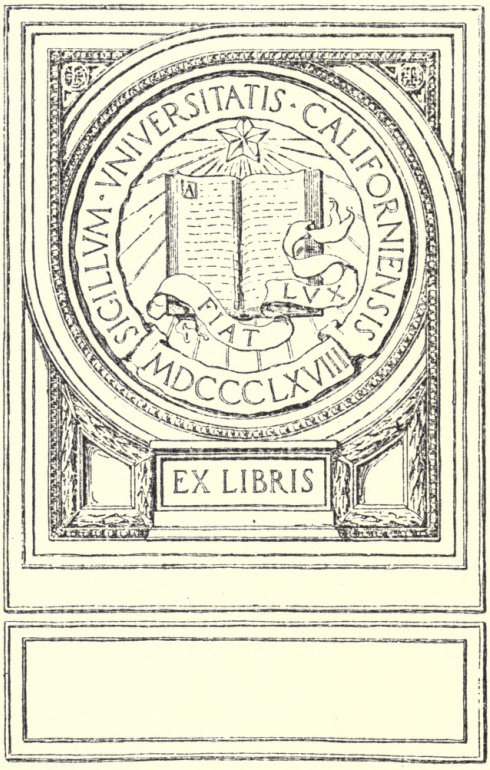
SYSTEMATIC DEVELOPMENT OF X-RAY PLATES AND FILMS

WENDELL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THE SYSTEMATIC DEVELOPMENT OF X-RAY PLATES AND FILMS

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BY

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PREFACE

This book has been written in the hope that it will throw some needed light upon a much neglected branch of radiography. Little has been written upon the photographic phase of radiography, and the few pages that have appeared are antiquated. It is a fact that few radiographers pay sufficient attention to the development of the x-ray film or plate, and even many of the so-called experts produce pictures which, considered from a purely photographic point of view, can be classed only as amateurish. The radiographer should be just as painstaking in the development of his pictures as the professional photographer, and unless he is willing to adopt a method which will eliminate the element of chance, he can never hope for uniformity of results.

In preparing this book I have at all times kept in mind the fact that the book will be largely read by the assistant, who, perhaps, lacks a technical education. The book has therefore been made as nontechnical as possible, and even the layman can read it with understanding.

I wish to lay special stress upon that portion of Chapter III which deals with the *tank* or *stand* method of development. The tank has fully proved its worth, both from a scientific and from a practical point of view, and there is no question but that the tank method is best suited for the worker whose knowledge of photography is limited.

The need of illustrative material for lectures has become so urgent among professional men that I deemed it advisable to add a brief chapter on the making of lantern slides from x-ray films or plates. While slide making is very exacting, there is nothing unduly difficult

about it, and the practitioner who is able to produce a good radiogram should find no difficulty in making a satisfactory slide.

Many of the radiographic illustrations in these pages will prove disappointing, because of the fact that the gradation and delicate details so often referred to in the text are largely absent. This is due not to faulty x-ray or photographic work, but to the inherent limitations of the halftone process of engraving. A halftone reproduction always loses at both ends of the scale, the whites becoming darker in tone, and the blacks lighter. If this fact is kept in mind when viewing book illustrations in general, much confusion and perhaps unjust criticism may be avoided.

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SYSTEMATIC DEVELOPMENT OF X-RAY PLATES AND FILMS

CHAPTER I

INTRODUCTORY

Considering the widespread use of radiograms one notes with surprise how few of the countless numbers produced are completely satisfactory. Many of them bear evidence of having been taken with a faulty or inferior machine, others have been taken at a wrong angle and are so badly distorted that they do not present the anatomic relations at all truthfully; the vast majority, however, are bad from a photographic point of view, and a film or plate that is bad photographically is more or less unreliable for diagnostic purposes. So universal is this last-named fault that there can be no doubt but that the majority of operators fail in one or more of the fundamental principles of photography, and the efficiency which their knowledge of radiography should give them is lost by faulty photographic work. Many seem to think that proficiency in handling the x-ray machine is all that is necessary, the development of the exposed film or plate being so simple and automatic a process that it would be foolish for the operator himself to waste any time over it. But that is a mistake. It is like a man who, knowing nothing about photography, purchases a very expensive camera, in the belief that the anastigmatic lens and the elaborate accessories will compensate for his lack of knowledge of photography.

An interesting story is told by Mr. Otto Doehn, of the X-ray Department of the Eastman Kodak Company, and since it has a direct bearing upon what has already

been said I take the liberty of putting it in print. In one of our large eastern cities a number of wealthy and philanthropic men erected a beautiful and thoroughly modern hospital, and in order that it should rank second to none, the best physicians available were chosen for the various departments. A promising young man was selected for the radiographic department. He prepared himelf by taking a special course in the subject in this country, then went to Europe and made a thorough study of radiography there. When he finally returned to take up his work he felt competent to handle anything pertaining to x-ray work. Several weeks after he had taken charge of his department Mr. Doehn paid him a visit, and, to use the words of the visitor himself, the radiographer was the sickest looking man he had ever seen. He was thoroughly familiar with his machine, and handled it with ease and certainty; yet, the pictures which he produced were practically worthless. He had just exposed an 8x10 plate which he placed in the developing tank at the moment Mr. Doehn entered. Unobserved by the radiographer, Mr. Doehn took out his watch to time the development. Fifteen minutes passed, and Mr. Doehn became restless because he knew that more than enough time had elapsed to produce a fully developed plate. Twenty minutes passed and Mr. Doehn asked the radiographer if he hadn't forgotten his plate. "No," said the latter, "it will take another ten minutes." At the end of the half hour the plate was removed from the tank and it was hopelessly bad. Mr. Doehn tested the temperature of the developer and found that it was a trifle under 60° F. Now, hydrochinon, one of the chief agents in an x-ray developer, almost ceases to operate below 60 degrees. The radiographer had overexposed his plate considerably and then tried to force an image out of it with a developer which was too cold to produce the desired chemical reaction.

CHAPTER II

FUNDAMENTALS

The X-ray Plate*

The sensitive part of the plate or film, called the emulsion, consists of a layer, about one-thousandth of an inch thick, of gelatine impregnated with silver bromide salts. The emulsion may be coated on glass and we have the photographic plate, or it may be coated on a thin celluloid base and we have the photographic film. When the x-rays, or light, or other types of radiation, strike the sensitive emulsion, an image is produced upon it. The image, however, is latent or invisible and must be made visible by chemical means.

The idea is quite prevalent that the x-ray plate differs in some mysterious manner from the ordinary photographic plate. There is a difference, to be sure, but it is not so great as one might imagine. Both plates are coated with a gelatine emulsion charged with silver bromide, and from the standpoint of thickness the emulsion is approximately the same. All x-ray emulsions, however, contain silver bromide in a more concentrated form. As regards speed, the x-ray emulsion when exposed to white light is approximately from one-third to one-half slower than ordinary kodak speed film. There is also an increase of contrast in x-ray plates over ordinary plates. This is necessary because the tissues of the human body are often nearly as opaque as the material of which it is desired to obtain an outline, and a soft-working plate would frequently result in no differentiation of parts. Again, x-ray plates are not sensitive to a full range of

*For the sake of brevity, the word *plate* will be used almost exclusively in these pages, but it should be borne in mind that what is said of plates may also be said of films, and the two words can, in the majority of instances, be used interchangeably.

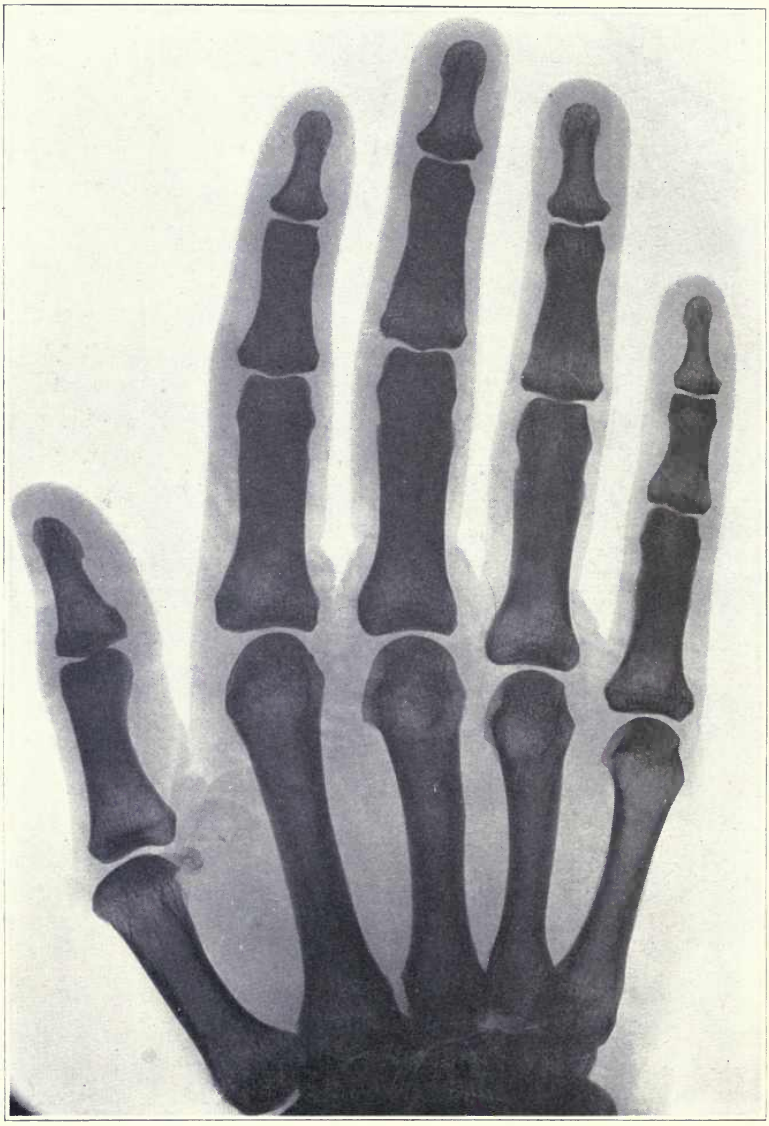

Fig. 1.

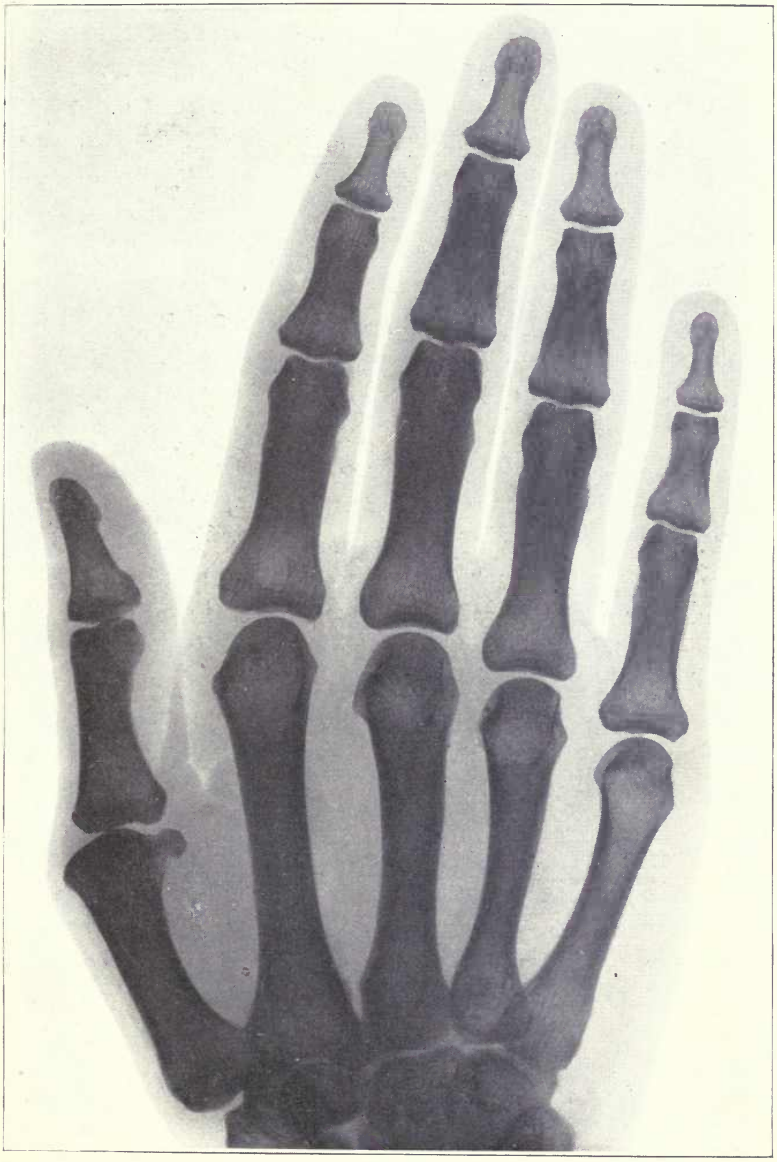

Fig 2.

colors because in x-ray work we deal with practically no colors. Such plates are, therefore, non-color-sensitive, or non-orthochromatic, using the technical term. Ordinary photographic plates, on the other hand, must be able to record the colors of the spectrum, and such color-sensitive plates are known as orthochromatic.

In order to illustrate graphically the difference between the x-ray plate and the ordinary photographic plate two negatives were made, one (Fig. 1) on an x-ray plate, the other (Fig. 2) on an ordinary Non-halation L Ortho Plate. Both were exposed for the same length of time, and were developed in the same solution for the same length of time. As will be seen, the results are practically identical.

Basic Principles of Development

Complex theories of development do not interest the radiographer so much as a direct method for producing the highest average of good results. It is, however, essential that he possess a knowledge of the fundamental principles of development, and the laws governing the various chemicals composing the developer, for without this knowledge it is extremely difficult, if not impossible to locate and correct errors of development.

The moment we place the exposed plate in the developer the image gradually appears, and it seems as though the developer were adding something to the plate, but this is not the case. A developer is what is known in chemistry as a "reducing agent," and it plays the same part for the exposed silver bromide that the coke of the blast furnace plays for the iron ore. When iron ore is smelted with coke in a blast furnace, the coke takes away the foreign matter which is combined with the iron and leaves the pure metallic iron, and this process is called the "reduction" of the ore. In the same way the developer takes away from the silver bromide the bromide

which is combined with the silver and leaves behind the metallic silver.

The image which the developing solution has brought out upon the plate appears black because the grains of metallic silver are small and irregular in shape. We think of silver as a white metal, but if we break it up into minute particles, they will appear grey, and the grains of silver in the plate are so spongy in their nature that they appear quite black.

There are many reducing agents available in chemistry, but only a limited number can be used for photographic purposes, because while they must be strong enough to reduce the exposed silver bromide, yet, if they are too strong, they will also attack the silver bromide which has not been acted upon by the x-rays.

The best reducing agents for x-ray plates are *metol** and *hydrochinon,* usually used in combination. Metol-hydrochinon is not sufficiently energetic to penetrate the emulsion, and so some chemical which has the power to open the pores of the gelatine and allow the reducing agents to penetrate and do their work must be added. This is an alkali, usually *carbonate of soda.* It is spoken of as the accelerator, because it accelerates, or hastens, the action of the reducing agent. The developer as it now stands has a great affinity for the oxygen of the air, and if no other chemical were added it would soon oxidize and lose its reducing power. Therefore, *sulphite of soda,* a chemical which has a great eagerness for the air without hindering the work of the other chemicals, is added. Lastly, a developer containing the two reducing agents, the alkali, and the sulphite may be so strong that there is some danger that it will produce a chemical fog over the entire film and so to restrain the activity of the

*Metol is a German product and was the standard developer for many years. It is not available at the present time, but there are many substitutes which work equally well. Among the best may be mentioned elon, rhodol, monomet, photol, serchol, phenomet.

developer a few grains of *bromide of potassium* are added.

The typical x-ray developer may therefore be tabulated as follows:

1. The reducing agent	Metol-hydrochinon.
2. The accelerator	Carbonate of Soda.
3. The preservative	Sulphite of Soda
4. The restrainer	Bromide of Potassium

When the plate is placed in such a developer the solution penetrates the gelatine and attacks the exposed grains of silver bromide and converts them into black grains of metallic silver, thus forming an image upon the plate. As action proceeds the developer which has penetrated the gelatine oxidizes, and, having lost its reducing power, is diffused out from the gelatine, and its place is taken by fresh developer, so that a constant supply of fresh solution is going to the grains of silver bromide. Development, therefore, *takes a certain definite time,* the image increasing in density as the time goes on. Enough time must be given for the developer to do its work, but if the plate is left in too long it will be overdeveloped; in other words, so much of the silver bromide will be reduced to metallic silver that not only will the image become too dense, but a chemical fog may spread over the entire plate. On the other hand, if the plate is not developed for a sufficient length of time, it will be underdeveloped; that is to say, only the superficial portion of silver bromide granules will be converted into metallic silver, while the underlying portion will not be acted upon at all by the developer and will subsequently be dissolved by the fixing bath. We are told by one of the largest plate manufacturers in the country that thousands of dollars worth of silver is thus wasted annually. *Most radiographers have a tendency to underdevelop their plates.*

Fixation

After the plate has been developed, which is one chemical process, another chemical process must take place before the negative is complete; that is, the plate must be "fixed," to remove unused material and to make the image permanent. Before using apparatus in any chemical operation, the rule is that it should be thoroughly washed. The same holds good with regard to the photographic plate. It should be thoroughly rinsed after the first chemical process (developing), before the second chemical process (fixing) is performed.

The chief ingredient of the fixing bath is *hyposulphite of soda* (commonly called *hypo*). It has the power of fixing the metallic image, while at the same time rendering the unexposed silver bromide into a soluble compound which is finally removed in the wash water.

Fixing will usually be completed in from ten to twenty minutes, but if the plates are left in longer no harm will be done. Fixation should in all cases be double the time it takes to remove the milky deposit.

CHAPTER III

METHODS OF DEVELOPMENT

In the latter part of the preceding chapter we spoke of the chemical composition of the x-ray plate and of the general action of the photographic developer upon it. We are now ready to discuss the various methods employed for bringing out the latent image upon the exposed plate. Three methods or systems of developing a photographic plate are in common use. The first may be called the Tray, or Visual Inspection, Method, the second the Factorial Method, and the third the Tank, or Stand, Method.

Tray, or Visual Inspection, Method

By the tray or visual inspection, method is meant a method wherein the worker watches the plate or film as it develops, and judges the completion of development by the appearance of the negative.

It is a curious fact that this method is practiced by two classes of workers—the most advanced, and the least advanced. It is the system that some of the most experienced photographic workers employ, and it is the system by which the veriest tyro in matters photographic will try to coax an image out of a reluctant plate. It is the system almost universally employed by radiographers, because of its seeming simplicity. However, the simplicity is only apparent, not real. In fact, far from being a simple method it is the most difficult of all methods, and to master it requires first of all a thorough knowledge of photography, and secondly years of practical application. The worker who follows these methods places the exposed plate in the developing dish, and flows

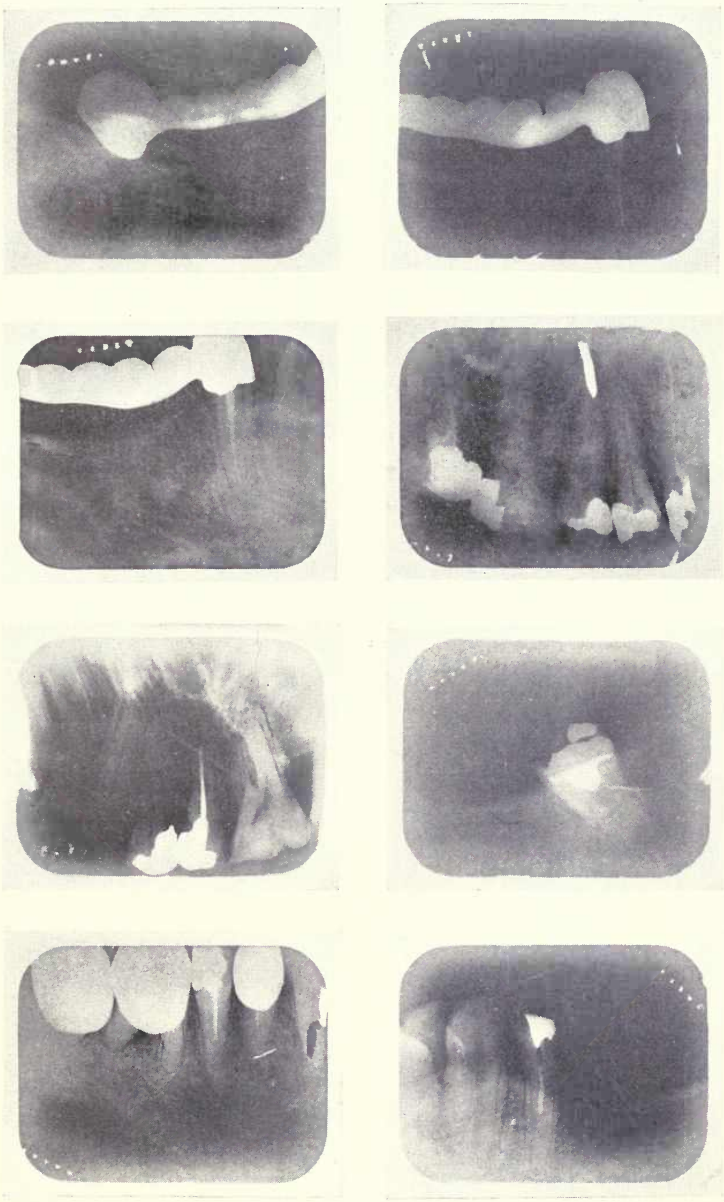

PLATE I

Examples of overexposed films developed with too warm a solution. Note the dense, muddy results, the detail and gradation being wholly or partly obscured. These pictures were all chosen from the daily output of a large hospital.

the developer over it, or in the case of small dental films, the tray is filled with the solution and the films submerged in it. From time to time the plate is removed from the dish, and an attempt made to look through it by the light of the red lamp, and to form a judgment as to how far development has proceeded. This sounds like simplicity itself, and so it is when one knows how to do it, but until one does, it is the reverse. It will be found that considerable experience is needed before one can with certainty decide that a negative is or is not fully developed. The negative is practically opaque before it goes through the fixing bath and even if it were to be examined in broad daylight it would be difficult to judge the density.

The most glaring mistake that the radiographer makes when he employs the tray method is that he pays not the slightest heed to the temperature of his solution. He fills his tray from a bottle of stock solution and, for all he knows, the temperature of the bath may be 60° or 70° or 90°. With too cold or too warm a developer he may produce a negative which will appear correct when viewed before the red light, but the finished product will not be correct. If, for instance, a perfectly developed negative is obtained when a certain degree of opacity is observed at 65° F. this same degree of opacity (as observed before the darkroom light) would yield an underdeveloped negative at 60° F. and an overdeveloped negative at 75° F. In other words, three plates developed at varying temperatures (60°, 65°, 75°) can be developed to a point where the opacity will appear to be identical when viewed before the red light but when these same plates have been fixed, washed, and dried it will be found that only that plate which was developed at 65° F. is perfect, the other two being inferior as regards brilliancy, detail, and gradation.

A comparison of Figs. 3, 4, and 5 will make the point clear. All three pictures were exposed normally and

simultaneously; that is, the three films were placed in the same container and given an exposure of two seconds. The films were next developed in solutions of varying temperatures; Fig. 3 being developed at 60° F.,

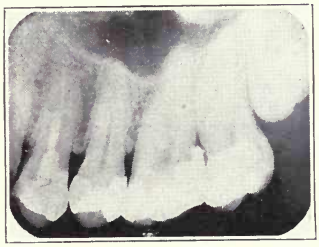

Fig. 3.

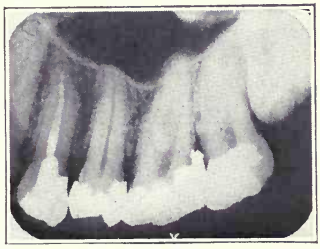

Fig. 4.

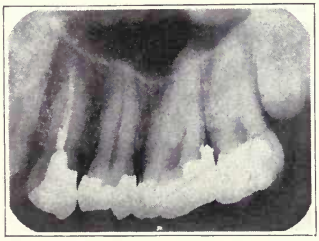

Fig. 5.

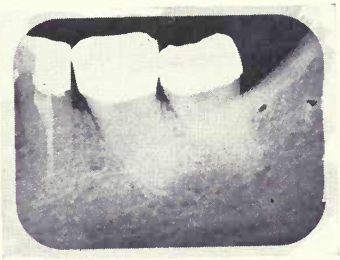

Fig. 6.

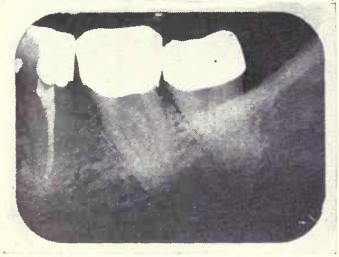

Fig. 7.

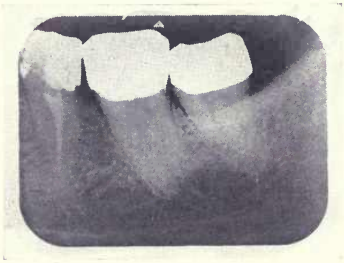

Fig. 8.

Fig. 4, at 65° F. (normal), and Fig. 5, at 75° F. Development proceeded in each case until the opacity of the image seemed correct when examined before the darkroom light. What was the result? Fig. 3 shows a weak

image, lacking in brilliancy and detail, and for diagnostic purposes the picture is practically worthless. Fig. 4 was developed at a normal temperature (65° F.). The picture is rich in gradation and shows as much detail as could possibly be got out of a picture of that kind. Fig. 5, while far superior to Fig. 3, shows a slight muddy appearance. Had the temperature been 80° F. instead of 75° F., a not uncommon temperature during hot weather, the muddiness would have been pronounced and would practically have obscured the details.

In a number of x-ray darkrooms we have actually found the temperature of the developer as low as 50° F. in winter and as high as 80° F. in summer. Let us see just what effect such an extreme of temperature would have upon normally exposed films, the developing agent being hydrochinone.

Fig. 6 was developed at a temperature of 50° F. With a concentrated solution, such as is used for x-ray work, full density of the negative should be obtained in seven minutes. In this instance there was practically no visible chemical reaction in that time. Development was therefore continued for another seven minutes with almost the same result, and it was finally lengthened to twenty minutes, or three times the normal. The result is a thin, transparent negative with so little detail that it is worthless for diagnostic purposes. What was the reason? Simply this, that hydrochinone practically ceases to operate below 60° F., and even prolonged development produces but a slight chemical reaction. Many operators who are in the habit of using a cold developer are led to believe that their thin negatives are the result of underexposure, and in the hope of bringing an image out of the film the exposure is increased tremendously.

Fig. 7 was produced under normal conditions throughout. The time of exposure was the same as for Figs. 6 and 8, namely, two seconds. The temperature of the

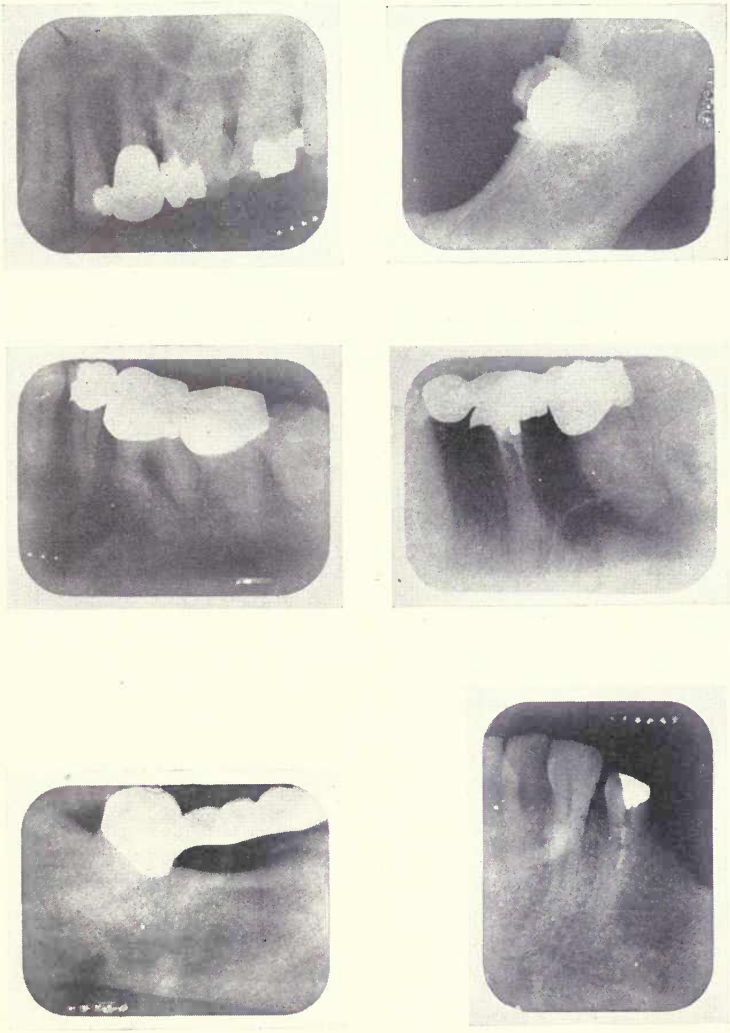

PLATE II

Examples of badly overexposed and very much underdeveloped films. Note lack of detail, contrast, and gradation. These pictures were all taken from the daily output of a large institution where the tray method of development is used and where the temperature of the solution is never taken.

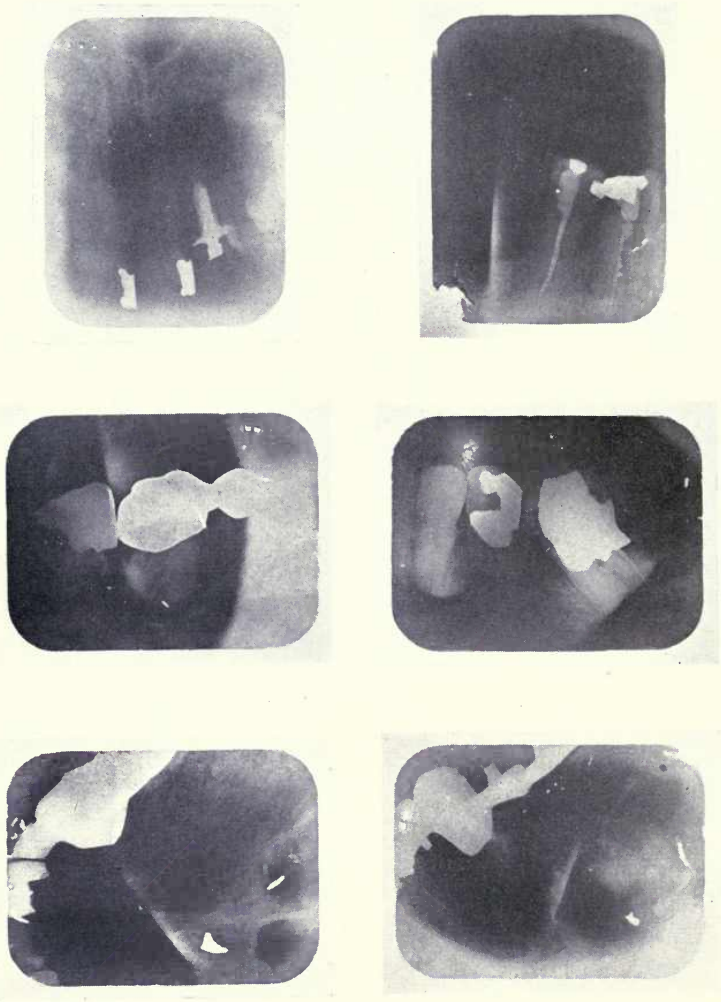

PLATE III

Extreme examples of poor radiograms which were actually submitted to a dentist for diagnostic purposes. All were badly overexposed, development was improper, and fixation was imperfectly carried out, resulting in badly stained negatives. Worst of all, the films were so carelessly handled that all are light struck.

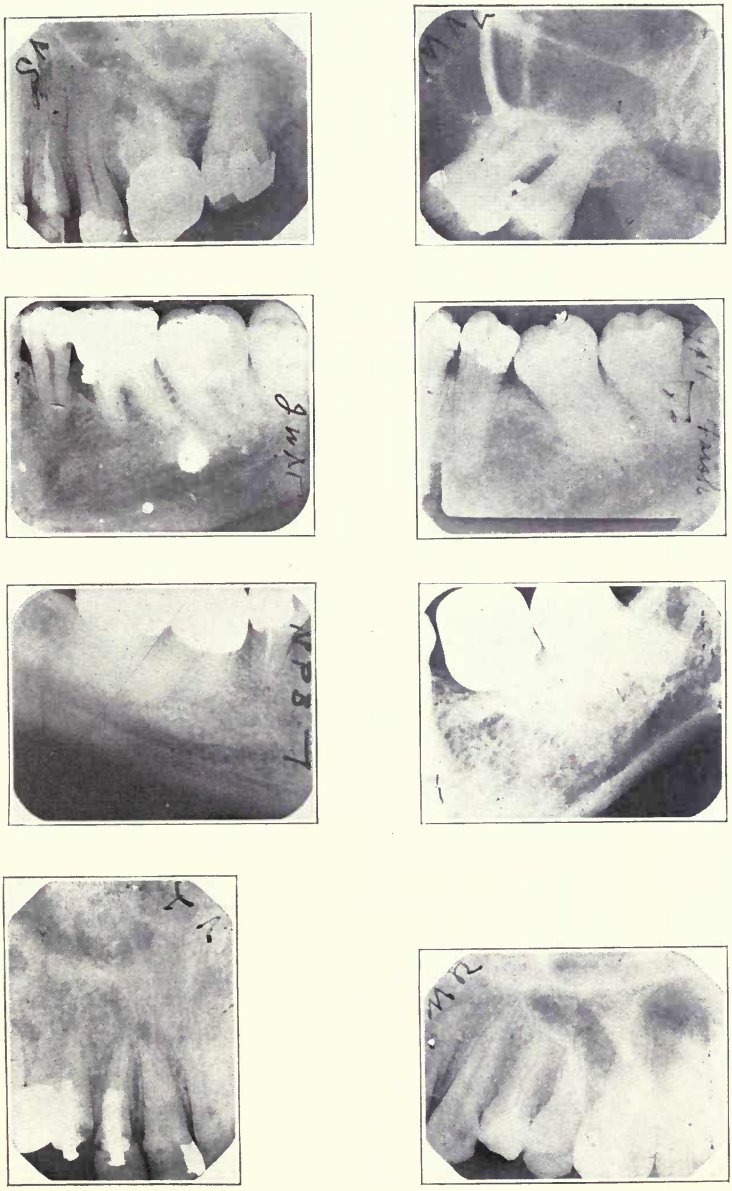

PLATE IV

Another group of overexposed and very much underdeveloped radiograms. Developed by the tray method, temperature of solution being unknown.

developer was 65° F. and the time of development was seven minutes. The result is a negative with sufficient detail, gradation and contrast to form a reliable picture for diagnostic purposes.

In Fig. 8 we have a picture which was correctly exposed and developed for the prescribed length of time, but the developer was too warm (80° F.), and the result is a dense, muddy picture in which the details are clogged by the general opacity. The excessive opacity could have been avoided by shortening the development, but this would have resulted in loss of detail.

In view of the foregoing, the tray, or visual inspection, method is not to be recommended for radiographic work, unless the operator is willing to heed the advice of those who understand the method and will follow their instructions implicitly. The tray method as employed by the vast majority of radiographers is not only unreliable and unsatisfactory, but wholly unscientific.

Should the radiographer, however, insist on using the tray method, let him observe the following simple rules:

1. Keep the developer at a temperature of 65° F.

2. Develop for a definite length of time regardless of exposure, correcting errors of exposure by reduction or intensification (see Chapter V).

3. Rock the tray during development, constantly and in both directions. If this is not done there may be a general mottling all over the plate. There is no remedy; prevention is easy.

4. Always use the same trays for the same purposes,—one tray for the developer, one for the fixing bath.

5. Wash trays before and after using.

6. Patches of fog may come from fingers that are contaminated with hypo. Even a trace of hypo in the developer will affect its working qualities. Strive for absolute cleanliness.

In order that the radiographer may fully realize the importance of rule No. 3 let us discuss this more in de-

tail. The object of rocking the tray is twofold. In the first place, it has a great influence on the vigor and brilliancy of the negative, because the action of the developer releases bromine from the silver bromide of the plate, which bromine immediately combines with the alkali, forming a bromide. Now bromide, as was pointed out in a previous chapter, serves to restrain the activity of the developer, and if the additional bromide which forms is not distributed by rocking, it will remain in the developer at the place where formed, so that the development at that part of the plate is additionally restrained. It will be easily seen that the most bromide will be formed and the greatest restraining action will result just at those places where action ought to be most vigorous. Less bromide will be formed in the less exposed parts. The latter will therefore develop more and the former less than they should, producing flatness in the resulting negative. Another result of rocking is to prevent a mottled appearance, which often becomes quite pronounced when the developer is not kept in motion.

Factorial Method

The factorial method of development is based on the fact that *the total time of development of a plate bears a fixed relation to the time of appearance of the image.* The exposed plate is put into the tray, and the operator's watch is placed so that the second hand can be clearly seen. When it exactly marks an even minute the developer is quickly flooded over the plate, and the dish covered with a piece of cardboard to exclude all light. The cover is removed at intervals of about five seconds and the plate examined to see whether it is still quite clear or white. After a brief time an almost imperceptible darkening will be seen here and there on the plate. The moment this appears, cover the dish again, and note the exact number of seconds which have elapsed since the

developer was poured on. Multiply this by the factorial number of the developer and the result will be the number of seconds required for complete development.

For the sake of illustration let us take a concrete example. A plate is exposed for two seconds and placed in a solution of, say, metol—a developer having 30 for its factorial number—and the first trace of the image appears in 10 seconds. Then the total time required for development will be $30 \times 10 = 300$ seconds, or 5 minutes. Again, another plate is exposed on the same subject, under identical conditions, for three seconds and placed in the same strength of metol. The first trace of the image will be apparent in less than 10 seconds as it has had a longer exposure than the first plate, say 7 seconds. Then the total time required for development will be $30 \times 7 = 210$ seconds, or $3\frac{1}{2}$ minutes. In this way two negatives are produced which are almost identical.

This system gives results which are extremely accurate, as it takes into account variations of exposure and within certain limits the temperature of the solution, though the temperature should be as nearly normal as possible. But it has one great drawback, a drawback which in my mind is almost fatal: it compels the radiographer to keep close watch on the early working of the developer. In order to distinguish the first appearance of the latent image, we must place the dish fairly close to the ruby lamp; we must, in fact, expose the plate to the deteriorating influences of the illuminant while it is extremely sensitive.

Most Common Developers with Their Factorial Numbers

Metol, 30
Kodak powder, 18
Metol-hydrochinon, 14
Pyro-metol, 9
Pyro-soda, 4.15
Hydrochinon with bromide, 5

The factorial system is useful in that it eliminates the element of chance, thus tending towards uniformity of results; but equally as good, if not better, results may be had by the far simpler tank, or stand, method; I would recommend the latter.

Tank, or Stand, Development

The tank, or stand, method is the ideal method of developing x-ray plates and films, and no radiographer who has given it a thorough trial will be satisfied with the old haphazard tray method, where the element of chance comes so largely into play. The tank method is probably more practiced by photographers today than either of the other methods. Yet, strange to say, few radiographers have gone to the trouble of acquainting themselves with it, although it is the only method with which the worker not thoroughly skilled in photography can hope to produce uniform results.

Tank development is based on the action of a developer of a given strength, for a given length of time, at a given temperature. The chief reason why it gives such splendid results is that the radiographer is *compelled* to know the temperature of his developer in order that he may know when development should be stopped.

The idea is quite prevalent among those not experienced in photography that the tank method can take care only of normally exposed plates, whereas under- and over-exposures must necessarily come out of the tank under- and over-developed, as the case may be. This idea is erroneous. The old theory that an underexposed plate should be given a prolonged or forced development, and that an overexposed plate should be given a shortened development is wrong. Let us see why. When an underexposed plate is placed in the developer the image builds up very slowly. The novice is apt to prolong the development for an immoderately long time, hoping to bring out

the missing detail, but he forgets that he can not bring out what is not there, or what the light has not impressed on the plate. All he does is to add *density* to the parts that *do* put in an appearance, so that an underexposed plate that has been forced in the developer shows contrast, but lacks detail. In the case of the overexposed plate what is the result? The image flashes up quickly and the whole plate darkens rapidly. The inexperienced workman is apt to remove the plate from the developer too soon, with the result that only the superficial layer of the emulsion has been acted upon, and on fixing he will find the plate very thin and without contrast, and almost useless.

Now, what would happen if under-, over-, and normally exposed plates were developed at the same time in a tank? The underexposed plate would be thin, not too contrasty, and would have all the detail possible. The overexposed plate would be dense, but full of detail and gradation. The normally exposed plate would, of course be normal in every respect. We may then formulate the following rule: *all plates should be developed for the same length of time, regardless of exposure.* It is true that the professional photographer does not follow such a rule, but we must remember that the professional photographer has had years of experience in matters photographic and knows exactly what will happen when he departs from the normal. The radiographer, on the other hand, is not likely to be a skilled photographer and for that reason I strongly recommend that he standardize the development, making it mechanical, rather than relying upon his own judgment. Development should, therefore, proceed for a definite length of time. If that rule is followed, thin negatives will at once indicate underexposure; dense negatives overexposure, and such negatives should be corrected *after* development by intensification or reduction. This process will be discussed

more fully in a later chapter, but it may be well to touch upon it here.

As previously stated, if an overexposed negative is developed by the visual inspection (tray) method the image will appear sufficiently dense long before a complete chemical reaction has taken place, so there is always danger of underdeveloping such a plate.

Fig. 9 represents a negative which was badly overexposed, then developed by the tray method to a point where the opacity seemed correct, as judged by the darkroom light. The opacity, however, was only superficial,

Fig. 9.

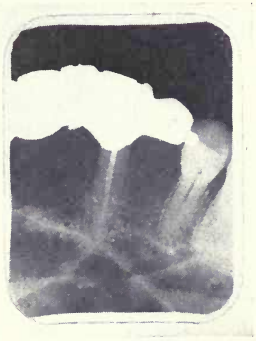

Fig. 10.

the deeper layer of the emulsion being untouched by the developer, and when the negative was placed in the fixing bath the undeveloped silver bromide was dissolved and finally washed away under the tap. The result is a thin negative, lacking detail, brilliancy and contrast.

Fig. 10 shows a negative which received the same exposure as Fig. 9. In this case development was carried to its logical end and the result was a negative so dense that transmitted light would scarcely penetrate it. The negative was fixed in the usual manner, then placed for a brief time in the reducing bath described in Chapter

V, and the result was a negative which is normal in every respect.

Tank development has many advantages from the standpoint of comfort, convenience, and results, and that it is the most efficient method for the radiographer there can be no doubt.

No better reasons can be given for the adoption of the tank method than those in "Photo Miniature," credited to Mr. A. Child Bayley:

1. It gives us perfectly uniform negatives when exposure has been correct, whether we develop daily or only have a few to develop now and then.

2. It brings everything out that can be got out of an underexposed plate, and removes the temptation to overdevelop in the hope that more details may be obtained.

3. It gives as good results as can be got with overexposed plates, and prevents any risk of insufficient development which may be caused by the difficulty of judging how far the development has gone when the plate is very opaque.

4. It reduces light fog to a minimum.

5. It overcomes entirely the difficulty of determining when development is complete.

CHAPTER IV

DEVELOPING FORMULAS

Hydrochinon Formula

(Tray)

Water	40 ounces
Hydrochinon	150 grains
Sulphite of soda	1 ounce, 238 grains
Carbonate of soda	3 ounces, 63 grains
10% Solution Bromide of Potassium	40 drops

Develop for 7 minutes at a temperature of 65° F.

In compounding formulas avoirdupois weights are used.

Metol-hydrochinon Formula

(Tray)

Water	20 ounces
Metol (elon, or other substitute)	20 grains
Sulphite of soda	1 ounce
Hydrochinon	80 grains
Carbonate of soda	1 ounce
Potassium bromide	8 grains

Develop for 5 minutes at 65° F.

Metol-hydrochinon Formula

(Tank)

Water	1 gallon
Metol (or substitute)	133 grains
Sulphite of soda	6 ounces 292 gr.
Hydrochinon	1 ounce 97 gr.
Carbonate of soda	6 ounces 292 gr.
Bromide of potassium	53 grains

Develop for 5 minutes at 65° F.

As has already been stated, the temperature of the developer should be as nearly 65° F. as possible. However, should it be necessary to use a higher or lower temperature than the normal, the following rule will prove useful: For each 5 degree F. increase in temperature, the developing time should be decreasd 33⅓ per cent; for each 5 degree F. decrease in temperature, the time should be increased 33⅓ per cent. The following table should be copied and hung up where it can be readily seen:

Temperature	*Developing Time (Metol-hydrochinon developer)*
60° F.	6 minutes, 40 seconds
61° F.	6 " 20 "
62° F.	6 " "
63° F.	5 " 40 "
64° F.	5 " 20 "
Normal 65° F.	5 " "
66° F.	4 " 40 "
67° F.	4 " 20 "
68° F.	4 " "
69° F.	3 " 40 "
70° F.	3 " 20 "

The Fixing Bath

The plain fixing bath (hyposulphite of soda, 4 parts; water, 1 part) has little to recommend it. Its keeping qualities are poor and the bath has to be made fresh every day. It discolors rapidly. An acid bath is to be recommended for all radiographic work, because it remains clear and fixes clean after long-continued use. In the succeeding pages formulas are given for three classes of acid baths.

No. 1 is a plain acid bath having no hardening influence. It is economic, will keep best of the three and is

excellent for use where the temperature of the bath can be kept under 70° F.

No. 2 has a moderate hardening influence on the emulsion and is intended for use where the temperature is not very high but where some hardening action is desired.

No. 3 has a decided hardening influence on the emulsion and is designed for use in hot climates where a rapid hardening of the emulsion is desirable.

For best results the fixing bath should be kept acid. This can be tested with litmus paper.

No. 1. Plain Acid Fixing Bath

(Tank)

Water	6 gallons
Hypo	25 pounds

When fully dissolved add the following solution:

Water	½ gallon
Sodium bisulphite	4 pounds

No. 2-A. Acid Fixing Bath

(Tank)

Water	6 gallons
Hypo	12½ pounds

When fully dissolved add the following hardening solution:

Water	½ gallon
Sulphite of soda	1 pound
Acetic acid (No. 8)	3 pounds
Powdered alum	1 pound

No. 2-B. Acid Fixing Bath

(Small Tank or Tray)

Water	64 ounces
Hypo	16 ounces

When fully dissolved add the following hardening solution:

Water	5 ounces
Sulphite of soda	1 ounce
Acetic acid (No. 8)	3 ounces
Powdered alum	1 ounce

No. 3. Chrome Alum Fixing Bath

(Tank)

A		*B*	
Water	96 ounces	Water	32 ounces
Hypo	2 pounds	Chrome alum	2 ounces
Sulphite of soda	2 ounces	Sulphuric acid, C. P.	¼ ounce

(Mix chemicals in order named)

When dissolved, pour *B* into *A* slowly while stirring rapidly.

Washing

When plates are fixed they should be washed in running water for twenty minutes or half an hour to remove all traces of hypo. If any hypo remains in the emulsion, the negative will eventually fade or become discolored.

Drying the Negative

Too great care can not be taken in the drying of a plate, and often a well-developed plate is spoiled by careless drying.

Plates are best dried in a moderately warm room, having a fairly constant temperature. They should be placed on end, not close together, on a negative rack somewhat similar to that shown in Fig. 11. Films should be attached to dental film clips (Fig. 12) and hung up on a line to dry. See Fig. 13. It is not advisable to lay them on a cloth pad, because in time such a pad will be-

come contaminated with chemicals and trouble will arise. In cold weather do not allow the negative to get too cold while drying. If the negative is partly dry and then removed to another room which is much warmer or colder, it will cause a difference in the density of the part to dry last.

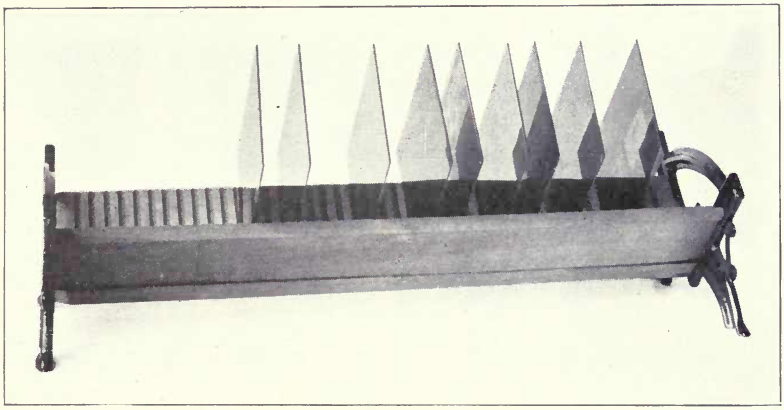

Fig 11.

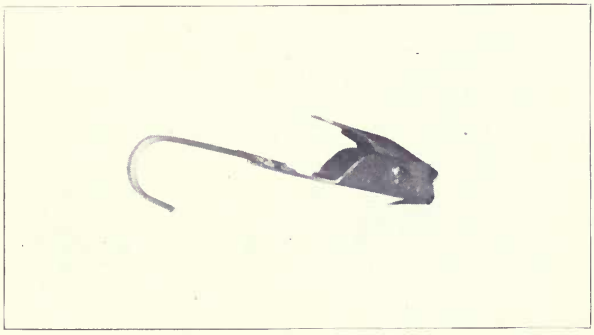

Fig. 12.

A negative may be dried rapidly with an electric fan, but care must be taken to avoid water marks.

If a negative is wanted in a hurry it may be dried rapidly by laying it for ten minutes (after thoroughly washing) in a bath of alcohol, and then standing it up to dry.

It will dry in a few moments. If dried in this manner the negative must first be thoroughly washed, because

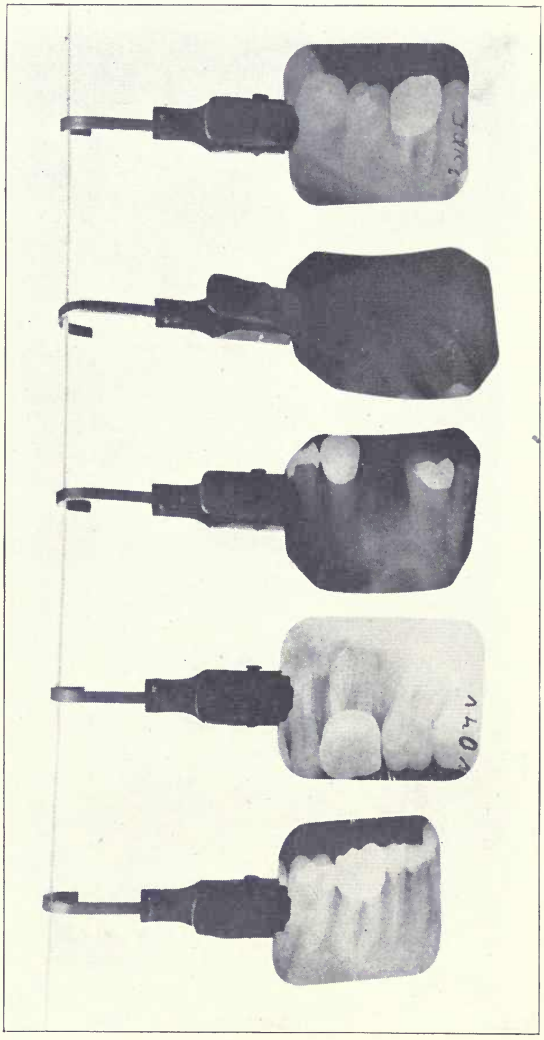

Fig. 13.

if there is a trace of hypo in the emulsion an insoluble white deposit will form which will ruin the plate.

CHAPTER V

ALTERATION OF THE NEGATIVE BY CHEMICAL MEANS

In a previous chapter I pointed out the fallacy of forcing the development of an underexposed plate, or of shortening the development of an overexposed plate. To prolong development will add nothing in the way of detail, while to shorten development means a loss of both detail and contrast. Development should always be carried to a point where there is a complete reduction of the detail portion of the silver salts to their metallic form. Unless it is carried *to* that point much of the exposed silver bromide will not be acted upon by the developer and will subsequently be lost in the fixing bath, whereas if it is carried *beyond* that point even the unexposed silver bromide will be acted upon by the developer, resulting in a heavy fogged negative in which the details are largely obscured. All negatives should therefore be developed for a definite length of time, regardless of exposure, and errors of exposure should be corrected after development by reduction or intensification, as the case may be.

Intensification

Negatives which show detail, but are not dense enough, can be intensified in the following solutions:

No. 1

Bichloride of mercury	200 grains
Bromide of potassium	200 grains
Water	10 ounces

No. 2

Sulphite of soda	½ ounces
Water	4 ounces

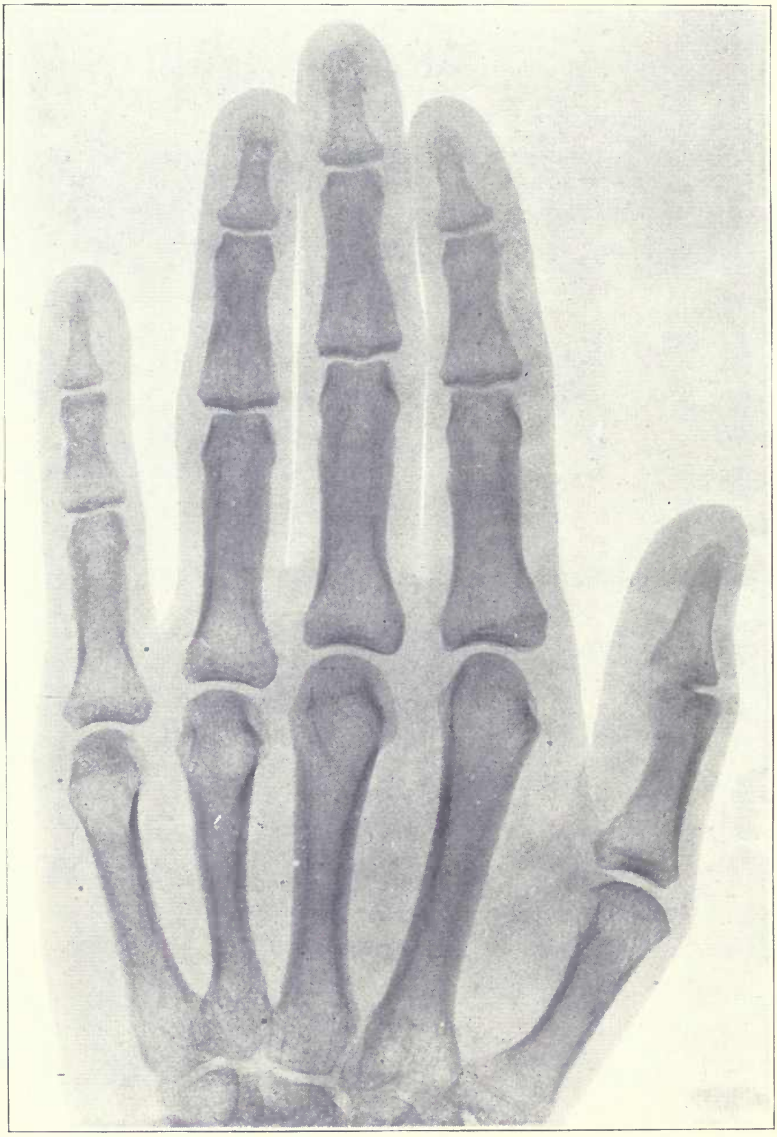

Fig. 14.

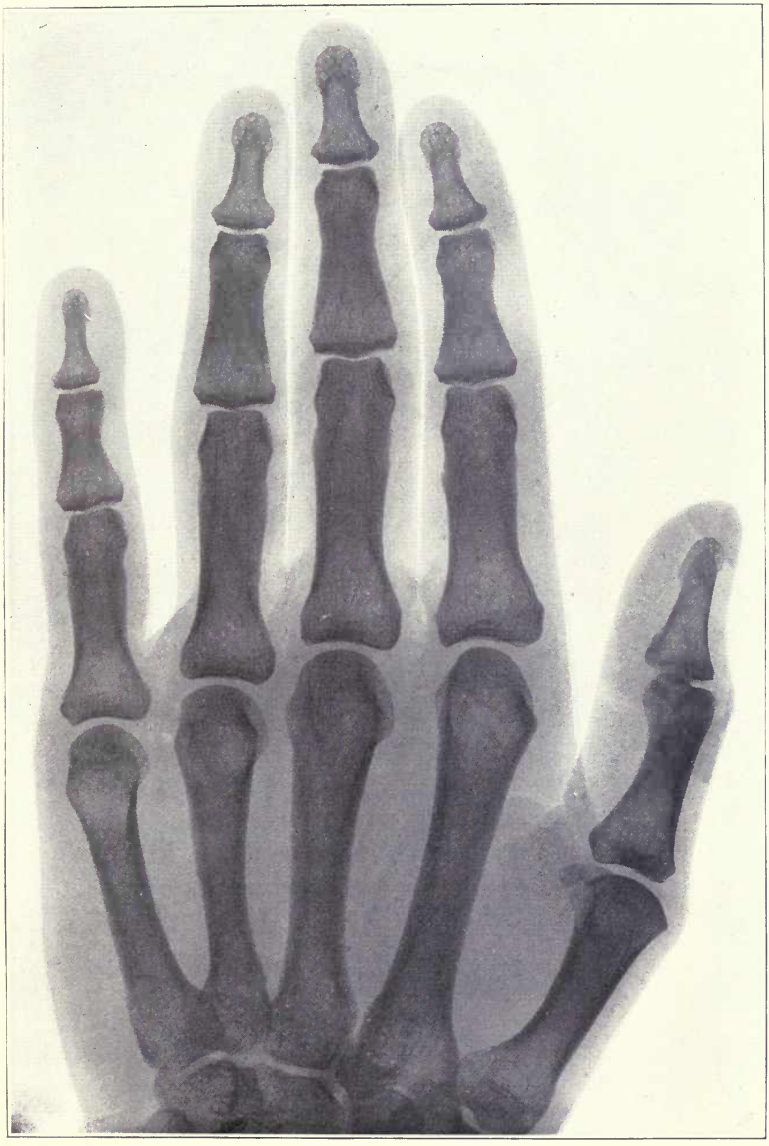

Fig. 15.

After the negative is well fixed and *thoroughly* washed, immerse it in No. 1 until it has become thoroughly whitened, and after rinsing carefully place it in No. 2, leaving it there until full density has been attained. In case sufficient intensification has not been gained, wash for ten minutes, repeat the operation and finally wash well. If, after intensification, the negative is too dense it may be reduced by placing it for a few seconds in water 16 ounces, hypo, 1 ounce. If left in the hypo too long the negative will be reduced to its original density.

Fig. 14 shows a print from an underexposed but normally developed negative. Owing to the thinness of the original negative there is a lack of contrast, and the brilliancy so much desired in a plate or print is largely lost.

In Fig. 15 we have a print from the same negative after intensification. The improvement is marked. The general flatness of the first print has disappeared and an added brilliancy is the result.

However, intensification is usually less successful and consumes more time than reduction and we would suggest that all badly underexposed negatives be retaken whenever possible and that intensification be resorted to only where a retake is not expedient.

Reduction

Negatives which are too dense all over, due to overexposure, or to overexposure and overdevelopment, should be reduced with Farmer's Reducer, as follows:

A

Water	16 ounces
Hyposulphite of Soda	1 ounce

B

Water	16 ounces
Red prussiate of potassium	1 ounce

As solution *B* is affected by light, the bottle containing it should be of amber color or wrapped in opaque paper and kept in the dark when not in use.

Mix for immediate use:

A	8 ounces
B	1 ounce

Use in subdued daylight.

The negatives can be transferred to this solution direct from the fixing bath without rinsing. The action is very rapid and must be watched closely. To avoid streaks, always rinse the negative before holding it up for examination. When sufficient reduction has taken place, wash the negative thoroughly in running water.

Negatives that have been dried should be soaked in water for half an hour before reduction.

When parts of a negative are too dense they can easily be reduced by applying the reducing solution to those parts with a tuft of cotton, gently rubbing until the desired reduction is attained. Wash in running water frequently during the operation, taking care not to allow the solution to run over the parts that do not need reduction.

Farmer's Reducer is necessary in every darkroom. By using this reducer, negatives which were so dense as to be worthless have been made into some of the best x-ray negatives I have ever seen.

Fig. 16 represents a badly overexposed but correctly developed negative. The opacity is so great that the details are practically hidden, while the flesh tones have entirely disappeared.

Fig. 17 shows the same negative after reduction with Farmer's Reducer. The negative is now rich in detail. The cancellous structure of the bone is clearly brought out, even the finger nails and delicate folds of the skin are to be seen.

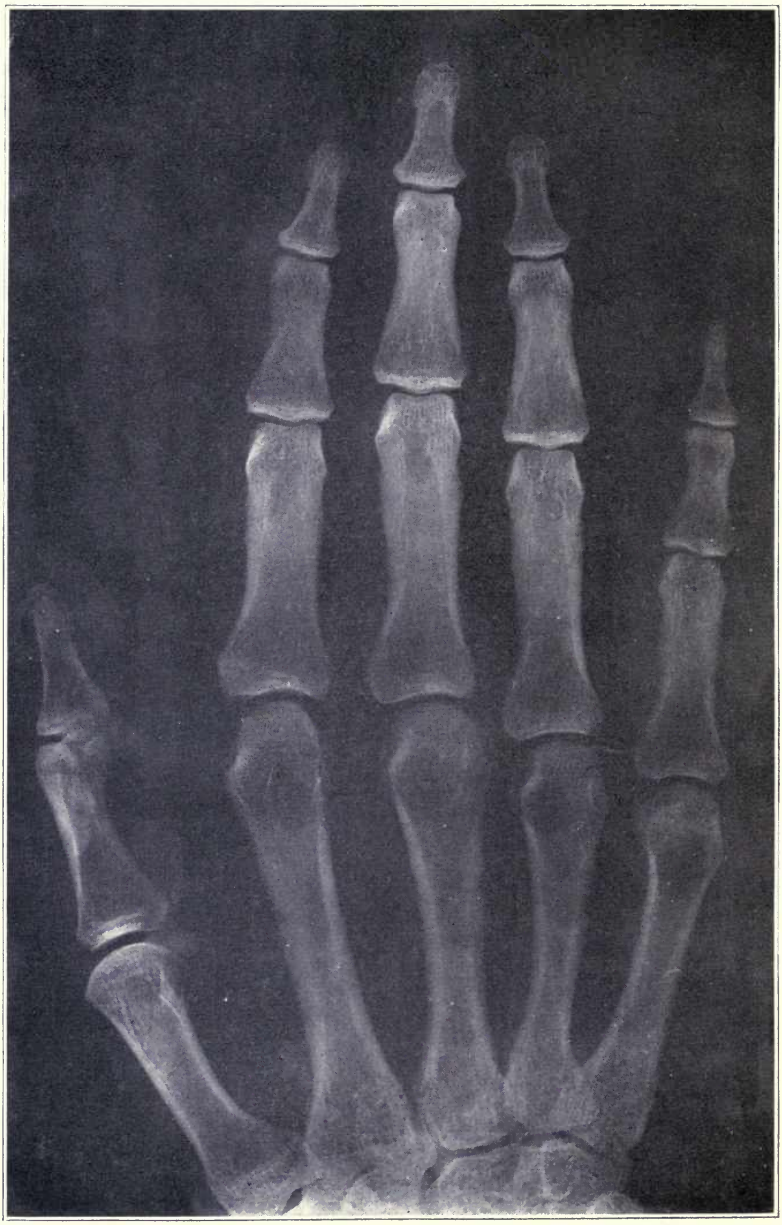

Fig. 16.

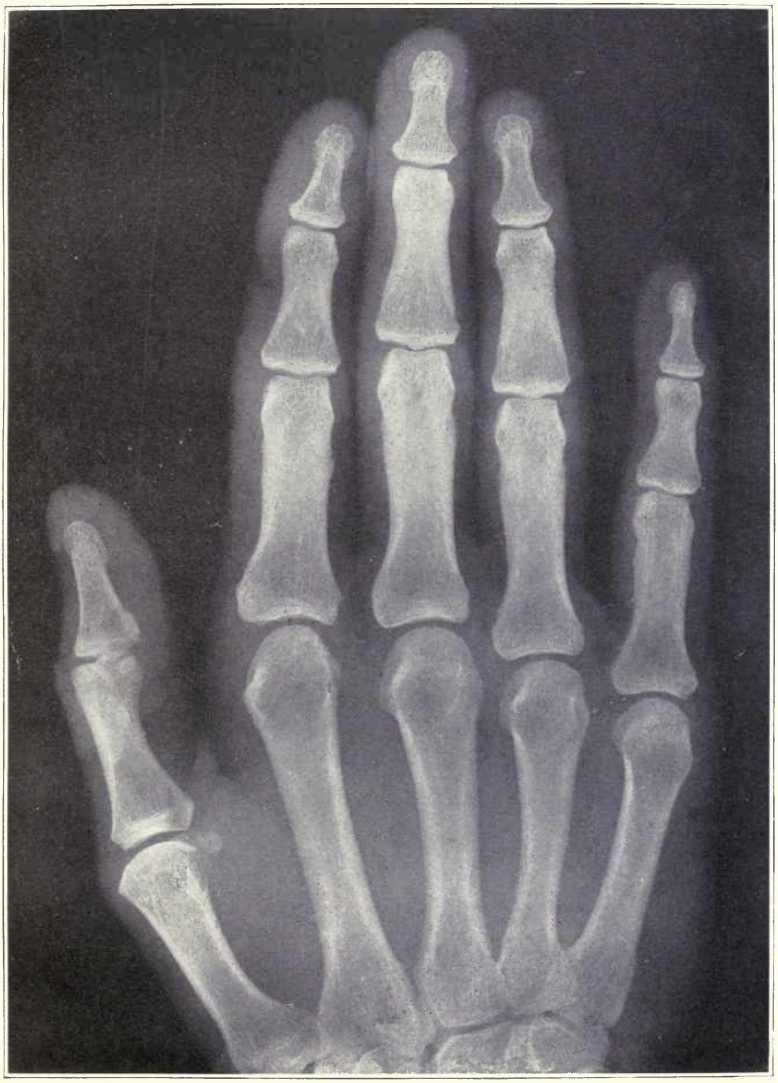

Fig. 17.

Persulphate Reducer

Plates which are too dense in parts, and where all the detail in the shadows must be retained, can be reduced as follows:

A

Water	16 ounces
Persulphate of ammonia	¼ ounce
Sulphuric acid	5 drops

B

Water	16 ounces
Sulphite of soda	1 ounce

After the negative is well washed to remove the hypo, place it in Solution *A*. When reduction begins, which should be in about two minutes, a slight turbidity will be noticed in the solution. Watch the negative closely and when sufficient reduction has taken place transfer the negative for three minutes to solution *B* to stop the reducing action. Wash for ten minutes and dry.

CHAPTER VI

TANKS

It may be well to add a brief chapter on the various kinds of tanks commonly used for photographic purposes and the method of using and caring for them. A great variety of tanks are manufactured for the developing of glass plates, but, so far as I know, only one tank has been designed for dental films. Since the two kinds differ markedly let us discuss them separately.

Plate Tanks

The plate tanks designed for photographic purposes are all based on the same mechanical principles and it will therefore be unnecessary in this brief monograph to describe more than one. In Fig. 18 is shown a simple, yet practical, tank for the development of glass plates. It consists of a metal box somewhat larger than the plate to be developed. An inside plate rack is provided to hold from one to a dozen plates. This rack is loaded in the darkroom, after which it is lowered into the tank, which has previously been filled with the developing solution. The lid is now clamped on and development proceeds for a definite length of time, depending upon the temperature and the developer used.

In tank development the negatives are not examined during development and there is no risk of incorrectly judging their density. Density is determined by the length of time of development, and the length of time of correct development is determined solely by the temperature and strength of the developer. The tank should be reversed or shaken several times during development to insure even development.

Film Tanks

An ingenious tank for the small-sized dental films is shown in Fig. 19. The tank is made to hold eight small metal tubes, each tube accommodating a pair of films.

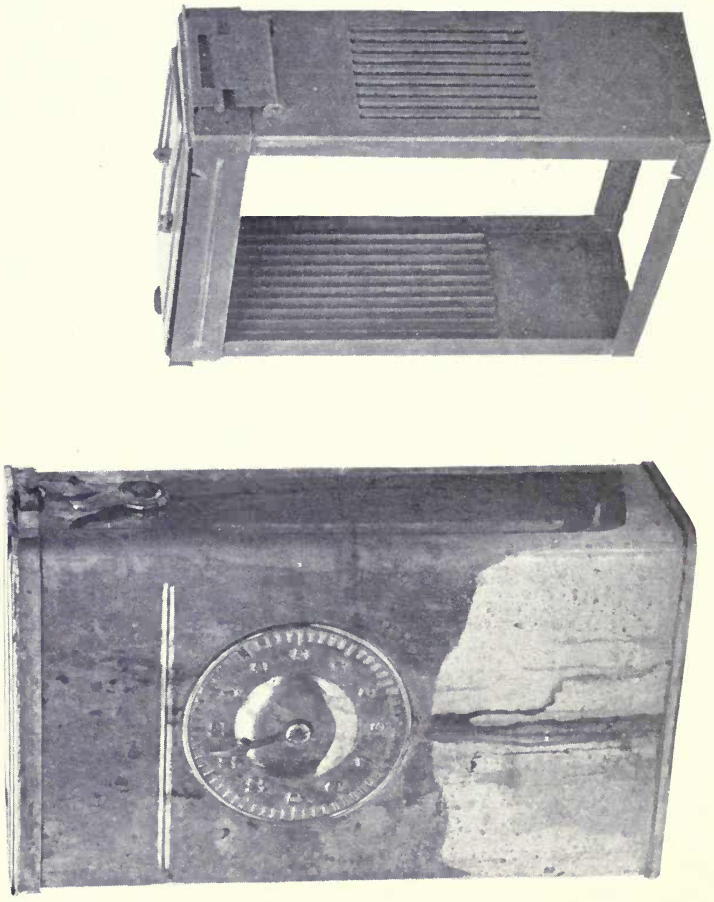

Fig 18.

(See Figs. 20 and 21.) The following simple directions are furnished by the manufacturers:

When the tubes are loaded, place them in the tank and when all are in position, pour in the developer. Six ounces of solution is sufficient for developing eight pairs

Fig. 19.

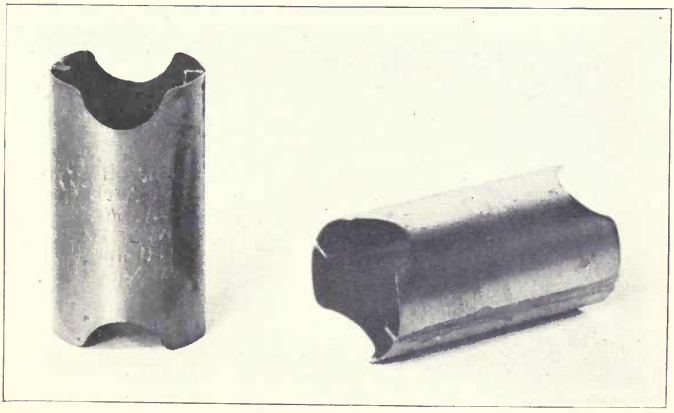

Fig. 20.

of films at one time, and as temperature is an important factor in film developing, the use of a thermometer will be found indispensable for ascertaining the correct working temperature (65° F.) of the solution. (Two types of thermometer are shown in Fig. 22.) Now replace the cover on the tank, securing it in position by turning it to the right as far as it will go.

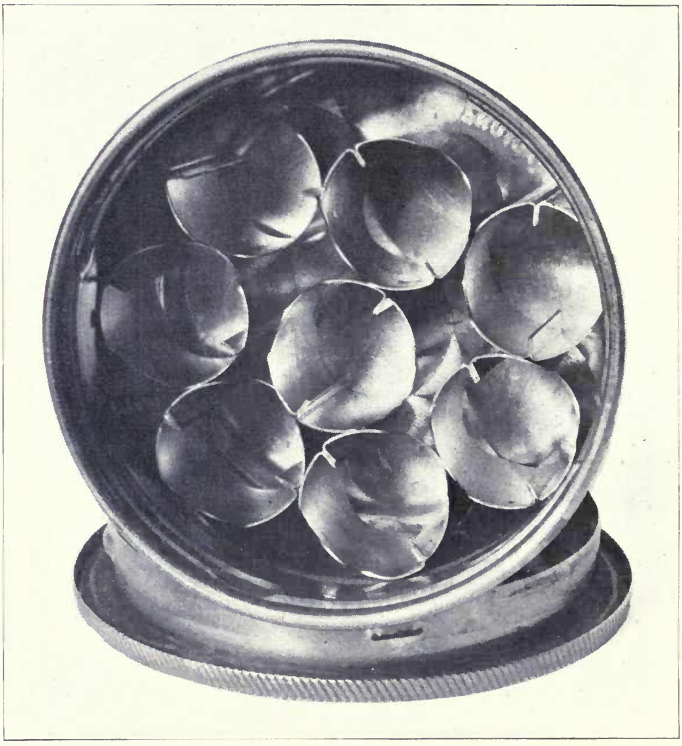

Fig. 21.

White light may now be turned on in the room and the time noted. With a developing solution used at the temperature of 65° F., as advised, the films should develop for seven minutes. During this time reverse the tank end for end several times, to insure even development of the films within.

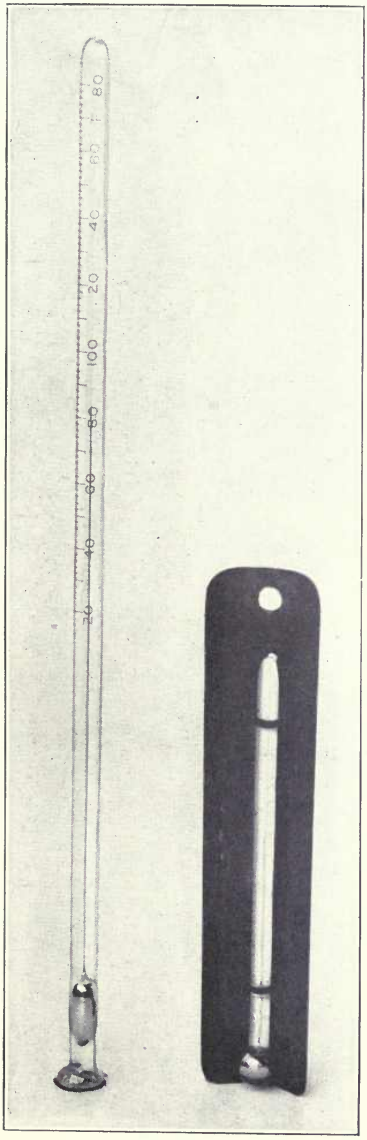

Fig. 22.

At the expiration of the seven minutes, remove the cover from the tank and pour off the developer, taking care when doing so to keep the tubes containing the films

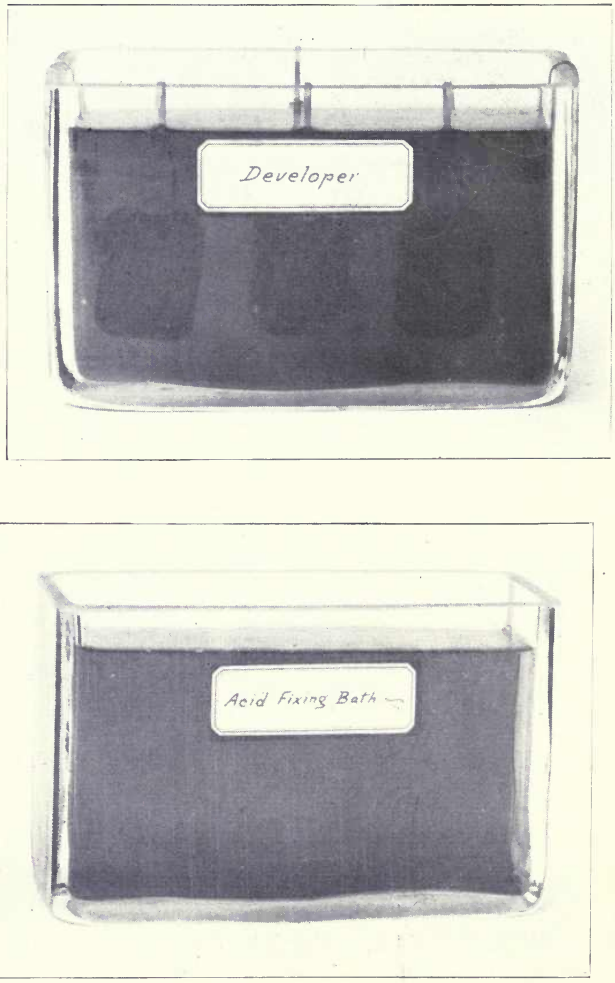

Fig. 23.

within the tank. Refill the tank with fresh water, in which the films must be thoroughly rinsed before fixing. Several changes of water should be given them in this

manner, after which the tubes should be taken from the tank and the films removed from them and placed immediately in the fixing solution. *Do not place the tubes in the fixing solution* as the chemicals will corrode the metal.

The Author's Tanks for Dental Films

These tanks (Fig. 23) are made of glass, and measure $2\frac{1}{2} \times 4 \times 6\frac{1}{2}$ inches. They are known as "rectangular

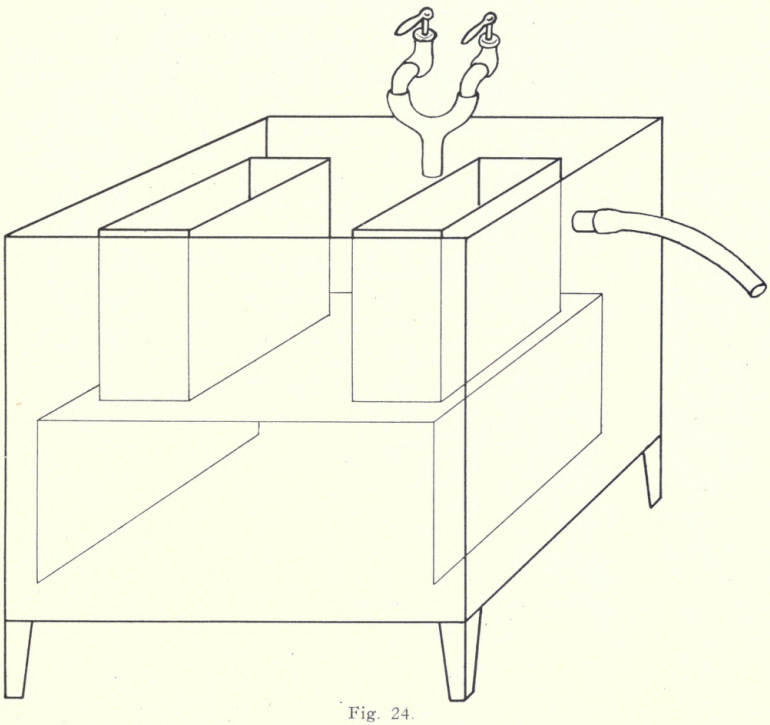

Fig. 24.

specimen jars," and although they are designed for an entirely different purpose, they make excellent tanks for the developing and fixing of dental films. Each tank has a capacity of 20 ounces, and by keeping the tanks well filled and properly covered when not in use, the solu-

tions will keep until exhausted. The films are attached in pairs to dental film clips, and these are hung over the sides of the tank. Needless to say, the films must be placed back to back, to prevent the emulsions from sticking.

To obtain the best results the tanks should be arranged on what may be termed the "unit" system. In this method the developing and fixing tanks are placed in a specially built sink which is so arranged that it may be filled with circulating water. The temperature of this water should be kept as near the normal as possible by combination hot and cold water faucets or ice. A design for such a sink is suggested in Fig. 24. It is constructed of galvanized iron and measures $12 \times 12 \times 16$. It is made purposely deep so that larger tanks can be accommodated when glass plates are to be developed. The overflow should be placed about 10 inches from the bottom. A rubber hose leads from this to the main sink. A metal shelf should also be constructed to hold the smaller tanks, which tanks should be about three-fourths submerged.

The Care of Tanks

First, never use the developing tank or cage for the fixing of the plates. The same may be said of the metal tubes furnished with the dental film tank. They should never come in contact with hypo.

Secondly, thoroughly clean the tank and cage, or tubes, at least once a week with hydrochloric acid, 1 ounce, and water, 10 ounces, rinsing the tank well and seeing that the solution has access to all parts of the cage, special attention being paid to the underside of the corrugations holding the plates.

The Tank as a Standard

Not infrequently when a radiographer changes from the tray to the tank method he will be surprised to find

that his negatives are exceedingly dense, much more so than when he was developing by the tray method. This is an indication, first, that the plates were overexposed, and, second, that they were underdeveloped by the tray method and, of course normally developed by the tank method. The tank thus becomes an excellent standard, and even if the radiographer prefers to use the tray method of development he should use the tank occasionally as a means of checking himself up on exposures.

Controlling the Temperature of the Solutions

We have repeatedly spoken of the importance of maintaining a uniform temperature during development. *It is just as important to observe the temperature of the developer as to use the right quantity of the right kind of chemicals.* Heat increases the chemical action and cold retards, so it is obvious that for uniform results the developer should always be kept at a certain definite temperature. Experience has proved that most developing agents work best at a temperature of 65° F. A cold developer will produce thin negatives, lacking in detail, whereas a warm developer will produce a heavy, flat quality without proper gradation. Hydrochinon practically ceases to work below 60° F.

The simplest way to maintain a uniform temperature has already been described in the paragraph dealing with the "unit" system of tank manipulation. Water of the proper temperature is allowed to circulate freely around the tanks at all times, the temperature of the water being controlled by combination hot and cold water faucets. During the summer months the cold tap water will often be found at the correct temperature, but where this condition does not obtain ice should be added.

The ideal method of maintaining a uniform temperature is to employ a so-called "constant temperature

bath." Such an apparatus is controlled electrically and is so constructed that the temperature never varies over half a degree. In Fig. 25 is illustrated a water-bath which can readily be modified to meet the requirements of the radiographer. The illustration is furnished by The Thermo Electric Instrument Co., of Newark, N. J., and the following specifications are furnished by the manufacturers:

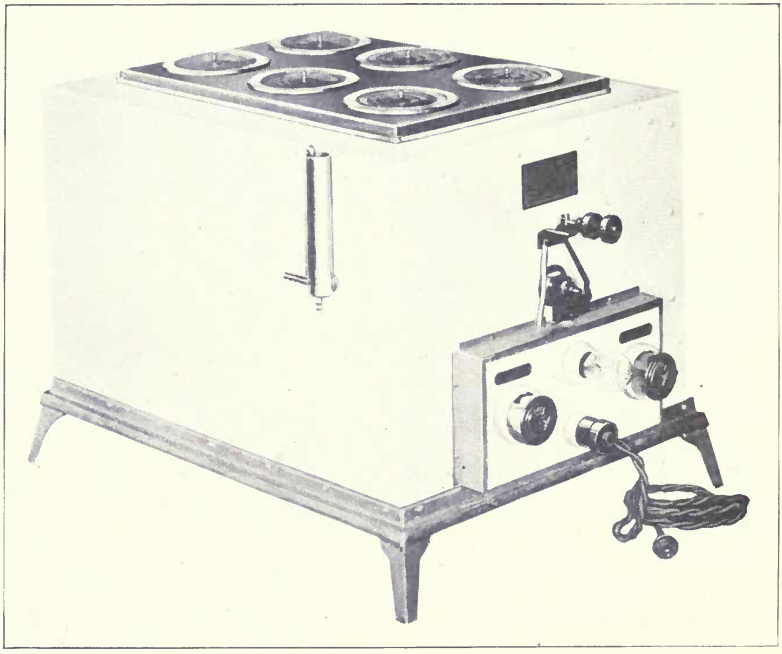

Fig. 25.

Specifications of Water-Bath for X-ray Developing

Copper tank surrounded on sides and bottom by an inner and outer wall of heavy asbestos transite; the space between the inner and outer asbestos wall is filled with heat insulating material.

Shelf.—A bound galvanized wire mesh shelf covers

the Freas Thermo-Regulator which is near the bottom of the tank.

This leaves a working space above the shelf of $12 \times 18 \times 10$ inches.

Range of temperature up to 65° C. or 145° F.

Heating element consists of a wire-wound resistance plate situated beneath the bottom of the tank and can be easily removed if necessary.

Cooling Coil.—A copper cooling coil can be supplied to keep the temperature constant when the room temperature is above the temperature desired in the bath. This cooling coil to be connected with a cold water supply.

Regulation.—Freas bimetallic thermo-regulator.

Constancy to within ½° C.

Operation.—Merely attach to ordinary electric light socket.

CHAPTER VII

A WORD ON CHEMICALS

In a work of this kind it is unnecessary to go deeply into the question of chemicals; at the same time, I can not leave the question untouched because of the lack of judgment which many display in handling chemicals and compounding formulas.

It is just as important to use pure chemicals as it is to use the correct amounts and the right kinds of chemicals. Only such chemicals should be used as have been prepared by reliable firms for strictly photographic purposes. This advice may seem unnecessary, but it is well worth remembering. I had an experience which convinced me that photographic chemicals may vary considerably. All the chemicals which I use are supplied by the University Department of Chemistry. During the World War there was often a shortage of chemicals, and many of the supplies which were sent out by the department bore the label of some obscure concern which had sprung up as a result of the war. For several months I was obliged to use a hydrochinon which was made by a munition manufacturer. During this period the pictures which I produced lacked the contrast and brilliancy which one usually associates with good photographic work, and not until I began to test the chemicals one by one by a process of elimination did I discover that the hydrochinon was worthless.

Some assistants not only are careless in the choice of chemicals, but even go so far as to substitute one chemical for another. I actually know of an instance in which the assistant in a large institution used ordinary baking soda (bicarbonate of soda) instead of carbonate of soda,

evidently in the belief that any kind of soda would do. Had he understood the rudiments of photography he would have known better. Bicarbonate of soda is not sufficiently energetic to open the pores of the film within the given time, and unless the developer formula is revised so as to call for an increased amount of bicarbonate, the chemical action will be entirely too slow. Only a trained chemist should attempt to substitute one chemical for another in photographic solutions, and the radiographer who is not so trained had better stick to pure chemicals and given formulas.

With the proper understanding of the function each chemical performs, it is easier to understand the necessity for maintaining the correct balance between the various chemicals. Some brands of carbonate of soda contain caustic soda or caustic potash and, the quantity being unknown, the action of the alkali can not be definitely predetermined. Impure sulphites also contain various undesirable chemicals thus producing uncertain and unusually undesirable results.

Dry or anhydrous sulphite of soda is double the strength of the crystals. If crystal sulphite is used, take double the quantity when the dry is called for in any formula. Sulphite deteriorates when kept in partly empty bottles. It should never be purchased in paper cartons, but in glass bottles.

Never dissolve more than enough sulphite of soda to last one week, as the solution has a strong affinity for oxygen, which it takes up both from the water and from the air, converting part of the sulphite into Glauber's salts (sulphate of soda) which produces yellow negatives and irregular stains.

Solid Matter in Alkaline Solutions

When the photographic developer is made up in bulk and kept for any length of time a deposit of small white

flakes may form at the bottom of the bottles. The inexperienced workman often takes this as an indication that the developer was either improperly mixed, or that it has deteriorated and become useless. The fact of the matter is that such deposits can hardly be prevented in alkaline solutions containing sodium sulphite and sodium carbonate. The flakes are substances formed by the action of the sodas on lime and magnesium salts contained in hard water or by their action on the glass, or both.

Sodium sulphite, in solution, is rapidly oxidized to sulphate. Sulphate reacts with lime (the lime found in hard water) to form insoluble calcium sulphate (gypsum).

Sodium carbonate reacts with lime to form insoluble calcium carbonate (limestone).

Sodium carbonate combines with glass (the glass of the bottle) to form sodium silicate (water-glass).

All of these solids are harmless unless they happen to settle on the plate and prevent the developer from acting. Simply filtering the developer before use is all that is needed.

If the water is not hard, that is, if it contains no lime salts, the flakes are due entirely to the action of the sodas on the glass. Hence filtering after standing is practically always necessary, even if rain or distilled water is used.

CHAPTER VIII

USEFUL SUGGESTIONS

Weights and Measures

In compounding photographic formulas Avoirdupois weights are now commonly used.

1. *Avoirdupois Weight:*

27.34	grains	= 1	drachm	= 27.34	grains.
16	drachms	= 1	ounce	= 437.5	grains.
16	ounces	= 1	pound	= 7000	grains.

An accurate photographic scale should be found in every darkroom. In Fig. 26 is shown an inexpensive scale which is sufficiently accurate for all photographic purposes and which will weigh from one grain to two ounces.

The Metric System is gradually being adopted by chemists and photographers and formulas are often given in metric as well as avoirdupois weights.

2. *Metric Weight:*

1	Cubic Centimeter	=	17	minims nearly.		
3½	" "	=	1	drachm.		
28.4	" "	=	1	ounce.		
50	" "	=	1	ounce,	6 drachms,	5 minims.
100	" "	=	3	ounces,	4 drachms,	9 minims.
1000	" "	=	35	ounces,	1 drachm,	36 minims.

1 Liter = 1000 c.c.

The unit of the metric liquid measure is a cubic centimeter (abbreviated c.c.). For all practical purposes we may say that one ounce is equivalent to 30 c.c. If a formula should call for 8 ounces of water, then, we would take 240 c.c.

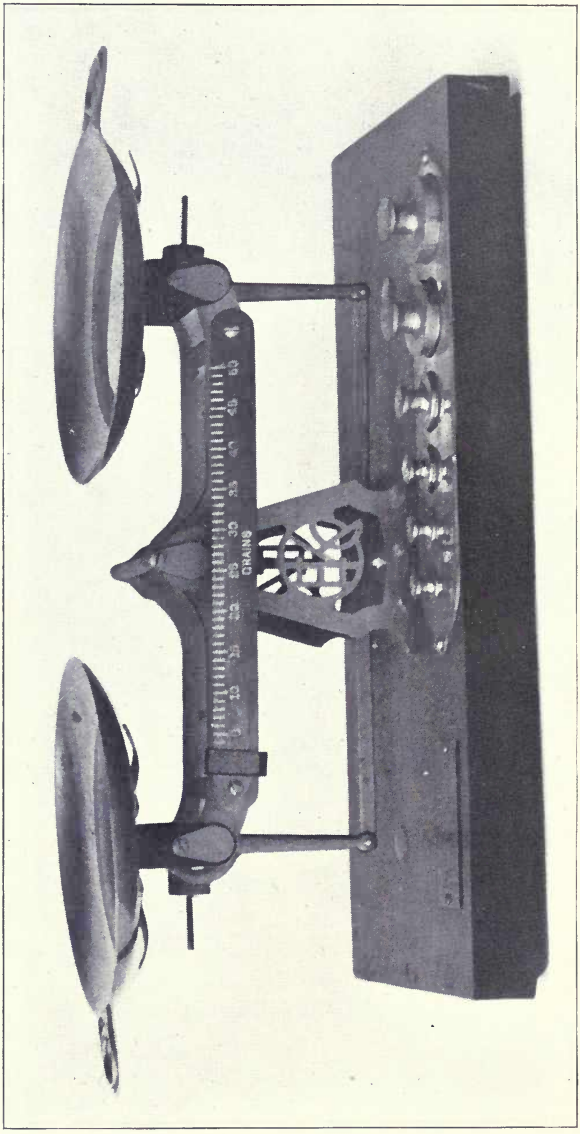

Fig. 26.

Weights and Parts

Frequently formulas will be found which are given in parts. When all these parts are solids, there is no difficulty in making up the preparations. Most formulas in parts generally include some liquid, principally water. Thus:

Metol, 1 part; sulphite of soda, 4 parts; water, 32 parts.

In such case, substitute grains for parts, and the formula will then read:

Metol, 100 grains; sulphite of soda, 400 grains; water, 3200 grains.

A fluid ounce of water weighs about 437½ grains, and the above quantity of water would then be about 7½ ounces.

Percentage Solutions

The difficulty about percentage solutions will disappear if the worker will always bear in mind that one fluid ounce of water weighs 437½ grains, which is, of course, equivalent in weight to one ounce avoirdupois. It follows that if one-tenth that number of grains—that is, 43.75 grains—of any ordinary soluble chemical is put into a graduate glass and water added to make up one fluid ounce, the result will be a 10 per cent solution.

In the following table the figures are worked out for solutions of various strengths. If the number of grains indicated in the table are taken and sufficient water added to make one fluid ounce, it will be found that the solution has the required strength.

For a	1%	solution	take	4.37	grains.
"	5%	"	"	21.87	"
"	10%	"	"	43.75	"
"	20%	"	"	87.50	"
"	30%	"	"	131.25	"
"	40%	"	"	175.00	"
"	50%	"	"	218.75	"

CHAPTER IX

THE DARKROOM

While any small room, which can be made absolutely dark, may be converted into a proper darkroom, it is imperative to the practical worker to have the convenience of a well-arranged and well-ventilated darkroom, with sinks and faucets supplying clear water. The room should be conveniently arranged and kept clean, well ventilated and at the proper temperature. Too many shelves in the darkroom are undesirable. A shelf for the developer, one for trays and one for changing plates are practically all that are necessary. If possible, the chemicals should be stored, and the various solutions prepared in a corner of the darkroom set apart from the essential portion of the room. The object of this is to prevent gases and floating particles of chemicals from reaching the negatives and unexposed plates. The darkroom should not be a storage room for empty cans, old solutions and other useless articles which are liable to contribute their share to future troubles. The utmost cleanliness is absolutely necessary in the darkroom. Have clean floors, shelves and sinks, and keep trays, graduates and all chemical apparatus clean. Wipe off the shelves frequently. Mop the floor; do not sweep it. Solutions spilled and left to evaporate will leave crystals which, at the least stir in the air, will fly about and cause troubles of various kinds. Experience proves that nearly all darkroom troubles come from carelessness, impure water, impure chemicals and dirt in its various forms.

A good darkroom entrance is in the form of a zig-zag shape which effectually excludes the light, but permits

free passage and ventilation. The diagram in Fig. 27 will serve as an illustration.

The essential part of the darkroom is within the heavy black lines.

The sliding door allows the use of both parts of the room independently. The entire room should be painted

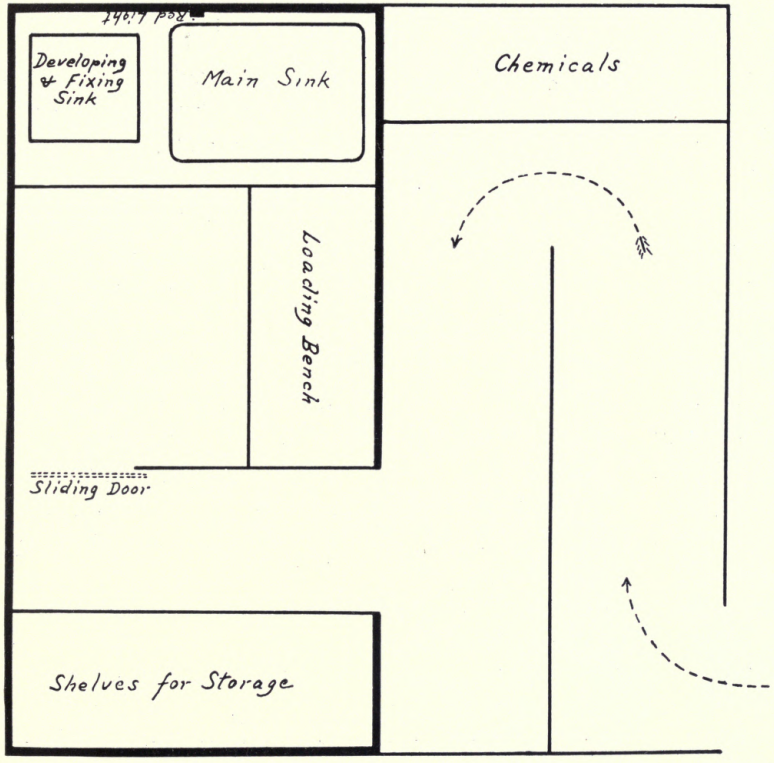

Fig. 27.

a dead black or dark brown. The wall between the x-ray room and the darkroom should be lined with lead to prevent stray x-rays from penetrating the wall, because such rays can easily pass through several walls and fog films and plates on the other side. If the entire wall can not be lined with lead, a lead plate should be fastened

against the wall, and all plates and films should be handled back of this plate. To further insure the permanency of x-ray plates, store all unexposed plates in a lead-lined box.

An electric fan is a great convenience in the darkroom, both to the operator and in drying the negatives, preventing the latter from becoming too intense, which would be the case when dried in a sultry or hot atmosphere. During the hot season the fan serves to keep the room and solutions cool.

If the bottles are wrapped in flannel and kept moist by placing them in a shallow dish filled with cool water, the draft from the fan will cause a considerable fall of temperature in their contents.

Testing the Darkroom Light

It should be remembered that no darkroom light is absolutely safe, and development should always be carried on as far from the light as possible. If there is any doubt regarding the safety of the light it can be easily tested. Take an unexposed plate, lay it on the table where development is usually carried on, then cover half of it with opaque paper and expose to the developing light for one minute. Now develop the plate in total darkness for three minutes. If the exposed half of the plate is perfectly clear and shows no fog, the darkroom light may be considered safe. If, however, there is the slightest variation in tone between the exposed and unexposed portions of the plate, it is an indication that the light is not safe, and the lamp should be covered with several thicknesses of orange postoffice paper.

CHAPTER X

LANTERN SLIDE MAKING

Quite often the radiographer wishes to make slides of certain negatives as illustrations to accompany a lecture. Before describing the various methods of making such slides from x-ray negatives let us briefly describe the process of lantern slide making in general.

A lantern slide is a positive transparency on a glass measuring $3\frac{1}{4} \times 4$ inches. The printing of the slide does not differ greatly from the printing of an ordinary photograph, either by contact or enlarging, and any one who can make a good photographic print should also be able to make a good slide. When the plate has been exposed, developed, and dried, a piece of opaque paper with a central cut-out is laid over the plate, and this mask blocks out the parts of the picture not wanted in the slide. Over the paper mask a piece of clear glass is laid of the same size as the one supporting the picture, and the two glasses are firmly bound together by gluing a strip of paper around their edges. This cover-glass, as it is called, serves the double purpose of holding the mask in position and protecting the film from injury.

A slide is printed either by contact or by projection. If the negative is of the same size as the lantern plate, or if a portion of a large negative is wanted, contact printing is the simpler, but if it is desired to make an enlarged picture from a small negative, or a reduced picture from a large negative, then the slide must be made by projection.

Contact Printing

The film or plate to be printed is placed in an ordinary printing frame, the lantern plate is laid over it, and the

two clamped together, emulsion to emulsion. An exposure is now made in the same way as when making a photographic print, the only difference being that a much briefer exposure is made. An exposure equivalent to the burning of a match at a distance of three or four feet from the printing frame will be found approximately correct. The plate is now developed and fixed in the usual manner.

Printing by Projection

When making a slide by enlargement or reduction it is necessary to use a projecting instrument with which to throw an enlarged or reduced image upon the sensitive plate. A simple, yet practical, apparatus is shown in Fig. 28. The negative to be printed is inserted between the illuminant and the lens and a projected image is thrown upon the easel. When the image has been properly focused and centered, the lantern slide plate is inserted in its holder and the exposure made. Such an apparatus must be operated in a room from which all light has been excluded, so that the only rays of light which strike the plate shall come through the camera lens. With this apparatus films or plates of any size up to 4×6 inches may be reduced or enlarged to lantern plate size.

A different type of apparatus is shown in Fig. 29. This camera is designed especially for lantern slide work and has several advantages over the former instrument. It consists of three compartments, the center compartment carrying the lens, the one to the left, the lantern plate, and the one to the right, the negative. The three compartments are connected by bellows. It is therefore evident that extraneous light can not reach the plate, and the exposures can therefore be made in broad daylight, a darkened room being unnecessary. The center compartment is fitted with a lens board which can be re-

moved and placed in front of the camera, thereby converting the instrument into an ordinary camera. The lantern slide back is adjustable in any position, either rising or oscillating, in order that any oblique lines in the negative may be brought into correct position on the lantern slide. Focusing is done by means of a heavy milled head engaging the rack and pinion with locking device for securing the back in any required position. The

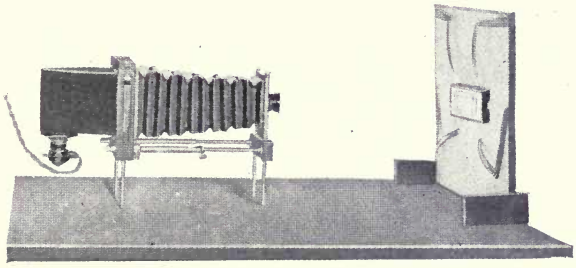

Fig. 28.

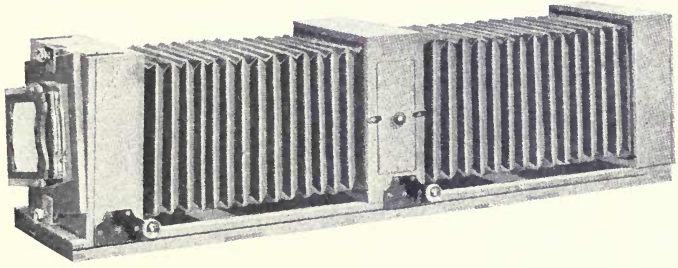

Fig. 29.

movement of the center compartment is controlled by a milled head with lock nut for holding the center section securely in position. The capacity of the camera is 5x7.

Other types of instruments can be had which will accommodate plates up to 14 × 17, but since they are fundamentally the same as the two already spoken of, a description is unnecessary here.

Lantern Slides from X-ray Negatives

The making of a lantern slide from an x-ray plate differs somewhat from the making of a slide from an ordinary photographic plate. The reason becomes clear when we realize that a slide is a *positive* print, whereas practitioners in general are accustomed to viewing the negative or x-ray plate itself.

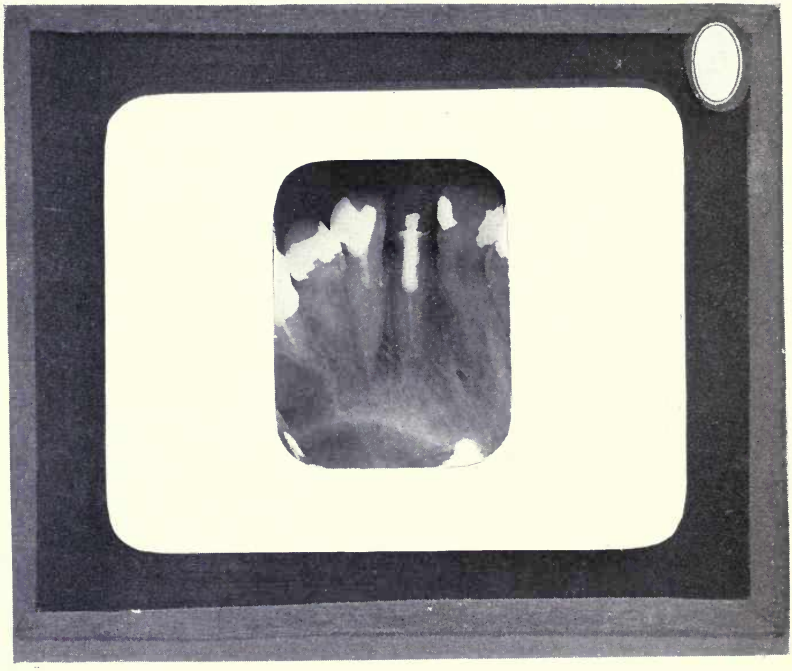

Fig 30.

There are two methods of making a slide from an x-ray negative. We may call these the *direct* and the *indirect methods.*

The Direct Method

The direct method is limited to small negatives, such as dental radiograms. It is extremely simple and effec-

tive. The film is simply clamped between two cover-glasses, after which the two are glued together with a binding strip. The one advantage of such a slide is that all the details that appear in the original film must necessarily show up on the screen, because there is no chance of losing or gaining contrast, as is often the case when printing a slide. Only films which have been correctly exposed and correctly developed will prove fully satisfactory for this class of work. Fig. 30 represents a slide of the type described.

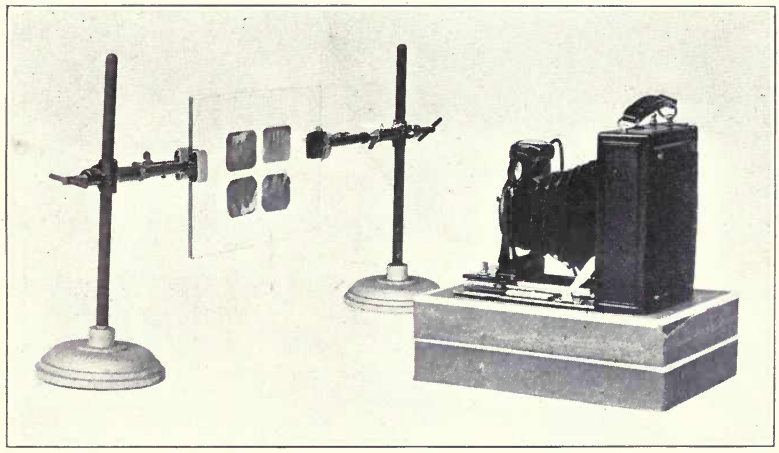

Fig. 31.

The Indirect Method

The indirect method is employed in all cases where we want to make a slide from a large negative, or from a group of small dental films..

The films are arranged between two pieces of clear glass, say 5×7, and the two are held in an upright position by means of a pair of burette clamps and stands. An ordinary camera is now placed at a suitable distance from the films and an exposure made in the usual manner by means of reflected light. (See Fig. 31.) By this

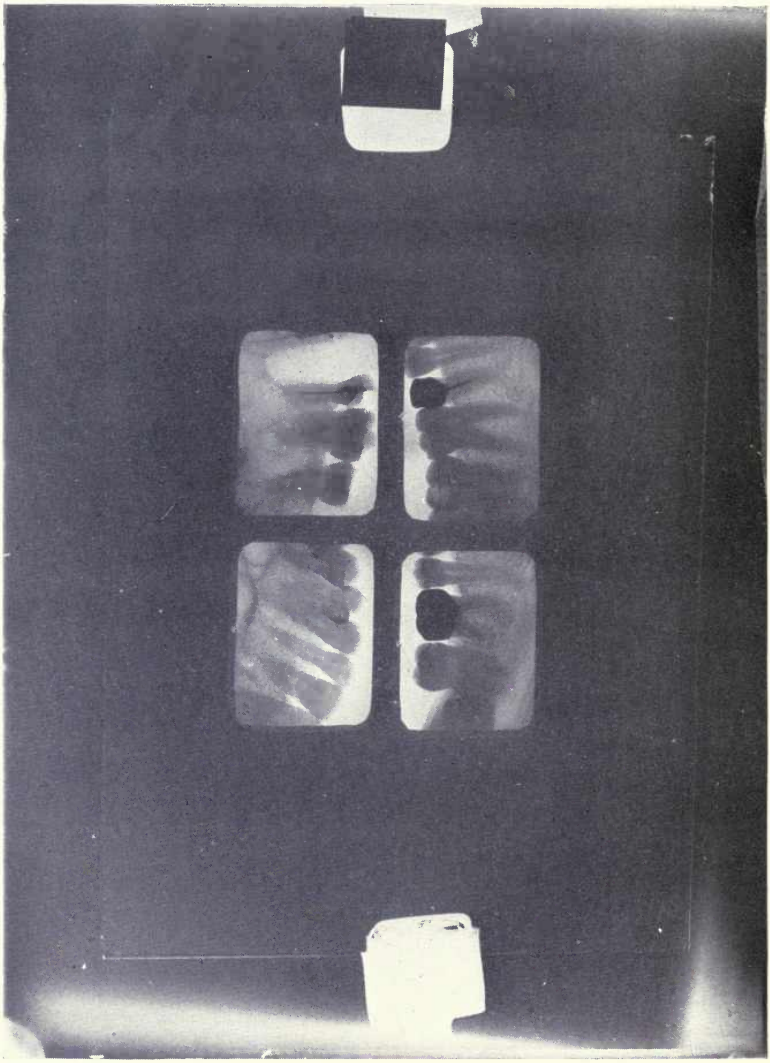

Fig. 32.

means we obtain what may be called a *master negative,* or more correctly speaking, a *master positive.* (See Fig. 32.) From this master positive any number of slides may be made. If care be taken to make the master positive on a $3\frac{1}{4} \times 4\frac{1}{4}$ plate, slides can be made by contact printing, and the necessity of using an expensive enlarging or lantern slide camera is thereby obviated. The finished slide is shown in Fig. 33.

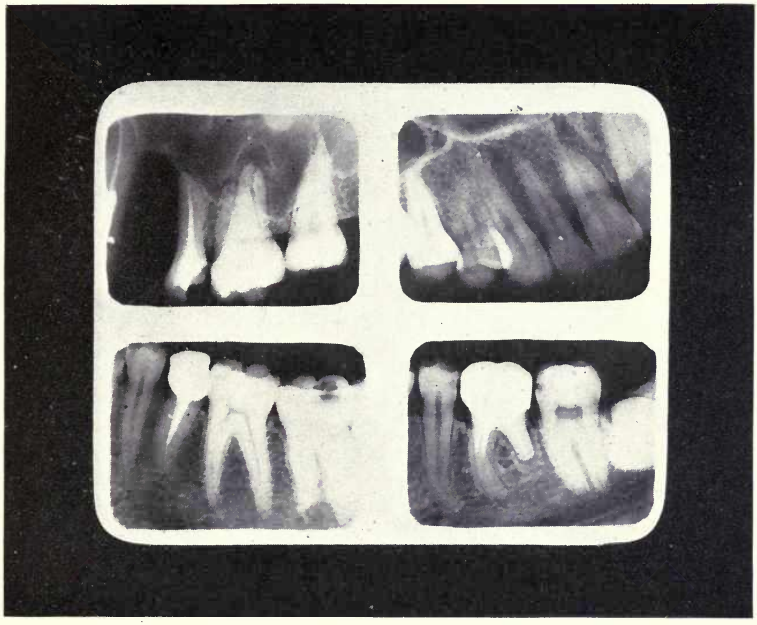

Fig. 33.

The proper developing formulas for lantern slide plates are given in each package of plates; otherwise the same general photographic procedure as previously outlined will apply with the exception that a considerably greater quantity of red light may be used with safety in the darkroom. Care must be exercised not to overexpose or overdevelop lantern slide plates.

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