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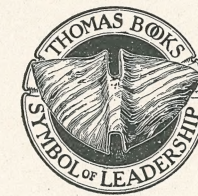
October 1936

AMERICAN MARTYRS TO SCIENCE
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ROENTGEN RAYS

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ROENTGEN RAYS

BY
PERCY BROWN, M.D., F.A.C.P., F.A.C.R.
HISTORIAN AND FORMER PRESIDENT
AMERICAN ROENTGEN RAY SOCIETY

WITH A SHORT GLOSSARY
OF THE SCIENTIFIC TERMS USED
IN THE TEXT



CHARLES C THOMAS

SPRINGFIELD • ILLINOIS

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TO THE MEMORY OF THE NOBLE PIONEERS
WHOSE BIOGRAPHIES ARE HEREIN WRITTEN,
ALMOST ALL OF THEM MY DEAR FRIENDS,
WHOSE GREAT TRIUMPHS AND SMALL DISAP-
POINTMENTS IT WAS MY HIGH PRIVILEGE
TO SHARE, THIS UNWORTHY BOOK
IS DEDICATED

" The world is ever ready to erect monuments in stone and sculptured bronze for the heroes of martial deeds, but the heroes of Roentgenology have their names perpetuated in the minds of students of medical history."

PRESTON MANASSEH HICKEY.

* * *

" Such spirits we do well to commemorate for they disclose to us the heroic way in which life may be lived when fate lays upon us a heavy hand."

WALTER BRADFORD CANNON.

* * *

"From my experience and personal communications from patients, I believe that the agony of inflamed x-ray lesions is almost unequalled by any other disease."

CHARLES ALLEN PORTER.

* * *

"For a description of the pain and suffering . . . no language, sacred or profane, is adequate."

JOHN TOWNSEND PITKIN.

PREFACE

One of the greatest of British biographers, the late Sir Sidney Lee, says in his *Principles of Biography*, "Death is a part of life, and no man is fit subject for biography till he is dead. Living men have been made themes of biography. But the choice defies the cardinal condition of completeness."

On the principle thus expounded by so eminent an authority, I have endeavored to review, in so far as they were connected with the early history of the x-rays of Röntgen, the lives of a group of Americans who gave to the cause of Science all within their power to bestow, and whose deaths, completing to the full, as Sir Sidney declares, the records of their lives, have entitled them to the posthumous decoration of *Martyr* in the strictest and finest sense of the term.

As it has developed under the strokes of the pen, this historical material will conform most closely, perhaps, to the tastes of the reader of medical training—indeed, it must be admitted that this small volume was prepared especially for his perusal and in particular for the eyes of my colleagues, old and young, in the medical field of radiology. Yet it is my hope that it may merit the interested attention of the lay reader, as well. We must remember that the preponderance of early report—of the "news" as it were—of Professor Röntgen's discovery, and the events that followed immediately, appeared first in the non-medical press; likewise, there has been always an intense lay interest in the infancy, adolescence and later growth of the science of roentgenology. For the possible assistance of the casual reader, a simple glossary has been appended which, I trust, may tend to clarify the meaning of certain scientific terms, the use of which it has seemed impossible to avoid.

Above all do I hope that these pages may serve to reveal to anyone who may read, even "he that runs," the extraordinary valor, no less, of this illustrious group of devoted

pioneers in a field of scientific endeavor that just forty years ago had its memorable inception. To "point with pride," or even voluntarily to refer, to his possession of the Congressional Medal of Honor or of the Victoria Cross would be unthinkable to the meritorious hero of an action in warfare. To be lauded, or even mourned, as martyr, even in its more flexible sense, would be equally irksome to these men and this woman who died in the peaceful but no less glorious cause of humanity. Their fate was accepted in the same spirit of loyalty and devotion that attended their unselfish daily labors. "To dwell too much on Dodd's suffering," wrote the late John Macy in his charming biography of the beloved Walter Dodd, "would be a violation of his spirit." Yet, if in these material and unvisionary days we still believe in the beneficial power of illustrious example, it is not in violation of their spirit that these lives and their sacrifice and suffering are memorialized, but for our own good and particularly for the good of future new comers to the field of Radiology that they may realize what her splendid reputé in the name of the humanities has cost her.

I am fully aware that, even after more than a year's sustained effort, I have doubtless failed to deal *comprehensively* with the biographies of the American Martyrs to Science through the medium of the roentgen-rays. Many records—a few of them are factual memories only—seem to be impossible of exhumation from the obliterating sands of Time. Limitations set up by the scope of the work, also, have obliged me reluctantly to omit consideration of the noble lives of the many martyred pioneers in countries other than the United States. For the same reason, as my title will indicate, I have made no attempt to include those who, after exhibiting unparalleled fortitude, have succumbed to the kindred untoward effects of exposure to radium. They really come under another category; among them the name of the valiant Viol shines with brilliant lustre.

I have made every endeavor to obviate a possible impression that this commentary constitutes merely a series of disjointed memorials of a nature necrological or obituarial. Such an effect upon my reader would be utterly subversive of the spirit in which these pages have been written. To this end I have avoided invariable mention of details that I have considered irrelative to this spirit—the usual details of social existence which are but collaterals to life's achievement. The best way, perhaps the only way, in which I have been able to correlate these careers of devotion was by emphasizing at every opportunity their common relation to the progress of the medical application of the roentgen-rays as it has developed from 1896 to 1936, a relation made the more definite by the single purpose of each life, conscious or unconscious as it may have been, to bring to bear some especial phase of this progress in the service of mankind.

Of those to whom thanks are due for assistance and encouragement in the pursuance of this work the number is almost multitude. To the members of the Publication Committee of the American Roentgen Ray Society at the time of its inception I am especially grateful, and also individually to Dr. W. A. Evans, of Detroit; to Dr. I. S. Trostler, Historian of the Radiological Society of North America; to Dr. E. H. Skinner, former Historian of the American Roentgen Ray Society; to Mr. Herbert D. Hawks, of Los Angeles; to Dr. Emil H. Grubbé, of Chicago, as well as for kindly aid given by the late Professor Michael I. Pupin, of Columbia University, and by Mr. Harry Westbury and Mr. Samuel T. Hutton. In addition, I am indebted for the assistance generously afforded by the Librarians, and their staffs, of the Boston Medical Library, of the Library of the College of Physicians of Philadelphia, of the Library of the University of Michigan, of the Library of the Johns Hopkins University and of the Boston Public Library.

Those who have helped me materially in the collection of

data for these biographies, and whose hearty co-operation I would gratefully acknowledge:

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Finally, I wish to express my appreciation of the effort of Mr. Charles Crankshaw Thomas, the spontaneity of whose

help has shown him quick to grasp the spirit in which I have attempted to depict the lives of those I so deeply cherish in memory. I would also convey my sense of profound obligation to my beloved colleagues of the American Roentgen Ray Society who, through their Executive Council, have made possible the extraordinary privilege of this small labor and, above all, to my Wife for devoted and always efficient assistance that has lightened its weight at all times.

P.B.

475, Commonwealth Avenue, Boston.
February, 1936.

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AMERICAN MARTYRS TO SCIENCE
THROUGH THE
ROENTGEN RAYS

THE CAUSE AND THE EFFECT

IF THE noun *martyr* be used in the sense implied by its derivation from the Attic Greek *μάρτυς* or especially the more generally used Aeolic form *μάρτυρ*, a witness, it must properly describe one who "testifies," or is prepared to testify with his life if need be, to the truth of his conviction, belief or faith, in the face of opposition, persecution or even torture. In this sense is the term employed throughout the history of the early religious conflicts, although its usual spiritual coloring is bedimmed at times by a discordant tinge of fanaticism. Allegiance to a Cause is naught but a confession of faith in it, tacit or otherwise—a *witnessing* or attestation of one's belief in it; thus, it is not difficult to follow the connotative transition of the word into its later implication of suffering, ending in death, in consequence of such loyalty. From first to last in the long story of human martyrdom, whether in the cause of religious faith or of patriotic idealism, initial courage and subsequent fortitude have been tested not more at the moment of supreme sacrifice than during the long and often bitter course of constant, unswerving devotion to that cause, in thought and by act, in contempt of physical danger presented as constantly in many forms.

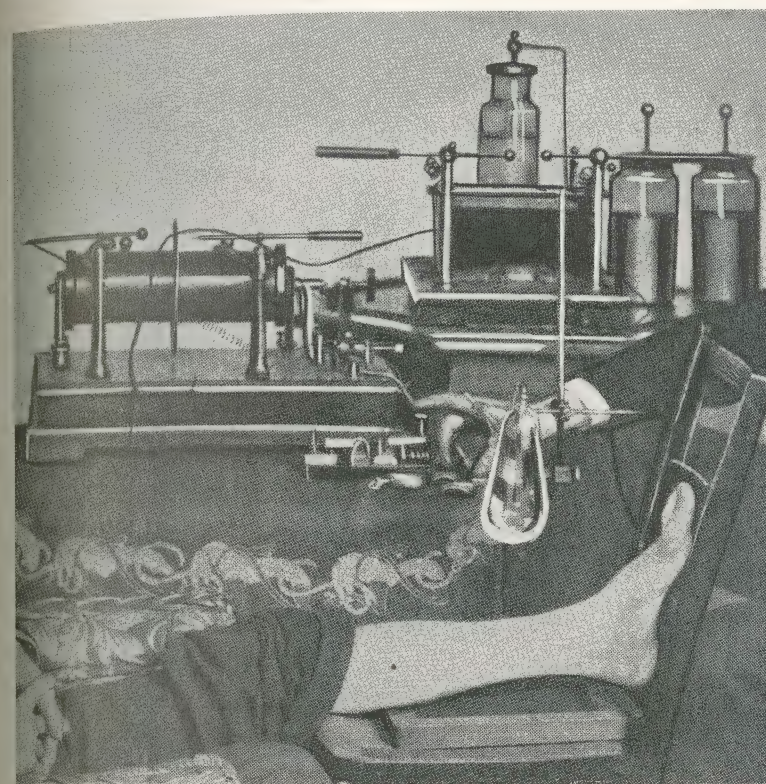
The comparatively crude methods formulated in the brain or fashioned by the hand of man by which to imperil or destroy his fellow-man have been the results of human ingenuity born of inhuman intent, in subtlety limited by man's power to dissemble. As such they have lacked the fundamental elements of invisibility or intangibility by which Nature has been able to conceal many of her forces for animate harm until they have been revealed by truth-seekers in the field of Science. Revealed—but only through the creation of a martyrdom of another order, wherein allegiance has been "witnessed" amid perils of the deepest subtlety and whereby,

among other revelations, it is now given us to know the cause and control of yellow fever, the intimate physical geography of the poles of the earth or the potentialities of the roentgen-rays in the relief of human suffering.

The intensity of the immediate search for scientific data in the virgin field of investigation created by Röntgen's discovery, in 1895, of the rays that now bear his name, suggests the ardor of the great Quests of history, Arthurian romance and mythology—the Holy Grail, the Elixir of Life, the Golden Fleece or the Philosopher's Stone. Although the cool caution of a scientific mind had prompted Professor Röntgen to withhold his *Preliminary Communication* of late December, 1895, until he had utterly verified his observations up to that point, the very nature of the phenomenon enveloped it with an aura of romanticism felt by even the least imaginative perception. Such impulsion added zest and piquancy to the world-wide research forthwith set in motion, with a resulting flood of recorded and published observations. By the wave of a seemingly magical wand in the hand of a gentle German physicist, the prospect of a great new field to conquer was spread before a scientific world that charged upon it without perceiving, *for the moment*, the presence of the hostile force that lay in ambush. Enthusiasm was in the saddle, accoutered with the lance of investigation and the spurs of continued experimental revelation, but not yet with the shield and armor of protection.

Quite unjustly, it has been asserted that the ascription of courage and fortitude which has been directed, and properly, to the martyrs and the pioneers of radiological science should be qualified by the fact that such attributes were not actually put to the test in view of a general unconsciousness of the existence of danger. That such ignorance obtained during the earliest moments, as it were, of this great quest, is to be admitted. As the accurate historian Glasser remarks, there was no reason to anticipate any physiologic effect from the

roentgen-rays. He also records¹ the fact that Röntgen himself, for the purposes of his earliest investigations, was enclosed by a chamber of zinc locally fortified with lead, not with any thought of protecting his person from the influence



Archives of Skiagraphy

FIG. 1—The earliest infancy of the Roentgen rays: The x-emanations from a Crookes tube of one of the original types are directed downward through the lower leg onto a plate contained in a simple photographic plate-holder.

of x-rays generated outside the chamber, but rather for the probable purpose of defining more clearly their beam through

¹ Glasser, Otto: "Wilhelm Conrad Röntgen and the Early History of the Roentgen Rays." *English Translation*, Springfield (Ill.), and Baltimore, Thomas, 1933; p. 293.

a variable aperture in a wall of the chamber and of preventing, as well, the "fogging" of the photographic plates that were a part of his experimental paraphernalia.

On the contrary, this momentary period of complete nescience as to the deleterious qualities of the roentgen-rays was soon over. Within a period of ninety days after Röntgen's *Preliminary Communication*, suspicion was aroused in the minds of many investigators² that x-rays, or something evolved in the production of x-rays might have some ill effect on living tissues exposed to them. The intrinsic structures of the human eye, known to be especially sensitive to all forms of irritation, were perhaps uppermost, at that time, in the belief of the investigating physicist as being as susceptible, or more so, to this new emanation as to the variable light-effect of any intense electrical discharge. The popular conception, on the other hand, was at once moulded by a conviction that the power for possible harm in the roentgen-rays was to be estimated in terms of *light*, of an intensity beyond belief, in spite of the fact that a popular periodical magazine of American publication³ in early 1896 reported an interview with Professor Röntgen during which he stated specifically that x-rays are *not* light.

The late William Rollins,⁴ an early investigator of great accuracy, habitually used the term "*x-light*" in the many communications he made to scientific journals from 1896 to 1904. Had these publications been seen and read by the public generally, the erroneous conception that x-rays are a form of intense light might well have been augmented; even today, forty years later, it persists in surprising degree. To the physicist, Rollins's signification is clear; by "*x-light*," he refers to roentgen-rays, themselves invisible, made visible

² Battelli, F., "The Reaction of Roentgen-Rays upon Various Human Tissues." *Atti. Acad. Med. Fis. Fiorent.* 14 Mar. 1896.

³ *McClure's Magazine* (N. Y.), 6: 403, April, 1896. Quoted in Glasser, p. 5 (*op. cit.* p. 5).

⁴ Rollins, W., "Notes on X-Light." Boston, (privately printed) 1904.

through the agency of any chemical substance capable of fluorescence in their presence. Of these, the best known have been the platinocyanid of barium and the tungstate of calcium.

One of the earliest reports dealing with the effect of roentgen-rays on the human eye was that of Battelli.⁵ At almost the same time appeared other communications of varying conclusion. William J. Morton of New York, a very early pioneer in radiology, complained of certain unusual ocular symptoms after prolonged gazing at substances in a state of fluorescence under x-rays, but these were probably not more than those of retinal irritation usual in eye-strain of this type. Thomas A. Edison, after a period of intensive experimentation with the phenomenon of fluorescence in the development of his "fluorescent lamp,"⁶ became conscious of annoying, not to say painful, eye symptoms, but he thought them due rather to the fatigue of hard use than to the direct effect of the roentgen-rays. At the urgent recommendation of his medical adviser, Edison abandoned the pursuit of this investigation, although, with the consideration of his employes for which he was noted, he was motivated more by concern for his laboratory assistants in this research than for himself.

From other quarters came reports that the roentgen-rays have no effect upon the *sight* of the eye. "Mr. [A.C.C.] Swinton informs us," writes the editor of *Nature* in early March of 1896,⁷ "that, though Mr. J. C. M. Stanton and himself have worked continuously with the Crookes tube for hours together, neither of them has experienced any ill effect so far as their sight is concerned." Dr. William Rollins was not so positive as this. The following July, in describing his

⁵ Battelli, F., "The Transmission and Effect of Roentgen-Rays upon the Eye." *Arch. ital. de Biologie*, 25: 202, 1896.

⁶ Edison, Thomas A., *Vide* p. 36.

⁷ *Nature* (London), Editorial Comment, 53: 421, 1896.

"reflecting cryptoscope"⁸ for use within the mouth in x-ray examinations of the teeth, he recommended the employment of "a heavy glass plate over the fluorescent screen to protect the eyes from x-light."⁹

Evolved from this early combined experience in the physical laboratory, the weight of evidence has favored the deduction that the function of sight is not destroyed or seriously inhibited by ordinary exposure to the roentgen-rays; indeed, the deeper knowledge of the passing years has determined that the intrinsic organs of sight are among the most resistant to x-rays of any of the body tissues. The weakness of any early inference to the contrary lay in the fact that many reports were premature and often based on the erroneous assumption that the effect of the roentgen-rays on the eye must needs be as swiftly acute as that of many other sources of retinal irritation. More extended observation might have afforded the information, so readily gained somewhat later, that irritations of the conjunctiva and cornea are usually the first reactions of the eye to undue exposure to roentgen-rays. Such manifestations have served as warnings to the experimenter to protect his eyes in one of various ways, and this is perhaps a reason why cases of irreparable loss of vision have been of such exceedingly rare appearance in the authentic records.

These moderately disputatious reports relative to the eyes of the investigator were, however, throughout the latter years of the nineteenth century, almost lost sight of amid the ensuing influx of recorded observation as to his skin. Of such records that appeared in 1896, many were from the pens of the physicists, who had contributed the major portion of the material published on the subject of x-rays during that

⁸ *Cryptoscope*. The name given by E. Salvioni (Perugia) to his tubular device for observing the x-ray effect upon a fluorescent substance (barium platinocyanid).

⁹ Rollins, W., "A Reflecting Cryptoscope and Cryptoscopic Camera with Non-radiable Walls," *International Dental Journal*, July, 1896.

eventful year. It is noteworthy that of twenty-nine of these early reports¹⁰ relating to the tissue-effect of the roentgen-rays, exclusive of the eye, but eight were of American source. All these appeared in the engineering literature of that day; outstanding among them were the reports of Mr. Herbert D. Hawks and Professor Elihu Thomson relative to the reactions produced in their own persons. The value of each can be well appreciated if it be quoted *verbatim*.

Mr. Hawks,¹¹ then (early 1896) imminently to be graduated from Columbia University, was a volunteer assistant in the x-ray laboratory of the late Professor Pupin of the Department of Physics. The published *Communications* of Professor Röntgen had interested him keenly, and at once he plunged into enthusiastic experimentation of his own with apparatus assembled for the purpose of study and demonstration. His equipment, for that day, was powerful. Aside from his own work of investigation, he gave generously many demonstrations to a multitude of curious as well as seriously interested persons in the vicinity of New York City. This resulted in his exposure, during that summer, to x-rays for a considerable portion of each day and evening. Mr. Hawks thus recorded his observations of the onset and progress of his condition:

It seems that all of the properties of the x-ray have not yet been discovered; among the latest is the physiological effect with the powerful apparatus now used [1896]. Experimenters are beginning to find that it affects the system. During the early part of July, I carried on a long series of experiments with an extremely powerful apparatus. At the end of a few days, I found that the rays were having quite an effect upon me. At first, the skin began to dry and to itch, all the moisture having been taken out of it. . . . After a little longer exposure, my hand, which was the part most exposed, began to swell, the inflammation being in the hand for about ten days; at the end of that time the swelling rapidly went away but

¹⁰ *Vide Bibliography* (and Index, p. 483) in Glasser (*op. cit.* p. 5).

¹¹ Hawks, H. D., *Electrical Engineer* (N. Y.) 22: 276, 1896.

the skin all came off, just as with a sunburn. The joints and fingernails seemed to suffer most, the joints becoming nearly transparent . . . new warts have since grown. Wherever the hair was exposed to the ray it fell out, but it does not seem to be permanently injured, as it grows again as the skin gradually returns to a healthy condition, but the growth is very slow. In my case, it was eight weeks after the exposure before it started to grow. The eyes were also very badly affected where not covered by the lids. The exposure to produce such effects as these probably amounted to be tween two and three hours. . . . Summing up, I will say that the effects seem to be confined to the skin alone, and consist principally in the drying up of the oils in it, which produces all the effects on hair and nails as noted, and none of these effects are permanent, but disappear when the skin becomes healthy again.

It is a satisfaction to be able to record that these acute manifestations did not pass into the ulcerative stage and result in malignant degeneration before Mr. Hawks relinquished his work with the roentgen-rays. They left their mark, however, as is shown by a personal communication from him *thirty-eight years* after his injury:

. . . My right hand was burned the most because this was the one generally exposed to the tube, the left hand being further away and holding the fluoroscope. [See p. 23]. . . . My hand recovered and has since been in good shape except for the peculiar scarred effects coming from such burns. The skin is a little bit thicker than normal skin but there is no discomfort. *My nails on both hands came off*—in fact the nail on the index finger of the right hand came off four times, and for a considerable time the cuticle continued to grow out over the nails and had to be periodically cut off. I still have all of the nails on my right hand, but they are rather brittle and the skin or tissue under the nails is not exactly normal as it becomes easily stained and hard to clean. I was in very excellent physical condition at the time and probably this accounted for my recovery.

Of great importance also was the widely-published report of Professor Elihu Thomson¹² regarding his observations of the effect produced *intentionally* in his own skin:

¹² Thomson, E., *Electrical World* (N. Y.) 28: 766, 1896; *Electrical Engineer* (N. Y.) 22: 520 and 534, 1896. Also quoted by Glasser, p. 300 (*op. cit.* p. 5).

I noted the fact that, after exposing the little finger of my left hand for one half hour close to the bulb [x-ray focus tube] at about 1½ in. from the bombarded platinum, no decided effect followed until over a week; that finger then reddened, became extremely sensitive, swollen, stiff and to a certain extent painful. I wish to add that at present about seventeen days have elapsed since the exposure and the finger is still quite sore but showing signs of improvement. Two-thirds of the exposed portion is covered by a large blister which becomes larger every day. The pain and sensitiveness is less after the blistering takes place. The effect has not extended through the finger, but is confined to the back and sides, and is strictly limited to the exposed portion. *There is evidently a point beyond which exposure cannot go without causing serious trouble.*¹³ It may be that several short exposures would have an equal effect if made within a few days. The effect on my finger was made in a single exposure of one half hour at a short distance, and by the law of inverse squares would be the same as from ten to twelve hours at 6 in. distance. I do not think that the effect is electrostatic at all, as has been suggested. The evidence, so far as it goes, leads me to think that the effect is another indication of the chemical activity of roentgen-rays, of like character to the effect of high-pitched waves of light in causing sunburn by penetrating more deeply into the tissues. It remains to explain the "period of incubation," which is peculiar. Here might be the place to issue a caution to experimenters—it is: Do not expose more than one finger; be satisfied with the effect of, say, five hours exposure at 6 in. distance, and do not prolong it to equal a longer time or there may be cause for regret when too late.

Professor Thomson shortly after wrote to Dr. E. A. Codman,¹⁴ of Boston, concerning the progress of this self-inflicted injury:

. . . I do not propose to repeat the experiment . . . under any conditions, at least not for the present, as the whole epidermis is off the back of the finger and off the sides of it also, while the tissue, even under the nail, is whitened and probably dead, ready to be cast off. The back of the finger for a considerable extent where it received the strongest radiation is raw and will not recover its

¹³ Editor's italics.

¹⁴ *Vide* correspondence of E. A. Codman, *Boston Medical and Surgical Journal*, 135: 610, 1896.

epidermis, apparently, except from the sides of the wound. It has, apparently, begun to granulate. . . . The wound itself is very peculiar and I never saw anything like it. It continued to develop and spread over the extent of the exposed surface for three weeks and I am not sure yet that the affection has reached its limit on the exposed surface. . . .

The experience of Dr. Emil H. Grubbé, of Chicago, was of equal historical moment and of more serious outcome. His report of it, made many years¹⁵ later, was based on notes recorded during the course of his experimentation in the last months of 1895 as well as in 1896. This *report*, consequently, does not hold the same chronological position in the literature as do those of Hawks and Thomson, yet the evident priority of Grubbé's first physical injuries produced by roentgen-rays and the fact that his bitter experience was well-known among contemporary physicists and medical experimenters must have served as an early warning to many. Of this pioneer work Doctor Grubbé, then a physicist and chemist, writes:

. . . At the very time [1895] when he [Röntgen] did this work, I also was working with Crookes tubes, studying the fluorescence of chemicals. I had read in *Annalen der Physik und Chemie* of September and October, 1895, of the experiments of Lenard,¹⁶ and I was duplicating this work when the discovery of x-rays was announced by Röntgen. Under the stimulus of this new discovery I worked almost continuously for several days, duplicating Röntgen's experiments and making new Crookes tubes. I was, in all probability, one of the earliest experimenters with the new rays. The subject was of particular importance to me because, at that time, I was not only an experimenter with vacuum tubes but a manufacturer of these devices. . . . The first Crookes tubes I worked with did not have a large output of x-ray energy. I judged that this was due to the fact that the cathode rays in my tubes

¹⁵ Grubbé, E. H., *Radiology* 21: 159, 1933.

¹⁶ Lenard, P. This observer, supplementing the work of Hertz (1892), found that many of the phenomena of the cathode rays could be seen *outside* the Crookes tube. Thus, in reality, did he observe x-rays without recognizing them.

were not concentrated sufficiently to transform them into effective x-ray value. Then I recalled having read that Jackson¹⁷ had in the two previous years improved the Crookes tube by decidedly cup-shaping the cathode. With this improvement the cathode stream could be brought to a focus. Also, in order to prevent the enormously high temperature, which was generated where this focal area occurred, from melting or puncturing the glass wall of the tube, an anode of platinum was placed in such a position that it would intercept the cathode rays, thus keeping the heat from the glass; in addition this anode was placed at an angle of sixty degrees in order that it might reflect the cathode rays out of the tube. Theoretically this offered a decided improvement over the old-style Crookes tube. I immediately made a tube embodying the ideas of Jackson. The very first tube I made after this pattern was much more efficient. . . . Undoubtedly it was because of my early use of this method of focusing or concentrating of the cathode ray on the anode of the tube that I developed x-ray dermatitis very shortly.

Incidentally, it must be remembered that, having worked with Crookes tubes in the study of fluorescence before December 28, 1895, my body had been exposed to x-rays some time before Röntgen made his announcement. I made a number of tubes, all of which I tested for vacuum by exposing my left hand between the tubes and fluorescent materials. This was done many times daily for many days. In other words, my left hand was practically touching the excited Crookes tubes during most of the testing periods. These frequent and long exposures to the x-ray produced a cumulative effect, so that, at the beginning of the last week of January, 1896, I had developed a dermatitis on the back of my left hand which was so acute that I sought medical aid.

At first my symptoms were erythema, oedema, hyperaemia and hyperaesthesia. A few days later, there was bleb- and blister-formation with skin desquamation and epilation of the hair. Later the skin cracked and ulcer formed. (Parenthetically I would state that this hand was amputated piecemeal and for some years has been gone entirely.)

The records of Hawks, Thomson and Grubbé, enhanced in value by the quality of accuracy for which such men are

¹⁷ Jackson, Herbert C., of King's College, London.

noted, are examples of the premonitory communications, positive and prompt, from physicists of authority the world over within ninety days, as has been said, after the discovery of the roentgen-rays. These reports were closely followed by enough more from biologists as well as from medical investigators and practitioners to establish the conclusion that some form of energy associated with the production of roentgen-rays was far from being an inert force—a power, indeed, for distinct physical harm, as shown by these deplorable manifestations in the skin and its appendages. This disturbing fact suggested at once a new field of inquiry. What was this agent? To what were these skin reactions due? Were they due to the effect of the cathodic rays of Crookes emanating from the negative pole within the discharge chamber? Or to that of ultraviolet rays produced coincidentally with roentgen-rays? Were they due to the effect of gaseous chemical products generated in the tissues exposed? Were they the result of bacteria driven into the skin, or due to the impact of minute metallic particles in like manner driven? Was there an electrostatic effect on the skin from the induced currents created in the vicinity of the Crookes tube, or were the skin-effects wholly due, indeed, to roentgen-rays independent of any associated phenomenon?

An important factor in the ultimate determination of this question was the widely-published observation of Elihu Thomson, above quoted. His theory, which was shared by others, that the roentgen-rays are the sole cause of all reactions in human tissues exposed to them, was the one ultimately to be accepted, although opposing theses were many. Longest, perhaps, to endure against it was the belief that the "burns" were produced by an electrostatic effect in the tissues created simultaneously with the excitation of the Crookes tube.¹⁸ This tenet was abandoned only after some

¹⁸ Leonard, Charles Lester. *Vide* p. 117.

months of heated discussion, as was also the hypothesis that synchronous ultraviolet radiation might be, rather, the cause of the reactions. In view of expressions of doubt as to the conclusiveness of his observations and in support of them. Thomson made reply:¹⁹

For my part I am willing to admit that ultra-violet rays might possibly, if they existed in great quantity, produce some such effect, but I am not ready to admit that brush-discharges had anything to do with it, for the simple reason that the potential [kilovoltage] I used was low, being obtained from a small 24-plate static machine, and there were no perceptible sparks from the [Crookes] tube to the finger. . . .

I am strongly of the opinion that it is really a Roentgen-ray effect and that neither ultra-violet rays or brush-discharges have anything to do with it. . . . Now, if it were a brush-discharge, since the finger was held in practically one position, the effect should have been far more local than it is, and not have affected the sides of the finger almost around so as to include the palmar surface. I have worked with brush-discharges around electrical apparatus when I know the sum-total of effect must have been many times what could possibly have been obtained from brush-discharges in this case, assuming that they existed imperceptibly. I worked in the dark, and saw none and felt none. Now, as to the ultra-violet rays, I am convinced that they are not responsible for the result, chiefly because of the effect being continued laterally on the fingers on each side, a portion of the finger which is not exposed to ultra-violet rays under the conditions unless they traversed a considerable thickness of the dermal layer, filled with blood-vessels which would absorb the rays. The rays, whatever they were, came from the bombarded spot, and were limited to the area which Roentgen-rays could reach. The tube was a blue-glass tube with a clear German-glass window of about one and one-half to one and three-fourths inches diameter opposite the bombarded spot. The fingers opposite the blue-glass were not affected, as this is so dense as to absorb the Roentgen-rays. Only where the little finger was opposite the clear glass was it affected, and there is a sharp line of demarcation between that portion and the rest of the

¹⁹ Codman, E. A., Correspondence, *Boston Medical and Surgical Jour.* 135: 610, 1896.

finger back of the blue-glass. . . . There is only the supposition left that the effect was produced by Roentgen-rays or something that comes from Roentgen-rays. . . .

In view of such ample warning, who shall say, as has been intimated from time to time, that the contemporary pioneers, and those to follow them until the close of the century, were in *complete* ignorance of their danger as workers with this extraordinary agent! For any who might be apprehensive, now was the chance to retire.

History records that the field was vacated forthwith by a comparatively small group: By those, naturally, who had hoped to exploit the x-rays in popular exhibitions and similar schemes; also, and quite properly, by those whose life-work lay in other directions—the physicists who had paved the way for the practical usefulness of the roentgen-rays, sounding an admonition of danger as they turned to other problems, and the medical practitioners who, although strongly attracted by the promise of roentgenology for the furtherance of their work, were compelled to relinquish its clinical development to special hands. It was these avowed and determined special workers, pioneers in the cause of their Work and in many instances ultimate martyrs to it, who remained in the field by a “right of eminent domain” created by their continual acts of self-effacing devotion in the name of the humanities.

The investigation of Grubbé and Thomson tended to establish the fact that the physical action of roentgen-rays on living tissue is cumulative, which accounts for the nature of the chronic lesions subsequently sustained by early roentgenologists. Also, the results of Thomson’s experiments disproved definitely the pseudo-scientific claim that “burns” of the skin could not be acquired from exposure to x-rays generated by the “influence” static- or “dynamo” static-machines. Such an assertion was dangerous; it created a false sense of security that was without doubt the cause of much damage to the operator, with its subsequent suffering.

The final determination of the causative factor of “roentgen-ray dermatitis” made the problem of protection against it an easier one. Some investigators there were who had, almost at the inception of their work, a seemingly intuitive sense of their need of protection. Among these were William Rollins and his eminent colleague Francis H. Williams. Said Williams: “I thought that rays having such power of penetrating matter, as the x-rays had, must have some effect upon the system, and therefore I protected myself.”²⁰ Rollins wrote later (1903): “That I have escaped injury is due to an early recognition of the dangerous nature of x-light and to the precautions recommended in earlier papers having been taken. . . .”²¹ The practical results of this prescience of danger were numerous devices created by the ingenious Rollins for the safety of both operator and patient.

It is a sombre commentary on the lack of vision or on the indifference of a majority of those engaged in the fabrication of x-ray apparatus, especially for the medical enthusiasts of that day, that precautions for protection of the experimenter or practitioner were not *generally* adopted until some years had passed, at least not in the United States. As early as 1898,²² Rollins devised a non-radiable box, with a diaphragmed aperture, to enclose the focus-tube in order that the scattering of its emanations might be controlled and directed onto a predetermined field; yet *five years later* he was constrained to write:²³

Most of these precautions are neglected even at the present time, as may be seen by examining the illustrations in the catalogues of makers of apparatus and in the papers and books of those who are writing on the subject, where open [unshielded] tubes are almost invariably figured. . . . That inefficient means are still employed . . . is partly due to attempts to ignore or disparage the crucial experi-

²⁰ Quoted in Glasser, p. 293 (*op. cit.* p. 5). Doctor Williams used almost the same words in a statement made to the author many years ago.

²¹ Rollins, W., *Boston Medical and Surgical Jour.* 148: 364, 1903.

²² Rollins, W., *Electrical Review* (N. Y.) 33: 107, 1898.

²³ Rollins, W., *Boston Medical and Surgical Jour.* 148: 364, 1903.

ments that have been reported in other notes on the effects of x-light on animals. . . .

One recalls with regret, therefore, that but very few of the early pioneers proceeded in their work with anywhere near the degree of personal protection that Williams and Rollins enjoyed. Why was this so? Those who attempted the construction of practical apparatus for the use of the early roentgenologists were for the most part technically trained, habitually prone to read the engineering journals, and presumably would be the first to hear, if not to heed, the published warnings of contributors such as Hawks, Thomson, Stine, Rollins, Edison and others in 1896. Why did they not promptly embody in their apparatus the principles of protection for the operator that were so early and so practically applied by Rollins?

In retrospect, an explanation is not easy. Dr. Lauriston Taylor, in his monograph²⁴ on roentgen-ray protection, writes: "It seems probable, in the excitement over new discoveries being made daily with roentgen-rays, that protection from them was allowed to lapse after the first few meagre precautions were taken. . . ." The writer has reason to remember that these "first few" precautions were meagre almost to the vanishing-point, and complete invisibility was prevented, at least in the United States, only by the foresight of Williams, Rollins and a very few others.

There is another attempt at explanation that can be made. At that moment, when not only scientific but lay interest was at its height, it was much to the advantage of fabricators of x-ray apparatus to preach *simplicity* as connoting, in their wares, both ease of purchase and ease of manipulation. Glasser²⁵ quotes from the *Scientific American* of early 1896 the following advertisement, which was typical of many, commending a—

²⁴ Taylor, L. S., "Roentgen-ray Protection." *The Science of Radiology*, chap. XIX, p. 332, Springfield (Ill.), Thomas, 1933.

²⁵ Glasser, O., *op. cit.* (p. 5), page 359.

. . . portable x-ray apparatus for physicians, professors, photographers and students, complete in handsome case, including coil, condenser, two sets of tubes, battery, etc., for the price of \$15. net., delivered in United States with full guarantee.

The principle of *multum in parvo* being thus strained to the utmost, what with the "handsome case" and all, such a detail as adequate protection for the operator in the form of a radiopaque enclosure for the Crookes tube was quite overlooked, although the need for it must have been apparent to every apparatus-manufacturer who read the engineering literature of the day. In fact, a considerable proportion of the physical damage to enthusiastic medical practitioners of this early era was inflicted by means of these "portable" apparatuses, cheaply obtainable, wherein the output of radioactive energy was so low that long exposures were required to accomplish results even approaching those to be obtained from others of a more powerful type. Through this amazingly widespread, though happily short-lived, disregard of known danger on the part of commercial implement-manufacturers did the physical trials of the pioneer roentgenologist begin. If, by some turn of the wheel of destiny, William Rollins and others of his type had lent their genius to the commercial production of apparatus embodying their insight and caution, the picture of American pioneer roentgenology might have been limned in brighter pigments. But Rollins had no thought of the commercial fabrication of his diagnostic devices. His experiments, as later (1904) he wrote,²⁶ were "made after the day's work as a recreation, yet with the hope of learning to design and construct apparatus for my friend, Dr. F. H. Williams, who has done most to show the importance of x-light in medical diagnosis." With his technical training and his mechanical genius, Doctor Rollins was an unusually skilful dental practitioner, possessing clinical

²⁶ Rollins, W., Foreword in "Notes on X-light." Privately printed at The University Press, Cambridge, June, 1904. Further mention is made of this remarkable work in *The Science of Radiology* (Thomas 1933), p. 381.

instincts that probably accounted for the emphasis he gave to the proper protection of both operator and patient in radiological work.

As may be inferred from the wording of the passage just quoted, Rollins was of a disposition modest almost to the point of diffidence; prior to 1904, his *Notes on X-light* appeared at frequent intervals in the national engineering and dental journals, but in the medical literature they were confined almost totally to the local (Boston) journal, and often inconspicuously placed therein. It would seem as if the very title of these important contributions made for their added obscurity. As such they were rarely reviewed for other medical publications and consequently did not easily reach the notice of the medical profession at large, which included the very enthusiasts to whom the measures of safety advocated by Rollins were of the utmost importance. In the engineering press, Rollins's *Notes* were given much greater prominence, but even here, while reviewed at their true worth by physicists, they evidently received scant attention from the very early producers of practical apparatus, to the distinct detriment of contemporary operators. It was not until the year 1900 that the designs of William Rollins were materialized in an induction-coil apparatus produced commercially by W. E. Oelling and J. O. Heinze. These designs were altruistically supplied by Doctor Rollins without thought of material gain. An important component of this equipment was a radio-paque enclosing support for the focus-tube, primarily intended for the protection of the operator as well as the patient.

Another reason why many pioneer roentgenologists were unduly exposed, with more than one fatal result, was the baseless theory that any untoward skin reaction (radiation-dermatitis) in the operator were impossible, or nearly so, if the influence (static) machine be used to excite the Crookes tube as against the Ruhmkorff or Tesla coil apparatus, in

the production of roentgen-rays.²⁷ In spite of Thomson's experiment in early and definite disproof of this supposition, its growth was persistent for some time once it had taken root, the soil being left not unfertilized by the astute maker of static-machines. Thus, many an earnest roentgenologist²⁸ prosecuted his work in the spurious security promised by this fantasy, in disdain of local modes of self-protection either at the source of roentgen-ray emanation (the focus-tube) or in more intimate relation to his own person.

To speak generally, it may be said that, of all *accessory* implements used by the roentgenologist in his practice, the one to which his bodily damage has been laid most consistently is the *fluorescent screen* in its various forms. In principle, this instrument is based on the power possessed by certain crystalline substances to become luminous, within a darkened space, in the presence of cathode rays or of roentgen-rays, thus "turning x-rays into light rays," to use the words of Rollins. From Edison's well-known experiments of 1896 with a great number of crystalline substances (*vide* p. 35) came the discovery of a salt which in many ways, though not in all, was superior to those in use among physicists up to that time, even before the discovery of the roentgen-rays. He coated a thin plane support with this substance (calcium tungstate) in a finely-divided form and covered this "screen" with a hood in the shape of a truncated pyramid to exclude daylight, placing an aperture, formed for the eyes, at the line of truncation, with a supporting handle on one of the sides of the pyramid. By this means the glowing luminosity of the coated "screen" is made visible without the aid of circumambient darkness. Edison called his device a "fluoroscope," but in declaring that he invented the fluoroscope many historical writers have created the false impression that

²⁷ Frei, G. A., "X-rays Harmless with the Static Machine." *Electrical Engineer* (N. Y.) 22: 651, 1896, *et alii*.

²⁸ For examples, *vide* pp. 56 and 129.

this was the original method by which the invisible roentgen-rays are changed to visible light rays through the medium of fluorescence. This, of course, is not so; other types of "hooded" screens there were, in form usually tubular or conical, devised by various²⁹ investigators, but to Edison is to be given the credit of the discovery of the tungstate of calcium as a fluorescent material of peculiar qualities of excellence.

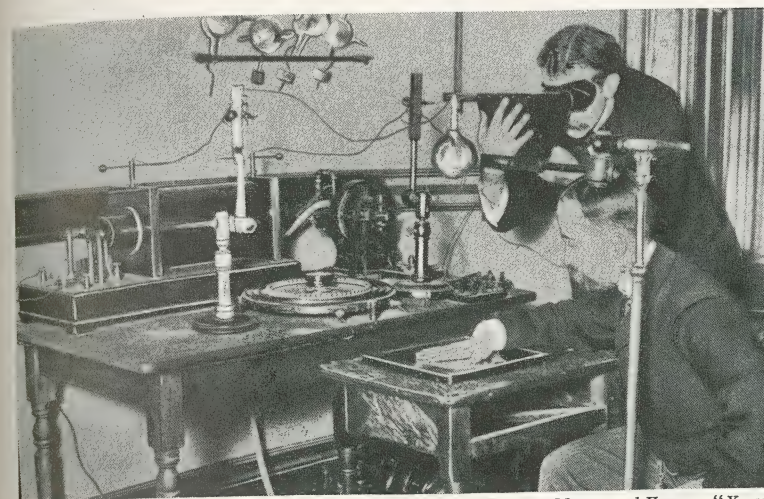
Throughout the entire history of fluoroscopy as applied to medical diagnosis, use has been made of either these enclosed screens or "open" screens without a hood. As long as the hooded screen was employed, so long did grave danger to the operator obtain. One reason for this was the fact that the pyramidal hood, enclosing his eyes against extraneous *light* rays and supported by one hand, made it easy for him to use his free hand, placed between screen and Crookes tube, as a gauge by which to judge the penetrating powers of the roentgen-rays at his command. Of the tissues within the hand, the bones were most commonly used in this estimation, probably because of their conspicuous shadows and the relative resistance they offered to roentgen-rays of all degrees of penetrability. From the densities of the bone-shadows a scale of penetration could be mentally formulated.

Unfortunately, this estimation of penetration could not be made properly without some delay, on account of the short time required for pupillary accommodation. Instead of acquiring this pupillary adjustment as we do today, by pre-shading the eyes in anticipation of our fluoroscopic manoeuvres, the pioneer observer acquired it *after* his eyes were applied to the hood of the fluoroscope and, one regrets to recall, usually after the excitation of the Crookes tube had begun. These few moments during which his eyes, for the purpose in hand, were not at their physiologic best and

²⁹ Salvioni, Magie, E. P. Thompson, Spies, Macintyre and others.

therefore not serving him to the full, but during which the convenient gauge of his hand-skeleton was probably constantly scrutinized, were but added drops to the bucket of cumulative effect that was to prove, in so many instances, his ultimate undoing. (Fig. 2.)

This deleterious method of qualitative determination, that now seems so primitive, was in almost universal usage among the early investigators. Even Francis H. Williams wrote as



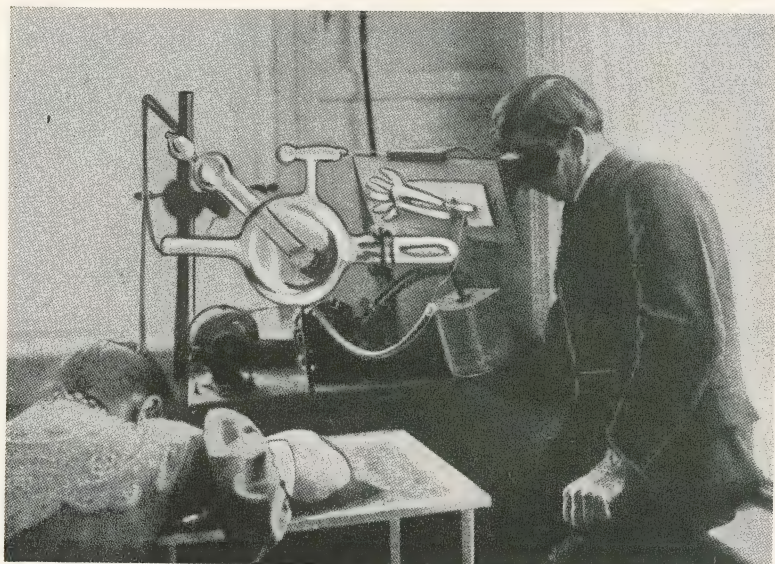
From Morton and Hammer "X-rays"

FIG. 2—The pioneer William J. Morton investigating the output of a Crookes tube by means of a hand fluoroscope in his New York laboratory. This shows the manner in which so much of the early fatal damage was incurred. (Courtesy American Technical Book Co., N. Y.)

late as 1901:³⁰ "A simple way of testing the quality of the light [the degree of penetration of the rays] is to examine the hand with the fluorescent screen," yet history reveals that, through the intervention of the ingenious and far-seeing Rollins, he was spared the necessity of putting his suggestion into long practice. At a very early moment Rollins had recognized the urgent need of shielding the observer wherever

³⁰ Williams, F. H., "The Roentgen-Rays in Medicine and Surgery." Page 46. (New York, Macmillan. 1901.)

fluoroscopic work was to be done,³¹ and this discernment as applied to the cryptoscope (fluoroscope) was exercised with particular reference to the eye, an organ which, the records reveal, caused him peculiar anxiety (*vide* p. 8). To the cryptoscope he added a sheet of lead-glass to its larger end, outside the screen, after constructing the walls of the instrument of radiopaque metal. The lead-glass, "weighing more



From Carl Beck: "Röntgen Ray Diagnosis and Therapy"

FIG. 3—Showing the use of Carl Beck's "osteoscope," wherein, to shield the operator's hand and forearm, corresponding parts of an articulated skeleton were substituted. This protected the operator locally, but the use of the instrument tended to establish a false sense of security concerning other parts of his body. (Courtesy D. Appleton-Century Co., N. Y.)

than four pounds," made this instrument too heavy to hold without prompt fatigue, so the lead-glass protection was transferred to the small end of the hood in front of the eyepiece, with an increase of its thickness to compensate for its diminished area. Thus was the weight upon the supporting hand more evenly distributed. While this application of radio-

³¹ Rollins, W., *loc. cit.* p. 6.

paque material to the fluoroscope no doubt furnished practical protection for the eyes of the observer, in no way did it mitigate the danger to the skin of his hand held even momentarily, as a gauge, between the screen and the source of roentgen-rays, or of his hand that grasped the supporting handle of the instrument. The supporting hand, while perhaps not as directly in the beam of x-ray emanation, was generally as much exposed to the radio-active field around the Crookes tube as was the hand serving as a gauge of penetration or "skiameter."

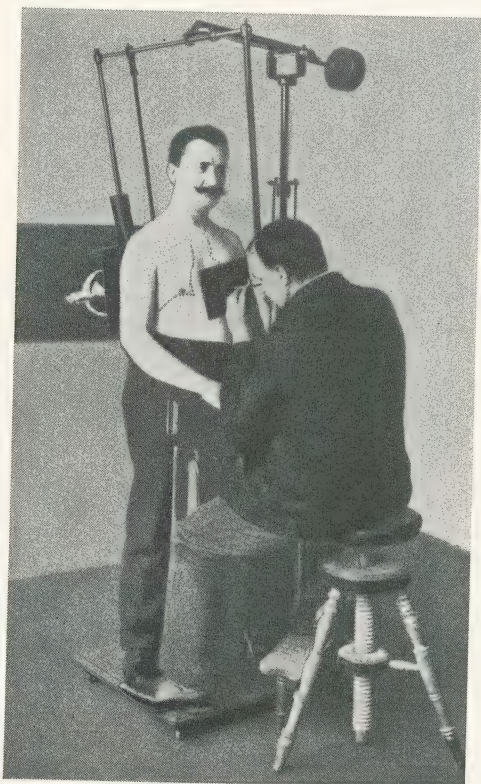
In the years from 1896 to 1902, the novelty of the fluorescent screen in the form of the hand "fluoroscope" and the interest and enthusiasm aroused at the moment of its use, tended mightily to prolong the exposure of the operator, who was ever glad to demonstrate its wonders to the casual observer or to the patient and his physician. X-ray "exhibitions" were popular at fairs and similar gatherings. Doctor Trostler of Chicago, the Historian of the Radiological Society of North America, recently narrates regarding the early history of an American martyr: "... he died in 1908 as the result of roentgen injuries, most of which were received while exhibiting his hands and arms at a church fair during the winter of 1907. . . .³² I personally cautioned him, but he laughed at my warnings."³³

In this connection may be mentioned the memorable fluoroscopic demonstration given by Mr. Edison and his assistants in May, 1896, at the annual exposition of the National Electric Light Association held in New York City. This was the first large public exhibition in the United

³² Trostler, I. S., "Some Interesting Highlights in the History of Roentgenology." *American Journal of Physical Therapy*, February, 1931. With reference to the demonstrator's danger at public x-ray "exhibitions," see p. 73 and 135, and also the experience of Mr. H. D. Hawks (p. 9), who, by his careful report of his "burns," becomes one of the great contributors to the knowledge of early radiology.

³³ *Personal Communication.*

States of the roentgen-rays made visible by means of their effect on fluorescent substances.³⁴ Here were shown simultaneously the uses of Edison's special form of hooded screen (the "fluoroscope") and the "open" screen, to a moving



From Carl Beck: "Röntgen Ray Diagnosis and Therapy"

FIG. 4—Another fluoroscopic procedure of great danger to the operator, in spite of the rudimentary protective screen in front of the tube. (Courtesy D. Appleton-Century Co., N. Y.)

queue of visitors who gazed in wonderment, even in awe. (*Vide* fig. 9, page 39).

³⁴ This event is reviewed in some detail on page 38 *et seq.*, and a description of it appearing in the *Electrical Engineer* (N. Y.) (21: 600, 1896) is quoted *verbatim* in Glasser, (*op. cit.* p. 5) page 237.

The open fluorescent screen was hardly, if at all, less perilous to its habitual user than the hooded "fluoroscope." In its earlier forms it was almost never covered with a thoroughly protective material such as lead-glass. All flexible surfaces thinly coated with costly fluorescent substances were fragile things, and on this account it seemed to be the first thought of the manufacturer to protect them, when in use, rather than to shield from the action of x-rays passing through them the person of the operator. The necessary size of open screens (twelve inches by fourteen, or larger) made them cumbersome to manipulate when covered even by light common glass or celluloid for the purpose of tracing or other notation. When lead-glass coverings were ultimately used, the screens became so heavy that it was found necessary to support them mechanically. Thus we find that the use of the open fluorescent screen in the days of the pioneer era was all too often unattended with a proper protection of the roentgen investigator, especially where a complete radiopaque enclosure of the Crookes tube did not obtain.

An accessory fluoroscopic procedure that was peculiarly hazardous to the pioneer was the so-called orthodiagraphy or epidiascopy. This process resulted in a traced outline of the "shadow" of any given organic structure (more especially the heart) or of a foreign body, free from the inexactitude of shadow-distortion, by allowing the central beam of x-ray projection to travel precisely with the controlled movement of a recording stylus (Fig. 4). This apparatus was of German and Austrian development, and fortunately did not gain wide use among Americans. The illustration shows that, even though an attempt was made to control by a diaphragm the area of the central-beam projection, the degree of the fluoroscopist's protection, especially when the tracing was made upon the integument of the patient, was practically *nil*.

The pioneer who worked daily in the close vicinity of the active Crookes tube was by no means always the fluoroscopist or the "skiagrapher." The exposure sustained by the

fabricator of tubes was even greater, and he incurred his peculiar injuries in his peculiar fashion. Long and exacting were the processes of exhausting the tube of its gases to the proper point and thereafter testing it for vacuum and general behavior. For the purpose of maintaining a certain temperature during the process of exhaustion, each tube was contained in an "oven." As the degree of vacuum increased through the action of a mercury pump, the "penetration" of the tube-emanations became higher. Many ovens were inadequately constructed to resist or absorb this penetration, and there was much leakage of x-radiation through their walls. The testing of the tube after its exhaustion was important work; it might represent a solid hour of exposure to x-rays unless the operative were sufficiently protected by the material used in the construction of the oven or in a shield between him and the oven. For the sake of accessibility the windows of the ovens were placed face-high or breast-high. Hence, and unfortunately in many cases, these admirably persevering men sustained radiation-lesions involving the skin of the face, neck and chest as well as of the hands.

While medical investigators and practitioners were subjected to undue exposure to roentgen-rays through the practice of demonstration to those that were casually curious or seriously interested, early producers of x-ray apparatus were even more so. Among medical men, each of whom in former times was almost invariably his own technician, this unhappy habit was formed by the wholly laudable desire to convince the apprehensive patient of the painlessness of the process of roentgen diagnosis or treatment. This is shown again and again in the history of their lives. All too frequently the pioneer radiologist offered some convenient part of his own person, usually the hand, for such exposition. Or again, if the patient were unafraid and at the same time interested, the demonstration was given in a spirit of sheer enthusiasm. The fine reputation which, at its inception, practical radiology

promptly acquired as at least one concomitant of the doctor's office wholly free from subjective distress, is due in very great measure to the proof furnished by these convincing but unfortunate exhibitions which, in the aggregate, entailed such grievous sacrifice.

The proof offered by the maker of focus-tubes, on the other hand, was of different label. His was the burden to show the efficiency of his wares, and the tests necessary to this end were prolonged and exacting. Such demonstrations were almost always fluoroscopic, and this exposure, added to that already sustained in the exhausting and the "tuning" of the tubes, produced a cumulative effect in the skin of the pioneer that was enormous. There is more than one recorded instance where fatal damage was done to men who served the industry of tube-manufacture nearly entirely in the capacity of demonstrator, so great was the frequency of exposure or so high their individual susceptibility to the effect of roentgen-rays. Such were the penalties paid at a day when there was no instrumental method of judging the performance of a Crookes tube under excitation and yet, such was general curiosity at that time concerning all matters connected with roentgen-rays, it is doubtful whether conviction as to the qualities of so fickle an instrument as the early focus-tube or so variable a medium as the contemporary fluorescent screen could have been established in any other way.

* * * * *

Lauriston Taylor observes³⁵ that the evolution of roentgen-ray protection, in other words, the adequate shielding of the operator from x-emanation, exhibited, through the early years after the discovery of x-rays, an unsystematic behavior manifested by what he aptly terms "spurts" and "lulls." "The 'spurts,'" he writes, "have almost invariably been brought about by painful experience and the sudden

³⁵ Taylor, L. S., *loc. cit.* p. 18.

but too tardy realization that roentgenology has offered to humanity another sacrifice, another martyr to medical science. . . ." The "lulls," he believes, have been "the partial results of ignorance and indifference, although it can scarcely be said that they have resulted really from negligence."

A contemporary of the pioneer days would perhaps agree with "ignorance" as existing for a very short period of time after Röntgen's *Second Communication*. Beyond that, it cannot be said that ignorance was by any means general, least of all among those who were giving serious thought to the abundant promise of the x-rays in clinical application. The works of such men as Williams, Rollins, Pfahler and many others who recognized the admonition in much of the early literature on the subject, are ample evidence to the contrary. As to "indifference,"—here again the application cannot be a general one, but must be considered as qualified by individual temperament. Indifference in the sense of *apathy* might be applicable to a certain proportion of the pioneer attitude toward the danger to the practitioner latent in the roentgen rays; in the sense of *disdain* the term admits of a wider adaptation—it should be remembered that "Enthusiasm was in the saddle." As to "negligence," one is inclined to take a somewhat less charitable view than does Doctor Taylor. The extraordinary unconcern on the part of some of the producers of x-ray apparatus regarding the physical welfare of the medical users of their wares, would seem to admit of no other interpretation.

Any consideration here of the history of roentgen-ray protection would be but the carrying of coals to Newcastle, in view of Taylor's recent thorough exposition; nor is such consideration within the scope of this writing. Suffice it to say that most of the martyrs in their early day, and some of them at a period not so early, got precious little of it, despite the warnings of such men as Hawks and Thomson, the experiences of Grubbé and others, or the exemplary efforts of Rollins, Pfahler, or Weston Price.

The subject of protection cannot be relinquished, however, without reminiscent note being taken of the consistent practice of the medical pioneers in radiology toward their patients—a practice that cemented the foundation of the vast machinery that obtains today for the comfort and protection of the bodily afflicted, for whom the benefits of modern radiology become necessary. Whatever one chooses to denote as the reason of their own lack of protection, no such cause existed where the patient was concerned. The pioneer Grubbé of Chicago is recorded as being the first to apply the metal lead as a protection for the patient in course of receiving the therapeutic application of roentgen-rays. Since then, be it in therapy or diagnosis, any medical use of the roentgen-rays, in qualified hands, is attended by complete protection of the patient's person outside the immediate field of operation—and today, indeed, within it—by tube enclosure and by accessory topical shielding. And in modern practice, accurate dosimetric control completes the triad.

II

CLARENCE MADISON DALLY

1865—1904

DURING the closing year of the American Civil War, there was recorded in the small town of Woodbridge, New Jersey, the birth of Clarence Dally, a son of Charles Clarence and Isabel (Tuttle) Dally. Growing up in those post-war years, in common with other boys his youthful imagination was stirred by veterans' tales of glorious deeds of the great conflict, and it required little to develop in him the desire for adventure in the National Service. Accordingly at the age of seventeen he enlisted in the Navy, to which he gave faithful allegiance, until his honorable discharge therefrom six years later, as gunner's mate. Young Dally then returned to his native New Jersey, and during the following year, his twenty-fourth, obtained employment in the Edison Lamp Works at Harrison, where a great industry had been formed as the result of Mr. Edison's prolonged labors in the development of the incandescent lamp. Here his father was already at work, and ultimately the four sons, Theodore, Walter, Clarence and Charles formed with their parent a family group possessing the utmost dexterity and skill in the delicate art of glass-manipulation as applied to the manufacture, exhaustion and "sealing-off" of incandescent lamp-bulbs.

About the year 1890 Clarence Dally was transferred to the Edison Laboratory at West Orange for continued service in connection with experimentation on the incandescent lamp, which was being constantly improved. His brother Charles followed him there five years later and the young men became two of Mr. Edison's most dependable assistants, quite ready for the investigation instantly commenced by Edison

CLARENCE MADISON DALLY

33

on receiving the cabled reports, in late 1895 and early 1896, of Professor Röntgen's discovery, the news of which travelled with telegraphic speed over the world. This investigation involved especially two lines of research; the development of the source-apparatus of the roentgen-rays (the focus-tube)

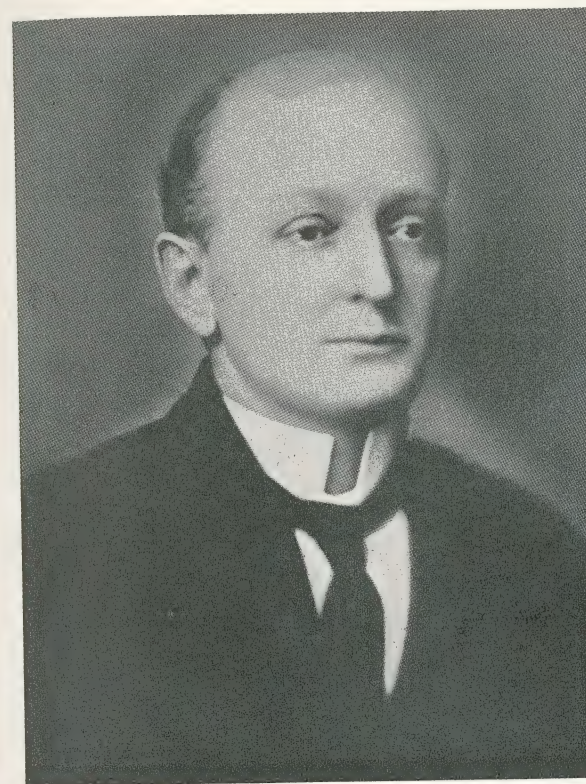


FIG. 5—Clarence M. Dally

and an inquiry into chemical substances which possess the quality of glowing or "fluorescing" in the presence of x-rays emanating from the focus-tube. The latter quest also laid open the way for further experiments relative to the employment of fluorescent materials to produce a means of illumination, embodied in the so-called Edison "fluorescent

lamp." Both researches had a distinct bearing on Clarence Dally's career at the West Orange laboratory and ultimately on his life. The part played by Clarence and Charles Dally at this laboratory in the development of the various types of



Photo by W. K. L. Dickson

FIG. 6—Clarence Dally "sealing off" incandescent lamps.

the Edison x-ray focus tube was an important factor in the commercial production of these instruments at the Harrison works under the supervision of Mr. William H. Meadowcroft, who recently¹ has written reminiscently:

¹ Personal communication to Dr. Otto Glasser (1932). *Op. cit.* (p. 5) page 390.

At the time of the Röntgen cable, I was at the Edison Lamp Works at Harrison, New Jersey. . . . It was sometime toward the end of January or beginning of February [1896] when I commenced my work, which soon became standardized by being largely directed to the development of the x-ray tube in a great variety of types and patterns, single and double focus. This work continued day by day for about three years. . . .

At the West Orange laboratories, Edison was likewise busy in his search for a substance possessing the most brilliant fluorescence. The interesting facts concerning his investigation of a multitude of materials to this end have been repeatedly recorded elsewhere. They may be merely mentioned here as relating to the work of this faithful assistant and his brother. Hereinbefore, reference has been made (*vide* p. 21) to the erroneous impression created by many of his biographers that Edison "invented" the fluoroscope in principle. In point of fact, his first published reports on experiments with the fluoroscope did not appear until April, 1896.² This name was given by him to the form of hooded screen he devised and employed to reveal the fluorescence of the *tungstate of calcium*. This salt, purified for such use, and so used in a hooded screen of this form, was his discovery. Mr. Edison himself probably made no claim to priority over the various apparatuses of others, although his qualifying statement is easily misinterpreted: "When the x-ray came up, I made the first fluoroscope, *using tungstate of calcium*³. . . ."⁴

That Edison had visions of a form of illumination practically to be derived from the fluorescence of the tungstate of calcium there can be but little doubt. Regarding his experimentation in this direction, he goes on to say:

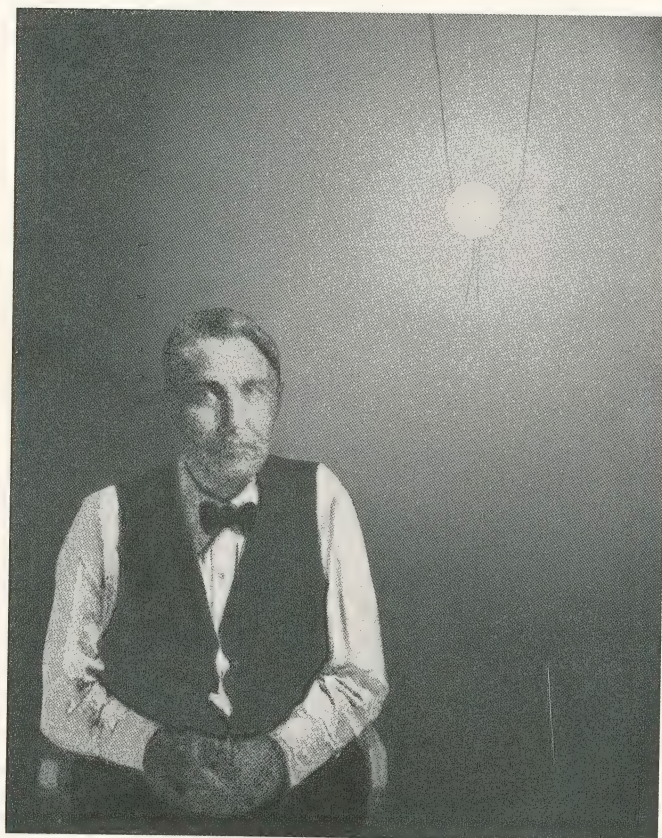
. . . I also found that this tungstate could be put into a vacuum chamber of glass and fused to the inner walls of the chamber, and

² *Vide* Glasser, p. 236. *Op. cit.* (p. 5.)

³ Editor's italics.

⁴ Dyer, Martin and Meadowcroft, "Edison—his Life and Inventions." Vol. 2, p. 581. New York, Harpers, 1929.

if the x-ray electrodes were let into the glass chamber and a proper vacuum was attained, you could get a fluorescent lamp of several candle-power

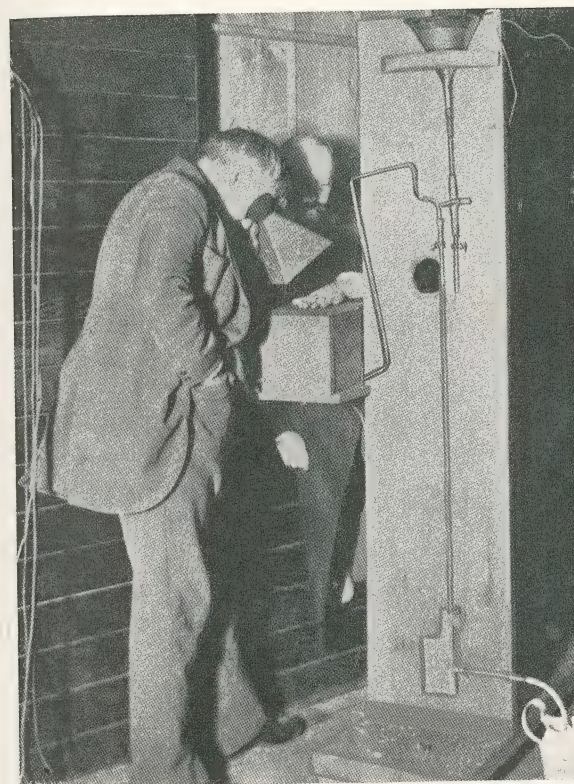


Electrical Engineer, N. Y.

FIG. 7—Mr. Edison in the glow of his “fluorescent lamp.” (1896)

While it was asserted at the time that these “fluorescent lamps” (fig. 7) gave off practically no x-rays sufficiently “hard” to be effective outside the walls of the chamber, the cumulative effect of their radioactivity, both primary and secondary, must have been considerable. In fact, concerning this lamp Mr. Edison concludes:

. . . I started in to make a number of these lamps, but I soon found that the x-ray *had affected poisonously my assistant, Mr. Dally*, so that his hair came out and his flesh commenced to ulcerate. I then concluded it would not do, and that it would not be a very popular kind of light, so I dropped it. . . .³



Electrical Engineer, N. Y.

FIG. 8—Testing the apparatus for the New York exhibition. The photograph of Mr. Edison’s companion has been designated as that of the late Mr. T. Commerford Martin, but it is believed on excellent authority to be, rather, that of Clarence Dally.

It is difficult to say to what extent Clarence Dally’s physical injuries were furthered by his work on the “fluorescent lamp” in proportion to the damage he sustained through his efforts in the development of the x-ray tube with the frequent

necessity of vacuum determination by fluoroscopic test during the process of exhaustion by mercury-pump. Suffice it to say that the cumulative exposure to which he and his brother Charles⁵ were subjected must have been enormous. With the skill born of their long experience as glass-blowers, these two young men continued to be of the utmost value to Mr. Edison throughout his brief but intensive experimentation with roentgen-rays. Aside from their daily laboratory activities in the course of this work, the assistance of at least one of them was essential whenever Crookes tubes were to be transported and manipulated in process of demonstration or practical use. This is historically illustrated by two important instances.

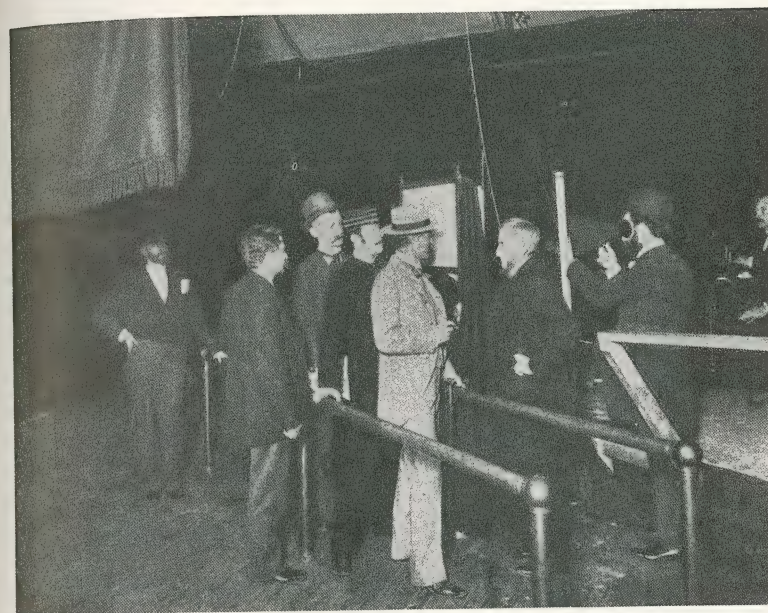
The first occasion was that of Edison's renowned fluoroscopic demonstration (*vide* p. 25) in connection with the exhibition of the National Electric Light Association held in New York City in May, 1896. Clarence Dally was an indispensable member of the "team" of highly-trained men that conducted the demonstration under the supervision of Mr. Luther Stieringer. Many there are today who recall the profound public sensation created by this extraordinary revelation, to say nothing of their own emotions when, passing in single file before the open fluorescent screen or gazing into the hood of the fluoroscope, they "saw their bones" for the first time. The Crookes tubes of that day were wont to manifest annoying vagaries under prolonged excitation, which, at this exhibition, it was Clarence Dally's duty to recognize and to control as far as possible by manipulation of the output of the induction-coil used to excite them. (Fig. 9.)

It was four years later that urgent need again arose for the services of the indispensable Dallys. This time it was

⁵ Mr. Charles T. Dally is, happily, now living at West Orange. His x-ray dermatitis of hands and face appeared shortly after that of his brother and, in spite of early finger amputations, has not ceased to assail him for thirty-eight years. To him especial thanks are due for much information concerning his brother Clarence that was most generously given.

Charles who responded to the call. In describing the "x-ray room" of the Edison plant at Orange, one of Mr. Edison's biographers, Mr. Francis Arthur Jones,⁶ mentions as a part of its furniture,

... the identical [x-ray] machine which Edison sent to Buffalo at the time of President McKinley's assassination, in order to locate



Electrical Engineer N. Y.

FIG. 9—Edison's historic fluoroscopic exhibition in New York City, May 1896, in connection with the exposition of the National Electric Light Association. Clarence Dally is to be seen at the extreme right, manipulating the induction coil.

the bullet. Curiously enough it was never used, and by a combination of circumstances its errand of mercy was rendered futile. . . .

Almost directly after the President was shot, a telephone message was received at the Edison laboratory asking if a machine might be held in readiness should it be considered desirable to send one to Buffalo. Edison himself was consulted and replied that the instrument could be forwarded at a moment's notice; and on the

⁶ Jones, Francis Arthur, "Thomas Alva Edison—an Intimate Record." New York: T. Y. Crowell and Co. 1924.

Saturday afternoon, about two-thirty, another message was received asking for the apparatus to be forwarded at once. Two young men from the laboratory accompanied it—Charles W. Luhr and Charles T. Dally.

They arrived in Buffalo Sunday morning and were busy installing the plant in the Millburn house, when a message came to say that the machine would not be required for at least a week, as it was considered unwise to search for the bullet just then owing to the condition of the patient. As a matter of fact, the doctors had come to the conclusion that the spent missile was located in a spot where it might safely be allowed to remain without danger of decreasing the President's chance of recovery. A few days later, Mr. McKinley had so far rallied that the Vice-President (Mr. Roosevelt) rejoined his family, Senator Hanna left for Cleveland and two of the doctors took the train for New York. Luhr returned to the laboratory, and only Dally was left with the machine. Everyone was hopeful, and the President continued to improve for some days when there was a sudden and alarming change for the worse. One of the doctors took it upon himself to inform Dally that neither he or his machine would be needed, *but the young operator continued at his post waiting for a possible summons*. Finally the end came and apparently the x-ray was destined to take no part in the tragedy. . . .⁷

By 1900 it was becoming more and more apparent that the degenerative skin changes in the hands and face of Clarence Dally were increasing in severity. The distribution of these lesions was typical of those that have always been observed in persons engaged in x-ray tube manufacture by the older methods—"burns" of the face involving the early loss of the hair of the anterior scalp, eyebrows and eyelashes as well as the backs of the fingers and hands. Since the onset of his symptoms during the year he had commenced his work on the focus-tube and the fluorescent lamp, Dally had periodically relinquished this occupation for a few days, when the acute manifestations were at their height, only to resume it after the pain and swelling had subsided. As has been almost invariably the case in right-handed individuals, his *left* hand

⁷ Editor's italics.

was the first to be affected, becoming reddened, swollen and extremely painful. This by no means deterred him from his work for any length of time; it merely compelled him forthwith to use his *right* hand in testing tubes fluoroscopically.

By 1902, Dally had practically exhausted all orthodox modes of treatment for burns of the skin; they seemed of no avail in this strange affection, never before seen and almost sinister in its persistent progress. The inflammatory infiltration of the dorsal skin of the left hand and wrist was followed by vesiculation which soon broke down into local ulceration. The pain in this hand that had already existed in varying degree for *nearly six years* now became intolerable in the presence of ulceration, and Dally was forced to seek more radical means of alleviation. For over two months prior to June of 1902 a raised ulcerative lesion measuring $3\frac{1}{2}$ by $2\frac{1}{2}$ inches had occupied the dorsum of the left wrist; accordingly, multiple (144) skin-grafts from the leg were applied to this surface, but the tissues lacked the vitality necessary to promote their growth. In view of this and the fact that an ulcer at the base of the little finger revealed microscopical evidence of carcinoma, the left hand was amputated above the wrist.

In the meantime an area of rather deep ulceration had developed in the right hand; its extent and characteristics necessitated the loss of four fingers and a portion of the metacarpus, as the early signs of improvement in this hand did not long obtain.

These major operative procedures did not, however, suffice to stay the progress of the invasion of carcinoma, since somewhat later it became necessary again to amputate both arms simultaneously, one at the shoulder-joint, the other above the elbow.⁸ All efforts were in vain, and death followed from mediastinal recurrence in October of 1904.

⁸ The information gained from the available records and in personal interviews is somewhat confused as to the sequence of these operative procedures. The matter is purely academic, however, from the historical viewpoint.

Through eight years of physical torment this life approached its end—the life of the first American martyr to Science through one of the greatest gifts of Science to Humanity, the x-rays of Röntgen. A life, first, of honorable endeavor in patriotic service; then, of continuous devotion as the indispensable auxiliary of the “modern Olympian” of American invention and industry; a life, finally, of constant self-abnegation, to be crowned at the end of its short span with the diadem of heroism.

“He was a most lovable man,” writes Clarence Dally’s physician and friend of many years.⁹ How frequently and how spontaneously may this be said of these devotees to a noble cause. How often their lovable traits—generosity, loyalty and forgetfulness of self—have shaped their ends!

⁹ Dr. Frank B. Lane of East Orange: *personal communication*.

III

ELIZABETH FLEISCHMAN ASCHEIM 1859—1905

YIELDING to the tractile force of one of the most powerful magnets of all history—the discovery of gold in California, Jacob Fleischman came the weary distance from his home in Austria to El Dorado County at the height of her glittering promise. His instincts, being those of the merchant rather than the miner, led him to establish a store for general merchandise. Through his integrity and upright dealings, he was appointed the local agent for Wells, Fargo and Company, a position of the greatest importance amid the wild prosperity of those “boom” days.

Just ten years after the discovery of gold and nine after her parents had settled in El Dorado, Elizabeth Fleischman was born. Her mother, Katherine Lezansky, was a native of Prague and sprang from a family of distinct medical prominence, several members of which were physicians of note, one being the personal medical adviser of the ill-fated Ferdinand Maximilian. The influence of this family is still strongly alive in the medical profession of the Czechoslovakian capital.

Elizabeth was the second of six children. Their father early sought for them the educational advantages of a large community, and a few years after her birth he removed to San Francisco, where ultimately all his children were educated in the public schools. In due course the youthful Elizabeth passed the difficult curriculum of the Girls’ High School and was graduated; she then entered upon a course of study in commerce and business, to embrace book-keeping as a vocation. By dint of hard work and industry the education of the children of the family was completed, certain of the younger ones becoming musicians. The responsibility

for the support of her children fell upon the shoulders of the mother, but this burden was soon shared by Elizabeth and later by her younger brothers and sisters, all contributing materially to the family exchequer.



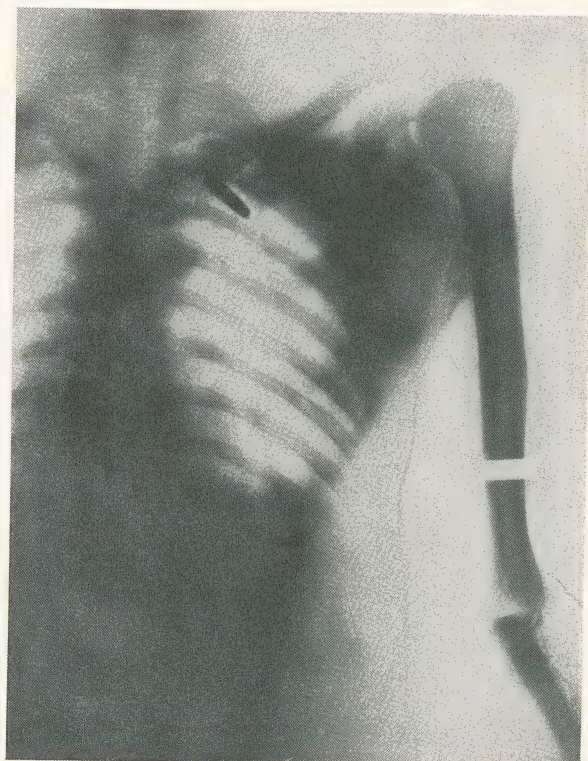
FIG. 10—Elizabeth Fleischman

On the death of her mother, Elizabeth Fleischman made her home with a sister and her husband, Doctor Woolf, who as a physician had become attracted by the very evident value of the newly discovered roentgen-rays to medical science. Doctor Woolf's enthusiasm was so intense that Elizabeth in turn became interested and then fascinated. Forthwith she relinquished her occupation as bookkeeper

and undertook a course of six months in electrical science at the Van der Naillen School of Engineering and Electricity in San Francisco. From her father she borrowed enough money to purchase x-ray apparatus, including a fluoroscope, which in time was delivered at the house of Doctor Woolf in Oak street that served the double purpose of home and professional office. This was probably one of the very first privately-owned equipments for the use of the roentgen-rays to be established in California.

Here, in 1897, began the labors of the two in absorbing experimentation, with each other as subjects, oblivious to all else but its fascinating revelations. Self-protection was hardly thought of, and both soon showed the manifestations of acute radiation-dermatitis. Now, for Elizabeth, began a short but intensive career enlivened at first by the stimulation of each disclosure of the marvelous, and later enriched by the consciousness of work being well done in the service of her country and of humanity. She was quick to grasp the opportunity that came to her with the outbreak of the Spanish-American War. The division hospital established at the Presidio at San Francisco was soon filled with casualties from the field of action in the Philippines. At that early day there were but limited facilities for the military use of roentgen-rays at Army stations or on hospital ships. During the War of 1898 such equipments numbered seventeen, twelve of which were coil-apparatuses and five, static machines. Casualties were frequently transported by ambulance to Miss Fleischman's modest laboratory in Oak street; many of the non-ambulatory cases she saw at the Army division hospital at the Presidio. At first her efforts, always thorough and painstaking as the records show, were confined to the recognition and localization of foreign bodies (lodged missiles), but in a short time her work became of equal importance in the determination of the extent of bone-injuries, including those of the skull.

One of Elizabeth Fleischman's radiographic results, remarkable in its balance of contrast and detail under the uncertain conditions of that day, is herein reproduced. (Fig. 11.) This was accomplished at the Presidio division hospital



War Dep't, U. S. A.

FIG. 11—Radiograph made by Elizabeth Fleischman in San Francisco of a foreign body (Mauser bullet) in the upper back, at the time of the Spanish-American War.

and the record is contained in the beautifully-illustrated descriptive atlas of (then) Captain W. C. Borden, U. S. Army.¹ "The radiograph, viewed from the back, showed a

¹ Borden, W. C., Captain and Division Surgeon, U. S. Army: "The Use of Roentgen Rays in the Medical Department of the U. S. Army in the War with Spain." (Prepared under the direction of Surgeon-General George M. Sternberg, U. S. Army.) Washington, Government Printing Office, 1900.

lodged Mauser [rifle] bullet, which had passed through the spine, lying two inches to the right of the spine over the third intercostal space. . . ."

It is not surprising that technical results of such quality should have received official commendation, and from no less a source than the person of Surgeon-General Sternberg, who visited the Presidio in 1898 and complimented Miss Fleischman on the excellence of her work. Nor is it surprising that high standards of merit such as that set by her should have elicited observations such as the following:

The x-ray has fully answered the expectations in military surgery as a diagnostic resource. The limited experience with this diagnostic aid during the Spanish-American War has fully demonstrated its great value in military surgery. It may be relied upon in locating bullets in almost any part of the body and in ascertaining, in doubtful cases, the existence, location and nature of fractures, and in determining the exact location of the fragments. . . . The probe, so constantly relied upon in the past in locating bullets, is an instrument of uncertain diagnostic value, and its use is always attended by more or less risk of infection. . . . The probe is as objectionable in the examination of a compound fracture as in exploring the track made by a bullet. The x-ray has a great future in this part of military surgery. . . . The fluoroscope has greatly enhanced the diagnostic value of skiagraphy [roentgenography] in military surgery.²

In 1900, Miss Fleischman married Mr. Isadore Ascheim of San Francisco, but her work continued as before. Her office was removed to Sutter street. Through her army experience with the skull and its adnexa, she became interested in the roentgen-pathology of the teeth and her services were extensively sought by dental practitioners. The growing possibilities of the roentgen-rays in the field of therapy likewise attracted her.

"In spite of warning," writes³ her niece, "she would not

² Senn, Nicholas, Colonel and Chief of the Operating Staff with the Army in the Field during the Spanish-American War: "The X-ray in Military Surgery." *Philadelphia Medical Jour.*, 5: 36, 1900.

³ Dr. Genevieve Fleischman Gaffney: *Personal Communication*.

protect herself, and exposed herself repeatedly, not only during experiments and routine, but also *for the benefit of patients to prove the operation was painless. . . .*⁴ She was prone to attribute her skin irritation to the use of chemicals in the process of radiographic "development." Under these adverse conditions she worked twelve hours a day. By 1903, the state of the skin of her hands began seriously to annoy her and in the early months of 1904 she was forced to seek surgical aid, coming under treatment for the first time:

The fingers of both hands were found to be badly ulcerated, chiefly the tissues over the middle phalanges and the middle joints . . . the surfaces presenting both an ulcerated and warty condition, the warts assuming the form of *necrogenica*—healing alternating with ulceration. All the secreting glands and hair-follicles were destroyed so that the skin was hard and dry and cracked easily. All forms of treatment by ointments and washes were without permanent benefit. In November, 1904, a wart appeared on the index finger near the terminal phalanx, which was very raw and grew with great rapidity. A portion . . . was submitted to Dr. Rifkogel, who reported a branching papilloma with a tendency to downward growth, and advised amputation. This the patient refused, so the growth was freely excised and healed healthily. A few weeks afterward, however, a nodule appeared near the scar, which pushed up through the epithelium, broke through it and appeared exactly the same as growth No. 1. The glands in the axilla were found somewhat enlarged. Radical operation was again refused until after Christmas [1904], when the axilla was freely opened and the whole space cleared of glands. Pathological examination of these showed undoubted involvement with epidermoid carcinoma. In the course of a week, more nodules appeared just below the acromioclavicular articulation. It was decided that the only chance of recovery lay in amputation at the shoulder. Accordingly, on January 27, 1905, . . . the arm and scapula, with the clavicle, were removed. The patient rallied well from the operation and the wound healed rapidly, but about the end of April, 1905, a recurrence took place at a point representing the position of the inferior angle of the removed scapula. This was excised and found to be carcinoma. Slowly and

⁴ Editor's italics. (*Vide* p. 91.)

then rapidly other nodules appeared, until ultimately the whole of the vertical scar, corresponding to the vertebral border of the scapula, became involved. Metastases took place in the pleura and lungs, and the patient died on August 3, 1905.⁵

Thus ended the noble career of an American *Jeanne d'Arc*, martyred in the cause of Humanity, not with fagots heaped by human hands, but by an enemy to her that she made daily a friend to others. Her love of country challenged her to meet this subtle enemy, and she accepted the challenge, forcing it to her will to restore, with her aid, her fellow-citizens to the relative happiness of life. Not in ignorance, scornful of "warning," her disdain dulling, perhaps, her realization of the sinister strength of her enemy, she pushed forward in her chosen work under the spell of a fascination that was not far removed from a glorious vision. Her efforts tended to force into favorable conviction an early scepticism as to the value of the roentgen-rays in military surgery, and she wielded worthily the sword that for this noble purpose was given her by Science.

⁵ Report of Dr. George Childs Macdonald in Porter, Charles Allen: "The Pathology and Surgical Treatment of Chronic X-ray Dermatitis." *Trans. American Roentgen Ray Society*, 1908, p. 155.

LOUIS ANDREW WEIGEL

1854—1906

DURING the early "nineties," the development of photography, notably among amateur workers, had reached a point where individual artistic feeling and skill were destined to produce pictorial results hitherto unapproached by methods of mere mechanical execution. The invention of the so-called "dry" plate had made it possible easily and quickly to obtain "negative" images upon a stable emulsion of sensitized gelatin supported by glass, without the necessity of preparatory sensitizing manipulation that, following the day of Daguerre, had attended the old "wet" or collodion process. Also, the introduction of various elaborations and refinements making for added flexibility in the production of the "positive" permitted a degree of individual artistic expression previously undemonstrable. Such manifestation of individuality, stimulated by the mild competition fostered by "camera clubs" and kindred organizations the world over, developed a high standard of excellence in photographic effort. This constructive era was punctuated, almost as an anticlimax, by the appearance of an "impressionistic" school of photography which, perhaps fortunately, did not survive as a subversive movement.

Left to his normal development, the amateur photographer of forty years ago, if in any measure possessed of artistic feeling, did not become an extremist, but was content to portray Nature in a manner most consistent with his impression of her beauty and his reaction to her endless and varied evidence of it. Thus, the avocational practice of photography became a real relaxation from the duties of daily life; its nature was less communal than that of the com-

petitive outdoor pastimes of a later and more athletic age. It was a hobby to be ridden gently by the many and more violently by the few. One of the many was Louis A. Weigel, an orthopaedic surgeon of Rochester, New York, and a man of sound repute in his profession.

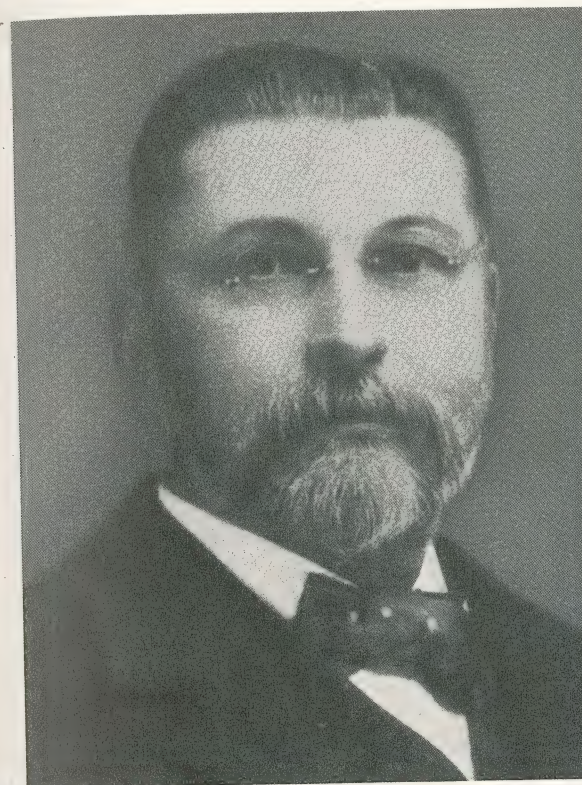


FIG. 12—Louis A. Weigel

Among American pioneers in the practice of radiology others there have been, such as Kassabian of Philadelphia and Early of Columbus, who have entered their field by the path of photography, but none of greater technical skill than Weigel. For many years before the discovery of the roentgen-rays he had been an enthusiast in his single avocation, with the added zeal of a scientifically trained mind. At one time

he had devised a peculiarly effective form of "ray filter" for the purpose of minimizing the untoward effect on the sensitized plate of the ultraviolet element in daylight through the photographic lens. Such filtration was utilized by photographers to emphasize the photographic contrast between cloud-masses and the clear light of the open sky. The possibilities in this procedure for the production of "positives" in varied color were of great interest to Weigel, with the result that many of his exquisite cloud-photographs are today in the possession of his former orthopaedic colleagues.

Louis Weigel was the son of a physician, Dr. Michael Weigel. He was born in Rochester in 1854, and there passed his entire life with the exception of travel and the period devoted to his medical education at the University of Maryland, from which he was graduated in 1875. He was engaged in the general practice of medicine for about eleven years before he became attracted to the rapidly developing field of orthopaedic surgery under the pioneer influence of Buckminster Brown, Hugh Owen Thomas and their contemporaneous school. Forthwith Weigel devoted himself to its practice, identified himself actively with the American Orthopaedic Association and, as the years passed, the increasing strength of his position in this surgical specialty resulted in his election to the presidency of that national scientific body for the year 1903. His contributions were many, and none of greater import than his labors in the direction of added accuracy in orthopaedic diagnosis through the agency of the roentgen-rays. His opportunities for clinical activity multiplied, and the afflicted and the needy of his community became the beneficiaries of his appointments as Orthopaedic Surgeon to the City Hospital of Rochester and to St. Mary's Hospital, as well as Consultant to the Craig Colony for Epileptics at Sonyea, New York. As a teacher, Doctor Weigel occupied the Professorship in Orthopaedic Surgery in Niagara University at Buffalo.

At the moment when a realization of the magnitude of Röntgen's discovery was dawning on the world, it was natural that Weigel should scrutinize the "X"-rays of the Würzburg laboratory in terms of their photographic effect as well as of their very evident value to Medicine; yet for this very reason was he especially sensitive to the promise for the future of orthopaedics in this new-found source of diagnostic accuracy. His vision seemed to involve a pre-science of the exacting demands to be made on the technics of roentgenology by bone and joint surgery, and his deep photographic experience, rarely possessed by the medical investigators of x-rays, helped Weigel to set for himself a standard of excellence in the technical qualities of the recorded shadow-complex, as revealed by a balanced proportion of detail, contrast and gradation. Such excellence was difficult to attain at that day of prolonged exposures to feebly-excited Crookes tubes of ever-changing vacuum. To one of Weigel's self-training any technical difficulty was attractive, and as an orthopaedist he set for himself problems which, as a practical worker with x-rays, he proceeded to solve. Fascinating to him as was his surgical work among his crippled patients, the new method of enhancing its efficacy made it more so, especially since therein lay a means of turning many of the principles involved in a pleasant avocation to practical and beneficent use.

Later, in an access of his enthusiasm, Weigel contributed generously¹ to a literary symposium appearing (1900) in the first of a series of "enlarged special monthly numbers" of the *Philadelphia Medical Journal* and devoted to various clinical applications of the roentgen-rays. Among other contributors to this number were Augustus W. Crane, W. W. Keen, Charles Lester Leonard, Francis H. Williams and Nicholas Senn. As might be expected, Weigel gave prominent

¹ Weigel, L. A., "Practical Points in the Use of the X-ray." *Philadelphia Medical Jour.*, 5: 41, 1900.

place in this paper to the photography of roentgenology and urged:

... every operator to become, personally, thoroughly familiar with the photographic part of the work. . . . It is a well-known fact that, in astronomic work, a photographic plate reveals many things that are not visible even with a telescope. In x-ray work there is also a striking difference, in the amount of detail, between the image as seen with the fluoroscope and that in an x-ray "negative." While under some circumstances an examination with the fluoroscope may be satisfactory, it cannot take the place of a negative. The latter, with its clear detail, fine definition and other qualities, is vastly more reliable and furnishes a means of permanent record. . . .

The differences in the results obtained by various x-ray operators from machines identical in construction prove that the possession of an apparatus is not the only requirement for successful and satisfactory work. . . . A machine is of no value unless it is properly manipulated, and it is this manipulation that enables it to do its work. As has been well said, "The best machine does the best work in the best hands," which means simply that intelligence, judgment and experience are the important factors in bringing about results. . . .

This communication attracted general medical attention partly by reason of the impression made on orthopaedic surgeons by a previous paper² from his pen, illustrated in such beautiful detail by lantern-slides of his own preparation that it established firmly the value of the roentgen-rays in orthopaedic diagnosis and convinced his colleagues that Weigel's methods were to be emulated. At least one embryo roentgenologist was later sent to sit at his feet and to absorb, if possible, some of his teachings. If in no other direction, the benefit of that pilgrimage lay in the inevitable acquisition, through sheer infection, of his enthusiasm over the beauty of the *stereoscopic* demonstration of radiographic records (plates).

² Weigel, L. A., "The Diagnostic Value of Radiography in Orthopedic and General Surgery." *Trans. American Orthopaedic Assoc.* 12: 76, 1899.

Stereoscopy, a long-known and exceedingly interesting form of photographic exposition, had been applied to roentgenography by Elihu Thomson³ in 1896. For Weigel, it became the perfect means of expressing his own ideals of meticulous accuracy in radiographic procedure. As a method by which to create a mental perception, by simultaneous observation of two images, projected on plane surfaces, of the three corporeal dimensions, particularly of an anatomic structure whereof the three dimensions are nearly the same, it gave him peculiar delight and his fervor was contagious.

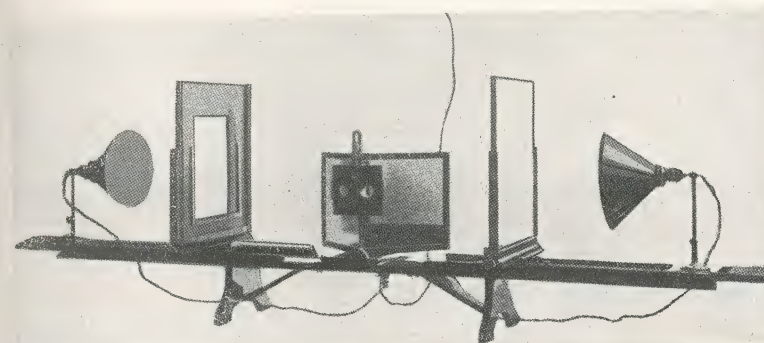


FIG. 13—Weigel's memorable adaptation of the Wheatstone stereoscope, which was the prototype of all subsequent apparatuses based on this principle.

Weigel's modification of Wheatstone's reflecting stereoscope⁴ enabled the observer to temper the intensity of illumination through one radiograph independently of the other by varying the distance between the plate and the source of illumination behind it. This device. (fig. 13), and that of Johnson, in which was utilized a form of camera-bellows to exclude reflected light, were the prototypes of all mechanisms apply-

³ Thomson, E., "Stereoscopic Roentgen Pictures." *Elec. Eng.* (N. Y.) 21: 256, 1896. *Elec. World* (N. Y.) 27: 280, 1896. *Electricity* (Lond.) 36: 661, 1896.

⁴ Concisely described in Pusey and Caldwell, "The Roentgen Rays in Therapeutics and Diagnosis." (Philadelphia, Saunders, 1903) p. 193.

ing the Wheatstone principle to radiodiagnostic purposes. The Brewster method of making stereoscopic vision possible by means of refracting prisms did not, apparently, appeal to Weigel as to some other pioneer workers, notably Caldwell (*vide* p. 160).

This very practical device was undoubtedly Weigel's major contribution to the development of roentgen-diagnosis. Although embodying an old principle, its value in the demonstration of roentgenograms is indicated by the promptitude with which it was adopted and progressively elaborated for use in problems other than those of bone and joint disease. Weigel's development of the stereoscope was a manifestation of the rare combination of the precise instincts of the surgeon and the joy of the artist in an expression of the beautiful. Added to these was the solicitude of the true Aesculapian for the welfare of those that entrusted themselves to his care. In one of such fine fibre of character, the coalescence of these three influences inevitably resulted in a total disregard of self that, for him, led to a long period of physical suffering.

To declare that Doctor Weigel labored in early ignorance of the possible risk involved in his work with x-rays were but empty assumption; too deeply had he studied the matter as somberly suggested in the initial admonitory reports of the physicists, but like many others he was deceived by the pernicious postulate that a Crookes tube excited by the discharge from a static machine emanated x-rays that were harmless. He continued to expose his hands to the rays, in the course of his investigations and his practice, with the false sense of security that this theory engendered. However, it was Weigel's solicitude for his patients rather than for his own safety that led him to adopt the use of the static machine. His paper before the American Orthopaedic Association in 1899⁵ was discussed at some length, with particular inquiry as to what apparatus he had used to produce the

⁵ Weigel, L. A., *loc. cit.* p. 54.

beautiful illustrations he had shown. In closing the discussion,

Dr. Weigel replied that he had used the static machine, as *he considered it safer*⁶ and far better than any other apparatus. . . . He had used a [n induction] coil for one year without producing a single burn, and he had then discarded it for the static machine. Another . . . had used this same coil and had produced in a short time three severe burns, one of them so extensive that it had been followed by gangrene.

As to one's choice of apparatus, based on the relative merits of the static machine and the induction coil, which he discussed the following year⁷ he says further:

This is a question which each operator must settle for himself. I have had some experience with both and personally prefer a static machine of large size. *Aside from its greater safety*⁶ the static machine illuminates the tube with a glow as steady as an incandescent lamp, which is a great advantage in fluoroscopic examinations. . . .

Having so definitely demonstrated the possibilities of the roentgen-rays in orthopaedic diagnosis in 1899 and again in 1900, Weigel continued his unselfish work through the first four years of the new century. Much the greater part of his investigation was carried on at his office in Rochester, where he maintained his "x-ray laboratory" although his status was eminently that of the orthopaedist. His equipment was elaborate for that day and much of his apparatus was of his own devising, with notable reference to stereoscopy. (Fig. 14.) In the early years of this special activity, he did much work for the hospitals, ambulatory patients being transported to his office. At the hospitals his labors were surgical, and to fulfill his constantly increasing duties, a great deal of his x-ray practice had to be done in the evening. A hard-working, conscientious man of quiet demeanor, accomplishing much.

⁶ Editor's italics.

⁷ Weigel, L. A., *loc. cit.* p. 53.

In the midst of this labor of beneficence, made more valuable by the diagnostic certainties inherent in the marvellous discovery to which he had become so ardently devoted, Weigel was beset by insidious physical reactions to which, at first, he paid but slight attention. The brittle finger-nails, the roughened surface of a drying skin concerned him but

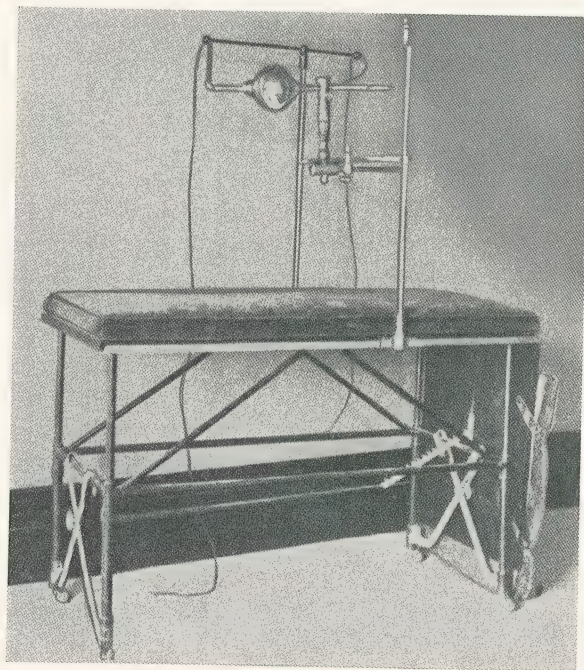


FIG. 14—Weigel's tube-holder, for centering the tube over any part of patient lying on table. Vertical, lateral and horizontal adjustment.

little as he pursued his daily work with the static machine. From the increasing inelasticity of the skin of his hands he sought temporary relief by the almost constant wearing of surgical rubber gloves, the macerating effect of which eliminated local discomfort for the moment. Atrophy of the sebaceous follicles of the skin was followed by the for-

mation of fissures and keratoses of the type usually seen in the early workers with x-radiation.

By the year 1904, areas of ulceration had appeared and developed on the back of each hand, with the onset of pain of an intensity beyond description. Specimens from these areas, examined microscopically, were found to be undoubtedly epitheliomatous. The process was found to have extended deeply in places, involving, indeed, the metacarpal periosteum of the index and middle fingers of the right hand. An amputation of this hand was therefore the only operation of choice, and at the same time a thorough excision was made of the ulcerated area on the left hand. The procedures on the right hand however, availed naught to check the extension of the condition by metastasis, with resulting recurrence in the glands of the axilla. Doctor Weigel's life was prolonged by repeated and undismayed surgical effort entailing a series of operations of major magnitude, but the appearance of a metastatic process in the liver was the immediate forerunner of his death, which occurred on May 31st, 1906.

In the soul of this resolute man we find the uncommon admixture of a deep sympathy for the beautiful in Nature and an equally profound instinct for scientific exactitude. The combination was happy in its results. In the possession of the one he apprehended, with acute sensibility, a means to add to the value of surgical diagnosis by the refinements of a new and beautiful process of anatomical delineation; with the other, he applied the precision of this process to the diagnosis and treatment of those conditions he met in his daily life—the problems of the crippled invalid. To see Weigel at work was to realize the extent to which he was absorbed in the application of these two innate gifts; in his laboratory, his eyes would dance with delight as he demonstrated the ineffable beauties of the human skull stereoscopically portrayed; in the operating-room, he proceeded with the certain confidence of one about to encounter a concrete

situation whereof the details are already familiar through pre-revelation. He was a genius, but possessing the more stable attributes of genius; he was practical, but without the myopia of utter practicality.

For the utmost expression of the anatomic beauties of nature; for equal demonstration of pathological departures from them; for the application of knowledge thus acquired to guide the strokes of his scalpel; for the consequent rehabilitation of the crippled child—for these things Louis Weigel lived and died.

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WOLFRAM CONRAD FUCHS

1865—1908

AS IN the temperament of Louis Weigel, so in Wolfram Conrad Fuchs could be found the unusual combination of the idealism of the artistic and the exact realism of scientific aptitude. By inheritance, he had good reason for his possession of the one, from which, perhaps because of its affinity for full and complete expression, might have developed the other. He was a son of Julius and Wilhelmina Fuchs. His father was a musician of distinction in Berlin—an organist and pianist of extraordinary gift, who was later and elsewhere to become, as well, a prominent critic attached to the Art Institute of Chicago and the Metropolitan Museum of Art in New York.

Just before the Franco-Prussian War, the Fuchs family emigrated to Chicago. The young Wolfram, then five years old, was sent forthwith to the city schools, where his early education was obtained. As thus his years of adolescence passed, he indicated mentally such distinct inclination toward the natural sciences, notably electricity and magnetism, that ultimately a generous and far-seeing parent sent him back to the University of Berlin to study electrical engineering. From this renowned seat of learning he obtained in 1889 the degree of Electrical Engineer. Young Fuchs, however, was true to his heritage, and before returning to the land of his father's adoption he entered the *École des Beaux Arts* in Paris. With an added degree in Art, he again made the journey to the United States, now the possessor of the best educational endowment that Europe could offer both in Science and Art. Not content with even this, the ambitious Fuchs matriculated for post-graduate work at the Massachu-

setts Institute of Technology at Boston, after which his proud father was prepared to acknowledge his fitness for the career of an electrical engineer.

Once more in Chicago, Fuchs engaged in private practice as consulting electrical engineer for three years. He then



FIG. 15—Wolfram C. Fuchs

went to Schenectady, New York, as supervising engineer for the Edison works. Returning West, he was employed for a time as construction engineer for the Milwaukee State (electric) Railroad. Subsequently, in Chicago, his services were engaged for the building of the Cicero and Proviso electric line and for a generating plant for the town of Harlem, Illinois.

On a visit to Germany at the time of the discovery of Professor Röntgen, his naturally keen interest as an electrical engineer was aroused to its possibilities. He obtained all available knowledge relative to x-rays and returned to Chicago, where in the meantime had been set in motion a centripetal course of events that led ultimately to the primary focal spot of radiology in Chicago—the laboratory of Wolfram C. Fuchs. The episode was related some years ago by the late Dr. Jacques Holinger:¹

... Dr. Friedrich Cort Harnisch, an ophthalmologist of Chicago, became interested in the x-ray soon after the first publications appeared, and started to correspond with Professor Röntgen. Doctor Harnisch had a very extensive knowledge of electricity and photography, but little practical experience. None of the necessary apparatus was on the market and substitutes were impossible, so practically everything was lacking. ... There being no street current available in his vicinity, a battery of ordinary cells had to be built. No one knew at that time, or cared to know, anything about an electric spark that was able to jump a gap of three or four inches, and more was necessary. Doctor Harnisch studied up the matter. He ordered apparatus, especially Crookes tubes, from Europe. Some tubes were made here in Chicago by Mr. W. J. Boehm [a local glass-blower] in 1896. After a long search, Doctor Harnisch found an induction-coil at the McIntosh Battery Company in Chicago which gave him a spark of six inches. At the end of January or the beginning of February, 1896, he started experimenting. For an interrupter he tried the common magnet-and-anchor device. It did not work well and proved to be one of the most difficult problems. The interrupter question was not definitely solved until several years later. The magnet remained magnetic, the anchor stuck and therefore the spark was irregular. In consequence, dry plates could not be used, as they were too sensitive and always overexposed. Wet plates were made. Dr. [Peter J.] Latz up to that time had done the chemical work.

The financial resources were limited, as may be imagined. Dr. Harnisch had been in practice but a very short time. But still the

¹ Holinger, J., "The Early History of X-ray in Chicago." *Journal of Roentgenology*, December, 1918.

work went on, and many good plates were made, the first successful one being of the hand of Mrs. Harnisch, showing the bones and the wedding ring clearly. The question of "reducing" the overexposed plates by means of ferrocyanide of potassium came up. This forced Doctor Latz to withdraw, since he was sensitive to cyanide on account of former poisoning from it.



FIG. 16—Fuchs's earliest electrolytic interrupter.

About the end of April, 1896, the laboratory was moved downtown and an electrician put in charge. This arrangement simplified matters, as a street current could be used. Still, it was not satisfactory. In June, finally, Dr. O[tto] L. Schmidt, who had shown great interest in the work from the start, took over the whole laboratory and put it in the hands of a man of experience as a practical electrician and photographer [Mr. Fuchs]. ... By that time more about x-ray was known and suitable apparatus could be had. ...

introduction of fine wire of blended lead and antimony, were, in 1901, the first of these difficult uro-radiographic accomplishments in the United States.⁶

It is recorded that Wolfram Fuchs was one of those operators having unusual experience with the roentgen-rays who



FIG. 18—A corner of Fuchs's laboratory in Chicago.

were called to the aid of the dying President McKinley just after his assassination at Buffalo in 1901. Historical research seems to show that, though many were called, no one was chosen, for the x-rays were never used in that memorable emergency. It is a satisfaction to note that the response was loyally prompt in every instance, but the condition of the

⁶ Kolischer and Schmidt, *Jour. Amer. Med. Assoc.* 37: 1228, 1901.

illustrious patient, in the judgment of his medical attendants, did not permit the use of this method of localization.

After he became established in Chicago, the life of Wolfram Fuchs was one of unremitting service. He held in his skilful hands one of the greatest boons for human good, applied by means of his efficient apparatus-equipment. (Fig. 18.) It remained for the medical community surrounding him to justify the Emersonian prediction and "make a beaten path to his door," which it did with dispatch, to reap the benefit of his aid in its problems. Among those who would engage in the same pursuit, he was known for the generosity of his help; he became, willingly, adviser to the ambitious, demonstrator to the desirous and exponent to the eager. The example of Fuchs fired the ardor of many a young man who had yielded to the fascinations of "a new kind of ray." While his hands could not be the hands of a healer, the knowledge derived from his clever technical manipulations made Aesculapian fingers more flexible. For him, as for many such men, this opportunity was a welcome privilege and for that privilege he paid as many such men have paid.

"His extensive experimentation," writes his son, "terminated in a severe roentgen-dermatitis, and as time went on the fingers and thumbs of his hands were amputated in an effort to stop the devastating effects of the x-rays. His affliction soon made it necessary for him to retire from his laboratory in 1905. Between 1905 and the time of his death in 1907, he made an effort to write a book based upon his knowledge of x-ray work, but it was never completed due to the terrific pain from his hands and his later inability to write." "After various plans of local treatment," wrote his surgeon⁷ in 1908, "and a trip to Europe in search of remedial agents, he came to me for the first time with an enormous axillary involvement. This was indubitably squamous-cell

⁷ Report of Dr. L. L. McArthur to Dr. C. A. Porter. *Trans. Amer. Roentgen Ray Society* for 1908, p. 156.

carcinoma. The radical operation . . . failed to effect an arrest of the trouble. Recurrence took place very promptly and within three weeks again filled the axilla and involved the supraclavicular glands. Deeming it hopeless to subject him to further surgical interference, trypsin injections were given. . . . After lingering for six weeks, he finally succumbed to multiple metastasis on April 24, 1907."

A review of the life of this true pioneer reveals clearly what may be accomplished by the unconscious impulsion of natural aptitude in the direction of a goal quite invisible at the moment of the development of the talent by educational influence. The artistic temperament of Wolfram Conrad Fuchs enabled him to appreciate the satisfaction of taking *infinite pains* in all matters, however small, that came to his hand. This, it has been said, is the mark of true genius, and fortunately for the medical community in which he ultimately found himself, he applied that genius at the psychological moment. During the very early years of the roentgen-rays, practical medicine and surgery in Chicago, as indeed everywhere, was in urgent need of properly qualified, high-minded individuals to demonstrate to clinicians the utter indispensableness of technical exactitude in diagnostic radiology, as the *sine qua non* of dependable diagnosis. In a most generous spirit Fuchs attempted to impart the essence of his technical skill to men of medical education, whereby these exceptional attributes of his might be combined with the pathologic training he naturally lacked. Thus was planted the seed that has resulted in the quality of the radiologic abundance that is now Chicago's.

Fuchs's singleness of purpose was proven by his martyrdom. His constant thought was to communicate to others that which he had learned for himself through arduous labor. The completion of his text-book, which only the torment of his bodily affliction forced him to renounce, would have been the satisfying culmination of his ambition.

Fuchs, Caldwell, Rollins—great technicians of American radiology at a day when the mists of uncertainty and discouragement clouded the vision toward the goal of attainment and the paths of advance were rugged—it is their spirit, and the spirit of such as they, that guides the humanitarian functions of the great roentgen laboratories of today.

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As he was not a physician, the records of Fuchs's pioneer accomplishments did not appear frequently in the contemporaneous medical literature under his own name. In 1902, however, a contribution from his pen appeared in the *American X-ray Journal*, 11: 1103, on "Detection of gallstones by the x-ray." This communication was accompanied by a description of four illustrative cases, which gave scope for demonstration of his remarkable technical ability in this most difficult field. Aside from this, the paper was important in that it represented one of the very earliest American efforts to reveal the "shadows" of biliary concretions in the living subject. But before the year 1902, and thereafter until his affliction prohibited further activity, the skilful work of Fuchs appeared vicariously in many publications of clinicians. Chief among these were:

1899. Church, "Cerebellar Tumor; Recognized Clinically, demonstrated by the X-Ray and Proved by Autopsy." *Amer. Jour. Med. Sci.*, 117: 125, 1899.
1901. Kolischer and Schmidt, "New Method of Skiagraphic diagnosis for Renal and Ureteral Surgery." *Jour. Amer. Med. Assoc.*, 37: 1228, 1901.
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In addition, the clinical papers on the subject of urinary calculus published very early in the era of the roentgen-rays by the Chicago surgeons L. L. McArthur and A. D. Bevan were illustrated by the radiographs of Fuchs, thus revealing that his technical work in this surgical field was begun as early as October, 1897!

WILLIAM CARL EGELHOFF

1872—1907

THIRTY-TWO years ago it was already clearly evident to roentgenologists that they were confronted by a serious agency which threatened not only to undermine their health and professional efficiency, but perhaps to terminate their lives. Doctor Blacker, in Great Britain, had already died from the effect of his roentgen-ray exposure; Clarence Dally and Elizabeth Fleischman and Louis Weigel, in the United States, were even then seriously injured. Every meeting of the American Roentgen Ray Society was in some measure occupied with intense discussion of this highly important matter. At the meeting of 1903, a paper was read by Dr. John Pitkin of Buffalo, in which the subject was presented in a most colorful manner. He spoke not only of the visible skin changes which over-exposure to roentgen-rays seemed to produce, but also of certain subjective internal symptoms, such as nausea and vomiting, diarrhoea, vertigo and dyspnoea, which he attributed to prolonged exposure and of which he spoke feelingly, having experienced them. In the light of modern experience, we now know that Doctor Pitkin was by no means the alarmist he may have seemed to be at that time.

This communication was variously received, naturally. Dr. William Egelhoff, of Chicago, evidently did not take the subjective symptoms as thus described quite so seriously, as may be inferred from his discussion of the paper:

After listening to the remarks of Doctor Pitkin, I am reminded of some symptoms that I had about a year ago. At that time I seriously considered taking a vacation, for I was certain that my stomach and bowels were being affected by the x-ray. I became

more miserable every day in spite of the fact that I was paying considerable attention to my condition, in the hope that I would find something that would relieve the trouble. Finally, I concluded to complete the work, since my symptoms did not tally with any known disease . . . and you can imagine my surprise when I found that I was suffering from *taeniasis*. But . . . I studied . . . my case for about two months, changing the diet every now and then. I grew steadily worse, and I came to the conclusion that it would be well [if] I took the remedy prescribed for that condition . . . I began to feel better, and have not had any trouble with my stomach or bowels since.

Continuing the discussion, Egelhoff treats of his hands a bit more soberly, although his optimism is revealed in the treatment he recommends for them:

In regard to the protection of the hands, I will say that within about a year and a half I was so unfortunate as to lose three sets of finger nails, and my hands have scaled at least seven times. I, too, used all the remedies that I could think of, but with the same result as mentioned by others, until I, at least, found one which seemingly gave me very good results. The treatment at bed-time consists in washing the hands with water as hot as could be borne, using plenty of green soap and the hand-brush. Of course, that made the hands feel very sore and tender, and very painful at first, but I continued to do this, and it improved my hands very much. After this washing, I anointed the hands with plenty of olive oil, and then put on a pair of kid gloves. Under that treatment my hands improved wonderfully.

That this optimism or, perhaps, disregard of possible consequences, continued throughout Doctor Egelhoff's short radiologic career is suggested by the present Historian¹ of the Radiological Society of North America when he reports that much of this radiation-dermatitis was sustained when he generously used his hands and arms in fluoroscopic demonstration at a church fair. As a colleague and friend he warned Egelhoff of the probable outcome of it, but the admonition fell upon deaf ears.

¹ Dr. I. S. Trostler, of Chicago.

William C. Egelhoff was graduated from the Medical School of Northwestern University in 1902. He had been in close contact with practical medical work as a member of the army hospital corps during the Spanish-American War almost before his undergraduate training began. It is possible that during this service his interest in the roentgen-rays was engendered, to develop with the passage of his school years, for a year after his graduation we find him a member of the American Roentgen Ray Society. Before his death he had been appointed as assistant in the X-ray and Electrotherapeutic Department of Cook County Hospital and Roentgenologist to the German-American Hospital.

Dr. Egelhoff's radiotherapeutic work at the Cook County Hospital was active but at the same time rational. His service there covered a period in the history of the treatment of disease with roentgen-rays when opinion was unsettled and practice indeterminate. Tuberculosis of the lungs was believed to be a most favorable field for the curative action of roentgen-rays; by many it was thought that, once in possession of this potent agent, medical practice could well afford to dispense with all other forms of treatment. In this matter Egelhoff was a conservative, as he had been a conservative regarding the theory of the untoward systemic effect of x-radiation. Said he in 1904:

... I have had the opportunity, while treating cases of tuberculosis at the Cook County Hospital in Chicago, of noting the stimulative effect of the roentgen-ray in these cases. In from ten days to two weeks after the beginning of the treatment there was great improvement in appetite, in the function of all the organs and in the general condition of the patient. But I do believe, and I have had this belief verified, that we can improve our cases still more by resorting to the use of other curative agents, either medicinal or non-medicinal. We should not be absolutely dogmatic and use the roentgen-ray only, when we know that other agents may be of great benefit.

From the standpoint of our present firmly established

therapeutic methods in pulmonary tuberculosis, such a statement may seem strange indeed, but it has ever been the tendency of radical thought in medicine, upon the appearance of a new therapeutic measure on the field, to pounce upon it as a cure-all or at least as the agent of unthinking choice, to the utter repudiation of the established order in therapeutics. Thirty years ago it required the concentrated effort of a group of far-sighted men, through the doctrine of conservatism, to counteract this tendency and its effect on the development of American radiology. William Egelhoff may well be classed as a member of this group, and had longer life been vouchsafed him, his salutary influence would doubtless have been felt more deeply.

In 1904, but two years after his graduation in Medicine, Doctor Egelhoff sustained a severe radiation dermatitis complicated by a chemical dermatitis of the fingers which in all likelihood was due to the effect of photographic solutions. A few months later, a small fissure appeared between the third and fourth fingers of the left hand which gradually developed into an ulcer extending over the entire dorsal surface of the hand. In November of 1906 this area was skin-grafted without favorable result, and again the following month, likewise with no result. During the early summer of 1907 an axillary abscess developed and was incised and drained but failed to close. It has been said that amputations were done at the wrist and again at the shoulder, but the hospital record does not verify this. It is recorded that such amputations were advised by many surgical counselors, but as both hand and axilla were receiving palliative treatment in December, it is probable that Egelhoff did not follow surgical advice, of which he was so fortunate as to have the best.

William Egelhoff died December 27, 1907, at the early age of thirty-five. He was a man of definite decisions and decided opinion, and had already made his voice heard on the side of conservatism in radiologic practice, a principle that he

religiously followed, to the great advantage of those who came under his care. The history of his brief professional years indicates the extent of his suffering, and the record of his acts reveals the ideals he served and for which he died.

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VII

ROME VERNON WAGNER

1869—1908

AND

THURMAN LESTER WAGNER

1876—1912

IN ANY historical consideration of the gallant careers of these young Hoosier pioneers in the field of radiology, it is together that the courses of their lives should be contemplated. During adolescence and throughout the fruitful years of their brief existence, it seemed that the blood-ties of a brotherhood were made stronger and closer by the sustenance of a common purpose and, as time passed, by the foreshadows of a common destiny. "Neither one of them," writes their sister,¹ "ever regretted giving his life to this cause. They never allowed themselves to be called martyrs. When their mother would say, 'If only you had become farmers, you would be well and strong today,' they were sincere in their reply that they would not exchange their experience for any other life they could imagine. . . ."

Rome Wagner was born to Joseph and Lavina (Dillman) Wagner at Logansport, Indiana, in 1869. Four years later his parents removed to the small village of Treaty, in Wabash county, where the father built and operated a saw-mill. Here the boy commenced his school life, and here was born in 1876 his brother Thurman. Subsequently, their father bought a farm north of the town of Wabash, on the banks of the Eel River, where may be easily pictured a pas-

¹ Mrs. Grace Wagner Palmer. *Personal communication*.

toral paradise for two boys and a dog—hunting, fishing and, in winter, skating a mile down the river to school at the village of Roann. To evoke this scene to the mind's eye is but to visualize the rural life of the Mid-west at an earlier day, that formed so strong a fibre in the weaving of the sub-

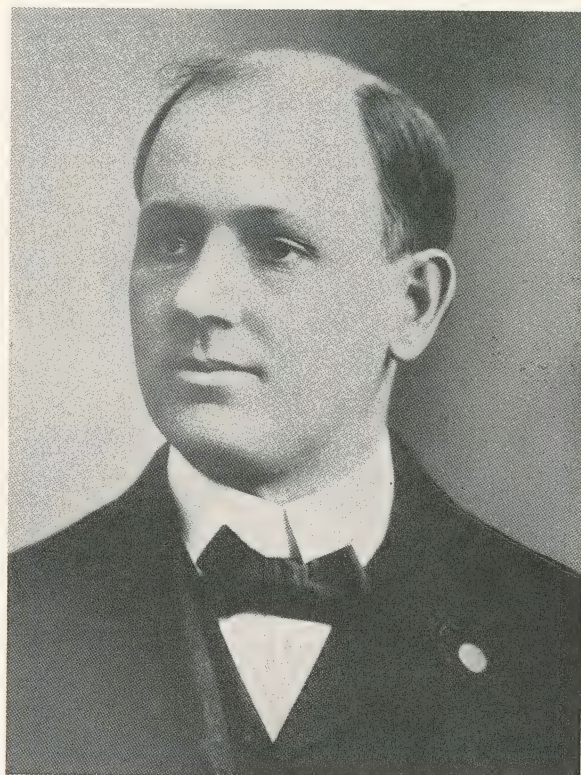


FIG. 19—Rome V. Wagner

stance of America. Such a picture retains the atmosphere that once enveloped the youth of a Great Martyr on the banks of the Sangamon, in the neighboring state of Illinois.

During the season of harvest, the father of these boys operated a migratory threshing-machine up and down that portion of the country. The boy Rome, evidently following

a mechanical bent, managed the steam-engine that supplied its power. In the winters of 1887 and 1888 he attended Central Normal College at Danville, Indiana, as a preliminary adjutant to the course at Central College of Physicians and Surgeons at Indianapolis, from which he was graduated

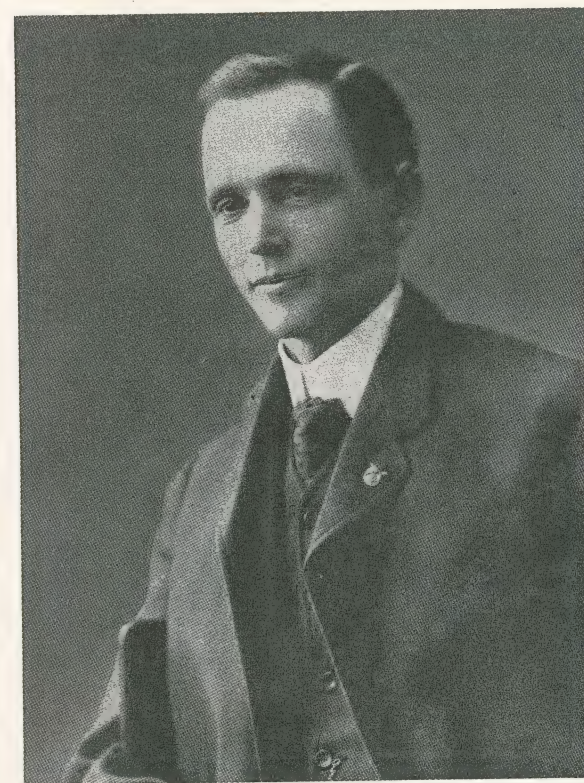


FIG. 20—Thurman L. Wagner

in 1889. This left him with a monetary supply of ten dollars for further study in Chicago, but he arrived there with an undepleted equipment of courage and high purpose. From that moment he supported himself totally.

In Chicago, young Doctor Wagner served as clerk to a pharmacist, on duty at night and Saturday to make possible

his post-graduate study. It was not long before he became apprenticed to an established medical practitioner, yet he could not be divorced from what was evidently a major interest—applied electricity. He soon obtained a patent for a device to improve the adaptability of the small primary batteries then in general use; other patents followed for kindred inventions. Before long, instead of in the practice of medicine, he found himself engaged in the construction of electrical appliances for medical use.

Thurman Wagner was now ready for high school and a younger sister had reached school age. As the daily journey down the river was difficult for her, the farm at Treaty was sold, and the parents removed to the town of Wabash where they made their permanent home. A quick-thinking, vivacious boy, Thurman was an excellent student and was graduated with honors from high school in 1895. The first year after leaving school he served as lay assistant in the office of a Wabash physician, but when his elder brother offered to assist him to obtain a medical education, he left Wabash for Chicago at once.

By this time, Dr. Rome Wagner had founded and developed a considerable manufacturing establishment in State street, Chicago. At once he discovered a most valuable assistant in his brother Thurman, who attended night classes at Jenner Medical College and worked at the factory during the day. Ultimately he was graduated from the College of Physicians and Surgeons in Chicago.

In 1900 Rome Wagner completed and patented his mica plate static-machine. By the use of tightly-compressed laminated mica in the construction of its revolving plates instead of the lead-free glass that had been employed previously, the revolutions per minute could be greatly increased, and this acceleration increased in turn both the volume and the tension of the electrical output of the machine. This apparatus was without doubt Doctor Wagner's major contribution to

the operative equipment of radiology—indeed, of electrol-ogy, since the use of the static-machine has a wider field than the production of radiation through the medium of the Crookes tube. From no source available to the author can be



FIG. 21—Rome Wagner, "the patron saint of the static machine,"—a fanciful but apt illustrative drawing that appeared in an early number of the *American X-ray Journal*.

derived any evidence that Wagner at any time supported the theory of many (*vide* p. 20) that roentgen-rays are innocuous when produced through the instrumentality of the static machine. His own early personal experience, as

that of Mr. Hawks and Professor Thomson, added weight to his constant warning as to protection.

Doctor Wagner devised also a form of Crookes tube in which the degree of focus could be variably adjusted by rotating a threaded anode-stem *through* the glass walls of the

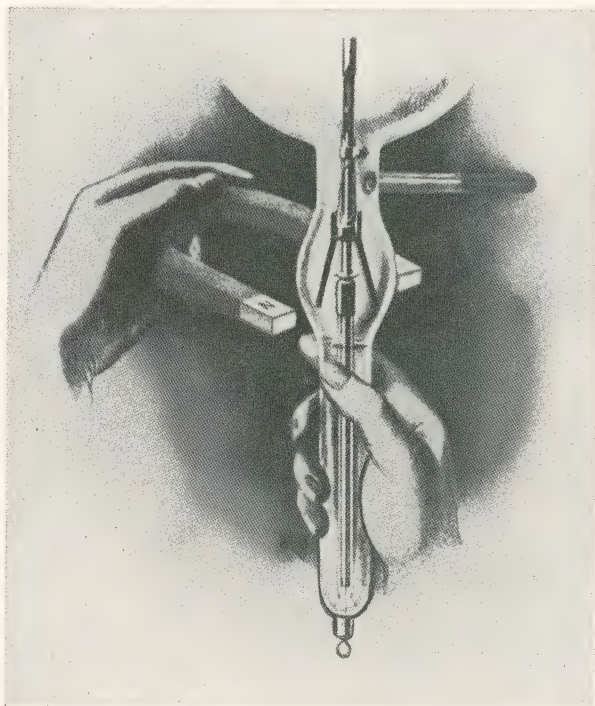


FIG. 22—Detailed drawing of the anodal stem of a tube made by the Wagners, in which the position of the target could be adjusted at will by the application of magnetic force through the glass wall of the stem.

anodal arm by means of magnetic force. The stem carried an armature within the small chamber made by a slight bulbous enlargement of the anodal arm; the variable position of this armature, when influenced by a U-magnet from without the tube-arm, would in turn govern the position of the target—toward the cathode, away from it, or circumferentially with the surface of the tube (fig. 22).

Both Thurman and Rome Wagner made frequent journeys afield for the purpose of demonstrating the use of their apparatus, especially to groups of medical men in the larger cities. It is safe to say that these exhibitions, at which they offered themselves as "subjects," were given generously to satisfy the desires of the merely curious as often as for the more direct purpose of selling their apparatus. Such is the history of the roentgen pioneer, whether scientist, artisan or merchant, possessed of a varied knowledge of the consequences of his enthusiasm, although unaware of the possibility of their ultimate magnitude. In 1903, on one of these trips to the eastern part of the country, Dr. Rome Wagner sustained a very intense acute "burn." He telegraphed to his brother who was on a similar journey into Iowa, warning him to avoid such an accident, but Dr. Thurman Wagner had already incurred his "burn" when the message arrived. Rome's acute lesions were of the face and hands; Thurman was similarly affected on the hands and back. Generally corresponding to the various anatomical areas they had submitted for fluoroscopic inspection to the seriously interested and to the simply inquisitive, each contracted eight or nine separate areas of ulceration. Once established, these lesions assailed them without respite, but the distress was matched by consummate fortitude. "Everything," writes their sister, "was always regarded as a joke, but if it had not been, we could not have borne it. When their suffering was greatest they walked the floor and sang a popular song or took a long walk. Thurman always said [later] he was extra fortunate—he was living longer than any other man burned at the same time. . . . They never allowed themselves to become discouraged. There were so many things they must do, that they did not give themselves time to think of their own condition. . . ."

The area of ulcerative dermatitis, degenerating into epithelioma, that finally caused Rome Wagner's death, made

its initial appearance on the face (cheek). This was excised by actual cautery in November, 1907. In January, 1908, it was necessary thoroughly to remove epitheliomatous glands on both sides of the neck, but it was impossible to make the extirpation sufficiently complete to prevent further extension of the disease. Certain ulcerative areas on the hands and back were found to have become also epitheliomatous. Rome Wagner died in March, 1908, in Chicago, of metastatic carcinoma of the liver.

In the meantime Thurman Wagner had been subjected to the very necessary amputation of three fingers of his right hand. This was followed later by excisions of ulcerative areas on his back and on the dorsum of his left hand. In the latter area, ultimately, a malignant process supervened with such energy that amputation of the entire hand became imperative as an effort to save the arm, but the fate of this noble pioneer ruled otherwise, and he died at his home in May, 1912.

Both with medical education, yet neither of them by his own choice a physician as healer, but rather as fashioner, with the physician's understanding of the physician's needs, of the beneficent tools of his clinical colleagues, did he serve Humanity. The steps leading to their useful position in life were steep and arduous for these brothers but, once ascending, they did not look down. As they neared the eminence, when both realized the magnitude of the sacrifice to be asked of them, they were concerned only with the lack of time and opportunity for further humanitarian endeavor before the hour of its fulfilment should arrive. In the presence of those most dear to them, to conceal and—where concealment was impossible—to make light of their physical impairment was their single thought. To all else they were spiritually insensible.

In the consanguinity of these heroic men lay their strength in the consummation of their destiny. It seemed to have

been ordained that the elder should be the leader, and that the younger should follow. This order obtained throughout their lives to the infinite betterment of both, and in this order did the good soil of their native Indiana in honor receive their dust on the original homestead acres of their grandfather.

MIHRAN KRIKOR KASSABIAN

1870—1910

DOCTOR KASSABIAN, one of the most prominent radiologists of his day, was an Armenian by birth, which occurred in 1870 at Caesarea (Kaisarieh) in the ancient province of Cappadocia, in Asia Minor. There he was educated at one of the excellent schools for boys and girls of the American Missionary Institute, after an early childhood fraught with almost constant danger of earthquake or massacre. Following his primary years as a pupil at the Mission, his continued aptitude and his growing seriousness of purpose won for him the post of an instructor there, as a stepping-stone toward the life of a medical missionary which it was his purpose to embrace. With this career in view, Kassabian journeyed to London in 1893, and the period of his life spent in that city marked the creation in him of a deeper interest in Medicine as a profession, and stimulated as well his strong inclination toward the practice of photography. His natural skill in this pursuit, already amply evinced stood him in good stead almost immediately. While in London he embarked also upon the study of theology as a necessary qualification for serious medical missionary work, but as the months passed he found himself more and more enmeshed by the fascinations of medicine and of photography. The persistent dominance of his thoughts by these two interests now seems a subtle presage of his future, as one today reviews his remarkable career.

Young Kassabian had been already impressed, at the Mission of his early education, by American methods of teaching, and on completing the period of study in London that combined employment had made possible, he emigrated

to Philadelphia. For this journey, his photography again came to his aid. The moment of Röntgen's discovery found him matriculated at the Medico-Chirurgical College of Philadelphia. To be able to undertake so long a journey and to make so momentous a change in the course of his life en-

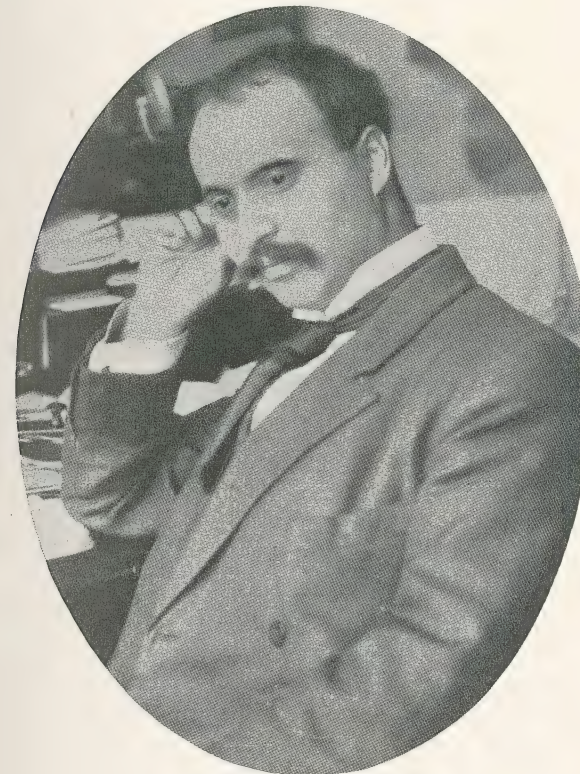


FIG. 23—Mihran K. Kassabian

tailed much sacrifice and hardship; a poor man as he had been always a poor boy, Kassabian was entirely self-supporting throughout his pursuit of a medical education, and here again his photographic talents served him, stimulating as well the growth of his interest in the new roentgen-rays. Well along his medical school course at the outbreak of the Spanish-American War, he was quick to appreciate their im-

portance as an aid to the surgery of warfare. In the spring of 1898, with his degree almost within his grasp and in urgent need of the livelihood that its possession might have made possible, Kassabian chose to heed a higher call for patriotic service to the country of his adoption. His naturalization having been obtained already, he immediately enlisted in the Hospital Corps of the regular army, wherein he worked faithfully and efficiently. In this manner he gained an experience in x-ray practice of great value to an incipient science, but of ineradicable harm to him. On his discharge from the Service at the end of the short war, Kassabian received his degree in medicine.

With due allowance for his qualities as a student and his capacity for thorough work, which must have been deciding factors, there is reason to believe that Kassabian's continued skill as a photographer and his later-developed interest in the treatment of disease by electricity had much to do with his appointment soon after graduation as "Skiagrapher and Instructor in Electrotherapeutics" at the Medico-Chirurgical College and Hospital. At that early day, the title "skiagrapher" could hardly stand alone—indeed, its life was not a long one. It was practically synonymous with "photographer." "The New Photography" continued to be the term spontaneously applied, in the general mind, to the process of producing "pictures" by the action of x-rays on a light-sensitized medium; thus the medical application of the roentgen-rays, as an institutional function, fell naturally to the lot of the hospital photographer. In this connection, Kassabian took a step which, measured in terms of its ultimate effect, may be called one of his major contributions toward the stabilization of roentgenology. At the Medico-Chirurgical Hospital he overcame an anomalous situation by combining closely his duties as "skiagrapher" with his responsibilities in the strictly clinical field of electrotherapeutics. In this way he gradually endowed his x-ray work

with the dignified status of a clinical department, wherein teaching, in his opinion, was a function definitely to be stressed.

Kassabian's tactful part in this process of adjustment gave him the opportunity to exalt, in turn, the position of electrotherapeutics. In itself a useful branch of therapeutics, practised by a great number of upright and sincere men, it had become honeycombed and undermined by the dry rot of charlatanism. Kassabian's serious interest in this work was the result of his steadfast confidence in its value when properly and appropriately applied. Although his was an ingenuous nature, with surprising acumen he realized the danger of a similar exploitation of the roentgen-rays, and he became a prominent member of the group that fought constantly this sinister tendency. Doctor Kassabian continued his work at the Medico-Chirurgical Hospital until 1903, when he was appointed Director of the Roentgen-Ray Laboratory at the Philadelphia Hospital.

The moment the value of the roentgen-rays to medical science was demonstrated, and thereafter until 1900, the use of the "fluoroscope" flourished. So widespread was its acceptance, especially by surgeons, that its routine use was demanded of the "skiagrapher" even to the exclusion of the radiograph. No doubt the influence of Mr. Edison, whose every pronouncement, naturally, made deep public impression, had much to do with the creation of this conviction. He had said in 1896:¹

With the fluoroscope, as I have already said, a surgeon should be able to determine in a moment, in case a man has been shot, just where the bullet has lodged, and operate accordingly. There is no occasion to take photographs, shadowgraphs or radiographs. I stopped that long ago. You see for yourself, the fluoroscope does the work in a moment.

Such dogma as this, absorbed by contemporary surgical

¹ *Amer. Jour. Photography*, 27: 160, 1896.

practitioners especially and reflected, through their urgent demands, into the atmosphere of the expanding x-ray laboratory, proved to be highly dangerous. As the demand of the surgeon was for fluoroscopic examination to effect a quick "diagnosis," so was it the ambition of the roentgen-ray operator to *demonstrate* by means of the skiagraph or radiograph, the medium to which the words of Edison ascribed



FIG. 24—Kassabian at work in his hospital laboratory in Philadelphia (circa 1900).

such little importance. Apart from the fact that Kassabian, through his technical sense, attached but secondary importance to the use of the fluoroscope in that type of problem wherein it has not now been employed for years, he also realized his own danger in pursuing this practice, but unfortunately too late permanently to arrest the cumulative effect of his earliest exposures in his army work and during the years immediately following—the heyday of the unshielding fluoroscope. In after years he said in retrospection:

"I would have stopped the [use of the] fluoroscope then, but they would not let me."

As if by the inspiration of the prophet, Doctor Kassabian made his first major contribution to the literature in October of 1900 on "X-ray as an Irritant."² As a basis for his observations, he recorded the fact that he had examined, in the course of two years' work, more than three thousand medical and surgical cases and had made more than eight hundred "negatives" (radiographs) at the Medico-Chirurgical Hospital and also in the United States Government service in the late war. These figures indicate clearly the proportion between his fluoroscopic work and the cases in which radiographic records were made, but the balance on the side of the fluoroscopic screen is enormously increased if he pursued at that time a practice which he admits using later—that of making a *preliminary* screen examination in every case! In the same paper he describes the course of his own affliction as it had progressed up to that time:

... About five months ago, [April, 1900] the fingers, knuckles and dorsum of my left hand exhibited a general erythematous condition. This continued about a month; the itching became intense, the skin became tough, glossy, edematous and yellow. On my right hand it was less marked, occurring only on the fingers. This I attributed to the fact that I hold the fluoroscope with this hand. I also put my left over [in front of] the fluoroscope and expose it direct to the x-rays. (*I used to show it to the patients before I began the application of the x-rays, as this tends to prevent the patient becoming emotional or excited.*)³

First I thought this condition was due to the chemical action of the developer (metol), but it was not, evidently, because the discoloration appeared first on the left hand and along the wrist, [an area] which is most exposed to the x-rays and less to the developing process; if it had been due to the developer the *right* hand would have been affected first and most. And again, this is not possible because I have been wearing rubber gloves while developing the

² *Amer. X-ray Jour.*, 7: 784, 1900.

³ Editor's italics.

negatives. This leads me to believe that the changes taking place in the tissues *after* exposure to the rays are due to their chemical (?) action on the tissues.

The subject dealt with in this paper gave Kassabian the opportunity, in its closing paragraphs of argumentation, to deplore the prevalent and lax application of the term "burn" to the dermatitis produced by undue exposure to x-rays. The ill-effect of this careless and indiscriminate usage he was quick to foresee, and he attacked it repeatedly until his death, often resorting to a description of his own case as a means of introducing the subject on appropriate occasions. His consistent position on this matter marks another of his contributions in support of the dignity of his specialty. It is believed that his antagonism to the use of the noun "burn" was not based on any misconception of its value in pathologic classification. He realized, as fully as does any pathologist, that burns of the skin may be produced not only by heat, but by cold, by sunlight, by direct electrical discharges and by chemical action. He did fear, however, that if "burns" came to be associated, in the popular mind, with the medical use of the roentgen-rays, the progress of a new science might be definitely inhibited at a crucial period in its development.

During his earliest medical years, Doctor Kassabian probably shared with all contemporary investigators of x-radiation an uncertainty as to just what agency the skin reaction was due. His writings of that period indicate that for a time he leaned toward the theory that it was the result of a radiation-produced chemical action, but subsequent experience, in his case a bitter one, convinced him of the strength of the thesis of direct action, as held by Elihu Thomson and others.

This uncertainty as to the causation of their acute afflictions having been dispelled, the pioneers could proceed to adopt the means of preventing repetitions of exposure, but what of their condition already sustained and perhaps es-

tablished? What steps should be taken for relief and possible cure? Their efforts to attain this relief and cure are interwoven with the fabric of their pathetic history—their comparison of notes in open discussion or by writings, their temporary victories over the unspeakable pain of the acute inflammation only to be assailed by the subtle advance of the sub-acute and chronic skin changes. Full five years after his initial symptoms, there is the faintest note of despair in Kassabian's words as he discussed the situation with his colleagues of the American Roentgen Ray Society in 1903:

Most of us have been "burned" by the x-rays when using the fluoroscope for indefinite periods, this being especially due to bringing the hand so near to the tube. Of course, today we are not making as many fluoroscopic examinations as formerly, so that . . . a smaller number of "burns" occur in this way An irritant of electrical energy is constantly coming from the larger coils,⁴ which increases the severity of the "burns" with which we are already suffering

In order to effect a cure of my hands, I have used every remedial agent mentioned in all the text-books on skin diseases and also every . . . medicine that has come to me by mail and otherwise from time to time. I would use one for two or three days, then throw it away and try another, but nothing seemed to me any good . . . I would like to have some of you discuss the matter of treating "burns" of our hands, because it is very vital with us. I have been unfortunate in finding a remedy to cure my hands. I hope that we will soon be able to prevent these injuries and find a specific remedy, so beginners will not have the same misfortune.

Herein one can discern a prescience of irreparable physical damage as the price of his diligence in earlier years, but this intuition did not visibly affect his sustained enthusiasm in his work. To Kassabian, evidently, it was merely another barrier over which he must climb—another resistance in the course of a career already beset with handicaps!

⁴ Now recognized as secondary radiation. During his early career, Kassabian supported the theory that the skin changes were due to *chemical reaction*, from either direct emanation or the static field. Also, he believed

Doctor Kassabian's second scientific paper⁵ was perhaps the most valuable of any of his productions. This was read at the first meeting of the "Roentgen Society of the United States" held in the Grand Central Palace, New York City, in December of 1900. Before this society, which on that occasion became, by vote, the American Roentgen Ray Society, Kassabian exhibited a series of no less than one hundred and fifty "skiagrams." His paper described in detail the "Technique of X-ray Work," with especial reference to its photography. As in a former paper by Weigel (*vide* p. 53), it gave its author the opportunity to make practical suggestions based on a wide experience. As such it was most welcome to a large group of early experimenters not deeply versed in the long-established methods of this important process. In the same paper, Kassabian discusses judiciously the functions of the fluorescent screen and of the radiograph. It was "fluoroscope *versus* skiagram" at that day, and Kassabian experienced to his cost the temporary favor accorded to the fluoroscope.

To those of long photographic experience, increasing ability to make short exposures denoted a distinct advancement of the art. Therefore the need of such short exposure in radiography was quickly apparent to Weigel and to Kassabian. In his expositive writings in support of this need, and by way of contradistinction from the older order of radiographic technique, Kassabian consciously uses the term "instantaneous" in its figurative sense only, as it had been used by photographers for years; it suggested merely an exposure of very short duration—shorter, perhaps, than any previously employed. The major controlling factor in the determination of Kassabian's scale of "instantaneous" ex-

that personal idiosyncrasy has great influence in determining the severity of the lesions. The latter tenet has never been disproven.

⁵ Kassabian, M. K., "Technique of X-ray Work." *Amer. X-ray Jour.*, 8: 867, 1901.

posure⁶ was the density of the anatomic part to be irradiated. In this scale, the criterion was the hand, to be exposed for one second! Read upward, it reached its maximum in the abdominal region, wherein an exposure of from fifty to ninety seconds was required. We may condescend to smile as we look down from the Olympian heights of our present-day practice, but we must remember that these recommendations punctuated an era in which x-ray exposures had been measured, of necessity, in minutes rather than seconds; so, by comparison, Kassabian's exposures were indeed "instantaneous."

Especially was Doctor Kassabian prompt to appreciate the paramount value of this technical procedure in the radiography of the thorax. He devoted much study to its development and in consequence he was soon able to say:⁷

... we are now in a position where the time of exposure has been lessened from one to four minutes to as many seconds, and even less, with a distinct improvement in the resulting picture . . . to overcome the defects in skiagrams due to movements during respiration, it is necessary to expose the part and plate to the action of the x-ray momentarily, and this at the end of the inspiration period. In the case of the heart, the exposure must obviously be instantaneous, or at least synchronous with the whole or a part of the cardiac cycle

For this purpose Kassabian used a twenty-inch Ruhmkorff coil with an electrolytic interrupter. Great was the amount of manipulative skill required to nurse a gas-tube through a series of such exposures; for him the task was greater as he employed almost habitually at this period a tube notorious for its fickle behavior. "The degree of penetrability is best measured," he observes, "by means of the fluorescent screen-hand method, but . . . I do not recom-

⁶ Kassabian, M. K., "Instantaneous Skiagraphy." *Amer. X-ray Jour.*, 12: 41, 1903.

⁷ Kassabian, M. K., "Instantaneous Skiagraphy of the Thoracic Organs." *Trans. Amer. Roentgen Ray Society*, 1903, p. 95.

mend testing the tube with the fluoroscope. It is very injurious to the hand and this is the reason why so many of us are suffering from dermatitis." Although Kassabian, in enumerating the *modi operandi* to effect exposures which at that day seemed so short, mentions the value of the intensifying-screen,⁸ he recommends its use only where the patient's safety demands the shortest possible exposure. This opinion reflected the adverse sentiment then prevailing relative to the use of intensifying-screens, as their structural imperfections impaired the quality of the finished "skia-gram."

To Doctor Kassabian in 1903 came an opportunity which he was prompt to embrace. With the advice and encouragement of many scientific men of Philadelphia, he entered upon the task of preparing a text-book dealing with the two branches of medicine to which his life had been dedicated.⁹ For over three years he worked on this volume—a labor the more arduous because of his naturally imperfect knowledge of the English language. The result was a splendid book of nearly five hundred and fifty pages, the first edition of which appeared in 1907. One of the three outstanding American text-books of its time to deal comprehensively with the subject of radiology and yet such is the evanescence of human impressions that mention of it does not appear in a late (1933) analytical review of American radiologic literature. A meagre third of the work is devoted to electrotherapeutics; the remainder to x-ray diagnosis, to radiotherapy, to radium, to phototherapy and to an exposition of the value of the roentgen-rays in forensic medicine. Kassabian's selec-

⁸ Intensifying-screen. Finely-divided crystals of calcic tungstate fastened to a thin support and placed between the part to be radiographed and the sensitized surface receiving the image. Its use decreases materially the length of exposure.

⁹ Kassabian, M. K., "Roentgen Rays and Electrotherapeutics" (with chapters on Radium and Phototherapy). Philadelphia and London, 1907 and 1910. Lippincott.

tive inclination toward forensic roentgenology was revealed in his article¹⁰ of 1904 as well as by his thorough consideration of the subject in this volume. He acquired subsequently a sound reputation as an expert medical witness in causes relating to electrotherapy and radiology. The second edition of his book was published in 1910; its appearance was almost coincident with his death. Without question this elaborate text was the *magnum opus* of "a constant student, hard worker and thorough investigator."¹¹

Not through these literary contributions alone, however, did Kassabian receive general recognition; his opinion had long since grown to be one of authority in matters connected with those branches of medicine in which the roentgen-rays are notably useful. He was honored by the Commonwealth of Pennsylvania by an appointment as X-ray Expert to its Tuberculosis Congress; frequently he served as a representative of the American Medical Association at international medical meetings abroad.

It would seem that Kassabian's search, which he had prosecuted for five years, for some form of palliative remedy to mitigate the discomfort of his chronically inflamed hands, had been successful in some measure, because by January of 1908 there was general improvement of the condition on the back of the right hand, with the exception of an extensive keratosis at the base of the fourth finger. On the left hand, however, an area of ulceration had persisted for a long time on the middle finger and at the base of the first phalanx of the fourth finger; within a few months these had become definitely malignant in character. In April these fingers were amputated in part and at the time of this operation no evidence of upward extension of the carcinomatous process was noted. In 1909, nevertheless, the axilla became metastati-

¹⁰ Kassabian, M. K., "The Medico-legal Value of the Roentgen Rays." *Amer. X-ray Jour.*, 9: 39, 1904.

¹¹ Manges, W. F., "Mihran Krikor Kassabian—an Appreciation." *Amer. Quarterly of Roentgenology*, 2: 280, 1910.

cally involved quickly, apparently from a more recent area on the hand. The axillary glands were excised, but tissue repair did not take place. Further involvement of the glands of the chest-wall necessitated wider operative intervention.

With characteristic fortitude, Doctor Kassabian continued his practice in spite of this tremendous handicap, yielding only when it became obvious even to him that he had no strength to continue. Again, it was characteristic of him that, during the entire eight years' course of his affliction, he left no stone unturned to forestall public intimation of the extent of his condition or his suffering from it. He was fearful lest such information might in some way conduce to the discredit of the roentgen-rays. He was jealous of the good name of a great natural force in which he could see so clearly a superlative benefit to mankind. Actuated by this sentiment, it is said that he even entered hospital for his first operation under an assumed name.

Doctor Kassabian's enthusiasm for his work never faded up to the moment of his end. One can still clearly visualize the sparkle of his dark eyes, the flush beneath his olive skin, the slight hesitation in the soft intonation of his English speech, as he expatiated on the beauties of an x-ray demonstration. To the portal of his death he brought this enthusiasm in his life's endeavor and with high-headed pride he carried it beyond, leaving behind in the lap of Humanity the full-ripened fruits of his labors.

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BENJAMIN FRANKLIN THOMAS

1850—1911

THE STORY of Professor Thomas's early contact with practical application of the roentgen-rays is a story of an act of gallant disregard of self which resulted in the sacrifice of years of physical well-being and, finally, of life.

Dr. Benjamin F. Thomas was one of the most notable of American physicists, of national reputation as an investigator and as a teacher of electrical engineering. Born in Palmyra, Ohio, a son of David and Eleanor (Evans) Thomas, he had been a consistently brilliant scientific career. For ten years prior to Röntgen's discovery and thereafter until his death in 1911 he occupied with distinction the Chair of Physics at the Ohio State University. During this useful period of his life he founded the University course in electrical engineering, and planned as well as guided the erection of a building devoted to teaching and laboratory investigation in that subject. So far as was known at the time of his death, this was the only college building constructed solely for this purpose. Also, his efforts were "largely instrumental in securing [at Ohio State University] the erection of Physics Hall, which, with its valuable equipment, constituted [in 1913] the consummation of the development of the Department under his administration."

Doctor Thomas was endowed with singular gifts as a teacher—qualities not always to be found in profound scholars or brilliant investigators. Said one of the earliest of his students¹ at the Ohio State University: "Professor Thomas's

¹ Dr. Clarence E. Skinner (a pioneer radiologist); Remarks in presentation of the Benjamin Franklin Thomas Memorial Tablet to the Ohio State University, 10 June, 1913.

teaching was very largely aimed at the developing of the resourcefulness of the student, as well as the teaching of an exact knowledge of the subject under consideration. Many of his students have realized in after years that some of the

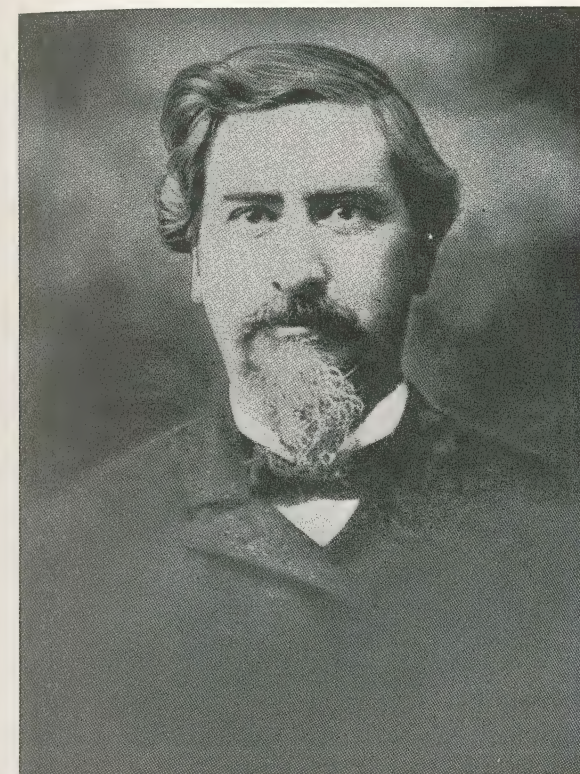


FIG. 25—Benjamin F. Thomas

teaching methods followed by Professor Thomas, which may have seemed out of place during their University course, were of the highest value to them when they came in contact with the real problems of an engineering profession, where resourcefulness and the ability to unravel any sort of difficulty, be it natural or artificial, are necessary to success."

All expositive writings dealing historically with the first

months of the "new science" indicate the existence of a distinct premedical era in which practically all of the experimental investigation of the roentgen-rays and much of their application in practical medical problems—which at once were brought forward for the purpose—was conducted by the physicists. So rapid was the expansion of public interest in this mysterious phenomenon, stimulated by prognostications as to its likely use in Medicine offered in the lay press, that these obliging and probably somewhat bewildered scientists were inundated with laymen urging diagnostic investigation of their chronic surgical abnormalities, to say nothing of the medical practitioners with their more acutely afflicted patients. If his experience was anything like that of scores of his colleagues in the world of physics, the kindly Professor Thomas was probably soon immersed in a situation of this kind. In common with physicists everywhere, and particularly as a specialist in electrophysics, he had promptly undertaken to repeat the experiments of the laboratory at Würzburg and to continue the line of investigation laid down in Röntgen's *Communications* as they appeared. His splendid general equipment at the University enabled him to proceed in this work at a much faster rate than could his non-teaching medical brethren who were equally interested in the portent of the news from Bavaria, but whose hastily-ordered apparatus was slow to reach their hands. Therefore Doctor Thomas was, so to speak, first in the field in a community which up to that time had no medical "skiagrapher," as roentgen-rays workers were called at first. At this moment he took the physicist's enthusiastic interest in the phenomenon and was called upon to do a considerable amount of radiographic work, in the course of which he sustained the radiation-injury that had such disastrous effects. He was quick to perceive, however, that the practical future of the x-rays was within the field of Medicine and when, finally, members of the medical profession in his

community took up the "new science," he was not averse, in view of other duties and interests, to pass the torch to their hands. In this, his was the attitude of other great electrologists of that day—of Edison, of Tesla or of Elihu Thomson. But at the moment, almost, of the relinquishment of his wholly beneficent activities with the roentgen-rays, he received a physical blow from which he never recovered.

In the autumn of 1896, before American roentgenology had completely emerged from its "premedical" era—in other words, an era when the number of medical men attacking its study with anywhere near the system and thoroughness of the physicists was far from being "enough to go around," Doctor Thomas was called on to make a radiographic record of the vertebral bone structure, at the lower thoracic and upper lumbar levels, in an adult patient of a local medical practitioner. In order to spare the patient the annoyance of an additional visit or of possible repeated exposures in the effort to determine the proper exposure-time in this deeply seated structure, he instituted an inquiry based on a series of experimental exposures on himself over the corresponding anatomic region. To reveal even the contour of the "shadows" of the vertebrae with the primitive Crookes tube of that day, whereof the penetration would drop rapidly with the inception of heat production, was a tremendous task. With his own body as the control, Doctor Thomas's first exposure lasted "roughly two hours," and was followed by several others progressively shorter!

The result, in about two weeks, was an area of localized dermatitis four or five inches square involving the anterior abdominal wall, an area which promptly broke down, with sloughing of the subcutaneous tissues until the *peritoneum* was denuded. "His suffering," writes Professor Thomas's son-in-law,² "was terrible," and he "was unable to carry on his work at the University for the greater part of the college

² Mr. Henry F. Walradt, *Personal communication*

year after 1897 came in." "I was in the class of 1898," relates a prominent alumnus³ of the Ohio State University, "and I can recall very definitely seeing Professor Thomas walking across the campus, well bent forward in order to relieve any pressure upon the bad abdominal burn which he received while attempting to obtain a radiograph of his lumbar spine. . . ."

For a number of years Doctor Thomas's life was spared, but he was spared neither physical distress nor disability. The extensive wound would show a tendency to heal under the assiduous care it received, only to break down at remarkably regular periodic intervals. With this handicap and that of the internal derangement engendered by it, he carried on his teaching work with increased periods of very necessary rest. The pre-occupation of work, as with so many of the roentgen martyrs, had a certain analgesic effect on him. His death, when ultimately his strength failed him, was not the type of metastatic death usually recorded in their history, but was due rather to a slow process of interstitial visceral degeneration in the immediate vicinity of the structures involved in the initial roentgen-disorganization. Two other similar instances have been recorded among the pioneers herein considered.

Committed in the thoroughly scientific spirit that was the very soul of this generous man, utterly oblivious of self in a conscientious effort to obtain exact knowledge, this single act of magnanimity, mirrors in concentrated miniature, as it were, the entire history of the martyrdom of radiology. As a humanitarian, which is but another name for the real scientist, Thomas's ardent desire to obtain this knowledge was augmented by the consciousness of what it might mean to the well-being of the invalid entrusted to him. For the moment he was the true physician, though without medical portfolio! As a culmination of the sincerity of his quest for

³ Dr. Walter C. Hill, *Personal communication*.

the means by which a fellow-being might be the gainer, he gave himself to himself for experimentation. It were folly to assert that this act was carried out in ignorance of possible consequences to himself. A man in his position in the educational world is ever aware of progress in his science, and beyond all doubt he had read the warnings of his fellow-physicists. And that she might be spared the conceivable outcome of experimentation such as had been described already by Thomson, Hawks and men of their discernment, *of which he knew*, Professor Thomas submitted his own person that he might determine how best to serve the interests of the patient placed, for the moment, in his care.

"Greater love hath no man" It is such conspicuous gallantry as that of this pioneer that illumines the pages of the history of radiology.

LEWIS MORTIMER EARLY

1859—1912

DOCTOR EARLY was another of that group of pioneers in whom the fascination of photography, in at least one of its applications, was the precursor of an even greater enthusiasm for the expected usefulness of the roentgen-rays, so promptly suggested to the medical mind at the time of their discovery.

Lewis Mortimer Early was the son of George W. Early and India (Evans) Early. Of ancient Irish and Welsh stock, in paternal line he was of more immediate Virginian and Georgian colonial ancestry. His grandfather, Andrew Early, was descended from Thomas Early who was born in Virginia in 1785, removed to Ohio in 1816, and ultimately settled in Brown county. His father, born in 1836, was a veteran of the Civil War and throughout his life had been engaged in mercantile pursuits. Lewis Early was born in 1859 in Huntington township, Brown county. His early life was typical of the country boy of that period, with summer work on the farm and winter attendance at the local schools. In 1875 the father removed to the town of Ripley, where schooling continued for the son, as well as at the Normal school at Lebanon.

Life's turning-point for young Early came when, following a custom obtaining so commonly at that day, he began to "read Medicine" with an old practitioner of Ripley, thus acquiring a very practical foundation for the course at Jefferson Medical College in Philadelphia, from which he was graduated in 1881 at the age of twenty-one. Thereupon he returned to Ripley, Ohio, to practise his profession for three years. In 1884 he removed with his parents and his wife to Columbus, where he took up the general practice of medicine with prompt and continued success.

As in the case of Weigel, Early's life at this moment coincided closely with an era wherein the rapid development of the photographic art made the practice of it attractive to many. It was yet the revolutionary period following the birth of the "dry" plate. Perhaps Doctor Early was attracted be-

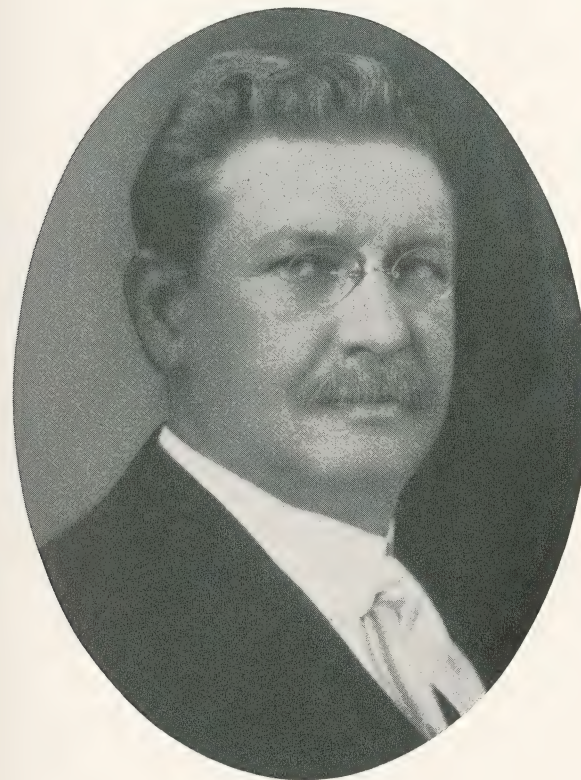


FIG. 26—Lewis M. Early

cause of the intense interest in clinical microscopy he had acquired at medical school, and in the technic of which he had developed much skill. The nice refinements of microscopical photography allured him. As he said years later in reminiscence, "I wanted to know how to make pictures, and as I could not get anyone to show me, I bought a [microphotographic] camera and began to experiment . . ."

About ten years after Early's removal to Columbus, a young artisan, Mr. Melville Yauck, settled there as an employé in a photographer's establishment. He was ardent in his desire to produce a quickly-manipulated photographic paper of the "developing" type that could be used practically and efficiently by the professional photographer. As Doctor Early had already recognized the desirability of a "developing" paper that could register, with greater clearness than the papers then available, the fine detail required by the best photomicrographic work, the problem was of great interest to him as well. These two young men combined experimental forces with the result that they evolved an "emulsion"-formula, as well as a method of producing it, that was far superior to any already existing. Later they were joined by Mr. Schuyler Colfax, whose abilities added much to the manipulative mechanics of the new process.

Although ultimately Doctor Early benefited materially by the prompt success of this new photographic product, as a medical man his life was destined for larger things. Upon hearing the news of Röntgen's discovery and studying its development as recorded in the successive communications from Würzburg, he made preparations for kindred experimentation. Obtaining the essential apparatus, he set to work with all the enthusiasm of his energetic nature. Adhering closely to Röntgen's procedure, and having in mind, evidently, the classic black paper enclosure of the Hittorf-Crookes tube at the Würzburg laboratory, he obtained a "skiagram," through black paper, of the composite structure of the lowly domestic button-hook. This was one of the very earliest of radiographs made in the United States, and the exposure for its production is said to be one hour and a half.

Early's chief interest lay, naturally, in the medical application of the "new science," with the result that by May of 1896 he was able to exhibit a series of radiographs at the annual meeting of the Ohio State Medical Association. For four

years he worked indefatigably in the limited roentgen-diagnostic field of that day, and, confronted with the uncertainties of performance peculiar to the primitive apparatus of the time, he used habitually the hand-fluoroscope for the purpose of testing its output from time to time. Consequently in 1899 he developed a dermatitis of the left hand. By 1900, it is written, Doctor Early was still the only physician in central Ohio engaged in this work, with rapidly multiplying opportunities for the exercise of his energetic effort and his beneficence. When, about this time, the first reports were forthcoming relative to the favorable effect of x-emanation on malignant disease, Early evinced much enthusiasm over the possibilities of this form of therapy. It is recorded that during the years of his later therapeutic work he would often remain in close proximity to a patient throughout a long exposure for the purpose of imparting confidence and assurance.

By the year 1903, the dermatitis that had involved his left hand had given way to ulceration, for which skin-grafting was attempted but with little permanent benefit. Finally during that year it became necessary to amputate a finger of this hand, which was followed by others, until eventually he had lost three fingers of his left hand and two of his right. The appearance of an area of epidermoid carcinoma on the back of the left hand resulted in the successive amputations of the hand, the forearm and finally the upper arm at the shoulder. The remainder of the right hand continued to be the seat of exquisitely painful ulcerations which required constant protection, but which revealed in part a tendency to heal under the effect of palliative treatment. Doctor Early died in 1912 from general metastasis.

Here was a life given gloriously in the cause of sorely-beset human beings in urgent need of help. Lewis Early could have remained in the field of non-clinical scientific research or he could have confined his clinical work to the diagnostic x-ray

investigation that had occupied his close attention prior to the last eleven years of his life. In the latter case he might have paid but a moderate price for his devotion. Rather, he chose the strict interpretation of "the laying on of hands." By habit, he chose to be literally at the side of the patient who was receiving under his ministration the beneficent effect of the powerful agent he employed therapeutically. Carried away by the earnestness of his solicitude, he had no thought for his own protection, a thought so necessary in view of the multiplicity of the exposures to which he was subjected. The way he chose lay martyrdom; a thorny way beset with suffering the like of which few men have had to endure. Upon such sacrifice is builded the structure of the art of healing, and through the example of such lives does it reveal its integrals—human love, devotion to its own ideals and, in the process, self-effacement.

XI

CHARLES LESTER LEONARD

1861—1913

THERE can be no doubt that American urological roentgenology owes the incipency of its impetus to the pioneer labors of Charles Lester Leonard. From the year following the Discovery to the year 1910 he had contributed no less than eighteen major monographs on the subject of urinary lithiasis, aside from frequent authoritative reference to it in various papers dealing with the general diagnostic application of the roentgen-rays. In a roentgen-diagnostic problem which in early times was most difficult, Leonard's technical results were so convincing that by the beginning of the century he had established himself as the foremost authority in this branch of x-ray diagnosis. His opinion was sought by his medical colleagues from far afield, and his writings describing his methods and conclusions were closely studied.

Doctor Leonard was of New England stock. His colonial ancestor, John Leonard, settled at Springfield, Hampden county, Massachusetts, in 1632. He himself was born a few miles distant at Easthampton in Hampshire county; his parents were Moses and Harriet (Dibble) Leonard, who removed to Pennsylvania during his early years. In Philadelphia the youthful Leonard was prepared for college at the old Rittenhouse Academy. From the University of Pennsylvania he received his baccalaureate in Arts in 1885, and the same degree from Harvard University, at Cambridge, in 1886. In the spring of 1889, Leonard was graduated in Medicine from the University of Pennsylvania and received therefrom also the degree of Master of Arts in 1892. Upon his graduation in Medicine, he became much interested in mi-

croscopy and especially microphotography. After a period spent in various European laboratories he devoted much time to the further study of photomicrography at the William Pepper Clinical Laboratory of the University of Pennsylvania. There he succeeded, by means of an electrically



FIG. 27—Charles Lester Leonard

operated lens-shutter of his own design, in photographing various periods in the life-cycle of micro-organisms. He contributed definitely to the literature of clinical microscopy.

At the moment of Professor Röntgen's announcement, Lester Leonard was a member of the surgical staff of the University Hospital. As to so many scientific men who at one

time or another had been engaged in photographic work, this news was to him a matter of the greatest interest, and he took up almost at once the study of the "new science" and gradually devoted his entire energy to it, ultimately becoming what is now known as "roentgenologist" to the hospital.

"At the time [1896]," writes Dr. Henry K. Pancoast,¹ Doctor Leonard's successor, "he possessed the meaningless title of 'skiagrapher'. His first work was carried out on one of

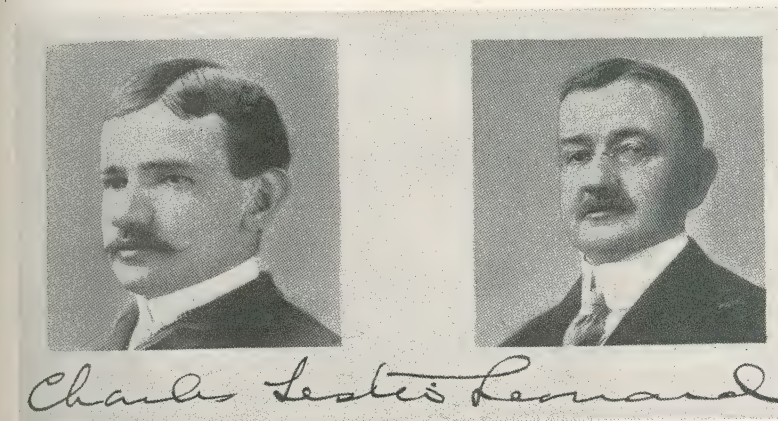
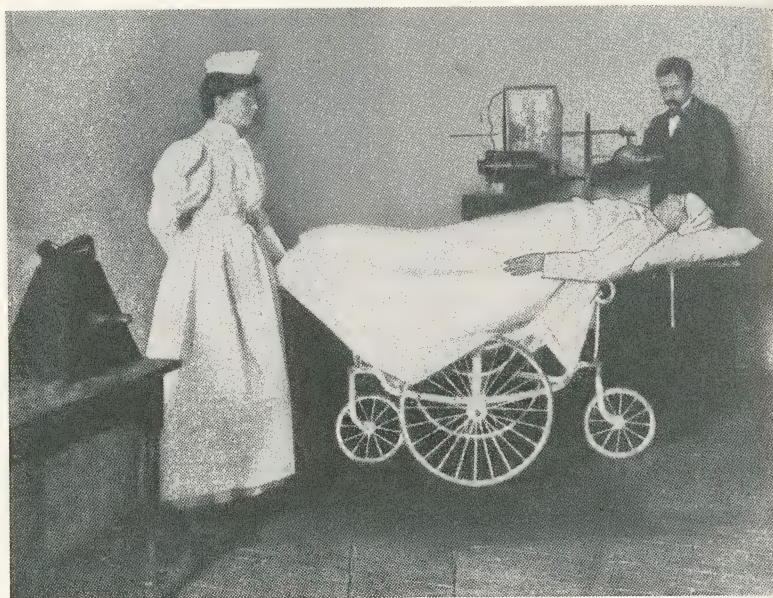


FIG. 28—Lester Leonard in 1886 and again in 1911. (From the twenty-fifth annual report, Class of 1886, Harvard College.)

the upper floors of the William Pepper Clinical Laboratory. As this was an inaccessible locality, his meagre equipment was later moved to a small inside room partitioned off from one of the surgical outpatient waiting-rooms. It was dark, poorly ventilated, far from windows and no bed could be taken through the door. Nevertheless, with the most meagre apparatus—a twenty-volt-primary induction coil operated by storage batteries—he was the first, at least in this country, to demonstrate the presence of stones in the kidney and other portions of the urinary tract. . . . His dark-room facilities

¹ Pancoast, H. K., *The Nurses' Quarterly* (Univ. of Penn. Hospital) Winter Number, 1934.

comprised a small closet containing a light, a sink with running water, two shelves, no ventilation and just sufficient additional space to accomodate his body. This was on the floor above the examining-room, and just off the general surgical amphitheatre and under the seats. Doctor Leonard continued to work in this embryo department until his resignation in 1902"



From the U. of P. Hospital "Nurses' Quarterly"

FIG. 29—Leonard at work in his early roentgen-ray department at the University Hospital, Philadelphia.

This description of the working tools of an x-ray pioneer typically illustrates the conditions under which all of them were forced to carry on their daily routine of diagnosis and treatment as well as their original investigations. It is to such sources that we can trace many of the major efforts and accomplishments of early roentgenology, and from the unlighted and unventilated work-room of Leonard came one of the greatest of them all—his contribution to the subject of

urinary concretions. It is not easy to determine, in retrospect, the origin of his intense interest in this branch of radiologic investigation. It is known that his contact with the British school of observers was always close, and perhaps the reported results of John Macintyre of Glasgow, in 1896, had much to do with it.

Lester Leonard's first publication on the matter of urinary lithiasis appeared in 1898. It dealt with the diagnosis of "cal-

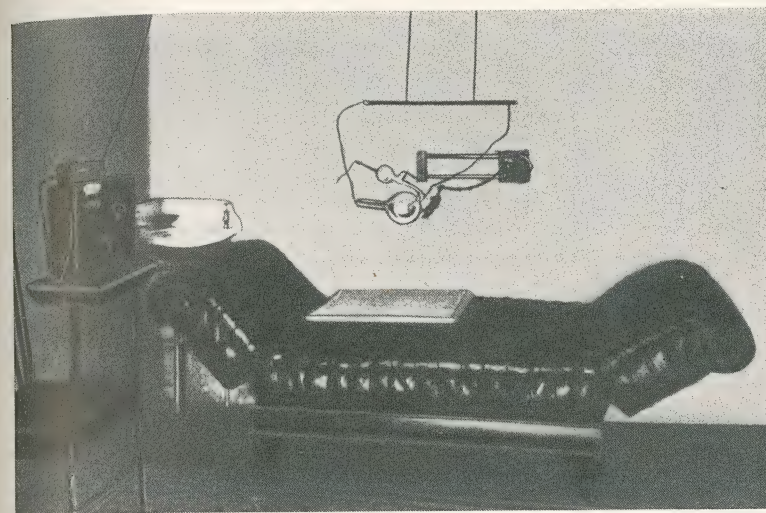


FIG. 30—The famous couch at Leonard's laboratory in South Twentieth street, Philadelphia, whereon were conducted most of the long series of examinations which made up his pioneer work on urinary calculus.

culous nephritis" by means of the roentgen-rays. This was the first of a long series of important papers extending from this early date to within three years of his death. The conclusions at which he arrived were based upon the results of a technique that was peculiarly his own, and in his hands successful because of the fact that his plates revealed all degrees of shadow-density of soft structure in the neighborhood of the urinary tract. As he wrote in 1904, his diagnosis, either positive or negative, required "negatives [plates] showing

clearly the shadows of tissues less dense than the least dense calculus." The manner in which Leonard accomplished these technical results was a source of great interest and some surprise to his contemporaries, but will amaze radiologists of a later generation who now read of them for the first time. Up to 1904, at least, he used a small Ruhmkorff coil of the portable type with a low-voltage (about twenty volts) primary winding. This was energized by accumulators. This coil in turn excited a self-regulating tube of the Sayen-Queen pattern which was adjusted to back up a spark of *no more* than two inches, or even one and a half inches if the patient were thin. The patient was placed in dorsal recumbency upon a plate enclosed by light-opaque paper. The plate-target distance was eighteen inches, or the skin-target distance at least eight inches. The average exposure was from five to ten *minutes* at a plate-anode distance of eighteen inches. No form of abdominal compression or of diaphragm was employed. The entire procedure was carried out on a couch, each end of which could be raised, thus producing flexion of the head and the knees (Fig. 30).

From early 1898 to 1904 Leonard examined three hundred and eighteen cases for calculus by this method. At the end of that period he reported² as follows:

The accuracy of the method has been demonstrated both in detecting (positive diagnosis) and in excluding (negative diagnosis) all calculi. The total amount of error, as previously reported, is not over three per cent, or ten errors in all. Three of these were in the negative or exclusion diagnosis, while in one, a second stone was overlooked. In forty-five cases of negative diagnosis that, to the author's knowledge, have come to operation, the diagnosis has been confirmed, while the subsequent developments in many more cases showed it to be correct. . . .

Aside from the constant expansion of his practice in calculus diagnosis, Leonard's field of opportunity in general

² Leonard, C. L., "The Technic of the Roentgen Ray; Calculus Diagnosis," *Fortschritte a.d.G.d. Röntgenstrahlen*, 7: 192, 1904.

radiology was also widening. He became the director of the laboratories at the Methodist Episcopal Hospital and the Philadelphia Polyclinic, but the demands upon him created by his wide reputation in calculus diagnosis compelled his resignation from the University Hospital in 1902.

During his very early years in the realm of radiologic investigation, Lester Leonard shared with many others the theory that the effect of x-emanation in the skin was due to the untoward influence of the static field created in the vicinity of the Crookes tube under excitation. As early as 1898 he expressed his opinion in this matter as embodied in these conclusions:³

(1) Static currents are capable of producing all the therapeutic and destructive changes ascribed to the Roentgen ray.

(2) A static field of sufficient strength is always present where a tube is said to be capable of producing these results.

(3) Why should we ascribe to the Roentgen ray therapeutic and pathologic effects which the static charges, always present, are capable of producing?

(4) It is impossible to produce a "burn" when a protecting shield of aluminum is employed, which collects the static electricity and conducts it by a grounding wire to the earth, although the Roentgen efficacy of the tube is unaltered.

(5) It is therefore reasonable to conclude that the devitalizing action attributed to the Roentgen ray is due to long continued or intense static charges or currents, while the therapeutic action is the stimulating effect of a mild and judiciously employed amount of static charge.

(6) The therapeutic results obtained are of undoubted value, but that value will be enhanced, and its employment facilitated, by the recognition of its true physical source.

This paper becomes historically important because, in writing it, Leonard threw himself definitely into the controversy wherein became embroiled so many scientific minds, even for a long time after Röntgen's *Third Communication*.

³ Leonard, C. L., "Roentgen-ray Dermatitis." *Amer. X-ray Jour.*, 3: 453, 1898.

Elihu Thomson took sharp issue⁴ with the conclusions of Leonard as being in opposition to the thesis he had proven in 1896. Leonard's paper is important likewise because its conclusions point to a very possible reason for his early skin reaction. If one could keep away from the static field about the excited tube, argued he, dermatitis would not follow, and the static field is eliminated by the interposition of a sheet of aluminum, grounded, in the path of the direct emanations from the anode of the tube. Hence for years Leonard took no other precaution to protect his hands. This is evidence enough to prove the sincerity of his conviction, which is further indicated by this notable statement made in another paper "The x-ray *per se* is incapable of injuring the tissues of the patient, and the dermatitis, which has been called an x-ray 'burn,' is the result of an interference with the nutrition of the part by the induced static charges."

At just what moment and through what influence did Doctor Leonard readjust his view on this question? Possibly he was convinced by the argument in Professor Thomson's reply, but as time went on he must have realized that the sinister progress of his own skin lesions had continued despite his consistent effort to disperse the electrostatic effect in the manner he had advocated; be this as it may, we find him in 1903 contributing to the discussion of a very important admonitory paper⁵ with these words:

... I have been suffering from x-ray burns for some time, and I have been putting in some time in the endeavor to find some way of preventing these accidents, and also to make it possible for me to recover. My hands were in very bad shape, and ... I have found that relief has resulted, not from protecting either my person or my hands, but from covering the tube in such a way that the rays are not carried out into the room. This eliminates not only the im-

⁴ Thomson, E., "Roentgen-ray Burns," *Amer. X-ray Jour.*, 3: 461a, 1898.

⁵ Pitkin, J. T., "Danger of the X-ray Operation." *Trans. Amer. Roentgen Ray Society* for 1903, p. 232.

mediate radiance emanating from the tube, but also the danger from the *secondary radiance* ...⁶

One of the paramount ambitions of Lester Leonard was the dignified growth of the specialty of radiology. He believed this could be furthered best by the careful nurture of a national Society, amplified by the formation of smaller local societies and stimulated functionally by international congresses. He was a firm supporter of this form of intercourse among scientists. It was by reason of his inexorable attitude on the matter of functional forthright in scientific bodies, and his ceaseless effort to preserve it, that the American Roentgen Ray Society, once the Roentgen Society of the United States, was sifted from a heterogeneous imbroglio. His presidency of this Society in 1904-05 marked the acme of these energies so well expended to this beneficent end. Leonard's influence also did much to establish and maintain the high plane that Philadelphia radiology has ever occupied; in 1906 he formed the Philadelphia Roentgen Ray Society and was its very active secretary until his death.

Doctor Leonard was a prolific writer. His contributions to the radiologic literature alone extend consistently from the moment the x-rays first attracted him to the last year of his life—to the day of his death, it can almost be said, for, in August of 1913, he and the late Guido Holzknecht of Vienna were to have reported on "The present status of Roentgen diagnosis in gastrointestinal conditions" to the Radiological section of the International Congress of Medicine at London. To finish his share in this communication he delayed a very necessary operation on himself; this delay hastened the end of his nobly generous career. A glance at Leonard's bibliography reveals the mass of his writings during a period of twenty-one years; very active years, eight of which were largely devoted to his work on urinary calculosis. In some

⁶ Editor's italics.

of his papers is reflected his very early application to clinical microscopy; some are the result of a short interlude of general surgical practice.

About ten years before his death, Leonard became much interested in roentgen-therapy, largely in the problem of cancer. He had long deplored the lack of a definite and dependable standard of dosage-measurement. In his discussion of a paper read by C. E. S. Phillips of London before the American Roentgen Ray Society in 1906, Leonard asked:

... Why should not a unit [of ionization] be adopted that can be expressed in these commonly employed terms? A unit of ionization will then be the unit quantity of electricity passing across a unit gap in unit time under the influences of radiation at unit distance under standard conditions of barometer and temperature. . . .

"This" recently observes Portmann,⁷ "is probably the first definition of a roentgen dosage unit to be made by an American clinical roentgenologist." The earnestness of Leonard's plea for accuracy in dosage-determination was equalled by the urgency of his demand for accuracy in reports of results in roentgen-therapy. He fought with vigor every influence that made for false or over-optimistic claims relative to the use of roentgen-rays as a curative agent. His resolute position had a stabilizing effect on his specialty that was utterly salutary. It was another of his beneficent contributions to the healthy development of radiology.

As firm as had been Lester Leonard's adherence to the use of long exposure, with low primary voltage and high amperage, in his diagnosis of urinary lithiasis, his advocacy for the *shortest* possible exposure in gastro-intestinal investigation was equally strong. During his last four years of life he wrote repeatedly on the subject of alimentary diagnosis, invariably on the basis of this technique of "momentary" exposures—exposures that might have been called "instantaneous" in

⁷ Portmann, U. V., "The Science of Radiology." p. 220 (Springfield, Thomas, 1933.)

the more flexible terminology of an earlier day. At no period in his life could Leonard have been called an ardent fluoroscopist, probably by reason of the manual affliction that had persisted almost from the start of his radiologic career.

Doctor Leonard's final conversion from his early belief as to the manner in which x-ray dermatitis could be prevented became fully established with the onset and rapid augmentation of his own painful condition. His generous nature prompted him to warn others at once. An area of malignant degeneration had previously made its appearance on the back of his forefinger and, "fearing excision or even amputation lest metastases result, [he] applied the *x-ray* very vigorously with the intention of destroying all malignant cells before operation . . . after which the finger was amputated and healed by primary union."⁸

During the course of three years following 1906, Leonard wrote several papers of admonition to those of the medical profession engaged in x-ray work. With the recent experience of his friend Doctor Weigel in mind, he cautioned especially against a misplaced confidence in the static-machine as a source of innocuous radiation. The specific notes of warning sounded in all these communications can be summarized by the conclusions reached in one of them:⁹

That much of the seriousness of Roentgen operators' lesions are due to meddlesome surgery and medication.

That this has resulted from an inappreciation of the character of these lesions.

That their course and clinical character, as well as experiment, have shown that they are due to injury to trophic nerve, decreased nutrition and blood-supply.

That the area involved extends wide of the visible lesion and hence reparative processes cannot follow local surgical interference or stimulant medication.

⁸ Porter, C. A., "The Pathology and Surgical Treatment of Chronic X-ray Dermatitis." *Trans. Amer. Roentgen Ray Society* for 1908, p. 128.

⁹ Leonard, C. L., "The Protection of the Roentgenologist." *New York Med. Jour.*, 86: 917, 1907.

That the first principle of treatment is to avoid all further depression and injury to local nutrition and to increase systemic tone.

That the best local treatment is to let the lesions alone and protect them from further irritation.

That the best treatment is prophylactic and therefore the protection of the operator should be carefully studied.

That the best method of protecting both operator and patient is to confine the radiations to the area to be examined or treated.

That this can best be accomplished by surrounding the tube or source of all radiation by sheet-lead of sufficient thickness (the weight known as six pounds to the square foot) over the active hemisphere of the tube.

That the entire tube should be enclosed in a box of sheet-lead having diaphragms of various size through which alone the rays are permitted to pass.

That this material can be employed by having an air-insulation of four inches on each side of the tube, or a total of six inches, which gives a sufficient working variation for the internal resistance of the tube.

Leonard's accomplishments as a roentgenologist, the sound character of his writings and, especially, the recognition abroad that was his by virtue of them, brought to him many honors. He was considered by his American colleagues a steadfast and dependable legate, eminently fitted to represent the scientific bodies of this land in foreign medical assemblies. In 1905, he was the official delegate of the American Medical Association to the Röntgen Decennial in Berlin; three years later, the officially invited guest to the British Medical Association and the delegate of the American Medical Association to the Fourth International Congress of Radiology and Medical Electrology at Amsterdam, where he read the report for the United States and served as an Honorary President of the Congress. In 1910, he attended the Fifth International Congress at Barcelona as delegate of the American Medical Association and the American Roentgen Ray Society. In the journalism of his specialty, he was an American collaborator for the British *Archives of the*

Roentgen Ray, the German *Zeitschrift für Röntgenkunde* and the Belgian *Journal de Radiologie*.

In a man of Leonard's stamp—in a man possessing the type of allegiance to a Cause that he possessed, it was inevitable that the ten years of his greatest activity for good and the ten years of his steadily increasing physical distress should be coincidental. The early loss of a forefinger that had no local aftermath by no means assured the security of other fingers, which in time became so definitely involved in a carcinomatous process that their amputation was required. But by this radical measure the progress of the disease was not stayed; there followed the loss of the hand and forearm, and finally the upper arm at the shoulder, but without avail to prevent metastasis in structures so vital that death ensued in the summer of 1913.

His contemporaries that are now alive can well remember Leonard's tall form surmounted by a massive head, with genial face and kindly eyes, that was ever prompt, in medical assembly, to take the floor in the cause of right, justice or humanity. Always her champion through his faith in her future, American Radiology could not have done without this man.

"Medical science is honored by such noble sacrifices as this, inspired by no mercenary aims, but by the purest motives in behalf of suffering humanity. Charles Lester Leonard has shed lustre upon Philadelphia and upon the profession he adorned and whose work he advanced at the cost of his life."¹⁰

"Always cheerful, never asking for sympathy even in his extremity, he died . . . at the age of fifty-one, a universally beloved, brilliant scientist who laid down his life for his fellows."¹¹

¹⁰ Editorial, *Philadelphia Evening Telegraph*, 24 September, 1913

¹¹ Thomas S. Stewart in Kelly and Burrage, *Amer. Med. Biographies*.

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XII

BURTON EUGENE BAKER

1871-1913

IF THE venerable state of Connecticut did not produce all the prominent roentgen-ray tube makers in the United States, she at least gave harbor to the efficient activities of four outstanding ones, Henry Green, John Bauer, Robert Machlett and Burton Baker, men of whom she may well be proud; especially so of one of them who was her native son—Burton Eugene Baker.

Baker was born in New Britain on the nineteenth of August, 1871, a son of George Marvin and Marcia Jane (Pease) Baker. Through the distaff side he was descended from one of the greatest of the Pilgrim Fathers, Governor William Bradford of the Plymouth Colony.

Young Baker attended the public schools of his native town as well as Professor Camp's private school for boys, and later a business college in Hartford. He was a studious lad, a serious-minded and deep thinking youth, and carried these traits through the course of his life. During the maturer years of his adolescence he manifested an intense interest in electrical science, and by hard work amplified his basic training through the self-education of close observation and practical contacts. In this way he was able to put his accumulated knowledge to practical use. Like most men of his type and training, he became fascinated by the news from Professor Röntgen's laboratory which continued to spread so widely as the old year of 1895 gave place to 1896. He gave much thought and time in experimentation to the use of the influence-machine as a means of generating the exciting energy for the Crookes tube of that day. It is possible that he may have been impressed by the groundless report promulgated

in 1896 that the roentgen-rays produced through the agency of the static-machine were inert in their effect on the human skin. At all events, he produced and used a small static-machine as early as 1897, which caused favorable comment by reason of its efficiency. Continuing in this direction,

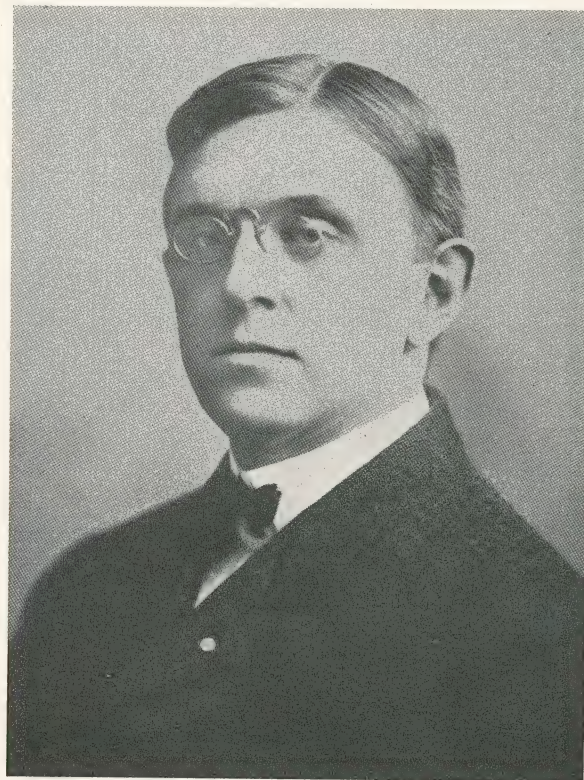


FIG. 31—Burton E. Baker

Baker established in 1905 "The Baker Electric Company" for the manufacture of mica-plate static-machines. In this venture he had the friendly encouragement and material aid of two prominent members of the medical profession.¹

His static-machine was a practical success, but among

¹ Dr. W. E. Clark and Dr. J. C. DaCosta, of Philadelphia.

roentgenologists especially Baker will be better remembered, perhaps, for the excellent form of roentgen-ray tube that he devised. In 1910 he formed "The Baker X-ray Tube Company," and the product of his factory was most favorably known among practitioners with roentgen-rays. Baker conducted much experimentation relative to the perfecting of tubes of especial form and function, such as valve-tubes for current-rectification, at the suggestion and with the advice of Dr. E. W. Caldwell of New York.

In many ways the career of Burton Baker is connected in mind with that of Rome Vernon Wagner. They were much alike; both affable and cheerful of disposition and gracious in manner. They had each followed the same inclination in education, although Wagner had amplified his education by the study of medicine. Both were warm champions of the mica-plate static-machine and both manufactured them commercially; both also fabricated vacuum-tubes. Each, unfortunately, was exposed in the same manner to the roentgen-rays and each was similarly afflicted. It was the face, neck and chest that suffered, among producers of x-ray apparatus, as much or even more than the hands. This apparatus, to be sold, must be demonstrated, and the chest, especially, was offered to enquiring eyes through the fluorescent screen. In the case of tubemakers, the tube must be watched closely at intervals during the process of exhaustion, and the face was often poorly protected.

Thus, in 1903, began the course of Burton Baker's persistent and inexorable malady—ten years of endurance that stayed not his effective progress in his work. His first dermatitis was severe, involving the back of his left hand and the skin over his breast-bone. A single large ulcer soon appeared on the hand and somewhat later on the chest. The area on the hand was skin-grafted, while that of the chest was removed and allowed to close by granulation. Microscopic investigation failed to reveal any evidence of cellular aberrations.

tion at that time. For a number of years the regions thus affected, as well as the right hand, showed fluctuating degrees of keratosis and minor ulceration.

Undeterred, Baker pursued his work energetically quite up to a year before his death, when there appeared upon his face an area that was manifestly epitheliomatous. This was first treated in Hartford by applications of the actual cautery, but it was soon evident that further intervention was necessary. An operation in Philadelphia could retard but temporarily the advance of the process. This was the second of a series of operative procedures and applications of radium in Hartford, Philadelphia and New York, numbering *ten* in all in the course of one year, that were unavailing. Burton Baker returned to his home in the early summer of 1913 and died on the tenth of July of metastatic carcinoma.

Thus was this useful life terminated while yet filled with the promise of future accomplishment. A life as definitely dedicated to the service of humankind in the warfare against disease as if it had been invested with the formal equipment of medical education and training. The relative obscurity in which these skilled artisans prosecuted their daily work, away from the note and observation of the public they so truly served, was illuminated and glorified by the courage so clearly manifested in their devotion.

XIII

HENRY GREEN AND JOHN BAUER 1860—1914 —1908

IT HAS been written of Henry Green that he "did more for the advancement of the x-ray tube than any other man engaged in its manufacture."¹ Especially is this true in connection with the elaboration of the concave cathode and with the production of an anode (target) in which the layer of platinum (to receive the bombardment of the cathode stream) and the layer of copper (to radiate the heat thus engendered) were joined in intimate contact without the aid of solder. In the construction of many focus-tubes, the use of solder to join copper and platinum reduced the melting-point of the platinum; this resulted in a quick blackening of the inner glass wall of the tube which rendered the instrument useless. In addition, a tube having an anode of copper and platinum thus soldered could not, during the process of exhaustion for use, be heated to a temperature high enough to rid it of its occluded gases. In the face of the requirements of an earlier day, a tube thus insufficiently exhausted was unable to withstand prolonged periods of excitation without losing vacuum and consequent penetration of its primary emanations.

Contrary to general impression, Henry Green was not a glass-blower, but was a skilful artisan in metals, with well-marked inventive genius. He was born in Birmingham, England, in the year 1860, and as a young man emigrated to North America, settling in Canada and there following his trade as a mechanic. He became much interested in the development of the incandescent electric lamp, and entered

¹ Hickey, P. M., Editorial in *American Journal of Roentgenology*, 1: 224, 1914.

the United States in 1888 to establish himself at Hartford, Connecticut, as a manufacturer of them. This industry involved glass-blowing and the exhaustion of the lamp-bulb by mercury-pump, so, as in the case of many others, it was natural that Green should be attracted by the report of



FIG. 32—Henry Green

Röntgen's discovery in late 1895. To him it seemed but a short step from the manufacture of incandescent lamps to the production of vacuum-tubes of the Lenard and Hittorf-Crookes types originally used by Professor Röntgen. Green followed closely the development of the focus x-ray tube subsequent to the published description of Sir Herbert Jack-

son's tube in 1896, and in spite of many vicissitudes and by unrelenting work, he produced a focus-tube of the "static" type, for use with influence-machines, during the course of the same year.

For the furtherance of this work, Green soon became

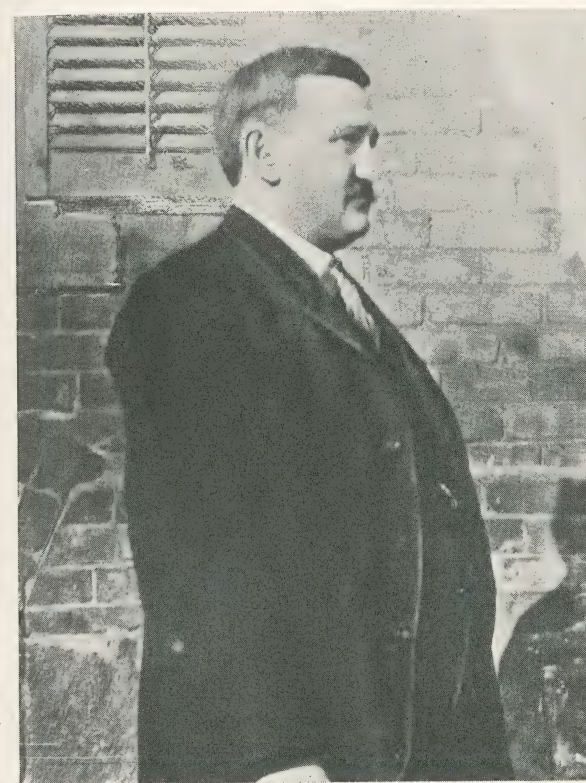


FIG. 33—John Bauer

associated with John Bauer, a glass-blower of exceptional skill, and there followed nine years of incessant labor for these two men. With their modest equipment of small induction-coil, its interrupter, a fluorescent screen and a few tubes of their own making, they attended public fairs and similar gatherings in the vicinity of Hartford, offering their

hands and their chests to the view of interested visitors. Some of these fairs would endure for the space of a week, so that many demonstrations were necessary to satisfy the aggregate of public curiosity. Such exhibitions were willingly repeated at their shop, where, in addition, radiographs were made by way of substantiation, and the necessary exposures for this purpose were generally long ones.

While it was by Bauer's skill that these tubes were blown it was Green's part to construct and to apply their metal parts, to exhaust and to test them. On an occasion long previous to his work with the x-ray tube, the vision of Henry Green's right eye was destroyed by a flying splinter of steel. To this misfortune was added another when, later, cataract developed in the left eye. With his total vision so greatly impaired, he was compelled to thrust his face into close proximity to Crookes tubes that were being exhausted in ovens whereof the construction was often sadly deficient in protective materials. This occupational necessity added enormously to the cumulative effect of the roentgen-rays on Green, but to him it seemed unavoidable because of his inflexible conviction that only he could do this work in a manner productive of results consistent with his own standard of excellence, which was high. "During 1912," writes one of his old associates,² "it was pathetic to watch him struggle in attempting to exhaust x-ray tubes. When the vacuum was high enough for the cathode-stream to strike the target, care had to be exercised (when the vacuum dropped on account of gases liberated from the target) lest the cathode stream spread out, pass the target, and impinge on the wall of the bulb back of the target. When this happened, if the current were not immediately cut off, the glass would quickly heat, then soften and finally suck in, thus destroying the tube."

During the course of the year 1905, John Bauer, whose invaluable co-operation with Henry Green up to that time

² Mr. F. J. Farrelly, of New York, *Personal communication*.

had resulted in a series of notable improvements in the construction of the x-ray focus-tube, was obliged to retire from the work by reason of increasing ill-health due to continued exposure to x-radiation. From the beginning, he had followed the daily routine of the roentgen-tube glass-blower, at a bench about breast-high, whereby constant skin-irritation from the effect of heat furnished, probably, a predisposing factor in the development of chronic dermatitis due essentially to radiation. In 1900, Mr. Bauer had noticed the appearance of small warty growths on the fingers, knuckles and backs of his hands. By 1904 a peculiar erythema had presented itself, becoming distributed over the face, neck and anterior trunk above the waist-line, and soon accompanied by small, hard, warty nodules. Wherever these were removed by such means as the actual cautery or silver nitrate, they tended promptly to recur, with increase in size and a tendency to ulceration. Bauer finally presented himself for medical examination in early 1907, when large epitheliomata were found to involve the dorsum of the bases of the index and middle fingers of the left hand. These fingers were forthwith amputated together with the heads of the corresponding metacarpal bones. Also there were observed, at the same examination, several ulcerations over certain joints of the right hand, one of which was deep. These were merely curetted, as more radical treatment was refused. Later in the same year, there took place a rapid recurrence of the carcinomatous process at the site of the amputations in the left hand, but only a curettage was permitted, followed by an unsuccessful attempt at skin-grafting. By the spring of 1908, the condition in the left hand had extended to such a degree that an amputation was done at the junction of the lower and middle thirds of the forearm. There was no evidence of glandular involvement and the amputation healed in a satisfactory manner.

A month later, another attempt was made to check the

process in the *right* hand by curettage and skin-grafting, but by June of 1908 cancer had become established locally in spite of these efforts. A few weeks later, a process of metastasis involved the glands above the seat of amputation in the *left* forearm. In the *right* hand, it became urgently necessary by this time to amputate two fingers above their bases. By the late summer, metastasis had very rapidly developed on the *left* side, involving in rapid succession the glands above the elbow and in the axilla. The remainder of the left arm was amputated at the shoulder in the autumn, but the constant exhibition of the utmost surgical skill, as applied to these conditions at that day, could not forestay the weakening state of the patient and his death on November 7, 1908.

By 1907, Henry Green had developed a very powerful and efficient focus-tube for use with an induction-coil and its interrupter. Owing to the close apposition of the platinum target and its heat-radiating copper base, these tubes would permit of a high initial exhaustion, which could be maintained under excitation by heavy induced currents. From retrospection of Green's useful life, aided by a clear memory, it may be said that this form of tube was his outstanding contribution to the consistent advance of roentgenology at that period, and that this tube, moreover, was one of the very best examples of such apparatus, to remain so throughout the declining gas-tube era.

Henry Green's modest but rigid confidence in his powers in the matter of gas-tube pumping and "tuning" was paralleled by his faith in his continued good health. Blessed with a rugged constitution, he believed that his capacity for unremitting hard work was limitless. He fostered a theory that this ability to expend energy without appreciable fatigue was due in some way to the stimulative effect of the radiation under which he worked, with an almost fatalistic conviction that, once this stimulation were removed, he would fail in health and ultimately succumb. Fate proved to be

indeed his master, but in a manner quite the reverse of his anticipation.

Much in accord with the history of so many of his contemporaries, Green laid the foundation of his later ills by his early practice of demonstrating the revelations of the roentgen-rays by generously offering his own person as the *modus ad finem*. This habit constituted the first step in the process of cumulation peculiar to radiation-pathology. Referring to this early experience, he wrote in January, 1908:

One peculiarity of my case is that, from frequent examination of my body by hundreds of doctors, the skin of my chest became black and hard, like parchment, giving me, however, no inconvenience and never becoming sore. In less than a year this blackened skin all came off in one piece, leaving the chest clean, without a scar, but of course removing all hair. . . .

Not so with his hands, however. For seven years prior to 1908, there had been induration, keratosis-formation and ulceration, in this order, over an area on the back of the left hand. "This had been treated in various ways and during the past six months [Porter's report of 1908] has shown signs of improvement under a dressing of vaseline, turpentine and creosote [*sic*]." On the dorsum of each wrist,³ also, was a circular ulceration which presented the characteristic appearance of epithelioma. In addition, a similar lesion occupied the forehead, which had grown in about three months to about the size of a quarter dollar. All these areas were excised; those on the back of the hand were skin-grafted by the Thiersch method. The lesion on the forehead was deep, involving the periosteum, so that its removal required a complicated plastic operation.

The results of these operative procedures were everywhere excellent, and Mr. Green enjoyed comparative surcease from

³ These lesions on the wrists were of common occurrence among the older pioneers of radiology. They were always on the dorsum and were due to the friction-irritation of the edges of the starched shirt-cuffs that were then in vogue.

the effects of his "burns" until 1912, "when a sarcomatous process appeared on his lower lip. In 1913 he underwent four serious operations for the removal of growths on his face. The last operation was in November of 1913, when his left thumb was amputated and glands in his chest and arm removed in the vain hope of saving his life."⁴

Two high-minded, courageous men, whose productive lives had as important a bearing upon the progress of American roentgenology as if they both had been clinical practitioners. If they could not apply the instruments of diagnosis and of therapy, at least they made the most important implement in the x-ray *armamentarium* against disease, and made it well, guiding its development through the most discouraging of technical handicaps and the most distressing of physical afflictions. Nothing could hinder the continued manifestations of their skill, nor anything in the way of bodily impairment deflect the unwavering direction of their vision toward the goal of high accomplishment. Down through the years we have heard much of the steady advance of radiological technic, but all too little of the earnest, faithful artisans, these men and others like them, who have made it possible by every sacrifice, including life itself.

⁴ *American Journal of Roentgenology* (Editorial), 1: 224. 1914.

XIV

WALTER JAMES DODD

1869—1916

THE NAME of Walter Dodd is as infrangibly interlocked with the course of early American radiology as is that of Röntgen himself an integral part of the scientific annals of Germany. The record of this extraordinary man will ever appear before the eyes of the student of the history of radiology, but only to the memory of those that knew him can be recalled the ineffable fascination of his personality.

Dodd was created for the humanities. No man of his generation more consistently lived his daily life "with malice toward none, with charity for all." To the fine conduct and worthy accomplishments of his fellow men he responded with full appreciation and hearty plaudit; to their baser acts he reacted with silence. It was said by one of his closest medical friends that "Dodd had a wide visual field for all goodness and beauty, but had a congenital blind-spot for the disagreeable qualities of men and things."¹

Walter Dodd was born in London in 1869. His friend and biographer, the late John Macy, relates that he was the only son in a large family and that his father was an artisan, as was also an uncle who worked as a stage-carpenter at the old Drury Lane theatre, behind the scenes of which the young Walter was often to be found. Thus was the young boy reared, as it were, in a Thespian atmosphere, which may have accounted for his signal gifts as mimic and *raconteur*

¹ Roger Irving Lee, indirectly quoted by the late John Macy: "Walter James Dodd—a Biographical Sketch," p. 62. Boston: Houghton Mifflin Company, 1918. Acknowledgment is made for the privilege of repeated reference to this biography, which, with the aid of Doctor Lee, so charmingly depicts the life of this illustrious pioneer.

to the delight of his friends in later years. At the age of ten, his life in London came to an end with his journey to America to live under the care of a married sister. The public schools of Boston gave him his earliest education in this country, and after a few years of this elementary training Dodd

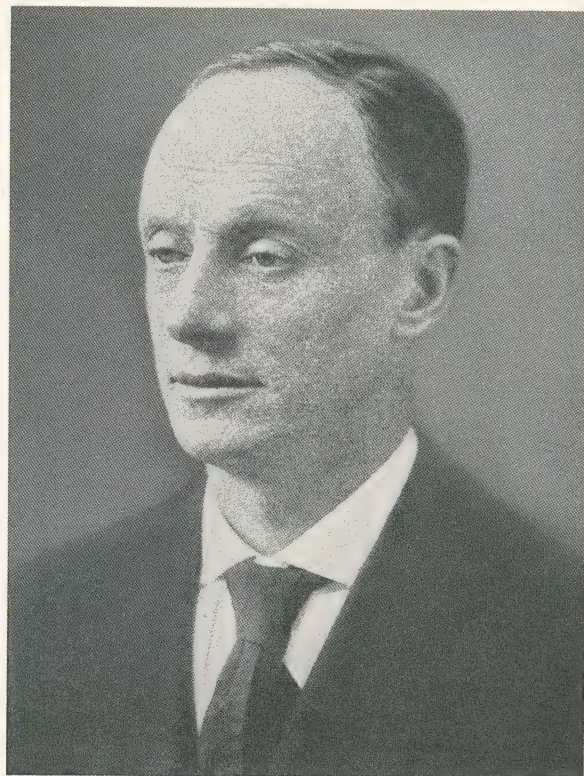


FIG. 34—Walter James Dodd

entered the employ of a firm of tea and coffee merchants. Here he worked with notable industry from early in 1883 to the end of 1887, in a neighborhood not far from the Massachusetts General Hospital, where later he was to rise, on the ladder of continuous efficiency and personal charm, to his ultimate prominence. It was his attractive personality,

writes Macy, that led to his next employment and on to the major activity of his life. In 1887 his Sunday-school teacher, in whom he found a friend as well, on learning that young Dodd's aspirations for a life at sea were strongly opposed by his sister, recommended the lad to her cousin, the late President Eliot of Harvard University. Doctor Eliot added his power of dissuasion and, in addition, obtained for Dodd the post of assistant janitor in the Boylston Chemical Laboratory at the college in Cambridge. True to his character, the young man labored faithfully in his new surroundings from 1887 until 1892, and here his remarkable qualities, developing with the years, began to assert themselves. "He was by far the best janitor we had," wrote Professor C. L. Jackson many years later, "the only disadvantage being that he was so much too good for the place that we knew we must lose him soon, as proved to be the case. . . ." "As janitor," explains John Macy, "he had not only to clean and sweep, but also to prepare the materials for the students' experiments. Thus he came in contact with the subject of chemistry. He asked permission to do the experiments himself, and the instructors encouraged this because they liked him and also because the opportunity to study was what kept him in a position for which he was too good. . . ." As time passed, the inevitable happened, and as Dodd took leave of the realms of chemistry as a pure science, for fields of practical application, he was thus "recommended" by Professor H. B. Hill: While he was in our laboratory, Mr. Walter J. Dodd attended regularly the lectures given in general chemistry and performed all the experiments required of our students. Upon that course he passed no examinations, but in the following year he took my own course in Qualitative Analysis. His experimental work was unusually good and he also passed with credit the two written examinations of the course. I think that he profited more from the instruction in the two courses than most of our matriculated students.

Dodd was appointed Assistant Apothecary at the Massachusetts General Hospital in 1892. "For the next two years,"

his biographer Macy records, "he continued his studies in chemistry; he passed the State examination and became a registered pharmacist. In the autumn of 1894 he was appointed Chief Apothecary of the hospital. He was an excellent chemist and he came into touch with Medicine long before the x-ray was heard of and longer still before he became a physician. . . ."

The moment of the discovery of the roentgen-rays, in late 1895, found Dodd not only most skilfully filling this highly responsible position, but the additional post of official photographer, as well. As in the instance of many others who became eminent radiologists, the practice of photography seems to have been the stepping-stone to his ultimate and more distinguished station. Unlike many others, however, Dodd, in the course of his development, distributed his allegiance between the two and for a considerable time his versatility was manifested in the excellence of his photographic work and by the remarkable skill of his radiologic practice.

Walter Dodd received the announcement from Würzburg and the subsequent *Communications* of Professor Röntgen with characteristic enthusiasm, and immediately applied himself to the pursuit of investigations based on the reports therein contained. His first experimental work was carried out in a small room of the department for nervous diseases in the old out-patients building of the hospital, where a small two-plate static-machine, commonly used for therapeutic purposes, furnished the means of activating his diminutive Crookes tube. The first tube he acquired was a disappointment and Dodd, possibly attracted by McNeil's description, in the *Scientific American*,² of a source of x-light created by connecting the (then) carbon filaments of an incandescent lamp bulb to one pole of an influence-machine or other high-voltage apparatus, with the other pole connected

² McNeil, R., *Scientific American*, 75: 27, 1896.

to a sheet of aluminum foil attached to the external surface of the lamp. At all events, he and his assistant Godsoe³ constructed a tube, perhaps of this type. Their almost negative results were not due to any constructional failure, as previous biographical account might intimate; all historians⁴ are agreed that this device was "a very primitive substitute for roentgen tubes." The results of Dodd and Godsoe were probably as good as any obtained elsewhere, and whatever the results, they were certainly worth the trial. After this experience another tube was purchased, and with it, under excitation of the small static-machine, the first successful radiographic exposure at the Massachusetts General Hospital was made. On account of the normal use of the static-machine by day in the work of the Nerve Department and their own diurnal duties about the hospital, much of this experimentation of Dodd and Godsoe had to be conducted at night. Here, without doubt, was laid the foundation of the radiation-dermatitis of both of them, notwithstanding the theory of Frei⁵ relative to influence-machines, which has been already referred to.

Before the year 1896 was far advanced, the Massachusetts General Hospital was offered by Professor Herman Lemp of the General Electric Company the use of a twelve-inch induction coil which he had constructed for experimental work. With the acquisition of this apparatus there began an intensive period of experimentation and practical accomplishment for Walter Dodd and his associate. They continued to work even more diligently during the night hours. By means of the new coil-apparatus and accessory equipment of their own construction, they were soon able to produce a most creditable radiograph of the adult thorax. "This plate," ob-

³ Mr. Joseph Godsoe, now Pharmacist-in-chief, Massachusetts General Hospital.

⁴ Vide Glasser (*op. cit.* p. 5) p. 323.

⁵ Vide biography of Dr. Louis A. Weigel, p. 56.

serves Dr. G. W. Holmes, "is probably one of the earliest satisfactory plates of the chest ever taken." This experimental work, with interrupters that demanded high amperages of the hospital current-supply, so increased the load on the conductors that the apparatus was considered unsafe by the hospital authorities. In obviation of this danger it was decreed that the work should be abandoned.

Such an obstruction as this in the path of his progress was no hindrance to a man of Dodd's calibre. Beneath his bland and gentle exterior he possessed keen discernment and foresight. Through his earnest effort, the borrowed induction-coil with its accessory apparatus was allowed to remain in place until after the exercises attending the observance, at the hospital in October, 1896, of the fiftieth anniversary of the first use of ether as an anaesthetic. On this occasion the equipment used and the results obtained by Dodd and Godsoe were publicly exhibited. The magnitude of the marvel created such an impression⁶ that the sum sufficient for the purchase of the apparatus was promptly forthcoming, and it was forthwith installed within a small chamber under the old "Bulfinch Steps" of the Massachusetts General Hospital, quarters strongly reminiscent of Charles Lester Leonard's x-ray cubicle under the amphitheatre seats of the University Hospital in Philadelphia. In such surroundings was an infant science nurtured and reared for its great service to humankind.

This intensive work of Dodd's during the first years of the roentgen-rays, to the mass of which the night hours had

⁶ The author will, perhaps, be pardoned a reference to his emotions on that memorable October sixteenth, 1896, when, as a first-year medical student, he was allowed to peer around the shoulders of his elders and betters at these wonders. In addition, the original ether apparatus of Dr. W. T. G. Morton had been shown and Dr. Weir Mitchell had read his splendid poem—in all, a great day for a very minor undergraduate who, unwittingly, was gazing from the remote past in surgery to its far future by a mere turn of the head.

freely contributed, had a prompt and distinct physical effect on him. As early as November of 1896 his first severe dermatitis took place. The acuteness of this initial inflammation was a definite characteristic of his case, as it was in that of Eugene Caldwell, and as prompt to appear. Walter Dodd's

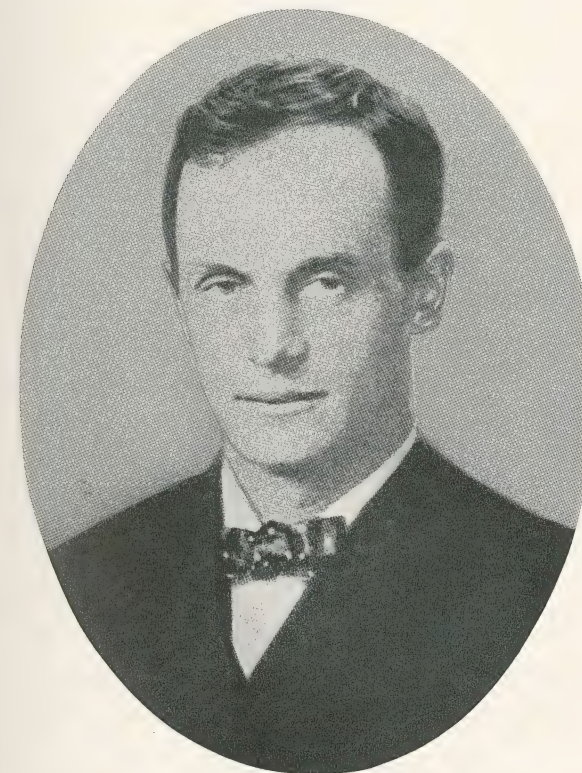


FIG. 35—Walter Dodd as a young man

first attack subsided under local medication, but during the succeeding spring (1897) it was followed by a most severe general dermatitis involving the face as well as the hands. The pain of this was beyond description.

"Dodd himself did not suspect the gravity of his injuries," writes John Macy. "... Though he endured untellable torments, he made light of his sufferings. The burns would get

well. It may be that he really thought his injuries were superficial and temporary; or it may be that he was practising a little self-deception—it was the only deception that he ever practised—for in spite of his courageous candor in facing facts, he never lost a slightly superstitious optimism about himself. And he was confirmed in his faith that things would come out all right by the number of times that he recovered when by all the rules a weaker man would have succumbed. Whether reckless or innocently unaware of the risks he was running, he certainly did not spare himself. As soon as pain abated and he could use his hands, he was back . . . with his precious machine. Mr. Godsoe recalls that as a matter of course before they went to bed they washed their hands in zinc oxide solution and wrapped them up in cloths. Often when pain made sleep impossible, Dodd would walk the floor of the pharmacy all night with his hand above his head."

This glimpse is perhaps enough to reveal the degree, in terms of pain, of Dodd's initial injuries, but no description can portray adequately the dominance of his spirit over his physical distress. A widespread disregard of such dominance of the spirit in the martyrs to science through the roentgen-rays has resulted in a misinterpretation of the demeanor-influence which brought about their plight. By no means was it recklessness, nor could it have been innocent unawareness; no man sanely enters a new realm of science carelessly or with closed eyes and ears. Rather was it manifested as utter disdain for collateral issues in the complete fascination of their work.

In view of increasing pain from ulcerative areas, a skin-graft was done on one forefinger during the summer of 1897. This was soon followed by fourteen additional grafts applied at one operation. The marked pain at once subsided. It is said that Dodd himself suggested the trial of this mode of treatment, which was new at that day. Between this event

(August 1897) and 1902, there were seven other operations, under ether, of a similar nature. Most of these multiple grafts proved successful, but some areas became carcinomatous and in the autumn of 1902 Dodd's first two amputations were the necessary outcome. From October, 1902, to June, 1905, "a dozen or more operations, consisting of partial amputations and excisions of growing ulcerations and keratoses, were performed." In May of 1905, *for the first time in eight years*, this intrepid scientist was free from pain and no dressings were necessary. In the meantime, during these years of surgical ministrations to his body, what of his dominant spirit? This: in 1900 he entered the Harvard Medical School but, as Macy records, "he stayed only a year. His real work would not let him alone; he was so persistently sought for his knowledge of radiography that formal study was impossible. The only thing to do was to leave Boston . . . and find a retreat far enough away from the work that had been his life day and night. He went, accordingly, to the University of Vermont [Burlington] where he studied intermittently until 1908, when he received his degree in Medicine." And by just one year previous to this date he had had twenty-five operations under ether!

On Walter Dodd's return to Boston with his medical degree, he was appointed Roentgenologist to the Massachusetts General Hospital, an official verification and formal recognition of the post he had held in fact for so many years. He returned to his daily routine, to the human contacts of the hospital life that he loved so well, to those who, in every nook and corner of the great institution, loved him with equal warmth. Again one heard his cheerful "Hey!" in greeting from the pharmacy or along the corridors as he approached with his memorably characteristic gait. The skin of his face, like parchment now from the fibrillary contractions of old scars, was never too inelastic to break into a smile, whereat the dimmest corner of the old Bulfinch cor-

ridors would brighten synchronously. The aura of his personality preceded his moving figure with perfect demarcation and seemed reluctant to fade away behind it. His spoken voice and his outright laugh had a peculiar *timbre* that could be heard from afar and, as it reached one's ears of a morning, it would somehow set the day aright.

Doctor Dodd's resumption of his beneficent hospital work was but a continuation of his battle with an affliction that could not beat down his resolution. Followed years of study, experimentation and practical accomplishment, intensified and enriched by a courageous ardor that was never dulled, apparently, by an almost continuous sequence of surgical procedures to obliterate, by excision and skin-grafting, the ever threatening roentgen ulcer and its exquisite pain, indescribable even by one who has experienced it, or, by amputation, the frank evidence of epidermoid carcinoma.

By the spring of 1909, Dodd had been operated on *thirty-two* times under ether, but through all this "his energy, taxed by pain as well as by work, seemed inexhaustible and he was prodigal of time; as is sometimes the case with the few men who accomplish much, he never seemed to be in a hurry and was always at the service of any one, doctor or layman, who showed genuine interest in the work." So far above the level of his bodily distress soared his spirit that perhaps it is not too difficult to see how his last years were his happiest. Aside from his exceptional gifts of personality and character, Walter Dodd was thrice blessed and during these years he reaped the harvest of his triple blessings. He was blessed, first, in the possession of surgical care that was unremitting and stimulated by an almost brotherly love for him, which brought him periodical relief from his suffering; second, he was blessed in a happy marriage, six years before his death, that brought him peace and comfort which without question prolonged his life; third, he was blessed with a great group of such friends as have been awarded to but few

men. In their midst he exercised to the full a capacity for joy than which no one had greater.

His friends had long represented to Dodd the advantages of his entering the private practice of what is today known as roentgenology, which his medical degree in 1908 made possible. He was eminently successful in this; it widened the field for the exercise of those qualities which had so endeared him to all those associated with him in his hospital activity. By no means did he sever his older ties; he merely extended the scope of his beneficent and salutary offices. In 1909 he was appointed "Instructor in the use of the Roentgen Ray" in a Harvard Medical School department that had been tardily created and endowed with this extraordinary title in evident bewilderment as to nomenclature, although more concise appellations had already been adopted elsewhere. While this appointment was added evidence of his consistent progress along its path, it was by no means the crowning event of Walter Dodd's short career, which, when it came a few years later, was beautiful in its culmination of a life of integrity, devotion, persistence and, finally, of patriotism in the full measure of his British-born soul. The history is best told by his devoted friend:

In June, 1915, Dodd went to France as roentgenologist with the first Harvard Medical Unit [British Expeditionary Force]. He consulted his physicians as to whether he ought to go. They tried to dissuade him on several grounds: he was doing a useful work in Boston; surely he had earned the comforts of home; and he ought not to subject himself to hardships the severity of which could not be foreseen. These arguments did not interest Dodd in the least; they did not answer the question; and he had a quietly inflexible way of dismissing arguments that did not interest him. The question was simply whether he would be a care, a burden, to other members of the Unit. His disease might grow worse, he would have to be looked after a little, and that might put his friends, Dr. Lee and Dr. Porter, to some inconvenience. Would they be good enough to let him go? Would they consent to grant him what he called "this great favor"? He talked quietly and calmly about

the inevitable outcome of his malady and the chances of his lasting through the term of service of the Unit. Of course, there was only one answer to the question as he put it.

When it was finally decided that he was to go to France, he underwent a severe operation. The vehicle that took him from his house to the train for New York was an ambulance. The operation had left a deep wound, still unhealed, in his arm and breast. Strange figure of a physician on his way to the War to minister to others! He planned to convalesce during the voyage, and as it turned out he and his surgeon were justified in taking what they both called a gambler's chance. For again Dodd's amazing power of recovery asserted itself. . . .

When they finally arrived at the hospital camp in France, Dodd had one fixed idea, that no concession should be made to him on account of his infirmities. Everybody from the commanding officer to the orderlies would have done anything for his comfort, but he obstinately refused any special attentions. . . .

His apparatus was not the newest and best; it was an ordinary field outfit. He had two imperfectly trained helpers But he loved difficulty. He rejoiced in his imperfect equipment because it recalled to him the struggles of his early days and also because he wished to prove that good work in roentgenology can be done under adverse circumstances. . . .

John Macy goes on to say that Dodd returned to Boston in the autumn of 1915 and that his general condition seemed better than it had been for years. In 1916, seeming very well, he was filled with plans for establishing a new office with greatly increased laboratory quarters for him and his associates, but "during the summer he grew worse. . . . A sudden infection . . . developed and . . . the epitrochlear and axillary glands quickly enlarged. He lost weight and had continuous fever." Macy continues that in spite of his grave illness, this valiant man continued with his preparations to the final limit of his great strength and greater fortitude. This "roentgen saint," as he has been called,⁷ died Decem-

⁷ Evans, W. A., "American Pioneers in Radiology," *The Science of Radiology*, p. 33.

ber 18, 1916, of pulmonary carcinomatous metastasis, after over fifty operations under ether!

" . . . Such, briefly, were the events in a life of singular beauty—the life of a gentleman, loving and beloved; cheerful beyond conception in the face of physical anguish. Glorified by a martyr's soul, his face turned toward the horizon of high purpose with an obliteration of self that cheapened and made tawdry the usual motives of ordinary men. He journeyed steadily toward that horizon, turning into the gold of loyal friendship all those who came within the Midas-touch of his personality.

"A life such as his gives charity a new meaning."⁸

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⁸ Brown, P., *Amer. Jour. of Roentgenology*, 4: 629, 1917.

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STEPHEN CLIFTON GLIDDEN

1870—1917

THE YOUNG surgeon of today sets forth on the journey of his career with the assurance that his most dependable diagnostic ally, the roentgen-rays, is in the hands of a group of well-qualified special workers, each of whom is ready to share the burden of his problems. A day there was when the field of diagnostic usefulness for the x-rays was so much more narrowly circumscribed that their use was an affair of no greater complexity than is that of the sphygmomanometer at the present time. Thirty-five years ago, therefore, it was not unusual for the younger surgical practitioners, especially, to interest themselves seriously in the matter of their personal use of the roentgen-rays as an adjunct to their daily work. Stephen Glidden was one of these, a young surgeon of exceptional gifts and of excellent training, already five years in practice when, in 1900, he commenced to experiment practically with the "new science" that had been discovered but a year after his graduation in Medicine.

Glidden was a young man of unusual promise and his progress had been consistent. A son of Stephen Smith Glidden, an iron smelter operator, he was born February 6, 1870, at Kingston, Tennessee. It was a large family and while the boy was yet small his father removed to Saint Paul, Minnesota—a longish journey but not unusual during the years of unrest that followed the close of the Civil War. After the period of his primary training in the graded schools of Saint Paul, young Glidden was sent to the Shattuck Military Academy at Fairbault, at which his continued training resulted in a fine physique and an erect military carriage. Good fortune in educational advantages still attended him,

for his preparation for college was acquired at Phillips Exeter Academy in New Hampshire, from which he entered the University of Michigan. Glidden was an exceptional student, especially in his work for the medical degree, which he received in 1894. His brilliance and ingenuity during these years attracted the attention of Professor DeNancrede, who made him a "student assistant" in Surgery. Later, Glidden



FIG. 36—Stephen C. Glidden

became laboratory assistant to Dean Vaughan in his research in toxicology, notably in the study of the protein poisons. His work with Doctor Vaughan was completed during the year after his graduation, and it was followed by his marriage in 1895. With his life-work in mind, the young pair went to Chicago, remaining there but a few months; they removed finally to Danville, Illinois.

In Danville, Doctor Glidden became associated with Dr. Rufus Gillette in the practice of surgery for five years, when he established his own office. His work with x-rays began,

as has been said, about 1900. With much enthusiasm he experimented, first with a static-machine and afterward with an induction-coil and mercury interrupter. Like many a pioneer, he "developed" his own radiographs. By some historical chroniclers it has been asserted that the effect of photographic chemicals upon the skin of hands and fingers, in the process of "development," was the primary cause of the dermatitis of many roentgen workers. Many facts tend to disprove this, one being that, among the pioneers, the left hand was the one preponderantly affected. Among right-handed individuals, the cause of this was the testing of x-emanation by fluoroscope, almost without exception. The right hand would have suffered primarily had the irritation been due to the effect of chemicals. Again, in radiation-dermatitis the palmar aspect of the hand is rarely affected; chemical irritation, however, might easily involve the palms as well as the backs. There were, indeed, as there are now, individuals whose skins were particularly susceptible to this chemical effect, especially that of the reducing agent metol, but such cases were in very small proportion to the almost universal lack of immunity to some degree of radiation-reaction, under the appropriate exposure-factors of time and intensity. It is certain that the incidence and course of Glidden's affliction furnish no grounds for an assumption that the severity of his initial skin lesions was enhanced by irritation from extrinsic chemical sources. On the contrary, there can be but little doubt that the existence of a personal idiosyncrasy, which, by the way, is still denied by a few students of radiation-disease of the skin, heightened the degree of his first roentgen dermatitis and lowered his resistance to succeeding exposure. In fact, as writes his former colleague and close friend:¹ "Glidden was large, with fair, clear skin of a type not as completely differentiated from embryonic

¹ Dr. E. G. C. Williams, *Personal communication*.

structures as most of us and therefore more susceptible to the action of the x-ray."

Stephen Glidden's early and repeated x-ray injuries to the skin of his left hand set up, through cumulative action, a chronic dermatitis, with ulcerations of the terminal phalanges of the first and third fingers especially. These phalanges were amputated. The remaining ulcerations as well as the amputated fingers showed a tendency to heal and subside until the year 1907, when there developed a typical epithelioma on the remains of the left index finger and numerous keratoses distributed elsewhere over the dorsum. This digit was now removed *in toto* and pathological examination determined the process to be definitely carcinomatous. The keratoses were excised and skin-grafted; although the region was dissected, no axillary glands were found to be involved at that time. Later, however, areas of local degeneration again appeared, with definite tendency to metastatic extension. Doctor Glidden made repeated visits to the surgical clinics of Baltimore, Chicago and Rochester, but over-conservatism seemed to rule his treatment until 1914, when the forearm was amputated and glands removed from the axilla. On this occasion a suggestion from a pathological source favored an amputation at the shoulder, but surgical opinion was against this procedure until July, 1915, when it was accomplished.

Glidden's contributions to the scientific literature were made, perforce, between the years 1909 and 1915. They were entirely surgical in character, the majority of them dealing with the practical matters of operative surgical technic which naturally appealed to a mechanical mind such as his. For fifteen years he pursued his surgery and his radiological work together, but by 1915 his disability had increased so that further practice of surgery was impossible. In the meantime his record as an indefatigable, courageous roentgen-worker had been indelibly established.

The loss of his arm did not in any way dismay this intrepid man. In 1916, in spite of his malady and the general poor health it engendered, and with the same zeal he had shown concerning x-rays years before, he purchased radium and started to avail himself of all published data relating to its clinical application. His health, however, failed rapidly during the closing months of that year, and he was forced into retirement by reason of the inexorable development of pulmonary metastasis.

"His last ten years," writes his friend of a lifetime, "are inseparably connected in mind with the character of *The Music Master* as played by David Warfield. He was calm, pleasant, smiling and always apparently . . . happy in spite of an unbroken succession of disappointments and losses. Some of his personal disappointments would have crushed a smaller soul."

Doctor Glidden died on the twentieth of February, 1917. In the course of that day, this same good friend met Professor Novy of the University of Michigan in a corridor of the Medical Building. "I hear that Steve Glidden is dead," remarked the professor, "and that you are preparing to do x-ray work. Why not go into something safe and sane, like aviation or the submarine service?"

But dedicated to peace was the generous service undertaken, to the utmost of his powers, by Stephen Glidden in the cause of Humankind. Of such is the Glory . . .

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EUGENE WILSON CALDWELL

1870—1918

THE PROGRESS of the science of diagnostic radiology over the course of more than twenty years found its ideal personification in Eugene W. Caldwell. Electrical engineer and physician, he devoted the majority of these productive years to its legitimate development, and by means of his sound training as a physicist he steadily promoted its adaptation to the requirements of medical diagnosis.

Caldwell was a Missourian. Born in the small community of Savannah on the third day of December, 1870, there he passed his earliest boyhood. His parents were William and Camilla (Kellogg) Caldwell who, soon after his graduation from the local high school, removed to the larger town of Concordia, Kansas. Young Caldwell was a boy of notable intelligence, with an early predilection for things mechanical, rather to the exclusion of the common sports of youth. Moreover, aside from this innate bent, his formative period had been contemporaneous with the pioneer developments of the so-called electrical age—the electric telegraph had been made practical, the first Atlantic cable long laid, and the telephone and electric light were in restless process of evolution. It was natural that such a youth should choose science as his life's work, with electrical engineering as his dominating ambition. At seventeen, Caldwell entered the University of Kansas at Lawrence.

During his first year in college, his aptitude arrested the attention of his instructors in science, especially that of Professor Lucien I. Blake of the department of physics, who was deeply interested at that time in the problem of submarine

telephonic signalling. Blake suggested to his young student that he accompany him, during the vacation months, to the Eastern seaboard and assist him in his series of experiments off-shore. Charmed by the prospect of this opportunity, Caldwell eagerly accepted the offer and forthwith there



FIG. 37—Eugene W. Caldwell

sprang up a close and lasting friendship between the two. In later years Caldwell frequently recalled with satisfaction this early association and its value to him.

The expeditions to the seacoast with Professor Blake, first undertaken during Caldwell's undergraduate days, doubtless shaped the course of his later life. Experiments were first

conducted off the southeastern New England coast, with headquarters at Taunton, Massachusetts. They were continued throughout a portion of the summer months of each year even after Caldwell's graduation from the University in 1892, but from then on it became necessary for him to com-

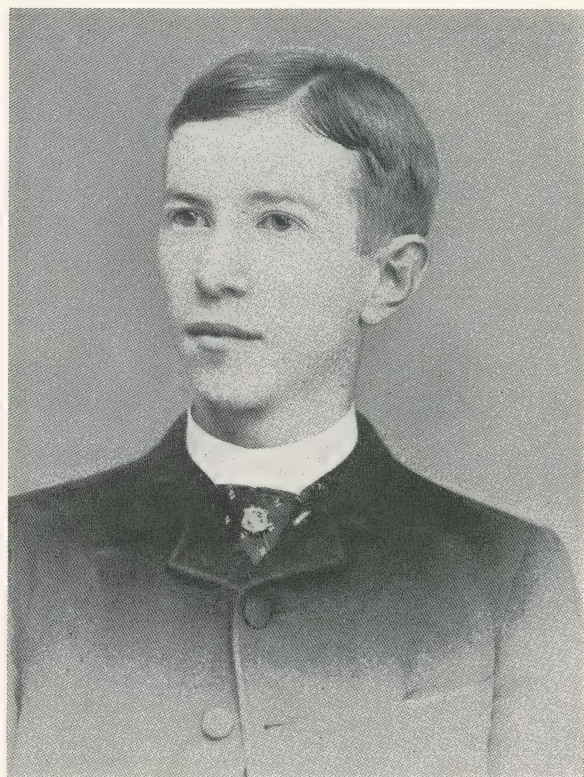


FIG. 38—Caldwell as a student assistant in the Department of Physics, University of Kansas.

bine them, whenever possible, with efforts to seek a remunerative position in electrical engineering. With this end in view he thought it best, after the work on the submarine telephone was over for the summer of 1892, to remain East to look for work, while Blake returned to Lawrence, Kansas, to resume his teaching at the University. Evidently through

Blake's influence, he was offered a position at the (then) Bell Telephone Laboratory in Boston. Apparently, he was unimpressed with its promise. Whatever disappointment he may have felt was soon dispelled, as shown by a letter he writes from Baltimore in early September:¹

I started from Boston yesterday to come home, and had bought a ticket to Kansas City *via* the Fall River Line to New York. At New York I had about six hours to wait for my train and spent the time looking around. I happened to go into the office of the J. G. White Company, contractors for electric railways, and there found a letter just ready to be mailed to me, offering me a position here in Baltimore. Another fortunate circumstance was that my ticket to Kansas City happened to be *via* Baltimore, so I didn't have to recheck my baggage. I have just arrived tonight and don't know what my work will be except that it will be installing an electric railway. . . .

This was the first formal professional engagement for the young engineer. Whatever bearing on his immediate future that chance pause in New York may have had, we may properly consider it as the critical event that turned Caldwell toward the arena of a life-work in which he was to become ultimately one of the world's chief figures. His first "job" in Baltimore was, as he anticipated, the construction of an electric railway line from the city to Fort McHenry, but it was not so much his work as his impressions of life in a city, that formed the theme of his letters at this time. "For comfort and culture," he writes, "a large city is the place to live. I would like to go to New York for a year or two and may have a chance to do this some time." The hope that may have been latent in these words was not directly to be fulfilled. His construction work in Baltimore finished, another opportunity came to young Caldwell in the post of assistant superintendent of the National Iron Works, a foundry engaged in the manufacture of industrial containers such as transformer tanks, gas tanks and the like, at

¹ E.W.C. to W.W.C. 8 September, 1892.

Linwood, Pennsylvania, on the Delaware River not far from the city of Chester. This work was not in direct line with his specific training as an electrical engineer; in reality he was sent to Linwood to look after the interests in the iron works of Mr. White, his employer in Baltimore. There is reason to believe, from his letters, that Caldwell chafed under the spell of relative inactivity in uncongenial occupation and consequently that occasional tentative messages from his friend and old mentor, Professor Blake, relative to experimental work for the summer to follow, were as music in his ears, as is indicated by the words of a letter in February, 1893: "I would like to go right now. This place is wearing on me. I don't have enough to do to keep me awake, and that makes me feel as though I were wasting my time. . . ."

In early July came the welcome call in the form of a telegram suggesting that he meet Professor Blake at Taunton, Massachusetts, in preparation for work at Wood's Hole. The next day found Caldwell in New York *en route* to Taunton. Of these experiments at Wood's Hole and its vicinity that brought such elation to his thoroughly scientific mind, Caldwell writes the following month:²

. . . Our experiments are going slowly. We laid a mile of cable yesterday and will have a lightship taken out and connected with it tomorrow or Tuesday. We shall probably know by the end of the week whether we can accomplish what we are after, if we have no bad luck in splicing our cable Yesterday we received a letter from the patent lawyers saying that Blake's application for patent on the other invention [in submarine signalling] would be granted. Blake says that a company will probably be formed at once to develop the thing and that, in that case, I will be made electrician of the company I would like ever so much to see the engineering exhibits at the World's Fair³ in September, but don't see how I can arrange it now. . . ."

His chance to visit Chicago came unexpectedly, for appar-

² E.W.C. to C.K.C. 6 August, 1893.

³ World's Columbian Exposition, Chicago, 1893.

ently he returned that autumn to Lawrence (Kansas) with Professor Blake and went to work at the University on the details of instruments to be used in telephoning to lightships and making plans for equipping Pollock Rip (Massachusetts) Lightship for the Government the summer to follow. On his journey West he was enabled to "take a hurried look," as he says, at the Fair.

Young Caldwell remained at Lawrence that winter (1893-94). He was engaged "off and on" in the Engineering Department, at work over the draughting-table on designs for the contemplated signalling apparatus, but there was time for a Christmas vacation trip with the University Musical Clubs, by way of reviving modest pleasures of undergraduate days. During the winter he had written from Lawrence that there was "every possibility" that the work on which he was engaged with Blake would be taken over by the United States Lighthouse Establishment. This came to pass the next summer (1894). Early July found Caldwell back at Taunton and in temporary charge of the experimental work, as Blake was not to arrive from Kansas until later in the season. Caldwell's sojourn at "headquarters" at Taunton was destined to be brief, as it had been arranged that his work for that summer was to be centered at Tompkinsville on Staten Island in New York Harbor. He was now twenty-five. He seems to have had complete charge of the preparatory work in submarine signalling of that summer for the Lighthouse Establishment, which consisted largely, as he writes, of draughting and detail-planning of apparatus. This work and its various ramifications evidently kept Caldwell in New York during the winter of 1894-95. Professor Blake had received funds for the erection of a new Engineering building at the University of Kansas, and the plans of this construction confined him to Lawrence. Caldwell outlines briefly the nature of his investigations at his latest station:⁴

⁴ E.W.C. to C.K.C. 14 April, 1895.

Blake went to Lawrence nearly a month ago [March, 1895] and I am taking charge of the work myself—that is, I am inventing the “calling-up” apparatus and having it made. It is a very difficult problem. If I succeed, it will be much to my credit, but if I fail I shall feel very “blue” indeed. The telephone to the lightship [anchored off Tompkinsville] continues to work satisfactorily and if it holds up a few months longer we shall probably begin to get a little money out of the invention. . . . I am designing instruments and making working drawings for them. Then when the drawings are made, I take them to the shop and have the machine-work done. When the instruments are finished I take them to my laboratory and try them. When they don’t work well, I have to go through the whole thing again and rack my brain for something that will work. . . .

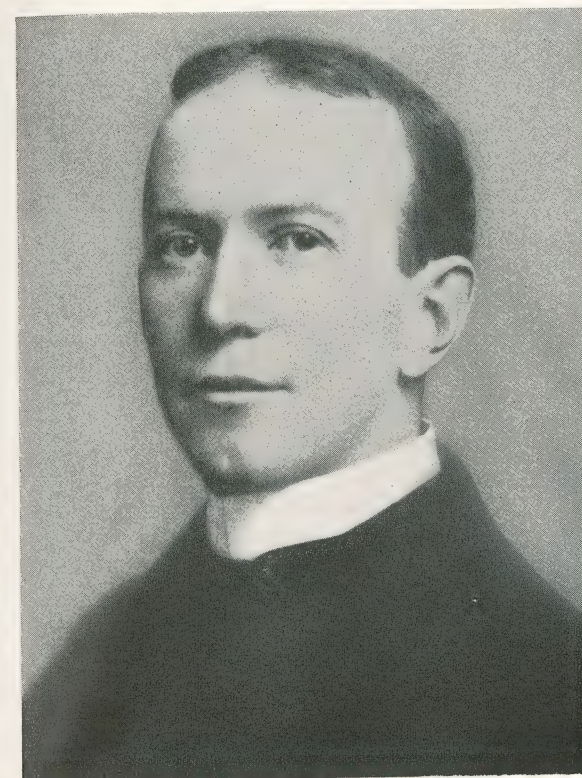
They evidently did “work” and it was not because of any shortcomings in his engineering efforts that Caldwell’s service with the Lighthouse Establishment came to an end that summer. From a letter of August:⁵

. . . I forgot to tell you that I finished my work for the Government on August first. I succeeded in ringing a bell on the lightship several days ago, but the appropriations for the Lighthouse Establishment have been reduced so much that they cannot afford to equip the thing permanently just now, so there is nothing for me to do. . . . Blake wants me to go West with him in the fall and perfect a new invention . . . and the increased facilities for work at the University make it attractive to me. However, I think I would rather get something permanent here in the East—in New York, if possible. . . .

Here again, a prescient Fate must have had in mind the superlative usefulness of his ultimate career. The desire expressed in this letter was soon to be fulfilled and he writes in October that he is in the employ of the “Metropolitan Telephone and Telegraph Company” which not long after became the New York Telephone Company. This was indeed a modest position, but with it there arose occasional oppor-

⁵ E.W.C. to C.K.C. 4 August, 1895.

tunity for “outside” engineering work. At about this moment, too, came cause for rejoicing in his election to Sigma Xi, an honorary scientific society greatly to be desired. This was substantial recognition, and with it came a wider acquaintanceship among the scientists of New York that



N. Y. Electrical Review

FIG. 39—Caldwell when Construction Engineer of the New York Telephone Company.

served to lighten what were sombre days for at least one young engineer. Among these new friends was the editor of the *New York Electrical Review*, who had been seriously attracted by the quality of Caldwell’s work in submarine telephony. From him came a request for a series of articles

on telephonic subjects. The first of these articles appeared in late 1895.⁶

At this point in Caldwell's early career, when discouragement might well have made him vulnerable, arose an incident that momentarily threatened the salutary influence that was holding his life-course true to the compass-needle of his destiny. He writes of the unbounded enthusiasm of "a former fellow-student, Fred Funston,"⁷ about to depart for Mexico to engage in the cultivation of coffee. The picture possessed the bright coloration so common to a subtropical atmosphere. To an adventurous spirit the temptation was strong and for an instant, Caldwell admits, the Achillean heel of his determination was exposed, but deep deliberation evidently assured its re-protection:⁸

... In regard to the climate of Mexico I know nothing from experience, but from what I have heard, I should prefer it to this climate ... there is about as much danger of getting fever there as here, and no more. I should not be afraid of it at all, and if I had not spent so much time studying electricity, I should rather go down there than do anything else I know about. ... I am having such a good chance to get started in the work here, and I feel like making the best of every opportunity ... The [telephone] business is growing wonderfully. We have had an increase in the number of subscribers of twenty-five percent last year in spite of hard times [!]. ...

By then (1896) the scientific world was in a ferment over the news of Professor Röntgen's discovery, that had appeared on its horizon in the closing days of the preceding year. Although Caldwell's mind had no doubt dwelt on it in common with every other physicist, no mention of it at this time is to be found in the available correspondence with his parents. In the spring of 1896 he is still busy with construction engineering affairs of the New York Telephone

⁶ Caldwell, E. W., "A Laboratory Telephone." *Electrical Review* (N. Y.) 27: 301, 1895.

⁷ The late Maj. Gen. Frederick Funston, U.S.A.

⁸ E.W.C. to C.K.C. 19 April, 1896.

Company and had resisted once again the call of coffee although, as he writes, he had "almost caught the fever!" The early months of 1897 represent a hiatus in the collected data of Doctor Caldwell's pre-medical life, but recalling that period in after years, he once commented on the rapid growth of his interest in the phenomena of x-radiation. Perhaps his early thoughts on the subject were potentially more serious than we realize, gathering weight to a point where the stimulus of opportunity gave impetus to sudden expression. At all events, he came in contact with a young man—a commercial photographer—who had had but indifferent success in exploiting the "new photography" as a popular diversion, which perhaps accounted for a sudden desire for greater wealth by way of the Klondike. Caldwell "bought out" this photographer, and the abruptness of the transaction is implied in his description of it:⁹

The night before the day I bought the x-ray man out, I was testing cable for the telephone company until about four oclock A.M. ... and closed the deal ... about seven oclock that [next] evening. I have made a very good bargain with the fellow, as he was ... anxious to sell. The machinery and apparatus I bought could not be replaced for less than four or five times what I paid for it. ...

The apparatus, which consisted of an oil-immersed coil, an Edison-G.E. x-ray tube, a hand fluoroscope and some accessories, did not prove to be such a "bargain" for, between the hour of its purchase and that at which Caldwell took possession, the coil had been burned out and the vendor was somewhat nearer the Klondike than he was at the moment the transaction was consummated! This disappointing experience served only to spur Caldwell on. The apparatus was temporarily repaired and a place found for its operation in a diminutive cubicle of a room in Fifty-Third Street, where Christmas of 1897 found Caldwell not much more than in possession. To arrange and prepare this meagre laboratory occupied him so intensely that he had no time to reflect

⁹ E.W.C. to C.K.C. 3 November, 1897.

upon his own solitude. Two days before Christmas he had written:¹⁰

... I have had to tinker and fuss with my machinery almost constantly to get it in first-class running order. This has not only kept me busy but has cost money. The machinery is now in good shape and after a little while I expect to have the very best outfit in the country. I am trying to get appointed consulting electrician [*sic*] to two or three hospitals. ... I am glad that I started out for myself. ...

As read the legend on his modest card, he was now prepared to do "x-ray work for physicians," and there is evidence to show that a moderate initial response was by no means lacking. In February, 1898, he speaks of "cases" that have been brought to his small office—old fractures with fragments in poor position and certain developmental deformities. But it was not enough to "make the mare go" and he was compelled to be on the alert for added opportunity. He reacted warmly, therefore, to the suggestion of combining his small establishment with that of the "electrical department" of a surgical implement manufacturer. Pleased with this arrangement, it was none the less his aim to maintain his "office" as a separate entity in the wareroom of the merchant, where he might derive the advantage of a closer contact with the surgeons who were constantly in and out of the establishment. "I [had] hoped," he writes at this juncture, "to make enough out of my present business to enable me to take the medical course at Columbia, but it now seems wise to give this up. ..."

Again, these were discouraging days for the young pioneer. Negotiations with the instrument-manufacturer had so far come to naught. The early spring air of 1898 was charged with pre-war hypertension. Discouragement and restlessness were hand in hand:¹¹

¹⁰ E.W.C. to C.K.C. 23 December, 1897.

¹¹ E.W.C. to C.K.C. 27 March, 1898.

I have been hanging on, trying to sell and at the same time trying unsuccessfully to get a decent position somewhere. I have also been trying to get some consulting and designing work to do, and have done a little in this line. ... I have invented a new electric buoy system which the Government officers are willing to try. I went down to Tompkinsville yesterday and had a talk with— and he seems anxious to put it in, but the Superintendent of Electrical Construction has a system of his own, and as his uncle is powerful in Washington, I am afraid I will not get a chance to try my scheme. If I could make the thing go, it would bring me some fame. ... Blake wants me to go with him for the summer on some experimental work, and I may do this but do not think it probable. I have written Commodore Schley and offered my services to the Government as Electrician in case of War. I may be ordered to Key West to look after signalling and torpedo circuits. ... I have thought of forming a small company for the manufacture and sale of some instruments of my design, but will not undertake this until Blake comes East. ... He is thinking about proposing to Secretary Long to do some sea-telephone work at Key West and the Dry Tortugas. If he does this I shall, of course, go with him. ...

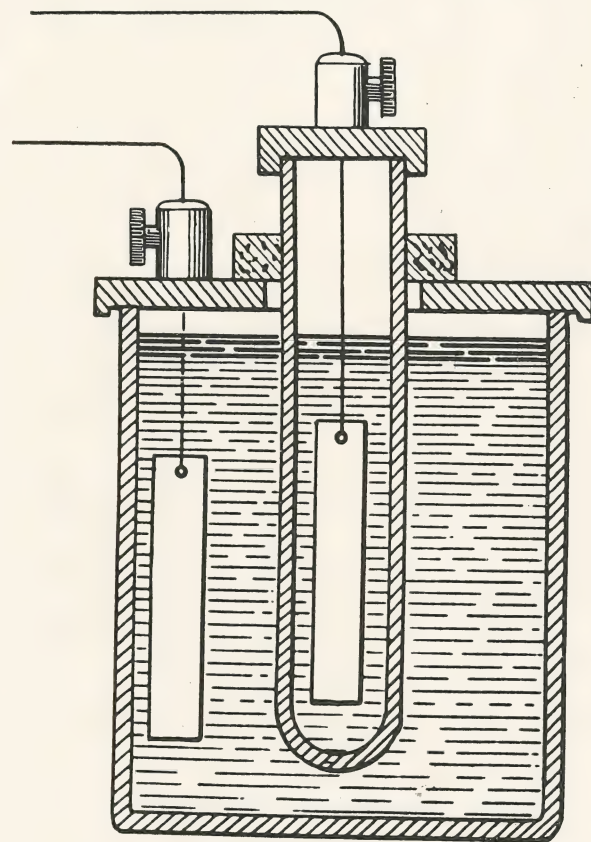
It was fortunate that none of these plans materialized and that, rather, Caldwell was re-stimulated for the furtherance of his great career. In June, 1918, he succeeded in making a satisfactory arrangement with Ford, the surgical instrument manufacturer, by which his desk and draughting-table were installed in a corner of the "store" at 315 Fifth Avenue. Occasional engineering work came to him in the shape of electrical water-pumping systems and the like. At the same time he was working hard on designs for x-ray apparatus, his devotion to which had never flagged and from which, as he writes, tangible results were now forthcoming:¹²

... My x-ray work is growing ... and I am getting quite a reputation for the work. A few weeks ago I took my "machinery" to a private house where there was no electric current. I went up to the electric cab company's station and had them fix up an electric cab so that I could run a wire from my machine in the house, out of a window, and connect with the battery in the electric cab at

¹² E.W.C. to C.K.C. 30 March, 1899.

the curb. This was considered quite a trick and the newspapers and medical journals had several articles about it, . . . but I kept my name back . . .

In lieu of the medical education that he desired so ardently but as yet had had no opportunity to acquire, the young



N. Y. Electrical Review

FIG. 40—Diagram of Caldwell's "liquid interrupter," with which he obtained the remarkably short exposures in radiography which characterized his early work with the induction coil.

engineer felt at this point the urgent necessity of at least a working knowledge of anatomy. Accordingly, arrangements

were made for a special course in dissection at the College of Physicians and Surgeons of Columbia University, to be taken five evenings a week. This laid upon him a heavy burden, as he could ill spare the time required for dissection and for study, but his vision was far-reaching enough to create an appreciation of the importance of anatomy to his work. In addition, he was deeply immersed in problems relating to the design and construction of electrical apparatus for use in the production and application of roentgen-rays. Important evidence of this appeared in May, 1899, when Caldwell completed the first of his major contributions to the science of radiology. This was a liquid interrupter¹³ (fig. 40) for "breaking" and "making" the primary circuit of an induction-coil, but in principle quite at variance with the former electrolytic interrupter of Wehnelt. Caldwell's device was not so susceptible to changes in the strength of the exciting current or to variations in the temperature of the electrolyte; therefore, it would remain in operation longer and admitted of wider ranges of adjustment of the exciting current. By one of those curious coincidences that are recorded on many a page of the history of invention, this type of interrupter was invented independently by Simon, of Berlin, and its description published by him at about the same time. Caldwell exhibited his device at the New York Electrical Exposition in May, 1899, and the engineering journals of the day, by their comment, indicate the intensity of the interest it created. Among Caldwell's former biographers it has been stated in error that this interrupter of his was a modification of the electrolytic form previously devised by Wehnelt, of Charlottenburg (Berlin), therefore it may be said here, by way of reiteration, that Caldwell's instrument, on the contrary, was based on quite another principle and in method of operation differed greatly from

¹³ Caldwell, E. W., "A New Liquid Interrupter." *Electrical Review* (N. Y.) 34: 277, 1899.

the Wehnelt device. In fact, "it is probable," wrote Caldwell in his original description, "that electrolytic action . . . is not at all essential to its operation, and that its action is entirely thermal."

It is doubtless known to the roentgenologist of a later day that the use of any form of liquid interruption, but especially that of Caldwell, to break the primary circuit of an induction coil, greatly increases its output at its secondary terminals, but perhaps it may not be realized to what an extent this increase could *decrease* the length of necessary exposure to a tube excited by such a discharge. Caldwell utilized this fact in conducting some memorable experiments¹⁴ with short exposures. Employing his liquid interrupter adjusted at thirty-four breaks per second, a fourteen-inch coil, a tungstate intensifying-screen and a tube especially made under the supervision of Mr. W. H. Meadowcroft at the Harrison Lamp Works (*vide* p. 34), he was able, by the aid of a clever timing-device, to obtain a clear radiograph with the x-emana- tion produced at a *single* discharge, or, as he writes,¹⁴ rather less than one five thousandth of a second!

During the ensuing December, Caldwell acquired a half-interest in the electrical department of Ford's instrument establishment, which was forthwith reorganized as the "W. F. Ford Electric Company." This combination seemed to prosper, and above all it gave him further facilities for designing and developing x-ray apparatus. His name had by now become well-known in connection with the evolution of radiology in medical diagnosis so far as it had then progressed. Although he had not yet been able to enter upon his course in medical school, he had already been asked to equip an x-ray laboratory (under the Gibbs Foundation) for the University and Bellevue Hospital Medical College and to operate it for a year. From now on his activities relative to the roentgen-rays increased rapidly, making serious inroads on the time he had to devote to the electrical instrument

¹⁴ Caldwell, E. W.: *Electrical Review* (N. Y.) 35: 49, 1899.

enterprise he still carried on with Ford. For this reason, he expressed a wish in early 1901 that he would like to dispose of his share in it. "There is every indication," he writes a few months later, "that I shall have plenty of x-ray work

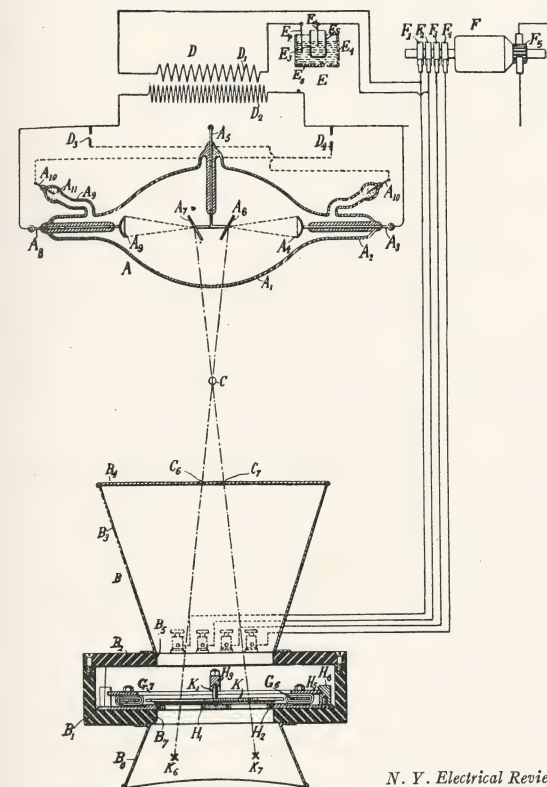


FIG. 41—Diagram of Caldwell's first (1901) stereofluoroscopic apparatus, using a bi-anodal tube.

to do this winter—more, in fact, than I want, for I want to get time to do some studying and some dissecting. I have written a story¹⁵ for the *Electrical Review* which is coming out November 9 [1901]."

¹⁵ Caldwell, E. W., "A New Method of Obtaining Stereoscopic Effects in the Fluoroscope." *Electrical Review* (N. Y.) 39: 601, 1901. The beauties of this remarkable device have been rather lost sight of in the brilliancy of his later instrument of 1918, employing two tubes of the Coolidge type.

The "story," of which Caldwell seems to speak so casually, actually appeared a week later, and was a detailed description, beautifully illustrated, of his first stereoscopic fluoroscope, employing a double-focus Crookes tube with the alternating bombardments on the targets synchronizing with the action of a shutter cutting off the vision of the opposite eye of the observer. The *Electrical Review* commented editorially on this apparatus as "one of the most ingeniously beautiful devices that has lately appeared. It will undoubtedly prove of high value in surgical diagnosis" (Fig. 41).

Caldwell's premedical years spent in his absorbing work at the Gibbs Laboratory undoubtedly augmented his long-cherished desire for medical school, and his choice of a school must have been influenced by the propinquity of his work, as the autumn of 1902 found him matriculated at the University and Bellevue Hospital Medical College, in course for the degree of Doctor of Medicine. His letters written at that period indicate his progress in every direction pertaining to his varied activity.¹⁶

... Now that the college has opened I am kept simply on the jump. The most difficult part of my medical school work will be finished this year, I hope; and I also hope to have the manuscript for the book I am writing with Dr. Pusey ready to go to press by February 1 My new x-ray tube for cancer treatments has created quite a stir, and it is impossible to get this made fast enough to supply the demand. Unfortunately my medical college connection makes it unwise for me to receive any profit from the sale of them. . . .

The book¹⁷ to which this letter refers appeared in its first edition in 1903 and in its second, definitely enlarged, in 1904. The section on Diagnosis, the smaller of its two parts, was written by Caldwell. The volume has been historically re-

¹⁶ E.W.C. to C.K.C. 6 October, 1902.

¹⁷ Pusey and Caldwell, "The Practical Application of the Röntgen Rays in Therapeutics and Diagnosis." Philadelphia, Saunders, 1903 and 1904.

viewed in recent years with these words: "... One may surmise that the publisher picked the two best men in America to do exactly what they did—produce a best-seller with merit based upon technical knowledge, sagacious observation and extensive experience. . . ." The book is rightly judged to be one of "the three most valuable books by American authors during the first decade of Roentgenology."¹⁸

In 1903 Caldwell anticipated a step which his graduation in Medicine two years later would have made imperative—he severed his connection with the electro-surgical instrument enterprise that had been of fluctuating aid to him during his late premedical years. Without the attention that he could not give it when once he had embarked upon the study of Medicine, it died peacefully.

Caldwell's degree in Medicine, given him in 1905, was a formal and hardly more than perfunctory burnishment of the already well-formed and brilliant crystal of his scientific career. However, the degree was most necessary to the dignity of his future position among his medical colleagues, and his own deep sense of its importance is indicated by the years he spent in toilsome progress along circuitous paths that finally converged on this goal. He attained his medical degree just *thirteen years* after his baccalaureate in Science.

Unleashed from the temporary bonds of pedagogy, Caldwell's mind leaped forward in freedom to attack new problems, and within a few months one of his most valuable contributions to roentgen-diagnosis was in process of evolution—a practical method of examining the accessory sinuses of the nose,¹⁹ which from then on bore his name. The means by

¹⁸ Skinner, E. H., "The Science of Radiology." Chap. 22, p. 380. Springfield (Ill.), Thomas, 1933.

¹⁹ Caldwell, E. W., "Skiagraphy of the Accessory Sinuses of the Nose." *Amer. Quar. Roentgenology*, Vol. 1, No. 2, p. 27, 1907.

which the application of this method was exhibited before the American Roentgen Ray Society in 1906 was typical of the fascinating originality of his manner of demonstration (Fig. 42). Almost at the same time appeared the instru-

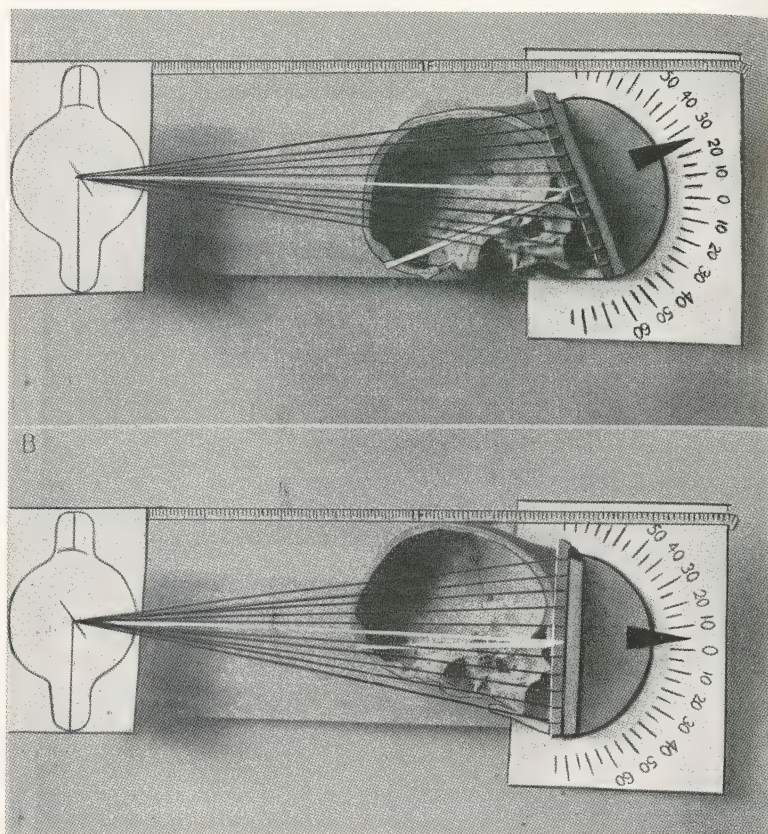


FIG. 42—Caldwell's memorable model which illustrated the principle of the "Caldwell position" in accessory sinus investigation. The lines representing the beam of x-rays from the tube-target were made of rubber, each thus maintaining the shortest distance between two points irrespective of the position of the plate with reference to the skull.

mental evidence of his remarkable adaptation to the uses of roentgenology of the time-honored Brewster or "refracting prism" principle in the production of stereoscopic vision.

The apparatus he devised to effect this²⁰ is one of the most beautiful of the many delicate mechanisms created of his mental fertility. In practical stereoscopy, however, the Brewster principle has been found to be more difficult of utilization by the casual observer; thus to little, if any, extent has it supplanted the now widely used Wheatstone method.

These two presentations to "the art," as Caldwell was wont modestly to designate his essentially scientific life-work, followed in chronological order other inventions, some of which have been already mentioned herein, such as his liquid interrupter, his form of focus-tube for therapeutic application of the roentgen-rays to the body-cavities, his osmotic regulator for gas-tubes and his vacuum valve tube. These preceded, however, other devices, hereinafter to be described, which in many respects transcended them for ingenuity of conception and beauty of action.

During the year preceding his degree in Medicine, Caldwell had found it necessary, by reason of increased pressure of practice, to remove his laboratory to a new location in Thirty-Fifth Street. Although the mere transfer was in itself quickly effected, the process of expansion and elaboration of his equipment seemed likely to be without end. In the late autumn, many weeks after a short visit to the radiological clinics of Europe, he writes: "I hoped to have my new office equipment complete by October first, but now it looks as if it would be nearly January before everything is ready. . . . When it is done we shall have a much better equipment than we could buy anywhere . . . certainly it will be better than any I have seen either in this country or abroad." Thus Caldwell continued to exercise his keen faculty of detecting imperfections in apparatus-design or technical methods in common use, and so to improve upon

²⁰ Described editorially in *Amer. Jour. Roentgenology*, 5: 547, 1918. No record of original paper found.

them in his own devices. He was ever impatient of the average products of apparatus-manufacturers and his annoyance ultimately moved him to establish a very practical machine-shop in connection with his office, with an expert mechanic to carry out his designs and suggestions.

At the University and Bellevue Hospital Medical College, where he had been for so long active in its Gibbs Laboratory, his practical diagnostic work was now combined with teaching. This additional routine work, making fresh encroachments on his time, already filled by many activities, he accepted in line of duty as a part of the clinical obligations that he had willingly assumed as a medical practitioner, but the quiet delights of scientific experimentation held paramount sway over his mental processes.

As time passed, Caldwell constantly added to his mass of technical equipment and to the elaboration of his methods, but he was powerless to increase cubic space which, even at the Thirty-Fifth Street establishment, was becoming manifestly inadequate. It was reported by the late Preston Hickey²¹ that Caldwell once said, with reference to his laboratory of 1906, that it seemed as if but two alternatives remained to him—to sleep on his fire-escape in fair weather or on his x-ray operating table when the night was foul! It became evident to him that another change of quarters was imperative. Immediately he returned to New York from the annual meeting of the American Roentgen Ray Society in the autumn of 1907, at which he had been elected its President, he once more removed to greater working space, this time in Park Avenue.

Even in biographical retrospection of the career of this remarkable man, the plenitude of his earlier works so en-

²¹ Hickey, P. M., "The Caldwell Lecture for 1928. *Amer. Jour. Roentgenology*, 25: 177, 1931. Herein may be found, as well, an excellent condensed description of many of Caldwell's instruments for the application and demonstration of the Roentgen rays in diagnosis and treatment.

gages the attention that it threatens to displace a realization of the subtle beginnings of the affliction that early became his constant handicap. Shortly after he commenced work with the roentgen-rays in 1897, Doctor Caldwell's attention was drawn to a process of cutaneous desquamation, followed by shallow ulceration, which appeared on the dorsum and on the backs of the knuckles of his left hand, as well as a development of telangiectasis on the left thigh and lower abdomen. Far from ignoring these manifestations and, as a constant reader of the engineering literature, in a position to note and heed the first warnings of the physicists, he adopted methods for his own protection as well as that of his patients. In his own case the parts so early affected continued to ulcerate by cumulative action until, in 1907, some of the lesions assumed an epitheliomatous character. A year or so before this, there appeared in the British radiological press²² an important exposition relative to the sources of direct, indirect and secondary roentgen-rays and also to a ray, or mass of rays, of marked skiagraphic value, that is to be derived only from the excitation of old tubes. Such a ray was designated as the "ray of selective absorption." This was a point in the realms of both pure and applied science which had an intense attraction for Caldwell. He spent much time in an attempt to work it out experimentally, and it was in the course of this investigation that he augmented the extent and degree of his radiation-dermatitis already established in 1897.

For the relief of his local pain, Caldwell had long tried all sorts of washes and ointments, as well as exposure to sunlight, to the light of the electric arc with and without screens, and to the so-called leucodescent light. To him, all these agents were harmful; the relief obtained from them

²² Cole, L. G., "Experimental research concerning direct, indirect and secondary skiagraphic rays." *Archives of the Roentgen Rays*, 9: no. 12, 275, 1905.

as reported in other cases he explained as due entirely to the heating effect, as the pain which prevented his sleep would often yield to treatment for fifteen or twenty minutes with an electric heating pad.

Caldwell sought surgical aid for these persistent and painful lesions in the late summer of 1907. On examination, the two areas found to be most suggestive of malignancy—one proved to be so by microscope—were at the base of the left index finger and in the cleft between it and the thumb. All areas were excised, the two suspicious ones more deeply, and thereafter skin-grafted. Every graft was successful except one—a most excellent result. Small keratoses subsequently forming at the margins of some of the grafts were afterward removed by the application of liquid air. The local pain that had for so long attended these skin lesions was relieved by the process of grafting.²³

In 1908, largely by reason of the increased pressure of his private practice but in part on account of the close attention to be paid to his physical condition, Doctor Caldwell relinquished his work at the University and Bellevue Hospital Medical College. He had been most fortunate in the type of support accorded him there through the generosity of the Gibbs family, dating from the foundation of the Edward N. Gibbs Memorial Laboratory in 1901. The facilities offered for his research and experimentation by this foundation had indeed been "rare opportunities," as Caldwell himself had appreciatively termed them. However, his position as "Director" had not been a formal hospital staff appointment, as were so few of the institutional posts occupied by the early radiologists even though holders of medical doctorates. Two years later, when Doctor Caldwell had been offered, and had accepted, the appointment of Visiting Physician

²³ The *minutiae* embodied in this paragraph were extracted largely from the report of the late Dr. Charles Allen Porter: *Trans. Amer. Roentgen Ray Soc.* for 1908, p. 126.

to the X-ray Department of the Presbyterian Hospital, the University and Bellevue Hospital Medical College, which he had served so long, perhaps finally realizing its loss, offered him the position of Consulting Radiologist. This he declined for the reasons that had compelled his prior resignation in 1908.

His new freedom from the cares of active institutional routine and the final centralization of his office practice under a commodious roof afforded Caldwell the occasion to direct his genius into broader channels. He was already recognized as the leading figure in a still new but speedily developing field of American medical practice and his advice and opinion were repeatedly sought in matters pertaining to it. Having deeply at heart the proper development of the new specialty and jealous of its good name, he sought every chance to eradicate misconception as to its status. In common with all medical pioneers in radiology, he deemed it his duty to strive constantly to elevate diagnostic roentgenology, especially, from its original anomalous position as a quasi-photographic pastime with a low commercial complexion to the dignity of a recognized branch of medical practice. To this end, one of his first steps was to clarify its terminology by establishing the definition of the radiograph, that medium upon which the roentgen-rays set their delicate and complex imprint. By likening the function and purpose of the radiograph to that of the microscopical slide of the pathologist, Caldwell and many others like him have made the best of definitive comparisons. Before the New York State Medical Society Caldwell said in 1909:²⁴

The Roentgenologist of today practises one of the most difficult, dangerous and unremunerative of medical specialties, but the stigma of the bell-hanger's x-ray picture-shop still clings to him. Strangely enough, although there are few if any legal restrictions,

²⁴ Caldwell, E. W., "A Brief Review of the Application of Roentgen Rays in Diagnosis." *New York State Jour. Medicine*, 9: 362, 1909.

the practice [of roentgenology] . . . by those without medical training has almost died out, except in some of the hospitals in our largest and least progressive American cities.

The almost irradicable impression that the radiograph is a picture or photograph which anyone can properly examine, interpret and criticize, has been a great hindrance to the progress of roentgenology and to its proper recognition. The radiograph is in fact not a picture or even a photograph except in the sense that photographic materials are used in its production. It is a special kind of projection and is essentially more like a slide for the microscope than a photographic view. Unfortunately, it may so much resemble a photograph that laymen and medical men alike are apt to regard it as a *view* and not suspect how incomplete and even how dangerous their overconfident interpretations of it may be. . . .

Caldwell realized also that the future of his specialty in Medicine was most distinctly dependent on the spirit of temperance and conservatism in which it was practised. During the first five years or so of his radiologic experience he had seen the effects of a diagnostic fanaticism that was rekindled with the birth of each succeeding phase of the work. He attacked relentlessly this flamboyance in radiographic interpretation and many of his scientific papers bearing on diagnosis contain some satirical reference to it, quite visible beneath a merely cellophanic encasement of humor. The late Dr. Preston Hickey, a biographer of Caldwell as well as a close friend, has quoted²⁵ one or two of these literary sallies to illustrate this altogether effective way of fortifying the structural chain of radiology by strengthening its weakest link. On the other hand, Caldwell's appraisal of strength was equally discerning. "No one . . . could have been more keenly sensitive than he to all important steps in the forward progress of . . . diagnostic roentgenology. The prophetic vision that seemed to guide to fruition his undertakings in the technics of this subject likewise enabled him to evaluate with unerring acumen the accomplishments of his con-

²⁵ Hickey, P. M., *loc. cit.* p. 180.

temporaries in their bearing on the future development of radiology in general."

Doctor Caldwell's name and the extreme accuracy which attended all his works became publicly conspicuous during the summer of 1910, when his services were required in the case of the Mayor of New York City, who had been feloniously assaulted with a firearm. Caldwell's diagnosis as to the position of the missile, lying as it did within the lower jaw, having passed among anatomical structures of the greatest importance, directly influenced a surgical decision as to the management of the case. It was yet another instance, frequent enough throughout the course of his career, where his precise, almost meticulous, methods showed to fullest advantage. It irritated him, therefore, that many public reports of this case were so far wide of scientific truth and accuracy. After his brilliant localization of the foreign body had been made, he took occasion to write, with especial and trenchant reference to the not infrequent superficialities of press reportorial effort:²⁶

My work . . . has been entirely successful and satisfactory to everyone but the newspaper reporters, who resent not being allowed to see the plates or to have them for publication. The surgeons in the case, with whom I was in consultation, congratulated me on the success of my work. The wild rumors are not official and not true. Remembering the [President] McKinley case, the reporters have no confidence in the surgeons' statements and print everything they imagine. . . . No other examinations then mine have been made. . . . Two were necessary for complete localization of the bullet. The first was a "preliminary survey" covering [the] entire trunk as well as [the] neck. The condition of the Mayor was such that it seemed not advisable to make more plates at that time. Three of the first six plates showed the bullet. The "split bullet" story was given out before the plates were dry and was not official.

Very little is recorded in the matter of Caldwell's interest

²⁶ E.W.C. to W.W.C. 16 August, 1910.

in cinematographic roentgenology, which is perhaps a reason why it may be mentioned here. It is known among his friends of an earlier day that he had been much attracted by the possibilities for further research in the report of John Macintyre's remarkable demonstration of 1897, whereat were portrayed, in simple motion and by projection, the "shadows" of the knee-joint of the frog. A vivid description of this epochal incident has been given²⁷ in recent years and Caldwell mentioned it formerly in his occasional moods of prospective calculation on the subject of roentgen-cinematography: Ten years after the Macintyre demonstration, there was shown before the American Roentgen Ray Society a synthesized motion film, from Köhler's laboratory at Wiesbaden, of the movements of the thorax in respiration. Caldwell noted the imperfections obvious in this remarkable pioneer effort, and, recalling to mind the early attempts of Mount Bleyer and others²⁸ to *photograph* the revelations of the fluorescent screen, he was moved to test the possibilities in this procedure (albeit the "indirect" method) of obtaining non-synthesized serial records of the physiologic activity of the thorax, provided a camera-lens of sufficient speed were obtainable. He finally received, from Messrs. Cook of London, an instrument which was the most rapid of its day, but it did not fulfil his requirement. When the earlier work of Groedel²⁹ appeared, Caldwell was convinced that real advancement in roentgen-cinematography, ultimately free from synthesization, lay in the development of the "direct" method of film-production.

²⁷ Jarre, H. A., "Roentgen Cinematography," *The Science of Radiology*, Thomas, 1933, p. 198.

²⁸ Bleyer, J. Mount, "On the Bleyer Photo-Fluoroscope," *Electrical Engineer*, 22: 10, 1896. Jarre correctly intimates that this early work was done without serious thought of its application to roentgen-cinematography.

²⁹ Groedel, F. M., "Die Technik der Röntgenkinematographie," *Deutsche med. Wchnsch.* 35: 434, 1909.

Likewise, almost nothing appears in the literature concerning Caldwell's system of multiple gas valve-tube rectification for the transformation of the alternating primary current into outputs of the higher energies necessary for x-ray production of great volume. This, as the case with so many of his conceptions, was a step in advance of the general radiologic progress of the day. No gas discharge-tube was there then that could repeatedly withstand the onslaughts of such energy. It remained for another great engineer³⁰ to solve this problem, to the utter benefit of humanity.

The course of such experimentation as this, so dear to Caldwell's perfectly trained scientific mind, was the accompaniment of an enormous professional practice that had grown without intermission. Its inevitable responsibilities often arose as irritating interruptions to the mental processes attendant upon the exercise of his genius, in spite of the excellent technical and medical assistance which he enjoyed almost from the beginning of his radiologic career. "I think I should be fairly happy in my work," he once remarked, "if it were not for patients. They take time, and there is so much, so very much, to be done." Moreover, the sinister progress of the affliction resulting from his radiation-injuries was seriously impeding him. The results of his ulcer excisions and skin-grafts of 1907 were of definite though temporary relief, as he had written the following year:³¹

... I have to report that all the grafts grew successfully, and most of them have contracted much more than I expected. They are all in splendid condition, except that there is a tendency to the formation of keratoses at some of the margins. It seems to me that this condition, so common in all x-ray hands, nearly always starts from a small abrasion, and that the trauma at the margin of the incision for the skin-graft is just the sort of injury which has produced this kind of growth. I have been able to improve the condition very much by having these spots treated with liquid air, after which

³⁰ Coolidge, W. D., *Physical Review*, 2: 409, 1913.

³¹ E.W.C. to C.A.P. 15 September, 1908.

there is no tendency toward recurrence. There are no signs of metastatic involvement of the epitrochlear or axillary glands. . . .

This report is an early revelation of Caldwell's cheerful optimism concerning his condition. Although the series of deaths among his American colleagues, from 1904 up to and including that of Kassabian in 1910, had left Caldwell, and all roentgenologists affected at that time, with no illusions as to the seriousness of their plight, yet his good cheer persisted. Indeed, for the course of some years prior to his country's entrance into the Great War, he was comparatively relieved of some of his painful dermal manifestations of an earlier day, but only by continued resort to the local application of liquid air, carbon dioxide "snow" and fulguration for keratotic growth, and by occasional recourse to skin-grafting on areas of ulceration. For recurring pain, he continued to find relief in the application of external heat.

One of the many evidences of Caldwell's fine fibre was his patriotism. He had been one of the very first radiologists to join the old medical reserve corps, but the outbreak of the War, while it gave him increased opportunity to exercise his patriotic impulses, brought to him also the realization that his participation must be less active than he had hoped, by reason of his disability. Yet there was much he could do, but, almost at the start of his plans whereby his extraordinary gifts were to be utilized in the Service, Caldwell sustained a minor abrasion of one of the fingers of his left hand. This wound did not heal, but, instead, the epithelial structures broke down and underwent rapid malignant degeneration. Amputation was advised by the surgeon who had so successfully grafted, in another city, the first of his ulcerative lesions. Caldwell was then so busily engaged with his major war work—the development of his second stereoscopic fluoroscope, which he hoped to carry to prompt completion for its trial overseas—that he reluctantly chose New York as the *locus* of the operation. He was unfortunate in not finding available the operator whom he had chosen in

that city, in whose hands the results would have been undoubtedly better than they turned out to be. Caldwell then besought help of the surgeon who had first seen him years before. The finger was re-amputated and another finger also removed, but by this time evidence of axillary metastasis was discovered.

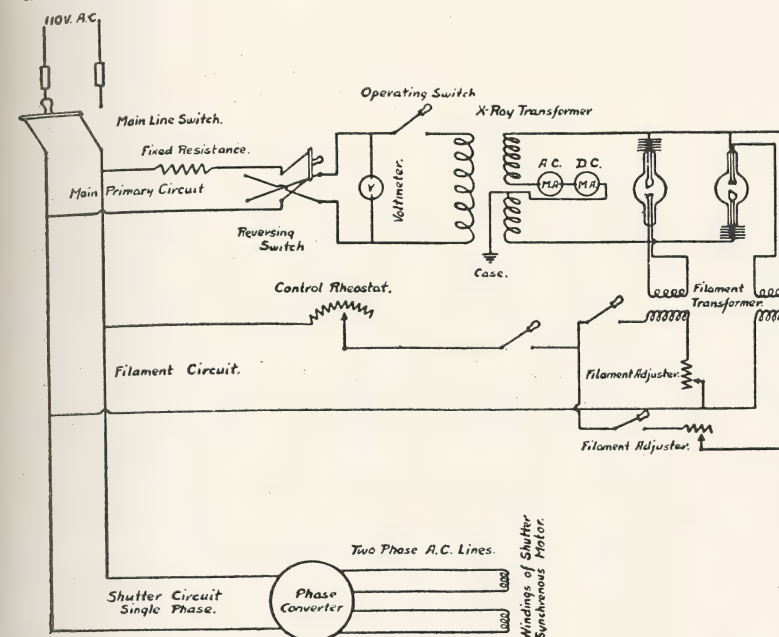


FIG. 43—Diagram of the electrical system of Caldwell's second and improved stereofluoroscope.

Caldwell's second stereoscopic fluoroscope, which was described in detail after the Armistice,³² was the final scientific contribution of this outstanding man of genius. It was a distinct improvement in many respects over his former apparatus of like purpose (1901), the chief of them being the utilization of two self-rectifying tubes, alternately under transformer-excitation. The principle of eye-shutter synchronization was essentially of the same application as in the former apparatus (Fig. 43).

³² Middleditch, L., Capt. Sanitary Corps, U.S.A., "A Description of the Caldwell Stereofluoroscope." *Amer. Jour. Roentgenology*, 5: 547, 1918.

The continuous distress of Caldwell's physical condition was complicated by his anxiety for the completion of this machine and its prompt carriage overseas, for, as Captain Middleditch writes: "Major Caldwell himself took the attitude [concerning its practical usefulness] that only by long and continued use under actual working conditions could a rational opinion of its usefulness be formed." Eugene Caldwell's friends were happy in the assurance that, before his death in June, 1918, he could be told that the first of these apparatuses for the localization of war-projectiles had been forwarded overseas.

As of thousands of his combatant compatriots, much was demanded of this valiant soldier by way of fortitude during those long months of 1917 and 1918. It was consistently forthcoming. The visible axillary involvement by cancer was cleared by the usual surgical procedure, but the type of the metastatic process was found to be extremely malignant and it soon reasserted itself. With radium and by chemical escharosis, desperate effort was made by Caldwell's loyal surgical friends, but to little avail. The necessity of amputation at the shoulder soon became apparent as a final attempt to stem the advancing process of inexorable Nature, but it was ordained that one of her most brilliant disciples, in the midst of his stewardship, should yield to the mandate of her laws, through the constant observation and demonstration of which he had become the Dean of American Roentgenology.

It was in the natural order that Eugene Wilson Caldwell should die in the army uniform of his country. Throughout the history of peoples at conflict it has been a raiment of martyrdom, and any citation of his life's accomplishment, as of that of Walter Reed and his glorious associates, shows how well it may befit the martyr both to science and to a patriotic cause.

"... As an example of the truest of soldiers, loyal to his

country and the cause of humanity, obedient to the call of service, facing suffering and danger without a murmur, carrying through his fight to the bitter end, he was the embodiment of all that is true and noble. So long as the science he represented is used by mankind, so long must his work endure."

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XVII

JAMES TOMASSON MOREHOUSE

1857—1920

A JOURNEY marked by practical accomplishment from the aromatic atmosphere of the pharmacist's dispensary to the ozone-laden air of the pioneer x-ray "laboratory" and thence to the clinic of the expert medical roentgenologist, by way of the austere road of a medical education, is both uncommon and difficult; it is one that has been rarely undertaken, yet it has been more than once successfully, even illustriously, achieved. One delights to recall the career of the magnetic Walter Dodd from the humble post of assistant janitor of an educational chemical laboratory to that of chief pharmacist to a hospital and then by dearly-earned medical training to his goal of roentgenologist of national reputation and member of a university faculty. Consistent upward progress involving such contrasts in life's station is of notable rarity, yet it was accomplished, by means of steps of ascent that were almost identical, by at least one other—James Morehouse, a young pharmacist of Newark, New Jersey.

Morehouse was born in Newark on February twenty-third, 1857. His parents were James and Ellen (Mason) Morehouse. He was an alert, precocious young boy and evidently a dreamer; so much so, perhaps, that he was classified as an eccentric by those who cannot see to the depth of the dreamer's vision. Morehouse's eccentricities can probably be translated into terms of genius—that "capacity for taking infinite pains" which may appear so early in the life of a boy that he cannot be estimated by means of the ordinary measurements of adolescent development and is not, therefore, thoroughly understood.

As soon as young Morehouse was graduated as a pharmacist, he was employed for a time in the shop of a Newark apothecary, but a sense of independence begotten of his graduation and registration in pharmacy impelled him to establish a shop for himself in the neighboring city of Orange.



FIG. 44—James T. Morehouse

As in others of his type, his boyhood existence had been enlivened by divers "hobbies," one of which was electricity in its more popular and practical applications. This leaning influenced his later thought and study, but in the meantime the ambition of this now independent apothecary was to study medicine. Procuring a manager for his shop, and sup-

porting himself by means of the income from it, Morehouse matriculated in the medical course at New York University. He was graduated in 1893.

Doctor Morehouse immediately entered the practice of medicine, but here again he was under the control of the multiple and varied interests of genius, in which his early predilection for applied electricity was, perhaps, the predominant influence. Röntgen's discovery in 1895 was just the spark for his tinder, and the glow of his enthusiasm was probably the brighter by reason of the propinquity of the Edison laboratory, wherein the "new science" was investigated with such promptitude. In cooperation with a well known manufacturer of dynamo-electric machinery of that day, Morehouse constructed an induction apparatus for the production of x-rays as well as the dynamo and accumulators to energize it.

Morehouse's medical work with roentgen-rays was pursued in connection with his general practice in Orange and Newark, which grew to large proportions. He had intense confidence in the value of the roentgen-rays as a diagnostic agent, and applied them through the media of the radiograph and the fluoroscope in every case amenable to their use in his day. Of this work he wrote little; nothing can be found in the medical literature from his pen on the subject of roentgen diagnosis or therapy except a paper¹ published in the *American X-ray Journal* of 1899. Therein he made use of a theme often dwelt on by the pioneers in their writings, usually with reference to the x-ray revelations in problems of minor surgery—the accuracy of roentgen-ray methods *versus* the comparative uncertainty of clinical diagnosis.

His almost constant use of the fluoroscope had its inevitable result. He noted a development of keratotic areas on the dorsum of his fingers, but at first he did not relinquish

¹ Morehouse, J. T., "Object Lessons in Radiology," *Amer. X-ray Jour.*, 4: 569, 1899.

either his active work in New Jersey or his visiting service at the clinic of the New York Hospital, which he attended faithfully each week. As the condition advanced, however, and realizing its cause, he abandoned his work temporarily and travelled through the West. The inflammatory process subsiding, he returned to his office, continuing to practise until two years later, when the hyperkeratosis and exfoliation recurred, necessitating a more protracted rest. Notwithstanding this, breakdown of the skin followed and extended upward, gradually involving the hand, the arm and the chest-wall, resulting in pain of the most terrific degree, although objective disability of the arm was not marked until at last Doctor Morehouse was compelled to seek hospital care. In hospital, amputation of the arm was advised, but the operation was refused by him.

James Morehouse died in the New York Hospital just before Christmas Day of 1920, after many years of suffering. He began his useful work as a pioneer in a new field of science, and in a small sphere he carried it on with patient persistence, the courage of his conviction and, finally, with fortitude and great bravery. While he did not associate himself personally or publicly with the development of radiology in marked degree, he was a true champion of its cause at a time when it most needed support. On its rising structure the design of his gravure was not elaborate, but his modest mark was cut deeply.

XVIII

HEBER ROBARTS

1852—1922

DR. HEBER ROBARTS, a founding member and the first President of the Roentgen Society of the United States (later to become the American Roentgen Ray Society), while one of the earliest to establish himself in the use of the roentgen-rays and of radium for the purposes of diagnosis and treatment, was by good fortune among the latter-day group of martyrs to this application of science, and at an age well beyond the usual allotment of years accorded to those who have finally met death through the chronic effect of radiation upon the skin. Robarts died on May-day of 1922. As he was one of the first of that great band of medical men everywhere to embrace with enthusiasm the successive *Communications* of Professor Röntgen, it follows that over twenty-five years elapsed before he finally succumbed to the terminal effects of his long exposure.

Heber Robarts was born in Godfrey, Illinois. His preliminary education was derived at McKendree college in the town of Lebanon, an institution in which his father, Dr. James Robarts, a physician of great skill and learning, was actively interested, and where the youthful Heber was admitted in 1869 at the age of seventeen. Here he acquired the academic foundation from which to follow his father's excellent example and to study medicine. After attending two courses of lectures at Jefferson Medical College, Philadelphia, he entered Missouri Medical College in St. Louis, to be graduated in Medicine in 1880.

One of his biographers¹ writes that, during the early years of his medical life, Doctor Robarts was intensely interested

¹ Ernst, Edwin C., *Amer. Jour. Roentgenology*, 9: 451, 1922.

in problems of sanitation, in health departments and in health ordinances, and was the author of many of those which, even today, are models of practical efficiency. After his graduation in Medicine, he established his practice in the town of Belleville, Illinois, not far from the city of St.

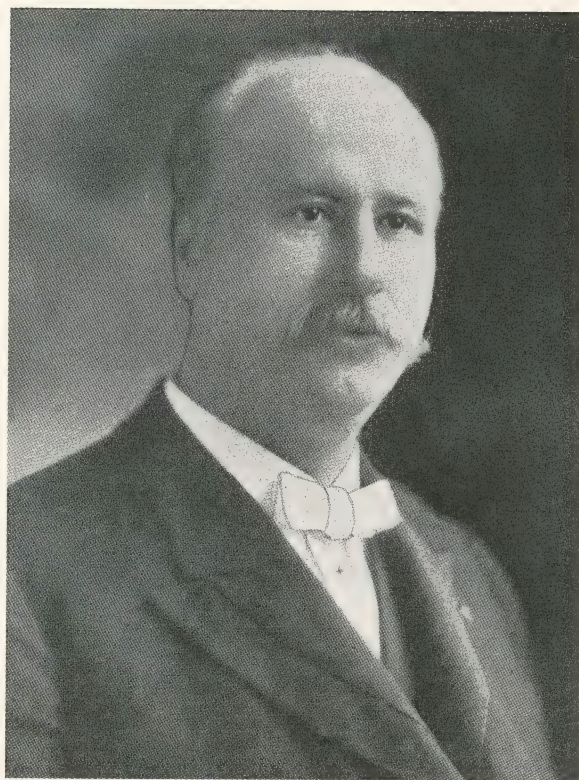


FIG. 45—Heber Roberts

Louis, but it was while he was on duty years later at Butte, Montana, as surgeon for the Great Northern Railroad, that he received the news of the discovery of the roentgen-rays. This aroused his interest to such degree that within a very short time he returned to Belleville with the intention of establishing a laboratory in St. Louis for the further study

of this extraordinary phenomenon. This modest office in Pine Street is vividly described by one² who very early became the assistant and associate of Doctor Roberts, later his devoted friend, and ultimately another of his biographers:

... I can close my eyes and see the room, with high ceiling as was the custom in building in those days. ... The gas fixture hanging from the center of the ceiling contained electric wiring and sockets in their proper places, and there were also wall fixtures for the electricity and the gas; to one of them Dr. Roberts was screwing the lead from the Ruhmkorff coil. ...

My mental picture of Roberts, bending over the coil—his head almost bald and the little hair that was left, gray at the temples; a stubby little moustache; clothes immaculate, but apparently flung at him; gruff of manner but with the heart of a child—cannot but vividly recall my affectionate interest in everything that he did.

... Dr. Roberts and I prepared some photographic plates ... by wrapping them in black paper; then I posed my hand, in a glove, on one. The Crookes tube sputtered and crackled for a period of *ninety seconds*³ ... the machines of today do not make much better radiographs of the hand than we made that night. Of course, at that time, it was a marvelous thing, and I kept that old plate for many years.

The veritable prototype of the primitive "private office" of the pioneer radiologist of 1896! Only by the persistent example of these small installations and the unquenchable enthusiasm which emanated from them were many established hospital institutions moved to visualize the future and to exert kindred effort, and then but slowly and with caution. The vision of institutional Boards is proverbially anything but hypermetropic, which accounts for the fact that the early radiologic functions under their control were so seldom in step with the vanguard of Progress. The few exceptions to this rule have been illustrious and epoch-making.

Once settled in his pioneer work in St. Louis, Roberts

² O'Hara, F. S., "Looking Backward," *Radiography and Clinical Photography*, 8: No. 3, 1932.

³ Editor's italics.

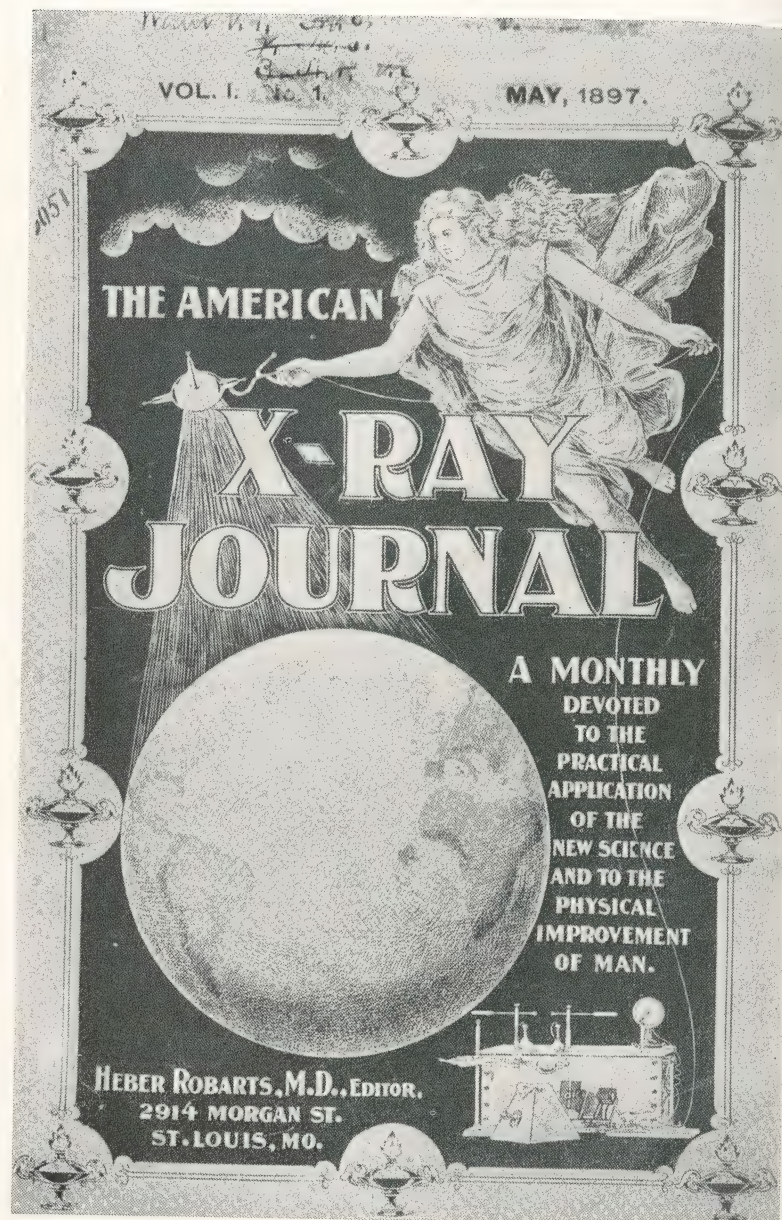


FIG. 46—The cover of the first number of the first volume of Doctor Robert's *American X-ray Journal*. The allegorical figure of Science is seen to be irradiating the Globe with the emanations of a double-focus Crookes tube energized from a Knott high-frequency coil at the lower right-hand corner. In front of the coil is supported another tube, evidently in reserve. No detail is omitted, even the corona along one of the cathodal leads being suggested. The border is appropriately ornamented with multiple Lamps of Knowledge.

evinced a flair for organization, which was directed toward a plane higher than that of local institutional radiologic methodization. One of his earliest ambitions was to found an American periodical publication devoted to the interests of a new medical specialty which, as he could see, was rapidly developing. Into this project he threw all the resources at his command of time, purse and energy, with the result that the *American X-ray Journal* made its initial appearance as a monthly magazine of contributory information in May, 1897. Some historians have recorded that Doctor Roberts made assertions relative to the priority of this accession to the early radiologic literature that were wide of the mark. No data have been found which tend collectively to substantiate these accusations. Surely Roberts was in a position to be aware of all existing literature devoted to the roentgen-rays, meagre as it was at that day. Especially as a member of the old Röntgen Society of London must he have known of the existence of the British *Archives of Skiagraphy*, which appeared just one year prior to his American journal. Therefore, in speaking editorially of the *American X-ray Journal* as being the "first-born of its kind," he doubtless pictured mentally future kindred publications in his own country. On another occasion, Roberts referred to his American journal as the only *monthly* journal of like purpose printed in the English language; this was likewise a fact, as the British *Archives* appeared at less frequent intervals during its early life.

In the first number of this product of his journalistic ambition and effort, Doctor Roberts, as its first editor, thus pledges his hand and heart to the fulfilment of its character and aims:

No apology is considered necessary for undertaking the publication of the *American X-ray Journal*, the "first-born" of its kind, and a Journal . . . devoted to practical x-ray work and allied Arts and Sciences . . . in line with human thought and the practical needs of man.

Robarts then gives reasons why, in his opinion, physicians do not readily adopt the "new science" notwithstanding public clamor for its use. He then reviews the application of the new rays in some surgical affections, "the ease and certainty of diagnosing which has advanced more in the past twelve months than any previous hundred years." Continuing in the spirit of his pledge, he writes:

It is the design of this Journal to give the readers and thinkers a faithful résumé of all x-ray work done in any portion of the globe. . . . It is the intention of the promoters of this Journal to give to the world only truthful results, with full credit to the experimenter, in all its relations to the new science. . . .

Concerning "allied arts and sciences" he has this to say: This field of inquiry [that of the "new science"] must have associated with it practical and useful adjuncts. The most essential which shall occupy space are medical jurisprudence, the therapy of electro-medical science, preventive medicine, hygiene, dentistry and collateral branches.

As to advertisements, the *sine qua non* of young and struggling medical journalism, he decrees:

No advertisements shall appear in this Journal that savor of quackery, deception or fraud. . . .

With reference to the conduct of the Editorship he declares:

The conduct of this Journal shall not be arrogant, defiant or bigoted, but it will have the courage of conviction to press forward the truth as we understand the truth. It will be ethical, as the throbbings of every breast should be, regardless of any written code devised by man for another's guidance. There will be no personal venom, as we hold no animus against any man, but false principles will be attacked with all the vigor of our ability. This is a pioneer Journal of x-ray work. We are not imitators. We are casting our hopes among the needs and wants of man. We expect encouragement.

While it cannot be expected or desired that we shall escape just criticism or it may be, contumely, yet our aim shall be to improve

each coming journal, encouraged as we are in the faith and usefulness of our mission. . . .

From the earlier numbers of the *American X-ray Journal* we may judge that its editor was forced to draw, at times, upon the "allied sciences" for material to fill its pages, but as the months passed and x-ray workers had more to report, the field of the Journal contracted to a scope more definitely consistent with its title, and its specific object was thus preserved through the period of its hey-day, after which it passed from the hands of Robarts. A change in its title was soon to indicate that its character also had changed and that the aims and hopes of Heber Robarts for a national journal devoted exclusively to the field he had cultivated, that of roentgenology, were not yet to be realized. Before the transition was complete, however, the pages of the *American X-ray Journal* served to record for posterity the transactions, at its first three meetings, of a newly-formed national association of "x-ray workers," as they were then broadly and very flexibly known.

It was to the editorial office of this publication, at St. Louis, that Doctor Robarts, in the early spring of 1900, summoned a group, chiefly composed of mid-western medical men, for the purpose of organizing "The Roentgen Society of the United States," a title adopted at this meeting. Robarts was chosen as the first president of this society, and, as the *locus* of its first regular meeting to be held during the following December, the city of New York was agreed on. Perhaps by pressure of necessity that has ever been a concomitant of pioneering, but unfortunately for Robarts, unfortunately for his ambitions for this Society, little or no provision was made as to restriction of membership in the course of its deliberations at New York. Because of this laxity, its ranks of earnest workers became infiltrated by those whose interests were merely commercial and who would exploit without compunction a young and struggling

scientific body to further their ends. Although he was re-elected to its presidential chair, Robarts could foresee no realization of his hopes and ideals for a journal or for a national organization thoroughly dedicated to the interests of the "new science." Ultimately he disposed of his proprietary control of the *American X-ray Journal*, and forthwith its identity with matters closely allied to roentgenology became dissipated. Fortunately, Robarts lived to see a complete restitution of the principles for which he stood; in 1902, the presidency of the national society passed into the able hands of Girdwood, of Montreal, and by 1905, the salutary influence of Goodspeed, Bullitt and Lester Leonard, acting in like capacity, had completely purged it of the corrosive pervasion that had so sorely tried Heber Robarts, and which would have surely resulted in its ultimate disintegration. As a later president of the American Roentgen Ray Society in the full flower of its scientific prosperity has recently written:⁴ "... With medicine appropriating the new science to its use, it seemed that there was no place for workers in x-ray without medical training. This opinion prevailed—hence the decision ... anyone familiar with the development of roentgenology in America must give great credit to Dr. Robarts. Apparently his work has been unjustly overshadowed by later workers who contributed less but who received greater publicity."

Had Heber Robarts preserved his established identity with the early American development of roentgenology, he might have been one of that group of medical men who, in 1905 or 1906, were finally to enjoy the fruits of a *renaissance* of the American Roentgen Ray Society, but the disappointments of his pioneer years, culminating, perhaps, in 1901, had tended to turn his attention in another direction, but not before he had made definite contributions to the science of roentgen therapy. "He was a pioneer in the advocacy of

⁴ Evans, Wm. A., *The Science of Radiology* (Thomas, 1933), p. 28.

the x-rays in the treatment of lupus and other inflammatory skin affections, and very early realized both the safe and the dangerous use of the rays in epilation."

The discovery of radium in 1898 by Marie and Pierre Curie had excited the intense interest of Doctor Robarts, and soon after the turn of the century he determined to give the subject his serious study. In 1904, accordingly, he visited St. Joachimsthal and St. Eliasschacht, in Bohemia, for the purpose of investigating the process of mining pitchblende and to procure radium bromide. In 1905, writes Doctor Ernst, Robarts visited Naples and with guides reached the rim of the crater of Vesuvius, whence, during a short period of considerable activity, he obtained enough of the ash to establish the fact that radioactive matter is not confined to the comparatively thin stratum of the earth's surface.

Except for his faithful contributions to the editorial pages of the *American X-ray Journal* throughout the four or five years of his tutelary authority, the pen of Heber Robarts was most active in the field of radium therapy. Probably his most important literary contribution was a small book published under the title of *Practical Radium*. The instructional portion of its text is in the form of dialogue, quite in the Platonic style. This form is adopted because, as the author explains, "it lessens fatigue in reading, and is also constantly suggestive." The principals in the dialogue are "Dr. Radium," the presumptive expert in radium therapy, and "Dr. Interrogator," the truth-seeker who would sit at his feet:

DOCTOR INTERROGATOR—"I have called, Doctor, for the purpose of getting some information about radium. Physicians have told me that you were thoroughly posted on this subject."

DOCTOR RADIUM—"It pleases me that you have called for this purpose, and, as I see that you bear an anxious face, it is quite certain that you wish to know more of the therapeutics of radium than of its physics and history. I am therefore persuaded to do all I can to help you, as your face bespeaks your interest. But permit me first to remove from your mind the idea that I am, or that any-

one else is, thoroughly posted on this subject. This is a broad field of inquiry, and new issues come up every day which call for our continued study and research."

DOCTOR INTERROGATOR—"You certainly have encouraged me, and I feel free to talk to you about a case. A patient came to my office the other day with this history"

And so on, to the conclusion of the "consultation." Any reader of this small volume will find ample entertainment as well as instruction. Robarts wrote also on "Ions Produced by Radium," "Radium Light," "Radioactive Tissues," "Thorad X," and "Radium Applicators."

Doctor O'Hara, for several years the faithful *Boswell* to the *Johnson* of Heber Robarts, writes feelingly of the many disappointments that led finally to his return to his old home in Belleville, but without a doubt his appreciation of the progress of his radiation-dermatitis must have been a contributory factor. Over a period of eleven years he successively lost four fingers by amputation for cancerous degeneration of ulcerative radiation-lesions. By the year 1918 these sacrifices had included the index-finger of each hand. He visited New York and also Baltimore for treatment as soon as the question of metastatic extension became imminent. Convinced from this experience that the sole hope of his relief lay in the use of radium, Robarts felt that a continuance of this form of treatment could as well be directed by himself. Therefore he returned to Belleville to enter St. Vincent's Hospital, to which he had given the very considerable amount of radium bromid he had accumulated. This was applied in accordance with his daily instructions, but it served only to effect a local arrest of the process. With the establishment of definite intrathoracic metastasis came his realization that he could not recover. His pain became increasingly severe and on May first, 1922, he died after giving detailed instructions as to the conduct of his post-mortem examination, which he desired for the scientific data it might afford.

The contributory factors to the martyrdom of Heber Robarts were by no means entirely physical. Generous indeed was his share of the mental trials and tribulations of the pioneer in roentgenology. During his latter years, some caprice of retrospection impelled him to allude to the irritations that attended his early efforts:⁵

When I began the publication of the *American X-ray Journal* in May, 1897, the first monthly journal of the kind in the world, I was looked upon by some doctors as an adventurer unworthy of consideration, and by others as flaunting defiance at their practice and intelligence. The x-ray was denounced by some leading men in our profession—by teachers in surgery, diagnosticians, pathologists and practitioners. It was regarded by them as foolery, spectacular only, and fit for the quack's armamentarium. The non-office-holding doctor—the one not in medical politics, the plain doctor whose great heart and best medical services enter the homes—accepted with kindness the showing of the first x-ray workers.

But such are the occasional rewards of generosity in effort and forgetfulness of self as were so completely manifested in the life of Heber Robarts, that it is the privilege of the historian to note that the descendant of his little journal, in direct line interrupted only by the temporary appearance of the American Roentgen Ray Society's transactions in the form of an annual volume and as a Quarterly, is the present *American Journal of Roentgenology and Radium Therapy*, a publication which, in kind, has no equal in any country of the world. By fortuitous but happy circumstance, its present title, adopted not so many years ago, refers to the two fields of scientific endeavor wherein Doctor Robarts was such an indefatigable worker at different periods of his professional life. From his early sacrifice there has eventually grown, through "the power of the press," a beneficent gift to the radiologist and through him reflected to the welfare of the patient in need of help. What more complete fulfilment of his vision of 1897 could Heber Robarts have wished?

⁵ Robarts, H., *Practical Radium*. Preface page xiv. St. Louis: Privately printed by Nixon-Jones Printing Company, 1909.

IRA SIMS

—1924

THE SPAN of the simple and unpretentious life of Ira Sims marks a period of dependable service daily and with fidelity performed, its inconspicuousness maintained by his own modesty, its effectiveness created by his own energy and close application to duty.

Sims' career was essentially a product of metropolitan hospital life, begun as an obscure institutional helper, later to expand and to mature as an indispensable laboratory assistant, and finally to end as a lovable figure, appreciatively to be recalled to mind by many of the great radiologists, surgeons and internists of New York City. As an elevator-operator at the Roosevelt Hospital, Sims came under the discerning eye of one of these radiologists,¹ who was about to initiate the roentgenological service at that institution. He attached Sims to his Department as a technical assistant, and in this way the efficiency of this adaptable man was developed under skilful teaching. Eventually Sims's work as a radiological technician at the Roosevelt Hospital was terminated by his entry into the employ of the Presbyterian Hospital of Columbia University in like capacity. By this time he was capable of assuming every responsibility, short of diagnosis and treatment, usually attaching to institutional x-ray work and when, in 1910, another great roentgenologist² was appointed as Director of the X-ray Department of the Presbyterian Hospital, he found there a technician of rare ability.

"Ira [Sims]," writes one of his former friends and surgical

¹ Dr. Lewis Gregory Cole, *Personal communication*.

² The late Dr. Eugene W. Caldwell.

benefactors,³ "was one of the most indefatigable workers and cheerful souls, always ready to oblige and a great favorite at . . . the Presbyterian Hospital and at the Roosevelt Hospital. I knew him at both places. He worked for Caldwell [at the Presbyterian] for a number of years. . . . He was not a doctor, but he did excellent work as an x-ray technician and taught us doctors many, many things."

In 1917 Ira Sims left his position at the Presbyterian Hospital, but his fortunate medical contacts were to continue, since his services were immediately engaged by another eminent roentgenologist.⁴ By this time he had been directly exposed to the action of the roentgen-rays, with inadequate protection, for over eight years, during which he had suffered intense pain from dermal ulceration, but his fortitude was such that his exceptionally fine technical work was in no way affected. The requirements of his new work in an especial roentgenologic field were peculiarly exacting, but he met them with his usual thoroughness and precision.

" . . . If no one was observing him, he would sit with his hands between his legs, his body bent forward, apparently suffering great pain. As soon as he found he was observed, he would straighten up and smile and make some facetious remark. He was very sensitive about his infirmity. Several fingers, of course, were continually bandaged."⁵

Sims's hands and fingers had been treated at various times and he had had one skin-graft and a partial amputation of one forefinger when he entered the Presbyterian Hospital as a patient, in May of 1918, for more extensive excisions and successful grafting on the dorsal region of the left hand and

³ Dr. Hugh Auchincloss, *Personal communication*.

⁴ Dr. Frederick M. Law of New York.

⁵ Doctor Law, *Personal communication*. This attitude regarding their affliction has been observed in nearly all those who have been seriously injured by roentgen-rays in the course of their chosen work, particularly those who were, or who are, not physicians and consequently had no impulsion toward impersonal professional discussion of the matter.

of an ulcerated area about the nail of the ring-finger, as well as a higher amputation of the forefinger. These procedures tended to arrest the local extension of the lesions then existing, but for five years longer he continued to develop keratotic areas which became infected, inflamed and exquisitely tender. In the spring of 1924 there formed a large squamous-cell epithelioma in scar tissue on the dorsum of this hand; this was excised and the area skin-grafted.

"About August first his pain was such that he concluded to have the axillary glands operated upon. This was done and he seemed to be progressing very nicely," when on August 29, after taking a walk, he lost consciousness at the door of his home and died in a short time from the effect of a "general carcinomatosis."

"I never knew anyone with such a cheerful disposition under such trying circumstances." This observation might well be cut in stencil, without thought of irrelevancy, for general application to the life-histories of all these patient souls. The serious import of their work, its responsibilities and the magnitude of its potentialities so thoroughly dominated their thoughts that they had but little consideration for the gravity of their own situation. It is not unusual that those in dangerous occupations seem to develop an uncommonly acute sense of humor which, in the case of those who worked with x-radiation and were disastrously influenced by its effects, often served as a temporary antidote for their bodily anguish. Who among their contemporary associates cannot remember the self-directed jocosity of Rome Wagner, the jovial mimicry of Walter Dodd, the merry anecdotes of Henry Green, the "shoulders shaking in silent laughter" of Eugene Caldwell, the keen wit of Frederick Baetjer, or the dry humor of Lester Leonard?

Ira Sims was no exception. As he took his work seriously, so did he take himself lightly, hence his disposition of good cheer and his jocular whimsy. Thus was his sombre history illumined and, in this light, his proud record written.

XX

ROBERT HERMAN MACHLETT

1872—1926

ROBERT MACHLETT was one of that band of loyal artisans from whose competent hands and keen minds the early practice of radiology gained so much. He was a benefactor of mankind in many ways. Of great importance was his contribution of a modification of the focustube, so contrived that it was essentially auto-protective, shielding the operator and the patient from all scattering x-radiation by permitting to pass only those rays necessary to cover the field of examination or treatment.

The son of Ernest and Caroline (Greiner) Machlett, he was born in 1872 at the small town of Gehlberg in the Thuringian mountains of Germany. This community is entirely devoted to the practice of the art of glass-blowing. Until recent years its factories were internationally known for the peculiar type and quality of glass they produced, which found its widest application in chemical glassware and other glass apparatus fabricated at the "bench."

Ernest Machlett, the father, was a glass-blower of exceptional skill. Under him his son Robert began his apprenticeship in the art of bench-blowing. When the boy was but eleven years old, he accompanied his father to the United States at the suggestion of Mr. August Eimer, of the scientific-instrument mercantile house of Eimer and Amend in New York. In the employ of these merchants, father and son commenced work, but Robert, at the early age of eleven, had not completed his apprenticeship as a glass-blower, and after a few years in New York it became evident to his father that the proper course would be to return with Robert to Germany in order that his industrial education might be consummated. Three years later, once again in New York,

the Machletts from then on directed their entire activities to glass-blowing in the country of their adoption, at first with Eimer and Amend, but subsequently as independent manufacturers.

During these early years, Robert Machlett occupied him-



FIG. 47—Robert H. Machlett

self chiefly with the construction of especial apparatus for scientific institutions and professional men. "In this way," writes his son,¹ "he came intimately in contact with new developments in the field of physics and chemistry. When Röntgen's discovery was announced he was very much in-

¹ Mr. R. R. Machlett, *Personal communication*.

terested and almost immediately began experiments to produce a practical x-ray tube as a commercial article of manufacture. If he was not actually the first, he was at least one of the very first, to make practical x-ray tubes."

Machlett was successful in this work from the start. He proceeded to develop, for his use in evacuating tubes, a mechanically fed mercury-fall pump which was highly effective. This probably aided him in the production of the auto-protective gas-tube already mentioned—a tube with discharge-

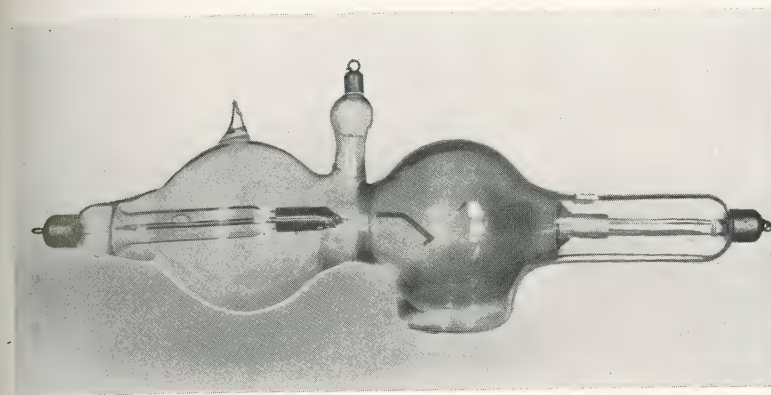


FIG. 48—A roentgen-ray tube having the discharge-chamber of lead-glass and the "window" opposite the face of the target of radiable lime-glass, said to be of a type built by Robert Machlett. This individual tube was given to the author by Dr. Eugene Caldwell to be used in the military medical service overseas. It was so used, brought back, and is still in the author's possession.

chamber walls and stem-walls of x-radiation resistant "lead" glass, but having in its wall, opposite the face of the target, a "window" of "lime" glass. Through this window only could the roentgen-rays pass without effective resistance, thus affording protection to the patient and those working in the vicinity of the tube. In the designing of this tube Mr. Machlett was associated with Dr. Henry G. Piffard of New York; it was generally known among roentgenologists as the "Piffard" tube (Fig. 48). Robert Machlett's skill was evident

in the construction of other types of x-ray tubes as well as in that of vacuum-maintaining glass apparatus not connected with the production of x-rays. He was a pioneer producer of a water-cooled tube so devised that the circulating water was brought into direct contact with the back of the metallic anode. Also, he aided materially in the development of the Cooper Hewitt (mercury vapor) lamp, particularly in working out practical designs which contributed to the efficiency and long life of this device. It is also noteworthy that the so-called thermos vacuum bottle was first produced on a commercial scale under his supervision.

The physical history of all too many of these unselfish and heroic artisans was likewise that of Robert Machlett—the careful scrutiny from time to time for hours on end, by means of the hand fluoroscope, of the progress of exhaustion of the x-ray tube within its oven. A tedious process—uncolored by the glamor of fluoroscopic revelation of suspected disease or the favorable progress of manifested disease in the healing; a process having as its sole requital the expert's satisfaction in the knowledge of mechanical work well done. In 1906, he first noted evidence of radiation-reaction in the dorsal skin of his left hand, in the form of multiple hyperkeratosis. In lesser degree the same condition appeared on the right hand. For seventeen years these lesions were treated by various methods, including the operation of fulguration and the application of radium, and many were permanently destroyed in these ways. One particularly persistent area on the middle finger of the left hand was subjected to a considerable amount of treatment by radium. True to much of the history of the use of radium in *radiation*-lesions of the skin, by 1923 this area, now ulcerative, was giving so much pain that the finger was amputated. By microscopical examination the process was found to be already malignant.

It was during the following year that an extension of the condition was found to occupy the lymphatic glands about the elbow and in the upper arm. For some time after the removal of these Machlett's health improved, but in 1926 the hope that recovery might be thus indicated was destroyed by the reappearance of metastasis in the axilla and also in the chest-wall. In the further search for relief, the "colloidal-lead" treatment for carcinoma was tried but proved ineffective.

Robert Machlett died on the first of June, 1926. To the scene of his life's work he brought, as a simple immigrant, a natural talent and hereditary skill. With this endowment and through humanitarian impulse he fashioned an effective means of aiding mankind in the hour of distress and need—the first of his great gifts to the cause of Humanity.

The second was the gift of life itself, offered without hesitation when it seemed the inevitable outcome of his fruit-bearing labors, in the pursuit of which he had been disdainful of physical hindrance or torment, so his vision were realized and his aim attained!

FRANK HOWARD SWETT

1868—1929

FRANK SWETT was well-known to the early radiologists of New England. A merchant of the commodities and apparatus of the radiological laboratory, his was a familiar figure often seen here and there in the x-ray departments of the hospitals or in private offices. A genial and cheerful soul, his arrival with supplies was often most welcome at the scene of one of the little accidents or emergencies so well remembered by the pioneer.

Swett was of old Yankee stock. Born in Amesbury, Massachusetts in 1868, he was a son of John Howard and Annie (Williams) Swett. He was educated in the local graded schools and finally at Phillips Exeter Academy. His early life was largely devoted to various mercantile pursuits. Before the year of Röntgen's discovery he was engaged in the distribution of electric motors as agent of the General Electric Company, but sharing the general initial interest in that event and visualizing the possibilities in its medical development, in the spring of 1897 he formed an association with his brother-in-law, Mr. Clarence H. Lewis, for the distribution of x-ray apparatus to hospitals and to physicians. Their establishment in Boston constituted one of the first American ventures for this purpose. As a distributor of Crookes tubes and fluorescent screens especially, it became Mr. Swett's duty to demonstrate and test this apparatus for the information of prospective purchasers, and at first much of this work was done by means of a small influence-(static-) machine.

Swett's first dermatitis appeared on the back of the left hand. This slowly healed with the deposit of pigmentation,

to be followed, for some years subsequent to 1897, by similar attacks which in turn subsided, but later leaving keratosis-formation. It was not until the year 1905 that an ulcerative process formed on the back of the left hand, which failed completely to heal although showing a tendency to do so.

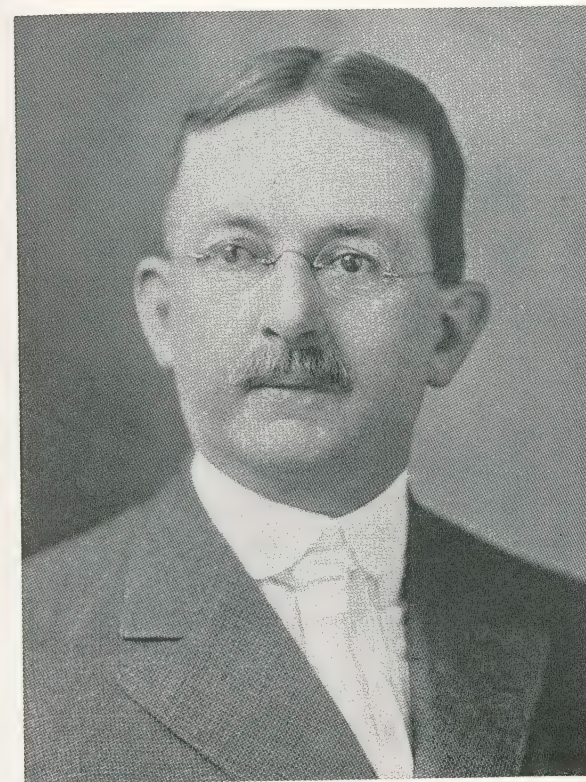


FIG. 49—Frank H. Swett

Many keratoses formed also on the left hand and the front of the chest, as well as a small persistent wart on the tip of the nose. These lesions were all successfully removed and wherever necessary were as successfully skin-grafted.

With this excellent reparative result Mr. Swett returned to the activity of his mercantile life. Being a merchant well-

liked and highly respected, his field of usefulness widened and he was the means of supplying much of the earliest x-ray apparatus to hospitals, physical laboratories and practitioners in urban New England. When his association with his brother-in-law was terminated, he joined forces with a group of Boston tube-makers and all were later combined as a branch of a large mercantile corporation engaged in the production of all forms of roentgen apparatus.

Swett's affability of manner and his generosity of his time and energies militated seriously against his physical well-being. During the six or seven years following 1908 he continued to work diligently, demonstrating—although now not so frequently by fluoroscope—and exhibiting apparatus that was rapidly developing in practicality and efficiency. A natural enthusiast, he gave little thought to his own condition, which seems not to have manifested itself acutely again until 1913, when a process of ulceration appeared on a thickened area of keratosis on the left forefinger. This was removed surgically and closed with a skin-graft.

In the early summer of that year by an unfortunate accident—the scratch of a cat, apparently trivial at the moment—the edge of this graft was wounded and an ulceration promptly appeared. This was removed and found by microscopical examination to be carcinomatous. Although the finger was immediately amputated, with healing in two weeks, it did not forestall the upward extension of the disease by metastasis. Toward the end of the year of 1914 the glands in the axilla and in the anterior wall of the chest were found to be involved. As soon as possible these glands were removed, as well as suspicious areas involving other fingers of the left hand.

In common with all who were engaged in the production and demonstration of Crookes tubes—*vide* histories of Henry Green, Rome Wagner, Burton Baker and others—Frank Swett sustained much x-ray damage to the tissues of the face,

lips and chest. Such lesions were the results of mechanical necessity, furthered by enthusiasm in the work and its future and glorified by a spirit of complete forgetfulness of self. From the year 1915 up to the moment of his death, almost, he submitted with the utmost cheerfulness to the unremitting efforts of his surgeons to stay the course of the disease in these regions. The length of time his life was conserved speaks strongly for their loyal persistence and his own never failing fortitude. More radium was used in his case than in any other of chronic radiation dermatitis recorded among the pioneers similarly affected, partly perhaps by reason of his own predilection for this form of treatment rather than orthodox surgery, but as time elapsed it seemed impossible to thwart the tendency to metastatic extension. In spite of radical surgical procedures to this end, Frank Swett died, a paragon of cheerful courage and stoical fortitude, his self-sacrifice crowning a life of continued usefulness.

"A quiet and unassuming man, who bore his burdens and did his work faithfully, effectively, patiently and without complaint. . . . He suffered that the realm of knowledge might be widened and humanity blessed with a new agency with which to combat disease."

LAWRIE BYRON MORRISON

1875—1933

FOR MEN having the prevision of Caldwell, the electrical engineer, or of Dodd, the pharmacist, both of them among the first of the pioneers of radiology, it was not difficult to perceive that the ultimate future of the "new science" lay in its status as a field of Medicine, and that fittingly to conform to this status they must possess the collegiate symbol of a medical education. It was fortunate for the furtherance of the splendid way in which Dodd practised radiology that he chose the University of Vermont for the formal culmination of a medical training which in reality was already his—a long hospital experience of the most practical contacts—because thereby he met a graduate of that University already a pathologist as well as the medical director of its hospital, a man who was destined to preserve, in his own personality, the fine fruits of Dodd's inestimable qualities. That man was Lawrie Morrison.

Morrison was born in Barnet, among the Green Mountains of Vermont. He was a son of Gilmore and Hannah (Knight) Morrison and by his death in 1933 a family of twelve children sustained its first loss. Acquiring his preliminary education at Peacham Academy in the town of that name, he afterward obtained his medical degree at the University of Vermont with the class of 1902. Morrison's chosen work of his earliest postgraduate years was pursued in the laboratories and after additional pathological training in Philadelphia and in Montreal, he became successively for a period of seven years Instructor in embryology, histology and pathology in the medical school of the University of Vermont at Burlington. During this period he engaged in

private practice for a short time, but, revealing an inborn gift of executive ability, he soon became Medical Director and Assistant Superintendent of the Mary Fletcher Hospital. Meanwhile, the seed of the first meeting with Dodd had been germinating, nurtured by the accord of two kindred spirits,



FIG. 50—Lawrie B. Morrison

for in 1914 Morrison removed to Boston to become his associate in the private practice of radiology.

For two years these men worked together, with Dodd as the modest preceptor, unconsciously imparting the wisdom of his long experience. Notwithstanding the fact that there was no one living at that day who could long resist the be-

neficient infection of Dodd's extraordinary personality, it was by no means through mere imitation on the part of his pupil that the characters of master and pupil were found to be so much alike; rather, they were each of the same fibre. Unhappily this felicitous alliance was terminated by the death of Dodd, but had it never existed and had Morrison climbed to the heights of his profession without those two years of advantageous association, his sincerity of lofty purpose, his deep compassion for others in their affliction and the charm of his demeanor toward them, would have been the same. Yet, "... In those years of intimate association," it has been written,¹ "the fine traits of the master's character imperceptibly strengthened those of the pupil during the daily transmission of knowledge and experience in the practical application of Röntgen's discovery. That the pupil had the character to accept the example shows his own greatness, for he, like the master, *was forewarned of the future.*"² ..."

Morrison had a great advantage in that he had been reared and educated among those who were, and those who were to be, country doctors. Thus from the beginning he became well versed in the religion of the humanities. He carried this schooling not only into the mellowing warmth of clinical contacts, but into the cooler, more impersonal atmosphere of purely scientific investigation. For this reason perhaps, it will be found that his published papers, each based on painstaking research, deal without exception with matters wherein the subjective *clinical* results of the use of roentgen rays are evidently uppermost in his mind. In 1925 he published a most important paper³ on diaphragmatic hernia of the fundus of

¹ Codman, E. A., A tribute to Dr. Lawrie Byron Morrison. *New England Journal of Medicine*, 208: 276, 1933. Dr. Codman, although a surgeon, was one of the earliest pioneer x-ray workers and has ever been a staunch ally of roentgenology.

² Editor's italics. *Vide* p. 000.

³ Morrison, L. B., "Diaphragmatic Hernia of the Fundus of the Stomach Through the Esophageal Hiatus." *Jour. Amer. Med. Assoc.*, 84: 161, 1925.

the stomach through the esophageal hiatus. This appeared at a moment of increasing surgical interest in this extremely important condition, the surprising frequency of which, as observed through augmenting accuracy in roentgen-diagnosis, he emphatically stressed. He maintained that the roentgenologist, therefore, is in excellent position to give good advice as to the choice of medical or of surgical treatment, once the diagnosis is established. Morrison's splendid presentation,⁴ a few years later, of the subject of the x-ray diagnosis of vascular calcification, especially in diabetes, was of equal importance. Although the efficacy of the x-rays to this end had long been known, the matter had been rarely studied systematically, and this paper, based on a great wealth of material, was one of the forerunners of modern arteriography. Even at that day, the results of Morrison's work led him to the conviction that roentgen-examination is more valuable than other diagnostic methods in the determination of vascular calcification.

Of Morrison's contributions to the literature of roentgenology, all of them sound, his thorough study of the hip-joint, completed the year before his death, was easily his *chef-d'oeuvre*.⁵ This was presented before his colleagues of the American Roentgen Ray Society. Those who had the honor of participating in the discussion it evoked were especially impressed by its completeness and finish.

Throughout the comparatively brief course of Lawrie Morrison's life as a radiologist, the fine qualities of character that had evinced themselves from his youth were in full flower, calling forth the admiration, respect and affection of all with whom he came in contact. By easy acquisition, therefore, there grew in him the added attribute of fortitude with

⁴ Morrison, L. B., (with I. K. Bogan) "Calcification of Vessels in Diabetes; Roentgenographic Study of Legs and Feet." *Jour. Amer. Med. Assoc.*, 92: 1424, 1929.

⁵ Morrison, L. B., "Study of the Hip-Joint from the Standpoint of the Roentgenologist." *Amer. Jour. Roentgenology*, 28: 484, 1932.

which to endure the weight of the burden his destiny was to lay heavily upon him. His skin was apparently of such type as to resist the *initial* effects of radiation of any kind, for he was in some measure free from the ravages of the acute dermatitis that had assailed so many of his colleagues, but at the height of his active career he sustained deep and painful finger ulcerations that resisted all usual methods of local treatment. The appearance of malignant degeneration of these areas required the amputation, in the autumn of 1929, of the ends of two fingers of the left hand. This loss, a mere triviality in the experiences of these dauntless workers in humanity's cause, cost Morrison not a stride in the march of his useful work. His ever increasing activity continued to the summer of 1930, when he was forced to relinquish another finger of the same hand; now an amputation *in toto*. At this time his private practice and his many hospital activities accupied him more closely than ever; he did not spare himself, as is clearly shown by the fact that some of the finest of his research work was consummated during the course of these months. He was blind to everything but the distress of those who came daily under his expert care; with complete disdain he turned aside from his physical handicaps—a scorn that persisted even though his *right* hand had become involved in his affliction.

Toward the close of the year 1931, Doctor Morrison noted an enlargement and some tenderness of the epitrochlear gland of the left arm. This being a lesion of a lymph-node and not too deeply situated, for a time he attempted to deal with it by radiation methods, but he soon agreed with his surgeon that the loss of his left arm was imperative. Accordingly just before Christmas the left arm was amputated at the shoulder, *as well as* portions of the middle and fifth fingers of the right hand.

What could stay this valorous Aesculapian? Undismayed, he was once more at his work, his gentle ministrations, his

generous and kindly acts, for a period of seven months, during which, in addition, he was in process of completing his investigation of the roentgen-pathology of the hip-joint. In the course of the summer of 1932, a reamputation of the middle finger of the remaining hand was necessary, to be followed in three weeks by a partial amputation of the fourth finger.

But the efficient mechanism of his physical structure could not continue to keep pace with the determination of his spirit and the mandate of his will. Gradually it weakened in spite of the spur of his conscientiousness and sense of duty. In early November, 1932, he was forced to relinquish his work, to which he was never able to return, owing to the inroads of general carcinomatous metastasis.

On 16 January, 1933, Lawrie Morrison died, as a result of his love, pity and solicitude for his fellow-beings in their hour of physical distress and of his insatiable eagerness to succor them at whatever cost to himself.

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XXIII

FREDERICK HENRY BAETJER

1874—1933

IF FIVE and twenty Lords Chesterfield—could that many have been found—had been moulded into one, the resultant concentration might serve by way of comparison to illustrate the affability and personal charm that were Baetjer's. To trace the ramifying courses of his prolific professional life is but to record all possible manifestations of the workings of a keen mind, among which staid verbal expression of his scientific philosophy was commingled with darting sallies of wit and humor. This habit of thought and utterance made of Baetjer an impressive teacher as well as a welcome aid in consultation, and in both capacities he was far-famed.

Doctor Baetjer was born in Baltimore in 1874, a son of Henry and Frederika (Cronhardt) Baetjer. Shortly after his birth his parents removed to Winchester, Virginia, where the days of his young boyhood were passed. His school-life at the Shenandoah Valley Academy terminated with his entrance to Johns Hopkins University, from which he received the Bachelor's degree in Arts with the class of 1897. He was graduated with the Doctor's degree from the Johns Hopkins Medical School in 1901.

Most interesting is the origin of Baetjer's devotion to the medical application of the roentgen-rays, so closely to be associated with the colorful history that attaches to the old "x-ray room" at the Johns Hopkins, wherein the primitive static-machine was rotated or electrical switches were thrown by men whose later lustre in other fields, among them the renowned Harvey Cushing, sheds a retroflective glow upon its aging walls. When routine had become established, it was

customary for the work to be assigned in rotation to one of the house-officers. In due course, this duty fell to Baetjer and thus, in "looking after the x-ray room," was his enthusiastic interest engendered and his career moulded, although there is every possibility that his early leaning toward en-



From the painting by Eric Haupt, 1931

FIG. 51—Frederick H. Baetjer

gineering, which he began to study after his four years of academic work, also furthered his stimulation.

Baetjer spent much of the year 1902 in the radiological laboratories abroad, particularly those of Albers-Schönberg in Hamburg and of Immelmann in Berlin. This visit was the first of a long series of almost yearly journeys to Europe to

observe the application of Continental roentgen-diagnostic methods and to learn, as he once dryly remarked, "what to adopt and what not to adopt."

This was at a time when, at Johns Hopkins Hospital, as elsewhere, the need of an especial department for x-ray work was becoming urgent; consequently, on Baetjer's return from abroad he was formally appointed "Actinographer" to the hospital, a title not altogether relished by him, but not to be changed until 1915, when the general radiological nomenclature now obtaining in the United States was adopted by agreement. As his connection with his hospital lengthened with the years, Doctor Baetjer was successively appointed Assistant, Instructor, Associate and Associate Professor, becoming Professor of Roentgenology in 1921. Always, throughout this *gradatim* advance, he was the virtual and responsible head of his department.

During the earliest years of his radiological experience Baetjer gave much study to the subject of *aneurysm* of the *thoracic aorta*, a pathological condition of the greatest interest to him. He made thorough use of the wealth of clinical material at his command and, in the autumn of 1905, at a meeting of the Johns Hopkins Hospital Medical Society, he briefly differentiated the x-ray appearances in thoracic new-growth, aortic dilatation and aneurysm as observed almost completely by fluoroscopic examination. This preliminary communication was made in his capacity as *assistant in actinography*, a label that may well give pause to the modern roentgenological chief-of-service, surrounded by his perfected organization, should he, perchance, read these lines. Somewhat later Baetjer read his classic paper on thoracic aneurysm.¹ It was essentially an elaboration of his earlier consideration of the subject. This communication, presented at

¹ Baetjer, F. H., "The X-Ray Diagnosis of Thoracic Aneurysms." *Johns Hopkins Hospital Bulletin*, 17: 24, 1906. *Trans. Amer. Roentgen Ray Soc.* for 1906, p. 72.



From Bulletin No. IX, International Association of Medical Museums. (Sir William Osler Memorial Number, Second impression, Montreal, 1927).

FIG. 52.—The Class of 1901, Johns Hopkins Medical School, grouped about the late Sir William (then Professor) Osler. The figure of Doctor Baetjer is designated by a cross.

a period in the evolution of roentgenology when the use of the fluoroscope was passing rapidly into temporary disrepute, was instrumental in establishing a settled conviction that the screen is a necessity in the determination of thoracic vascular pathology—a conviction that even the modern development of long-distance roentgenography has failed to dispel. It was one of the finest of pioneer contributions, crystallizing the elaborate presentation of the subject by Francis Williams² of a few years before. Notably, among Americans, Williams and Baetjer stabilized the superiority of x-ray examination, when alone resorted to, over auscultation and percussion, when likewise alone employed, in the differential diagnosis of thoracic aneurysm.

There can be but little doubt that Doctor Baetjer's loyal support of fluoroscopic procedure, with the extended exposure, especially of the hands and face, that it entailed in former days, was a precursory factor in the acquisition of his radiation injuries. Beginning his roentgen-ray work even before his graduation in Medicine, he suffered at the start from an acute dermatitis. When this subsided, all his fingernails came off with the exception of those of the thumbs.³ His six months rest abroad at the end of his medical school course allowed a reformation of all the nails but that of the right forefinger; this, however, never reformed. "In the spring of 1902, after resumption of work with the x-ray," writes one of his former surgeons, "there was no active dermatitis, but keratotic patches formed on the hands, with the appearance of the usual telangiectatic areas. Gradually the nails became deformed. Up to this time there was little pain, but considerable stiffness in the hands." Although with increasing keratosis, Baetjer pursued his effective and beneficial pioneer work in comparative comfort to the year 1905. That year

² Williams, F. H., "The Value of Examining Aneurisms by the Roentgen-Rays." *Boston Medical and Surgical Journal*; also, *The Roentgen Rays in Medicine and Surgery*, New York, Macmillan, 1901, Chapter 11.

³ *Vide* case of Mr. H. D. Hawks, pp. 9-10.

the annual meeting of the American Roentgen Ray Society was held in Baltimore. It was also Doctor Baetjer's first year as a member. The occurrence was most fortunate, as it gave many of his subsequent colleagues their first glimpse of him. Those of them now alive "will recall to mind without difficulty the active and seemingly omnipresent figure of a gentleman of affable mien and soft speech, as solicitous for the comfort and pleasure of his guests [he was the official host] as if, instead, we had been gathered beneath the roof of his ancestral home. Those of us who had not known him previously soon learned that our gracious host was Baetjer"

To one who had already known Walter Dodd, the personalities of the two men seemed much the same. Frederick Baetjer was quicker of speech and manner, but the ready humor, with the slowly wreathing smile as its forerunner, was alike in both. They had the same storage-capacity for the warmth of friendship. On occasions of scientific assembly it was often not too difficult to find Baetjer seated *outside* the conclave, amid a fascinated group determined to let conversational "joy be unconfined." He was intolerant of the tedium of corporate procedure too deliberate for his mental tempo.

In 1905 appeared the first roentgen ulcer on the back of his left hand and another on the right forefinger. The latter resisted all attempts to heal it and was followed by others in various locations on the same hand, all very painful. "The pain is most intense and is best described as a sharp, shooting neuralgic pain of the worst character. It lasts two or three seconds and occurs from eight to ten times every minute." In 1909, surgical aid was sought for the relief of this pain. As a result, portions of both forefinger and ring finger of the right hand were amputated and many keratotic and small ulcerative areas were excised and skin-grafted, with entire relief of pain. This bodily distress, severe as it had been, did not long disturb the tenor of his professional activity nor the

tractile effect of his magnetic personality which was steadily guiding the course of his efficiency into the two major channels of roentgen diagnosis and of pedagogy.

A good old Scottish adjective has been employed repeatedly to describe Baetjer's powers of diagnosis from the evidence produced by roentgen-rays—uncanny. The speed of his mental processes doubtless contributed to these, but the underlying factor was his sound pathological groundwork, as well as his clinical training under the great Osler. The latter is especially shown by the fact that, with the roentgen evidence on plate (film) or screen before him, "it was his joy and delight to deduce and to reconstruct therefrom the *clinical* picture of the case under discussion, to the fascination of his colleagues and the inspiration of his students."⁴

All biographers of Doctor Baetjer speak of his extraordinary ability as a teacher. Never was this quality more distinctly revealed than during the intensive War years when as a Major in the Army Medical Corps he taught military roentgenology in the service schools established for that purpose. As a lecturer, the rapidity of his diction was amply compensated for by the incisive power of his exposition. Among his students in civil life, the fabric of his pedagogic methods, especially successful in his University work, was strengthened by the intertexture of his personal charm and of his extraordinary skill as a diagnostician. Knowledge may be acquired, but the ability effectively to impart knowledge to others is inborn. Yet this gift, in its formative period, may acquire added refinements through the influence of a brilliant example. Baetjer was one of a great group of men who in their student days had been privileged to sit at the feet of Osler.⁵ Who shall say that in him, once the pupil, were not to be found reflected the talents of the master?

⁴ Dr. Charles A. Waters, *Personal communication*.

⁵ The late Sir William Osler—"one of the most greatly beloved physicians of all time."

It was at the period of Doctor Baetjer's brilliant War teaching that his important paper on bone tumors appeared.⁶ This work, together with that of other representative American roentgenologists at almost the same time, tended definitely to improve the early status, in the literature, of bone and joint roentgenology as a mere appendage of orthopaedic and general surgery. These contributions also represented the emersion of American bone and joint roentgenology from the Continental influence to which it owed much of its earlier development. Baetjer's first publication on the differential diagnosis of bone tumors and his communication of the following year (1919)⁷ on the roentgenology of osteomyelitis were the precursors of his memorable monograph of 1921 in collaboration with Dr. C. A. Waters,⁸ on injuries and diseases of the bones and joints. It hardly needed the effect of this thorough treatise to establish him as the major authority in this branch of x-ray diagnosis, so closely had his name been associated with it since before the War. As a result of his increasing fame, much of his time aside from his routine diagnostic work was required in consultation. Many such requests were sent to him, accompanied by film-records submitted for his scrutiny. On this basis, as once remarked he whose every turn of speech was spiced with humor, "I could very nearly conduct a practice by mail."

Through Baetjer's long established habit of periodical European visits and his powers of accurate observation while there, he maintained close *liaison* between the American and European schools of radiologic practice. These clinical sojourns were invaluable to those who benefited through his ministrations at home, sometimes in a negative

⁶ Baetjer, F. H., "Differential Diagnosis of Bone Tumors." *Amer. Jour. Roentgenology*, 5: 260, 1918.

⁷ Baetjer, F. H., "Osteomyelitis." *Amer. Jour. Roentgenology*, 6: 259, 1919.

⁸ Baetjer and Waters, *Injuries and Diseases of the Bones and Joints*, New York: Hoeber, 1921.

way, for he was by no means committed to European methods. In 1908 he represented the American Roentgen Ray Society at the International Radiological Congress at Amsterdam. His services to this Society were ever valuable, from that memorable day when he so gracefully acted as its host in Baltimore, through its prosperous years of his effective presidency in 1911-12, to the evening in 1929 when, though sorely pressed by his malady, he ably fulfilled his promise to deliver its annual Caldwell Lecture.

Concerning his affliction Doctor Baetjer's mouth was almost hermetically sealed—a trait of silence by which the roentgen pioneer may be identified. Such was the usefulness to him of his special senses that what would probably have been classified by him as a mishap proved to be, in reality, a disaster. The loss of one of his eyes ruined, of course, his power of stereoscopic vision, an aid in roentgen diagnosis that had become more and more valuable. No one can more fully realize what this loss meant to Baetjer than he who daily enjoys the diagnostic advantages of this method of x-ray investigation. He accepted it with the sublime philosophy that was his.

In retrospect, this especial misfortune arises from a vista of *twenty-eight years* of disability and physical distress of a degree, often, beyond depiction, albeit puny attempts have been made here and there within these pages. Both Baetjer and Dodd were fortunate in one respect—the sources of their surgical aid were almost at their elbows and their treatment was pursued as if their surgeons had been their brothers, so great their solicitude and care, so manifest the evidence of their skill. The operative procedures in Baetjer's case, at the time of his death, totalled *over one hundred*—aside from the removal of fingers, a long series of excisions followed by skin grafts, transplantations and transferences. This extended exhibition of the finest of plastic surgery prolonged his life for many years.

Those who for years knew Baetjer well, in the hospital, in the classroom, among his patients, and at the assemblies of his colleagues, might well be convinced that no pen were fluent enough to trace even an outline word-picture of the beauty of spirit of this gallant man of fortitude or the magnetic quality of him, in manner, word and deed. Yet let them read the words of the late Dr. William Sydney Thayer in presenting a portrait of him to the Johns Hopkins University on Commemoration Day of 1932. Although these words have been more than once quoted in part, they cannot be omitted here. To the lover of the memory of Doctor Baetjer and to the lover of the beauties of his native tongue they will make like appeal:

It is a rare privilege to speak . . . in the name of the friends of one who is among the most generally loved of his colleagues—for who is more universally loved than Baetjer!

As one of his former teachers, it seems to me but yesterday that he began his medical studies. A singularly alert and engaging figure, interested in clinical medicine and surgery, he was one of the earliest to devote himself to the applications of the then new Roentgenology to diagnosis. To this study he brought a sound clinical basis and a scholarly interest and understanding. Endowed by nature with an unusually acute, lucid, logical mind, this interest and understanding led him to follow and study the clinical and anatomical histories of his patients, and to associate with clinician and pathologist in such fashion that, as we all know, he has become a diagnostician of rare ability, a recognized leader and an unsurpassed teacher in his special field.

The Department of Medicine has long been in the habit of inviting him to demonstrate and to discuss once a week the roentgenograms in cases of special interest. This he does at first without knowledge of the clinical history or nature of the case, and later, on the basis of the accumulated information.

There are few diagnostic signs in medicine. The truth is to be reached only through keen and accurate observation and examination, the accumulation of such auxiliary information as may be obtained, and the orderly exercise of his powers of reasoning by an observer of sound fundamental training and experience.

These conferences of Baetjer's are impressive—I had almost said incomparable—demonstrations of the power of acute observations, of orderly, logical reasoning, of sound deduction; they are an inspiration alike to student and colleague.

Baetjer was born in an enchanted spot. As he opened his eyes a laughing fairy fluttered over him. Unseen by all but the child, she touched him lightly with her wand, and whispered in his ear a few soft words such as only babies and fairies can hear or understand. That fairy baptism endowed him with an unsurpassed capacity for friendship, an immunity from enemies, and an inward light more potent and penetrating than the rays with which he treats, a light which neither the mists of time nor the leadened cloud of misfortune can dim, which irradiates all about him.

Mr. President, in behalf of a group of Baetjer's colleagues I have the honor to present to the Johns Hopkins University this remarkable portrait from the cunning brush of Eric Haupt. It is a portrait with which one may commune; it speaks. But in one sense, alas, it must remain an eternal enigma, for only the fairy who whispered to him at his birth can understand the words that we can almost see issuing from the parted lips.⁹

"Baetjer's personality radiated . . . such good cheer, even joviality, that it was difficult to detect beneath it any trace of the momentary vexation that might well assail an ardently enthusiastic spirit under the restraint of physical handicaps. His fortitude made him appear blind to the causes and effects of the operative procedures . . . that his injuries entailed. Within his visual fields there was only the race to be run over a course of his own plotting, and the tape to be breasted. His colleagues the world over need [naught] to deepen their insight into this man's character and life. For them, its strength and its accomplishment are written in terms of hindrances overcome, resistances thrust aside, hazards scorned. In its record they see the allegiance to duty, to ideals and to purpose inherent in the fibre of an American gentleman, physician and soldier consecrated to a life of devotion within the cloisters of his beloved university. As she

⁹ *The Johns Hopkins Alumni Magazine*, 20: 337, 1932.

contemplates her service to humanity through the medium of his loyalty and skill, she may well and pridefully perpetuate the memory of one of the greatest of her great alumni."¹⁰

* * * * *

One night, as he lay in sleep, his fairy once again fluttered over him, and again she whispered in his ear—but we can never ask him what she said, because the touch of her wand released him without waking him.

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¹⁰ *Amer. Jour. Roentgenology*, 30: 406, 1933.

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JOHN TOWNSEND PITKIN

1858-1935

OF THE charter members of the American Roentgen Ray Society now living there is probably none that cannot recall to mind the colorful figure of Dr. John Pitkin or the force of his message to them in annual meeting assembled in 1903.¹ By spoken and written word, his practical observations relative to the untoward effects of the roentgen-rays were described to this small group of pioneers in a way that could not but carry conviction, although the enthusiastic ardor of a pioneering era gave scant place to the deterrence of admonition.

Doctor Pitkin was a son of Dr. John and Mary (Townsend) Pitkin. He was born in Palmyra, New York, in 1858, and educated privately in preparation for his entrance to the University of Buffalo to study medicine, from which he was graduated in 1884. In Buffalo he practised throughout the entire course of his medical life which, after the first years following Röntgen's discovery, was in great measure devoted to the "new science" The early onset of his own dermatitis in connexion with his pioneer accomplishments gave him the opportunity to issue the memorable warning to his colleagues for which his name is notable in the early literature of roentgenology. Although Pitkin lacked the modern advantage of radio-transmission by which would have been spread far and wide the wisdom of his admonition and advice had it been intended for lay ears, he amplified for the benefit of the medical profession the earlier premonitions of Thomson, Hawks and others in the engineering journals. This was

¹ Pitkin, J. T., "Danger of the X-Ray Operation." *Trans. Amer. Roentgen Ray Society*, 1903, p. 232.

accomplished by papers that appeared in the medical journals of communities remote from each other, such as the *American Electrotherapeutic and X-ray Era* of Chicago (the periodical succeeding Heber Robarts's *American X-ray*



FIG. 53—John T. Pitkin (From a photograph made in the early day of the roentgen-rays.)

Journal) and the *Virginia Medical Semi-Monthly* of Richmond. These papers were based on his original communication, hereinbefore mentioned, to the American Roentgen Ray Society, meeting at the University of Pennsylvania in 1903. Its members were impressed by his figures of speech and attracted by his poetic diction if, at the moment, not

all of them were convinced by his admonitory argumentation.

It is evident from the sequence of his published writings that Pitkin began his radiological work during the course of the four years immediately preceding the birth of the twentieth century; in other words, he was one of the considerable number of American medical men charmed thus early by the revelations of "a new kind of ray" and intrigued by its very evident value in medical diagnosis and treatment. He was like so many of them in that his enthusiasm tended to minimize his appreciation of the peril latent in his fascinating work. Also from his bibliography it is apparent that he became an early devotee to the use of the influence-(static-) machine as a means of energizing the frail Crookes tubes then in use. It is possible that he may have been won to the illusory theory that roentgen-rays generated from tube-excitation by the static-machine are of an innocuous character. At all events, his first skin-reactions must have convinced him to the contrary and he was prompt to report the course of his radiation signs and symptoms to his assembled colleagues as soon as the evidence was sufficiently comprehensive.

"For purposes of study," as he writes,¹ Pitkin divided the physical action of x-rays on human body-tissues into four clinical stages. The first stage he designates the preparatory stage, or stage of first impression, wherein, as indicative of its subtlety, he describes

... a little change of color of his [the operator's] hands and face. This he may erroneously attribute to the action of the solar rays A few papules or pustules with itching here and there, or bran-like scales, he attributes to a local skin trouble (prurigo, acne or pruritus); a little swelling of the hands and features to a circulatory disturbance; the falling out of his hair to senility—when, in reality, they are caused by the roentgen-rays, which are rendering the integument more and more susceptible to their ac-

tion. Such symptoms should be looked upon as harbingers of an impending storm.

During a long period of increasing susceptibility, the operator may imagine himself an x-ray immune, as if by some special dispensation he, like Shadrach, Mesach and Abednego, can walk in the fiery furnace (of the x-ray field) and not be burned. . . .

In the same metaphorical style Pitkin recites the characteristics of a "premonitory or threatening stage," a "stage of inflammation and disintegration" and a final "stage of chronic skin changes." He describes minutely the objective signs and subjective symptoms pertaining to these clinical "stages" as experienced by himself "after seven years exposure in the x-ray field." Therefore, his analysis of the torments of the inflammatory stage is no flight of fancy, as many of his contemporaries yet alive can testify:

For a description of the pain and suffering . . . no language, sacred or profane, is adequate. The sting of the honey bees or the passage of a renal calculus are painful enough, but are comparative pleasures because, being paroxysmal, they have a time limitation. Extreme tenderness to the slightest touch; hot and cold waves and flashes; warmth, tingling, pricking, throbbing, stinging, crawling, boring and burning sensations, as if the parts were on fire . . . feelings as if the anatomical structures were being moved from one position to another—all of these sensations are proportionate to the depth of the inflammatory process. The parts are irritated by . . . attempts to use them for any purpose. The suffering is also augmented if the affected members are allowed to become dependent, hence the afflicted operator holds his hands high above his head² even sleeping with them in that posture. If the inflammation in his hands is severe, muscular action will be temporarily lost, the fingers immobile. He must be dressed, undressed and fed by attendants. . . .

Whether an attack of erysipelas, sustained in both hands about twelve years previous, predisposed me to x-ray inflammation, modified its course or prevented cancerous *sequelae*, I am unable to determine; certain it is that the two diseases—x-ray dermatitis and erysipelas—have many symptoms in common.

² *Vide* page 148, end of paragraph 1.

This was in 1903. Unfortunately, Fate was to grant this courageous man no such immunity from "cancerous *sequelae*," but for thirty-two long years was to test to the full his spirit and his fortitude.

Without much question this dramatic report of Doctor Pitkin was a potent factor in bringing to an end the favor in which the use of the fluoroscope was held for *all* diagnostic purposes at the beginning of the present century; a partiality among clinicians that had a direct and sinister effect on more than one pioneer career, among them that of the otherwise indefatigable Kassabian, Philadelphia's first martyred radiologist.

It is said that John Pitkin was the first in western New York regularly to practise roentgenology. His fellow charter members of the American Roentgen Ray Society easily remember his energetic personality at the second annual meeting of that body held at Buffalo in 1901. He was one of a strong group of four x-ray workers practising individually but contemporaneously in that section of the state, the other three being Weigel, Johnson and Andrew of Rochester. The life and death of Doctor Weigel are now a part of the glorious history of American Radiology; Doctor Andrew sustained a carcinoma of the left hand resulting in amputation, but it is a satisfaction to note that he is still alive.

The undaunted Pitkin never recovered from the sequential effects of his first radiation injury, the tremendous severity of which he reported so faithfully to the medical world for the benefit of those in his especial field of practice. For thirty-nine years his suffering persisted in varying degree, and always in the direction of that climax of carcinoma which he had dared to hope, at the outset, might be spared him by reason of a previous erysipelas! During these long and difficult years he practised steadily up to within a week of his death, in spite of the fact that, in 1932, the invasion of carcinoma made necessary the amputation of three fingers of his left hand and that

for several months his health had been progressively failing, due to the systemic effect of this disease.

John Pitkin died in the spring of 1935. So ended a life that had been preserved, although sorely afflicted, throughout the history of the development of the roentgen-rays from those days of rumor, report and revelation in early 1896, to the year that is now marking the fortieth anniversary of Röntgen's discovery. Almost his first contact with the "new science" left upon him an indelible mark by which can now be traced the long course to his death. He had no thought of accepting his affliction supinely, but put his bitter experience to a noble use—the education of his scientific co-workers and, through them, the betterment of the disease and distress of others. In addition, he labored for almost the entire course of those fifty years, under the weight of his affliction, in behalf of the sick of his own community, alleviating their suffering by means of the experience gained from his own—an altruistic career sublimely lived and heroically ended.

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FRANCIS LE ROY SATTERLEE

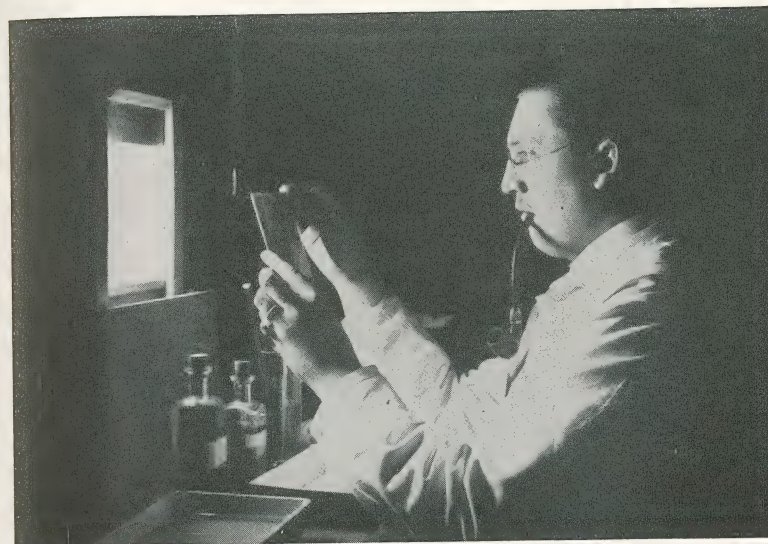
1881—1935

IN RETROSPECTION, the life of John Pitkin recalls to mind the similarity of the honorable career of Le Roy Satterlee. Both of these men among the earliest workers with roentgen-rays, both destined to receive radiation-injuries at a period early enough in the course of their activities to enable them to lay down authoritative rules for the safety of their colleagues, they were permitted a continuance of life long enough to allow them to realize the ultimate salutary effect of their unselfish example on modern roentgen practice, today a dependable implement for good in the hands of the physician educated to its use, and an unqualified blessing to his patient.

Francis Le Roy Satterlee was one of two sons born in the city of New York to Francis Le Roy and Laura (Suydam) Satterlee. His father was a physician of renown who practised in New York for many years. The date of his birth proved to have in more than one way a momentous bearing on his career, for it was on its fifteenth anniversary, in 1896, that he made, as a young boy, the first radiograph—a radiograph of his father's hand—to reveal satisfactory detail in the "shadows" of the bone-structure. This fifteenth birthday of his was but the eleventh day after Professor Röntgen's memorable public *Communication* before the Physical Medical Society of the University of Würzburg. Mentally to recall from the dim past the date of this boy's pioneer effort is to realize the speed with which the report of the great discovery was experimentally investigated throughout the world.

There can be no doubt that this accomplishment in the

early days of his youth tended to develop in young Satterlee a pre-existing leaning in the direction of the natural sciences, as well as to guide his career thereafter, for upon receiving the Master's degree in Arts he continued at the laboratory of the New York College of Dentistry his investigations already begun in his father's private laboratory. Through this contact with his father he acquired a considerable knowledge of



(From a self-exposed photograph, by courtesy of Dr. H. S. Satterlee.)

FIG. 54—Le Roy Satterlee at work amid surroundings (circa 1907) familiar to all contemporary radiologists.

anatomy and physiology and when later he became, as a physicist, the radiologist to the New York College of Dentistry, it was but another of the many posts of usefulness he occupied at that institution from first to last. From assistant to the Professor of Physics, Chemistry and Metallurgy, he became Lecturer on Physics, Lecturer on Radiology, and finally Director of both the Practical Physics Laboratory and the X-ray Laboratory. He received the degree of Doctor of Science during the course of his many teaching activities.

With the enormous advantage of this broad and practical background, Doctor Satterlee made his valuable contributions to the development of dental radiology, beginning in 1904 and culminating in a most instructive monograph under the title of "Dental Radiology" in 1913. While the diagnostic roentgenology of the mouth, teeth and jaws had been the principal teaching and practice of his career, his later experience in general radiology became widened by his service for a number of years as radiologist to the Flushing (Long Island, New York) Hospital, which enjoyed the benefit of his extraordinary technical skill in the use of roentgen-rays until his failing health forced him to relinquish the work entirely.

Doctor Satterlee's physical suffering was that of the roentgen pioneer, to which his spirit was totally immune. For thirty-nine long years of patient fortitude he could not be defeated. The injuries to his fingers were especially distressful, through the effect of the very early custom of holding the diagnostic film in the mouth of the dental patient, a custom wherein the extreme danger to the operator was quickly recognized by him and concerning which he speedily gave frank warning to others, but unfortunately not before he had paid a grievous price for the early experience which prompted the admonition. In 1913 he wrote in words that could not be mistaken:¹

Never, under any circumstances, hold the film in the mouth yourself during the exposure! This caution cannot be emphasized too strongly. The temptation is often great to hold the film in a difficult case, but don't do it! Your hand, in holding the film, receives as much exposure as the patient does, which in itself is negligible, but if you do it once you are apt to repeat it in other cases, and before you are aware of it you have exceeded the limit of safety and will develop a case of dermatitis. The effects of the x-ray are unfortunately cumulative, and an exposure of ten seconds today,

¹ Satterlee, F. L. R.: "Dental Radiology," New York: Swenarton Stationery Co., 1913.

twenty tomorrow and twenty next week, and even ten next month, would have the same effect as one minute exposure at one sitting. There are many of the early operators who have lost their fingers, hands, arms and even their lives, as the result of exposure years ago. . . . Be warned in time and you will find that there is no more danger in radiology as practised today than in photography itself. . . .

Doctor Satterlee was equally forthright in his admonition as to the *general* protection of the roentgen-ray operator. No doubt, as one of the earliest of the pioneers and a physicist as well, he had weighed and tested in his hours of experimentation the various theories put forward as to the actual cause to which the skin damage of the pioneer investigator was due. In fact, he mentions in historical consideration the early and short-lived belief held by many that high-potential discharges from the various inductoria then employed in the production of roentgen-rays were the principal cause of the untoward dermal changes. But in the matter of general protection of both operator and patient he took great care to emphasize the inimical potentialities of the *secondary roentgen-ray* field as an influence which might be very easily overlooked. He warns against such disregard in his exposition of the x-ray tube-shield as a vitally important means of avoiding the results of these emanations:

This . . . piece of apparatus is absolutely essential . . . to the protection of the operator. There are different means of protection. Some operators prefer to cover their own persons with a substance that is opaque to the x-ray, as, for example, a suit of lead armor, thus protecting their bodies. . . . This method is not a good one. You will readily appreciate the discomfort of the operator carrying about with him a heavy suit of lead, and you may rest assured that the instance he is through . . . and has turned his current off, he will immediately strip himself of his lead suit. He forgets that the *secondary rays* that are given off by every object in the room that has absorbed the primary rays, *are still active in the room*, and he therefore submits himself to the secondary radiation which in time may produce even more serious results than those of the primary radiation.

Satterlee then declares parenthetically that he "has made an actual radiograph with the secondary emanations from objects in the laboratory that have received direct x-ray exposure." As the "ounce of prevention" to outweigh the "pound of cure," he asserts that

The best method of protection is not the shielding of the patient or the operator *directly*, but to place a box lined with some material opaque to the x-ray . . . *around the tube itself*, thereby confining all rays, *both primary and secondary*, to the inside of this box or shield.

In the words of this simple statement we read again the gospel of William Rollins, preached and practised ten years previously, yet so quietly and modestly that it was either not heard by many ears or not adequately appreciated, as the need for its repetition by Satterlee bears witness.

A most important point in the technic of practical dental roentgenography to which Doctor Satterlee gave much didactic effort was the matter of dental shadow distortion, inevitable were not careful attention paid to the angle of incidence of the "central ray" upon the structures under investigation. He realized that much of the dental roentgenography of his day was placed in the hands of medical rather than dental roentgen-practitioners, and rightly judged that the former might naturally lack the intimate appreciation of para-dental anatomic relations possessed by the latter as a matter of course. In his monograph, although prepared primarily for the dental student, he paid so much attention to this point that he doubtless anticipated its wide perusal by contemporary medical roentgenologists. Time has proved that this expectation was justified.

It was thirteen years before his death that Le Roy Satterlee was compelled by physical suffering to retire from his multiple radiological activities. This by no means implies that the usefulness of his fruitful life was ended. As Heber Robarts, the physician, turned his attention to the art of healing by means of radium when overtaken by impairment

due to roentgen-radiation, so Satterlee, the physicist, sought in the development of radio transmission, distraction from the sleepless nights that were the common lot of the roentgen pioneers similarly afflicted. During the last years of his life, most of the problems attending his experimentation in this field were worked out from his bed or couch. During the course of ten years he underwent *forty-four* operative procedures on the hands, involving multiple skin-grafts and amputations of two fingers of the right hand. ". . . despite the mounting toll of his operations, he demonstrated his new developments in 'guided radio,' enabling ships at sea to re-transmit programs from a master receiver, before the Bureau of Navigation and Steamboat Inspection in Washington [January 1935]. A month later he conducted tests with an underground wireless antenna that demonstrated, he said, that static interference in the twenty-mile peninsula between Montauk Point and Nepeague Beach was caused by radio-activity that had been brought to Long Island from Labrador during the Glacial Age."²

In the martyrdom of this dauntless scientist is to be found the humanitarianism of a Dodd or a Morrison disseminated with the generosity of a John Pitkin in the interest of those who sat at his feet as pupils. His solicitude for their physical welfare was measured by the eagerness with which he utilized for their benefit the example set by his own injuries. When finally these impaired his usefulness in the field of his early choice, with no thought of renouncement he sought other avenues toward scientific accomplishment wherein he might apply his genius anew.

Dental radiology owes much to this genius of Le Roy Satterlee. Its practitioners owe even more to his intuition, his discernment, his courage and his fortitude. By precept and by example he taught the necessity of precaution, and his sacrifice proved the wisdom of his teaching. Wisdom and

² New York *Herald Tribune*, 4 December 1935.

prophecy alike are revealed in these words of his pioneer days:

"Just as surely as the profession has advanced to what it is, so surely will the time come when every dentist will have to *admit Radiology as an integral and necessary part of his profession*. . . . It is a wonderful agent that has been placed at our disposal, but it should not be abused."

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XXVI

WILLIAM KRAUSS

1861—1935

YET ANOTHER American pioneer of radiology who labored also in other fields of medical investigation, serving all of them well, was William Krauss. His early and keen interest in the x-rays of Röntgen was but an added manifestation of his enthusiasm for all things new that gave promise of beneficial service in the interest of the public health. Yet by this fresh evidence of his zeal he laid the foundation of bodily damage and distress such as had fallen to the lot of the benevolent Pitkin and the unselfish Satterlee, whereof beginning and end were separated by a span of many years.

Doctor Krauss was born in 1861 in Germany, at Reichholdsmühle, near Kaiserslautern in Rhenish Bavaria. His parents were William and Barbara (Müller) Krauss. His elementary education was gained in the town of his birth and at an early age he emigrated with his parents to America, as the pioneers Wolfram Fuchs and Robert Machlett had done, their paths converging, by the ordainment of destiny, toward a common goal of scientific achievement. With the acumen of the German parent who so easily discerns in his offspring the trend of thought or predilection that tends to lay life's course, young Krauss's father encouraged in him the study of pharmacy at the University of Maryland at Baltimore while he, with the boy's mother, proceeded to Memphis (Tennessee) to establish their home. In 1883, as soon as his graduation from the University had been attained, William joined his parents in Memphis, and three years later entered the Memphis Hospital Medical College, which he attended for a year. During the years 1887 and 1888

he was a student in the Medical Department of Washington University at St. Louis, and the ensuing year received his degree in Medicine from Memphis Hospital Medical College. This was followed by post-graduate study at the renowned Universities of Kiel and Würzburg in the land of his birth.

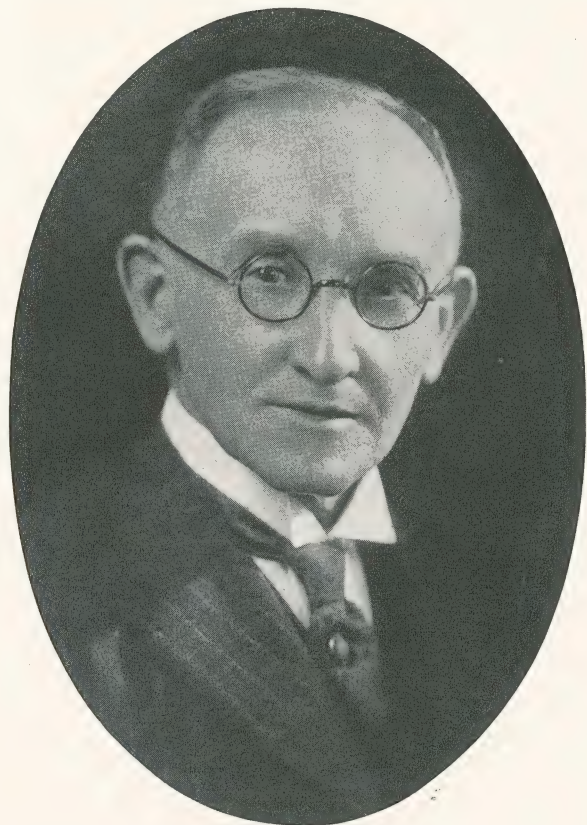


FIG. 55—William Krauss.

In possession of this sound training Doctor Krauss returned to Memphis to engage actively in laboratory practice and to identify himself at once with the rapid technical developments of bacteriology, pathology, tropical medicine and the public health. As the years passed, the reputation acquired by Krauss as a technician and diagnostician in

these branches of medicine widened until it embraced the entire South. Especially did his researches in the subject of malaria achieve for him a standing of authority. His earlier days in Memphis were shadowed by the deaths of his father, his mother and one of his sisters during the early yellow-fever epidemic there. This misfortune spurred his activities in matters of the public health relating to this disease. With energy apparently limitless he fulfilled his duties as City Physician as well as of Acting Assistant Surgeon in the United States Public Health Service throughout the epidemics of 1897 and 1905. His research resulted in the publication of at least two authoritative papers on the subject of yellow fever and of endemic fevers in general.^{1,2}

Doctor Krauss's interest in malaria and his work on the subject of its investigation by laboratory methods is evidenced by the number of his contributions to its literature almost from the time of the discovery of the *plasmodium*. No less than sixteen papers are revealed in his bibliography from 1891 to 1932. During the latter year he published an analysis of the reports of over eight thousand cases of this disease induced by inoculation in paretics as a therapeutic measure.³

It was inevitable that the first reports of the discovery of Professor Röntgen should quickly reach the alert ear of this former postgraduate student of the University of Würzburg. Imbued for years with the spirit of investigation, he became instantly enthusiastic. He was the first in his community to possess himself of the rude roentgen-ray apparatus then obtainable, even as he had been previously the first to use an oil-immersion objective lens for the microscope. As a result,

¹ Krauss, W.: "Yellow Fever; its Cause, its Prevention, its Cure," *Memphis Med. Monthly*, 18: 301, 1898.

² Krauss, W.: "Southern Fevers," *Jour. Amer. Med. Assoc.*, 41: 86, 1900.

³ Krauss, W.: "Analysis of Reports of 8,354 Cases of Inf-Malaria," *South. Med. Jour.*, 25: 537, 1932.

his services were sought from far and wide as soon as the extraordinary powers of the roentgen-rays became generally recognized. For about ten years his investigations in this new science were added to his many activities in other fields. The therapeutic application of roentgen-rays interested him especially, as is shown by his contribution to the literature of this subject as early as 1903.⁴

Doctor Krauss's constant use of the hand fluoroscope in connection with his early roentgen-ray investigations was consistent with the practice of the day—not merely for the purpose of diagnostic information, but for the necessary and inevitable testing of the Crookes tube as well. The result was that he incurred very soon the damage to the dorsal skin of the left hand that was of such common occurrence among the contemporary pioneers. Although the dermatitis was in abeyance at the period of Krauss's relinquishment of roentgen-practice and for a time thereafter, the lesions later became especially painful without sign of amelioration. He abandoned his work with roentgen-rays not because of any apprehension of physical consequences, but on account of the demands of his duties in other branches of medical investigation. In spite of this, the local effect of his ten years of exposure slowly augmented. After a long period of chronic suffering which did not sway this determined man from his salutary efforts in the interest of the public health, it became necessary to amputate three fingers successively in an effort to arrest the extension of a process of disease that had become definitely malignant in character, but all effort was unavailing. Metastatic extension progressed inexorably, and ultimately, no less than thirty-eight years after his initial exposure to roentgen-rays, the intrepid William Krauss died of general carcinosis.

"I know of no other case," writes his successor in the

⁴ Krauss, W.: "Therapeutic Value of the Roentgen Rays," *Memphis Med. Monthly*, 23: 416, 1903.

practice of radiology at Memphis and his friend of many years,⁵ "that has resulted fatally from exposures received so long ago." The histories of the pioneers Baetjer, Pitkin and Satterlee suggest parallels, to be sure, but in no other case, as far as has been learned, has the fatal ending so long followed the date of the *last exposure* to the emanations of the Crookes tube which, in this instance of William Krauss, was twenty-seven years.

Few men have served humanity in so many ways. The magnet which drew him into the many especial fields in which he worked so indefatigably was always the public health—the common good. Ironically enough, the branch of science to which he gave the least attention, in point of years, was the one that demanded of him the greatest of all sacrifices.

"His entire life was a search for knowledge that would benefit others." What words could more adequately serve as the legend for the picture of this worthy career?

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⁵ Dr. W. S. Lawrence, *Personal communication*.

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XXVII

GARNER FORESMANN PARKER

1894—1935

AFTER the manuscript for this book had been submitted for publication, after, indeed, the greater portion of it was already in press, notice was received of the death of this physician "as a result of a lingering illness caused by x-ray burns." Doctor Parker was graduated from the Hahnemann Medical College of Chicago with the Class of 1912 and, so reads the report in the *Journal of the Iowa State Medical Society*, "had long been a member of the Pocahontas County Medical Society."

THOUGHTS IN CONCLUSION

NO HOPE could be more earnestly expressed than that these distinguished lives, which herein have been touched upon perforce so incompletely, yet with memory undimmed by the passing years, might have comprised the entirety of American sacrificial fidelity to one of the most fascinating of the sciences. A realization that this could not be has added zest to a quest for dependable, even if meagre, records of added examples of like tenacity to the same cause. Many names which in other days were connected less prominently, perhaps, with the development of roentgenology are now well-nigh forgotten. To the careers of others there is today but rare reference, even by those who profess to have known them well. So quickly close the occasional rifts in the thickening murk of Time that we are enabled to obtain but momentary glimpses of such lives as those of the ill-fated August Luschka, the Chicago electrologist, of the warm-hearted Robert Friedlander, famous in the tube-making industry, or of the versatile therapist, Monell, or of the earnest investigators Hough, Lee, Snow and McIntosh.

Whether such pioneers as these were luminous figures or not, whether or not the details of their accomplishments may have been forgotten, the fact remains that all of them in life gave much, all of them in death gave more, to the science they embraced and then helped to evolve—at first in hope, then in faith and finally in confidence. They became enamored of their work for reasons too subtle, perhaps, easily to define at the time of its inceptive stage; yet later they had but to look, for answer, at the record of their accomplishments; then it would have become apparent that the allurements might have been due to at least two influences: first, to an appeal to the imagination created by the element of romance surrounding the discovery of the roentgen-rays; second, to the prompt and unmistakable implication of scientific exactitude that attached to the first revelations of

the "new science," suggesting to the physicist unlimited possibilities in further research and, to the physician, increased accuracy in diagnosis as well as another, and most potent, addition to the *armamentarium* of treatment.

Experience has ever been the most enlightening of teachers, and from the bitter experience of the martyrs to science through the roentgen-rays much has been learned and much yet to be learned. One lesson already learned by the successors of these pioneers in the same field of humanitarian endeavor is the lesson of self-protection and thereby self-preservation. "Happy is he who gains wisdom from another's mishap."¹ The mishaps that are now a sombre part of the history of the roentgen-rays have created an instinct for protection in the modern worker with them. Obedience to this intuitive sense has resulted in our erection of a bulwark against the inimicalities of this potent force and the placing of resistances in its path that forestall all danger. The operator and the patient now share total immunity from its adverse effects, which has made possible a wider application of its blessings. Those pioneers who yet live and still carry the marks of the roentgen-rays will do so until the end of their allotted days. When the last individual shall cease to exist, the species will be extinct.

Today there is no process of diagnosis in medicine that can be regarded as complete without recourse to the x-rays of Röntgen. There is no especial branch of science of broader usefulness in the relief of human ills. This has been brought about through the concentrated effort and devotion of hundreds, nay, thousands of men and women who continue to work with a vigor and a spirit which can mean but one thing—that they are imbued with the humanitarian impulses they have instinctively gained from the example of the martyrs to Science through the roentgen-rays.

THE END

¹ "Feliciter sapit qui alieno periculo sapit." Publilius Syrus, *Sententiae* No. 825.

GLOSSARY

A SHORT GLOSSARY, especially for lay reference, of the more common scientific terms used in this book.

Accumulator	A storage battery for the accumulation of electrical energy; also known as a secondary battery.
Acromioclavicular	Pertaining to the anatomic relationship of the acromion process of the scapula (shoulder-blade) and the outer end of the clavicle (collar-bone).
Adnexa	In anatomy, appendages or adjunct parts.
Aesculapian	Pertaining to Aesculapius, the god of Medicine, or to the art of Medicine, or to a disciple of Aesculapius.
Aneurysm (-ism)	The swelling of an artery due to the stretching of its walls. It may be caused by injury or by the weakening of the walls through the degenerative changes of chronic alcoholism, Bright's disease, syphilis and other diseases.
Anode	The positive pole of a galvanic battery or other source of electricity. In radiology, the anodal terminal of the Crookes tube is electrically connected with the "target," which receives the impaction of the electronic "stream" from the cathode.
Aorta	The main trunk from which the entire arterial system proceeds.
Articulation	In anatomy, a joint or an arthrosis.
Axilla	The technical name for the armpit.
Barium platinocyanid	A double salt of barium, $\text{BaPt}(\text{CN})_4\text{H}_2\text{O}$, used in finely divided crystals for coating the screen of the fluoroscope.
Bleb	Any bulla or skin vesicle filled with fluid.
Bombardment	In physics, the impingement upon the surface of a body of small particles or rays; especially, in the roentgen-ray tube, the cathode stream upon the face of the anode or target.

GLOSSARY

Brush discharge	The brush-like, luminous electrical discharge which occurs between conductors or terminals charged to high potential (voltage) when no spark can pass.
Calcium tungstate	A crystalline substance, CaWO_4 , used for coating the screens of fluoroscopes.
Calculus	An abnormal concretion occurring within the animal body and usually composed of mineral salts.
Calculus nephritis	A form of chronic inflammation of the kidney secondary to or associated with the presence of urinary calculosis.
Carcinoma	A malignant tumor or cancer; a new-growth made up of epithelial cells tending to infiltrate and to give rise to metastasis.
Cathode	The negative pole of a galvanic battery or other source of electricity; in the structure of a roentgen-ray tube, that part from which the electronic emission takes place to meet the target at the focal point thereon.
Cautery (actual)	The application of an agent that actually burns the flesh, such as fire, a lens, a red-hot iron or the moxa.
Conjunctiva	The delicate membrane that lines the eyelids and covers the eyeball in front.
Cornea	The transparent structure forming the anterior part of the external layer of the eyeball.
Crookes tube	An exhausted vacuum tube, bulb or otherwise formed chamber of glass, in which the rarefaction is carried to such a degree that molecular actions have free play. Sir William Crookes (1832-1919) demonstrated that within such a chamber there was a rectilinear radiation from the cathode which was a projection of particles of highly attenuated gas at exceedingly high velocity. He called this radiation <i>cathode rays</i> . He concentrated these rays at the focus of a concave cathode, and by this means was able to produce brilliant fluorescence and a very high temperature both at the walls of the tube and in various substances within it. From this point of impact on the tube-wall Röntgen discovered

	emanations possessing new characteristics which he called <i>x-rays</i> .
Cryptoscope	The name given by Salvioni, of Perugia, to his tubular device for observing the phenomenon of fluorescence.
Curet Curette	A kind of scraper or spoon for removing growths or other matter from tissue; hence curettage: the use of, or treated by, the curet.
Degeneration	Deterioration; change from a higher to a lower form; especially in medicine, change of tissue to a lower or less functionally active form.
Dermal	Of, or pertaining to, the skin.
Dermatitis	Inflammation of the skin.
Desquamation	The shedding of epithelial elements, chiefly of the skin, in scales or sheets.
Discharge-chamber	That part of an x-ray vacuum tube wherein the stream of cathodic particles meets the face of the target (anode).
Dorsum	In anatomy, the back, also any part corresponding to the back in position, as of the foot, hand, tongue, etc.
Dyspnoea	'Shortness' of breath; difficulty of respiration.
Epidermoid	Resembling, especially in the histological sense, the epidermis or outer skin.
Epidiagnosis	A form of fluoroscopy wherein the focal source of x-radiation can be moved or adjusted simultaneously with a pointer or marker against the patient's skin or the face of the screen.
Epilation	The removal of hair (by the roots) by any agency.
Epithelium	The covering of the skin or mucous membranes, consisting wholly of cells of varying form and arrangement.
Epithelioma	An epithelial cancer; a malignant tumor consisting mainly of epithelial cells and primarily derived from the skin or mucous surface.
Epitrochlear gland	A small lymphatic gland in the immediate region of the elbow articulation.

Escharosis	The process of producing a slough by burning or by corrosive action.
Excise	To cut out or off.
Excision	An act of cutting away or taking out.
Exfoliation	Scaling off, especially of surface skin tissue; desquamation.
Fissure	Any cleft or groove, normal or otherwise.
Fluorescence	The property certain bodies, especially organic fluids and solutions, and certain minerals, manifest when irradiated; the light they emit differs in wave-length from the light they absorb.
Fluoroscope	A device used for examining organic and inorganic structures by means of the roentgen-rays. It consists of a plane surface (fluorescent screen) covered with fine crystals of calcium tungstate, or, now less frequently, of barium platino-cyanid.
Follicle	A very small excretory or secretory sac or gland.
Fulguration	Destruction of animal tissue by electric sparks of varying intensity, the action of which is controlled by a movable electrode.
Gland	An organ that separates any fluid from the blood; such ductless bodies as the spleen, the lymphatic organs, etc., which do not appear to secrete anything, are also called glands.
Hyperaemia	Excess of blood in any part of the body.
Hyperaesthesia	Excessive sensitiveness of the skin or of a special sense.
Hypermetropia	Far-sightedness.
Induction	In physics, bringing about of an electric or magnetic state in a body by proximity (without contact) of an electrified or magnetized body.
Induction-coil	Apparatus for producing electric currents by induction.
Induration	The quality of being hard; the process of hardening. An abnormally hard spot or place.
Integument	The covering of the body; the skin.

Interrupter	A device for making and breaking an electrical circuit at regular intervals.
Intrathoracic	Situated within the chest or thorax.
Keratosis	Any horny growth, such as a wart or callosity; any disease attended by horny growths. Hence, hyperkeratosis: hypertrophy of the corneous layer of the skin, or any disease characterized by it.
Lesion	Any hurt, wound or local degeneration.
Lupus	Used in the sense of <i>lupus vulgaris</i> , a tuberculous disease of the skin and mucous membrane, marked by the formation of brownish nodules in the corium.
Maceration	The process of softening by soaking.
Mediastinum	A median septum or partition, especially the septum formed in the middle line by the approximation of the two reflected pleurae, which divide the chest into two pulmonary cavities.
Mercury pump	A form of dynamic pump invented by Sprengel (1865) which exhausts air from a given vessel through the action of the fall of a column of mercury in a vertical tube the lumen of which is connected with a vent from the vessel.
Metacarpal	Pertaining to the metacarpus (the group of five cylindrical bones extending from the carpus to the fingers; also that part of the hand in which these bones are placed).
Metatarsal	The analogous group of bones in the foot.
Metastasis	The transfer of diseases from one organ or part to another not directly connected with it.
Myopia	Near-sightedness or short sight.
Necropsy	Post-mortem examination; autopsy.
Necrogenic	Having origin in dead matter.
Nodule	A small boss, node, swelling or protuberance.
Oedema	Swelling due to the accumulation of fluid in the tissues or cavities of the body.
Orthopaedic	Pertaining to the correction of deformities; pertaining to orthopaedics.

Papilloma	An epithelial tumor in which the cells cover finger-like processes or ridges of stroma. Includes warts, condylomata, cutaneous horns, etc.
Pathology	That branch of Medicine which treats of the essential nature of disease, especially of the structural and functional changes caused by disease.
Periosteum	The tough fibrous membrane surrounding a bone.
Phalanx Phalanges	Any bone, or all the bones, of a finger or toe.
Pleura	The serous membrane that invests the lungs, lines the thorax and is reflected upon the diaphragm.
Potential	In electrical parlance, the pressure, electromotive force or voltage, of a current.
Pulmonary	Having to do with the lungs.
Radiograph Roentgenograph	A graph or delineatory record obtained by the action of the roentgen-rays on the salts of silver embodied in the gelatin emulsion of a film. The term "x-ray photograph" is a misnomer because the records obtained are not the result of solar light, which is usually understood when the Greek $\phi\omega\varsigma$ is used in any combination.
Radiology	The science of radiation, in any form.
Roentgenology	The science of roentgen-radiation or x-radiation, as applied to medical diagnosis, therapy with roentgen-rays or roentgen-rays applied to the industrial arts.
Sebaceous	Pertaining to the production of fatty matter, with especial reference to the sebaceous follicles and ducts of the skin.
Scalpel	A small, light knife used in surgery.
Skiagraph Sciagraph	A graph or delineation of a shadow (Greek $\sigma\kappa\iota\alpha$) made by the action of the roentgen-rays; this word is obsolescent, but when in common use it was infinitely preferable to the piebald "x-ray photograph."
Skin-grafting	The implantation of healthy skin (in various ways according to the method employed) to form centers of healing on skin-denuded surfaces.

Sphygmomanometer	An instrument for measuring the blood-pressure in the arteries.
Squamous-cell tumor	A type of malignant tumor in which the cells are scaly or plate-like.
Static-machine	An apparatus which converts mechanical energy directly into electricity at suitable potential for use with x-ray tubes, by means of rapidly revolving discs of glass or mica (laminated). An electrical charge is produced upon the surfaces of the revolving plates, collected from them by means of toothed "collecting combs" and is led out of the enclosure of the machine to terminals for use. A static-machine is also called an influence-machine, although not with precise accuracy.
Supraclavicular	Situated above the clavicle.
Target	The anodal metallic plate of a roentgen-ray tube upon which the electronic bombardment impinges and from which roentgen-rays are emitted.
Telangiectasis	Dilatation of the capillaries and smaller blood-vessels, producing a form of angioma.
Therapeutic	Pertaining to the art of healing; curative.
Thorax	The chest; the part of the body between the base of the neck and the abdomen.
Trypsin	The main proteolytic ferment of the pancreatic secretion, converting proteins into peptones.
Ultraviolet rays	Those invisible rays of the spectrum which are beyond the violet rays; they vary in wave-length from 4000 to 200 Ångstrom units.
Ureter	The fibro-muscular tube which conveys the urine from the kidney to the bladder.
Urinary lithiasis	The formation of urinary calculi and concretions in the kidney, ureter or bladder.
Vascular	Pertaining to, or full of, vessels. Blood-vessels are usually implied.
Vesicle	A small bladder or sac containing fluid; a small blister.

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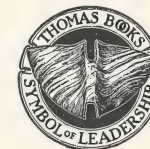
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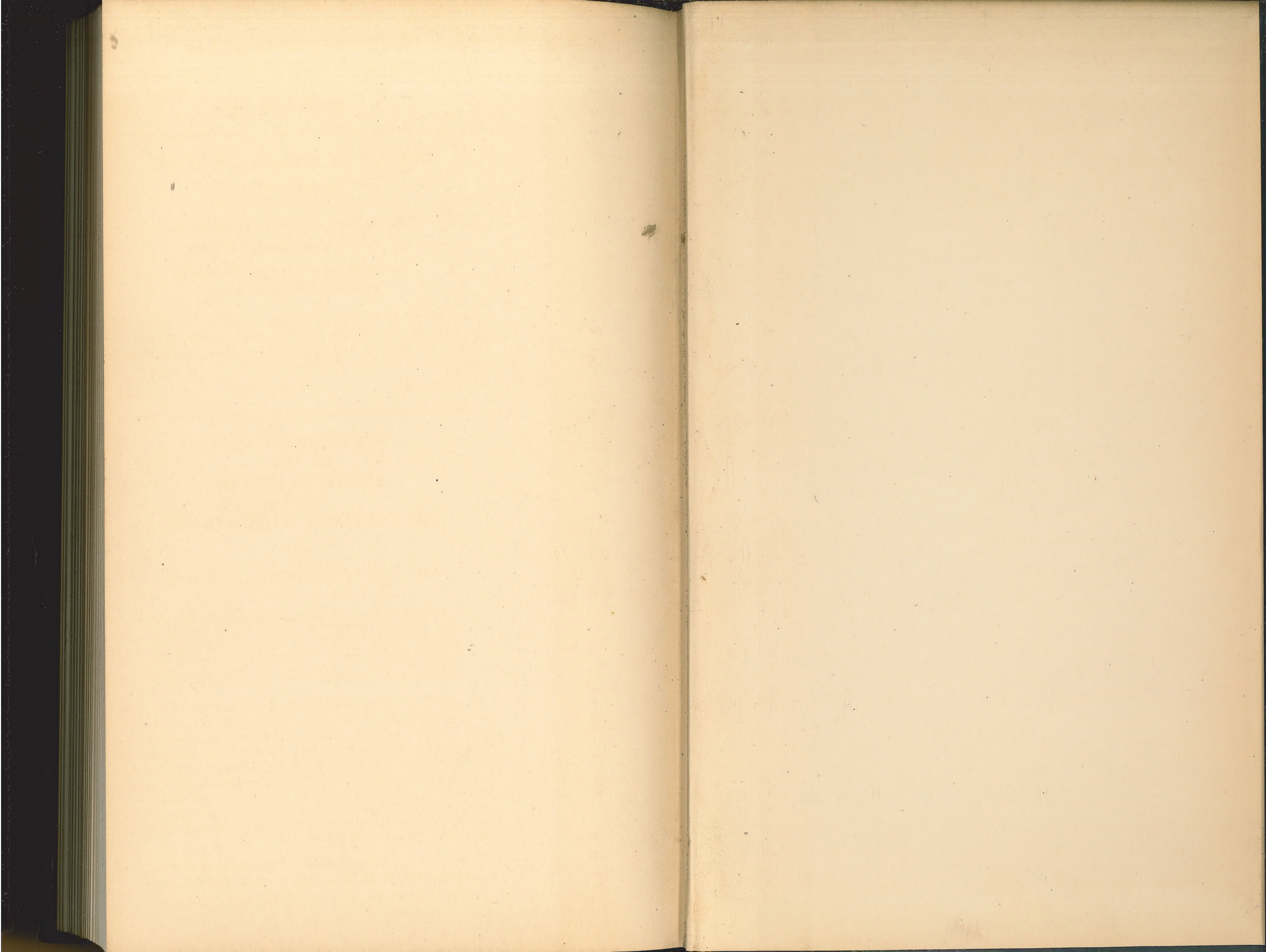
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