The Protection of the Roentgenologist

BY

CHARLES LESTER LEONARD, A. M., M. D.,

of Philadelphia.

The powerful physiological action of the Roentgen Rays has been demonstrated by clinical experience in its therapeutic application and by serious accidents to patients and operators. The care essential to the protection of patients has been carefully studied and diagnosis and therapy have been rendered safe in the hands of experts. Accidents are now no more frequent, when this agent is employed by those fitted to use it, than those from any other therapeutic agent of equal potency. Rules and limits of safety have been determined which render accidents rare and the more serious are now only found in the hands of students and this includes many practitioners who are attempting to employ this powerful agent, whose potency they cannot comprehend, with little theoretical and no practical knowledge or experience. This is the grave danger of Roentgen therapy at the present time. Its mysterious and powerful action, its brilliant results, are leading many practitioners to attempt its employment in their own practices. The majority acquire no theoretical knowledge and their clinical experience is limited by their own cases suitable for experimentation. Their results are necessarily poor and injure the name of Roentgen therapeutics. The practitioner should be warned against the employment of this agent unless he is willing to devote sufficient time to acquire technical knowledge and clinical experience. The general medical public should be warned not to entrust their patients to those inexperienced in employing it safely and effectively.

The novice is fearful of producing ill effects and hence produces none. He prefers to employ inefficient dosage protracted over long courses of treatment rather than court invisible dangers.

The insidious manner in which it acts upon metabolism, and by repeated though minute doses lowers the vitality and sets

up retrograde changes in the operator, seem impossible to him. A seeming disbelief renders more experienced operators careless. They are immune to its action. It may be dangerous for others but not for them. Because they cannot see immediate effects they cannot appreciate that any injury is being done. The earlier operators had the excuse of an ignorance that was common to the whole scientific world. They exposed themselves freely for experiment and scientific research. The injuries they suffered were not manifested for four or more years. The operator of to-day who has had only four or five years' experience, and has in a measure protected himself, feels certain he will suffer no ill effects. His dose has been less powerful, it probably will not manifest its ill effects so speedily, but if he continues to expose himself to repeated though minute doses, the injury though slow in appearing may be more chronic in course and more resistant to treatment.

The warning of past experience has not been heeded. Accidents to operator continue to be reported though fortunately they are less severe. It is true that rules and limits that will insure safety should be determined, that the consensus of opinion by experienced operators should be expressed, so that the inexperienced and the careless expert may follow and their protection be certain.

Many Roentgenologists have determined rules and methods of protection which seem sufficient. Many devices are offered by the manufacturers that are apparently safe, others are of questionable value, while others are totally valueless and by engendering a false sense of security lead the operator into grave danger. One of the most notorious of these fallacies was the claim made at one time that a static machine could not produce a "burn."

Before discussing the various methods and means of protection the earlier symptoms that should warn the Roentgenologist of his danger ought to be mentioned. The clinical picture of the operator's later sufferings has been depicted and not exaggerated by writers in this and other countries. Perhaps the earliest manifestation is the trophic dermic changes that take place in and about the nails. These become ridged and brittle, breaking when an attempt is made to cut them. The skin becomes glazed and pink about the matrix and on the dorsum of the

fingers extending to the back of the hand. The skin becomes thickened and deeply wrinkled. About the joints the wrinkles deepen into cracks and finally form indolent, unhealthy ulcers with grayish base and no tendency to form healthy granulations. In the later stages the margins of these ulcers, if subjected to further irritation, may take on a hypertrophic growth becoming swollen, thickened and tender. Callous corn-like patches appear at points which seem symmetrical in various individuals.

The prophylactic treatment by protection and prevention is by far the most valuable. The nature of these lesions has not, however, been rightly appreciated and the treatment applied has often increased and aggravated the injury. The serious results have perhaps not been due so much to the pathologic character of the primary lesion produced by the Roentgen rays as to the irritation of treatment. They are in a great measure, if not wholly, due to meddlesome surgery and the ill-advised prescribing of sufferers and their solicitous friends. The Roentgen lesion is trophic, one of lowered vitality incapable of re-acting to ordinary stimuli or of renewed growth and healing. The visible lesion is a localized area surrounded by tissues of such low vitality that any added trauma results in their death. The folly of attempting to heal such lesions by methods and means used in areas capable of re-acting and surrounded by healthy tissues is self-evident. Many a sufferer has however yielded to the curette, to excision and to skin grafts upon unhealthy devitalized tissue. There is no excuse but ignorance of the nature of the lesion for such surgery. Is it to be wondered at that these half-dead tissues refused to re-act, that the ulcerated area increased and that hyperplastic growths often engrafted themselves upon its margins. The Roentgen rays certainly provided the predisposing cause, but the surgeon has too frequently added the irritating stimulus that caused or at least hastened the development. The same can be as truly said of the many ointments, powders, cauterants and lotions that have been prescribed. They have all added their quota to intensify the irritation and increase the devitalization. The pain suffered by the patient has been temporarily relieved by drugs that increase the injury done to the nerves. It seems impossible that these further insults and injuries to such devitalized tissues should have been offered by thinking clinicians with any expectation that healing and recovery could follow.

It is to be hoped that the chronic character of these lesions will point out to the profession their trophic nature so that they will refrain hereafter from further injuring in any attempt to induce immediate healing.

A realization of the trophic nature of these injuries and that the tissues that surround them are devitalized and deficient in blood supply, leads naturally to the first principle of rational treatment.

Do nothing that will further injure the terminal trophic nerves or further exhaust them by calling for increased action. Until the larger areas, as well as the visible lesion, recover from the injury to their nutrition they are incapable of reacting and healing. Protective measures with asepsis and possibly mild antisepsis are indicated. Letting nature alone is the surest if not the speediest method of securing a return to normal vitality and repair. The hands should be protected and kept warm. The aseptic dressing should never be tight as this obstructs circulation and causes pain. Immersing in hot water as hot as can be borne, two or three times a day will relieve pain and increase the circulation. Ointments to soften the skin should only be applied sparingly, as their extensive use will lead to ulcerations beneath the callous areas. Particularly should ointment be avoided that contains coal-tar derivatives having local anaesthetic properties, especially those containing acetanalid, antipyrine or of unknown chemical composition. The temporary relief from pain does not compensate for the further injury done to the nerves. Relief from pressure and hot soakings are more valuable in relieving pain and are not injurious. These precautions apply equally to the earlier and later stages. The use of rubber gloves prevent the irritation of photographic chemicals and antiseptics, while care should be used in selecting toilet soaps employed. Those containing an excess of animal fat are most soothing.

The best therapeutic measures are the prophylactic. This is particularly true of these injuries and it is with the purpose of determining through discussion what are the best methods of protecting the operator that this subject is brought before you. The invisible therapeutic activity of the Roentgen Rays is potent for harm as well as good. The Roentgenologist should most carefully guard against the injurious action of oft-repeated minute doses. It is possible that only some of its serious effects have

been so far demonstrated. It is impossible for the author to enter in detail into a discussion of all the means of protection, nor is it his province to discuss the relative value and merits of protective methods and devices which have been brought forward. The principles which should underlie the protection of patient and operator will be discussed, while various devices which he has employed will be alluded to and that which seem to him most satisfactory will be described. The variations in form of apparatus and the requirements of the individual practitioner are so manifold that forms adaptable to the needs of each are necessary, but the underlying essential principles of complete protection for patient and operator can be so clearly determined by open discussion that they will form a guide by which operators and students can protect themselves from the dangers consequent to the employment of this powerful yet invisible therapeutic agent.

Since the source of danger is the active Roentgen tube and the active agent is the rays emitted from it, or the secondary rays produced within it, the first principle of protection seems to be to limit the field of emission of these rays. As the source of rays has been approximately determined to be a point within the tube the nearer the media limiting the radiations is brought to their source the smaller it can be and consequently the thicker for a given amount of material. Substances, however, that limit these radiations to any great extent are unfortunately weighty and are also conductors of electricity and hence in a high potential field must be insulated by air space. The protecting shield must, therefore, be at a distance greater than the equivalent air resistance of the tube, or where shields are introduced within the tube they must not decrease its internal resistance. Unfortunately the introduction of efficient shields within the tube is made difficult because of the impossibility of properly exhausting the occluded gases from the metal composing them. Thus the problem practically resolves itself into effective protection outside the tube as close to it as practical when its variations in resistance are considered. The substance which is the most obstructive to the rays is lead, which is of great specific gravity. It is possible to stop the majority of rays by reasonably thin sheets of this material, by bismuth and by materials containing salts of these metals. Unfortunately we do not know the effects of the more penetrating rays or whether they are or are not injurious. It is, there-

fore, necessary for complete protection to employ lead of considerable thickness. Perhaps it is safe to cut off only the less penetrating rays, but it is certainly safer to cut off all that it is possible, till the more penetrating have been proved to be innocuous.

The secondary, and what have been termed vagabond rays, have shown their effects upon the photographic plate and it is, therefore, necessary to safety that both operator and patient should be protected from their action. The protecting shield must, therefore, encompass the entire active hemisphere of the tube. This must include the area above the cathode and because of the vagabond rays practically the entire tube. The practice of some operators of working behind a lead screen with an open or semi-protected tube is unsafe, because familiarity breeds carelessness, and while the occasional exposure may not result in visible injury such exposures will certainly become more frequent with results that are certain to be serious. Such precautions, and observations of the tube from a distance by means of suitably arranged mirrors are valuable methods in addition to properly protected tubes, but should not be depended upon to protect the operator and do not in any way limit the area irradiated and thus protect the patient. The necessity of limiting the area of irradiation in patients under examination has been made evident by the serious results produced, especially in cases of faulty metabolism, by exposing too great an area to the influence of this agent.

These considerations make it evident that both for the protection of the operator and the patient the field of Roentgen radiation ought to be confined to the part to be examined or treated. The limiting of this field by the introduction of shields within the tube has only been accomplished by decreasing the efficiency and life of the tube. The same can be said of shields that fit closely to the tube, for by confining the radiations they increase the heat within the tube and render its resistance variable. Tubes are manufactured of lead glass with transradiant windows. They are open to the objection common to all shields of lead glass; that is, they are readily penetrable by rays that will affect a photographic plate. A Roentgenogram of such a tube shows anode and cathode, as well as areas of increasing density depending upon the varying thickness of the bulb as pro-

jected on the plate. They perhaps should have a use in therapeutic work where only rays of low penetration are employed. They cannot, however, be considered absolutely safe and when employed by the author are always surrounded by other means for intercepting the rays.

The author's experimentations in the line of protection of the operator have thus led him to conclude that the only safe protection is metallic lead of at least a thickness commercially known as 6 lbs. to the square foot over the active hemisphere of the tube. He employs in addition a protecting screen of equal thickness covering the switches, interrupter, etc., so that the tube can not be made active while the operator is within its field of irradiation. The tube is observed in mirrors placed in convenient positions. The tube is placed within a box of metallic lead closed on all but the upper side and one end, the anodal end. This sheet lead is three pounds to the square foot and double over the active hemisphere. The box is twenty inches in length, twelve inches deep and twelve inches wide. This permits an air insulation of six inches, giving a possible variation in vacuum sufficient for practical purposes. The bottom is made of the same thickness of lead with diaphragms of convenient size. The entire tube, including the spark gaps of self-regulating tubes, as of the Queen or Müller tube, is enclosed within the box. Connections to the secondary circuit are made by means of springs, so that tubes can be readily changed without attaching wires. The entire box weighs a little over fifteen pounds, and is suspended by double pulleys and a counterbalancing weight from an overhead track. This adjustment permits it to be readily placed in any position over the recumbent patient and to be raised or lowered at will. Its weight insures steadiness and excludes all vibration. The diaphragms cut off all secondary and vagrant rays and increase definition. Its chief defect is its weight but this is counterbalanced by the safety which it insures.

The conclusions arrived at by the author are therefore:

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

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

3. 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.

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

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

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

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

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

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

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

11. 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.

Protection of Patient During Roentgen Exposure

RUSSELL H. BOGGS, M. D.
Pittsburgh, Pa.

The danger to the patient of prolonged Roentgen exposure has attracted considerable attention from the medical profession, and as it is apparent that conclusive data is obtainable upon this subject, the Executive Committee requested me to collect something definite for this meeting. Therefore, I will bring this very important subject before you for discussion rather than attempt to lay down any rules to be followed. Methods of protection and precaution in using the Roentgen Rays vary but little among those who are familiar with this branch of medicine, but there are still some physicians who use the rays carelessly, and evidently do not know that they are employing a powerful agent.

At the last meeting of the American Medical Association there was a physician who made the statement, "that he employed the Roentgen Rays without any of the necessary precautions and had never had any bad results." We all know that his experience was very limited, as good luck will not follow everyone who disregards the laws of physics and the physiological action of the rays on tissue. On the other hand, there are a few physicians who have seen one or two undesirable results from the rays, and from their limited knowledge assume that the Roentgen Rays are dangerous in the hands of everyone. Of course such assumption, based on such unreliable information, is not only worthless but misleading.

As late as last winter an *x*-ray burn was produced by making a radiogram of the clavicle. The patient weighed less than one hundred and twenty-five (125) pounds, and in five days something over three hours exposure was given.

Another case which had been treated for tinea tonsourans, a permanent alopecia had been produced. In this hospital the resident did the *x*-ray work, and as this was the first case he had

treated, and as he had never had any instruction, except shown how to turn the switch, told the time and tube distance by a member of the staff, (who had never operated an *x*-ray machine), and had no knowledge of the amount of current going through the tube or the degree of its vacuum, is it surprising that a permanent alopecia was produced? In the first case that another operator treated, after he had given about thirty treatments and no effects had been produced on the skin, he decided that his patient had an immunity to the rays, and the treatment should be discontinued. Many similar illustrations would show that everyone taking up Roentgenology should do as in any other specialty, prepare himself to do work up to the standard.

I sent a circular letter to forty Roentgenologists asking the following questions:

(1) How do you limit the area irradiated in treating a patient?

(2) Means of clinically measuring the dose employed?

(3) What would you consider a safe exposure with the tube placed twelve inches from the skin with ten milliamperes of current passing through a Walter six tube or its equivalent?

Thirty-five answers were received. The answers showed that, while the methods varied considerably, all of these physicians were using about the same means of protection for their patients.

The following is a summary of the answers received.

(1) The irradiated area in Roentgen treatment is limited by tube shields and diaphrams of various makes and descriptions. The metallic composition shield, the lead glass shield and the rubber composition tube shield are the ones mostly in use, and, when further protection is necessary, lead or tin foil with holes cut to the shape of the lesion under treatment is used. Price's opaque cloth is in favor with many operators. Dr. Pfahler's answer to this question included: I cover my tube with a lead glass shield, which I believe cuts off all of the soft rays that ordinarily affect the skin, and probably one-half to two-thirds of the total quantity of the rays given off from the tube.

(2) Means of clinically measuring the dose employed? The answer includes:

(a) Length of exposure.

(b) Distance of anode from surface.

(c) Vacuum of tube, estimated by length of equivalent spark gap, Walter skiameter Benoist penetrometer, etc.

(d) Milliammeter.

(e) Judgment and clinical experience.

(3) With the tube placed at twelve inches from the surface of the skin with ten milliamperes of current passing the tube, and tube reading Walter six or its equivalent, how long would you consider a safe exposure within twenty-four hours and how soon could this exposure be repeated?

This only pertains to radiography and must be modified with the urgency of the case. The average time for the same portion of the body, providing the tube reads Walter six all the time during exposure, was between three and three and one-half minutes without a filter, and five minutes when a sheet of aluminum or leather was interposed between the patient and the tube, and if the skin showed no effects of the rays, one-half the amount of exposure could be repeated in ten days.

The letters showed the necessity of this society adopting a standard penetrometer and also the advisability of appointing a committee for the purpose of comparing standards and reporting at each meeting. At present at least two standards should be used, the milliammeter and the penetrometer. While neither are accurate and experience certainly exceeds any standards of measurement we have at present, the most scientific methods should be employed, not only because our results will be more uniform but we will be in better position to study and compare technic. Many of the writers were not familiar with the reading of a Walter six tube or its equivalent to the Benoist scale and quite a few had never used a milliammeter.

The value of *x*-ray filters has been overlooked by many. In treating deep seated lesions the patient is not properly protected unless filters are used, nor can the same results be obtained.

Dr. Pfahler presented a very interesting paper at the last two meetings of this society, and as it has been used so extensively everyone is familiar with the leather filter and its value. Leonard advocates the use of the aluminum filter. Other material can be used but the leather and the aluminum seem to have the preference.

The importance of tube distance, in order to protect the skin when treating deep lesions must not be overlooked. I described this in a paper read at the meeting in 1905. In regard to the safety limit I will quote a paragraph from Dr. Williams' paper read before the society in 1906.

"By experience I have found that about ninety minutes is required to produce an erythema on the surface ten inches from the anode of a tube of medium penetration, the milliammeter reading three-quarters of a milliampere."

With this knowledge and the law of inverse squares, Dr. Williams constructed the following table:

Distance.		Relative Intensity.		Safety Limits.
2 inches	1	1.000	25.00	2.5 minutes.
4 "	1/4	.250	6.25	10.0 "
6 "	1/9	.111	2.77	22.5 "
8 "	1/16	.062	1.56	40.0 "
10 "	1/25	.040	1.00	62.5 "
12 "	1/36	.027	.69	90.0 "
14 "	1/49	.020	.51	122.5 "
16 "	1/64	.015	.39	160.0 "
18 "	1/81	.012	.30	202.5 "
20 "	1/100	.010	.25	250.0 "

The safety limits are about 30 per cent less than the number of minutes required to produce a decided erythema. The table also shows the relative intensities at different distances so that if a number of exposures are given at different distances they can be reduced to the equivalent of a common distance and the total number of minutes then added.

Susceptibility of various tissues to the Roentgen Rays must be borne in mind in protection of the patient, and as time will not permit a review of the work which has been done both in this country and abroad, I will only describe the physiological action of the rays in a general way. It is generally conceded about the changes (both general and microscopic) which tissues undergo, that the effect seems to vary from stimulation to complete abolition of the vital principles.

When healthy structures are exposed to the action of the rays the primary changes of degeneration and destruction of epithelial cells have been found to precede proliferation of the connective tissue, the vascular changes being a late manifestation of irradiation.

Heinecke's experiments, showing the destruction of the Malpighian corpuscles and cellular elements of the spleen, have been confirmed by many, and illustrate the influence of the rays on organs built up of lymphoid tissue.

The stage of maturity to which the cells have attained has a decided influence upon the cellular reaction. Dead cells are unaffected, fully matured cells are resistant; the more embryonic forms of cells are very easily affected, a retardation in development preceding degenerative metamorphosis.

Lepine and Bould have shown that the glycogenic function of the liver, as well as the cells, is affected by irradiation. Tilden Brown, Albers-Schoenberg, and Frieben, among others, have shown the specific influence of the *x*-ray upon the reproductive organs.

From Schultz's experiment he concludes the following: the Roentgen Rays exercise their chief influence on the cellular elements of the skin. The cells are attacked first, and undergo a slow process of degeneration, whilst the connective tissue, the elastic tissue, the muscles and cartilage are but slightly affected, the change in these tissues being secondary to the cellular degeneration and to the inflammatory process of reaction.

The degeneration primarily attacks the cells of the epidermis, afterwards in less degree, the gland cells, and those of the muscle and connective tissue.

The phenomena of degeneration are variable, and extend to the muscles as well as the body of the cell.

When the process of degeneration has attained a certain degree, phenomena of inflammatory reaction set in. These are manifested by dilatation of the vessels, serous infiltration of the tissue, and a migration of the leucocytes, which often result in considerable infiltration.

Wherever a considerable degree of cellular degeneration occurs as a consequence of intense irradiation, the leucocytes flock thither en masse, and aid in the complete destruction of the injured tissue.

The lesions, both of the larger vessels and those of smaller calibre, play a most important part in the production of the Roentgen ulcer, and explain the extremely slow course of its reparation.

From the above it can readily be seen what changes take place and also the importance of protecting organs which are easily influenced by the Roentgen Rays, among which are the reproductive organs, spleen, liver, kidneys, thyroid gland and in fact any of the organs made up largely of epithelial cells.

Muscle, cartilage and bone are not easily influenced by the rays, and for this reason the amount of radiation which cause destruction of a gland will not seriously injure muscle cells.

Strong exposure to the rays will produce more or less waste in the tissue depending on the susceptibility of the patient, also according to the part of body exposed and the quantity and quality of radiation. The Roentgenologist when treating large masses should be careful that more waste is not produced than can be eliminated by the natural processes. The condition of the patient as regard the eliminating organs should be determined before and during a course of treatment.

The amount of surface exposed should be considered. Where large areas are exposed the same amount of reaction cannot be produced as where a small area is under treatment. While toxemia has been produced when treating hopeless cases of carcinoma, it should be understood that this can be avoided by a slower process and also that the urgency of the case may demand radical treatment just the same as in surgery.

That a ten or fifteen minute exposure of the hand with any apparatus we have at present will produce any systemic effect does not seem reasonable nor is there sufficient clinical evidence that such was the fact in a single case, although one or two such instances have been reported. Many cases have had similar symptoms who have never been near an *x*-ray machine.

The following letter of Dr. Boyce, which he has given me permission to publish serves as a good illustration.

Pittsburgh, Pa., Sept. 18, 1907.

DR. RUSSELL H. BOGGS,
319 Empire Bldg.,
City.

DEAR DOCTOR BOGGS:—The case to which I referred in conversation with you the other day, was that of a man aged 54 years, who on March 14th received a severe bruise or rather a crush of the left knee. When I saw him the swelling was very

great and it was impossible to determine whether a fracture were present or not. The next day I telephoned to you, and in your absence tried to arrange with Dr. Bradford to take a radiograph of the knee. On account of the flood prevailing in Pittsburgh, the electric light current in your office and in the patient's hotel was out of commission, and it was not convenient to remove the patient to a hospital. Subsequent progress of the case showed there was no fracture. On the 25th, ten days after I wanted the *x*-ray examination, the patient had a rise of temperature, which was due to pleurisy. On the 29th his condition was worse than the pleurisy warranted. The examination of the urine showed a moderate amount of albumen and a number of granular casts. He died in Uremic Coma on the 31st.

The microscopic examination indicated that his kidney lesion had been of considerable duration. I had been his family physician for several years, but he had never consulted me for any personal symptoms. If I had succeeded in getting a radiograph the day I wanted it, I certainly should have attributed the subsequent uraemia to the action of the *x*-ray, and would probably have reported this case as an illustration of the dangers of your branch.

Yours very sincerely,

JOHN W. BOYCE.

DISCUSSION ON PAPERS OF DRS. LEONARD AND BOGGS.

DR. H. W. VAN ALLEN, Springfield, Mass.: (Dr. Van Allen prefaced his remarks by describing a diagram of his office and laboratory, showing the means he takes to protect himself against the Roentgen ray by a lead wall between the *x*-ray room and the switch and dark-room.)

I agree with Dr. Leonard that insufficient protection is a danger. I fear that the use of tube shields give us a false sense of security. The light is allowed to extend downward, and, with the authors, I believe that the ray is more effective as it approaches the heart. I also believe in the greater danger of the small oft-repeated dose. Nearly two years ago I published a paper on the result of exposure of the genital region. I found that those men who had a long series of light exposures, some as many as thirty times, remained sterile much longer than the men who were ex-

posed harder but a less number of times. It is the constant effect of the ray that is deleterious.

I do not believe in the use of a small protecting screen, as is used some places; the operator hiding behind the screen. He gets behind it to turn on the tube, and then walks around the room. It is tedious to remain behind the screen all during the treatment.

As to the protection of the patient, I believe that the lead diaphragm, which is being used almost entirely for all my ray work, protects the patient sufficiently over the surface not to be treated.

I agree thoroughly with what Dr. Boggs said in regard to treating large bodies too often or too carelessly. I have had several cases where annoying, even dangerous, symptoms developed.

Another thing not mentioned is that some other .r-ray man may have had the patient under his care before the patient comes to you. Recently a fat woman came to me to have her shoulder radiographed. I proceeded in the routine way, and obtained a good picture. She said, "Isn't that wonderful. They tried all morning at the other place to get my picture." Recently I saw a medico-legal case where the lawyers tried to prove that a burn and not the railroad injury was responsible for a man's incapacity to raise his arm; he having been rayed by several different men in successive days, the sum total being sufficient to produce a burn.

Dr. Lewis Gregory Cole, New York City: I want to ask several questions which I wish the other gentlemen who will take part in this discussion will answer. First, is it safe to have a valve tube in a small dark room or in the room where the switches are? Are there sufficient .r-rays from a tube of that kind to be detrimental? Second, do you think it is detrimental to have the spark gap near you?

Another point as to the arrangement of the booth. I suggested having a switch on the door so that you cannot turn on the current until the door is shut tight. It is a great temptation to step into the room and turn the switch before the door is closed, and unless the door is closed the operator is not protected properly.

Another point is the protection of a man when he is selecting a new tube and particularly at these meetings. I have not been

exposed as much to the ray in the past year as I have since I have been at this meeting. It may not be dangerous to be exposed to the tubes as we are, but I feel that we cannot be too careful. We should demand of the manufacturers a place where we can test a tube without exposing ourselves in the slightest degree, and insist on the manufacturers having a booth which is amply protected so that we can see what we are buying without exposing ourselves. Those are things which the Society can and ought to demand.

In regard to Dr. Leonard's paper, he spoke of coal tar products. Any preparation of zinc when put on an *x*-ray burn, either acute or chronic, materially aggravates it and delays healing months or even years.

DR. E. W. CALDWELL, New York City: The subject of the protection of the operator has been very well reviewed in the papers we have heard. One point, however, that has not been emphasized is, that the secondary rays which are set up in the air and other materials, such as woodwork and walls of the room, are radiated in every direction, and therefore, some of them pass behind the screen. This was very clearly shown in Roentgen's Classical Third Paper published in 1897. Since then many other experimenters have demonstrated that any screen which does not completely enclose the operator will not shut out all of the secondary rays.

Just how much danger there is from these secondary rays, which are comparatively very weak, we do not know. There is no reason to suppose that these rays differ in any respect from other *x*-rays, except in their relatively small intensity, and their very large areas of origin. Undoubtedly we should avoid all unnecessary exposure, but I believe there has been undue alarm over the dangers of the secondary rays, and that we are not warranted in sacrificing facilities for observing and controlling our tubes in order to exclude the last vestige of secondary radiation. It is well known that over-exposure to sun-light may produce very disastrous results, but it does not follow from this that we must live in darkness in order to avoid the deleterious effects of light. I think that a screen which will protect a photographic plate so well that only a little fog is shown on development after two or three weeks exposure in the position occupied by the

operator, is practically safe, even if all the secondary rays are not excluded. Many of us know of operators who have worked in rooms where *x*-ray treatment has been given for from four to six hours per day for several years, with two or three tubes running and no coverings. Among these operators those who have avoided placing their hands directly in front of the tube to examine them with the flouroscope have, so far as we know, been uninjured by the rays, although they must have received far greater exposure than any one who makes an occasional radiograph while protected by the simplest sort of a screen.

It seems to me that with the closed booth containing spark gap and electrolytic interrupters there is much more danger from the fumes produced by both of these appliances than there is from the slight exposure to secondary ray behind an ordinary plane screen.

In regard to the surgical treatment of *x*-ray dermatitis and its sequelae, I do not at all agree with the views of Dr. Leonard. I have recently had an opportunity to see some of the plastic work done by Dr. Porter in the Massachusetts General Hospital, Boston. He has treated a number of men with every stage of this trouble from the beginning keratosis to the epithelioma, and his results in the surgical treatment of these conditions are the best I have seen anywhere. Objection is often made to surgical interference in these cases on the ground that it may produce metastases. In one of Dr. Porter's cases epitheliomata were excised successfully nearly nine years ago with as yet no evidence of metastatic involvement. I believe that the occurrence of metastasis in these cases is due to the delay in surgical intervention and not to the surgery, and I am convinced that many of our colleagues who have died from metastatic growths following *x*-ray injuries might be with us today if they had had thorough, competent surgical treatment early enough.

I quite agree with Dr. Leonard that it does no good to put irritating dressings on the so-called *x*-ray burn. In this connection it must be borne in mind that the bases of most ointments contain enough free fatty acid to be irritating. When ointments are used, therefore, it is important that they shall not have become rancid.

DR. F. H. BAETJER, Baltimore, Md.: In this matter of protection of the patient and operator, I occupy a middle ground. A word about Dr. Caldwell's remark about the man who has been in an *x*-ray laboratory for seven years without suffering any inconvenience. In that case we must take into account the personal equation, the existence of an idiosyncrasy. When in Europe some time ago, I met an operator who gave from ten to fifteen exposures a day, and he would expose his hand at a distance of a few inches from the tube for from ten to fifteen minutes during each exposure. His hands were smooth and clean. He said that he had been doing that for six years.

I examined one patient for a foreign body in the eye. I followed the routine procedure, placing the tube about twenty inches from the face, and exposed for thirty seconds. I first made an exposure to determine the presence of a foreign body, and then made a second to locate it. The patient came back in two weeks with a pronounced dermatitis, which persisted for three or four weeks. Fortunately no ulcer formed.

As to the secondary rays. Shortly after Albers-Schoenberg built his new laboratory in Hamburg I visited him, and I was with him when he opened the new laboratory room, a room about 20 x 40. It was entirely darkened. He worked there from two to six hours making a number of exposures. Hanging around the walls were a number of instruments. When he turned out the lights and prepared to turn on the tube, there was fluorescence from the entire room. This was so marked that we could almost see one another. He could not account for it, but when he took down all the metal objects in the room, there was absolute blackness, showing that the walls gave off the fluorescence. If, then, the secondary rays can produce that amount of fluorescence, it seems to me that we ought to protect ourselves against these rays.

DR. HENRY K. PANCOAST, Philadelphia: I wish to offer a suggestion in connection with the construction of screens and booths, which may be of some value. A reduction of expense and an increase in efficiency is possible in constructing a booth if a light but strong wooden framework is first made, and this then covered inside and out with sheet lead, and the space of an inch or more between the lead covering and lining filled in with sand, which is comparatively dense to *x*-rays.

DR. GEO. E. PFAHLER, Philadelphia: I feel that we are not in any particular danger of going too far in our protection; in fact, I think, that the great danger has been pointed out by several speakers of not being sufficiently careful, deluding ourselves by false protection. I believe that the screens placed around the tubes do cut off the majority of the rays, but, as was stated by Dr. Leonard, we do not know what the hard rays will do. At the beginning of this work we knew nothing of danger; five years later we recognized the great danger and took a little precaution; now we recognize that a little protection is not sufficient. Therefore, we will never regret having gone too far in the matter of protection.

The point made by Dr. Caldwell with regard to having the spark gap in the booth must be recognized, and I am sure that the point raised by Dr. Cole as to the fluorescent action of the valve tube must be considered. As to the degree of protection, of course we all know that the amount of penetration or the effect of the light will vary approximately in inverse proportion to the square of the distance. Therefore, the further you get away from the tube the less protection you need, so far as lead sheets and that sort of thing is concerned. I have around my tube a lead glass shield and outside of that one half inch of lead and 1/32 of an inch of silver. The rays still go through all of that, even the side rays from the tube, not the direct rays, because they go down. Therefore we must learn to protect ourselves during the exposure of the tube.

I am sure that the chief danger is in the direct line of the rays, although we must also avoid the secondary rays. I do all of my work from the adjoining room by means of reflecting mirrors, and from my desk where I make my notes and do every thing I would do ordinarily, I can see all of my indicators at a glance, and also the patient and the tube. That gives me not only the protection of the lead glass shield, but the protection of the wall and the distance from the tube, about eight or ten feet. I believe that we must go as far away from the tube as possible, and that the work should be watched by means of reflecting mirrors.

DR. A. W. CRANE, Kalamazoo, Mich.: The operator can not protect himself from the ray too carefully. There is, however,

a misapprehension about the physiologic action of the ray. Its action can be viewed by analogy with other substances that affect the body. Take strychnin, for instance. In therapeutic doses strychnin is the best tonic we have, while in large doses it is one of the most virulent poisons. I believe that the *x*-ray, in sufficiently small doses, is stimulating, like every other destructive agent in very small doses, while in large doses it is very destructive.

I think that operators who have been burnt would do well even to exclude the secondary rays. They may be injured by diffused *x*-rays which are to the direct rays of a tube what diffused daylight is to the direct rays of the sun. But the *x*-ray is not the only agent that has a destructive influence on the body by bringing about trophic changes. The same thing is true of many other known agents such as phosphorus and cinnabar. Miners working in cinnabar mines become very anemic and die at an early age, if they are not taken out of the mine. Workers in match factories become the victims not only of necrosis of the jaw but of the liver and kidney degenerations. Syphilis will produce azospermia as well as degenerative changes in the tissues. The same is true of bacterial poisons. The physiologic action of the *x*-ray does not differ essentially from that of these other poisons mentioned. But all this does not lessen the necessity of the most thorough protection of the operator as has been urged by some of the pioneers in this work,—men who have suffered martyrdom in the mastery of a new agent for human good.

DR. M. K. KASSABIAN, Philadelphia: About four years ago I devised a method of protecting the operator by arranging the office in such a way that I can go into the adjoining room and regulate the current and spark gap and switch board. I place the tube so that I am standing behind the anode, always placing the active hemisphere the other way; I remain in the adjoining room. My hands are the best proof of the efficacy of this arrangement. They are getting better, because of the little treatment perhaps I am giving.

I immerse my hands in hot water two or three times daily, and rub them well with lanolin or cold cream. Fissures I touch up with a two per cent. solution of argyrol. Once in a while I remove the bandage and expose the hands to the air and sunlight,

because when covered always with a bandage, the tissues become raw looking and itches and their vitality is reduced. Coal tar products are very injurious. I once used orthoform, suffered from insomnia because of the pain nearly a week afterward. In the acute stage, zinc oxid ointment is useful, but in the chronic stage it is better not to use it continually. One of my assistants in Philadelphia General Hospital 4 years ago, exposed a patient to the fluoroscope for perhaps about fifteen minutes, and the results were an *x*-ray dermatitis. Diluted carbolic acid solution was being used, but I recommended to use hot water, normal salt solution and sterile gauze, and within six weeks the patient fully recovered.

Mr. H. C. Snook, Philadelphia: With respect to hard radiation, the question raised by Dr. Pfahler, I wish to say that before I began protecting myself by the use of lead glass shield, I had a slight burn on the left hand. It healed pretty well, but a few nodules persisted. After I began using the shield, these nodules disappeared almost entirely, and there remain only two very small ones which can hardly be detected.

For some little time I have been using more *x*-rays than any one has ever used, without any other protection than the lead glass shield. I have had some symptoms which Dr. Pancoast tells me must be ascribed to the effect of the hard radiation which comes through the lead glass and which affects the long bones. I usually stand within six or seven feet of a tube which is very powerfully excited, say 40 or 50 milliamperes of current, and within a few seconds after that current passes through the tube, I have felt, during the past few weeks, a dull aching pain in the wrist of my left hand, and also about my knees. I have purposely repeated the observation, reproducing the symptoms, so that I am fully convinced of its correctness. During the past two months I have radiated myself with more hard radiation than I have ever had before, not understanding the effect of hard radiation on bones.

Dr. Henry Hulst, Grand Rapids, Mich.: Dr. Leonard has succeeded in converting me to his views. I agree with what has been said by most of the speakers, but I doubt some of the statements that have been made, and some of them may easily be misunderstood. Mr. Snook attributes his sensations to the effect

of the vagrant rays, He thinks that he has excluded the possibility of suggestion. I do not think that he has. The only way to find out would be to energize a tube when he does not know it? If he continues to perform his experiments as he has, and if his symptoms are due to suggestion, the result will be better all the time.

It has been said that a small dose of the ray may act as a tonic, but I doubt it. The same speaker proved by what he said that small doses of certain substances, frequently repeated, act most disastrously. I do not think that he has enough evidence to warrant the statement that frequently repeated small doses of vagrant rays act desirably. It is better to be on the safe side. I do not think that our protection can be too complete, although it is not necessary to wear a suit of armour. If any experiments are to be made to ascertain the tonic effect of the ray, they should be made on animals first.

Dr. Rome V. Wagner, Chicago: One of the most difficult things about this work is to determine what absolute protection is. I meet many *x*-ray workers in my work, and I used to find, when I called on one of them, that the first thing he wanted was to show me some tube that was defective in some way, so that I could tell him what was the matter with it. He had no idea of protecting either me or himself. I found it a good plan to carry a little camera. Every operator knows how to protect the photographic plate, but he never stops to consider the protection of himself in the same way. The thing is to know whether you have exposed yourself during the day. I use heavy lead glass tube shields over one half inch in thickness, and even then I used to wonder whether I got any detrimental effect of the ray. I concluded that I would not take chances with any ray that would affect a photographic plate, so I carry one in my pocket, and in the evening, after the day's work, I develop this film to see whether I have been exposed to the ray. Once in a while I find that I have, and then I try to figure out where I have been exposed. Now I often go for a week without any exposure; in fact, only seldom is the film affected. I believe that this plan is a good one because you need not worry about being exposed when you have not been exposed.

Dr. W. S. Lawrence, Memphis, Tenn.: It seems to me that there is no such thing as absolute protection, unless you go

to an adjoining town and operate by telephone. Then, the question is, how much protection is it wise to take? I believe that there is a point of tolerance in the human body to the *x*-ray as there is to other injurious agents. We all know that tobacco in certain quantities will kill the individual, but if one will limit himself to a certain number of cigars a day he can smoke and still live to be old and die from some other cause than tobacco poisoning.

The same thing is true of some drugs, and I am sure that the body will tolerate a certain amount of *x*-ray energy, either the direct or the secondary ray. For that reason I do not believe that it is necessary to clothe ourselves in armour or to leave the city and operate our apparatus from a distance.

To work without protection is foolhardy and inexcusable, but I believe attempts at absolute protection have been carried to rather absurd extremes.

DR. GEO. C. JOHNSTON, Pittsburg: One of the best methods of protection is to work without having to walk around the apparatus. The average operator gets his burn in treatment work. When he does picture work he uses a heavy current and protects himself, but when giving treatments all day, using three or more machines, he is constantly exposed. Both the operator and the patient must be protected. This can be done by remaining away from the excited tube, and by regulating the time of the treatment in some way.

(Dr. Johnston exhibited an apparatus provided with a clock which is adjusted to the duration of the treatment, and when that time has expired, a switch is thrown out, and the alarm rings until the operator comes in. The apparatus was constructed by Dr. Wagner, of Chicago, although the idea was not claimed as being original with him.)

DR. THOS. S. STEWART, Philadelphia: I think that most of us have reached a point where we can stand an immense amount of the *x*-ray without suffering any appreciable damage, but after we have reached that point, we are much more sensitive to the effects of the ray. I can not stand the slightest amount of the *x*-ray now without showing some dermatitis.

DR. LEONARD, closing the discussion: With reference to the secondary rays. Professor Goodspeed has in his laboratory on one wall a heavy sheet lead and on the opposite side of this wall another in an adjoining room, the two connected by a piece of lead pipe. He sets his tube in action in the other room, and brings the fluoroscope back of the lead protector, and any one can see that the secondary rays do produce fluorescence and are to be regarded as dangerous. This ray will also photograph in the same way as every other ray. If the *x*-ray does this and produces physiologic action, why should not the secondary ray do the same thing?

In reference to the surgical treatment of *x*-ray lesions. I think that Dr. Caldwell is correct, but the time at which an operation should be done is open to question. There can not be any regeneration of the ulcers while the tissues are devitalized. I think that Dr. Caldwell's citation of operations had reference to cases where the operation was done three or four years after the lesion was produced, hence the results obtained.

The other troubles that arise from the *x*-ray dermatitis are known to all of you. I know a man who has worked with the ray for ten years, using it for all kinds of work, and he has never had the slightest attack of dermatitis on his hands. He has worked with the fluoroscope and everything. There is that tolerance that prevents some men from getting burned, yet this man came to me the other day worried because he had found a physiologic effect from the ray. There was no dermatitis or other lesion on the skin, but the ray had affected him without question. That shows what the rays will do in some cases.

Another point made was the effect of the fumes given off by the spark gap and the electrolytic interrupter. The poisonous action of the ray may not be known to you. Before I had a dermatitis on my hands I read in a German journal that nitrous acid fumes produce a poisonous effect, somewhat similar to the effect of lead, but instead of the blue line on the gums there is a brown line. I found it on my gums. I had been working over the coil constantly and absorbed enough of the acid to produce that poisoning. So that there is danger in absorbing air when it is broken up by the spark gap. I would not like to ask any man here to take a small dose of strychnin for every large

dose he gives a patient, or a small dose of any kind of medicine he prescribes. I do not believe that it is safe.

Mr. Snook has had a very valuable experience in .r-ray work, and he has recovered, as we all know. He is a happy father. If you want to convince a man that he is doing wrong in not taking care of himself, tell his wife.