ULTRA-VIOLET RAYS

Their Application in the Practice of Dentistry

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1929

RANGE OF ELECTROMAGNETIC WAVES

Octaves Uniform Velocity of 30,000,000,000 centimetres per second.

LE RAYS 1 Octave

om hot bodies & emitted by ionised gases.

ensation of light. (b) Photography.

action. (d) Photo-electric effects.

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RAYS

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HERTZIAN WAVES
28 Octaves

INFRA-RED RAYS
9 Octaves

Generation
Heat radiations from hot body.

Detection
(a) Heating effects on thermo-couples & on bolometers.
(b) By rise of temperature of receiving body.
(c) Photographic effects on special plates.
(d) Can be reflected & refracted by comparatively coarsely ruled gratings.

SHORT HERTZIAN WAVES
17 Octaves

Generation Spark-gap discharge. Oscillating Triode-valve.

Detection
(a) Coherer.
(b) Spark across minute gap in resonant receiving circuit.
(c) Can be reflected, refracted & diffracted.

USED IN WIRELESS
11 Octaves

Generation Spark-gap discharge. Oscillating Triode-valve.

Detection
(a) Coherer.
(b) By conversion into alternating current which can then be detected or measured.
(c) By rectification, with or without "heterodyning", & production of audible telephone signals.

SLOW OSCILLATIONS CORRESPONDING TO VERY LONG WAVES

Generation
Coil rotating in magnetic field

Detection.
(a) Mechanical.
(b) Electrical.
(c) Magnetic.
(d) Thermal effects of alternating currents.

SOLAR RADIATION
Limiting Wave Lengths reaching the Earth

B.B.C. RANGE CHELMSFORD

Wave Lengths in Ångström Units

4000 8000 1×10^{6} 4×10^{6} 1×10^{11} 3×10^{12} 5×10^{12} 1.6×10^{13} 3×10^{14} 3.5×10^{16}

Wave Lengths in Centimetres	Approximate Frequencies
0·000 02	375 000 000 000 000
0·000 08	94 000 000 000 000
0·000 32	23 500 000 000 000
0·001 28	5 900 000 000 000
0·005 12	1 460 000 000 000
0·0205	366 000 000 000
0·0819	91 500 000 000
0·328	23 000 000 000
1·31	5 730 000 000
5·24	1 430 000 000
21·0	358 000 000
83·9	89 000 000
336	22 400 000
1342	5 590 000
5369	1 400 000
21 470	350 000
85900	87 300
343 600	21 800
1374 000	5 460
5 498 000	1364
22 000 000	341
88 000 000	85
352 000 000	

Fig 1.

RANGE OF ELECTROMAGNETIC WAVES

62 Octaves Uniform Velocity of 30,000,000,000 centimetres per second.

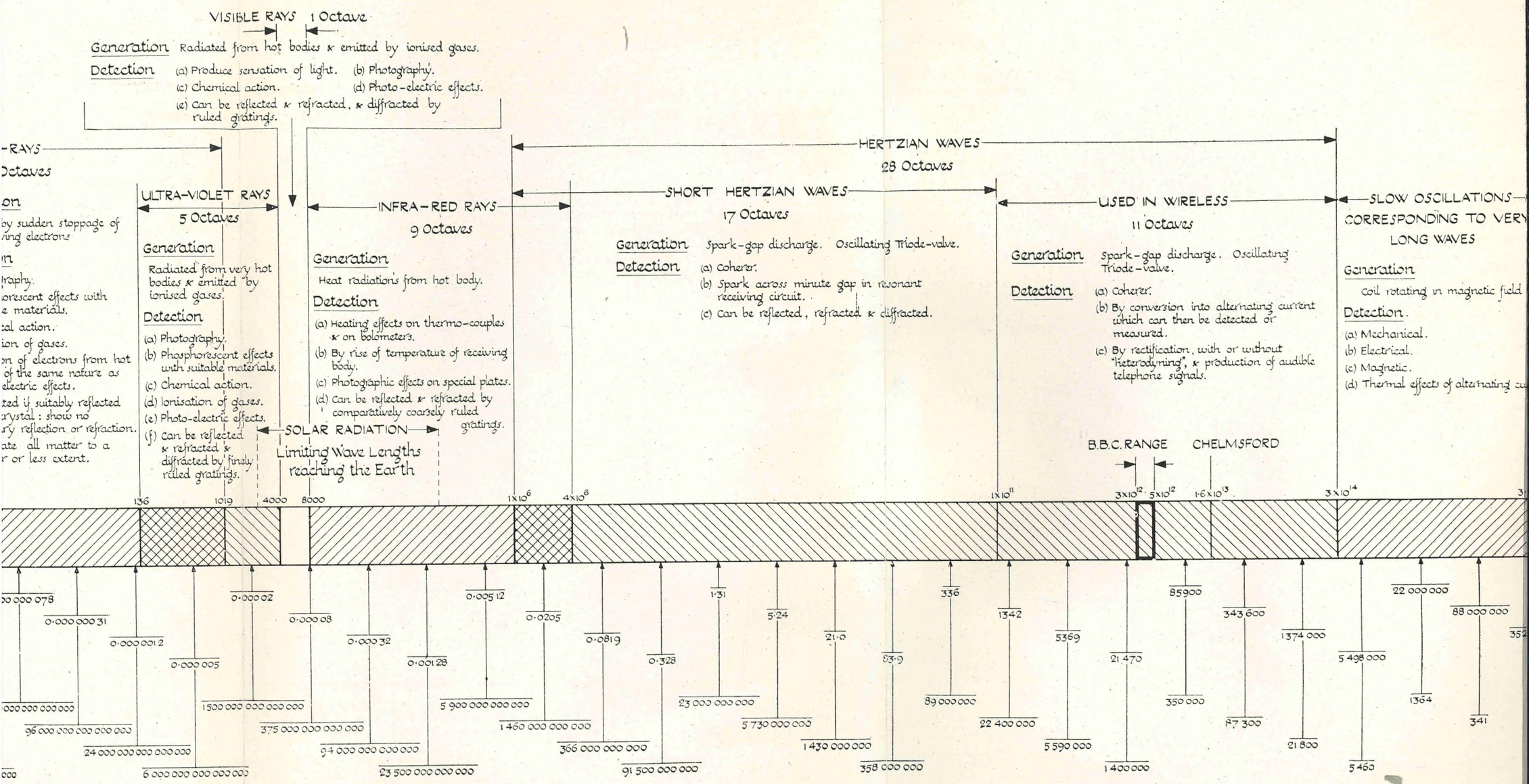
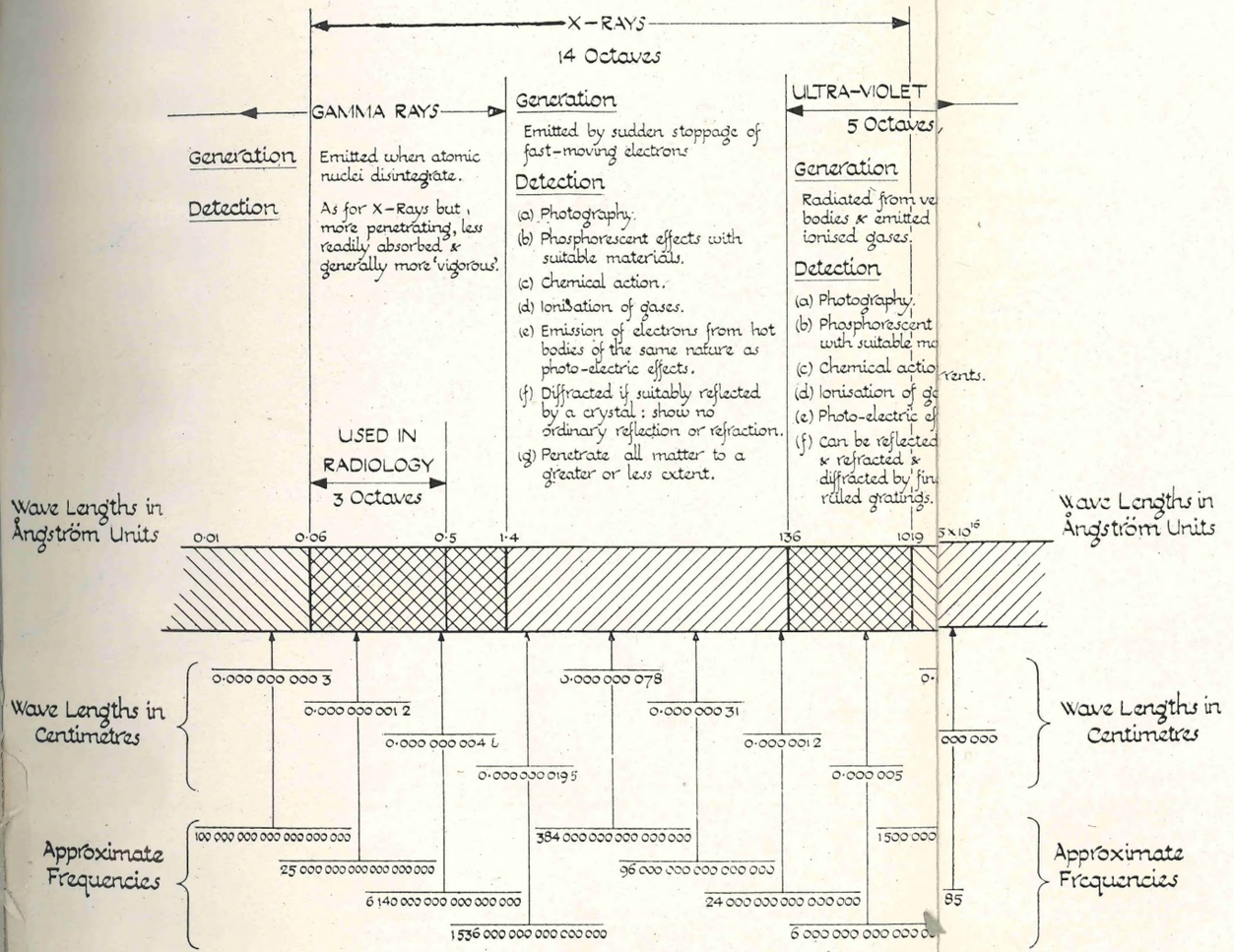


Fig 1.

VISIB

Generation Radiated fr

Detection (a) Produce
(c) Chemical
(e) Can be r
ruled gr



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CONTENTS

PREFACE.

A. E. WEBSTER, M.D., D.D.S., F.A.C.D.

In presenting this brochure on the ultra-violet rays, the author has placed the dental profession greatly in his debt. Just at this time, when extravagant claims are being made for the rays, a steadying hand was needed. On the other hand, he points out clearly the value of the rays when properly applied. He again enunciates the foundational principle in all treatment that a part cannot be successfully treated without a consideration of the whole. So the chief value in the ultra-violet ray treatment is the establishment of a general well-being of the patient, and through this hope to prevent pus pocket formation, irregularities of the teeth, dental caries, pus infections and general disease. The conclusions arrived at are very comforting, and again direct our minds into the scientific channels at the base of successful treatment. The work of the author as presented here can be used as a yard stick for the dental profession to measure the value of the ultra-violet ray in their own practises. The author has sought all sources of information and tested it alongside of his own observations.

The bibliography is not the least valuable portion of the brochure. It indicates the width of the search for truth, and makes it easier for those who follow.

ACKNOWLEDGMENT.

I have had the honour of being associated with Dr. William E. Cummer in assisting to revise some of his notable research articles on prosthetic dentistry. It was during this intercourse that Dr. Cummer was consulted regarding the application of the ultra-violet rays in the practise of dentistry, and it was at his suggestion that the present bulletin was written. His assistance is gratefully acknowledged.

I also wish to express my indebtedness to Dr. Trevor Owen, F.R.C.P., of the staff of the Toronto General Hospital, for his revision of the proof sheets.

HISTORY

IT may readily be supposed that in the early existence of animal life, both man and beast, by basking in the sun, instinctively made use of solar radiation for the sense of well-being it produced.

In the natural course of events history would show that the human race existed some considerable time before a conscious study was made of the relationship that existed between solar radiation and the life, health, and growth of animals and plants.

Records bear witness that the Greeks of old knew of the healing powers of the sun's rays. That the Romans were fully alert to the advantages to be derived from basking in the sun is evidenced in their architecture, by their building solaria in connection with their dwellings.

In the first century of our era Celsus and Galen advocated the employment of the sun's rays in treating certain diseases. From the first to the eighteenth century medical literature has preserved records of the uses made by the profession in adopting the healing properties of the sun for the purpose of alleviating certain maladies. It is interesting to note that in the eighteenth century a distinction was made between the sun's visible rays, and those rays beyond the red rays, that is to say the rays outside the visible spectrum. Thomas Finneus made use of a lens to concentrate the sun's rays for the purpose of cauterizing. That is he used the heat producting rays—the infra-reds. A few years later Walter Harris used for medical purposes ground or powdered clam shells which had been exposed to the sun's action for a long time. He found that by administering this powder in certain cases (probably tetany) that beneficial results followed. Doubtless these were maladies due to a lack of calcium in the blood. A little later Schale, in the course of his experiments, learned that the rays at the extreme end of the violet spectrum exhibited a chemical property by their action of darkening silver nitrate.

In the beginning of the nineteenth century more interest in the use of sun treatment was aroused in the medical profession owing to the benefits received by patients. Toward the middle of the century a sun clinic was opened in Austria, at Vildes, for the purpose of treating diseases, as well as restoring the sense of the general well-being of the body. Later, in 1902, Dr. O. Bernhard of St. Moritz, Switzerland, obtained encouraging results in treating suppurating wounds by using solar radiations. The treatment of tuberculosis by exposing patients to the action of the sun's rays was receiving greater consideration and approval on account of the happy results obtained. This lead to the establishment of more clinics for the out-door treatment of this disease with sunshine. Many investigators were now working scientifically on the spectrum of the sun's rays, and it was Charcot who first enunciated the finding that the rays beyond the violet region of the

spectrum were essentially chemical in character. He drew attention to the fact that the light produced by an electric arc, if passed through a plate of uranium glass, did not produce erythema* of the skin for the reason that glass absorbs the ultra-violet rays, especially the shorter ones. He also called attention to the similarity of the erythema produced by the arc light and the sun's rays. It was thought that the inflammation produced by the sun was due to the heat rays, but Widmark, of Stockholm, showed, in 1880, that the condition was due to the chemical rays of the sun. Bernhard, in 1917, points out the connection between sunlight and bone formation, attributing to seasonal conditions the appearance of rickets in a little village of Switzerland, where winter lasts nine months. He says that children born in autumn who remain indoors all winter develop rickets, while those born in the spring and who enjoy the advantages of the sun's rays escape the malady. In 1922, in Toronto, it was demonstrated that metabolic changes of the body were favourably affected by the energy of actinic rays.

And, bringing the history to the present moment, almost daily reports show the recognition of the importance that the ultra-violet rays play in the life of the world.

In London, England, in the Zoological Gardens, where the most up-to-date reptile house has just been completed, there is provision made in the infirmary for ultra-violet ray treatment of the animals.

There appeared the other day a report on children's health in Chicago with the following heading:

"*Synthetic Sunshine is Beating Luminary in Building Children's Health in Chicago.*"

Synthetic sunshine in wholesale quantities, declared even more efficacious than the actual article, is building health and strength in hundreds of children at the Spaulding School for Crippled Children. An apparatus, said to be the world's largest mercury-quartz lamp and the only one of its kind, has been constructed there, and administers treatment at the rate of 150 children an hour.

After tests and experiments for two weeks the equipment was demonstrated recently to a group of scientific and medical experts by Dr. Benjamin Goldberg, director of the municipal tuberculosis sanitarium, and designer of the machine.

The chief feature of the contrivance is an automatically moving platform that carries the children through at a rate designed to give each small group the prescribed dosage of ultra-violet rays. Six large mercury-quartz lamps are ranged, three on each side, giving radiation to every part of the body.

Each of the small patients wears a minimum of clothing for his daily sunshine bath and colored goggles to protect his eyes from the glare of the lamps.

* See description of different degrees of erythema under section on technique of application.

The following is a report from Guy's Hospital, London, England, respecting the nurses on night duty:

Artificial Sunlight for Night Workers.

Nurses on night duty, and there are hundreds of them, as can be imagined, have been found to suffer sadly through lack of sunlight. Even in the best weather they can secure little, spending as they do the major part of their time off-duty in rest. The general rule is for them to take a short constitutional after coming off duty, then retiring until time to start their work again. Guy's Hospital has devised a most successful means of repairing the lack of the sun's rays. Artificial sunlight baths are taken, three times a week, by the nurses at this hospital, with most beneficial results. Other hospitals, it is expected, will follow suit, and perhaps night workers in different professions will seek the treatment.

The vital importance of sun baths in preventing and curing disease, particularly in infants and growing children, and the accompanying need of avoiding dangerous burning, are stressed in a health bulletin prepared by Dr. C. J. O. Hastings, Toronto's Medical Officer of Health.

He points out that the medical properties of ultra-violet rays of sunlight are practically eliminated by ordinary window glass, clothing, fog, smoke, dust, and by the cold of the northern hemisphere, and that children and persons living in the north, especially in cities, are robbed of the valuable elements of sunlight.

"Sunlight is a most important factor in the lives of growing children," he writes, "and treatment with sun baths if the weather will permit, should begin when they are about one month old. The normal growth of bone is primarily dependent on the food a child eats, food containing an ample supply of calcium and phosphorus."

At the American Medical Association to be held in Oregon of the present July, 1929, a report on the relation of ultra-violet rays and rickets will be made. Figures held to indicate that lack of sunshine is the direct cause of rickets in children and that under-nourishment is not a contributing cause have been compiled by the United States Children's Bureau.

It is a substantiation of the theory that the sun bath alone will give immunity from the juvenile bone disease.

SOLAR RAYS

An intelligent application of "Light Theraphy" requires some acquaintance with the constitution of the solar spectrum, and the significance of the different rays composing the spectrum. Matter is composed of atoms, and the atom is built up of electric units. The simplest is the hydrogen atom made up of two electric particles. Those particles are of two kinds, a positive and a negative, respectively named the proton and electron. The only difference in chemical elements is in the number and arrangement of the electric particles. Just as in the solar system the planets revolve around the sun, so do the electric particles move, the electron around the proton which is more massive. Further the atoms radiate energy just as the heavenly bodies radiate, and it is by their radiation that we know of

their existence. The ether is a something that pervades space, and it is by the vibration or tremor in the ether, excited by a corresponding movement in the protons or electrons, that different wave lengths are caused. This consideration will give some idea of what is meant by radiation, and different wave lengths. Electrons are given off by bodies when struck with the ultra-violet light.

Only a small portion of the sun's rays that reach the earth are visible—hence the expression the "Visible Spectrum." So, strictly speaking, the term "Light Waves" should be applied to that portion of the sun's rays that so affect the optic nerve as to produce the sensation of color.

The spectrum of the sun's rays admits of three general divisions:

1. The visible spectrum—red, orange, green, blue, indigo, and violet.
2. The infra-reds, those rays beyond the red.
3. The ultra-violet, those rays beyond the violet.

The detection of the invisible rays below the reds, the infra-reds, can, among other ways (consult fig. 1), be effected by means of a bolometer which, being placed on the spectrum just below the reds, shows an increase of temperature. The infra-reds are the heat producing rays and the wireless waves.

A photographic plate placed on the spectrum beyond the violet rays demonstrates the presence of chemical rays by a darkening of the silver salts.

The qualities of the various waves are due to the difference of the length and frequency of the ether waves. Some of the waves are so short that a nomenclature has been devised to describe them, as in like manner in dealing with great astronomical measurements the distances are so great that they are measured in "Light Years."*

There are three ways in use to express short wave lengths, and they are all based on sub-division of the meter, namely the micron, the millimicron and the Angstrom Unit.

The symbol for the micron unit is the Greek letter μ, and its length is one thousandth (1/1,000) of a millimeter. That is to say the millimeter is divided in a thousand parts.

The Millimicron is denoted by $m\mu$ which means that the millimeter is divided into a million parts, therefore the millimicron is one millionth (1/1,000,000) of a millimeter.

The third method is the use of the Angstrom Unit, so named after the Swedish physicist who invented it. The Angstrom Unite, written A.U. or A°, is one ten millioneth (1/10,000,000) of a millimeter. In long measure the Angstrom Unit is one two hundred and fifty-four millionth (1/254,000,000) of an inch.

On account of the decimal system employed it is quite easy to convert the A.U. into terms of the $m\mu$ or vice-versa by dividing or multiplying by ten.

* A Light Year. Light travels at the rate of 186,000 miles per second—so a Light Year would be 186,000x60x60x24x365, which equals 5,865,696,000,000 miles.

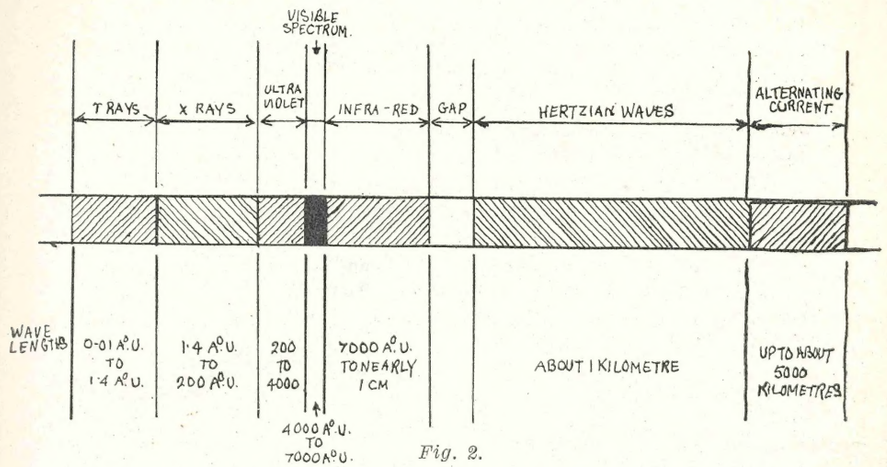


Fig. 2.

Figure 2 gives a working scheme, for our purpose, of a division of the sun's spectrum. In the central portion is the region of the visible rays—red, orange, green, blue, indigo and violet. The wave lengths range from the red 7,000 to the violet 4,000 A.U. Beyond the visible spectrum, adjacent to and below the reds, is the region of the infra-reds; it is the field of the heat-producing rays; then comes an uncharted section of which not a great deal is known at the present time, but which is receiving close scientific study; beyond this uncharted section are the long Hertzian waves of wireless energy. The infra-reds then are those rays longer than 7,000 A.U. Beyond the violet of the visible spectrum there is the ultra-violet field which includes all waves less than 4,000 A.U. The ultra-violet field is shown to be sub-divided. The region immediately beyond and next to the violet is the Actinic or Chemical portion of the spectrum commonly indicated by the assumption of the name of the whole region, that is ultra-violet. It is this part of the electro-magnetic spectrum with which we are now concerned, and which includes wave lengths of 3,900 to 200 A.U.

Then come the X-rays and radium rays. The shortest waves known are the gamma rays of radium which range in length from 1.4 to 0.01 A.U.

There is a variation in the amount of solar rays that reach the surface of the earth. This variation is due to the atmosphere which exists between the earth and the sun. As this atmosphere varies in depth and composition so does the proportion of the sun's energy that reaches the earth vary. It is estimated that only sixty per cent. of the sun's rays reach the earth even in a clear atmosphere. This loss to the earth of solar energy is mainly due to the absorption of the rays by the ozone, water-vapor, and oxygen of the surrounding atmosphere.

This envelope has the property of absorbing, in addition to other rays, some of the shorter ultra-violet waves, so that the shortest rays that reach the earth are 2,900 A.U. That is to say the ultra-violet rays of the sun

that reach the earth vary from 3,900 A.U. to 2,900 A.U. It has been shown by investigators that the shorter ultra-violet rays are the most effective from a metabolic point of view, so that the ultra-violet rays ranging from 3,100 A.U. to 2,900 A.U. are the most efficient sun rays for the well-being of life. It is estimated that these rays constitute less than one per cent. of solar radiation.

An estimation of the value of the different ray-lengths is arrived at by means of the use of various glasses of known transmisility, known as filters. These different glasses have been tested and compared with common window glass by the United States Bureau of Standards, and results set forth in scientific papers. (Consult Circular 235, January 14th, 1928.) These experiments demonstrate that wave lengths of 3,200 A.U. or more, have no protective value in the treatment of rickets,* while actinic rays of 3,100 A.U. and less have been found to have a profound effect on the disease. This means that the difference of only 100 A.U. in length is the difference between effectiveness and ineffectivness. This fact may have a very important bearing in the further study of light theraphy, and filters may play an important role in treating various ailments.

For those pursuing the subject of heliotheraphy, it is interesting to consider the significance of the experiment of Burge which proved that the longest waves capable of coagulating the white of eggs was 3,000 A.U. The effect of different wave lengths on the condition called rickets points to the value of a further analysis of the rays employed in heliotheraphy to ascertain if eliminating or combining certain ray lengths will produce results not yet known.

One of the notable characteristics of the ultra-violet ray is its feeble power of penetration. This peculiarity of the rays requires a consideration of the conditions which govern the amount of ultra-violet rays which are accessible to us.

The localities in which moisture, smoke, and dust are present, such as large manufacturing centres, are lacking in the normal quantity of ultra-violet rays because these particular rays are intercepted by absorption before they reach the earth. Other localities, where the atmosphere is dry and free from such impurities as smoke and dust, receive the normal amount of ultra-violet rays sent forth by the sun, and are consequently more suited for such uses as require these special waves.

In addition to the consideration of the peculiarities of the locality, the time of the year has much to do with the quantity and quality (that is the length) of the ultra-violet rays that pass through the atmosphere. In the winter the sun is so low that the rays come obliquely and so must pass through a greater depth of the atmospheric envelope to reach the earth, and in consequence more of the ultra-violet rays are absorbed.

Another very important circumstance that relates to the time of exposure to the sun's rays, is the time of day. Here again, in the early morning and late afternoon, the sun's rays shine obliquely and must pass through a greater depth of atmosphere with the consequent absorption of the ultra-

* For a description of rickets see page 15.

violet rays. So the mid-day is the time when the earth's surface receives the rays in greater abundance.

It is often stated that sunlight at the top of Mount Blanc is richer in ultra-violet rays than in the sunlight of lower altitudes. Thorne Baker has shown that at an altitude of 5,000 meters the sunlight contains no shorter rays than 2,900 A.U. The ozone atmosphere which surrounds the earth absorbs ultra-violet rays shorter than 2,900 A.U. If this is so how could it be supposed that any reasonable altitude that a human could reach would contain shorter rays than the oxygen atmosphere will allow to pass through it. So the statement that altitude affects the proportion of ultra-violet rays available for humans must be reconsidered.

Another factor to keep in mind is that ordinary window glass cuts off the short ultra-voilet rays. So that an individual sitting in a sun-room, closed in with ordinary glass, although apparently bathed in a flood of the sun's rays, is quite cut off from the essential ultra-violet rays.

The following findings of the Bureau of Standards, Washington, on the ultra-violet transmission of various new glasses and window glass substitutes as compared with that of common window glass, are not only interesting but of vital importance, because of the manufacture of special ultra-violet transmitting glass for solaria, sun-rooms, schools, homes, office buildings, animal houses, and greenhouses. The ultra-violet rays that reach the earth from the sun vary in length from 3,900 A.U. to 2,900 A.U. The most essential rays for biological purposes are 3,100 A.U. and less. Ordinary window glass eliminates ultra-violet rays shorter than 3,200 A.U. From these findings it is evident that sun treatments given for their actinic rays when given behind ordinary window glass must prove a failure. It is pitiful to think of the mistakes made in the past when patients spent hours in the sun-room expecting to receive the benefits of sunshine when those special rays longed for were cut off by the intervening glass.

With the manufacture of various substitutes for window glass the transmission of the sun's ultra-violet rays is to some extent effected, but it must be clearly understood that there is a difference of transmissibility among the various substitutes, and, furthermore, the percentage of transmission varies when the substitute is new and when it is old.

PER CENT. TRANSMISSION OF VARIOUS GLASSES AT 302 MM, WHEN NEW

Trade Name	Number of Samples Tested.	Average Thickness.	Average Per Cent. Transmission At 302 mμ
Fused Quartz	1	4.7 mm.	92
Corex	4	2.8	89
Helioglass	15	2.3	56
Vitaglass	15	2.5	44
Cel-o-glass	5	.1 (about)	30
Quartz-lite	16	1.9	0.5
Common Window Glass.	14	3.3	0.0

When aged, that is in about six weeks or more of exposion to ultra-violet radiation, the following change takes place in glass substitutes. When the glass is aged it is said to be solarized, and then it becomes constant.

PER CENT. TRANSMISSION OF VARIOUS GLASSES AT 312 mμ., WHEN OLD

Trade Name.	Average Per Cent. Transmission At 302 mμ.
Fused Qaurtz (no change)	92 per cent.
*Corex (no appreciable change)	89 "
Helioglass (marked)	30 "
Vitaglass (marked)	25 "
Cel-o-glass (marked)	5 to 10 "
Quartz-lite (no appreciable change)	0.5 "
Common Window Glass	0.0 "

Another condition that requires attention is the relation that clothing bears to the transmission of these vital rays. Such covering on the body interferes with access to the body of these special health-giving rays. A sufficient surface of the body must be nude so that there will be no medium of adsorption to prevent the ultra-violet rays reaching the skin.

Hess had made experiments to test the penetrability of clothing to actinic rays. He selected thin material of a white cotton dress, cotton and wool sacks. These were interposed between the rays to be examined and the subject, and it was found that the rays afforded protection against rickets. These materials were white. Black material of the same texture was then used and no protection against rickets was afforded.

Other Sources of Ultra-violet Rays Than Solar Radiation.

It will be noted that the previous section is under the caption of "Solar Rays." There are, however, other sources of actinic rays. In the development of light for clinical purposes, methods have been evolved to produce a spectrum closely resembling the sun's spectrum, or simulating the actinic spectrum, or corresponding to the infra-red region of the spectrum. All artificial light emits ultra-violet energy—but in some cases the energy is very slight. There are three principle sources for securing actinic energy for clinical purposes, namely, the Sun, the Carbon-Arc Lamp, and the Quartz-Mercury Vapour Arc Lamp.

Professor Finsen, of Copenhagen, invented a lamp, known as the "Finsen Lamp," in order to obtain a maximum of ultra-violet rays with a minimum of infra-reds. One of the first lamps to be used clinically was his Carbon-Arc Lamp. It was due to his discoveries that work was continued that led to the development of the lamps in use at the present time. The Carbon-Arc Lamps may vary in the spectrum they produce by modifying the composition of the carbons by coring or impregnating them with metals such as aluminum, tungsten, iron, and chrome-steel. Other Carbon-Arc

* Exposure to a quartz-mercury arc causes a very marked decrease in the transmission, but no appreciable change on exposure to solar radiation.

lamps, besides the Finsen, are "Siemen's Aureal Lamp," the "Wohlite Lamp," the "Solar Arc Lamp of Battle Creek," and "Sunzone Carbon-Arc Lamp," and others. Particular information regarding construction and merits of the different lamps can be obtained by consulting the bibliography.

The Quartz-Mercury Vapour Arc Lamp, consists of a quartz vacuum tube and liquid mercury. When the circuit is closed the mercury is vapourized giving off an intense light rich in actinic rays. There are two types of Quartz-Mercury Vacuum Burners. One type (the Hanovia) has the two electrodes of mercury. Another type (the Cooper-Hewitt), the cathode is of mercury and the anode of tungsten. The quartz tube will not emit rays shorter than 1,850 A.U. Compare this with the length of the ultra-violet wave that reaches the earth from the sun. The spectrum from the quartz-vacuum tube does not consist solely of ultra-violet rays, but radiates a portion of the visible section and the infra-red; but the infra-reds are not so strong from the quartz-vacuum as from some other sources of ultra-violet energy. With the water-cooled Kromayer Lamp, the ultra-violet wave intensity to visible wave intensity, is much greater than it is either with the Carbon-Arc, or with the sunlight. There are two kinds of Quartz-Mercury Vacuum Lamps. One, which is air cooled and used for general radiations, as, for example, the Hanovia and Victor Lamp; the other is the water-cooled lamp used for local applications, as the Kromayer and Victor Quartz Lamp. The lamp for local applications is constructed so that it can be fitted with tubes of quartz of different sizes and shapes for use in the oral cavity.

Fig. 3.

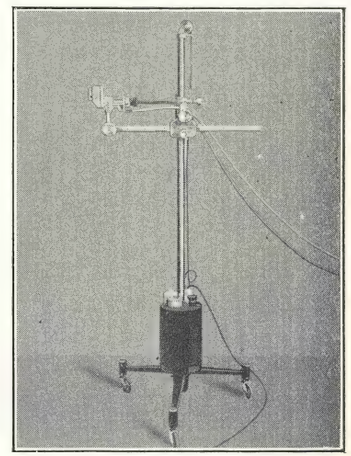


Fig. 4.

Fig. 3.—The Alpine Lamp for general radiation of the body.
Fig. 4.—The Kromayer Lamp for local applications.

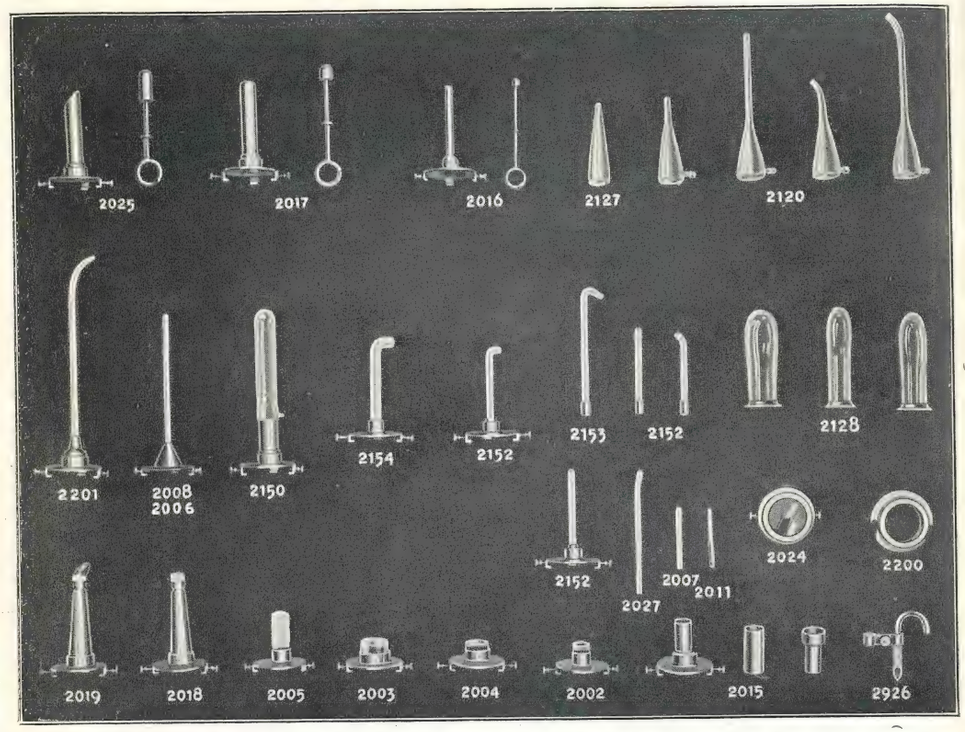


Fig. 5.

Applicators for local treatments.

THE USE OF APPLICATORS

2002—Small round lens
2003—Large square lens
2004—Medium round lens
} Used in all compression where it is desired to force the blood out of the tissues and obtain deep penetration as in deep infections.

2152—Sampson pyorrhea rods.—The popular type of pyorrhea applicators.
2153—Used in hay fever.
2005—Long round lens.—Used in Vincent's angina where compression is necessary as in hemorrhoids.
2007—Quartz rod 2¾" long.—Used principally in the outer ear, eczema, and furunculosis, etc., about 6 mm. diam.
2008—Long quartz rod 6¾" long.—Used in empyema, tubercular kidney, gonnorrhea, about 6 mm. diam.
2011—Weaver applicator, small rod about 3 mm. diam.—Used in children's ears and small sinuses.
2015—Shapre localizer.—Three open cylinders for confining the rays to a small area, as in boils, etc.
2016—Sinus applicator.—Used in tubercular sinuses.
2018—Pharyngeal applicator.—Used in tonsillar conditions.
2154 and 2019—Used in tubercular laryngitis.
2027—Nasal applicator.—Used in ozena, hypertrophied turbinates, etc.

RICKETS

The most definite knowledge of the action of ultra-violet rays on the metabolic processes of the body has been gained through a study of its effects in relation to the conditions due to a disease called rickets. An understanding of the pathological conditions observed in this disease is necessary to an intelligent understanding of the results we expect to attain in dentistry by the use of actinic energy. The similarity of the pathological conditions found in rickets to many deficiency dental conditions encountered will gradually be observed as the pathological anatomy of rickets is studied.

Rickets is a disease of infancy, characterized by an impaired nutrition of the whole body, and lack of development of the bone tissue. There is a deficient deposition of calcium salts in the bone, and in the intercellular cartilage of the epiphyses. It rarely begins before the sixth month, and usually in the first or second years. The disease begins insidiously and shows symptoms before the child begins to walk, about the time of dentition, which process is much disturbed and retarded. The teeth erupt late, and decay early. In the morbid anatomy the changes most noticeable are in the ends of the long bones and the ribs. The ossification is more irregular, and the bones more spongy and vascular than normal. The parieto-occipital and the parieto-frontal fontanelles remain patent, due to a lack of ossification. There is also the appearance of the "rickety rosary," 'a beading of the ribs at their junction with the cartilage. The primary lesion seems to be in the periosteum, marrow, and cartilage. It is believed that rickets is due to a disturbed nutrition by the arterial blood in which there is a marked diminution of calcareous salts. There seems to be a causal relation between rickets and broncho-pneumonia, asthma and epilepsy, that is a reduction in the defensive power of the blood.

Rickets is associated with a marked lowering of general resistance to infection in children. The greatest mortality among them is due to broncho-pneumonia and similar conditions.

In the adult also the ultra-violet rays are in some way related to metabolic processes which increase the resistance of the individual to bacterial invasion. After exposure to the rays there is found to be a marked increase in the number of platelets in the blood. The blood platelets are considered to be in some way related to the resistance of the body against infection. The resistance of the whole population to ward off disease is reduced in winter months, and this is apparently due to the lack of exposure to the beneficial effects of sunshine, especially the shorter ultra-violet rays. This lack of resistance is shown by the greater mortality during the late winter months. Tisdall says, "If a knowledge of these facts can be disseminated throughout our communities, and applied by the people, particularly during the late winter and spring months, it will result in a marked reduction in the incidence of disease and also will be the means of saving thousands of lives."

For an account of the theories regarding the etiology of rickets, the reader is referred to an article by Tisdall in the *Canadian Medical Association Journal*, December, 1922.

In rickets the concentration of inorganic phosphorus in serum is low. As the salts of the bone consist chiefly of calcium phosphate, it is likely that calcium and phosphorus in the blood plays an important part in bone formation. The calcium content in the blood of a normal healthy individual is remarkably constant, and slightly higher in children than in adults. There is no demonstrable amount of calcium in the red blood-cells. The average amount of calcium in the serum is 10.8 Mg. per 100 cc. The average amount of inorganic phosphorus in children from 4 to 22 months is 5.4 Mg., and the average in adults is 2.1 Mg. per 100 cc. In the blood of the rachetic the amount of calcium is normal or only slightly reduced, while on the other hand inorganic phosphorus is reduced to an extreme degree. Also it is to be noted that during recovery the phosphorus content increases to normal. So far as these findings are concerned they would point towards the conclusion that the lack of bone formation is not due to a lack of calcium, but rather to a deficiency of phosphorus content of the blood. It is observed by Tisdall that "physiological conditions such as diet, exercise, etc., exert little, if any, influence on the calcium of the serum."

The action of light on the organism is based on clinical observations and is, therefore, empirical. The physiological process is still obscure. Vitamins are considered potent agencies in promoting the growth and maintaining the normal health equilibrium. Vitamins are substances contained in various foods; they act like drugs on specific tissues.

For example: Vitamin A is a fat-soluble abundant in cod liver oil and many vegetable oils. Its primary source is green leaves and sea-weeds. It seems to have to do with the utilization of the fats of the body. A deficiency of this vitamin causes an atrophy of the mucous membrane of the intestines, and thus opening a way to infection from the intestines.

Vitamin B is a water-soluble found in cereals, eggs, yeast and lemons. It is considered an anti-neuretic, being antagonistic to certain forms of nervous degeneration.

Vitamin C is abundant in green vegetables and fresh fruits. It protects against scurvy and is termed anti-scorbutic.

Vitamin D is allied to fat-soluble Vitamin A, and has a similar distribution. It is named anti-rachetic, one of its functions being to promote the proper calcification of bone.

The Medical Research Committee of Great Britain published a report on rickets in which it says: "In spite of a most varied and extensive research we have practically no knowledge of the nature or causation of this widespread malady, or of the factors which determine its onset." There are two divergent theories, each of which enjoys the approval of clinicians at different times, namely, the dietic and hygienic. Mellanby claims that the lack of a vitamin fat-soluble is the potent cause of rickets. Yet it must be remembered that rickets is more frequent among the children in large cities than in the rural districts. Another consideration is that cases of rickets increase during the winter and early spring, and rapidly disappear in the summer. This calls for an enquiry into the seasonal variation of rickets. Hess and Unger report: "In the course of our experience in a large child-caring institution rickets has been found to occur with every food, without exception. Cases have developed when the dietary contained a large quota of milk, and therefore was rich in fat; when fat and fat-soluble vitamin were lacking in the diet; when milk was raw or pasteurized. It has been noted on a diet of fluid milk, dry milk, condensed milk, protein milk and human milk. On every one of these dietaries some babies have developed rickets, whereas others have remained perfectly normal in this respect."

Clinical evidence has shown that cases that develop rickets when fed on diet of pasture dry milk, malt soup, condensed milk and breast milk, when treated with ultra-violet rays showed an increase in the percentage of haemoglobin and red blood cells in every instance; also the X-ray showed an increase in the deposition of salts at the epiphyseal ends of the ulnar and radius; and this in the most unpropitious months of February and March. At present there seems to be no means of knowing the modus operandi of this deposition of salts, whether it is through direct action, or whether it is due to some intermediate factor. The effect seems to be systemic rather than local.

Raczynski performed the following experiment to show the chemical effect of solar rays on the inorganic salts of the body. Two puppies of the one litter and suckled by the mother were used. One was kept in darkness, and the other in sunshine. At the end of six weeks they were killed. When the bodies were analyzed it was found that the one subjected to the sun's rays showed over fifty per cent. more calcium and twenty-five per cent. more phosphorus than the one deprived of the sun's rays. The effect of light seems to afford some explanation of the fact that rickets is more prevalent in large cities, where children are more deprived of the sun in winter than in the summer time.

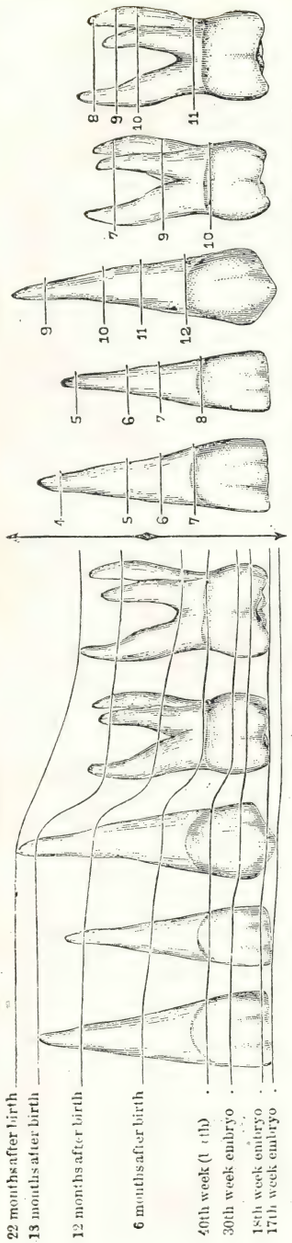
In writing of sun and artificial light treatment Leonard Hill says: "To make good for our dark winter climate and indoor life, we want to use arc baths just as we use water baths, and getting the skin in a healthy, active state, keep up resistance to disease."

THE TEETH

About the 7th week of intrauterine life, the beginning of the teeth germ is first observed. From the 7th week to the 17th week modification in development in the temporary teeth, and the first permanent molar is under way. There is the development of the ameloblasts for the enamel, and the osteoblasts for the dentine, with the deposition of lime salts. About the 25th week of foetal life calcification of the first permanent molar begins. Calcification of the temporary teeth begins about the 17th week of foetal life and is completed twenty-two weeks after birth. Calcification of the permanent teeth begins about the 25th week of foetal life and is completed about the 20th year after birth. At the same time the jaws, and the process surrounding the roots of the teeth, is in process of formation. These facts have important relationships to the results looked for in the biological action of the ultra-violet rays when applied for in their control of rickets.

CALCIFICATION AND DECALCIFICATION OF THE TEETH.

FIG. 1.

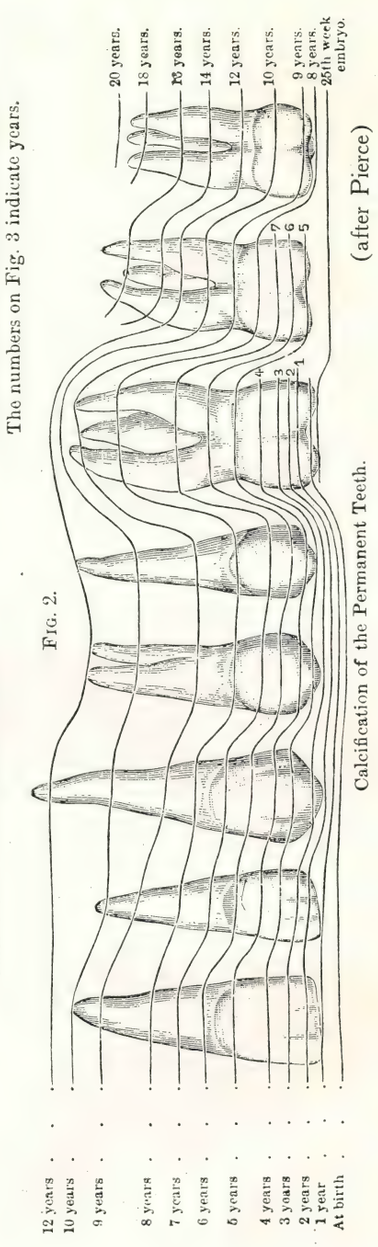


Calcification of the Deciduous Teeth.

FIG. 3.

Decalcification of the Deciduous Teeth.
The numbers on Fig. 3 indicate years.

FIG. 2.



Calcification of the Permanent Teeth. (after Pierce)

It has been shown that the application of the actinic rays results in the prevention of rickets, and the building up of healthy bone tissue. So should the same treatment result in the development of normal teeth with their supporting bone structure. This use of ultra-violent rays would naturally result in the development of such tooth and bone structure as would tend to eliminate that almost universal and dreaded disease periodontoclasia. Such degrees of mal-occlusions and other causes that would break down the periodontium in poorly formed tissue might have little or no effect in cases of strong development. This treatment would be preventive dentistry in the building up of healthy structures that would resist in a great measure the onslaughts of bacterial invasion. From the foregoing data of the periods of formation of the teeth and their calcification it will be gathered that the body must be kept in a state of normalcy, so that during the process of bone formation the tissues will receive proper pabulum from the time of conception until the period is past when rickets makes its appearance. The effect achieved will not only produce a resistant periodontium, but the tooth itself will be more resistant to decay because the islands of calcification of the enamel will coalesce and a perfect enamel covering result.

This treatment, being preventive, only partly covers the problem of dental disease. The consideration remains of those cases that have not received the preventive treatment, but present with the periodontium in various stages of disintegration.

PERIODONTOCLASIA

There are different degrees of periodontoclasia, beginning with a simple gingivitis to the absorption of the alveolar process to such an extent that the tooth becomes movable, and finally falls out owing to lack of support of the surrounding tissues.

Before the application of the actinic ray treatment it should be understood that every mechanical irritant must be removed, as calcareous deposits, irritating crowns and fillings, ill-fitting bands, badly designed and constructed artificial dentures, and traumatic-occlusions.

In a case of simple gingivitis the analgesic property of the ultra-violet ray soothes the nerve endings in the irritated tissues, and so hastens the return of normal circulation with the color of the gingiva changed from an inflammatory red to a normal pink.

In his studies on the "Treatment of the Periodontal Pocket" Dr. Box dwells at some length on the method of taking advantage of the organization of the blood clot to obliterate the pocket. The pocket is lined on the one side with connective tissue which is covered by an invagination of the mucous epithelium; on the other side is the cementum, encrusted with lime salts. The mucous epithelium and the lime salts must be removed, and the pocket irrigated with a normal saline solution. Filling the pocket with drugs will interfere with the vitality of the cells lining the pocket, and also with the absorption of the ultra-violet rays. With the pocket suitably treated, a blood clot is formed by finally curretting the soft tissue

of the pocket. The clot which fills the pocket must be sealed and protected with a varnish. These details being attended to, it is now to nature one must trust for the transformation of the clot and the obliteration of the alveolar pocket, by the fixation of lime and phosphoric acid in the osteogenic tissue.

The cementum as a thin layer covers the root of the tooth from the enamel to the apex. In structure and chemical composition it resembles bone, containing sparingly lacunæ and canaliculi which characterize bone.

The lacunæ near the surface have canaliculi which radiate towards the periodontal membrane. In every respect cementum is closely allied to bone, and its development provided for in similar manner. The tooth-sac is made up of an outer and inner layer, both of which are rich in blood-vessels. These membranous walls continue to invest the roots of the teeth during their upbuilding. The outer layer of the sac remains as a permanent structure placed between the root and the alveolar walls, forming the alveolodental periosteum, while upon the surface of the inner layer osteoblasts (cementoblasts) are developed, which are speedily converted into bone or cementum. In this process the tooth-root may be compared to one of the long bones of the body, and the development of the cementum considered under the head of sub-periosteal ossification.

Dr. Box observes: "Examples of reattachment following conservative surgical treatment of the pocket have been noticed in abundance. This is not to say, however, that union is always assured when the necessary procedures appear to have been taken." The conclusion to be stressed in connection with this observation is, first, that it has been shown that the ultra-violet rays have a regenerative action on the growth of bone in the case of rickets by supplying a necessary food or stimulant; and that by a legitimate process of reasoning it might be fairly supposed that the rays would stimulate the cells to form a tissue that would be sufficiently dense to retain the tooth operated upon in a stable condition, and more successes might result.

In cases of periodontal diseases where the alveolar process has been destroyed, regeneration in some cases seems proved by the evidence of radiographs. If pathological conditions are removed and the teeth stabilized, more of these cases will likely be observed if the conditions due to the lack of normal deposition of lime salts are removed. It should be remembered that in cases of complete destruction of the fibrous connective tissue the condition is such that the most optimistic could not reasonably expect a favourable prognosis.

For a further understanding of the possible advantages of a calcium forming, and protective, and bactericidal energy in the blood, Box's "Treatment of the Periodontal Pocket," Bulletin No. 10, issued by the Canadian Dental Research Foundation, is recommended. The details of the transformation of the blood clot is considered, and how it is related to the connective tissue and fibrous tissue formation.

A splendid example of the reparative powers of the peridemental connective tissue and its ability to form new cement substance under suitable conditions is to be seen in a case where, through trauma, a fracture of the

dentine has occurred. Following proliferation and extension of peri-cemental connective tissue cells, which are cement forming, into the fissure formed by the break of continuity in the outer dentine, there is deposted on the fissure walls a formless ground substance. This cement-matrix presents here and there enclosed cement-corpuscles, and later, with deposition of calcium throughout, it becomes hard, like bone or cementum.

It will now be perceived why the effect of ultra-violet rays on rickets was discussed. In part it was to show how the process of bone building was related to the calcification required to obliterate pyorrhea pockets. The principle of fortifying the body with the required energy is the same in both cases.

ORTHODONTIA

It might be said that if the environment of intrauterine life were normal, orthodontic services would not be required. It is just because the foundation on which the teeth are built is weak and ill-constructed that the skill of the orthodontist is so valuable to humanity. The moulding and development of the maxilla and mandible with the building up of the alveolar process for the support of the teeth are dependent largely upon the nutritive conditions that surround the foetus. If a study be made of Cryer's dissections of the head it will at once become evident that the function and structure of the jaws and teeth has much to do with the development of the nasal fossae, and the sinuses. This condition the skilled orthodontist has in view when he is engaged in securing a normal occlusion.

The promotion of the growth of normal jaws and dental structure is just a part of what has been described when treating of rickets. The same treatment that will promote the growth of normal bone will produce properly developed dental conditions. It has been shown that such favourable results in the bone framework of the body have been secured by the action of the ultra-violet rays for the prevention of rickets.

But when this early treatment has been omitted, with such a result that abnormal conditions prevail that require the orthodontist, the treatment very often resolves itself into an effort to expand the dental arches in the effort to secure a normal condition of the size of the nasal passages and sinuses to produce a condition favourable to normal breathing, and a proper occlusion of the teeth for purposes of mastication. To obtain these conditions it may be necessary to move the teeth in many directions. These movements result in an absorption of bone tissue in one direction, and a space left in the other direction, which space must be filled with a deposition of new bone, so that the tooth may be firmly maintained in its new place.

The alveolar process and periodental membrane are rich in their vascular supply, being perforated by minute openings for the transmission of nutrient vessels. In the periodental membrane are various kinds of cells. There are fibroblasts to form fibres; there are osteoblasts to form bone; and there are cementoblasts to form cementum.

One of the difficulties the orthodontist has to contend with is the problem of the retention of the teeth in their new positions until nature has

formed new bone around the roots of the teeth to secure them firmly. In healthy children this process takes place fairly rapidly. But in the case of a weak child with a frail bony structure the problem of securing stability is a very serious one, sometimes an impossible one.

As the studies in the case of rickets have shown, this disease of lack of bone formation can be overcome by the action of ultra-violet rays. There seems no reason to doubt that such a course of treatment by the orthodontist would hasten the deposition of lime salts and secure a stronger support for the teeth in a shorter time, and so lessen the period for wearing retention bands. In the cases of debilitated children the ultra-violet ray treatment may mean all the difference between success and failure.

PROSTHODONTIA

Dr. W. E. Cummer spoke to the writer of the great value that would accrue to the patient if some method could be discovered whereby the absorption of the jaw bone, due to extraction of teeth, could in some measure be controlled. This control of tissue would give the prosthodontist a better foundation on which to construct his appliance; it would also afford the patient a much more satisfying prosthetic service. The same principle that applies to the regeneration of the blood clot in the pyorrhea pocket holds good in cases of extraction. When a tooth is moved from its socket in a case of ordinary extraction, a blood clot should be encourage, so that it fills the socket and the clot is protected with a film of varnish so that it will not be dislodged. Every means should be taken to allow for the organization of the clot by the general and local application of the ultra-violet ray, which has been shown to be a particularly efficacious agent for this particular kind of metabolism. This treatment would materially overcome that condition in which the teeth adjacent to the extraction are losing their alveolar support. The germicidal action of the actinic ray, which will be considered later, should be taken advantage of in cases of extraction by inserting into the socket, before allowing the blood clot to form, a suitable quartz rod to irradiate the tissues with bactericidal rays.

BACTERICIDAL EFFECT OF THE ULTRA-VIOLET RAYS

The practising dentist will at once perceive the importance of the bactericidal action of the blood on the outcome of a number of operations. The periodontist, the exodontist, the prosthodontist, and the orthodontist are in a great measure dependent upon this property of the blood for the ultimate success of their operations. In the extraction of a pulp from a tooth, in the removal of the apex of a root, the success of the operation will largely be governed by the bactericidal action of the blood. This quality will reside in normal blood, or, if lacking in this respect, it may in ordinary conditions be rendered germicidal by the action of actinic rays. Eidinowe publishes accounts of experiments made by him to show that in cases where the bactericidal power of the blood is low the irradiation of the skin with the ultra-violet rays will raise that power by a constant improvement from sixty per cent. to a level of ninety-five per cent. This

change was brought about after two months' treatment. The method of irradiation was to produce a slight erythema of the skin. He also observed that too long an exposure to the rays will lower the bactericidal action of the blood. Too long an exposure is avoidable by causing only a slight erythema. It is also stated that "during menstruation the haemobactericidal power of the blood is in some cases found to be lowered, irradiation appears to make this worse, and therefore light treatment should be avoided during this period."

Many bacteria and pathogenic organisms are rapidly destroyed when subjected to the ultra-violet rays. This action can also be obtained in the presence of a thin film of blood.

Most of the constitutents of the living cells are colourless so they do not absorb rays of wave lengths of visible light. In a substance the part of the beam absorbed sets in vibration the molecules, if any of the vibration periods of the rays coincide with the vibration of the atoms. The result may be a chemical or physical change in the molecules.

Many constitutents of cells absorb the ultra-violet rays, which have a powerful effect on living tissue. The actinic rays produce degeneration of the epidermal cells, and there follows an absorption of the products. If the initial energy has short enough wave lengths to produce vibrations in the atoms, it is paralleled with activation of the electrons. If the result of the activation is to eject the electrom from the atom, the result is ionization of the molecule; if the electron is displaced to an outer orbit, the atom is activated. In either case it results in altered chemical reactions. A bacterium is a unicellular organism, and thus similar to other tissue cells of the body, and so the statement that ultra-violet rays are destructive to tissue cells holds good in the case of bacteria.

DENTAL CARIES

Dental Caries may be due to poor tooth structure, and also to faulty formation of the tooth and its supporting structure—such are prenatal influences. Under the section dealing with teeth and their development, a mode of treatment was discussed that would tend to bring about certain conditions in the nourishment of the ovum that tooth structure would be of such a kind as could resist the ordinary exciting causes of decay. The present section deals with the exciting causes of decay apart from any consideration of tooth texture. A detailed account of the history of the different theories advanced as to the exciting cause of dental caries can be found elsewhere. It is sufficient for our purpose to state that it is agreed that an acid condition causes the decalcification of the tooth. The cause that produces the acid and the kind of acid found has been discussed in a voluminous number of papers.

Burchard and Inglis in their work on Dental Pathology treating of Dental Caries, write: "This bodily condition (referring to general health) is seemingly the key to any change which can occur in saliva, or mucous, or oral phagocytosis, to one of which must be attributed any possible systemic effect upon caries bacteria, which can aid or inhibit their growth or localization." Although it is not yet clearly proved, there is a strong

suspicion, in the minds of some, that the condition of acidosis expresses itself in the acidity of the saliva, which itself may cause decalcification of the teeth, or promote a condition favourable to bacteria that can dissolve the lime salts of the teeth.

Arterial blood is sligthly alkaline; if this alkalinity is lowered below a certain point the condition becomes one of acidosis; if the alkalinity is increased, the condition is known as alkalosis. Acidosis is the result of incomplete fat metabolism owing to deficiency of carbohydrate.

Dr. G. V. Black's theory of Dental Caries is that a plaque or covering is formed to protect micro-organisms and maintain them in position on the enamel of the tooth, so that when they develop lactic acid it would not be diluted and washed away. It was this lactic acid that dissolved the enamel. In seeking the cause of dental caries he says: "Conditions of the saliva that enable micro-organisms to form these coverings, or which form them independently of the action of micro-organisms, are apparently the important objects of research." A difference in the composition of the saliva, perhaps due to the salts it contains, may influence the action of the micro-organisms and render it more rapid in some cases than in others. The relation of the conditions of the saliva to dental caries has not yet been determined, and so it is difficult at the present time to say what role the ultra-violet rays would play in the control of caries. This at least could be advanced, that the general health of the body would tend towards a normal condition of the saliva.

A theory of the cause of dental caries by Bodecker will be found in the Dental Cosmos, June, 1929. The theory is based on the fact that there is a system of channels in both the dentine and enamel, and that these channels are permeable from within and without. These channels are filled with blood plasma. This tooth plasma comes to the surface of the tooth, and normally being sufficiently alkaline, neutralizes the lactic acid that may lodge on the surface of the tooth. This dental lymph, being derived from the blood, will vary in its alkalinity as the blood varies in this respect. On the treating of rickets it has been shown how the blood does vary under different conditions with respect to its percentage of lime salts and phosphorus. Now if Bodecker's theory can be shown as related to dental caries, then the ultra-violet ray treatment, which controls the conditions of alkalinity of the blood, would be very efficient in the control of dental caries.

There are cases that present in which there is taking place a solution of the enamel at the cervical portion of the tooth manifesting itself by that white chalky appearance indicative of acid formation. These cases are distressing. Unlooked-for good results have been obtained by using the quartz applicator on the gums. The only explanation that has suggested itself is that there was some reaction on the glands of the gums which altered their biologic action and changed the acid secretion to a normal alkaline one.

ANALGESIC PROPERTIES

The ultra-violet ray has analgesic properties which it exerts on the tissue to which it is applied at the same time as it has its chemical effect.

It is a soothing and pleasing adjunct to prophylactic treatment when applied at the end of the operation. The nerve terminals of tissues which have been irritated during the instrumental procedure are acted upon by the rays in such a manner that the irritation is reduced so that the inflammation subsides, and a sense of comfort is experienced.

In cases of extraction after the application of the rays for any bactercidal action that may be required, an analgesic action follows that is very soothing to the patient.

As for the effects of the ultra-violet rays upon pus pockets and root abscesses, it is only reasonable results that should be expected. If there is a pus pocket at the root of the tooth it could hardly be hoped that the application of the rays to the gums would eliminate the necessity of skilful instrumentation and stabilization. But these conditions being attended to, the actinic rays will have their own beneficial action.

As regards an abscessed tooth, unless the conditions causing the abscess can be eliminiated it is in vain to expect the ultra-violet rays to initiate an action they do not possess. Just because digitalis has the property of producing certain effects, it is not to be expected that the drug will cure a malady that requires a surgical operation.

Certain types of neuralgia and neuritis will respond in an unexpectedly favourable manner to ultra-violet ray therapy if applied with the proper technique. But there are other types of neuralgia—for example, that due to a calcerous growth in the foramen through which the nerve passes and which impinges upon the nerve, that naturally would not respond to the analgesic properties possessed by the rays.

ACTIVATION OF FOOD STUFFS BY ULTRA-VIOLET RAYS

The value of ultra-violet rays in producing in inactive foods an antirachitic virtue by means of irradiation is receiving much consideration at the present time. Experiments seem to point to the conclusion that the antirachitic factor of the food depends upon the phytosterol or cholesterol they contain. Cholesterol is the constituent in animal food from which the antirachitic vitamin is derived by irraditation; the corresponding constituent in vegetable substances is phytosterol.

Steenbock and Daniels report: "The number of food materials that can be made antirachitic by simply exposing them to the light is far from being limited. It is a property quite common to foods of both plant and animal origin. In fact, one would almost be led to assume that it is a universal characteristic, but it is not the case. We have been very successful with such diverse materials as wheat, Indian corn yeast, cream of wheat, crude casein, hominey, rolled oats, corn starch, patent wheat flour, shredded wheat biscuits, meat, milk, egg yolk, butter and liver." It has been shown by Hess and Weinstock that "activated spinach" does not lose this property of protection against rickets even when boiled for half-an-hour.

The ultra-violet rays have been demonstrated a protection against, and cure for, rickets. It is also shown that they do not deeply penetrate

the skin. The supposition then is that in some way the rays activate the skin. The skin is particularly rich in cholesterol. The question then presented itself—could the skin be irradiated so as to afford protection against rickets. Experiments have been made that show that skin activated by ultra-violet rays when fed to rats afford that protection. It appears, then, that the action of the rays on the skin so affects the cholesterol content that the blood carries away in its stream, to be distributed to the proper parts of the body, that principle that creates such biological action that affords protection against rickets. In experimenting with the activation of cholesterol it was found that an "ageing" followed the activation; when a test was made one or two weeks later the activated cholesterol, when kept in a dry state, rapidly became inert; but the active principle was found stable when suspended in oil.

There is also a time limit for the exposure of cholesterol to the ultra-violet rays. Thirty to sixty minutes' exposure at about ten inches distances produces the antirachitic property. An exposure of seventeen hours annuls the antirachitic virtue which had been established by the shorter exposure. The fact that irradiated food and actinic rays have the same effect on the condition of rickets would lead to the supposition that the active principle was a form of radiated energy.

Steenbock and Daniels give an account of an experiment that is very interesting and one that invites much thought.

Rats were fed on a diet that would cause rickets. Some were irradiated each day, and the others were not. That the environment would be the same the two classes were kept in the same cage. To the surprise of the investigators it was found that both the irradiated and non-irradiated rats all grew. The question is—why? Did the irradiated rats give off radiant energy to the non-irradiated rats? And is it radiant energy stored in the anti-rachitic food that causes normal functioning of the body cells?

Rosenheim and Webster found that the substance which undergoes change by activation is a sterol, ergosterol, which is closely allied to cholesterol. This ergosterol can be extracted from ergot a fungus on yeast and mushrooms more particularly from a fungus which develops on grain. Ergosterol has been proven to be highly antirachitic for man and beast.

Activated ergosterol is two thousand times as potent as activated cholesterol; one hundred thousand times as potent as cod liver oil. 1/20,000 mg. prevents rickets in rats.

Hess and Lewis state that one ounce of average activated ergosterol is the equivalent of four tons of cod liver oil. Their experience is that this drug never failed in rickets; that even in cases in which cod liver oil had not brought about healing, irradiated ergosterol insured a rapid cure.

TECHNIQUE OF APPLICATION

A general agreement regarding technique has not yet been evolved. To solve the problem of the best method of applying the rays each operator should keep written memoranda of his methods of treatment, together with an account of the results obtained. Careful observation is necessary, because

every patient does not respond equally to the treatment. The operator will find that the ultra-violet rays will produce a sunburn and blister exactly the same as the sun will, and with apparently equally painful and harmless results. Yet it should be realized that care ought to be exercised in the use of the rays. If reference is made to Fig. 1, it will be noticed that the x-rays and ultra-violet rays are near neighbours. Both are invisible rays, and also each has a powerful action on the human body.

There are four recognized degrees of erythema that can be caused by the actinic rays:

First Degree Erythema is very mild, and does not cause any subjective symptoms. There is a very slight flush of the skin, which is not so affected as to produce any visible exfoliation.

Second Degree Erythema is likened to a very mild sunburn. The skin is reddened, and after the reaction there is a slight granular exfoliation of the skin.

Third Degree Erythema amounts to a severe sunburn. The skin becomes very red and, as in a bad sunburn, peels off in strips.

Fourth Degree Erythema is so severe as to cause a blister.

Tables have been compiled giving both the distance of the lamp from the patient and the time required to produce the different degrees of erythema. These rules are not dependable, for there is a difference in the powers of lamps built by the same companies. There is also a difference of energy given off by a lamp when it is new and when it has been used for some time. It is also stated, but only generally true, that the skin of blondes is more readily affected by the rays than the skin of brunettes. That is to say, blondes will be burnt by an exposure to the rays that would not seriously affect a brunette. The only safe guide is to consider each case by itself. There is a very safe method to determine the susceptibility of the particular patient to the rays. This is conveniently done by baring the patient's arm and applying the rays on different areas for different lengths of time, and next day noting the various degrees of erythema produced. If a quartz applicator is to be used for local contact, as, for example, to the gum tissue, then the applicator is pressed against the arm in different localities for different lengths of time, as one-half minute, one minute, one minute and a-half, and next day results noted for guidance in calculating the time exposure for treatment. If the rays are to be applied without the use of the quartz applicator, at a distance, as, for example, to the side of the face, or for general systemic treatment to the body, then the bared arm can be covered by a paper sleeve, secured in place, to protect the arm. Before adjustment, in this sleeve on the inner aspect of the arm, several apertures about the size of a ten-cent piece are cut, so that the rays can reach the skin. After the rays have been applied for one-half minute, one of the apertures is covered. The application is continued till the second aperture has admitted the light for one minute; it is then covered. This operation is continued, and finally there are several areas which have been irradiated for different lengths of time. The results can be observed next day by noting the varying degrees of erythema produced.

If a general treatment is to be given to the exposed body, the safest advice is to go slowly, giving the first treatment at a safe distance for a short time. A treatment can be given each day, gradually increasing the time of exposure. For the first treatment let the distance of the lamp from the body be about thirty inches, and the time of the exposure two minutes each on the back and chest. It should be noted that a patient lying on the back is a few inches farther from the source of the ultra-violet rays than when exposing the back, and perhaps lying on the arms. Increase the time each day according to indications till there is a ten-minute exposure, then begin to lessen the distance. There are some operators who desire to secure a severe reaction. This is not rcommended, because a pinkish flush of the epidermis produces the reaction necessary to bring about that biologic action necessary to prevent or cure rickets. The reason for this recommendation is the consideration of the results obtained by the ultra-violet ray contained in "Skyshine," as compared with direct sunshine. If an object is placed in the shade it receives only the reflected light from the sky, that is skyshine. If it is placed in the sunshine it receives both the direct rays from the sun and also the rays from the skyshine. Tisdall and Brown found that the antirachitic effect of the ultra-violet rays in skyshine was about one-half as great as in sunshine. It was also noted that the antirachitic effect of the skyshine was produced without reddening of the skin. It would seem that the reddening of the skin cannot be used as a measurement of the beneficial results of radiations. Further, too severe a reaction is likely to bring about a defensive action of the skin to the rays. After all, experience must be the guide that distinguishes a safe from an unwary operator. When the desired reaction is established the treatment may be reduced to two or one a week. One or two treatments a month during the winter time will have a tendency to establish a protective resistance to ward off colds that are so prevalent between the fall and the spring of the year. If after any one exposure too great an erythema has been produced, there should be a longer interval before the next treatment.

In order to secure the full action of the lamp in the production of the ultra-violet rays it should first be allowed to burn for five minutes. Goggles may be used to protect the eyes of the operator. Looking at the light too long causes an iritis. One should not look steadily at the ultra-violet light any more than a prudent person would gaze at the strong sunlight. Experience has proved that there is no need for the casual operator to be encumbered with goggles. But the case is different with the patient receiving a general treatment. While exposing the chest, the goggles or some protection for the eyes should be provided. Goggles seem to be unpleasant to the patient because they produce an uncomfortable sensation of heat around the eyes, and may give rise to the suggestion that other people have worn them. A gauze napkin laid across the eyes is all that is necessary, besides each patient then can have the pleasureable sensation of knowing they are using a clean napkin. Another method to protect the eyes is to drape the hood of the Alpine Lamp with a material of sufficient length to cut off the rays from the face.

After treatments have been discontinued for some time, for example, a

month or six weeks, the operator should be wary not to begin again at the distance and time exposure of the last treatment. It will be found that the defensive action of the skin to the ultra-violet rays has subsided. An initial treatment at the time and exposure of the last treatment would likely have unpleasant results as regards the degree of erythema produced.

For local application to the gums by means of the quartz applicator a greater degree of erythema may be desired so that it may act as a counter-irritant.

CONCLUSION

The conclusion to be drawn from the foregoing facts and experiments is that the oral cavity cannot be successfully treated as a separate entity. The several parts of the body form a connected whole. The tissue cells in whatever parts of the body they may be situated are subjected to and are controlled by the same general laws For example, if the normal germicidal property of the blood is lowered, in a general way the same disastrous results will attend a like injury whether in the abdomen, or at the apex of a tooth root. Conditions that would respond to treatment in a healthy individual, *i.e.*, to say, with a normal bactericidal action of the blood, may in an unhealthy organization resist the effect of treatment.

If, when abscessed conditions prevail in the mouth, it is considered unwise to expect a favourable result in the treatment of what is called "a run-down condition," a case of general debility; it is also unwise to expect a successful termination in the treatment of mouth conditions when any diseased organ of the body is lowering the general health and vitiating the fluids which bathe the tissue cells.

The dentist must realize the direct relationship, as regards cause and effect, that exists among the different parts of the body. It is not the mouth that we are finally concerned with, but the general health of the individual as related to the conditions of the oral cavity. It is only in this way that we may hope to realize the possibilities of our profession in rendering service to mankind.

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