exposures, spread over a period of fourteen days, she had ceased coughing entirely and treatment was discontinued.

DISORDERS OF THE ALIMENTARY SYSTEM

The disease of the alimentary tract most favourably influenced by ultra-violet radiation is tubercular peritonitis; the condition has already been referred to in Chapter XII.

Dyspepsia ; Gastric Ulcer ; Constipation ; Diarrhœa.
—Ultra-violet radiation has proved a particularly

useful aid to medicinal treatment in cases of hyperacidity, chronic gastritis, and duodenal or gastric ulcers. The pain of these conditions can often be relieved—probably owing to a diminution of the acid content of the gastric juice following irradiation. The general health is improved and the blood-calcium deficiency, with the disturbance of hydrogen-ion balance, which is such a common symptom in these cases, is remedied.

Calcium salts in the form of calcium lactate, Kalzana (which is sodium calcium lactate), or Phytin (the calcium magnesium salt of inosito-hexaphosphoric acid), can be taken orally. The rays probably also have an important effect on the reflex cutaneous areas. A second-degree erythema should be produced daily, or every other day, over the front and back of the patient with the air-cooled lamp. Constipation is often relieved, probably by a tonic effect on the unstriated muscle of the intestines, or by stimulation of the endocrine glands, particularly the pituitary and thyroid.

Chronic diarrhoea and irritating catarrhal conditions of the bowels, such as mucous colitis, often respond favourably to this mode of treatment, owing to the disinfection of the bowel which results from the increased bactericidal power of the blood.

Functional Disorders of the Gastro-Intestinal Tract.—Cases of nervous dyspepsia, where worry, anxiety, and nervous exhaustion often have more to do with the condition than any actual lesion of the stomach, respond quickly to ultra-violet radiation; irritability vanishes, patients sleep better, and acid eructations

soon disappear. Appetite returns, and with it a generally happier feeling. The air-cooled lamp is most satisfactory in these cases.

We have also had rapid improvement in patients suffering, through nervousness, from imperfect control of the anal sphincters. The disturbing desire to defæcate at socially inconvenient times is soon relieved.

Spasmodic conditions of the alimentary tract, œsophageal spasm, pylorospasm and enterospasm have yielded satisfactorily in our practice to a combination of ultra-violet radiation and diathermy applied directly over the affected area. Spasmophilic vomiting and the vomiting of pregnancy are greatly benefited by actinotherapy, and the vomiting of acidosis quickly clears up.

Abdominal Adhesions following inflammatory conditions or operation can often be improved by the conjoint use of ultra-violet radiation and diathermy or radiant heat.

Marasmic children generally improve with ultra-violet radiation. Those who have become a source of worry to their parents, who will not take their food, who are not thriving, and who are generally irritable and petted and prone to fits of crying, soon lose all these unpleasant little traits, rapidly regain their normal appetite, and become self-reliant and happy.

Cirrhosis of Liver; Cholecystitis.—Cirrhosis of the liver and chronic inflammatory lesions of the gall-bladder are other conditions in which ultra-violet radiation has caused some improvement, especially when combined with diathermy treatment.

The amelioration in these cases is obviously due to a lessening of the amount of blood in the portal system, owing to the larger amount circulating in the superficial skin areas. Irradiation will sometimes cause cirrhotic ascites to disappear.

Jaundice is benefited, especially if calcium salts, which combine with the bile pigments, are given by the mouth.

Hæmorrhoids.—Ultra-violet radiation has been used for the treatment of hæmorrhoids, the water-cooled lamp with a special quartz applicator being employed, but in uncomplicated internal cases diathermy with metal electrodes, with a dose of one ampere for fifteen to twenty minutes every second or third day, is probably more satisfactory.

Special electrodes, vacuum, or, better, non-vacuum, can also be used with high-frequency current, but diathermy is more beneficial. Operation is better resorted to for all external or complicated cases.

Cases of *Fistula* which have been incised and drained improve with actinic treatment, the water-cooled lamp having a direct bactericidal action on the lesion, and the general irradiation increasing the general resistance.

We have used ultra-violet radiation successfully in cases of ischio-rectal and perineal abscesses, and prophylactically in patients subject to these conditions, as has been previously mentioned.

Marasmus.—Case 26. Baby, aged 3½ months. The child weighed 8 lb. when born. The mother was unable to feed him, and several kinds of patent food were tried, but the child was unable to digest them.

Diluted cow's milk also failed to agree with him, and he gradually lost weight. At fourteen weeks he weighed 6 lb. and was only able to take small quantities of condensed milk. The child was very fretful and slept badly; he coughed a great deal, and frequently made a curious crowing sound, as if there were some obstruction in the larynx. General irradiation, first with the quartz mercury vapour lamp and later with the carbon arc, was given. At the end of the first week, after the commencement of treatment, the child had gained 4 oz., and each week during treatment he gained 4½-5½ oz. He became less fretful and slept better, and after the first month was able to digest dried cow's milk. Treatment was continued for three months and during that time the child gained 10 lb. 3 oz.

Pyloric Spasm.—Case 27. Baby, aged 8 months, weighing 14 lb. The child weighed 8 lb. at birth and was breast-fed, and developed normally until six months of age, when her weight was 17 lb. She then commenced to vomit after food. She gradually became worse and lost weight each week. An operation was advised, but consent was refused. General irradiation with the quartz mercury vapour lamp was given thrice weekly; during the first week after the commencement of ultra-violet treatment the child did not vomit, and gained 4 oz. Treatment was continued for two months. During that time the child vomited only two or three times. She looked well, took her food well, slept well, was happy, and lost her previous worried, drawn expression.

Case 28. Female, aged 35, had been subject to

violent attacks of diarrhoea and enterospasm when there was any suggestion of going to a friend's house or to an entertainment, with the result that she refused to leave home. A short course of general irradiation with the air-cooled mercury vapour lamp was given, and after the second treatment there was a complete cessation of the unpleasant symptoms, of which there has been no return.

INFECTIOUS FEVERS

Ultra-violet radiation is particularly useful in the treatment of infectious fevers, especially after the acute febrile symptoms have abated, and it is also invaluable in the convalescent stages. Cases of measles, rubella, scarlet fever, mumps, and chickenpox have all been treated. The use of actinic rays in whooping cough and erysipelas has already been referred to. Diphtheria cases can be treated by the water-cooled lamp, and the use of ultra-violet rays for treating diphtheria carriers has frequently been successful. In chicken-pox the intense irritation is soon relieved by irradiation, and it is unusual, afterwards, to have permanent pock-marks.

Desquamation is expedited in scarlet fever cases. Raying is very convenient for relieving the intense pain which occurs in the affected parotid glands in cases of mumps; it may also be applied to relieve the orchitic pain which is present in about a third of the cases occurring in adult males.

Tetanus.—Tamm and Jacobsthal, experimenting with animals which had wounds artificially infected

with the tetanus bacillus and also with the bacillus of malignant oedema, found that they could sterilize the

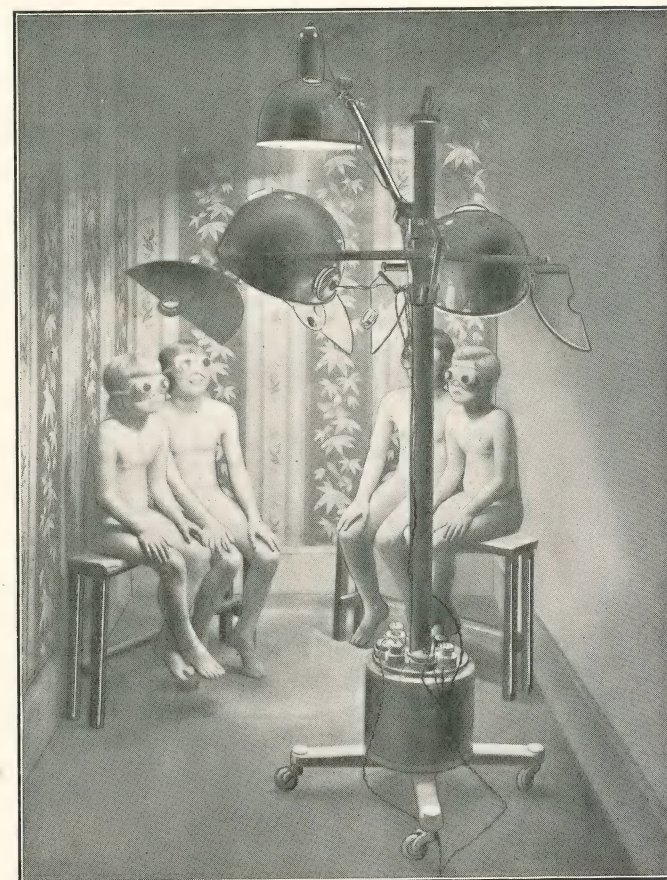


FIG. 232.—Combined Ultra-Violet Treatment and Radiant Heat with the "Trilite" Lamp.

wounds with intensive local irradiation. Jesionek discovered that similar results could be obtained in human beings, and he thought that the beneficial

effect was due to the serotactic action of the actinic erythema in flushing out the wound with immunizing fluids. He found that the mortality in tetanus was greatly decreased by the conjoint use of sera and general irradiation.

Prophylactically, the rays can be used to increase the resistance of a patient subject to rheumatic fever, lobar pneumonia, etc.

Huldschinsky, describing two hundred cases of rickets treated during a period of two years at the Oskar-Helene Home for Crippled Children, Dahlem, Berlin, says: "The children's constitutional power of resistance against affections of the lungs increased visibly. After the first month of ultra-violet light treatment I did not lose a single child from broncho-pneumonia. During a severe epidemic of whooping cough, during which some thirty children fell ill, no child died, as all had been rayed. Measles, contracted by some fifty patients, also caused no deaths. Considering the number of cases of just these two illnesses terminating fatally, when contracted by rickety children, we can be justly proud of the exceedingly favourable results of our treatment."

We ourselves have had several interesting opportunities of noticing the power of raising body resistance possessed by ultra-violet rays. Recently, in a family of six young children, five contracted acute tonsillitis. Two of the family had been irradiated with the mercury vapour lamp: one of these escaped the infection altogether, and the other, although a very delicate child suffering from *Tabes mesenterica*, had the least severe attack of sore throat. This case,

one of many, serves to demonstrate the prophylactic properties of ultra-violet radiation, but at the same time it is only fair to mention that children sometimes develop infectious fevers while they are having ultra-violet treatment.

Latent Malaria.—Laqueur advocates the administration of intense provocative doses of ultra-violet radiation in cases of latent malaria. Exposures of five to ten minutes, increasing to an hour, should be given at a distance of 60 cm. The parasites often appear in the blood after the first irradiation. It is no use giving more than three or four applications when there is no response.

CHAPTER XV

ULTRA-VIOLET RADIOTHERAPY IN DISEASES
OF THE GENITO-URINARY SYSTEM

Conservative Treatment in Gynæcology—Nephritis—Cystitis—Orchitis—Epididymitis—Prostatitis—Urethritis—Amenorrhœa—Dysmenorrhœa—Sterility—Treatment of the Menopause—Menorrhagia—Metrorrhagia—Vulvitis—Vaginitis—Erosion and Ulcerations of the Cervix Uteri—Endometritis—Parametritis—Salpingitis—Ovaritis—Pelvic Peritonitis—Incontinence of Urine—Pyelitis—Infantilism and Impotence.

ULTRA-VIOLET irradiation is beginning to play an increasingly important part in the conservative treatment of many gynæcological conditions. The surgical removal of a diseased pelvic organ may often ensure a more rapid recovery, but as a means of treating inflammatory lesions of the genito-urinary system caused by the tubercle bacillus or the gonococcus it leaves much to be desired.

Conservative treatment, as Lang has said, aims at the preservation of important organs and the retention of the possibility of subsequent conception, and it avoids the risk of mortality from operation and the development of psychical defects.

Ultra-violet treatment in gynæcological conditions can be: (1) General; (2) Local; (3) Internal.

There are several lamps which can be used for internal treatment. The "Wintz" lamp is designed for

introduction into the vagina, and the "Gallois" vaginal quartz high-frequency electrodes can be used in the same way. There are hollow quartz applicators which can be attached to the "Kromayer" lamp, the best known being those designed by Wagner. They are kept cool by the water circulating in them. Special applicators can also be attached to the

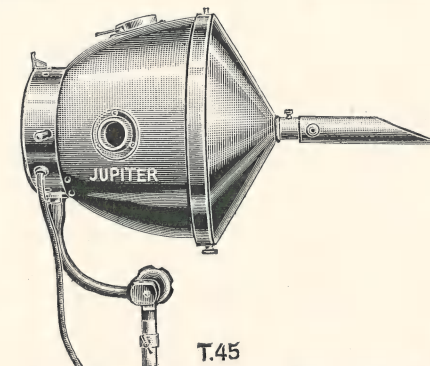


FIG. 233.—"Jupiter" Lamp with Hood and Speculum for Gynæcological Work.

"British Hanovia" air-cooled lamp, and there are metal vaginal speculæ for use with the "Ultra Sonne" and "Jupiter" lamps.

The lithotomy position generally proves the most convenient for intra-vaginal or intra-uterine irradiation.

Rest in bed should always be enforced during treatment. Internal irradiation should never be resorted to in the acute stage of any inflammatory lesion of the genito-urinary system.

It is generally possible to apply twice the skin erythema dose to mucous membranes without causing any unpleasant symptoms. There is usually a more

copious discharge for the first two or three days after internal irradiation, but this soon subsides.

Nephritis.—Mild irradiation may be given in the subacute and chronic stages of this disease with some beneficial effect. Pain, headache, and insomnia are often relieved, and diuresis is increased.

Actinotherapy is very useful in the convalescent stage, for the purpose of toning up the general system.

In chronic nephritis good results are obtained, especially in tubercular cases, when irradiation often results in the disappearance of hæmaturia and the diminution of pyuria and pain. Results are not so hopeful when pulmonary infection is also present.

The use of ultra-violet radiation is inadvisable in cases of nephritis accompanied by œdema.

Ultra-violet radiation is being used increasingly in the operating theatre, and Professor Leguen reports that nephrectomy cases less frequently develop fistula when there has been exposure to ultra-violet radiation during the actual operation. A special screened lamp suspended above the operating-table is used.

We have treated many cases of chronic nephritis associated with high blood pressure, and there has been improvement in nearly every case. It is a matter of conjecture what is responsible for this amelioration of symptoms. It may be due to an alteration in the blood condition, since anæmia is always a prominent symptom of these cases; or it may be due to a fall in blood pressure. A general improvement in metabolism, with the elimination of poisonous waste products, which would otherwise

be retained and cause harmful sequelæ, may be responsible for good results in nephritis; and the increased bactericidal property of the blood after irradiation is also helpful.

Undoubtedly, the hyperæmia induced in the skin is beneficial, particularly because, unlike the hyperæmia caused by radiant-heat baths, it is lasting.

Cystitis.—For this condition Sampson strongly recommends diathermy treatment. He places one electrode in the rectum and one over the symphysis pubis. In very acute cases he claims almost instant relief. General ultra-violet irradiation, combined with the administration of urinary antiseptics, such as hexyl resorcinol, and the adoption of general hygienic measures, is invaluable in the tubercular form of the disease. Saidman has also obtained good results by means of a small lamp, which may be introduced through the urethra into the female bladder, or through a cystostomy opening into the male.

Orchitis, Epididymitis.—A fairly severe erythema over the scrotum, perineum, and inner surface of the thighs will give relief in the acute stage. Diathermy should also be applied when possible, and as early as practicable after the onset of the condition. General irradiation should also be given in tubercular epididymitis, the patient standing as near the carbon arc as the heat allows; the testicles are raised with the hand and the maximum radiation is allowed to fall on the affected area.

Saidman advocates the use of the polymetallic arc in tubercular orchitis, peritonitis and tuberculosis of the female adnexa, and is very enthusiastic over

the excellent results which he has obtained from this method of treatment.

Prostatitis can be treated with the water-cooled lamp. Quartz applicators are introduced into the rectum. Frequency of micturition and pain are alleviated. Some workers have had encouraging results with this form of treatment in cases of enlarged prostate, where it was impossible for the radical operation to be performed. Sampson mentions a

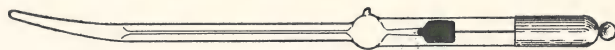


FIG. 234.—Curved Urethral Electrode which is active only at the end.

number of successes obtained by the conjoint use of diathermy and ultra-violet radiation.

Urethritis.—This condition is generally caused by the gonococcus, but a large number of other infective organisms may also bring about inflammation of the urethral tract. General irradiation is very valuable in the chronic stages, and a second-degree erythema should be produced.

Intra-urethral treatment would obviously be too painful in the acute stages of the disease, and the profuse discharge would also render it impossible. A special thin quartz rod attached to the "Kromayer" lamp can, however, be introduced into the urethra in the chronic stages of the disease and the whole of the canal can be irradiated by gradually withdrawing the applicator. Mild dosage should be the rule.

Gonorrhœa.—Ultra-violet treatment has given indifferent results in cases of gonorrhœa. Meatal lesions have responded most satisfactorily to it.

Saidman advises an initial dose of half-a-minute, and an increase of a minute at each succeeding exposure. Treatment to be given twice a week. He says the treatment should be continued if, after five applications, there is a decrease in the number of organisms in the discharge. If there is not, it should be stopped.

Amenorrhœa.—One of the physiological properties of ultra-violet radiation is the stimulating effect it has on the menstrual flow. A stabilization of the calcium salts in the body may bring about this effect. In young girls the growing skeletal structure makes the first demand on the calcium salts in the body; after its needs have been satisfied the salts can then be utilized for reproductive functions. If an increased amount of calcium is retained in the body the menstrual cycle generally becomes normal. Increased ultra-violet radiation in tropical countries may account for the early appearance of puberty in those regions.

The action of ultra-violet radiation on the internal secretions has a very important effect on menstruation, on the nervous system, and on the vasomotor mechanism.

It is now generally agreed that hypo-ovarian secretion is responsible for the disorders associated with the menopause. The endocrine secretions are so intimately associated that when one gland is not functioning correctly the effect is felt throughout the whole system.

Amenorrhœa may be: (1) Organic; (2) Functional. Organic amenorrhœa is due to malformation or

absence of the uterus or adnexa, which may be congenital or the result of an operation or of damage caused by disease; irradiation is obviously of no value in these cases.

Amenorrhœa may also be due to some general condition, it may be secondary to anæmia, diabetes, or tuberculosis, and it may occur after an acute illness. At the onset of puberty amenorrhœa may occur after periods have taken place for a few months. In these cases, which are generally due to hyposecretion of the ovaries, the patient often begins to put on weight.

Before commencing physical treatment the patient must be thoroughly examined for any signs of serious disease, such as febrile tuberculosis, and then, if not contra-indicated, general ultra-violet irradiation should be administered.

Landeker advocates intravaginal irradiation, and Lang suggests that the vagina should be irradiated for fifteen to twenty minutes with the "Ultra Sonne" lamp. A neon lamp is used simultaneously (at a distance of 30 cm. from the abdomen to avoid the heat), and the affected ovary is irradiated with the yellow and red rays. Lang also mentions the value of injections of extract of placenta and of the posterior lobe of the pituitary gland twenty minutes before treatment, and he also frequently uses injections of agomensin.

For amenorrhœa associated with puberty Donnelly recommends general ultra-violet irradiation combined with diathermy, the electrodes being placed over the epiphyses of the femora. This increases the flow of

blood and lymph to the shafts of the bones, raises their temperature, and causes the marrow cells to produce a greater number of red blood corpuscles.

Amenorrhœa due to general debility responds most quickly to actinotherapy. Cases associated with hyposecretion of the endocrine glands, where there is genital hypoplasia and secondary genital atrophy, also do well, but need considerably more patience. Weekly exposures should be given over a period of at least three months, when normal menstruation will generally be established. A second course of treatment should be given if the periods become scanty or irregular some months later. Ultra-violet radiation is useless in amenorrhœa following exposure to X-rays, as well as in cases of dystrophia adiposogenitalis.

Dysmenorrhœa.—This distressing condition responds well to ultra-violet radiation in some cases, especially if organotherapy is used conjointly. There is often a derangement of calcium metabolism in dysmenorrhœa, and the oral administration of calcium salts may be advantageous. Lang has had very good results from intravaginal irradiation. The conjoint use of diathermy and general ultra-violet irradiation is very beneficial in this disease. Diathermy can be conveniently applied with the Schittenhelm couch used as the negative electrode, the positive being placed over the lower part of the abdomen. The strength of the current should depend on the size of the electrode, and this should be as large as convenient. Towels soaked in salt and water should be placed under the metal plate of the electrode, as a deep effect is desired.

Treatment is best commenced about four days before the menstrual period is expected, and should be given daily, or every other day. It can be continued even during the first day or two of menstruation if necessary. Excellent results may anticipated.

Hysterical manifestations, which sometimes accompany menstruation, and which may be due partly to the excessive excretion of lime salts at that time, are greatly relieved by irradiation, since it checks this excretion of calcium, and this undoubtedly plays a large part in the control of nervous irritability.

Sterility.—Some cases are undoubtedly cured by ultra-violet irradiation, probably on account of its action on the ovarian secretion. When necessary, the cervix should be dilated and the uterus curetted. Three months' treatment should be given.

We have had several interesting cases of patients who have been married for many years without having children, although they have wished for them, and after a lengthy course of ultra-violet radiation treatment for some other condition, have had their wish gratified.

Case 29. A woman, aged 36 years, had been married for fourteen years without having a child. At the end of 1926 she developed tubercular glands in the neck, and was in a very weak state of health. She had general ultra-violet treatment for about twelve months and made a complete recovery. In February 1928 she consulted us again for amenorrhœa and indigestion, and on examination was found to be pregnant.

Case 30. A woman, aged 38 years, had been

married for fourteen years and was greatly disappointed that she had had no children. During 1927 she had had ultra-violet treatment from July to November, having a total of thirty-seven applications for neurasthenia and debility. In February 1928 she became pregnant.

Case 31. A woman, aged 38 years, had been married nine years. She had one child seven years of age, and had given up hope of having any other children. Shortly after a two-months' course of general ultra-violet treatment for debility following mucous colitis she again became pregnant.

Dufestel advises irradiation of the lumbar region and iliac fossa or scrotum, according to the sex undergoing treatment, and also combines radiant-heat applications to the latter regions. Organotherapy should not be neglected in these cases.

Treatment at the Menopause.—The disorders associated with this period of life are greatly influenced by ultra-violet radiation, most probably on account of its effect on the internal secretions, and in some cases of premature menopause the periods may even be re-established, probably because of an increase of ovarian secretion. Nervous and vasomotor disturbances are decreased, high blood pressure is relieved, and the excessive deposition of fat which occurs so often at this time is controlled. We have had excellent results in a large number of cases.

Menorrhagia and Metrorrhagia.—It is necessary to determine the cause of this condition before deciding to try ultra-violet radiation, which obviously will not cure fibromata or polypi; if, however, it is due to

anæmia or uterine sclerosis the results are good. The rays have an action on the glandular system, and general irradiation should therefore be employed in all cases, combined with large doses of Kalzana or Phytin by the mouth, because an adequate quantity of calcium in the blood is essential for clotting to occur in any form of bleeding. Blair Bell has stated that the menstrual discharge may contain a quantity of calcium as much as thirty times greater than that which is found in the systemic blood.

Case 32. A girl, aged 17 years, had menorrhagia and metrorrhagia for some months. Amelioration was obtained after eight general irradiations with the air-cooled mercury vapour lamp.

Postpartum Hæmorrhage.—Irradiation helps the involution of the uterus, and thus acts prophylactically against postpartum hæmorrhage.

Vulvitis, etc.—Good results are obtained in cases of Bartholinian abscess, in cases of trauma of the vulva where there is bruising and effusion of blood but no secondary infection, and in chronic vulvitis. Lang considers that ultra-violet treatment (local and general) should be tried in every case of kraurosis.

Pruritis vulvæ sometimes responds well to ultra-violet radiation, but in some cases resort must be had to small doses of X-rays. Occasionally ultra-violet radiation combined with a high-frequency discharge gives satisfactory results.

Lang has obtained good results in cases of "white leg" by applying ultra-violet rays every alternate day. A rapid consolidation followed by a speedy resorption takes place, and the short duration of the

resorption fever enables the patient to recover in a surprisingly short time.

Vaginitis.—If this condition is secondary to cervicitis, endometritis, salpingitis, or the like, it is futile trying to treat it without first attempting to deal with the primary cause. General irradiation should be given in all cases with the quartz mercury vapour lamp or the carbon arc, and a mild erythema should be produced. When the pain associated with the acute condition has subsided, local intravaginal irradiation can be applied, after all discharge has been removed by carefully douching the vagina with a solution of hydrogen peroxide.

The following are some of the possible ways of giving treatment. (1) The "Wintz" water-cooled lamp can actually be introduced into the vagina. (2) Twenty minutes' exposure can be given with the "Ultra Sonne" lamp, fitted with a special vaginal speculum. (3) The "Wagner" quartz speculum, which is hollow, and cooled by water circulating inside it, may be attached to the "Kromayer" lamp after the quartz window has been removed. The first exposure should not exceed thirty seconds. (4) The "British Hanovia" air-cooled quartz mercury vapour lamp may be used, fitted with a suitable speculum. A total exposure of five minutes should be made at the first application, the speculum being withdrawn a short distance at the end of each minute. (5) "Gallois" quartz high-frequency elerctodes can also be used; they emit simultaneously ultra-violet rays and a high-frequency discharge.

After intravaginal irradiation the vagina feels tense and stretched and then becomes red, and for the

first few days after treatment there is a more profuse watery discharge, but this gradually lessens. Diathermy should always be the method of choice in gonococcal cases, for in these ultra-violet radiation has not proved very satisfactory. It has been found that six applications of ultra-violet rays are often sufficient to cure cases of granular and senile vaginitis, and actinotherapy has been efficacious even in cases of adhesive vaginitis. Irradiation is very useful in the vaginitis associated with pregnancy. Lang has had very good results in the treatment of vaginitis in children, and advocates general ultra-violet radiation combined with local irradiation of the vulva. It should be remembered, however, that vaginitis is a condition where there is always the liability of a relapse.

Leucorrhœa, which is often associated with vaginitis, has been treated in the same way, but diathermy applied by means of a special egg-shaped metal electrode is also very successful in these cases. The condenser couch may be used conveniently as the negative electrode, and the positive pole is attached to the special metal electrode by means of an insulated handle. The condition soon clears up; the unpleasant discharge ceases; and the excoriation of the skin so often present in these cases disappears.

Erosion and Ulcerations of the Cervix Uteri, Endometritis, Parametritis, Salpingitis, Ovaritis, Pelvic Peritonitis.—Intravaginal treatment should be given with one of the lamps mentioned on pages 516-517. The use of a metal speculum attached to the "Kromayer," "Ultra Sonne," or air-cooled mercury vapour lamp is

to be preferred, because the radiation can then be confined to the cervical region and irritation of the vagina is avoided. Strong dosage is required, and with the "Ultra Sonne" lamp a first exposure of half-an-hour should be given. The results are generally very



FIG. 235.—Intra-Uterine Quartz High-Frequency Electrode which is active only at the extremity.

satisfactory. In endometritis an endeavour should be made to remove the cause, but the condition does not respond so readily to actinotherapy as cervicitis. Intra-uterine irradiation by means of quartz rods is possible, but great care is necessary. General irradiation in all these local conditions is valuable in raising the general resistance of the body, and the conjoint

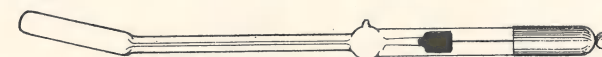


FIG. 236.—Uterine Quartz High-Frequency Electrode which is active only at the extremity.

use of diathermy is also of very great value in such conditions as salpingitis and ovaritis.

Ultra-violet radiation is extremely useful in these inflammations of the uterine adnexa, especially if they are primary lesions and are of tubercular origin. Very encouraging results have been obtained on the Continent. Saidman uses the polymetallic arc, and gives heavy doses over the abdominal and lumbosacral regions. Successful treatment has also been given with the water-cooled lamp, a special quartz applicator being necessary.

Incontinence of Urine.—As a general rule incontinence of urine is less marked in summer than in

winter, and it may often cease while treatment is being given, only to return later. The best results are obtained in cases where the general health is

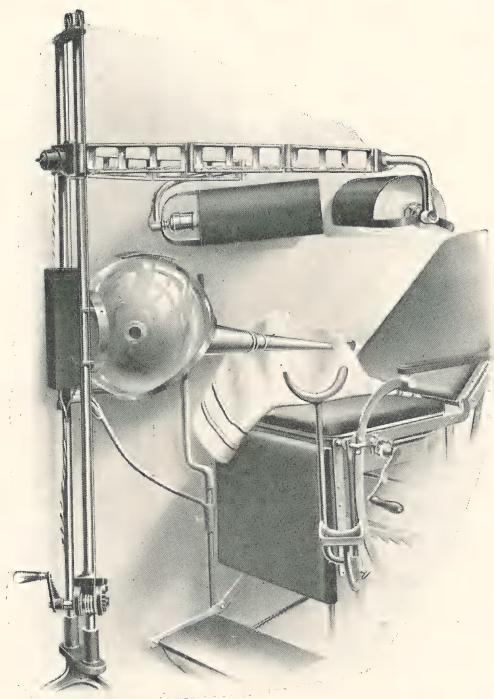


FIG. 237.—“Ultra Sonne” Carbon Arc Lamp and Carbon Filament Lamps arranged for Gynecological use.

poor, and in hypocalcæmic conditions where there is atony of the muscles or a spasmodic condition of the detrusor muscles. We have recently treated a little girl who suffers from enuresis. She had no incontinence while having general ultra-violet radiation, but there was a return when the treatment was discontinued

on account of some intercurrent affection. No further trouble was experienced, however, when irradiation was resumed.

Pyelitis due to the bacillus coli is benefited by actinotherapy. General treatment should be given.

Infantilism and Impotence.—Good results have been obtained in cases of deficient testicular secretion. In cases of impotence there is improvement when the general health is poor, or when the condition is associated with neurasthenia.

CHAPTER XVI

ACTINOTHERAPY IN DERMATOLOGY

The Effect of Ultra-Violet Radiation in Skin Diseases: Local, General—Pruritis: General, Anal, Vulval—Bromidrosis—X-ray Dermatitis—Burns and Scalds—Dermatitis Venenata—Eczema—Seborrhœa: Capitis, Corporis—Erythema Pernio—Herpes: Facialis, Genitalis, Zoster—Prurigo—Impetigo Contagiosa—Ecthyma—Pityriasis Rosea—Psoriasis—Parapsoriasis—Xeroderma—Ichthyosis—Rhinophyma—Rosacea—Acne—Sycosis—Alopecia: Areata, Totalis, Seborrhœica—Lichen Planus—Onychia—Tinea: Circinata, Tonsurans—Erysipelas—Furunculosis—Benign Pemphigus and Dermatitis Herpetiformis—Lupus Erythematosus—Soft Chancres—Syphilis—Keloid—Cicatrices—Scleroderma—Nævi Pigmentosi—Angioma Simplex—Xanthelasma Palpebrale—Stellate Veins—Telangiectases—Ulcers—Rodent Ulcer—Wounds—Skin Grafts—Bedsore—Chloasma—Leucoderma—Lentigo—A few Illustrative Cases

THE beneficial action of ultra-violet radiation in skin affections can be due to either local or general effects.

Local phenomena valuable in dermatology are:

(1) A bactericidal effect limited to the organisms actually lying on the surface of the irradiated area.

(2) Keratogenous action. The ultra-violet rays are absorbed by the cells of the basal layer of the epidermis, and, according to Grotthus's Law, reactions occur only in those tissues which absorb radiation. All cells external to the basal layer are formed from the basal layer, and by stimulating this the rays cause new epithelial cells to be formed.

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(3) Pigmentophoric and hormonal action. Pigmentation of the skin protects the body against excessive ultra-violet irradiation, and causes the skin to be more resistant to infection. The ultra-violet rays, which are absorbed by the pigment granules in the basal layer, are converted into some substance which passes into the capillaries of the corium and influences the organism as a whole. The skin is the most important source of immune bodies.

(4) Hyperæmia can be readily produced by irradiation, and the capillaries of the dermis remain dilated for long periods; cellular nutrition is improved by the increased blood supply to the tissues.

(5) Inflammatory and serotactic action. Inflammation is excited after a latent period and serum is poured into the irradiated area when the rays are used to produce a strong reaction. The rays can also produce a caustic effect, and this may be valuable in such conditions as lupus or nævus flammeus.

(6) The ultra-violet rays have an analgesic and antipruritic effect.

(7) The exfoliative action of ultra-violet radiation can be made use of in such cases as acne or psoriasis.

General effects following irradiation are:

(1) There is a rise in the resistance of the whole body to infection. Many cases of lupus have been cured by general irradiation alone, even when the lesion has been covered over during treatment.

(2) Metabolism is stimulated (this applies to carbohydrate, protein, fat and mineral metabolism).

(3) Some of the endocrine glands are stimulated, others are depressed.

(4) There is a fall in blood pressure in cases of hyperpiesis; this may influence skin lesions due to circulatory disorders.

(5) A redistribution of the blood amongst the different organs takes place, and the functional activity of the skin becomes greater in consequence. The temperature of the skin is actually raised.

(6) Stimulation of the vasomotor reflexes of the skin results, together with an increase in tolerance of extremes of heat and cold. The skin remains anæmic and flabby when stifled by clothing.

(7) Vitamin D is formed, and it has been found experimentally that the local application of vitamin D to burns expedites their healing.

(8) General irradiation produces a marked psychical effect.

The physiological functions of the skin are stimulated by exposure to radiant energy, and cool moving air.

Captain Braithwaite, of the West African Medical Service, informs us that eczema, impetigo, furunculosis, lupus, and psoriasis are unknown among the Nigerian negroes, and that extensive wounds heal rapidly without sepsis; and, as has already been noted, Dr Leuba, of the Swiss army, found that pigmented skins would not respond to vaccination until the skin had actually been cut through, instead of merely being scarified as usual.

As a rule, acute conditions require sedative dosage, but heavy, and often blistering, doses are necessary for the cure of chronic forms of disease.

In conditions where there is marked induration, occasional application of Röntgen rays in addition to

ultra-violet radiation often hastens recovery. Some workers also combine high-frequency sparks with ultra-violet rays. The sedative effect of ultra-violet energy on the nerve endings in the skin is invaluable in allaying the intense and distressing itching associated with many dermatoses. Often enough, the first exposure relieves this symptom, which is so much more difficult to endure than actual pain.

Ultra-violet radiation is obviously not a "cure-all" in dermatology, as many "quack" advertisements would have us believe, but at the same time, when efficiently employed, it can be of great service in dermatological practice. It is interesting to note the opinion of Dr Dore and the late Sir Malcolm Morris:

"Although in our opinion the results we have obtained have fully justified the employment of the treatment, and in some cases no other treatment could have produced such good results, we do not regard it as the only method to be used in all cases, nor advocate it indiscriminately to the exclusion of other methods; but we can say that the Light Treatment has, in our hands, produced results on the whole superior to those which we have obtained by any other."

It is obviously often advantageous to combine actinotherapy with external and internal medication.

DISEASES OF THE SKIN ACCOMPANIED BY ANOMALIES OF SENSATION

Pruritus (General, Anal, and Vulval).—This condition, if severe, can become intolerable, causing grave discomfort and insomnia. Medicinal treatment

is usually inefficacious. The first thing to be done in treating this affection is obviously to discover any ascertainable cause, seeing that pruritus can be a symptom of a large number of totally different conditions, and uniform results are therefore impossible. Pruritus often occurs in pregnancy, uterine disease, chronic dyspepsia, hepatic cirrhosis, exophthalmic goitre, certain blood diseases, and such nervous diseases as tabes dorsalis and general paralysis of the insane. Oxyuris vermicularis, pediculus capitis and pubis, and acarus scabiei should all be looked for; the urine should also be tested for the presence of bile, sugar, or albumin, and for hyperacidity, pruritus being frequently associated with jaundice and some forms of uræmia and diabetes. The diet should be carefully regulated, and such things as shell-fish, spices, and condiments avoided.

In *Pruritus ani*, hæmorrhoids, fissure, anal catarrh, and small sinuses should all be sought; and in *Pruritus vulvæ*, vaginitis. If possible, the cause should be removed. If none of these possible sources can be found, and especially if the pruritus is paroxysmal, the condition is almost certain to be essential or true pruritus. Ultra-violet radiation is very useful in such cases, the analgesic effect being very quickly felt.

General Pruritus is treated by mild doses over the whole body, preferably given thrice weekly, and gradually increased in duration.

Local Pruritus, Anal.—Before commencing ultra-violet treatment all hairs should be removed and the parts should be well washed with soap and water and

thoroughly dried. We have used both air-cooled and water-cooled lamps in these cases; the patient can bend down with the buttocks facing the lamp, and with his hands protected by black cotton gloves he can himself pull apart the cheeks of the buttocks so as to smooth out any folds which may exist; or he may adopt the knee-elbow position and have the cheeks of the buttocks separated by means of our special retractor; or a special chair may be used with part of the seat capable of being slid away so as to expose the parts to the radiation from the lamp, which is placed below the seat.

All parts which have not to be exposed must be suitably protected, or a tubular diaphragm may be used. A quartz compressor can be used conveniently with the water-cooled lamp, and mild erythema doses should be given two or three times a week. Ultra-violet radiation is undoubtedly less dangerous than X-rays in the treatment of this condition. High-frequency, with glass electrodes, is frequently helpful.

Relief is afforded by the radiation, owing to the analgesic effect of the rays on the interepithelial nerve fibrils, and also to the powerful bactericidal effect of the radiation. The condition can usually be cured by from six to twelve applications. Any small perineal abscesses and sinuses which may be present are also benefited and cured.

For *Pruritus vulvæ* the lithotomy position is most convenient. If there is any vaginitis it should be treated by diathermy, or by Dr Sloan's method of ionization.

Anomalies of Secretion.—Bromidrosis is always

associated with excessive sweating, and micro-organisms probably cause the unpleasant smell characteristic of the disease.

Two or three applications of ultra-violet rays with the air-cooled lamp will generally clear up this distressing condition.

INFLAMMATORY LESIONS OF SKIN

Dermatitis due to Physical Causes: X-Ray Dermatitis.—We have recently had occasion to modify our views in regard to the actinic treatment of X-ray burns, and now consider that very careful irradiation should be given when the skin is unbroken. X-ray ulcers are benefited by ultra-violet radiation when they are small. Irradiation is valuable for bringing about regenerative changes and removing keratoses. The water-cooled lamp is most useful, and should be used with compression. All sloughs and dead skin should be removed before treatment. Two or three exposures of three to ten minutes should be given at intervals with the "Kromayer" lamp, using the blue filter and compression. After this procedure lighter reactions with the air-cooled lamp are advisable.

If the condition is simply a dermatitis, and not severe, mild doses may be given with the air-cooled lamp thrice weekly, and are all that is required to stimulate regeneration without destroying newly formed epithelium.

Many workers prefer to use radiant heat. Hagen has reported eight cases of "radiodermatitis" which

have been cured in fifteen to thirty minutes by two applications of the "Kromayer" lamp. The telangiectases also disappeared.

In old X-ray burns, which threaten to become malignant, ultra-violet radiation is strongly advised, and many successful cases are reported.

Burns and Scalds—however they may be caused (thermally, electrically, or chemically)—respond well. Strong doses should be used at first to cleanse the wound, and, later, regeneration of the destroyed epithelium is promoted by mild doses. The newly formed epithelium should be carefully covered during the exposure of the wound, because the rays might easily damage the new cells. The rays have a bactericidal action, and stimulate new cell formation.

Irradiation should be given thrice weekly, beginning with a dose of one and a half minutes at thirty-six inches, and very gradually increasing the exposure to five minutes and decreasing the distance to eighteen inches.

Sterile gauze or picric-acid dressings should be applied after irradiation. Cellophane dressings are also very useful in the treatment of burns, because irradiation can be carried out without removal of the dressings. The application of ointments, which are opaque and difficult to remove, should always be avoided.

Ultra-violet radiation may also be applied while the patient is lying in a warm bath. Good results are often obtained by spraying the wounds lightly with medicinal paraffin and then irradiating them.

Sometimes it may be advantageous to use a blue

Uviol filter, so as to absorb the short abiotic rays, which may destroy the new epithelium.

Dermatitis venenata.—This condition responds readily to ultra-violet radiation, especially when it is due to the poison ivy. The burning and stinging associated with the condition are usually dispelled by the first or second exposure, and spreading is also prevented if the skin is rayed over an area of several inches round the original lesion.

A second-degree erythema should be given with either the "Kromayer" or the air-cooled lamp, and if the lesion is of any considerable size the latter is preferable. Exposures should be given every other day until the condition has cleared up.

We have successfully treated several cases of acute dermatitis caused by the dye from fur collars; the intense irritation was relieved after the second or third exposure to the rays.

Bakers' rash and grocers' itch are other examples of this condition which respond well to ultra-violet irradiation. We have recently been able to cure an old-standing case of bakers' dermatitis.

Eczema.—It should be remembered that this condition is not a clinical entity, and an endeavour should always be made to remove the exciting cause and to remedy any accompanying metabolic disorder. Ultra-violet radiation proves a very valuable therapeutic agent in this common condition, especially in its subacute and chronic forms.

In very acute types, associated with profuse exudation and oedema, ultra-violet radiation is contra-indicated. In less severe forms mild sedative

doses are beneficial. All discharge or crusts should be removed before irradiation. Starch poultices may be useful in this connection.

The subacute forms so often associated with bacterial (staphylococcal and streptococcal) infection

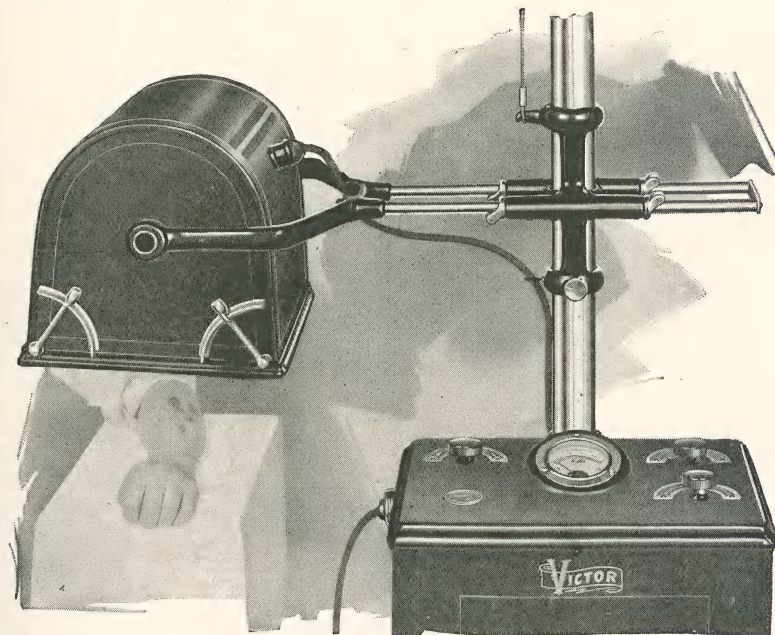


FIG. 238.—The "Uviarc" Air-cooled Mercury Vapour Lamp being used for the Treatment of a Skin Lesion of the Forearm.

respond most readily to ultra-violet treatment, on account of the bactericidal action of the rays, the increased blood supply to the part, and the stimulation of epithelial growth. The blue filter may often be used with advantage in these cases.

The eczemas of childhood and infancy are generally of this type, and respond well to irradiation,

particularly when associated with rickets, scrofula and anæmia; and so do cases of eczema occurring at puberty and in chlorotic girls.

A mild erythema to stimulate the keratic function should be produced, and repeated two or three times weekly. General irradiation, in addition to local treatment, is often advisable, since it raises the general resistance of the body.

The chronic forms are more resistant to treatment, and need more drastic measures. Third-degree erythema should be produced, and if progress is slow—and especially in the infiltrated, scaly, lichenoid types—X-rays should be used in conjunction with ultra-violet rays.

Lomholt advocates the use of the "Finsen" lamp in cases of chronic eczema, especially in dry, infiltrated lesions where there is much hyperkeratosis, and has found it useful in many vesicular cases also. He reports 60 per cent. of his cases of chronic eczema cured, and 25 per cent. improved, and he advises an average exposure of fifteen minutes. Erythema should be produced in every case.

Saidman obtains good results in resistant cases by the combined use of ultra-violet rays, X-rays and the high-frequency spark discharge.

We have had good results in many cases of eczema intertrigo by combining actinotherapy and X-rays. It is worth saying again that in every case an endeavour must be made to remove any primary cause, such as leucorrhœa, diabetes mellitus, hypothyroidism, or excessive acidity of the urine.

Rhagades round the mouth and nose are often

relieved by ultra-violet radiation. Schindler advocates painting the affected part with 5 per cent. silver nitrate dissolved in 70 per cent. alcohol and then applying the rays locally.

Cracks on the nipple and fissures round the anus are also benefited, and the itching is often allayed. High-frequency applications may be combined with ultra-violet radiation with advantage in many cases.

Seborrhœic dermatitis—especially of the scalp—responds with remarkable rapidity to ultra-violet radiation.

Nagelschmidt has always found a few applications sufficient to cure *Seborrhœa capitis*. He mentions fifty-three cases of alopecia of a seborrhœic type which were all cured, generally after one application. It is probable that the best results with this treatment have been obtained in Germany, where it is the national custom for males to wear the hair closely cropped. Nagelschmidt gives four tests of cure:

- (1) The disappearance of subjective discomforts—tickling, itching, etc.
- (2) The cessation of the formation of scurf.
- (3) Regrowth of lost hair.
- (4) An increase in the length of the original growth or of the total growth.

The scalp should be washed the day before irradiation. A stimulative third-degree erythema is necessary for each portion of the scalp, which should be carefully divided into furrows about half-an-inch apart, radiating from the crown; non-inflammable combs should be used for this purpose.

Another application should be given when the

reaction from the previous one has subsided. If three or four treatments are given every six months, at intervals of about twenty-one days, the scalp will be kept in a normal condition.

Seborrhœa corporis is even more satisfactorily treated by ultra-violet radiation than *Seborrhœa capitis*; it can generally be cured rapidly. The "Kromayer" lamp should be used for treating any infiltrated areas.

Erythema pernio.—As might be expected, ultra-violet radiation is particularly useful in this condition, owing to the stimulating effect of the radiation on the peripheral circulation. The increase of calcium in the blood probably contributes to the improvement. A third-degree erythema should be produced, and general irradiation is of more value than local. If the condition is present in the fingers and toes only, diathermy or Schnee sinusoidal baths given in conjunction with the radiation are very efficacious. It is customary to give fifteen to twenty minutes' bath treatment before the radiation. When the ears and nose are affected, ultra-violet treatment alone, or in conjunction with the high-frequency discharge of vacuum electrodes, is indicated. Pain is soon relieved and any ulcers which may be present usually heal rapidly.

Debilitated and anæmic people subject to this condition should undergo treatment with the onset of cold weather and continue with intermittent short courses until the spring. Arsenic and iron or calcium lactate, Kalzana, or Phytin may be given by the mouth during general treatment. Warm stockings should also be worn, and comfortably fitting boots.

Herpes (facialis, genitalis, and zoster).—Ultra-violet radiation is rightly considered to be the best method of treatment for this condition. The duration of the illness is considerably shortened, and scarring and pain are reduced to a minimum. If the condition is seen before definite development of the vesicles, the water-cooled lamp should be applied to each lesion, the quartz compressor being used. The vesicles in these cases will not develop, and the whole condition will be aborted. If the eruption is well developed and covers a large area, the air-cooled lamp is of more use. A second-degree erythema should be produced.

The pain of the herpes will be greatly relieved after the first application. The vesicles will dry up and fall off, leaving very little scarring, and the whole condition, even when severe, will clear up in a fortnight. No neuralgic pains remain after the disappearance of the vesicles, as often happens in cases of herpes in old people who have been treated solely by medicine, when the condition is apt to prove most refractive.

Neuralgia following an attack of herpes is greatly aided by irradiation producing a second-degree erythema with the air-cooled lamp, and the whole general condition of the patient is improved.

Urticaria.—The intolerable itching, which is the most distressing feature of chronic urticaria, can soon be relieved by the application of ultra-violet rays, but, naturally, dietetic and medicinal measures should also be taken. A second-degree erythema with the air-cooled lamp applied generally is most satisfactory

as a rule. We have often found that one application is sufficient to banish the itching.

Anaphylaxis, which is the probable cause of urticaria, is always associated with a decrease in the blood calcium. For this reason calcium lactate should be taken orally.

At least twelve exposures should be given, beginning with two and a half minutes at thirty-six inches to both surfaces of the body, and gradually increasing to ten minutes at twelve inches.

Prurigo.—Ultra-violet radiation is contra-indicated in Hutchinson's summer prurigo. Finsen found that ultra-violet radiation generally cured prurigo senilis, and that prurigo Besnier and prurigo Vidal were usually benefited. Good results have been reported in cases of Hebra's prurigo, in treating which a mild erythema should be produced. Delicate children who have suffered for years from prurigo are generally benefited by irradiation.

INFLAMMATIONS OF THE SURFACE EPIDERMIS

Impetigo contagiosa.—The "Kromayer" lamp is often advised for this condition, which is caused by the streptococcus, but equally good results may be obtained by the use of the air-cooled mercury vapour lamp.

Local treatment should be given, and a third-degree erythema is necessary, both for its bactericidal effect and for the increase of blood and lymph it brings about in the part treated. All crusts and discharge must be removed, and the application of oil or starch poultices may be necessary to accomplish this before

irradiation. A smart reaction is required, and the exposure is repeated when the first reaction is beginning to fade (on the second or third day, according to the severity of the reaction). The first application prevents the lesions from spreading, and if the condition is not too far advanced three or four applications will prove sufficient to cure the disease. The treatment should not be discontinued too soon, however, or a relapse may occur. It is often advantageous also to apply antiseptic ointments, but not on the day on which ultra-violet treatment is to be given.

Ecthyma, which can be regarded as a severe and deeper form of impetigo, is generally improved by ultra-violet irradiation.

Chronic staphylococcal dermatitis in children rapidly responds to actinic treatment.

Pityriasis rosea responds well to ultra-violet radiation. The itching is relieved and the duration of the condition shortened. Mild doses of the rays to stimulate the keratic function of the skin should be given two or three times weekly. The condition can generally be cured by a few treatments.

Psoriasis.—As is well known, exposure to the sun (particularly the tropical sun) can cure this intractable condition. It is very rare to find lesions on any part of the body habitually exposed to the sun's rays. It might, therefore, be expected that ultra-violet radiation would be successful in the treatment of psoriasis, and this is often the case.

Sequeira states that he has recently had "a number of cases treated by light baths, and extensive eruptions have been entirely removed by them. The results

have been obtained after prolonged treatment, and one extensive case was free from recurrence for two years."

Relapses, however, frequently occur in this disease, and it is quite impossible to state, at the outset, in which cases this is likely to take place. We have also known dissemination of the disease occur during treatment.

Patients who have not had a previous attack, and in whom the onset has been rapid, respond most readily to actinotherapy. Either the air-cooled or the water-cooled lamp may be used to produce the necessary third-degree erythema. If three or four exposures, spread over a period of seven or eight weeks, are given after all signs of the lesions have disappeared, there is practically no fear of relapse in this type. It is often valuable to cover the patient's skin with a very fine spray of sea-water before irradiation; the sodium chloride and iodine in the water increase the effect of the rays.

Generalized psoriasis is more resistant to treatment, especially if the patient has had several attacks, but it will often clear up after repeated doses. This type is more liable to relapse, and the patient must recommence treatment as soon as the first sign of a return is noticed.

The type most commonly seen—namely, the large isolated old-standing plaques on the knees and elbows, and often also scattered over the body—responds well to intensive treatment. If the patches are well localized the water-cooled lamp with compression is perhaps the most beneficial. The surrounding skin

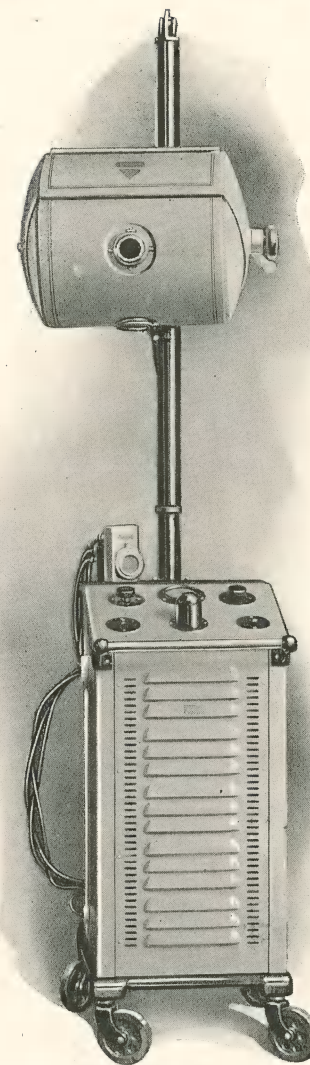


FIG. 239.—The Standard Self-Contained Combination Quartz Lamp Equipment. (The Burdick Corporation, Milton, Wisconsin.)

must be well protected, and prolonged exposures of the thickened areas are often necessary, because in these cases exfoliation is undoubtedly beneficial; two or three applications of X-rays often expedite the cure.

It is advisable in severe cases, if the reaction is not too trying, to apply between exposures a mild keratolytic ointment, such as salicylic petroleum jelly, but the patient should have a hot bath and remove all the ointment and as many of the scales as possible with spirit soap before another irradiation.

In this type the treatment should be carried on for two or three weeks after the disappearance of the lesions.

We have recently succeeded in curing with radiation a case of twenty years' standing when all other forms of treatment, including injections of manganese, had been unavailing.

After irradiation, the scales reappear much more slowly, the lesions become less coarse and indurated and after a time disappear and are replaced entirely by normal skin. The conjoint use of injections of manganese and ultra-violet radiation will shorten the time necessary to effect a cure.

Goeckerman advises the covering of the psoriasis lesions for twenty-four hours with crude coal-tar ointment (White's formula), at the end of which time the excess of ointment should be removed with oil, and the parts irradiated with the air-cooled mercury vapour lamp for one minute at thirty inches distance, increasing by one minute each day. A bath is given at the end of treatment. He claims that all cases clear up in from three to four weeks.

In psoriasis we find it very difficult to give a correct prognosis at the commencement of treatment. Some cases do extraordinarily well and others do not seem to respond at all.

In psoriasis of the scalp compression treatment is sometimes useful.

We have had both successes and failures with localized types, as well as with widely spread lesions, but it is generally easy to say whether the result will be satisfactory after treatment for a week or two.

Parapsoriasis.—Ultra-violet irradiation, combined with the internal administration of arsenic in the form of sodium cacodylate or solarson, often gives good results.

Xeroderma.—Patients with this condition are very sensitive to dampness and cold. The internal administration of thyroid extract is often helpful. Ultra-violet irradiation stimulates thyroid secretion and improves the nutrition of the skin, and is therefore very useful in this disease, which is characterized by an excessive dryness of the skin.

Ichthyosis.—A strong inflammatory reaction is required in treating this condition, to produce erythema and also to stimulate the keratic function.

Rhinophyma.—We have treated mild forms of this condition with ultra-violet radiation, using the air-cooled lamp for the purpose. Severe forms are best dealt with surgically. A second-degree erythema should be produced. The whole appearance of the skin improves wonderfully after a few exposures, and the usual contrast between the red nose and the paler colouring of the other parts soon disappears in

the general pigmentation which follows the radiation. Appropriate dieting is also helpful.

Rosacea.—Out of twenty-five early cases of rosacea Finsen was able to cure thirteen by means of ultra-violet radiation. Morris also achieved excellent results with the "Finsen" lamp. Mild hyperæmic forms of rosacea can be satisfactorily treated with ultra-violet rays from the air-cooled lamp by producing a second-degree erythema. In the more severe types, such as the telangiectatic and the hypertrophic, compression treatment with the water-cooled lamp fitted with a blue "Uviol" filter is necessary, a blister dose being given; this causes thrombosis and, subsequently, obliteration of small vessels, as well as contraction of the connective tissue. The results obtained are as good as those with X-rays, and are free from the dangers associated with the latter.

INFLAMMATIONS OF THE DEEP EPIDERMIS

Acne vulgaris.—Finsen, in the earliest results which he published, stated that he had cured, by the use of his lamp, thirteen out of twenty-five cases which had resisted ordinary measures. Acne, especially in its milder forms, responds very favourably to actinotherapy. In its most obstinate forms, which have resisted treatment with vaccines, medicines, soaps, and ointments for years, marked improvement is generally obtained after the first few applications; but when there is keloid formation or much induration, and when there is a tendency to relapses, conjoint Röntgentherapy is also necessary; hypertrophic scars become less noticeable after ultra-violet treatment.

In acne the general condition of the patient is very important, and at first about half-a-dozen general exposures of the whole body should be given for their tonic effect; the anæmia often associated with the acne is benefited. Constipation should be avoided, and plenty of open-air exercise taken, with a plain diet and an avoidance of greasy and sugary foods. Sequeira has stated that in acne he has found that "artificial sunlight treatment given to the whole body has proved of value, probably by improving the general health, and possibly by increasing the hæmobactericidal power of the blood."

The depth of the lesions has a great influence on the time required for cure, superficial lesions clearing up much more quickly than indurated. Comedones should be expressed mechanically before treatment, and if pustules are present these should be opened surgically and evacuated. Ultra-violet radiation soon controls the suppuration. It is advisable also to clean the skin with spirit before exposure.

Heavy exfoliative reactions are necessary, because it is most important to obtain satisfactory desquamation, which results in the shedding of all but the deep-seated lesions. During exfoliation mild applications of sulphur and resorcin can be made; bacteria are killed and the erythema stimulates the flaccid superficial muscles and the anæmic skin itself. The secretion of the sebaceous glands becomes thinner and less abundant. For ordinary *Acne vulgaris*, without induration, only four or five treatments are required. We have found that the chest and back respond to the treatment more quickly than the face; probably

shaving may account for this, since the heads of pustules are incised by the razor blade and the infection is thus spread.

In very stubborn cases weekly exposures to X-rays are very helpful. X-rays directly inhibit the activity of the sebaceous glands, and this is very useful in cases which tend to relapse.

Sycosis.—This intractable condition can often be benefited by ultra-violet radiation, especially when combined with epilation and the application of antiseptics, such as iodine or perchloride of mercury. Schindler advocates painting the affected parts with a solution of 5 per cent. silver nitrate in 70 per cent. ethyl alcohol, and then applying local irradiation. General irradiation should always be applied in these cases, because it is possible by this means to raise the resistance of the patient, especially when he is suffering from debility.

In the more resistant chronic type, heavier dosage and more patience are necessary; epilation should be produced with X-rays, and afterwards compression treatment with the water-cooled lamp is often beneficial.

The treatment should be continued for two or three weeks after the disappearance of the condition, to avoid relapse.

Alopecia.—*Alopecia areata* especially gives remarkably successful results with irradiation, which is now considered to be by far the best treatment for this condition. Finsen reported 39 cases cured out of 49 treated with his lamp. Of Nagelschmidt's 104 patients who completed their treatment, 80 were

completely cured, 16 improved, and only 8 were not benefited.

Out of 22 cases of *Alopecia totalis*, 14 were cured. McCormac states that he was able to cure five cases of several years' standing out of six treated.

One doctor mentions two cases of almost complete baldness of some thirty years' standing which began a new growth of hair after six weeks' treatment with bi-weekly exposures. The improvement in the growth of hair is undoubtedly due to the increased blood supply in the scalp produced by the erythema; a localized depression of the sympathetic nerves may cause the arterioles to dilate.

Recent cases have, of course, the best prognosis. If the hair follicles are atrophied the results are not so good, and when the follicles have been destroyed by wounds no improvement can be expected.

Progressive cases, where hairs are still coming out, do not give such good results with actinotherapy, and local irradiation will not prevent other non-irradiated patches from coming out.

For small areas the "Kromayer" lamp should be used, with compression; for larger areas the face and ears should be carefully covered with a towel pinned round the margin of the hair, and the air-cooled lamp should be used, producing a fourth-degree erythema, with an initial dose of from ten to twenty minutes at twelve inches distance, the dosage being gradually increased.

Treatment should be reapplied when the previous reaction has faded, usually in seven to fourteen days. One application is sometimes sufficient to cure a recent case.

Men are naturally more easily treated than women, whose hair has to be parted and retained in position during treatment.

The regrowth of hair usually begins in from ten to twenty days after the commencement of actinic treatment. Fragile white lanugo hairs first cover the site of the lesion, and gradually normal hairs appear, which in several of our cases have been darker than the original growth.

Treatment should always be patiently persevered with in *Alopecia areata*, even though it may seem, for a considerable time, quite unlikely that any favourable response will take place.

Alopecia seborrhæica has already been mentioned. Ultra-violet radiation is sometimes useful in *Alopecia præmatura*.

When treating ringworm and impetigo on the scalp, and when the hair covering and surrounding the lesions is cut short, we have noticed that it grows with great rapidity and needs clipping every two or three days. After irradiation has ceased the cut portions are soon indistinguishable because the clipped hair regains its normal length so quickly.

Lichen planus.—Ultra-violet radiation is sometimes useful for relieving the irritation which is often so troublesome in the acute stages of this disease. A second-degree erythema should be produced, and repeated when the first reaction has disappeared.

In the cases we have treated, however, we have never found any improvement in the lesion itself. Resort has usually to be made to X-rays, especially in chronic cases affecting the shins.

Onychia.—Varying results can be expected in treating onychia with ultra-violet rays, from the fact that onychia is a term describing any inflammation of the



FIG. 240.—The K.B.B. "Kerr Russell" Housing being used for the Treatment of a case of Onychia. The Detachable Curtain is seen in use.

nail, matrix, nail bed, or fold. We have had successful results with the cases we have treated.

General treatment, giving a first-degree erythema, should be combined with local applications of the air-cooled lamp. For local irradiation we use the velvet curtain attached to our own housing; the hands (or feet) are laid flat, with fingers (or toes) outstretched,

and at the first irradiation five minutes at twelve inches from the burner can be given safely; this can be increased later to fifteen minutes at eight inches. The curtain prevents any rays from falling on the arms or face.

Treatment has generally to be very prolonged, owing to the inaccessibility of the parts, even if the nail has been enucleated, but the results obtained are well worth the trouble.

The difficulties are greatest when the inflammation affects the nail-fold or the matrix.

Tinea (circinata, tonsurans).—Experimentally it has been found that ultra-violet radiation will not kill the fungi. Ringworm on the body can, however, be cured with one exfoliative dose produced by the "Kromayer" lamp, using compression. The desquamation removes the parasites mechanically. This method of treatment should not be resorted to on the face or other exposed parts of the body, since pigmentation usually follows. If the patches are large, the air-cooled quartz mercury vapour lamp may be used.

Ultra-violet radiation passed through an oxide-of-nickel filter and used in a darkened room is invaluable for diagnosing cases of suspected *Tinea tonsurans*. Each infected hair stands out vividly, showing a brilliant greenish fluorescence. When the whole of the hair has been closely cropped, and fluorescence is only visible on one or two small localized patches, several intense irradiations with the "Kromayer" lamp, using compression, will often effect a cure; it is only fair, however, to say that this is a rather uncommon

condition, and that the condition is generally widely spread, making X-ray or thallium acetate epilation an absolute necessity.

LOCAL INFECTIVE INFLAMMATIONS OF THE CORIUM

Erysipelas.—This streptococcal skin infection generally responds very well to ultra-violet radiation. Czepa, who has treated over a hundred cases with ultra-violet radiation, is very well satisfied with the results.

The inflamed area and one inch of surrounding skin should be irradiated with the water-cooled lamp, a third-degree erythema dose being given. The air-cooled lamp may also be used, and the following dosage given:

First application . . .	10 minutes at 27 in.
Second ,, :	12 minutes at 18 in.
Third ,, :	15 minutes at 12 in.

We have treated a large number of cases, and have found that if irradiation is given early enough one application is generally sufficient. The pain is relieved immediately and the temperature rapidly falls. Even in the most severe case it is never necessary to give more than five exposures. Irradiation should be given every day.

Furunculosis.—Septic lesions, boils, carbuncles, localized axillary furunculosis, pyoderma in children, and ischio-rectal, mammary, and alveolar abscesses yield readily to radiation from the air-cooled or water-cooled mercury vapour lamp. Sugar in the urine is

not a contra-indication to ultra-violet treatment, but it indicates the need for a much more guarded prognosis. We ourselves tested the effect of ultra-violet rays on cultures of staphylococci, and found that exposures of five seconds at a distance of ten inches from the air-cooled mercury vapour lamp were sufficient to kill the organisms.

The local action on the lesion is directly bactericidal as regards surface organisms, and there is an increased blood supply to the part, with an augmentation of the lymphocytes and phagocytes. A single lesion is most effectively treated with the water-cooled lamp; if it is in its early stages a single application, with the quartz compressor producing a blister, will often abort the condition altogether, or cause the lesion to subside rapidly without pus formation, causing an almost immediate relief of pain. If pus is present it should be evacuated before actinic treatment is commenced, and then a severe erythema should be produced by an exposure at a very short distance from the burner. In every case an area half-an-inch beyond the circumference of the lesion should be irradiated, but not too strongly or further infection might occur.

Patients who are subject to septic conditions should undergo general irradiation also, so that the bactericidal action of the blood may be improved and the resistance of the whole body increased. The pigmentation which occurs also protects the skin from bacterial invasion.

Ultra-violet radiation is thus invaluable as a prophylactic agent in the treatment of patients with low resistance to pyogenic organisms. The old-fashioned

poultices so greatly in vogue in treating these conditions were often the means of spreading the infection and causing secondary lesions.

In a case of refractory carbuncle—a condition which occurs occasionally—an application of X-rays will often hasten a cure.

Benign Pemphigus and Dermatitis herpetiformis.—Actinotherapy will not cure these conditions, but it will prevent relapses. Mild doses should be given.

Lupus erythematosus.—Good results can be obtained by the use of ultra-violet radiotherapy in this intractable disease. Actinotherapy should never be employed, however, in cases where dissemination is occurring.

Finsen cured fourteen cases out of forty-four treated with the "Finsen" lamp, and improved fifteen. Morris and Dore state: "We have treated a considerable number of cases of lupus erythematosus, in nearly all of which some improvement took place; of fifteen cases thirteen were greatly improved and only two showed no improvement."

Sequeira, however, considers that "the Finsen light treatment is of value in a small proportion of the chronic cases, but undoubtedly may increase the area of the eruption in the more acute type."

There is probably no skin disease about which so many contradictory opinions on the value of actinotherapy have been expressed as in *Lupus erythematosus*.

Both the telangiectatic and scaly forms do well with general irradiation, particularly if injections of a special gold preparation are given at the same time.

Great care must, however, be taken when this combined therapy is adopted: in one of our cases a very extensive, deep purple-coloured confluent papular eruption appeared over the trunk, which took over a year to subside. Local treatment with the "Kromayer" lamp is, however, most important, and very strong doses of five to thirty minutes with compression should be given. We have often noticed after the reaction has subsided that the irradiated area is easily distinguishable from the adjacent untreated parts, because it is so much paler.

Diathermic cauterization is sometimes useful in refractory cases.

Soft Chancres have given satisfactory results with ultra-violet radiation. In the early stages irradiation with the water-cooled lamp under compression gives the best results.

If suppuration has taken place the pus must be evacuated before irradiation. Irradiation hastens healing in fistulous and ulcerated forms. The time taken to cure the condition varies, of course, with its severity, and ranges between a fortnight and four or five months.

Obstinate cases sometimes occur, and two or three exposures to X-rays will hasten resolution of these.

Syphilis.—Ultra-violet radiotherapy is an invaluable adjuvant in the treatment of syphilis. In this disease there is usually a very poor general state of health, and severe anaemia is nearly always present. General irradiation quickly relieves the anaemia, as can be confirmed by blood examination, it increases the defensive mechanism of the blood, and there have

been a few cases where the Wassermann reaction was positive before irradiation and negative afterwards, though this is not a regular occurrence. There is no doubt that ultra-violet radiation increases the tolerance of the body to drugs and causes their more rapid excretion. Patients undergoing antisyphilitic treatment who are not responding well, and who are subject to syncopal attacks and vomiting, do well if the injections are stopped and general ultra-violet radiation is substituted for a few weeks, followed by the two forms of treatment given in conjunction.

Ulcers and broken-down gummata respond rapidly to local irradiation, which causes dead tissues to be cast off and stimulates the formation of granulations. A description of a case has been published in which a tertiary sore healed with five local applications, and another where a hard chancre healed in ten weeks, with a disappearance of the inguinal gland enlargement. Breiger has obtained improvement in syphilitic bone lesions by general irradiation.

Local irradiation of the scalp is valuable in syphilitic alopecia when it is combined with the administration of mercury and salvarsan. Rollier has obtained satisfactory results in the treatment of syphilis by combining heliotherapy with antisyphilitic medicaments.

NEW GROWTHS

Keloid.—Concentrated ultra-violet rays, using the "Kromayer" or "Finsen" lamp with compression, have given good results in recent cases where the lesion was not too thickened. Kromayer advises strong doses of half-an-hour with the blue "Uviol" filter.

Other workers prefer ultra-violet radiation used conjointly with radium or X-rays. We have found the former method very satisfactory.

Old Scars and Cicatricial Contractures.—Morris and Dore state that "all cases of simple hypertrophic scars showed improvement with ultra-violet radiation, and in some cases it was much greater than could have been anticipated." Volk has often seen scars in lupus patients recede very well when the "Kromayer" lamp fitted with a blue filter was used with compression.

Scleroderma.—Good results have been reported with actinotherapy in this condition.

Nævi pigmentosi.—These blemishes can sometimes be removed satisfactorily by giving blister doses of ultra-violet rays.

The "Kromayer" lamp with a compressor is the most convenient apparatus to use, and the surrounding skin must be effectively protected by means of chamois leather, lead-foil or, most conveniently, adhesive plaster. In some cases a single application will remove a mole, but generally two or three are necessary. The exposure should not be repeated until the reaction from the previous application has faded.

Diathermic cauterization with sparks, or the use of carbon dioxide snow, will often give more speedy results, but the skin covering the site of the lesion approaches the normal most nearly after the use of ultra-violet rays.

Angioma Simplex or Port-Wine Stain.—Electrolysis, radium, carbon dioxide snow and ultra-violet rays are all used in the treatment of this condition. The

difficulty of this can be realized when it is remembered that the dilated vessels are actually in the skin itself, and that it is necessary to cause their disappearance with as little damage as possible to the surrounding tissue. There is no doubt that this can best be achieved by means of ultra-violet irradiation under compression, because no permanent scar follows the most severe reactions, and the skin texture quickly assumes its normal characteristics, apart from some pigmentation which may persist for several months, but this is negligible compared with the original disfigurement.

Finsen published an early record of nineteen cases treated by him; in a few instances disfigurement entirely disappeared, in others the colour diminished in intensity.

The "Finsen" or "Kromayer" lamp should be used with quartz compressors about an inch in diameter.

If the lesion is small (say, one or two inches in diameter) it may be treated at one sitting; otherwise portions of the lesion, as widely separated as possible, may be irradiated on the same occasion, and others chosen on the next until the whole area is cured. Exposures lasting for from five to twenty minutes should be given, and fourteen days should be allowed to elapse before any area is a second time irradiated. Thin, bluish non-hypertrophic cases which disappear on pressure give the best results, and sometimes only one exposure to each area is necessary to eradicate the condition.

When deep reddish blue coloration is present treatment is more prolonged, and when there is much

hypertrophy of the tissues other methods of treatment should be chosen.

Occasionally exposures of sixty minutes' duration to one area are required, and failure must often be acknowledged in very deep-seated lesions. If there is not an improvement after six applications of ultra-violet rays the treatment should be discontinued. An emollient cream should be applied to the area which has been irradiated. Healing generally takes place in from seven to ten days, and in successful cases the lesion becomes lighter in colour after each application, until it is normal.

Xanthelasma palpebrale.—Concentrated ultra-violet rays from the "Finsen" or "Kromayer" lamp will cure this condition. Lomholt considers that actinotherapy gives much better cosmetic results than excision. Sometimes only one application is necessary, but more often two or three are required.

Stellate Veins.—Spider nævus (*Nævus araneus*) is generally treated by electrolysis, but ultra-violet radiation with compression will give equally good results. Only one or two treatments are required.

Telangiectases often occur after prolonged X-ray treatment in such cases as exophthalmic goitre, and are very unsightly; Hagen advocates the administration of strong doses with the water-cooled lamp, using compression, so as to induce the necessary *Arteritis obliterans*. He claims that only one or two applications of twenty minutes' duration are needed, and that the cosmetic results are very satisfactory, only a faint white scar remaining after the reaction has completely disappeared. Volk, on the other hand, advises

the exercise of great caution, as he has seen ulceration follow irradiation. We have treated a case of *Keratosis pilaris* of the axilla with actinic radiation without effecting any improvement.

Ulcers (varicose, perforating, and tubercular).—Changes which take place in the basal layer of the epidermis after ultra-violet irradiation lead to the development of an increased tolerance to the rays. This is not the case, however, in tissues devoid of this important epidermal layer, and when they are irradiated the dosage should not be increased.

Chronic indolent ulcers, however caused, should be treated by ultra-violet radiation. Patients suffering from chronic ulcers are invariably found to have a decreased blood calcium content, and therefore general irradiation must be carried out in conjunction with local treatment in these cases. Actinotherapy causes an increase in the blood calcium and in the bactericidal properties of the blood, and improves the general health.

Locally, a severe reaction is necessary at first. The lesion must be carefully cleaned and all pus and crusts removed before exposure. The result is a direct bactericidal action on the organisms on the surface of the ulcer and an increased blood supply to the part, which stimulates the growth of healthy granulation tissue and leads to the elimination of morbid tissue. After the first one or two exposures great relief is felt from the irritation and pain which often accompany the condition, and new epithelial formation can be noted round the edge of the lesion. This epithelium is very delicate, and great care must be taken to protect it

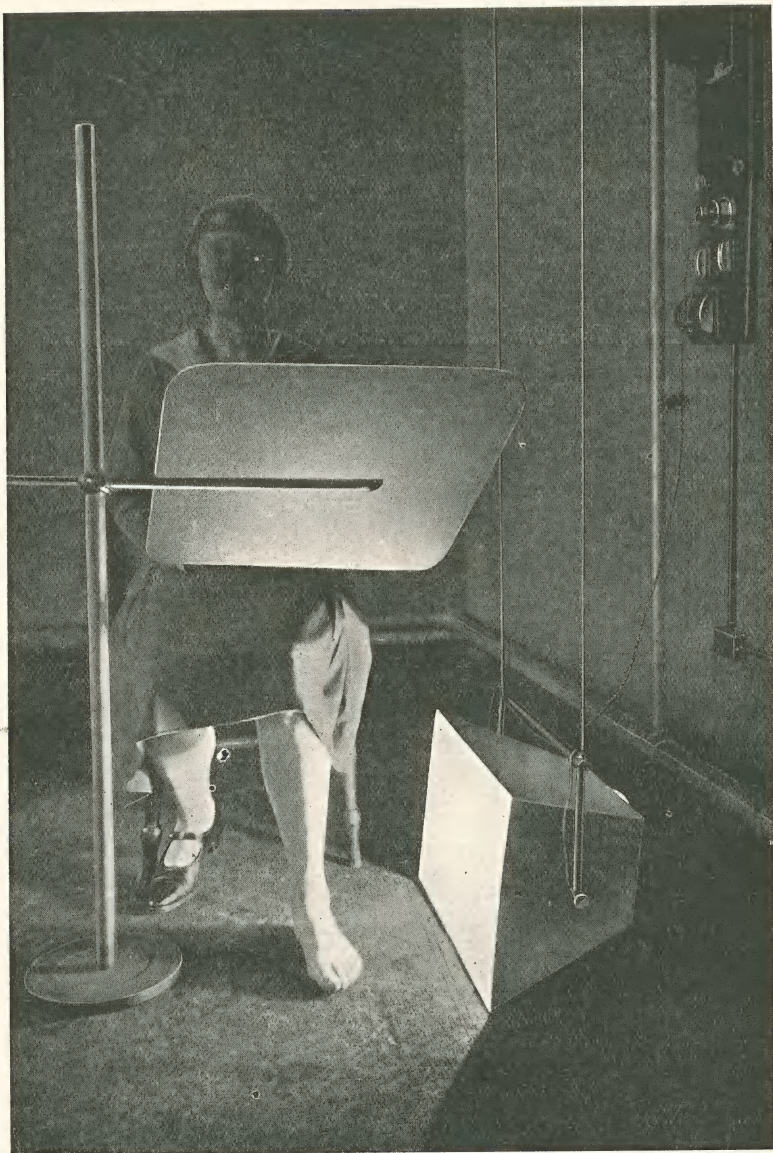


FIG. 241.—Illustration showing the adaptability of our Suspension Housing, manufactured by Kelvin, Bottomley & Baird. The Lamp is being used for the Irradiation of the Ankle in a case of Varicose Ulcer. The Screen is protecting the patient's face and hands.

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from destruction during subsequent exposures. It is often advisable, therefore, to use the blue "Uviol" filter after the first two or three applications, and to cover up the new epithelium during irradiation. The lamp should also be used at a greater distance than usual.

Treatments once or twice weekly are advocated. Some refractory cases heal more quickly if zinc ionization is carried out in conjunction with the ultra-violet radiation.

In old-standing lesions, where a large amount of cicatricial tissue is present, diathermy, X-rays, or radium may be applied to soften the scar tissue before commencing actinotherapy.

Rodent Ulcer.—Finsen obtained a favourable result in eleven cases out of twenty-four treated, and Morris and Dore obtained good results with the "Finsen" lamp in the pre-ulcerative stages of the condition. Radium or diathermy, however, seems to be the method of choice now.

Wounds.—Surgical measures should obviously be the first consideration in the case of fresh wounds, but ultra-violet radiation is exceedingly useful when there is any delay in healing. The production of an intense erythema is very valuable in causing sloughs and other dead tissue to be thrown off. If it is possible, the base of the wound should always be irradiated.

When healthy new granulation tissue begins to appear, and epithelial growth occurs, much milder doses should be given, so as to avoid injuring the delicate new cells. Epithelium can only grow over a wound from the edges when all the basal epidermal

layer has been destroyed; and therefore mild irradiation of the edge of a wound will stimulate the growth of epithelium at this stage. The blue filter may be used with the air-cooled lamp, or the lamp

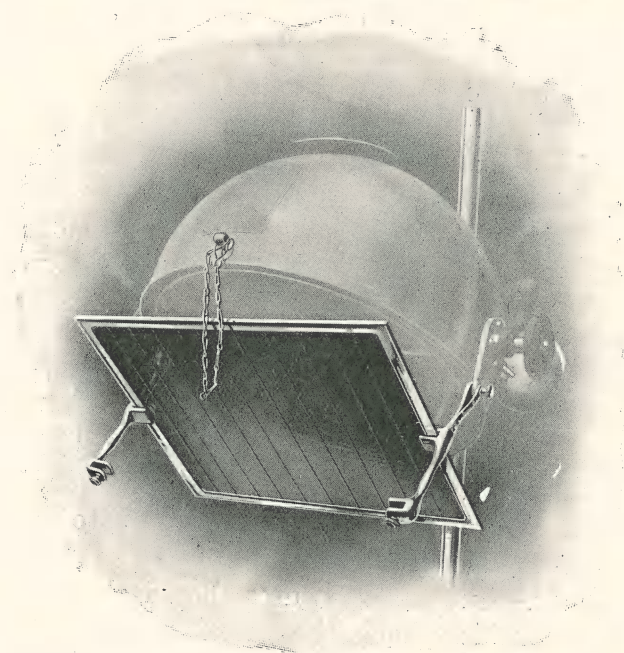


FIG. 242.—The "Uviol" Blue Glass Filter for use with the "British Hanovia" Air-cooled Quartz Mercury Vapour Lamp.

may be applied to the wound at a greater distance than usual, so as to make use of the air as a filter for cutting out the shorter wave-lengths.

Skin Grafts.—Better results are obtained if ultra-violet rays are applied, because they have a sterilizing effect and stimulate epithelial growth.

Bedsore.—General irradiation should be given, to increase the calcium content of the blood and improve

the general condition of the patient. A stimulative erythema (second or third degree) is beneficial if applied to the site of a threatened bedsore. Long-standing lesions need treatment similar to that given to chronic ulcers.

Anomalies of Pigmentation (Chloasma, Leucoderma, and Lentigo):

Chloasma.—Good results have been reported with ultra-violet radiation in this condition which occurs in pregnancy.

Leucoderma or Vitiligo.—Improvements in some cases of leucoderma have been obtained, but, on the whole, the results of ultra-violet radiation are not very satisfactory. Recently eau-de-Cologne, containing bergamot oil, has been painted on to the non-pigmented areas before irradiation, and better results have been obtained by this means, the normal skin having been carefully protected. Pigmentation has been developed in the achromic areas and has lasted several months. Areas normally uncovered have been found to respond better than those which are screened by clothes, but failures have also been reported in treating these.

Lentigo or Freckles.—Actinotherapy is not of any use in this condition.

A FEW ILLUSTRATIVE CASES

Baker's Dermatitis.—Case 33. A man, aged 35, a baker by trade, came with a moist eczematous condition affecting both arms from the fingers to the elbows. The arms were exceedingly irritable. Prolonged medicinal treatment had proved unavailing. On eight occasions the arms were irradiated

with the air-cooled mercury vapour lamp, and at the end of that time the skin was perfectly normal.

Eczema.—Case 34. Female, aged 28, came to us suffering from extensive patches of moist eczema in each axilla. She had been treated for several months, by different medical men, with various lotions and ointments, but without appreciable success. Mild, sedative doses of ultra-violet rays were given, and after nine applications, spread over a period of three weeks, the condition was entirely cured. Several months afterwards there had been no recurrence. This case was particularly interesting, since it was one of the worst cases of regional eczema we had ever seen.

Eczema.—Case 35. Female, aged 30, had eczema on the dorsa of both hands for seven years. Medicinal treatment had been entirely unavailing. In all, thirty-one applications were given with the air-cooled lamp and two with the water-cooled. After a few treatments the condition healed, but subsequently broke out again. Now the lesions are satisfactorily healed and there has been no recurrence for over fifteen months. The first exposure with the air-cooled lamp was two and a half minutes at a distance of thirty-six inches, gradually increasing to ten minutes at eight inches. Only the hands were exposed to the rays.

Eczema intertrigo.—Case 36. Female, aged 46, had suffered from very severe eczema intertrigo for four years. It was associated with intense pruritus and pain, and great difficulty in walking. She had had treatment from several doctors, without any improve-

ment resulting. She was treated with a multiple arc lamp, using special white-flame carbons. After the second irradiation the lesion looked better, but there was no alleviation of the pruritus. The condition was cured after fourteen applications of ultra-violet radiation and four of X-rays.

Chilblains.—As has already been mentioned, this condition is, in our opinion, best treated by a combination of ultra-violet radiation with Schnee sinusoidal baths, and we have adopted this method with beneficial results.

Case 37 is typical. He had had chilblains on the hands and feet for years, those on the hands generally breaking. After four combined treatments, as described above, the condition completely cleared up, and so far there has been no recurrence.

Case 38. We had a curious case a short time ago of a woman who came to us complaining of coldness in the breasts, and stated that she had sat at an open window for a considerable time in her nightdress a few days previously, watching something on the street. On examination, the breasts were found to be cyanosed and cold, as if affected by a condition of venous stasis. The erythema produced by one application of ultra-violet radiation gave immediate relief, and the chilly feeling was followed by a comfortable, warm glow. The same result could probably have been obtained with oil of mustard or a mustard plaster, but the radiation was more pleasant and equally efficient, and it must also be remembered that there are a number of places where a mustard plaster could not possibly be applied. A week later

the beneficial effect had not waned, and there was no subsequent return.

Herpes.—Case 39. Female, aged 64, had very marked *Herpes zoster*, which formed a band five inches wide and twenty long round the left side of the abdomen and back. The pain was very marked, and the patient stated she had been unable to sleep for a week. After the first application of ultra-violet rays, of two and a half minutes at twenty-four inches, there was a complete cessation of pain, and she slept soundly at night. In all, she had nine exposures, spread over a period of four weeks, the last two being accompanied by diathermy (auto-condensation couch). The lesions healed with very little scarring, and there was no subsequent neuralgia, which often follows this condition in elderly people, and generally proves very intractable.

Case 40. Male, aged 18 years, suffering from herpes of the face, was cured with four exposures to the rays, extending over one week, the herpetic lesions disappearing with the resultant desquamation.

Impetigo.—Case 41. Female, aged 19 years, had an impetigo of the chin which was rapidly spreading. An exposure of two minutes at ten inches from the mercury vapour lamp was given, which caused a smart reaction and immediately stopped the spread of the condition. The following day an exposure of four minutes at ten inches completed the cure. The application was followed by profuse desquamation, and at the end of the week the skin was again normal. We have treated a large number of children suffering from this condition, and have been uniformly successful.

Psoriasis.—Case 42. Female, aged 42, had had this condition for over twenty years on various parts of the body. She had been treated with ointments, including chrysarobin, and recently had undergone a course of injections of colloidal manganese. This was followed by an improvement, but the lesions on the knees and elbows remained. After thirteen exposures to the mercury vapour lamp the lesions were practically unnoticeable, and the patient has been able to wear sleeveless gowns for the first time for many years.

Case 43. Male, aged 35, was a very severe case of psoriasis, being practically covered from head to foot with lesions. He was a seafaring man, and consequently was unable to come regularly for treatment. He gave us an interesting account of the effect of natural sunlight on his condition, stating that when he was trading in the tropics, and was able to expose his body systematically to the sunlight, the condition completely disappeared in nine months, but returned four months later when he came home.

Case 44. Female, aged 48 years, had had psoriasis for thirty-one years. There were very large indurated patches, principally on the abdomen and back. The condition was completely cured after thirty-one applications of the air-cooled quartz mercury vapour lamp to the whole body, and fourteen applications of the "Kromayer" lamp to different areas. Several months afterwards there had been no sign of relapse.

Case 45. Female, aged 55 years, had had psoriasis for many years; the lesions were small, being about the size of a shilling, and uniformly distributed over the body and limbs. She was completely cured after

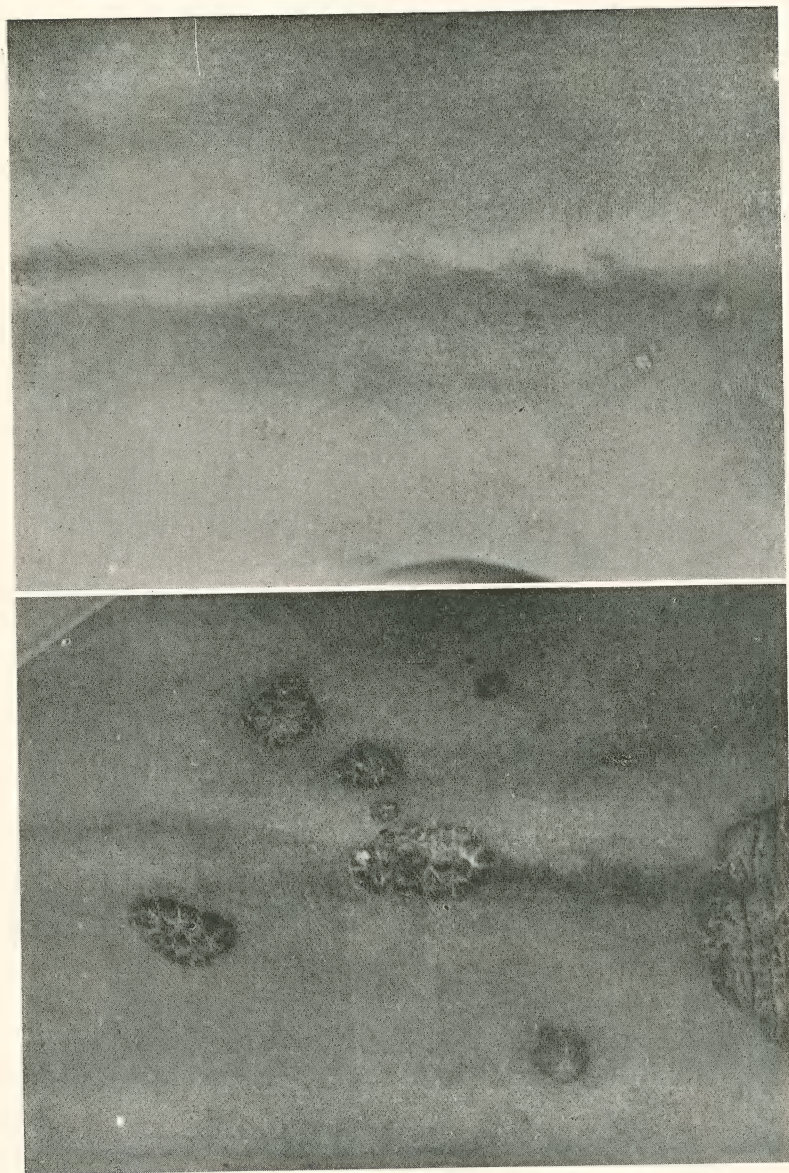


FIG. 243.—A Case of Psoriasis of Thirty-One Years' Duration, which was entirely uninfluenced by Medicinal Treatment, but was rapidly cured by exposure to Ultra-Violet Rays: A, Case 44's back before Irradiation; B, after Irradiation.

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seventeen applications of the air-cooled mercury vapour lamp. A year has now elapsed and there has been no sign of any recurrence.

Case 46. Male, aged 48 years, had had psoriasis for fourteen years. Medicinal treatment had been entirely unavailing. General treatment with the mercury vapour and carbon arc lamps was given on twenty-five occasions, and local treatment with the "Kromayer" lamp on ten, and three applications of X-rays were made. A large area on the abdomen showed improvement where the compressor of the "Kromayer" lamp had actually been applied: the skin became almost normal. Later the condition became as bad as it had been before treatment, and many new lesions appeared on the back. Treatment had therefore to be discontinued, and it seems definitely established that it is unwise to continue actinic treatment if an acute exacerbation takes place, with the appearance of new psoriasis lesions.

Ichthyosis.—Case 47. Girl, aged 12, who had had this condition practically since birth, improved greatly with a course of general ultra-violet treatment. The skin became healthier and more supple.

Acne.—Case 48. Male, suffering from acne of twenty years' standing on the front and back of the chest, had tried many forms of medicinal treatment without any improvement. The first application to the back, followed as it was by desquamation, apparently cured it, but subsequently another crop of pustules appeared. The condition was finally cured, however, after twelve applications, extending over a period of five weeks.

Case 49, which was similar to Case 48, was cured in seven applications, extending over three weeks.

Cases 50 and 51. Recently we have treated two cases of *Acne rosacea*, one of which had had a prolonged course of vaccine treatment without any favourable result. Ten applications completely cured one case, and thirty-five irradiations with the air-cooled mercury vapour lamp the other. A year afterwards there had been no relapse.

Sycosis.—Case 52. Man, aged 24 years, had had sycosis for three years, affecting his chin and upper lip. The condition had resisted various forms of treatment, including the administration of vaccines. Both general and local irradiation were given with the air-cooled mercury vapour lamp and the poly-metallic arc lamp. The condition cleared up after eight treatments, spread over a period of two months, but recurred three months later. A second course of treatment, consisting of thirteen applications, extending over a period of three months, was given, and the skin once more became normal. Three months later there was no sign of relapse.

It is, however, only fair to mention that other cases have not responded well to treatment until epilation has been performed either by means of X-rays or by hand.

Alopecia areata.—Case 53. Female, aged 24, in July 1926 noticed a bald patch, about an inch and a half in diameter, over the left parietal region. In spite of the application of lotions the condition became worse, and when we first saw the patient, in February 1927, the scalp was almost completely bald. Exposure to

the quartz mercury vapour air-cooled lamp was given to the whole scalp. After four applications, over a period of four weeks, the scalp was almost covered with fine white hair. Three further exposures were given during the second month, after which the scalp was covered with a thick growth of black hair, except for a few



FIG. 244.—Case 20: *Alopecia areata* before and after Treatment.

small, thin patches, about the size of sixpenny pieces, over the occipital area; these were treated locally by means of the "Kromayer" lamp. Two applications were given, and no further treatment was necessary, because the patches soon disappeared.

Case 54. Male, aged 22, had large patches of *Alopecia areata* on the back and sides of the head, of six months' duration. The condition became worse during treatment with lotions. The "Kromayer" lamp was used to treat the several areas individually, and exposures of from five to seven and a

half minutes at a distance of four inches were given. The lesions were all uniformly covered with fine lanugo hair after four exposures. Fresh lesions, however, developed, and eight further irradiations became necessary. The hair is now perfectly normal, except that the new hair is much darker than that covering the rest of the head.

Another case (55). A man of 43 had had *Alopecia areata* for eighteen months. Five weekly exposures with the "Kromayer" lamp were sufficient to cover the patch with fine white hair, which was gradually replaced by normal hair.

Cases of seborrhœic baldness in men have been treated, but progress is slower than in cases of *Alopecia areata*, for which ultra-violet radiation is practically a specific remedy.

Tinea.—Case 56. Girl, aged 4, suffering from widespread lesions on the back, abdomen and legs. All the lesions had completely disappeared after five applications of the rays, and there was no subsequent recurrence. This case was of interest because several other children in the family were being treated medicinally for the same condition at a clinic, and were making extremely slow progress, the condition remaining uncured after several weeks.

Tinea tonsurans.—Case 57. Boy, aged 4, was treated two and a half years ago. At first he had a single patch of *tinea tonsurans* over the left temporal area, about the size of a two-shilling piece. Treatment was given for two minutes with the small quartz compression lens attached to the "Kromayer" lamp, the area surrounding the lesion being purposely left unshielded.

Three days later the same area was given five minutes' exposure, with compression. A week later a further exposure of five minutes was given, and one of two minutes to a fresh area which had developed.

Seven days afterwards three different areas were each treated for three minutes; the original patch was now normal. During the next fortnight four applications of five minutes' duration were made to four separate areas. A week later, ultra-violet radiation filtered through an oxide-of-nickel filter revealed the fact that the scalp was free from infection, and there has been no recurrence of any kind since.

Lupus erythematosus.—Case 58. Male, aged 36, had extensive lesions on both cheeks. Five local applications with the quartz compressor attached to the "Kromayer" lamp were given; intense reactions resulted, with marked oedema, and when these had subsided, in about a week, the different areas of skin which had been treated appeared to have become quite normal. General treatment was also given.

Chronic Onychia.—Case 59. Female, aged 34, came complaining of onychia affecting all the digits of both hands. The condition had been in existence for a year. The fingers were exceedingly painful and tender, so that she had difficulty in using them at all. Local and general treatment were combined, the air-cooled mercury vapour lamp being used in each case. The condition of the fingers was splendid after forty treatments spread over a period of five months. Three months later there had been no recurrence.

Carbuncle.—Case 60. Female, aged 46 years, had a very large carbuncle situated on the posterior surface

of the lower part of the chest wall. The condition was very extensive and wide incisions had to be made.

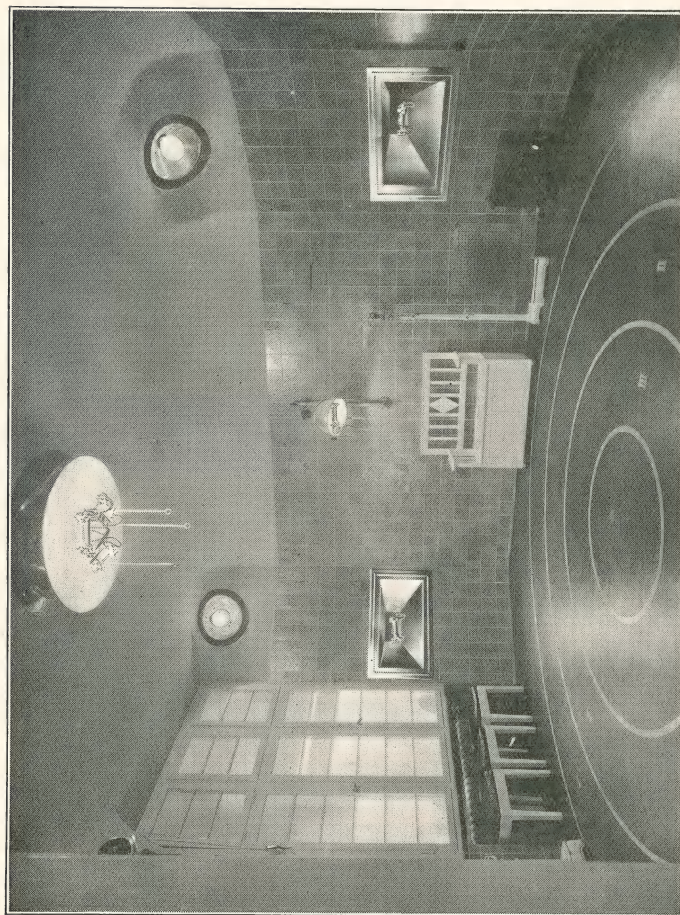


FIG. 245.—Special Irradiation-Room fitted with Lamps which are built into the walls. An Overhead Lamp with three burners, two "Jesionek" Lamps, one "Alpine Sun" Lamp and two "Sollux" Lamps can be seen; also the Dosage Rings on the floor.

An area in the centre of the scar was very intractable, and refused to heal under ordinary treatment. After six applications of ultra-violet rays the wound had completely healed.

Very rapid healing was achieved in the case of a granulating wound, resulting from a scald, on a child's arm.

Chronic Ulcers.—Case 61. Female, aged 65, had suffered for twelve years from a varicose ulcer situated on the lower third of the right leg. It was accompanied by a good deal of varicose eczema and consequent irritation. Various kinds of dressings had been applied, including bismuth subgallate and Unna's paste, and the patient had rested for months in bed without any favourable result. During the first week of ultra-violet treatment applications were given daily. After seven days the itching, which had been almost unbearable, had entirely disappeared, and the ulcer itself had healed. Applications were continued thrice weekly for the accompanying eczema, and by the end of ten weeks the whole condition had completely cleared up, pigmentation only remaining. This is a typical example of several cases treated in which we have obtained equally good results.

Ischio-rectal Abscess.—Case 62. Male, aged 26, had had several ischio-rectal abscesses, extending, at intervals, over a period of four years. A short time ago he came complaining of a lump in the ischio-rectal area. The lump was tender, about the size of a hazelnut, but not fluctuant. After the first application of ultra-violet rays the condition aborted. Subsequent weekly doses were given to allay the slight pruritis which remained, and as a prophylactic measure against further infection.

Port-Wine Stain (Nævus flammeus).—Case 63. A woman with a port-wine stain about the size of an

olive on the forearm, just below the elbow, was cured with two applications of the "Kromayer" lamp. Compression was applied, and exposures of fifteen and twenty minutes were given at intervals of a fortnight. A curious feature of this case was that on each occasion the reaction did not appear after irradiation until an interval of 112 hours had elapsed.

CHAPTER XVII

ULTRA-VIOLET RADIATION IN DISEASES OF THE ORGANS OF SPECIAL SENSE, AND IN DENTAL AND VETERINARY PRACTICE

Diseases of the Eye—General Treatment—Diseases of the Eyelids—Blepharitis—Stye—Dacrocystitis—Diseases of Conjunctiva—Acute Conjunctivitis—Chronic Conjunctivitis—Phlyctenular Conjunctivitis—Vernal Catarrh—Trachoma—Diseases of the Cornea—Superficial Keratitis—Corneal Herpes—Ulcus Serpens—Iritis—Irido-Cyclitis—Choroiditis—Chorio-Retinitis—Diseases of the Throat—Acute Pharyngitis—Chronic Pharyngitis—Acute Tonsillitis—Chronic Tonsillitis—Diphtheria Carriers—Acute Catarrhal Laryngitis—Spasmodic Laryngitis—Diseases of the Nose—Acute Rhinitis and Coryza—Acute Purulent Rhinitis—Chronic Nasal Catarrh—Chronic Atrophic Rhinitis or Ozaena—Eczema—Vasomotor Rhinitis or Hay Fever—Epistaxis—Infection of Accessory Sinuses—Diseases of the Ear—Eczema—Otitis Media—Chronic Otitis Media—Mastoiditis—Uses of Ultra-Violet Radiation in Dental Practice—General Treatment—Local Treatment—Ultra-Violet Lamps used in Dentistry—Diseases of the Mouth and Teeth—Gingivitis—Glossitis—Stomatitis—Pulpitis—Diseases of Periodontal Membrane—Acute and Chronic Periodontitis—Treatment of Oral Cicatrices—Relief of Pain in Dental Conditions—Whitening Teeth—Veterinary Uses of Ultra-Violet Radiation

DISEASES OF THE EYE

Before commencing treatment of the eye with ultra-violet radiation it must be remembered that all waves shorter than 2950 Å are absorbed by the

cornea, and that rays with longer wave-lengths than 3050 Å have no abiotic action on the cornea.

The lens absorbs rays below 3200 Å, and in some

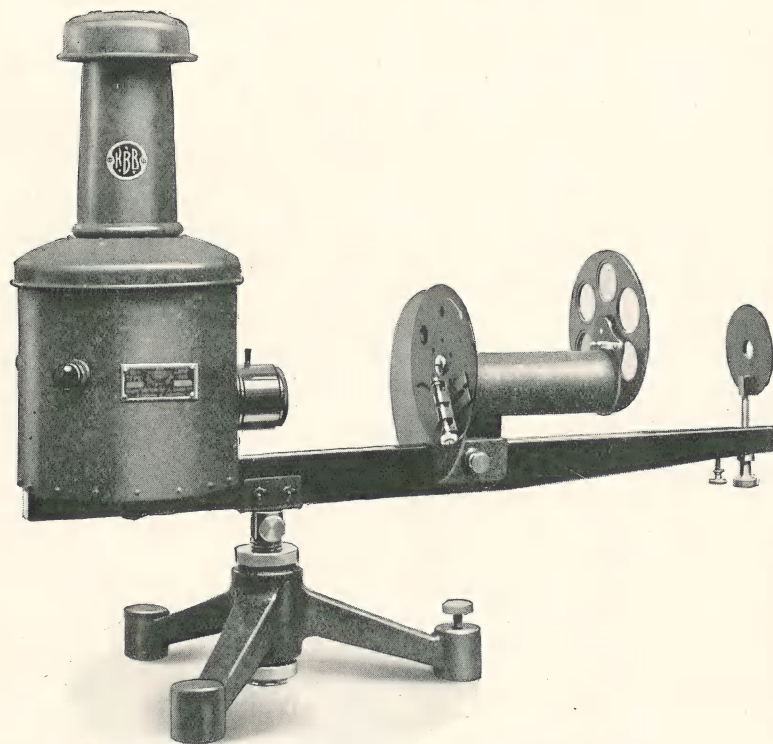


FIG. 246.—A "K.B.B." Lamp designed for the Ultra-Violet Treatment of Diseases of the Eye

cases even those situated higher in the spectrum. Old and very opaque lenses may even absorb up to 4000 Å. Therefore all rays above 4000 Å reach the retina always, and youthful and very transparent lenses may allow those above 3200 Å to pass to it.

These, however, are all absorbed by the pigment in the retina and converted into heat.

Various workers have used ultra-violet radiation in the treatment of eye conditions with very encouraging results, but probably the most interesting recent contribution to the subject has been that of Stewart Duke-Elder.

In the treatment of eye diseases the general condition of the patients is of the utmost importance, and every possible means should be taken to raise the standard of their general health. There is no better agent than general ultra-violet irradiation for this purpose. A prolonged course of sunbaths, natural or artificial, should be a routine practice in a large number of eye conditions, and as a matter of fact, many ophthalmologists prefer this method of ultra-violet therapy to local applications. Attention must be paid, of course, to the general hygiene of the patient.

General Treatment.—The cases which respond most favourably to general ultra-violet radiation are the more chronic conditions, such as tubercular diseases of the eye, phlyctenular keratitis, blepharo-conjunctivitis associated with rickets, scrofulous conditions, general poor health, or malnutrition, and trachoma.

The technique is the same as that employed for ordinary general treatment. When the mercury vapour lamp is used the patient generally lies down, and the front and back of the body are each exposed for two and a half minutes at a distance of thirty-six inches from the lamp. Applications are given thrice weekly, and the exposure is lengthened

on each occasion by one minute, until the irradiations of the back and front of the body last for ten or fifteen minutes. The distance between the lamp and the patient is then gradually shortened to twelve inches. At least twelve exposures should be given, and in many chronic conditions the treatment should be continued for several months, according to the progress of the disease. Local medicinal applications, varying with the nature of the condition, should not be neglected in any eye diseases treated by ultra-violet radiotherapy.

DISEASES OF THE EYELIDS

Local skin conditions, such as eczema, lupus, or herpes, should be treated in the same way as on other parts of the body, though great care is necessary to keep the conjunctiva free from irritating ointments or lotions.

Blepharitis responds well to ultra-violet radiation, especially in badly nourished children. General irradiation should always be given. Local applications may be made by means of quartz applicators, care being taken to protect the cornea and conjunctiva. One or two applications often result in cure. Eyelashes which have been shed grow again, unless the follicles have been destroyed by deep ulceration. Some workers claim to have cured blepharospasm by the application of radiation from the air-cooled mercury vapour lamp, but we ourselves have not been so successful, although we noticed a certain amount of improvement in the cases we treated.

Stye.—This condition can be effectively treated by ultra-violet radiation in the same way as furunculosis of other parts of the body. In cases where the lesions appear successively in crops, a course of general irradiation should be given for the improvement of the general health.

Injuries such as contusions or lacerations may be irradiated with benefit.

Dacrocystitis, either tubercular or simple, can be

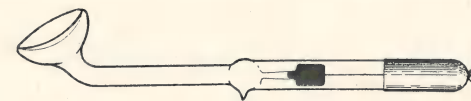


FIG. 247.—A Curved Ocular Quartz High-Frequency Electrode.

treated by means of ultra-violet radiation, with good results. The cause of the chronic inflammation must be sought and removed. Friel recommends zinc ionization in this condition.

DISEASES OF THE CONJUNCTIVA

Acute Conjunctivitis.—Great relief is obtained in this condition from radiant heat applied every day, or twice daily in very acute cases. Exposures of twenty minutes are given over the closed eyelids with the lamp placed as near the patient as comfort allows. Pain is generally relieved after the first exposure. Medicinal treatment, cold packs, and so on, must be used, as well as radiant heat in very acute conditions, such as gonococcal ophthalmia.

Chronic Conjunctivitis.—This is generally a very stubborn condition to treat, but encouraging results have been obtained by ultra-violet therapy.

For tubercular conjunctivitis, Lundsgaard advises prismatic compression, and an initial dose of thirty minutes with the "Finsen-Reyn" lamp. This is followed by marked oedema and swelling, which subsides in from three to six days after irradiation.

The quartz mercury vapour lamp may also be used, with doses of five minutes at eighteen inches. When using the "Kromayer" lamp great caution must be exercised. Doses of one to five minutes may be given. If the blue "Uviol" filter is inserted, five to thirty minutes' exposure is possible.

After exposure a false membrane is formed, which is thrown off when the reaction has subsided, but re-forms if removed before. A prolonged course of general treatment with carbon or polymetallic arc lamps should also be given.

Phlyctenular Conjunctivitis clears up very satisfactorily under treatment, especially in children, and general irradiation alone usually cures the condition.

Vernal Catarrh.—This condition is considered by some authorities to be due to a deficiency of blood calcium. General irradiation should therefore be given in conjunction with the oral administration of calcium.

Trachoma.—Radiant heat is valuable in the acute stage, and ultra-violet radiation may be given later with good results. The "Finsen" lamp has given excellent results in the treatment of trachoma, which is often very stubborn under the usual methods of treatment.

Gronholm, at the Finsen Institute, reports on a series of ninety-eight trachomatous cases; seventy-

nine were cured, and the remainder improved. There was no spread of the lesion in any of the cases treated. Relapses, however, occurred in twenty-one of them.

An intense reaction is caused by the rays, and the eyelids become cedematous. This may last for a



FIG. 248.—Quartz Compressor for Treatment of Diseases of the Eye with the "Finsen-Reyn" Lamp. (G.R.S.A. London.)

week. When the reaction has subsided the lesions are found to have disappeared, and to have left only very superficial scars.

Sometimes ten minutes' treatment is sufficient, but occasionally it is necessary to give as many as six applications.

Visual acuity decreased in only three of the cases treated, although there were corneal ulcerations in about 20 per cent. of the total number.

Special forceps used for everting the eyelids are illustrated on page 428.

DISEASES OF THE CORNEA

Birch-Hirschfeld, who has had ten years' experience of ultra-violet treatment of diseases of the eye, considers that superficial keratitis, corneal herpes, malignant marginal ulcers, rodent ulcers, severe scrofulous ulcers and freshly infected wounds, all respond well to irradiation. Parenchymatous and deep keratitis have not given such good results up to

the present. The first step to take in the treatment of *ulcus serpens* is to arrest the progress of the ulcer by irradiating the advancing edge, which can generally be achieved by a few applications. Birch-Hirschfeld uses a carbon arc lamp, taking five amperes, with a quartz lens, a "Uviol" glass filter, and a quartz cell

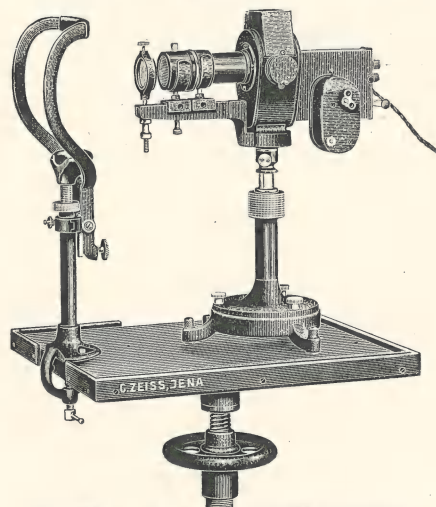


FIG. 249.—Birch-Hirschfeld's small Eye Radiation Lamp.

containing a solution of sulphate of iron for the purpose of absorbing the heat rays. The rays are accurately focused on the lesion for a period of from three to six minutes once or twice daily. Sensitizing agents, such as fluorescin or Rose Bengale (2 per cent.), are instilled into the eye to increase the effect. Two hundred and eighty-one cases have been treated, and improvement generally takes place after the first few irradiations, the average duration of treatment being a fortnight. Ninety-two cases recovered, with delicate

and almost transparent scars, and without any injury to other structures of the eye. Atropin and cold compresses are used in all cases.

Zinc ionization may be employed in the treatment of corneal ulcer, although Young considers the use of the thermophore the specific treatment for infected corneal ulcers. Syphilitic keratitis does not respond so well to ultra-violet radiation as to X-rays.

Tubercular keratitis and kerato-conjunctivitis may be treated both locally and with general irradiation, and the results are good. Sulzer has obtained encouraging results in the treatment of corneal opacities.

Iritis and Irido-Cyclitis.—An endeavour should first be made to determine whether the disease is due to some systemic affection, such as tuberculosis, syphilis, or rheumatism; if this is so, general ultra-violet irradiation will be a valuable adjunct to such local treatment as the use of cold packs, atropin, or radiant heat. In the acute stage radiant heat is very useful. Tubercular irido-cyclitis, the treatment of which by other means is so very unsatisfactory, as a rule yields well to general ultra-violet radiation. The results in infective cases are not so satisfactory, but Duke-Elder mentions 29 very severe cases, most of them being of considerable duration: 5 were cured in a few weeks; 12 showed slower but steady improvement; in 8 there was an improvement in the general health, but not in the eye; and in 4 the eye condition became worse.

Local irradiation of the iris and of the deeper structures of the eye can be carried out only with rays of

longer wave-length than 2950 Å, because all rays of shorter wave-length are absorbed by the cornea.

Choroiditis.—General ultra-violet radiation is useful when the condition is due to some systemic disease, such as tuberculosis.

Chorio-Retinitis.—Birch-Hirschfeld has reported good results with the "Zeiss Redfree" lamp. He



FIG. 250.—The small Eye Radiation Lamp of Birch-Hirschfeld in use.

focuses the rays into the interior of the eye in this condition and also in *Tubercular retinitis*.

Technique: General.—Light baths should always be given, in the manner described on page 587.

Local.—The mercury vapour lamp is generally preferable to the carbon arc, because the radiation is comparatively cold. The eye should be cocainized before treatment. When treating the cornea and iris a bent quartz rod is most useful, since the beam of light is then more easily controlled.

The eyelids may be treated by everting them and then focusing the rays from an air-cooled mercury vapour lamp on to them with a quartz lens.

Sedative doses may be given through Chance's ultra-violet filter and a glass lens: rays of wave-length longer than 3000 Å are the most efficacious for this purpose.

Case of Blepharitis.—Case 64. Boy, aged 6 years, had suffered from blepharitis for over a year, and the condition had not responded to medicinal treatment. General ultra-violet irradiation was given with quartz mercury vapour lamps and with carbon arcs. No protective goggles were worn during treatment, but the child kept his eyes closed. Three exposures weekly were given for three weeks, and at the end of this time the condition was greatly improved and the general health of the child was considerably better. He was eating and sleeping better than he had done for several weeks. After six further applications he was discharged as cured.

Conjunctivitis.—Case 65. Two applications of the small quartz compression applicator attached to the "Kromayer" lamp, to each closed upper eyelid for thirty seconds, immediately relieved the marked photophobia.

DISEASES OF THE THROAT

Radium and X-ray ulcerations of the tongue, lips and mucous membrane have been cured by concentrated carbon arc radiation. Care should be taken not to provoke a severe reaction, because this causes great discomfort to the patient.

Acute Pharyngitis.—Any cause, such as accessory

sinus infection, nasal or tonsillar disease, tuberculosis, or syphilis, should be looked for and, if possible, dealt with. Direct irradiation by means of the "Kromayer" lamp is often helpful. A quartz applicator should be used and exposures of two minutes given at first, or a metal speculum may be fixed to the hood of the air-cooled lamp.

The "Landeker-Steinberg" lamp is also convenient for treating these cases. It is an arc lamp enclosed in a metal housing, to which various metal specula can be attached. The dosage depends entirely on the type of electrodes used, varying from five minutes with polymetallic or tungsten-cored carbons to thirty minutes or more with plain carbons.

Chronic Pharyngitis, in its varying forms, may also be treated in this way, and good results have been obtained.

Acute Tonsillitis.—Rest in bed should be prescribed together with ordinary medicinal treatment. A strong dose of ultra-violet radiation with the "Kromayer" lamp, using compression, directly applied to the affected tonsil, will generally give relief and reduce the inflammation. If given at the beginning of an attack the condition may be aborted.

Radiant heat applied to the neck is useful for its sedative action, and the production of small localized areas of erythema on the neck is valuable as a counter-irritant.

Chronic Tonsillitis.—The use of ultra-violet radiation is limited in this condition.

If tonsillectomy is refused irradiation should be tried.

Edematous enlargement of the tonsils will clear up under ultra-violet radiation, but its effect on true hyperplasia is limited. A certain amount of fibrous change follows heavy dosage, but the method is not entirely satisfactory. Denman combines the use of X-rays and ultra-violet radiation, applying local and general irradiation.

Diphtheria.—Infection carriers of this disease may be treated by means of the water-cooled lamp.

Donnelly treated 40 diphtheria carriers with ultra-violet radiation, and 20 of these were cured after the first application, 16 after two applications, and 4 after three. Lautenschläger and Adler do not consider this possible. Pfeiffer has found only a transient decrease of bacilli after treatment with ultra-violet radiation. The shape of the throat makes it difficult to rid it thoroughly of these germs. Leicher has designed a large, slightly arched quartz applicator for attachment to the "Kromayer" lamp, by means of which pressure treatment of the tonsils can be carried out. It can also be used in non-malignant ulcerations of the tonsils. We have treated only one case ourselves (Case 66), a child, whose condition proved most refractory to ordinary treatment, swab after swab being positive. On 6th September 1927, (1) we irradiated both tonsils for two minutes with a metal speculum attached to the "Kromayer" lamp, and used the Cemach quartz applicator for a further period of thirty seconds, and (2) we irradiated both nostrils for two minutes by means of the metal nasal speculum attached to the "Kromayer" lamp. On 10th September 1927 both

tonsils were red and angry-looking. On 15th September 1927 they had healed, and a swab was taken and found to be negative. No further trouble was experienced.

Laryngitis: Acute Catarrhal Laryngitis.—General irradiation is useful, and relief is also often obtained by means of diathermy applied to the neck. Local

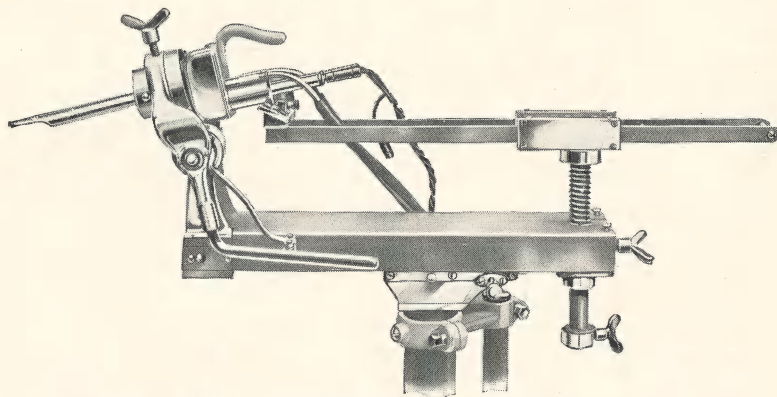


FIG. 251.—The Cemach "Photostat" Mount for the "Kromayer" Lamp.

treatment may be given with special curved applicators. *Chronic Laryngitis* is described under tubercular laryngitis on pages 439-443.

Spasmodic Laryngitis clears up under general ultra-violet baths. Strandberg considers that the quartz mercury vapour lamp is more useful than the carbon arc in this condition, because the heat given off by the latter may cause violent attacks of laryngospasm during treatment. In severe cases from 0.25 to 0.5 grm. of chloral hydrate may be given shortly before treatment to avoid psychic shock. The calcium content of the blood, which is usually

diminished, is rapidly raised to normal, and the condition usually clears up after about eight applications.

DISEASES OF THE NOSE

In all nasal conditions thorough cleaning of the parts before irradiation is of course essential, and all mucus and crusts must be removed.

Acute Rhinitis and Coryza.—Varying results are obtained in these conditions. Either the air-cooled or water-cooled lamp may be used. We have had very satisfactory results with our special applicators attached to the former, and exposures of from two to ten minutes may be given.

An attack of this annoying complaint can often be aborted if the nose is irradiated at the commencement.

If the water-cooled lamp is used, Cemach's quartz applicator should be used with it.

It must be remembered that the rays emerge only from the tip of the rod, and therefore, to expose the whole mucous membrane of the nose, the rod must be first inserted as far as possible and an exposure given, and then drawn out almost to half of its length and another exposure given, and, finally, the third application to that nostril should be given with the applicator almost entirely drawn out. Each nostril should be sprayed with a ten to twenty per cent. solution of cocaine before any attempt is made to introduce the applicator.

Some workers claim that they obtain better results by treating the mucous membrane of the nose with intra-nasal tampons of colloidal silver before applying ultra-violet radiation.

Thormetz uses galvanism in these cases, the positive electrode being attached to a copper wire round which is wrapped cotton soaked in a non-irritant germicide. Good results are obtained by this method, some cases being cured by one application.

A course of general irradiation should be given in conjunction with local treatment.

Acute Purulent Rhinitis can also be treated by one of the methods mentioned above, with good results.

Chronic Nasal Catarrh makes demands on the time and patience of both doctor and patient. But good results are often obtained.

We recently asked Cemach whether he got good results in the ultra-violet treatment of chronic nasal catarrh, and were surprised when he said that, apart from accessory sinus trouble, the condition was unknown in Vienna. This, unfortunately, can by no means be said of Britain.

Chronic Atrophic Rhinitis or Ozæna.—Any inflammatory focus in the accessory sinuses, mouth, or fauces must be eradicated before treatment of the ozæna can be commenced. General disorders, such as syphilis or tubercle, should be looked for. Good results have been obtained by means of ultra-violet radiation. Crusts and discharge should be removed before irradiation, and some workers first swab out the nasal passages with a 2 per cent. solution of mercurochrome. Our applicator may be used attached to the air-cooled mercury vapour lamp in this condition, or Cemach's applicator with the water-cooled lamp. A few applications are sufficient to remove the characteristic odour. Permanent cures can be obtained in

the early stages, when there is only a moderate amount of atrophy of the mucous membrane. Ultra-violet radiation, even in very bad cases, will always relieve the pain and stop the smell. When syphilis is present the results are not good.

We have had very satisfactory results in the cases we have treated. Irradiation should be given twice or thrice weekly, with gradually increasing doses. Strong doses of unfiltered rays are necessary.

Eczema of the Nose may be treated with ultra-violet radiation. The treatment of tubercular conditions of the nose has already been described.

Vasomotor Rhinitis or Hay Fever.—All cases of this distressing condition, which is so very resistant to many different forms of treatment, should be submitted to a course of both general and local ultra-violet treatment. The results are very encouraging, although failures occur. About 80 per cent. of cases are cured, and most of the remaining 20 per cent. are considerably improved. A thorough search should be made for any possible cause, and any deformity or local focus of infection in the nose or throat should be treated. In intractable cases it is often advantageous to apply diathermy to the nasal mucous membrane by means of the Oudin terminal, so as to eradicate any sensitive area.

There are two types of hay fever—perennial and seasonal. The perennial type persists, with intermissions, throughout the whole year. The seasonal type appears only for a definite period each year, generally during the summer months, and varies slightly in different patients. The two conditions are very similar

in ætiology and treatment. In both of them there is often an abnormally low amount of calcium in the blood, but this is more marked in the perennial type. Any systematic disease or disordered functioning of metabolism should be looked for, and, if possible, remedied. A prolonged course of general ultra-violet irradiation should be given to increase the blood calcium content and, at the same time, thyroid gland, or, preferably, small doses of parathyroid gland, with calcium lactate, should be given by the mouth.

In the seasonal type, treatment should be commenced four to six weeks before the onset of the condition is expected.

Local ultra-violet treatment of the nasal mucosa should also be carried out. For this purpose Cemach adopts the same procedure as he uses when treating ozæna or acute rhinitis, excepting that in these cases of hay fever the rays are filtered through blue Uviol glass. We also use our own applicator, which provides conveniently for the irradiation of both nostrils simultaneously with the air-cooled lamp.

Treatment should be given each day for one week, beginning with an exposure of three separate areas in each nostril for one minute, using Cemach's applicators; each nostril is thus irradiated for three minutes.

If there has been no excessive reaction, an exposure of two minutes is given to each separate area on the second day, and the exposure is increased by one minute daily, until, on the seventh day, a total exposure of twenty-one minutes is given to each nostril.

With the ordinary "Kromayer" lamp it is simplest to place the quartz applicator in position first, and then to attach it to the lamp. With Cemach's

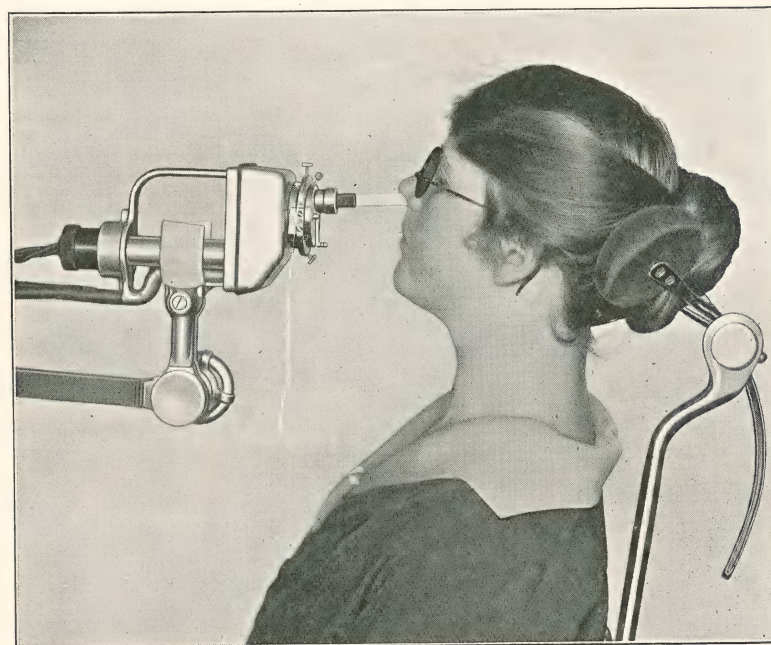


FIG. 252.—Our "Kromayer" Lamp fitted with Dr Cemach's Nasal Applicator being used for the Irradiation of the Nose. The use of the Adjustable Head-Rest should be noted.

"Photostat" it is possible to introduce the applicator while it is attached to the lamp.

Case 67 was an interesting case of a school-mistress who had been a martyr to hay fever for over thirty years. Before ultra-violet treatment she was using as many as thirty handkerchiefs a day. After five minutes' irradiation with the air-cooled

mercury vapour lamp, by means of our applicators, the hydrorrhœa greatly decreased; only one handkerchief was necessary during the subsequent twenty-four hours. After three applications in all there was no return of the symptoms.

In the following year a course of twelve general exposures was given, together with six local applications of the air-cooled lamp to the nasal mucous membrane. The patient remained free from the complaint for the first year in a period of over thirty years. In the next year no treatment was given, and no untoward results appeared.

Case 68. Female, aged 36. Hay fever commenced when she was nine years of age. It usually began about the end of May or the early part of June and lasted until the end of July. The nose had been cauterized and the membrane incised. Inoculations with autogenous vaccines had been given for four years. General treatment with the mercury vapour and carbon arc lamps was given on twelve occasions, and local treatment with the Cemach applicator on six. For the first time in twenty-seven years no symptoms of hay fever were experienced.

Case 69. Male, aged 40 years, had suffered from chronic nasal catarrh for two years, following a short sea voyage when he got very wet, and was unable to change his clothes. Seven exposures to both nostrils were made with the small carbon arc for from three and a half to seven and a half minutes. The catarrh did not occur again, and a year afterwards there had not been any relapse.

Epistaxis.—The coagulating effect of the rays

benefits epistaxis. A quartz rod should be introduced into the nostril.

General irradiation is very important in these cases.

Calcium lactate may be administered orally if there is a tendency to chronic bleeding.

Infection of the Accessory Sinuses.—In the acute stage Hollander and Cottle advise the combined use

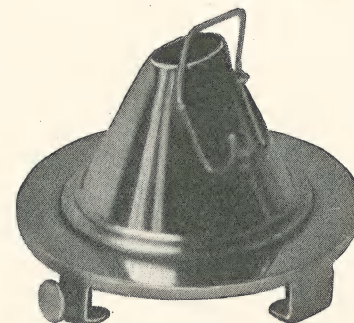


FIG. 253.—Vernon's Nasal Applicator, which can be attached to the "Kromayer" Lamp. It allows, however, only one nostril to be irradiated at a time.

of radiant heat and intra-nasal ultra-violet radiation. Later, diathermy over the affected sinus is useful when drainage is satisfactory.

In chronic sinusitis, when free drainage is established, diathermy combined with intra-nasal ultra-violet radiation is the treatment of choice.

General ultra-violet radiation should be given in all cases to improve the general condition of the patient.

Zinc ionization is of great value in stubborn cases.

DISEASES OF THE EAR

Eczema of the external ear and auditory canal, canal furunculosis, and chronic *Otitis media*, have all been treated with actinic radiation. Dr Cemach says: "My experience, which extends over more than one hundred cases, has convinced me that the quartz lamp has now provided us with a means of treating eczema in the ear much more successfully than we have been able to do in the past." He advises ultra-violet radiation in perichondritis, a condition which was previously treated unsuccessfully by making large incisions. By conjoint radiant heat and ultra-violet radiation he has been able to cure cases without deformity in from two to four weeks. Inflammation of the external ear, when ultra-violet radiation is applied, soon improves; the rays ease the pain, stop the inflammation, and promote resolution.

Case 70. We treated a case of perichondritis of the nose, which had recurred several times after carbon-dioxide-snow applications. Although only three exposures to the air-cooled lamp, of from five to ten minutes' duration at a distance of twelve inches, were given, improvement was noticed. During treatment the patient wore a child's mask, the eyeholes of which had been covered up, and from which an appropriate area had been removed to allow the lesion itself and the normal skin for about a quarter of an inch beyond it to be exposed. Unfortunately, the patient did not continue treatment.

Otitis media.—In acute *Otitis media* great benefit is derived from radiant heat. Two exposures of from

twenty to thirty minutes should be given daily. The pain is greatly decreased and severe cases may be aborted without damage to the drum of the ear if treatment is commenced early enough in the disease.

Chronic Otitis media.—When treating cases of chronic *Otitis media* a thorough search should first be made for any cause, such as adenoid growth, nasal or eustachian trouble, tuberculosis, or rickets. Mastoid involvement must also be looked for, and it is wise to ascertain whether there is caries of the bone by means of an X-ray examination; surgical aid is necessary if caries should be present. General irradiation should be a routine practice, and is of the utmost importance, especially for tubercular or rachitic children.

Ultra-violet radiation applied locally has given very encouraging results. Before irradiation is commenced the canal should be swabbed out with dry gauze, so as to remove any accumulations of discharge.

The rays may be applied by means of an ear speculum attached to the air-cooled mercury vapour lamp, or of a quartz speculum fixed to the "Kromayer" lamp. Cemach advises the use of the blue filter in the latter method.

György and Gottlieb recommend the oral administration of 0.1 gramme of Eosin Höchst in powder form before commencing irradiation, and claim that in this way a cure can be effected in half the usual time.

Hollander and Cottle advise the use of a 2.5 per cent. solution of mercurochrome as a sensitizer. The solution is instilled into the ear and allowed to remain for from five to fifteen minutes, after which the excess is wiped away, and irradiation, by means of the

"Kromayer" lamp, is commenced. The first exposure lasts only one minute, and each subsequent exposure is lengthened by half-a-minute, until, in some cases, the period is as long as ten minutes.

Kragh has published the results obtained by him in the treatment of 30 patients with ultra-violet rays applied by means of quartz applicators: 3 of these were suffering from catarrhal *Otitis media*, 15 from otosclerosis, 8 from the results of middle-ear suppuration, and 4 from *Otitis internus*. The last-mentioned did not show any improvement under treatment. Two of the three patients suffering from catarrhal *Otitis media* showed no improvement, but the third, who had been treated by catheterization for ear noises without effect for several months, was completely cured of this distressing symptom after two and a half months' treatment with unfiltered quartz lamp radiation. Eleven and a half months later no recurrence was observed.

Eight of the fifteen patients suffering from otosclerosis did not respond to ultra-violet radiation, but the remaining seven were greatly improved. One patient showed particularly marked improvement; his head noises disappeared entirely and his hearing became normal. Improvement was noticed in all of the eight patients suffering from middle-ear suppuration. Discharge was lessened, hearing improved, and head noises diminished. Leicher obtained improvement in otosclerosis by means of general ultra-violet irradiation: the head noises were lessened, and he attributed the slight improvement observed in hearing to this fact. Cemach, on the other hand, has not found cases

of otosclerosis respond favourably to irradiation. Zinc ionization is often of value in these cases.



FIG. 254.—Sixteen Children being Irradiated simultaneously in a special Ultra-Violet Room. The first exposure given is generally five minutes at a distance of three feet from each burner. This is gradually increased to a maximum of twenty minutes.

Mastoiditis.—Radiant heat is the treatment of choice in the acute stage: many cases respond to it, and operation may not be necessary if treatment

is commenced early enough. When surgical interference has been necessary, ultra-violet radiation is useful to hasten the healing of the wound or to clean up a wound in which secondary infection has occurred. For this purpose unfiltered radiation is useful, but where granulations are present and stimulation of epithelial formation is required, very carefully regulated doses of blue filtered radiation should be given. Before the lesion is irradiated the surrounding skin should be protected.

General ultra-violet treatment is of the utmost importance in all these cases.

USES OF ULTRA-VIOLET RADIATION IN DENTAL PRACTICE

Ultra-violet radiation, which is exceedingly valuable in dentistry, can be employed in two different ways by the dental surgeon. Irradiation may be: (a) General; (b) Local.

The typical appearance of the teeth in cases of congenital syphilis is an example of the way in which a generalized disease can profoundly influence their structural development. There is a very intimate relationship between the teeth and the osseous system, and so the action of ultra-violet radiation in stimulating calcium metabolism is very useful in dental diseases. Rickets, a disease for which ultra-violet radiation is a specific remedy, is very common among our town-bred children and is one of the commonest causes of retarded eruption and maldevelopment of the teeth.

It has been found that the irradiation of rachitic children markedly accelerates the eruption of teeth. It is obvious that general irradiation will also benefit other conditions due to inflammation or imperfect development of bone, such as osteomyelitis and osteoporosis, and that it will also stimulate healing in fractures of the jaw. The occurrence of extensive and rapid dental caries is exceedingly common during pregnancy and lactation, when the growth of the child makes such a heavy drain on the calcium reserve of the mother. In some cases, a condition known as osteomalacia may even occur: the deprivation of the maternal lime salts so weakens the bones that they are unable to bear the weight of the body without bending.

The prophylactic value of ultra-violet radiation in dentistry is strikingly shown by the results of an experiment carried out in the United States by Pacini. He kept three hundred children under observation for a year and carefully noted the condition of their teeth. They were all fed on exactly the same type of food, but half of them were given frequent exposures to ultra-violet rays, and the remaining half were not. At the end of the experiment an extraordinary difference was found in the teeth of the two groups; practically no development of dental caries had taken place in the teeth of the irradiated children, but the condition of those of the non-irradiated children had become very much worse.

Mellanby has recently confirmed the fact that exposure of the body to ultra-violet rays greatly improves the calcification of the teeth, and

considerably lessens the risk of subsequent dental caries.

Calcium salts lessen the permeability of the lymph and blood vessels, and their presence in adequate quantity is essential to ensure clotting when there is bleeding. General ultra-violet irradiation is, therefore, of great value in the prophylactic treatment of hæmophilia, a condition which can be a source of great worry to the dentist when he is faced with the necessity of performing an extraction. General irradiation also raises the resistance of the body to infection by micro-organisms, and is therefore invaluable in any infective condition. The tonic action of the rays is useful in cases where dental caries has taken place during some prolonged illness. The stimulating action of ultra-violet radiation on several of the endocrine glands has already been referred to, and there is little doubt that in this way the development and calcification of the teeth is influenced to a considerable extent.

General irradiation can be carried out with the carbon, quartz mercury vapour, or tungsten arc, as described in the chapter on technique.

Local ultra-violet treatment is also beneficial in dentistry, and there are several lamps which have been specially designed for the purpose. The best known are the "Arnone" carbon arc, the "Pashler" water-cooled tungsten arc, and the "Densolarc" air-cooled tungsten arc. These have already been described in Chapter IV.

The "Kromayer" lamp is also frequently used in dental practice, and so too are the special dental

quartz high-frequency electrodes made by Gallois. Local treatment in dentistry can be employed with advantage for the following :

- (1) Bleaching discoloured teeth.
- (2) Relieving pain in erupting wisdom teeth, after root-filling, after extractions, and in hypersensitive conditions of the dentine.
- (3) Gingivitis (catarrhal, marginal, interstitial), stomatitis (simple catarrhal, aphthous or vesicular, ulcerative), Ludwig's angina, acute superficial glossitis, sinuses and fistulæ in the mouth.
- (4) Oral cicatrices.
- (5) Periodontitis (acute and chronic), and periodontal abscess.
- (6) Infective alveolar osteolysis.

To obtain beneficial results with local irradiation optical contact should be obtained—that is, there must be no opaque material interposed between the source of radiation and the site of infection undergoing treatment, although it is obviously very difficult to ensure this in many cases.

It is quite safe, as a general rule, when applying ultra-violet rays to the mucous membrane of the mouth, to give, at the first exposure, twice the dose which produces erythema on the skin. Quartz applicators are invaluable in some conditions for dehæmatizing the tissues and allowing the rays to penetrate more deeply, but metal or porcelain speculæ are also often used. They confine the radiation to the affected area and protect the adjacent tissues.

Ultra-violet rays may be used locally for their

bactericidal properties : all surface bacteria are killed by them, but their limited power of penetration prevents them from securing satisfactory disinfection of the mouth. The good results which follow the ultra-violet treatment of diphtheria carriers are probably due to the intense inflammatory reaction resulting from effective irradiation. Anilin dyes are often used in conjunction with ultra-violet radiation. Eosin, gentian violet, brilliant green, fluorescein, crystal violet, and cyanosine are the most frequently used. They may be painted on the area which it is desired to treat, or they may be injected subcutaneously. The solution most commonly employed is : anilin dye, 2 parts ; distilled water, 50 parts ; and alcohol (95 per cent.), 50 parts.

Capillary attraction and absorption ensure the impregnation of the periodontal membrane with the photosensitive solution, and it may finally even penetrate as far as a periapical abscess.

With the "Kromayer" lamp treatment every other day is advised, special quartz applicators being used to render the tissues anæmic and localize the rays, which should be applied to both the facial and the lingual surfaces of the gums.

A first exposure of one minute is generally given to each area treated, a second of two minutes, and so on, an extra minute being added at each application.

If a blister should happen to form, a week is allowed to elapse, and the last dosage given is repeated.

Dr Galbreath, of Montreux, demonstrated the "Arnone" lamp to us in 1925. He has used it successfully in several different conditions found in

the mouth, and prefers it to the "Kromayer" lamp for dental work, because he finds that, unlike the "Kromayer," it does not set up an intense reaction.

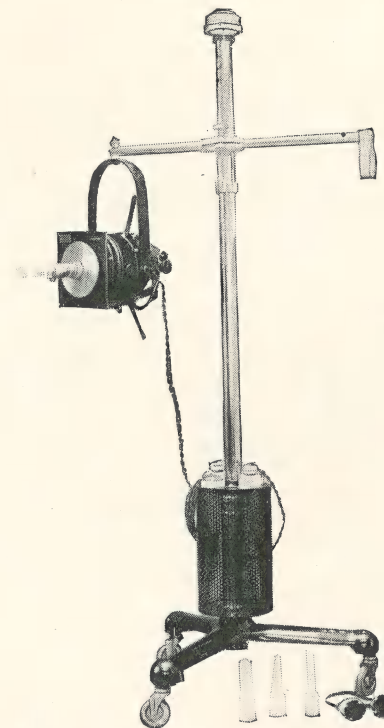


FIG. 255.—The "Arnone" Stand Model of Carbon Arc Lamp taking 3 to 8 amperes D.C. or A.C. This Lamp is designed for Dental Treatment.

Gingivitis, Glossitis and Stomatitis.—These cases may be (a) traumatic ; (b) secondary to systemic conditions ; or (c) of the infectious type.

Those due to trauma are generally caused by mechanical irritation, and often follow the use of a

badly fitting denture. The exciting cause must obviously be removed before irradiation is commenced. Ultra-violet rays have a valuable regenerative action in these cases.

General ultra-violet radiation is a valuable aid in



FIG. 256.—The "Uviarc" Water-cooled Mercury Vapour Lamp being used with a curved Quartz Applicator for Irradiation of an area on the Lingual Surface of the Gums.

the treatment of cases due to some systemic condition, such as lactation, pregnancy, scurvy, tubercle, syphilis, diabetes mellitus, or nephritis, as well as in cases where lead, mercury or iodides have been acting on the body for long periods. Cases of the infectious type generally respond favourably to combined general and local ultra-violet treatment.

Gingivitis may be acute or chronic, and catarrhal, ulcerative, or hypertrophic.

After irradiation, mastication and deglutition cause less pain, excessive salivation subsides, the breath becomes less offensive and the speech becomes clearer.

Rowlett records an obstinate case of gingivitis, of several years' duration, which was cured by three treatments of twenty minutes each with the "Landeker Steinberg" carbon arc.

Reed, in an article in *The Dental Magazine* of May 1922, describes various cases he has successfully treated with the "Pashler" water-cooled tungsten arc lamp, concentrating the rays through a quartz lens. He has found that ultra-violet rays have a considerable curative effect in cases of gingivitis.

A first application of two minutes to one area, gradually increased to ten minutes, will quickly cure gingivitis of local origin, if the original cause is first removed.

Ultra-violet radiation is excellent in marginal gingivitis occurring in adolescence, a condition which may lead to chronic periodontitis if not treated correctly. Talbot treats these cases solely by producing erythema over a circumscribed area on the front of the chest or abdomen. He finds also that adult cases benefit, but less markedly.

Cases of ulcerative gingivitis, Ludwig's angina, or trench mouth respond favourably to actinic treatment administered locally.

Galbreath describes a case of Vincent's angina, in which the first application of the rays from the "Arnone" lamp relieved the pain, and six subsequent applications effected a cure. His technique is four minutes' exposure of the front teeth and three

minutes' of the side, gradually increasing to five minutes, the applications being given every second or third day.

Apthous stomatitis, which so often occurs in rachitic children, can generally be cured rapidly by a short course of combined local and general treatment; the carbon arc is probably the most useful for the local treatment of these cases.

Ulcerative stomatitis is often cured after four or five applications. Tubercular ulcers of the tongue also do well, but, naturally, require prolonged treatment.

Pulpitis.—A condition where the rays cannot be used is in diseases of the dental pulp, an increase of pain being provoked in as short a time as thirty seconds. In fact, the rays can be used for establishing a differential diagnosis between the early stages of periodontitis and unsuspected pulpitis.

DISEASES OF THE PERIODONTAL MEMBRANE

Acute and Chronic Local Periodontitis.—Ultra-violet radiation may be useful in these cases owing to its bactericidal and sterilizing action, and on account of its stimulation of bone regeneration. Cases may be acute or chronic, and the inflammatory reaction may resolve with or without the formation of an abscess. When pus forms, it may remain circumscribed, or may point towards the surface. In acute lesions, counter-irritation, produced by ultra-violet radiation over the gums, will generally relieve the pain and may aid resolution. Early infective cases generally do well with irradiation. When an abscess has formed the condition should be localized by X-ray examination, and the state of the

tooth and its relationship with the abscess should be noted. It should be decided whether it is possible or prudent to endeavour to save the tooth. In the case of acute apical abscesses the abscess should be drained through the alveolar canal, which should then be thoroughly cleaned out, and an antiseptic dressing should be inserted for one or two days. Ultra-violet rays should be applied to the gums directly over the abscess cavity each day; they generally relieve the pain. Galbreath mentions a case of periodontitis in which there had been incessant pain for two days and two nights, and which was relieved by three and a half minutes' irradiation with the "Arnone" lamp.

Chronic Local Periodontitis may commence at the apex of the root or at the gingival margin of the tooth; and, in addition, there may or may not be fistula. Cases without fistula may be subdivided into those where the root canal is wholly occluded, and those where the occlusion is only partial. In the first type, Lake does not endeavour to establish drainage, but applies the rays directly over the gums in the immediate neighbourhood of the abscess, whereas in cases where the root canal is partly patent he drains and fills it. Good results are generally obtained in young children. In cases complicated by fistula the rays are first applied with a compressor to the fistulous opening, and then, when the sinus closes, the gums are treated in the usual way with compression over the labial and lingual surfaces.

Chronic General Periodontitis commencing at the Gingival Margin or Pyorrhæa Alveolaris.—At present there are great discrepancies between the results

obtained by different observers in the treatment of pyorrhœa alveolaris. X-ray examination of suspected teeth is, of course, essential. Then thorough, deep scaling should be carried out, and followed by the establishment of drainage, after which ultra-violet radiation should be applied at each space between adjacent teeth on the labial and lingual surfaces of the gums; exposures should be made twice weekly, and only two teeth should be treated at one sitting. During treatment cotton rolls may be used to absorb the saliva.

In successful cases the pus disappears after two or three applications, the œdema of the gums subsides, and the teeth gradually become firmer. The best results occur in the early stages, when the periodontal membrane is not destroyed. General and local irradiation should be given.

We must confess that our own results in the few cases of pyorrhœa we have treated have not been very satisfactory.

Oral Cicatrices often cause great difficulty in opening the mouth; speech is affected and mastication impeded. The "Kromayer" lamp fitted with a quartz applicator is generally used for treatment, and doses of three to twenty minutes should be given. The scars usually become softer after a few weeks' treatment.

Relief of pain in erupting Wisdom Teeth or after Root Filling and after Extraction.—In these cases the gum above and around the tooth is irradiated as well as the cavity, if one is present, and erythema is produced.

In the treatment of cavities the bactericidal action of

the rays is valuable, and pain is relieved by the well-known analgesic effect of the rays. Cases of delayed eruption are benefited by intense local irradiation on the gums over the non-erupted tooth.

For Whitening Teeth.—The use of actinic rays for whitening live teeth provides a method free from the risk of causing decalcification or irritation of the gums or dental pulp. The tooth which it is desired to whiten is first isolated by means of a rubber dam. Next, a piece of cardboard is provided, with a hole in it corresponding in size to that of the patient's open mouth. The protective rubber is attached to this cardboard. The tooth is then moistened with hydrogen peroxide, which must be free from any acidic impurities, and the actinic rays are directed on to it for periods varying from ten to sixty minutes, as may be required. Usually ten minutes is quite long enough. Two or three treatments are generally all that is necessary.

Most stains of organic origin can be removed in this way, but metallic discolorations are not affected.

Veterinary Uses of Ultra-Violet Radiation.—Ultra-violet radiation is being used more and more extensively in the treatment of animals in a similar way to that employed in the treatment of human beings. For experimental work small animals, such as rats, mice, and guinea-pigs, were used, but now stock animals are being irradiated on a much larger scale, and very encouraging results have been obtained.

A recent example of the prophylactic use of ultra-violet radiation has been the installation of

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ultra-violet apparatus in the new monkey-house and reptile-house at the London Zoological Gardens.

Professor Cinotti, of the Naples Veterinary School,



FIG. 257.—A special Carbon Arc Lamp designed for Irradiation of Chickens. Any falling pieces of Carbon are caught on a Vitaglass Tray which is suspended below the Arc. The mortality of young birds has been greatly lessened by the use of Ultra-Violet Rays.

has found ultra-violet radiation very useful in cases of parasitic dermatitis, such as mange. We have recently cured a cat suffering from mange with ten applications of the rays.

Cases of acute and chronic eczema in animals have

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responded well to ultra-violet radiation, and indolent wounds and ulcers have been stimulated to heal.

Orr, Henderson, and Crichton, of the Rowett Research Institute, Aberdeen, consider that ultra-violet

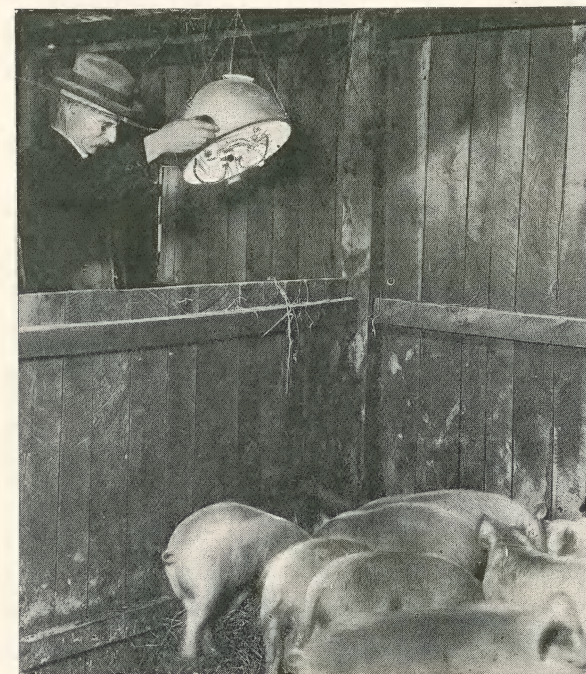


FIG. 258.—Irradiation of Pigs with a "British Hanovia" Quartz Mercury Vapour Lamp.

radiation is of as much interest to the stock farmer as to the medical practitioner. They carried out extensive experiments on young pigs, and found that irradiation of young animals nine weeks old, by means of a carbon arc lamp at three feet distance for one hour daily, produced a marked increase in the retention

of calcium and phosphorus as compared with that of control animals. Young pigs, owing to their rapid development, are very liable to contract rickets, but exposure to ultra-violet radiation both cured and prevented this disease even when the animals were on



FIG. 259.—Irradiation of Poultry with a "British Hanovia" Quartz Mercury Vapour Lamp. (From *The Poultryman*.)

an ill-balanced diet. The weight of the irradiated pigs increased much more rapidly than the weight of those kept in dark pens.

These workers consider that in many cases the expense incurred in the installation and upkeep of ultra-violet apparatus by pig breeders would be more than balanced by the prevention and cure of rickets among their stock.

Another valuable use of ultra-violet radiation is its beneficial effect on lactating animals, such as cows and goats. The absorption of calcium and phosphorus is greatly increased, a negative balance, in many cases, being converted into a positive one. Irradiation increases the amount and quality (antirachitic property) of the milk, and, in addition, maintains the breeding power of the animals, and increases their resistance to disease, both of which are diminished after heavy calcium drainage.

Chickens are very susceptible to rickets and derive great benefit from ultra-violet irradiation. At the Rowett Research Institute, one group of chicks receiving no sunlight died off in six weeks, the average weight being 100 gm. The "all-day sunlight group," on the other hand, attained a weight of 250 gm. in eight weeks. Hens need large amounts of calcium for producing eggs, and the absorption of calcium salts is increased by exposure to ultra-violet rays.

Hughes and Payne have proved that with ultra-violet irradiation, egg production, hatchability, and percentage of calcium in the shell and in the egg itself, are all increased. Ultra-violet radiation benefits animals generally in the same way as it does human beings, and it is being used extensively in order to improve dogs and other animals for show purposes.

It is hoped that the reader will have appreciated, from a perusal of the foregoing pages, the value of ultra-violet radiation in many varying conditions.

In some its action is almost specific, and in the great majority it is an invaluable adjuvant supplementing other forms of treatment.

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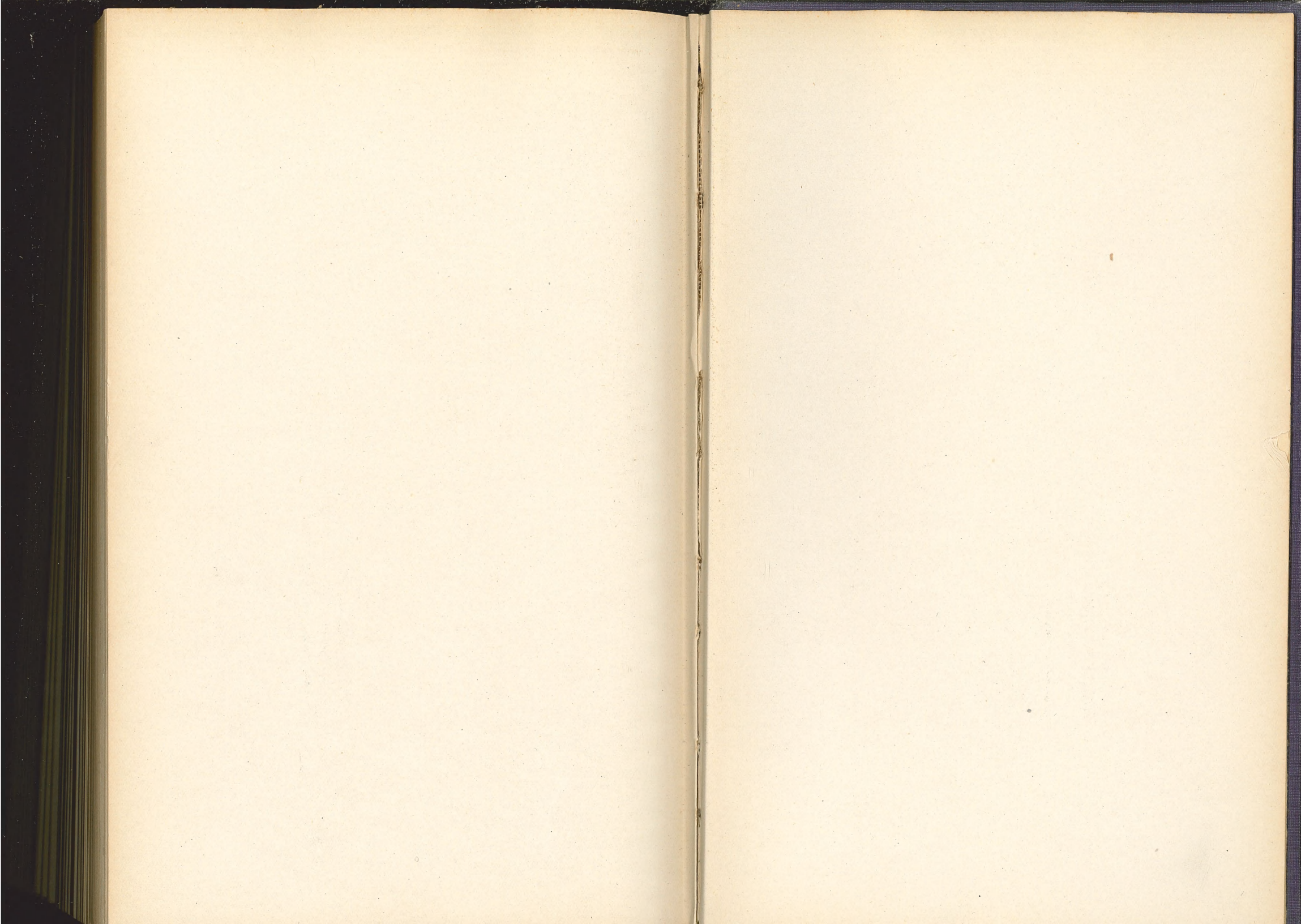
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