my patients take a brisk cathartic the night before and on the following morning an enema is given. When there is any doubt whether the stone is in the kidney, I have the patient wait for a week or ten days, when I make another exposure. I do not do this because I fear a dermatitis, but I want to make my diagnosis all the more positive.

SKIAGRAPHY OF THE ACCESSORY SINUSES OF THE NOSE.

By E. W. Caldwell, M. D., New York.

The use of the Roentgen ray as an aid to diagnosis in certain diseases of the accessory sinuses of the nose was brought to my attention a little over two years ago by Dr. Coakley, of New York, and Dr. Ard, of Newark. Dr. Ard had just returned from the clinic of Dr. Killion at Freibourg, and had brought with him some excellent plates, in which the outlines of frontal and maxillary sinuses and the ethmoid cells were distinctly shown. On one of these plates there was an increased density of shadow over one of the frontal sinuses, which was believed to indicate pus in the cavity.

There is, in different individuals, such wide variation in the size of the frontal sinuses, in the number and position of their septa; and occasionally such a great lack of symmetry, that the use of the X-ray in this region would be fully justified even if it could give us no other information than the anatomical details just mentioned.

Therefore, at the suggestion of Dr. Coakley, I at once began making radiographs of cases from his clinic at the University and Bellevue Hospital Medical College. To this clinic and to the anatomical department of the college I am indebted for splendid material for a series of experiments which were directed toward securing a good technique for making radiographs of such cases, and for determining their practical utility to the rhinologist.

This work was carried on at the Edward N. Gibbs Memorial X-Ray Laboratory, which is the Roentgen Ray department of the college.

Read by invitation before the 7th Annual meeting of the American Roentgen Ray Society at Niagara Falls, N. Y., August 29 to 31, 1906.

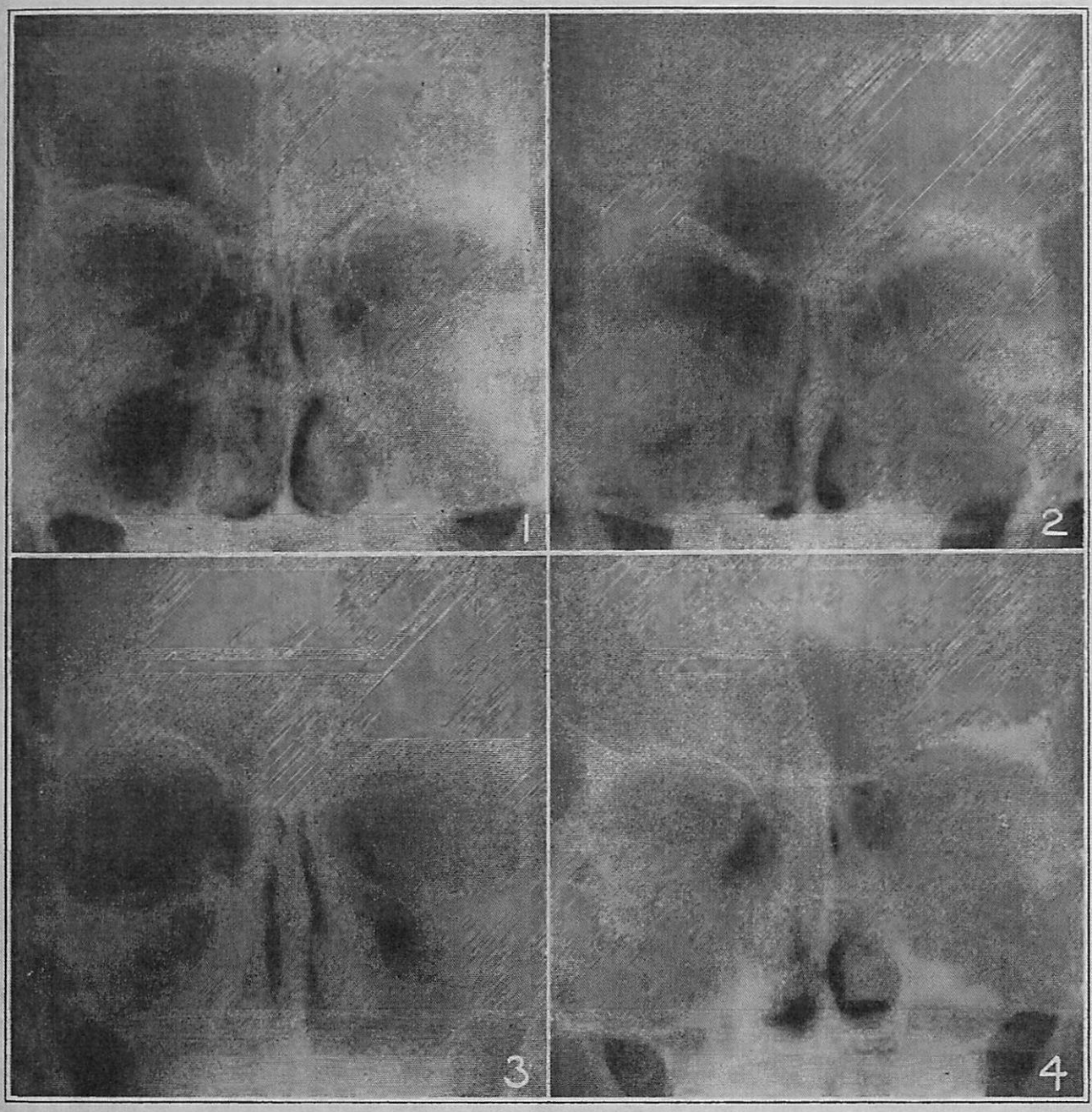
By comparing the frontal sinuses of several cadavers with the radiographs made of them, it was readily shown that the extent of the sinuses, and the location of their septa could be determined by the X-ray with sufficient accuracy for the purpose of the surgeon. The indications given by the X-ray of diseased conditions in the sinuses of patients from the clinic were confirmed in many cases by operation and by other means, but it seemed desirable to make further experiments to determine why the X-ray indicated such conditions, and how much reliance could be placed in these indications. Some experiments with this end in view were therefore carried out by Dr. Chisholm and myself.

It seemed probable that the increased density of the shadows of diseased sinuses was due chiefly to an increase in the amount of fluid in the cavity, either in a swollen and edematous lining membrane or a collection of exudate or pus. Radiographs of specimens of pus and exudates from various sources show that their opacity to X-rays was practically the same as that of a normal saline solution, or of pure water. This was determined by radiographing at the same time equal volumes of the various fluids in little thin celluloid dishes of exactly the same size and shape.

A piece of mucous membrane from a cadaver was cut in half. One piece was kept moist by placing it in a sealed jar while the other piece was dried. The radiograph of the two pieces showed that the water in the moist specimen cast a shadow many times as dense as that cast by the solids of the dry specimen.

We then made radiographs of some heads of cadavers before and after filling parts of the sinus cavities with water or with pieces of moist mucous membrane introduced through trephine openings. It was easy to detect the added liquid and membrane in the radiograph, but the rather large trephine openings were objectionable and it was found very difficult to keep the liquid from leaking out of the cavities. Dr. Coakley then made the very practical suggestion that we use moist gelatin instead of water or membrane for filling the cavities, and the demonstration was then repeated with more refinement in detail. Control radiographs were first made to show that the opacity to X-ray of the moist gelatin was practically the same as that of the water or pus or edematous membrane.

Radiographs of the heads of some fresh cadavers were made. Then the scalp was turned down over the frontal bone until the supraorbital ridges were exposed.



1. Very large frontal sinuses with many septa. Fluid is shown in right frontal and right maxillary sinuses. Operation by Dr. C G. Conkley demonstrated that these cavities were filled with pus.

2. Asymemetrical frontal sinuses. In this case, trans-illumination was misleading. The principal angle is a little too small and the shadows of petrous bones are shown over lower third of orbit.

3. Frontal sinuses rather large, but contain no fluid. The left maxillary sinuses contained small amount of pus The transverse line across upper third of orbits show the limit of shadow of horizontal plate of frontal bone. The principal angle is approximately 25°.

4. Left frontal and both maxillary sinuses filled with pus. Principal angle a little too small for best results.

By means of tracings from the first radiographs, the frontal sinuses and their septa were outlined in ink on the frontal bones of the cadavers. Then by using a small drill, directed downward and backward from points above the superior limit of the sinus, we were able to enter unerringly the different cavities formed by the septa. By means of a small syringe needle introduced through the drill holes, we were able to show that these cavities contained no fluid. We then injected into some of the cavities gelatin which was just warm enough to flow through the syringe needle, and which solidified immediately after. The scalp was then replaced, and more radiographs of the head were made. In these radiographs the empty cavities could be readily distinguished from those filled with gelatin.

These experiments convinced us that the X-ray indication of fluid in the sinuses was fairly reliable,—a fact which had been recognized by our German colleagues before we began our experiments.

In order to use the X-ray successfully for exploring the accessory sinuses of the nose, it is necessary to obtain radiographs of very good quality. Such radiographs are not easy to make. They call for the best possible appliances, and an amount of attention to petty details of technique which the busy clinician is unable, or unwilling to give, and of which he has usually not the vaguest idea.

Owing to the thickness and opacity of the skull and brain, it is necessary to make long exposures, and to use rays of rather high penetration. The use of rays of too high penetration, however, results in a lack of contrast in the negative. Rays of low penetration act more energetically upon the scalp, and longer exposures are necessary with them, in order to obtain sufficient effect upon the photographic plate. Unnecessarily long exposures must be avoided, because they increase the liability of blurred pictures due to movements of the subject, and also because they increase the danger of harmful effects of the rays, both upon the scalp and upon the deeper structures.

The necessity for long exposures, and sometimes for repeated exposure, together with failure to secure the proper degree of penetration and sufficient distance between tube and scalp, sometimes cause X-ray allopecia, and even X-ray dermatitis over the back of the head. Not only these unfortunate accidents, but also the disclosures of Dr. Edsall, of Philadelphia, and others, as to the profound effect of X-rays upon all living cells, remind us of

the importance of working with especial caution and certainty in this region. Indeed, I think it is unwise to expose the same individual during a period of three weeks, for a longer time than is necessary to obtain two or three radiographs in the antero-posterior position.

The danger of X-ray allopecia and dermatitis may be considerably reduced by interposing between the tube and the patient some sort of protective ray filter. For this purpose, I use a sheet of aluminum, 1-50 of an inch thick, very close to the tube, and work with the target of the tube 18 inches from the center of the plate. No accidents have occurred in my practice under these conditions.

It is, of course, necessary to use some screening device to cut off as much as possible the rays originating from the glass walls of the tube. For this reason, most operators use the Albers-Schonberg compression screen, or some modification of it. These appliances, although exceedingly clumsy, are perhaps the best for the purpose which the market affords.

The usual procedure is to place the patient in a recumbent position, face downward, with his forehead and nose resting upon the plate holder, and to adjust the tubular part of the compression apparatus over the back of the head. The usual length of exposure in Germany is two to three minutes, but it is quite possible, with good apparatus, to obtain brilliant negatives with exposures of ten to twenty-five seconds.

The length of exposure, and the degree of penetration depend somewhat upon the thickness of the skull, which varies greatly in different individuals. For determining the degree of pentration of the ray, and for estimating the length of exposure necessary in a given case, I like to observe the degree of fluorescence produced on a barium platinum-cyanide screen by the X-rays which pass through the skull of the subject at the time the exposure is made. This is one reason why I do not use the Albers-Schonberg apparatus. I work with my patient lying face up on a canvas stretcher. I place the tube and diaphragm under the stretcher, support the plate over the face, place a fluorescent screen over the plate, darken the room, and watch the effect of the rays on the screen. Two advantages of this method will be apparent at once. The patient is more comfortable, and hence less likely to move during the exposure, and then, if the penetration of the tube changes and becomes too high or too low, it will become

apparent at once to the operator, and the exposure may be terminated without delay.

The appearance of a radiograph of the face and its usefulness in diagnosis depend much upon the position of the tube and the direction of the rays with reference to the base of the skull. We must avoid superimposing the shadow of the horizontal plate of the frontal bone upon that of the frontal sinus, or the shadows of the petrous bones upon those of the maxillary sinuses, or the shadow of the basilar process of the occipital bone upon that of the ethmoid cells. Any of these undesirable results and some others as well may occur if the exposure is made in a careless manner. The necessity for a standard distance and position of tube is, therefore, apparent.

The direction of the rays with reference to the plane of the photographic plate is comparatively unimportant, and since we must bring the plate as close as possible to the face, this direction will be determined by the prominence of nose and forehead, and therefore subject to considerable variation with different individuals.

The distance of the source of X-ray (the target of the tube) from the face and the plate is, however, of some importance, partly because upon it depends the amount of divergence of the rays which give us the shadow picture. Considerations of safety to the patient and length of exposure are, however, the chief factors which determine this distance. I find that 18 inches answers all the requirements for safety and that this distance does not necessitate longer exposure than about 20 seconds for the antero-posterior projection and 10 seconds for the transverse projection.

In order to secure a standard position for the source of rays we may select one of the diverging rays which produce the picture and measure the angle which it makes with a plane corresponding approximately to the base of the skull. The ray I have selected for this purpose is the ray which passes through the skull in the mesial plane and pierces the center of the glabella. This ray I have called for convenience the principal ray. A suitable plane which can be readily located by external landmarks is the one which passes through the centers of the external auricular orifices and the center of the glabella. To save time I shall call this plane the basal plane and the angle between it and the principal ray, the principal angle. With a fixed distance between the target of the tube and the glabella

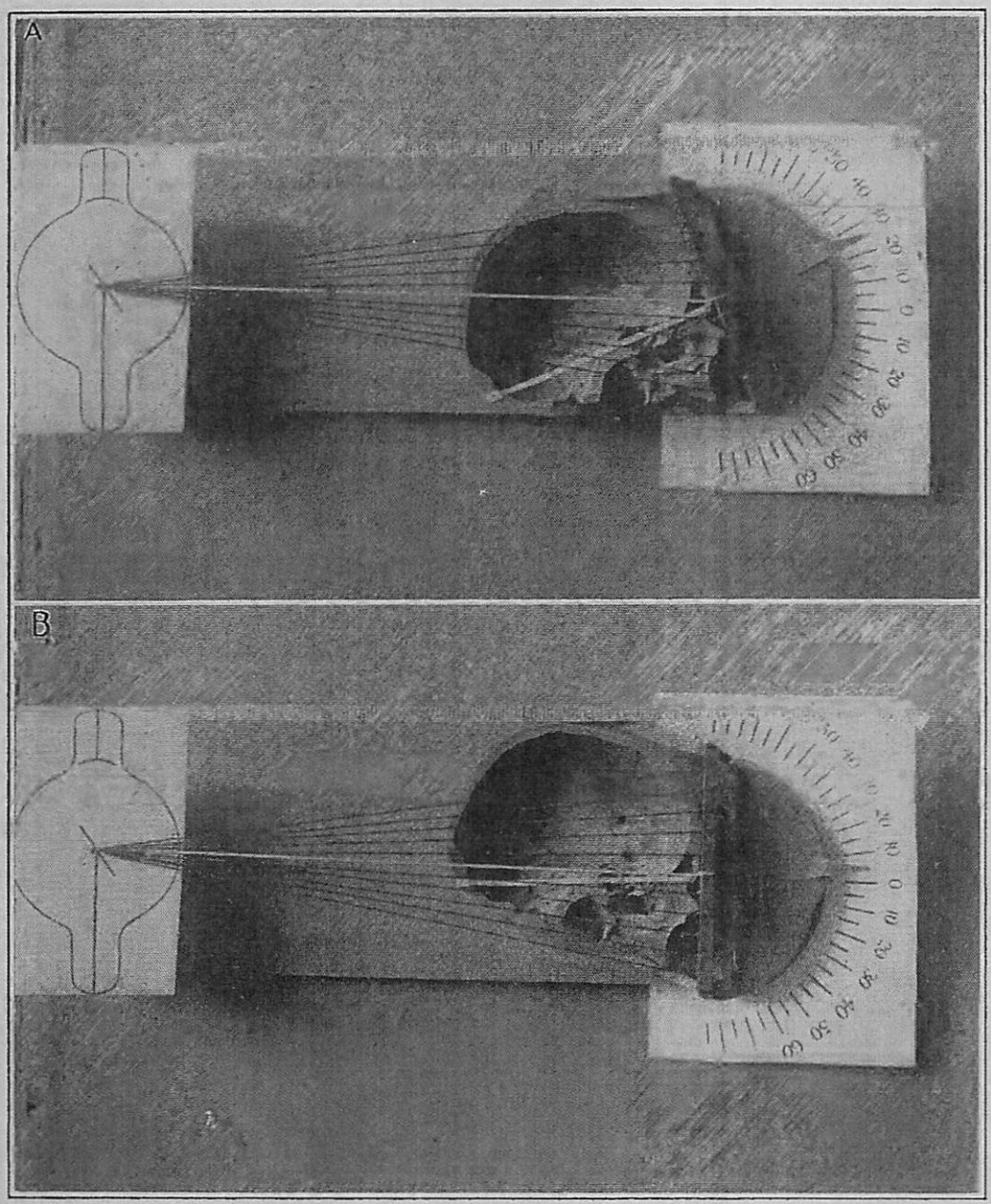
the general direction of the rays may be expressed by the measurement in degrees of the principle angle.

From measurements of a number of skulls which had been split in the median plane, and from a number of radiographs of skulls and heads at different measured angles I have found that, with the target 18 inches from the plate at the glabella, the best results are obtained when the principal ray makes an angle of from twenty-three to twenty-eight degrees with the basal plane. I have therefore adopted twenty-five degrees as the standard angle for the principal ray, and the basal plane, or the standard principal angle. With this distance of tube and direction of ray, the shadow of the edge of the horizontal plate of the frontal bone, where it joins the wings of the sphenoid, appears as a transverse line passing across the orbit about one-half inch below the supra-orbital ridges. The appearance, in a symmetrical picture, of this shadow in the position mentioned is a fair indication that the principal angle is approximately correct. I regret to say that some of the plates I shall show here were made before the importance of this angle was apprecaited, and before we had accurate means for adjusting it.

A few degrees variation from this standard direction is unimportant, but accuracy and uniformity are desirable. In order to obtain a fair degree of accuracy, I have arranged my tube with an indicator of transparent celluloid which locates the principal ray, and a scale graduated in degrees, which shows the angle between the principal ray and the perpendicular.

I have also a little instrument which measures approximately the angle of the basal plane with the perpendicular. This device carries a conical plug, which fits into the external auricular orifice, and a ruled celluloid strip which can be adjusted so that the ruled line passes over the center of the glabella and therefore lies in the basal plane. A scale, graduated in degrees, to which is attached a spirit level, may be turned until the zero point on the scale is perpendicular. In this position, one of the little pointers indicates the angle of the basal plane with the perpendicular, and the second pointer, placed twenty-five degrees away, indicates on the scale, the correct angle for adjusting the tube holder.

With the Albers-Schonberg apparatus, the same result may be obtained approximately by placing the tubular diaphragm in such a direction that its axis lies in the plane passing through the glabella, and about three-quarters of



Two photographs of a model constructed for showing the effects of changing the position of the tube with reference to the skull. The direction of the rays in mesial plane is shown by stretched elastic cords passing from a point representing the target of tube to a bar placed in front of face and representing a line in the middle of plate. The principal ray is represented by a cord of lighter color than the others and the basal plane is shown by a strip of tape fastened to the skull at its base.

In A, the principal angle is approximately 25°, and it will be seen that the rays passing through frontal sinus are not obstructed by irregular parts of the base of skull.

In B, the principal angle is too small (about 5°). In this position the shadows of parts of base of skull would be superimposed upon those of the sinuses.

an inch below the parietal eminences on each side. It is understood, of course, that in making the antero-posterior projection the principal ray, or the axis of the Albers-Schonberg cylinder lies in the median plane of the body.

The radiograph of the head in the transverse direction, is comparatively easy to make, and is of little importance. It gives an idea of the depth of the frontal sinus, and a knowledge of this depth is sometimes useful in interpreting the shadows on a so-called "front view" plate. The outline of the sphenoidal cells may be shown in the lateral projection, but I am told that this is of little use to the surgeon. I therefore make this plate with especial reference to the frontal sinus. The plate is supported parallel to the median plane, and the ray passing through the center of the glabella is perpendicular to the plate. The sphenoidal cells may be best shown by passing the perpendicular ray through the middle of the line joining the external auricular orifice, and the external angular process.

It is well known that photographic prints of X-ray plates fail to show the detail of the original negative. This is especially true of plates of the skull. In these sinus plates, the print is particularly disappointing, and we rely solely up the negative. Contact copies on glass are difficult to make, and they seldom show as much as the original negative.

The examination of these negatives is facilitated by having a dark mat around the part of the picture we want to see. I therefore make these radiographs on plates eight by ten inches, and have devised a method of giving them a very dense black border, which is as follows: After the exposure is made, I cover the plate with a piece of cardboard the exact size of the plate holder. This cardboard carries at its center a sheet of lead of sufficient size to cover the useful part of the picture, and carries also the words "right" and "left" with the plate number in lead letters and figures. An exposure to X-ray of about three seconds through this cardboard and lead, produces in the developed plate a dense black border around the useful part of the picture, which has been protected by the lead plate, and leaves the indicating words and figures on the plate in the proper position. The appearance of the black border in the developing tray is found to assist materially in examining the plate by ruby light to determine the stage of development.

DISCUSSION ON DR. CALDWELL'S PAPER.

DR. GEORGE E. PFAHLER, Philadelphia:—The society is indebted to Dr. Caldwell for this excellent presentation of this subject. This also gives me an opportunity to mention another point. That part of the profession that is interested in the study of frontal sinuses was pleased at the light that the X-ray threw on the study of these sinuses about a year ago and we wondered who really did the work. Now we learn that this beautiful work was done by Dr. Caldwell.

Some clinicians will accept such hard labor and beautiful work without giving credit to the man who did the work. We should insist on receiving at least half the credit when we do all the work. I shall insist when doing this work in being a joint author of the paper, instead of not being mentioned. I read one of Dr. Coakley's papers about a year and a half ago, but found no mention made of Dr. Caldwell, although he did all the X-ray work.

About six weeks ago in a case of alopecia I wanted to examine the progress I was making in the treatment of a round cell sarcoma of the frontal sinus. I made an exposure of thirty seconds, although usually I make it in ten or twenty-five seconds; but in this instance I wanted to be sure of my results. About four weeks later the patient lost the hair exactly corresponding to the outline of my diaphragm. This emphasizes the importance of short exposures and the use of the filter. I treated that patient for nearly three years and was one of the first on whom I used the leather filter and she first recognized the absence of a burning sensation when the filter had been used. I believe that if I had used a filter in the instance mentioned that it would have saved that patient's hair.

As to the angle. When Dr. Caldwell read his paper, I thought that he was making the angle in the opposite direction as I have been doing. Albers-Schoenberg makes his plates with the angle in the opposite direction from the base of the skull. Albers-Schoenberg passes his rays through a line drawn through the glabella and lower portion of the mastoid process which will throw the rays below the skull, and it seems to me that that should give us at least a better view of the antrum of Highmore. It may not give quite as good a view of the frontal sinus, but I am quite sure that it will give you something, and the rays pass through the spinal column very near the second vertebrae and those rays are so much diverted by the time they reach the plate that they do not obscure the shadows of the frontal sinus.

DR. ALFRED L. GRAY, Richmond, Va:—I want Dr. Caldwell, in closing his discussion, to tell us how he can determine whether the cavity is filled with pus or whether the shallow is caused by an abnormal thickening of the bone. It has been my experience in observations of frontal sinuses that very often we find one plate considerably thicker than it is on the other side. I would like to know how Dr. Caldwell determines that point.

DR. PERCY BROWN, Boston:—Dr. Caldwell spoke of using a hard tube, and yet not one that is too hard. I should like to ask him if he can give us approximately, in terms of Walter, the hardness of the tube he uses in the ordinary skiagraphic procedure.

DR. LEWIS GREGORY COLE, New York City:—I think that the paper which Dr. Caldwell presented, especially the matter of the angle, is very fine. I have done some of this work and I have followed in a way the same angle Dr. Caldwell has, that is, having the ray come through in the same direction he does, although I have not measured it with the same accuracy.

I would like to ask him with what degree of certainty he can make a negative or a positive diagnosis as to the presence of pus in the cells. In some of the plates shown there is no question as to the diagnosis, but in the borderline plates, I wish he would tell us how he makes his diagnosis.

DR. CALDWELL, closing the discussion:—With reference to Dr. Pfahler's criticism, I think he has overlooked the fact that the author of the papers he mentions has not claimed that he made the radiographs himself, but has given full credit to the Roentgenologist. I fear that Dr. Pfahler is a little overgenerous to the X-ray worker.

We are indebted to the clinician for material for suggestions and for his demonstration of the usefulness of the X-ray in this comparatively new field.

I have never tried to make a radiograph with the tube placed so that the rays which cast the shadow of the frontal sinus must first pass through the cervical vertebrae and the base of the skull. The shadows of these irregular bones superimposed upon that of the frontal sinus would in my judgment, be far more objectionable than those produced by the comparatively smooth and regular bones of the skull with the direction of rays I have used.

When the radiograph shows that there is something in the sinus which casts more of a shadow than is normal we assume that this is fluid. We have not been deceived by thickened bone on one side. I fancy that the shadow due to thickening of the bone would not be sharply limited by the septa as is the case with those due to cavities filled with pus.

As to the accuracy of this work I cannot tell. I imagine we have about the same degree of accuracy that we have in raying for kidney stones.

I do not use any of the well-known penetration gauges for the reason that the tubes may change so quickly during the exposure that a measurement made before or after will not be reliable. I gauge the penetration by two things. By the appearance of the fluoroscopic screen during the exposure and by the reading of the milliampereremeter in series with the tube. With a certain interrupter and coil, with the rheostat resistance all out, a reading of ten milliamperes shows that the penetration of the tube is about high enough. This method of gauging the penetration has proven quite satisfactory in my work.