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RADIOACTIVE SUBSTANCES AND ALUMINUM

with Experimental Research of the Same

BY

MYRON METZENBAUM, B. S., M. D.

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[MONOGRAPH.]

Radium, Radioactive Substances and Aluminum with Experimental Research of the Same

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History: Following the discovery of the X-rays, the entire scientific world, turned its attention to the seeking of new forms of light. In February, 1896, M. Henri, of Paris, showed that if zinc sulphid be exposed to the sunlight so as to render it phosphorescent, that it could be sprinkled on a photographic plate, which was first covered with black paper, and that the plate would be affected just as if it had been exposed to the X-rays.

Following this announcement Professor H. Becquerel, of the Institute of France, commenced a systematic investigation of phosphorescent substances on photographic plates, which were first covered with black paper. A plate thus covered with black paper may be exposed to the sunlight for 24 hours without being affected.

In the course of his research, he exposed the various uranium salts on the covered plates and allowed the sun to act upon them. This showed that under the uranium crystals the photographic plates were affected just the same as if they had been exposed to the sunlight.

On one occasion the weather being stormy he laid a plate on which there were some uranium salts in a drawer. It remained there several days and then he decided to develop it, not expecting to find any change, but much to his surprise, there were well-defined impressions on the plate. Repeating the experiment he found that the uranium salts need not be exposed to the sunlight in order to obtain an impression, but that the uranium was capable of emitting its own rays of light and that these rays were capable of penetrating black paper.

Preliminary Paper presented at the Experimental Section of the Academy of Medicine of Cleveland, March 12, 1904

In justice to the discoverer's name all substances, which emit rays of light, that are capable of affecting a photographic plate through black paper in the dark, are said to possess Becquerel rays.

Following up the experiments of Prof. Becquerel, Madam Curie, of Paris, assisted by her husband, M. Curie, found that crude pitchblend, from which uranium is derived, was much more active than the uranium salt itself; and they further found that the waste product of the pitchblend, remaining after the uranium had been extracted, was even more active than either the uranium or the pitchblend. They not only determined this activity by the action on photographic plates, but also by noting the increased velocity with which a charged electroscope was discharged, when the pitchblend was brought near it, as compared with the velocity with which the uranium discharged the electroscope; and also that the waste product of the pitchblend discharged the electroscope with a greater rapidity than did the pitchblend. They, therefore, rightly concluded that pitchblend contained something which uranium did not, and that this active property was to be found in the waste product.

After two years, in 1898, the Curies extracted a new substance, which they called polonium, and soon thereafter a second new substance, which they called radium. A year later their assistant extracted a third new substance, which they called actinium. The discovery of radium promises to be the most important scientific discovery ever given to the world by a woman.

For the discovery of the Becquerel rays and these new substances, the Royal Academy of Stockholm has awarded to M. Becquerel, M. and Madam Curie conjointly the Nobel prize of 100,000 crowns ($28,000), as being the most important contribution to "Physics and Chemistry" for the year 1903.

Pitchblend: Pitchblend, or uraninit, is found in Bohemia, Saxony, Cornwall and Colorado. It contains about 81% of uranium, and it is in the waste product after the uranium is extracted that radium is found. Commercially, the uranium salts are used in the coloring of glass and give to the Bohemian glass their beautiful dark brown and blue tints.

Uranium nitrate is used in photography in the intensifying solution, and it is to be wondered at that no photographer should have discovered the action of this salt on photographic plates. If the uranium salts are rubbed in the dark they emit short blue or violet rays.

Radioactivity: If a piece of hard rubber or a stick of sealingwax be rubbed with a flannel and brought near an electroscope, it will cause the two leaves of the electroscope to fly apart, due to the fact that both leaves are charged with the same kind or negative electricity. Now if metallic uranium is brought near this charged electroscope it will cause the leaves to come together. The rapidity with which pure metallic uranium discharges the electroscope is taken as the unit or one. The rapidity with which any other substance discharges an electroscope is known as the radioactivity of that particular substance. All the products of radium, uranium, thorium, and as I will show later zirconium and yttrium possess this property of discharging an electroscope. The rapidity with which the electroscope is discharged is noted by a watch, and the distance the leaves approach each other during the interval noted is read by means of a telescope and a finely graduated scale. Certain specimens of radium have an activity of 1,700,000.

Investigation: Following along the line of work suggested by Professor Becquerel, I obtained various samples of uranium salts from different manufacturers in this country and abroad, thereby believing them to have come from different products of pitchblend. Then taking sensitive photographic plates and covering them with black paper, there was placed on each plate a flat object, generally a key, and around the key the pulverized uranium crystals were sprinkled. The plates were then placed in a triple photographic plate-box, each box enclosed in a cigar-box and finally placed in a cupboard in my photographic dark-room. In this way all possibilities for the action of sunlight were absolutely excluded.

Every six hours a plate was developed, and after 36 hours a rather definite image appeared. Most of the uranium salts, even after recrystalizing them several times, require 48 hours to produce definite outlines of the object.

Each experiment was repeated at least twice and many as often as 10 times under exactly the same conditions, using the same substances in exactly the same quantities and allowing the same length of time. I will not enter into many details of the work covering many months, nor of the many unsuccessful results, nor will I speak of the vast number of so-called phosphorescent substances, which are either naturally phosphorescent or in which phosphorescence was induced by exposure to sunlight, or by the burning of magnesia strips near the substance, which I have tried but which have not affected a photographic plate. Beside these substances to be mentioned in this paper, there are several which I will not report as showing activity on a photographic plate until I have completed an entire series of experiments with them.

That the action on a photographic plate is not a chemical action, but one due to the so-called Becquerel rays, I infer from the fact that the substances were separated from the film of the plate by either black paper, a plate of glass, bone, or were placed on the reverse side of the photographic plate, so that the rays had to penetrate the glass before reaching the film. The activity of a particular product I judge from the depth the rays have penetrated the film of the plate, when the same weight of crystals, generally 120 grains, were placed at the same distance, for the same length of time, and spread over the same area.

In this paper there will be mentioned only a single experiment, illustrating the typical action of a particular substance under each different condition and owing to the lack of space, only a few of the pictures typifying the results can be shown.

The full data of the experiments, with all the objects exposed and negatives, are in my possession, by which any experiment may be verified.

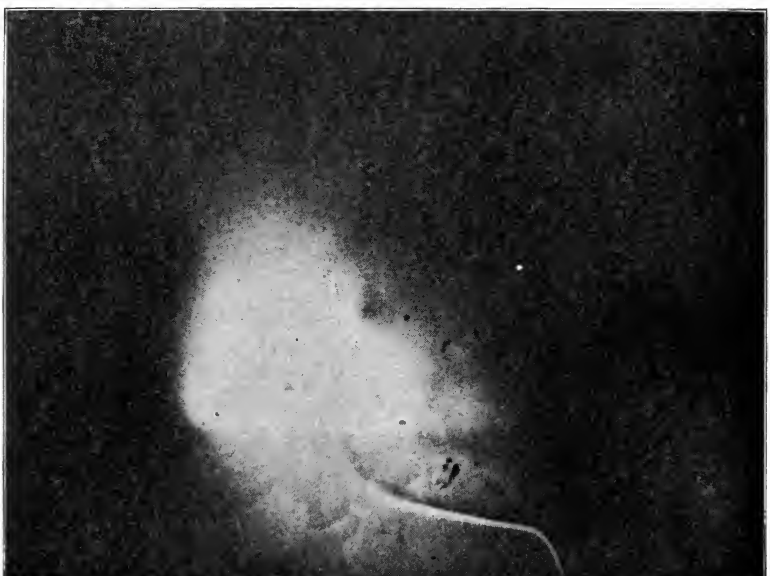

Figure I URANIUM SERIES Experiment 1

Piece of Bohemian Pitchblend placed on bare photographic plate. Produced its own image and affected plate for ½ inch around. Time 24 hours.

Experiment 1: Figure I—A piece of pitchblend or uraninit, obtained from Joachemsthal, Bohemia, was placed on a photographic plate and not only did it produce its own image, but it emitted a sufficient amount of rays to affect the plate for more than a half inch all around itself. Time was 24 hours.

Experiment 2: The same piece of pitchbend as in Experiment 1 was placed on the reverse side of a photographic plate, which was covered with black paper, and remained there five days, after which time not only did the pitchblend produce its own image but it cast out sufficient amount of rays to affect the plate for three-quarters of an inch all around itself. In this case the rays first penetrated the glass before reaching the film.

Experiment 3: A hermetically sealed tube of very thick glass, containing five grains of pure metallic uranium, was placed on a photographic plate covered with black paper. After 48 hours it gave a very deep print of itself.

Experiment 4: The same tube as in the above experiment was suspended over a key placed on a bare photographic plate at a distance of half an inch. The time was 90 hours. This specimen of metallic uranium does not seem to be specially active.

Experiment 5: Six crystals of nitrate of uranium were placed on a photographic plate, which was first covered with black paper, and allowed to remain 48 hours, after which time they produced their own image and also cast out a sufficient amount of rays to flash the plate for a distance of half an inch around.

Experiment 6: Powdered crystals of uranic oxid (yellow oxid) were sprinkled around the key, which was laid on the covered photographic plate. The rays in this case have partially penetrated the key. The time 48 hours.

Experiment 7: Powdered crystals of uranous oxid (black oxid) were sprinkled around the key, which was laid on a photographic plate covered with black paper. The time was 48 hours. In this case the Becquerel rays have penetrated the thin steel chiefly around the head of the key. This product of uranium is the most radioactive of any of the uranium salts I possess, and seems to be even more active, than the metallic uranium.

URANIUM SERIES
Figure II Experiment 14.

Crystals of uranous oxid (black oxid) were placed on glass plate suspended one inch above a plate covered with black paper. Time 92 hours.

Experiment 8: A bone pleximiter of one mm. thickness was laid on a photographic plate, covered with black paper and the powdered crystals of nitrate of uranium was placed on the plate of bone and allowed to remain 72 hours. In this case the rays have penetrated the bone.

Experiment 9: Thinking that possibly some of the action on the plate might have been due to some of the crystals being accidentally forced under the bone plate, or that the bone did not lie absolutely flat on the plate, thus allowing some of the rays to penetrate under the side of the bone, I made a trough of black paper, placed this on top of the bone plate, which was laid on a photographic plate, which was covered with black paper, and placed the uranium nitrate crystals in the paper trough, and after 72 hours I obtained a picture showing that the rays had penetrated the bone and the two layers of black paper.

Experiment 10: I placed crystals of uranous oxid in an aluminum cup and placed the cup on a plate of bone of one mm. thickness which was on the bare photographic plate. In this case the rays have penetrated the aluminum and the bone. Time 120 hours.

Experiment 11: Uranous oxid was placed in an aluminum box which was placed on a photographic plate covered with black paper and after 60 hours it produced a very deep print.

Experiment 12: Uranous oxid was placed in an aluminum box, which was placed on the reverse side of a photographic plate, and after 72 hours it produced a very deep print.

Experiment 13: Crystals of uranous oxid were placed on a glass plate, which was suspended half an inch above the object which was placed on a photographic plate, covered with black paper, and after 72 hours it gave a well-defined outline of the object.

Experiment 14: Figure II—Crystals of uranous oxid were placed on a glass plate suspended one inch above the photographic plate, the left half of which was covered with black paper and a key was laid on each half. The time was 92 hours. At this distance (one inch) it requires nearly twice the length of time to produce the same depth of print. There is very little difference between the half covered with black paper and the half not so covered—the black paper offering but little hindrance to the rays.

SUMMARY

From the foregoing experiments we may draw the following conclusions: that the various uranium salts are capable of affecting a photographic plate without the aid of the direct sun rays; that these rays can penetrate black paper, aluminium, bone, and glass; that they can act at a distance of several inches. At a distance of one inch, it requires about twice the length of time for the rays to act as compared with their action, when only separated from the photographic plate by black paper. After several months, during which time these uranium salts have been used almost constantly, they do not seem to show any loss of power in their action on photographic plates.

The radioactivity, as exhibited in the uranium products, I believe is due to the fact that uranium is derived from the same crude product as radium, and that it possesses none of these properties itself, but probably contains very minute quantities of radium. The different products of uranium vary as to their action on photographic plates, which probably depends upon the amount of radium present in the product.

THORIUM SERIES

All the experiments performed with thorium are the exact duplicates of those performed with uranium, and in all respects the results obtained are the same, except that some thorium products affect a photographic plate with greater rapidity than some of the uranium products I have examined and with less rapidity than others, a notable exception is one particular specimen of uranous oxid, which is very active.

Thorium is considered the most radioactive substance known, next to that of radium itself. Thorium was originally found in Greenland, but is now obtained in great quantities in a very pure form in South America.

Commercially, thorium is used for the manufacture of Welsbach and similar mantels, these mantels containing about 98% of pure thorium nitrate.

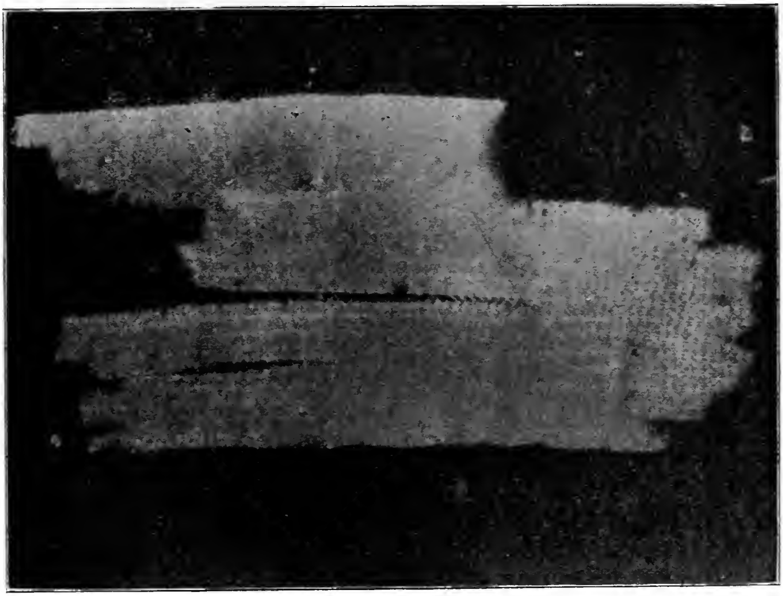

Figure III THORIUM SERIES Experiment I

Fragment of Welsbach mantel laid on bare photographic plate. Due to the Becquerel rays of the thorium it photographs itself. Time 72 hours.

Experiment I: Figure III—I took part of a Welsbach mantel which had been burning on my gas for some time and placed the same on a bare photographic plate. The mantel produced its own image in 72 hours, due to the Becquerel rays contained in the thorium.

Experiment II: A photographic plate was covered with black paper and the Welsbach mantel was placed on top of the paper, it requiring seven days for the rays to penetrate the black paper and 14 days to produce a strong print. The reason for such a long exposure is due to the small quantity of thorium in this fragment of the mantel.

Experiment III: Figure IV—A photographic plate was covered with black paper, a key was placed on top, and the powdered crystals of thorium nitrate were laid around the key. The time 60 hours.

Experiment IV: Crystals of thorium nitrate were placed on a glass plate suspended one inch above a plate which was covered with black paper on which lay a key. The time 96 hours.

Experiment V: Crystals of thorium nitrate were placed in an aluminum cup, and the cup was then placed on a photographic plate covered with black paper. It required four days for the rays to penetrate the aluminum and paper.

Experiment VI: Thorium nitrate was placed on top of a plate of bone of one mm. thickness. The time necessary for the rays to penetrate was 92 hours.

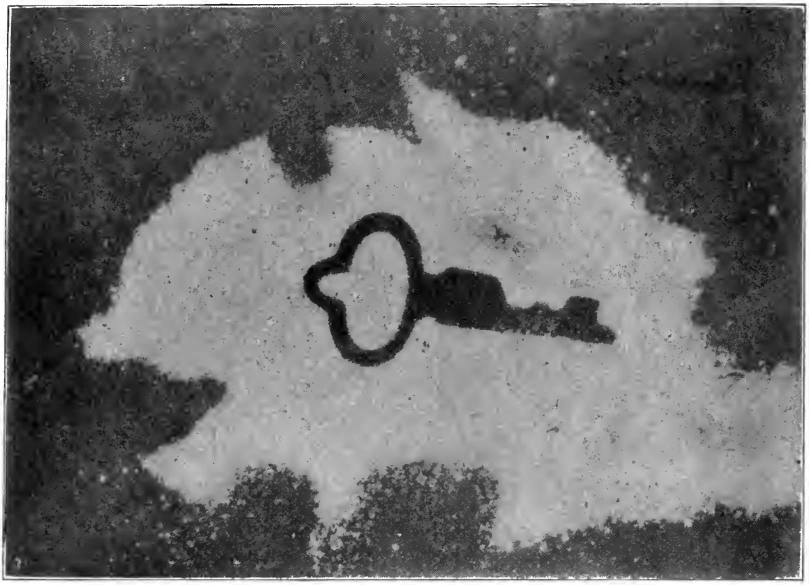

Figure IV THORIUM SERIES Experiment III

Polar Bear picture. Spread crystals of thorium nitrate around key placed on plate first covered with black paper. Time 60 hours.

CONCLUSIONS

From these experiments we can conclude that the Becquerel rays of thorium are capable of affecting photographic plates in the dark without the aid of sunlight; that they can penetrate black paper, aluminum, bone and glass, and at a distance of one inch it requires about twice the length of time it would if it were only separated from the photographic plate by black paper. This radioactivity of thorium is most probably due to a minute quantity of radium, which it contains.

In the investigation of many substances belonging to the same class as thorium, as to the action on photographic plates in the dark, I now wish to report two substances, as affecting photographic plates in the dark, which have hitherto not been reported as having this property. The first is zirconium nitrate, the second yttrium.

I think one may almost draw the inference that all of the other rare substances belonging to this same group similar to thorium, zirconium and yttrium will show a radioactivity.

These substances are used in the manufacture of the Welsbach mantel, and under the stimulation of the burning gas they emit their strong light.

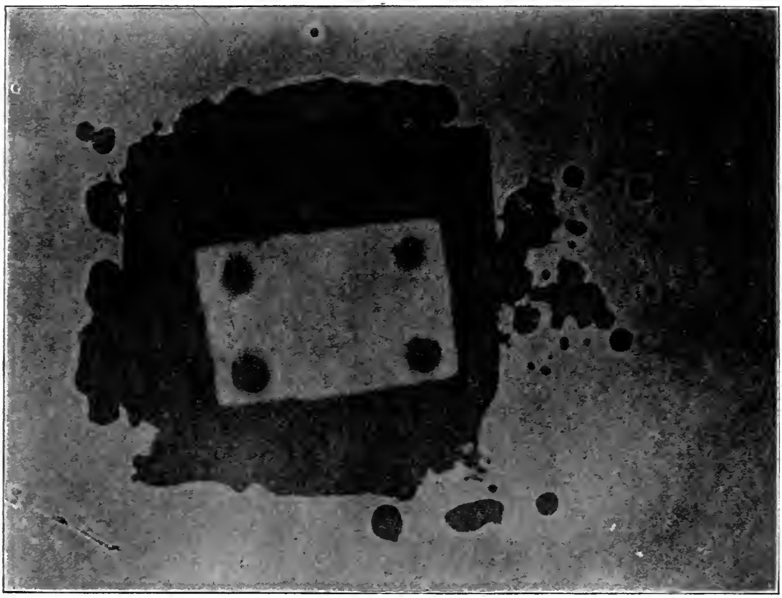

Figure V ZIRCONIUM SERIES Experiment I

Crystal of zirconium nitrate spread around object, which was laid on photographic plate first covered with black paper. This is the first picture made showing zirconium to possess the Becquerel rays. Time 48 hours.

Experiment I: Figure V—I covered a photographic plate with black paper, spread crystals of zirconium nitrate around the object, and obtained a very definite outline of the object in 48 hours, showing the rays to have penetrated the film very deeply.

Experiment II: I placed the crystals of zirconium nitrate on a glass plate which was suspended one inch above a bare photographic plate on which a key was placed. After 92 hours there I obtained a very good outline of the key. These are the first pictures produced by the Becquerel rays of zirconium.

Experiment III: The crystals of zirconium nitrate were placed in an aluminum box and placed the same on a covered photographic plate and after 72 hours there was a strong picture, showing the rays to have penetrated the aluminum and black paper.

In repeated experiments with zirconium it seems to affect a photographic plate in less time than any preparation of thorium I have thus far obtained. It is possible that zirconium may even be shown to be more radioactive than thorium.

Experiment I: A photographic plate was covered with black paper and crystals of yttrium were spread around the object. It required four days to affect the photographic plate.

Experiment II: Some yttrium was placed in an aluminum box and then placed on a covered photographic plate. A definite impression was obtained after 72 hours.

RADIUM

The source of radium is from pitchblend or uraninite after the uranium has been extracted. It comes in hermetically sealed tubes, for it absorbs moisture readily, in the form of radium carbonate in the lower activities, and as radium bromid or chlorid in the higher activities. Pure radium is practically unknown. It has a spectrum of its own and Madam Curie determined its atomic weight as 225. This is the largest atomic weight of any substance known and, therefore, has a very large molecule. It has a spectrum of its own. It has thus fulfilled all the requirements of an element. It belongs to the group of strontium, barium and calcium. It is capable of affecting a photographic plate in the dark at a distance of many inches.

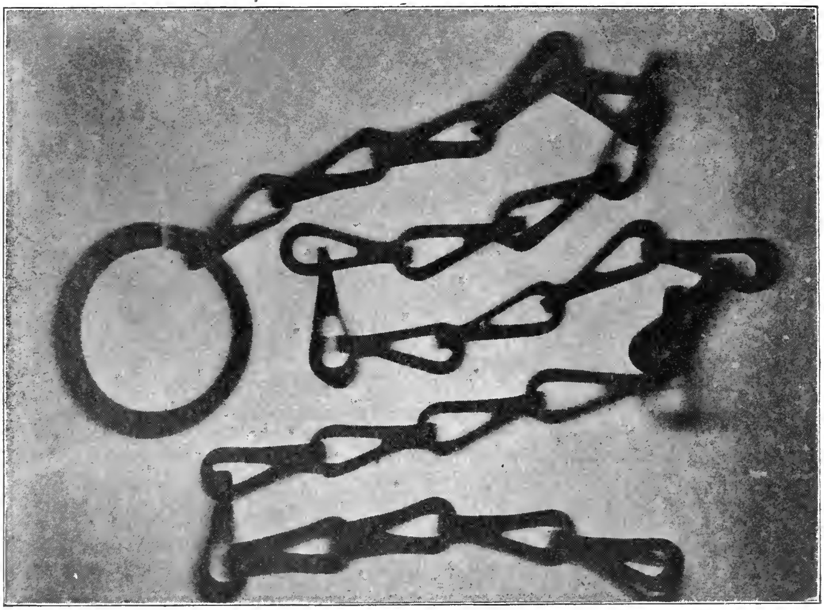

Figure VI RADIUM PICTURE

Suspended tube 15 gr. Radium 40 activity under surface of cigar-box cover. On bottom of box placed chain on bare photographic plate. Time 24 hours.

In Figure VI the chain was placed on the bare photographic plate, which was placed on the bottom of the cigar-box and a tube of radium of 40 activity containing 15 grains was suspended from the under surface of the cigar-box cover. The time was 24 hours.

A tube of radium of 7000 activity containing 20 milligrams was placed on the brass hook, which lay on a photographic plate covered with black paper. The time 24 hours. In this case the rays have penetrated the brass.

The rays of radium of very high activity are capable of penetrating very dense bodies. In the dark, when placed back of the ordinary fluoroscope screen, there appears a rather bright area. When placed back of some Willimite it seems as if a light were placed back of a yellow stained window. When brought near a diamond in the dark it causes the same to phosphoresce very brilliantly.

When radium of high activity is placed against the closed eyelid it gives a very peculiar brilliant light. In the dark, radium gives out a phosphorescent light which is very similar to that obtained by rubbing the head of a match with one's fingers in the dark. If one arises at night after the eyes have been relaxed for several hours, and if the room be perfectly dark, one may be able to follow out and read a line of print. Radium emits enough heat to melt its own weight of ice per hour.

The ability of radium to give out both light and heat for an indefinite time without apparently losing any of its weight or power has startled the scientific world, and, as Lord Kelvin said, "Radium has placed the first question-mark back of the law of conservation of energy;" for here there is a kind of perpetual motion, and it is seemingly, as if radium was creating its own energy. But already several observations point to a solution of the problem. However, it is true that no known substance is capable of giving out the same amount of energy without becoming inactive.

First theory: Is that radium has a very large molecule, since its atomic weight is 225, and that these molecules are continuously breaking up into smaller particles, namely into ions or electrons, and it is because of the breaking up of the molecules and thereby changing its form, that radium emits light and heat.

As bearing on this theory, Prof. Crooks constructed an instrument called the "spinthariscope." This instrument consists of a small X-ray or fluoroscopic screen of platino-barium-cyanide, back of which there is placed a small particle of radium. When you look through a low-powered microscope on this screen, in the dark, there can be seen continuous brilliant flashes on various parts on the screen, which appear very similar to the silvery flashes seen on the screen during a kinetescopic view. These flashes are interpreted as being due to the ions striking up against the screen.

Second theory: This is one in which it is supposed that radium acts as a transformer and is capable of capturing or absorbing some form of energy and of converting the same into the ultra-violet light and heat.

As bearing on this theory the following may be offered: If zinc sulphid be exposed to the sunlight it becomes phosphorescent and is capable of affecting a photographic plate in the dark for as long a period as six weeks.

Second—If calcium sulphid is exposed to the sunlight or after it is placed near burning magnesia it will affect a photographic plate in the dark for a long time.

Third—I took some polysulphid of calcium and mixed the same with some varnish and with this I painted the inside of a large test-tube. (This is practically known as luminous paint.) This tube was then exposed to the sunlight which rendered it phosphorescent, and when taken into the dark it gives out sufficient light so that one can read several lines of a newspaper at

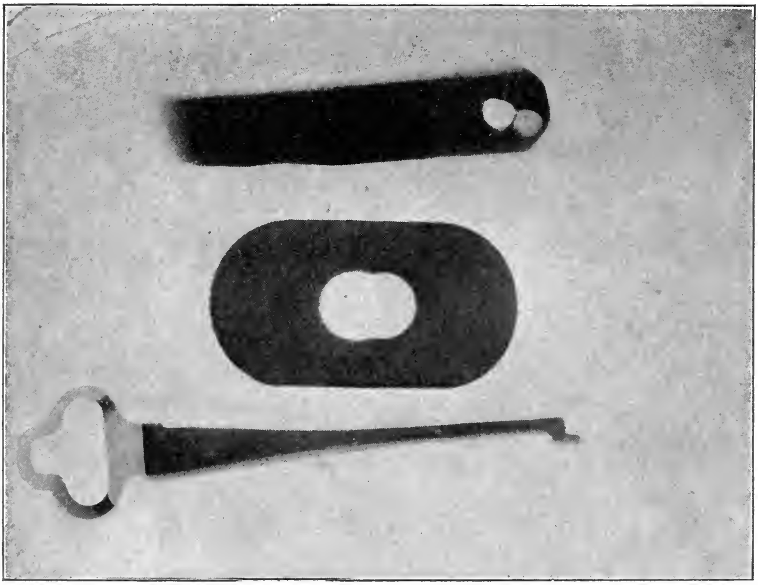

Figure VII

Test tube painted with polysulphid of calcium rendered phosphorescent by exposure to sunlight, suspended from under surface of cigar-box cover. Bare photographic plate with objects laid on bottom of box. Time seven days. Double image due to moving box after three days.

a time. (Fig. VII.) This tube was then suspended from the under surface of a cigar-box cover, and at the bottom of the box was placed a bare photographic plate on which was laid the three objects, the distance from the tube to the plate being about two inches. The box was wrapped up in paper and laid away in a drawer in the dark-room and remained there for seven days, after which time a very definite outline of the object was obtained. The double outline of the objects is due to the fact that the box was moved on the third day. This tube has been kept constantly in the dark for six weeks, after which time it affected the photographic plate very actively in five days. Thus we see that these two substances, zinc sulphid and calcium polysulphid, are capable of absorbing some energy from the sunlight, and calcium sulphid of absorbing some energy from either the sun's rays or from the burning magnesia, and that these substances are capable of retaining this energy and of giving the same out slowly for a period of six weeks, during which time they can affect a photographic plate.

INDUCED RADIOACTIVITY

It has been stated that if a sealed tube containing radium of high activity be suspended in a normal salt solution, and solutions containing various drugs, that these solutions become radioactive and are capable of affecting photographic plates.

It has further been intimated that if radium has a therapeutic value, then these solutions which have been rendered radioactive might likewise have a therapeutic action, and since solutions can be taken internally, the possibilities of these radioactive solutions might be of considerable value.

In view of this fact, I conducted a very large series of experiments from which the following negative results have been obtained:

Two tubes of radium of 1,000,000 activity, each containing 5 milligrams, and two other tubes of lesser activity, each containing 50 milligrams, were placed in a normal salt solution and remained there for 10 days.

This solution was placed in test-tubes of very thin glass and in the small vials in which hypodermic tablets are contained. These were then strapped with adhesive plaster on to the film side of photographic plates. Some of the plates had first been covered with black paper.

These tubes remained from a period of 24 hours up to 21 days, and in no case was there the faintest sign that the photographic plates had been affected.

It has been known for a long time that aluminum offers very little resistance to the rays of radium and radioactive substances.

I therefore took many boxes made of very thin aluminum and filled these with so-called radioactive solutions, and placed them on photographic plates, first covered with black paper. But in no instance, even after 10 days, was any image obtained.

Then aluminum boxes were filled with these solutions and placed on the bare photographic plates, and after 40 to 48 hours very definite outlines of the boxes were obtained. Stimulated by this last observation, which I then considered a correct one, as indicating a result due to the so-called radioactve solutions. I practically completed a series of 96 experiments, from which I made the following inferences, which would be very pleasing if true, but as I will soon show, are incorrect.

1. That a normal salt solution becomes radioactive, as proven by the outline of an aluminum box containing this solution, when this box is placed on a bare photographic plate for 40 to 48 hours.

2. A saturated salt solution becomes more radioactive than a normal salt solution.

3. As the amount of salt in the solution is increased, so is the induced radioactivity.

4. A tube of 10 milligrams of 1,000,000 activity does not induce a greater amount of radioactivity into a salt solution, than does a tube of 20 milligrams of 7,000 activity or a tube of 15 grains of 40 activity. From this it would seem as though a salt solution could be rendered radioactive to a certain degree only.

5. The radioactivity seemed to be just as great after a tube of radium was suspended in a salt solution for 10 hours, as it was after the tube of radium had been kept in the salt solution continuously for three weeks.

6. That a tube of radium could be placed in some salt and if this salt were made into solution, it would retain its radioactivity.

7. That this radioactivity is not lost after several weeks.

If all of these inferences had not been overthrown, and if these radioactive solutions had any therapeutic action, then surely these results would have been of great value, for it would be possible to transport these solutions, or to render substances radioactive, and to apply the same, and again a tube of radium costing a few dollars would accomplish the same result as a tube costing $250.00.

ALUMINUM

When these aluminum boxes were placed on the photographic plate, they only produced an outline of their rim. This I explained by the fact that they were slightly concave and only affected the plate at the points of contact. It was also noticed, no matter what solutions the boxes contained, that there was always about the same amount of print for the same length of time. I had also noticed that distilled water, when submitted to the tube of radium, produced the same amount of print. This caused me some doubt, for I believed it to be the solids in the solution which became radioactive. When aluminum boxes were filled with these salt solutions and empty ones were placed on the reverse side of the photographic plate, they did not affect the plate after a period of 10 days.

During the entire series no aluminum box had been used more than once, for I soon observed that if a box had contained any of these solutions or any radioactive substance, no matter how much I cleaned or boiled it, the box still affected the photographic plate; while the steel keys, which had been covered with the various uranium salts, and thorium, if they were cleaned thoroughly, would not affect the photographic plate. These boxes were always kept in a place where I thought them out of the influence of all radioactive substance.

These observations forced me to seek for an error. This action of metallic aluminum on the photographic plates I concluded must be sought for in the boxes themselves.

Then several empty boxes were placed on bare photographic plates and after 48 hours they gave as good prints as if they had been filled with the solutions. I then thought that somehow they might have been rendered radioactive. Then some new boxes were obtained and placed on bare photographic plates, and after 48 hours these also affected the plate, and so did many other new boxes.

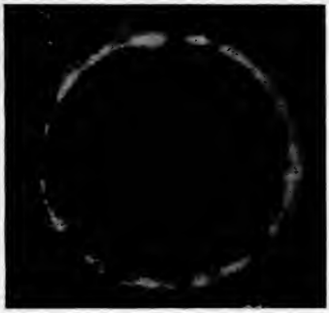

Figure VIII

An empty aluminum box was placed on the bare photographic plate. Time 60 hours. The box is slightly concave and only gives an outline of the rim where it touches. This action is not one due to radioactivity, but is probably either chemical or electrical.

The next questions which presented themselves, were:

1. Is the particular product of aluminum, from which these boxes are made, radioactive?

2. Is all aluminum radioactive?

3. Is this action of aluminum on photographic plates due to radioactivity, or some other cause?

4. If this action of aluminum on photographic plates is not due to radioactivity, what then is it due to?

5. What action will aluminum salts have on photographic plates?

Summary: Many aluminum articles were placed on bare photographic plates, and in every instance they produced their own image in 48 to 96 hours.

These same aluminum articles, when placed on photographic plates covered with black paper, did not produce an effect on the plate in 10 days.

These same aluminum articles, when placed on the reverse side of the photographic plate, or when separated from the film by a plate of glass, did not affect the plate in 10 days.

The summary of the experiment of placing aluminum salts, of which there are many, on the bare photographic plate, is that in no instance was the plate at all affected after 10 days.

The inferences to be drawn are:

1. When metallic aluminum is placed on the bare photographic plate in the dark, it will produce its own image.

2. That aluminum will not affect a photographic plate when separated from the film of the plate by black paper, glass, or when placed on the reverse side of the plate. Therefore, aluminum is not radioactive.

This action of metallic aluminum on photographic plates is probably either a chemical action or an electrical action between the metal and the albuminate of silver of the plate.

This observation, that metallic aluminum when placed on the bare photographic plate produces its own image, has heretofore not been pointed out.

Tubes of radium were placed in various powders, as bismuth subnitrate, for several days, and then these powders were placed directly on the film of the plate, and in no instance, even after 10 days, did they show the slightest effect on the plate.

These conclusions give positive proof, that by suspending tubes of radium of varying strengths for long periods in various solutions and various powders, that neither the solutions nor the powders are capable of affecting photographic plates.

Nor was it possible to show the supposed induced radioactivity by means of an electroscope.

Radium-therapy is a word I chose to suggest some months ago as signifying the application of the radium rays in the treatment of diseases, in counterdistinction to the word radiotherapy, which signifies the application of the X-rays in the treatment of disease.

There has never been a discovery but has been heralded as a panacea or cure-all, and already the radium rays are supposed to have accomplished wonders, especially in the cure of cancers and consumption. I have canvassed the subject thoroughly, collected all the published literature from medical magazines to date, and written to many who have reported cases of cure, and I must say that, up to the present time, there are but few cases reported by thoroughly reliable observers, wherein the radium rays have shown a beneficial action. Furthermore, it is far too early to draw any inferences, though it does seem as if these rays do exert some influence in lupus and rodent ulcer, but, in cases of deep-seated cancer, it is not possible to apply the rays without affecting all of the tissues, through which the rays must pass.

It has been proclaimed that the radium rays are life-giving. Now my inferences are quite the opposite, namely, that it is a death-producing agent to all living cells, either animal or plant, if applied in sufficient strength and for a long enough time, and its value in medicine is the hope that it may destroy the life of simpler cells of germs or of cancer before destroying the healthy cells of the body, thus leaving the healthy body-cells to regain themselves.

That healthy cells of the body may be destroyed is proven by the already frequent observations that when radium is applied to the healthy skin for a considerable length of time, it will produce an irritation, which may result in an ulcer requiring months to heal. I have seen such a scar in a physician, who had placed a tube of radium in an aluminum box and fastened the same to his forearm for three hours. The experiment was made over two years ago, and at the present time there remains a red irritated area, on which the hair no longer grows, and in many respects it acts like some vaccination scars.

There are some reliable reports showing that radium has retarded certain growths of bacteria. Prof. Curie introduced a few milligrams of radium under the skin of a mouse near the vertebral column and it produced death by paralysis in three hours. He also placed tubes of radium of high activity on the backs of guinea-pigs, which were either paralyzed or died of paralysis in a few hours. This seems to indicate that the radium rays have an action on the nerves.

The obtaining of definite knowledge as to the therapeutic effect of radium will be very slow in forthcoming owing to the present rarity of the element and the great cost of the same, and the time which must necessarily elapse before a malignant growth can be pronounced as cured.

It was thought that radium might be used similar to the X-rays in obtaining skiagraphs of the bones, but the rays of radium penetrate the bone quite as easily as they do the flesh, and it requires at least 24 hours, using a tube of radium of high activity, to obtain an outline of the bones, during which time the rays will have caused a very severe irritation of the exposed area.

The next two figures of a false joint of the ulna (which I reported in the *Cleveland Medical Journal,* April, 1904) give a very good example of the comparative value of the X-rays and radium in the examination of bones directly. The first figure is an X-ray of the bone itself after a three-minute exposure. In the second figure the bone was fastened directly on the bare photographic plate and a tube of 15 grains of radium of 40 activity was suspended directly above for one week. The rays have but slightly penetrated the connective tissue between the ends of the two bones. When tubes of radium of high activity were suspended above this same bone for a period of two weeks it did not show a sharp differentiation between the fibrous tissue and the solid bone.

X-ray picture of false joint, showing the ends of the fragments. Three-minute exposure.

Radium picture. Tube of 15 grain of Radium 40 activity suspended one week above bone which was placed on a bare photographic plate.

Thorium, being a very radioactive substance, might have some value in either medicine or surgery, for it is a nice, clean, white, stable chemical, and it is possible that it might be added to our list of drugs.

The toxicity of this substance, as determined on animals, as well as the clinical findings of the same, with those of radium, will be published later.

As this article goes to print, I wish to state briefly the history of a case of lupus which I am treating with radium and which seems to be healing.

Mrs D——, age 57, had a beginning lupus 16 months ago. Under the applications of the X-rays it improved. Then the eye itself became involved to such an extent that it was necessary to remove it eight months ago. While the wound from the operation was healing the X-rays had to be discontinued for a period of six weeks, during which time the disease spread. Further application of the X-rays caused the center to heal, while the ulcerated area spread at the periphery.

The patient was referred to me April 7. At this time there was a round healed area 1½ centimeters in diameter. Around this was an ulcerated rim varying in width from one to one and a half centimeters and extending from the outer corner of the eye to within 2½ centimeters of the ear and well down on the cheek. The entire area was deeply congested.

I applied a tube of radium of 7000 activity and two tubes of 40 activity, for 35 minutes every three days. After the second treatment much of the congestion disappeared and the edges, as well as the base, took on a better appearance, and much of the deep-seated pain had left.

The improvement was very rapid, and now after 21 days there is a new, healthy looking skin covering the entire ulcerated area excepting a few small places. The internal pain has left entirely, and nearly all the congestion has disappeared.

This case may be considered as practically healed, but many months must elapse in order to see whether the deep-seated germs will not assert themselves again, before the case can be pronounced as cured.

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NOTE—The author earnestly solicits all monographs and articles on this subject and will appreciate any that may be received.