NASA CR 61216

RADIOGRAPHY. VOLUME V - FILM HANDLING AND PROCESSING

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Radiography. Vol. V Film Handling Processing

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INTRODUCTION

Although much processing of radiographic film is now done in automatic processors, a radiographer should have the knowledge and ability to process his film by manual methods. In this volume, you will be exposed to some of the basic requirements of darkroom procedures including cleanliness, preparation for processing, film handling, and the consequences of not observing these simple requirements. The step-by-step procedure for developing, fixing, and finishing a film are covered in a general way since specific details of the process vary depending on the manufacturer and type of film being processed.

This volume, more than others in the 5330.14 series, can stand by itself. However, it will be of advantage if the first four volumes of the series are completed prior to starting Volume V - certain terms and concepts that are mentioned in Volume V are presented in the first volumes.

INSTRUCTIONS

The pages in this book should not be read consecutively as in a conventional book. You will be guided through the book as you read. For example, after reading page 3-12, you may find an instruction similar to one of the following at the bottom of the page --

- Turn to the next page
- Turn to page 3-15
- Return to page 3-10

On many pages you will be faced with a choice. For instance, you may find a statement or question at the bottom of the page together with two or more possible answers. Each answer will indicate a page number. You should choose the answer you think is correct and turn to the indicated page. That page will contain further instructions.

As you progress through the book, ignore the <u>back</u> of each page. THEY ARE PRINTED UPSIDE DOWN. You will be instructed when to turn the book around and read the upside-down printed pages.

As you will soon see, it's very simple — just follow instructions.

TURN TO THE NEXT PAGE.

In this first chapter we are going to discuss the film processor's workshop - the DARKROOM. There are almost as many layouts and designs for darkrooms as there are film processors. However, they all have certain basic equipment and they all serve the same purpose.

Despite its name, the darkroom is usually not entirely dark. Although capable of ensuring total darkness, the darkroom is designed for light control — for exclusion of all unwanted light. Most of the time it could just as appropriately, perhaps more appropriately, be called the controlled light room. At times, the lighting in this room is as brilliant as that of any other room. Most lighting, however, is quite dim, being controlled as necessary to fit the task being performed.

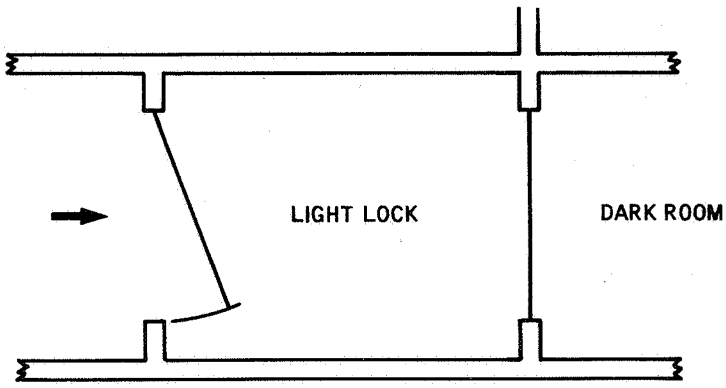
But the darkroom provides more than just a controlled light environment. It provides an "island" for the practice of cleanliness — the failure or success of which is dependent on human nature rather than technical achievement. Lighting is a function of technology — cleanliness a matter of care and performance.

The design you will see in the next few pages is merely a convenient darkroom layout with desirable features for effective film handling and processing. Deviations in both design and equipment are common — they can be just as effective.

Please open the door and step inside.

Turn to the next page.

Dark isn't it? At this point you are not in the darkroom proper, you are in the light lock.



This and similar designs prevent accidental light exposure during critical phases of film processing. By the time you reach the inner door, the outer door will have closed, shutting off all light from the adjoining room.

The light lock is the first of several well-planned technical devices by which the darkroom achieves its primary function of:

Keeping out unwanted dust . . . . Page 1-3

Light control . . . . Page 1-4

While dust is certainly unwanted and though the light lock helps keep dust out, it is primarily designed for light control, barring unwanted light, not dust.

Unwanted light can effectively be kept out by good darkroom design. Dust will inevitably be tracked into the room and must be removed. Darkroom cleanliness, basically, is a function of care and performance, more than design.

Turn to page 1-4.

[redacted]

A light lock bars unwanted light, right. It is the first of a series of devices designed for light control, the darkroom's primary purpose.

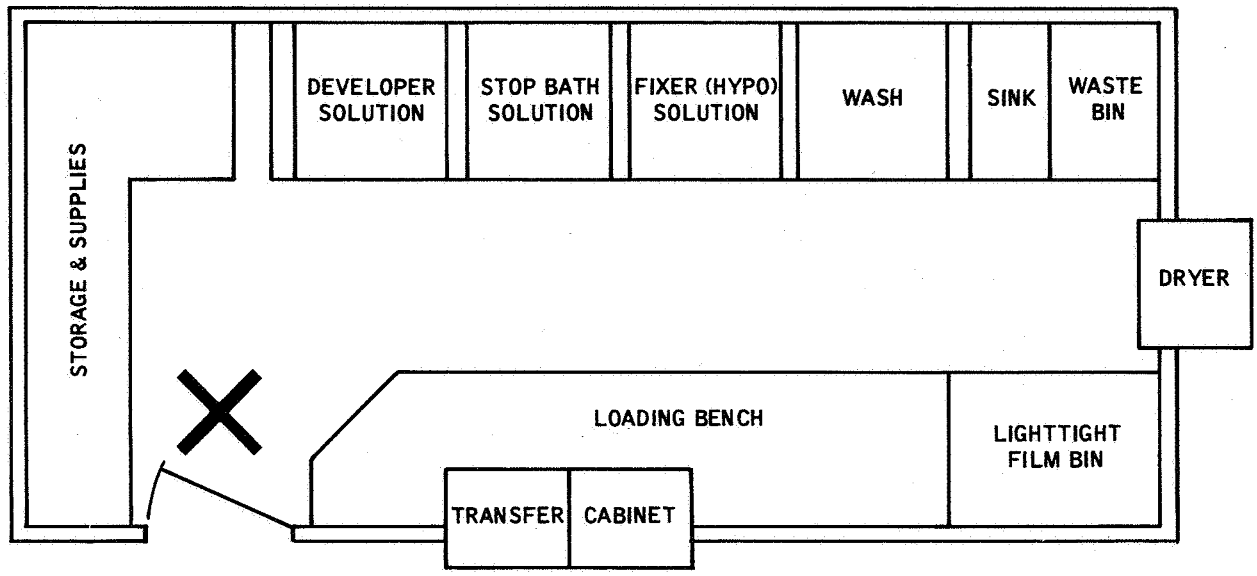
Dust is also most unwelcome and the very nature of the darkroom's light control design helps minimize this problem. However, keeping dust down is a secondary benefit, it is not the light lock's primary function.

Although a light lock is a handy design, unwanted light can also be kept out of the darkroom by other means — a warning light outside the door for example. Such a light will caution your co-workers not to open the door — that you are in a critical phase of film handling or processing.

The purpose of all this control is film protection. You will learn more about film in the next chapter; for the moment let's just say that film is sensitive to many things, among them — light.

There is no film processing in progress at the moment so when you step through the inner door you will find the overhead white light burning.

Turn to the next page.



"X" marks your spot. You are now standing inside a typical darkroom. There is nothing which says this is the only possible design, there are many others.

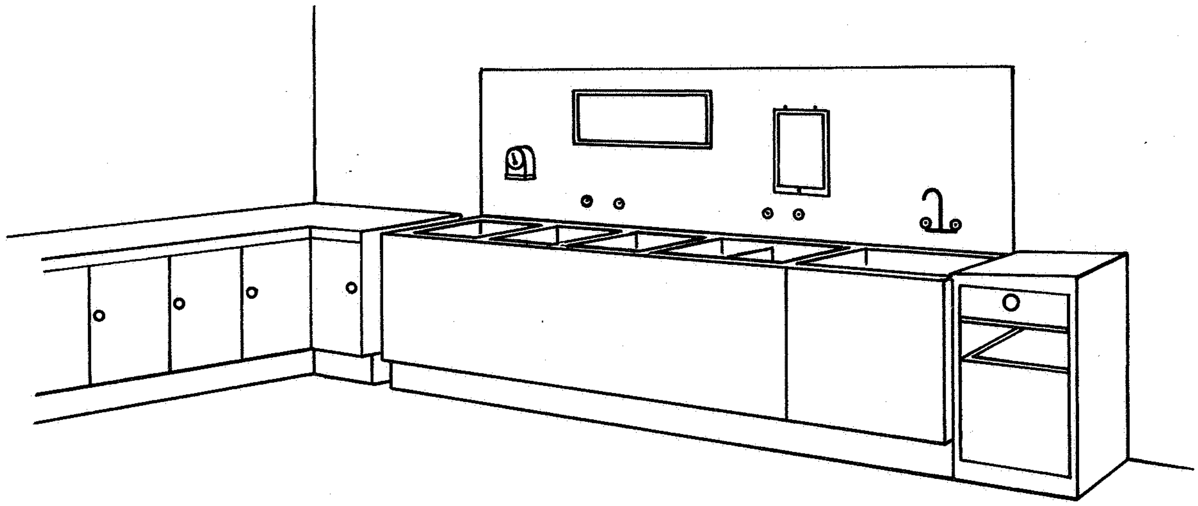
A darkroom is not large. In fact, within reason, the smaller the better so that most items can be reached with minimum effort and movement.

Darkrooms are generally divided into two areas: a so-called wet side and a dry side. Having just entered, which side are you now facing?

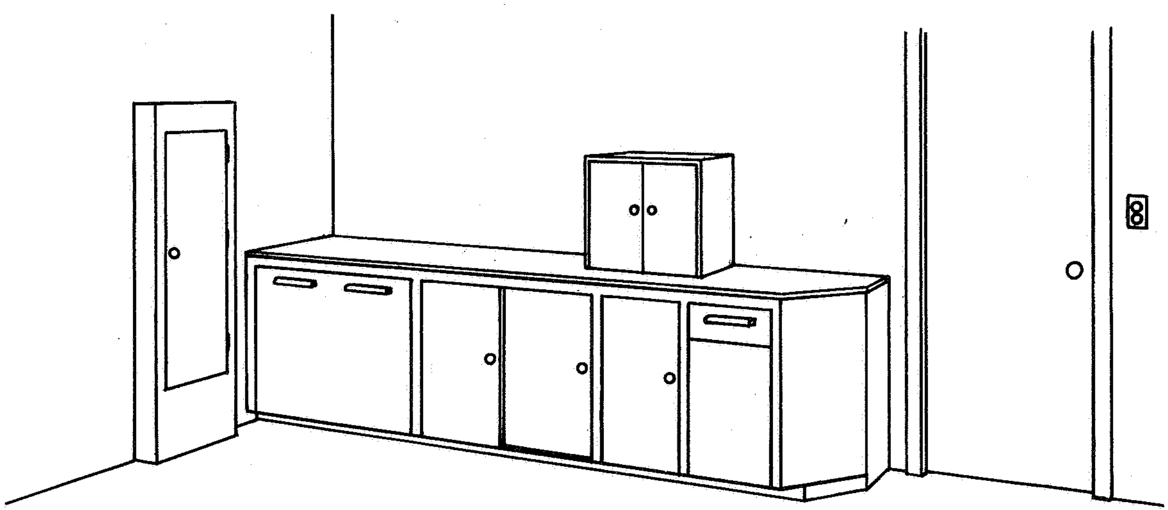
The wet side . . . . Page 1-6

The dry side . . . . Page 1-7

Correct. A wash tank, three types of solutions and a sink for mixing them should leave no doubt that you are facing the darkroom's wet side.



On the opposite side are facilities for loading and handling the film. The distinct separation of wet and dry activities is no accident — it helps to prevent the contamination of one area from the carry-over of the other.



On this side are storage facilities for film, chemicals, cassettes, film holders, hangers, cutter, etc. In short, this is the____________________side.

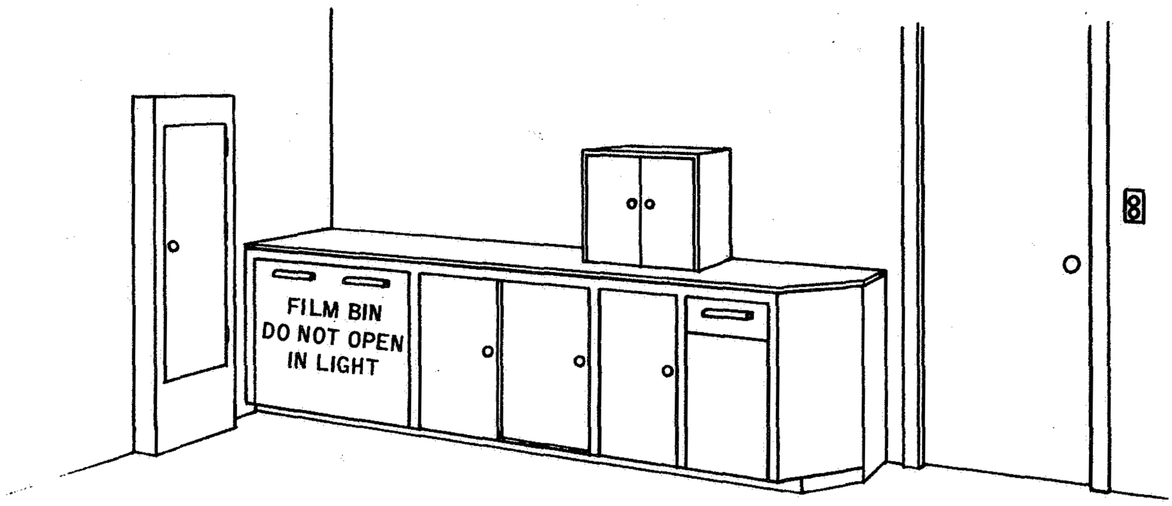
Fill in the missing word and turn to page 1-8.

If you really think you are facing the dry side you're quite likely to get damp when the light goes off, for this is the wet side.

There will be no doubt in your mind when you actually enter a darkroom. It will quickly be apparent which side is which. But all darkrooms may not be this distinctly arranged into wet and dry areas, and it is advantageous to realize that, for efficiency, the two activities should each be concentrated in its own area. Separating the two activities (wet and dry) precludes contamination of one area by carry-over from the other.

Turn to page 1-6.

Dry side, sure. Since this side is the starting point for the radiographic process, let's consider it in closer detail.



A good way to do this is to go through the process of actually loading some film. A logical first action would be to:

Remove the film from its bin . . . . Page 1-9
Turn off the white light . . . . Page 1-10

Lesson number one — no, you should <u>not</u> remove the film from the lighttight film bin prior to turning off the white light. The darkroom exists because of films' sensitivity to light.

You missed a give-away clue on the front of the film bin which reads:

FILM BIN

DO NOT OPEN
IN LIGHT

Although most film within the bin is packed in cardboard boxes which are themselves lighttight, some may be lying free. And, some of the boxes may no longer be light-tight. In either event should the bin be opened while the overhead light, or any white light is still burning, any film the light reaches will be ruined.

Turn to next page.

From page 1-8

Precisely. A simple instruction, a vital precaution — before removing the film from its lighttight bin, turn off the white light. Most of the film within the bin will be packed in lighttight boxes but some, for one or another reason, may be within reach of the tenacious light when the bin is opened. At this time any film touched by white light is exposed and ruined. So before you open the film bin, turn off the white light.

So now you are standing in the dark. At least to your eyes it is dark. You might have noticed that all references to light have been to white light, the common household light bulb kind, good for cleaning and mixing tasks but ruination itself to film. It is time to introduce you to safelights. Click.

That click was the darkroom safelight switch being turned on. Or the safelights may already have been on and you just hadn't noticed them. When your eyes become adjusted to these dim, colored lights you will be able to navigate and function in the darkroom.

Safelights are colored, both to keep illumination dim and to provide a color to which film is relatively insensitive. There are many types of film and for each type there is a color which affects it less than other colors.

When using safelights there is no danger to film . . . . Page 1-11
Using safelights merely lessens danger to film . . . . Page 1-12

The world of the darkroom technician would be less burdensome if safelights did not endanger film but, unfortunately, they do. Your answer is wrong.

While handling film under white light is not safe at all, handling film under safelights is safe only within reason. Proper safelight color is important and a color will be used which will best satisfy the safety requirements for the majority of film used in a particular radiography lab. A color which will, in other words, subject the film to as little danger as possible.

Turn to page 1-12.

[redacted]

From page 1-10

Absolutely. Using safelights merely lessens the danger to film.

Safelights are <u>safer</u> than white lights; but they are not completely safe. Wattage, as well as color, is important. A bulb having more than the necessary wattage may damage the film, cause it to fog. Even with correct safelight wattage, however, a film can be damaged if it is exposed to the light for too long a period. Sensitivity of the film to light varies at different stages of handling and processing.

Considering the varying sensitivity of film at different stages, a happy combination of utility and film protection can be achieved by:

Ensuring all safelights are dim enough to leave film unaffected even during the most sensitive stages . . . . Page 1-13

Dividing the darkroom into zones of illumination with lower intensity lights used at the points of highest film sensitivity . . . . Page 1-14

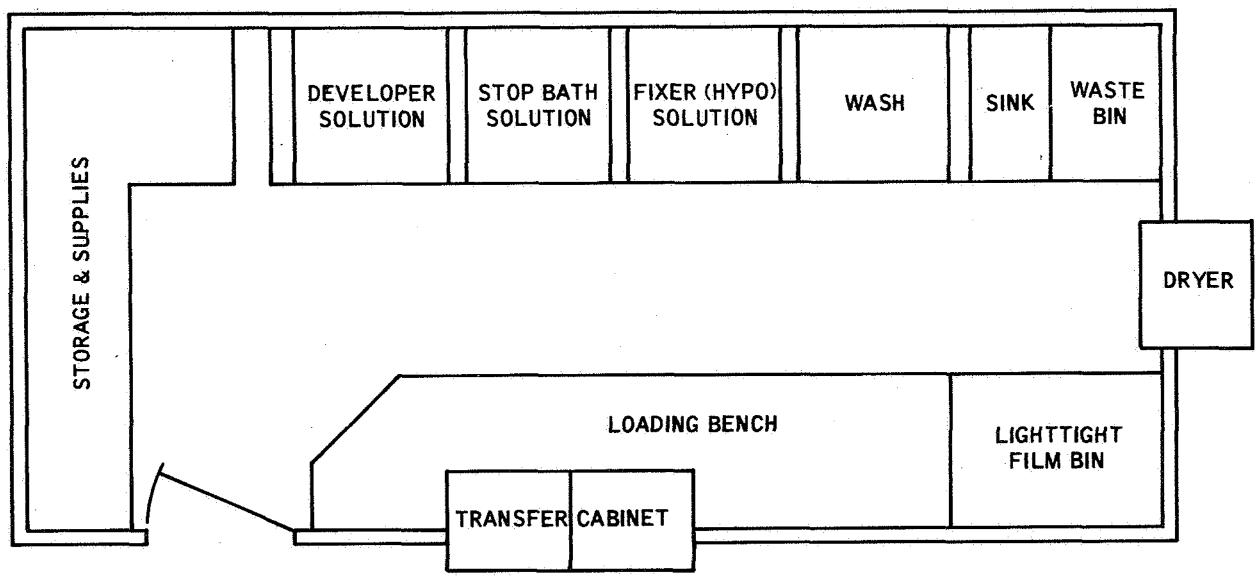
It is true that (presuming proper handling) film protection can be achieved if all safe-lights are dim enough to leave the film unaffected even during its most sensitive stage. . . but! This considers only film protection, not utility — the ease with which you are able to navigate and function in the darkroom.

A combination of the two (protection and utility) is achieved by dividing the darkroom into zones of illumination.

Turn to page 1-14

It's a fact. Divide and conquer. Zones of illumination, with lower illumination at the places where film sensitivity is the greatest, is the means of achieving a combination of utility and film protection.

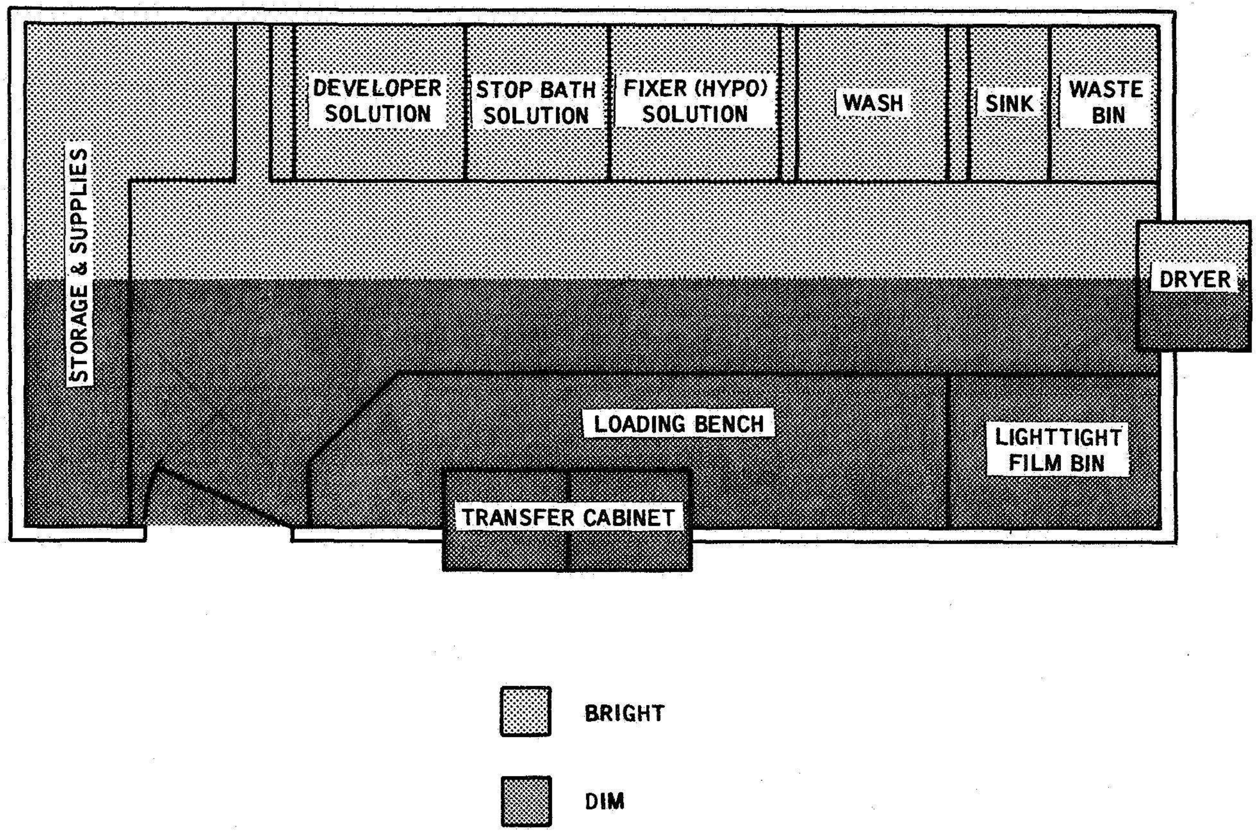
If all safelights were so dim that none would affect the film, however sensitive, the film would be safe (assuming proper handling). But what about you? At best you would have a hard time seeing what you were trying to do. Safelights provide the relative safety, and illumination zones furnish the utility.



The first zone — the brightest degree of illumination — is normal white light. This light, of course, is used to illuminate the entire darkroom for cleaning and mixing tasks and, if desired, for the final stages of processing during which the film is no longer sensitive.

Turn to the next page.

There are two other zones of illumination, both lighted by safelights.



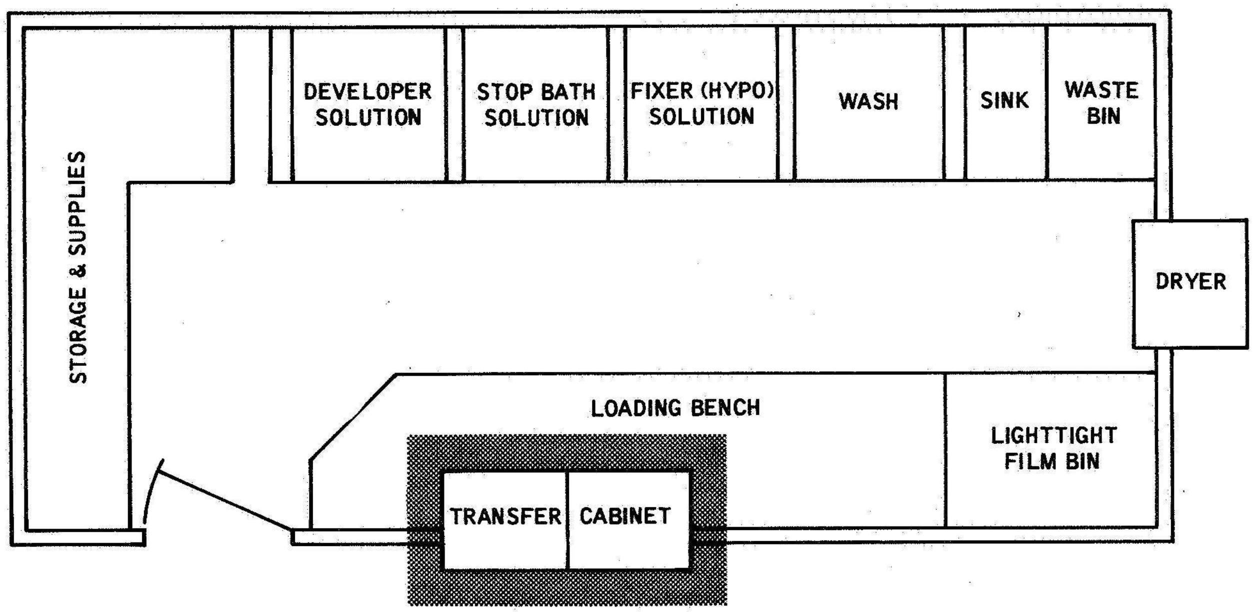
According to the above illustration, in which of the two safelight zones of illumination is film handling <u>most</u> critical?

Dimmest . . . . Page 1-16

Brightest . . . . Page 1-17

Correct. Your selection indicates the zone of dimmest safelight illumination and thus the most critical zone for film handling — the loading bench.

Chapter 3 will explain what can happen to the film if it is handled improperly at the loading bench. But for now let's continue the darkroom orientation.



When the film is ready for processing it can be passed into the darkroom without anyone actually entering the room. This is accomplished by use of the transfer cabinet, a two-compartment, lighttight cabinet imbedded in the wall over the loading bench.

The illustration shows that film can be passed not only into but out of the darkroom.

True . . . . Page 1-18

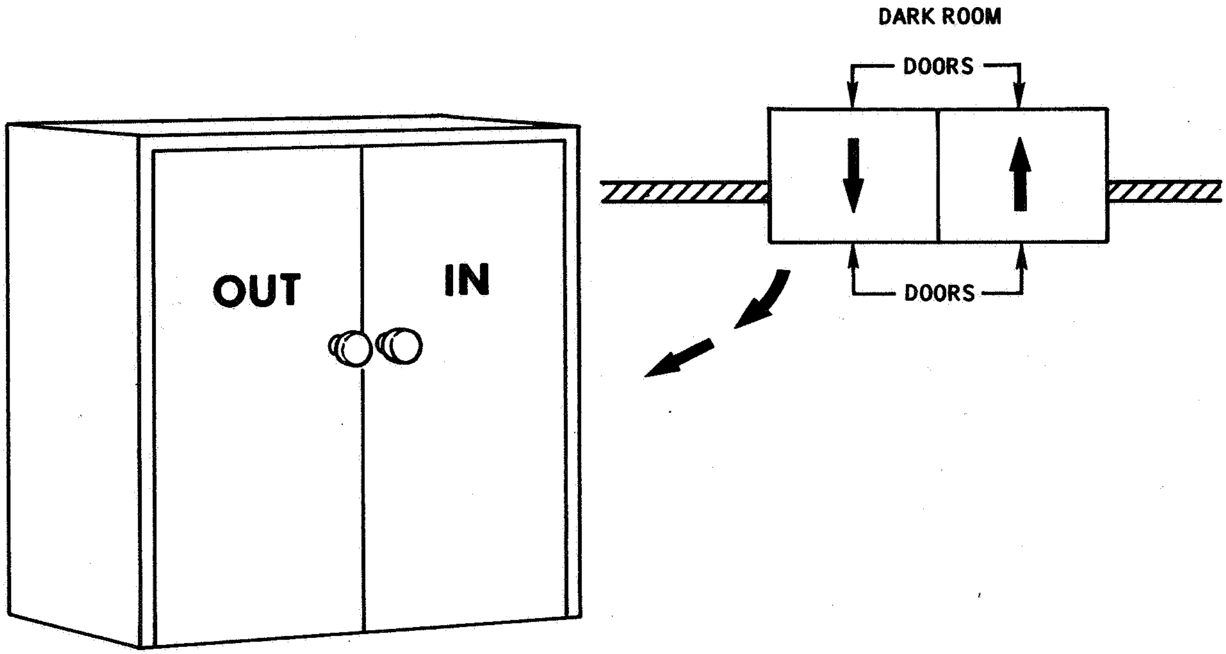
False . . . . Page 1-19

No, it wouldn't make sense at all to handle the film during its most sensitive stage in the brightest safelight zone and that is what you have indicated by your choice.

Consider your own eyes for example. When you first awaken they are sensitive to bright light. Subdued lighting is more welcome. In a sense so it is with film. In its most sensitive stage it welcomes the least bright or <u>dimmest</u> safelight zone which is the loading bench.

Turn to page 1-16

True.



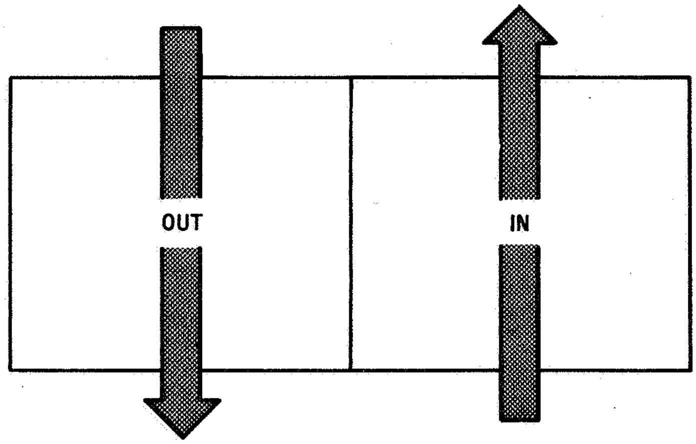
With this device, film ready for processing can be passed into the darkroom and freshly loaded film cassettes can be passed to the outside.

Each compartment is independently lighttight. All four doors have safety locking devices which prevent both doors of a compartment being open simultaneously. Suppose the IN door, for instance, were opened to place some exposed film into the compartment. While this door remains open, the IN door on the darkroom side of the cabinet cannot be opened. This safety device maintains the controlled light integrity of the darkroom, preventing accidental entry of light.

Now that the film has an efficient, safe way in and out of the darkroom, how about getting your feet wet.

Turn to page 1-20.

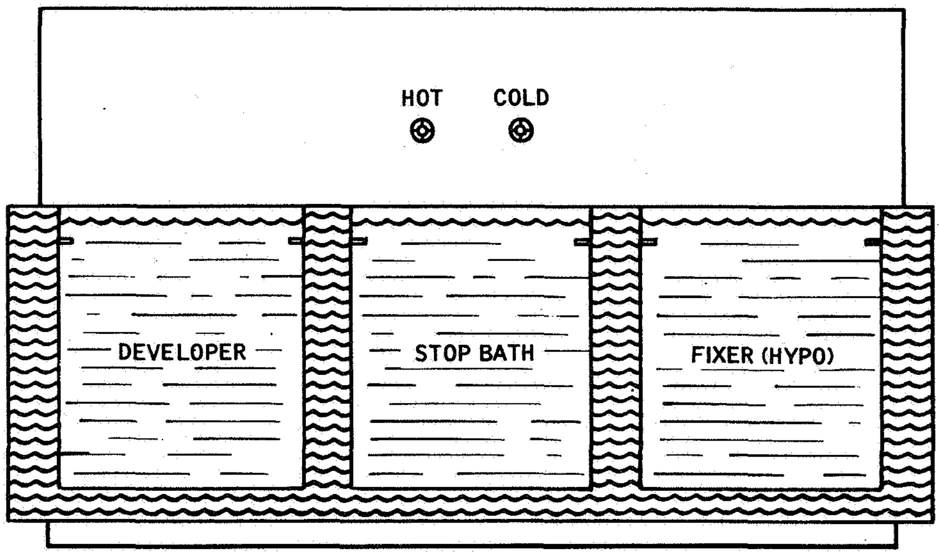
Sorry, the only thing false is your answer. Film can be passed into and out of the darkroom. Look again.



The arrows indicate an in-out arrangement for passing film into, and out of, the darkroom. Film is originally loaded into lighttight film holders or cassettes in the darkroom under safelight conditions. It is then placed in the "out" compartment. The radiographer can reach into this compartment from outside the darkroom and remove loaded cassettes. When he has exposed the film he will then place the cassette containing the exposed film into the "in" compartment. The darkroom technician knows that any film in this compartment is ready for processing.

Turn to page 1-18.

Only figuratively speaking are you now going to get your feet wet.



You are looking at part of the reason the wet side of the darkroom is called wet. The drawing depicts a common, efficient method of radiographic film processing in which three stainless steel insert tanks rest in a large tank containing temperature-controlled water. The water surrounding the tanks, in turn, controls solution temperature.

The name given this method is derived from the insert design and is referred to as:

The water temperature method of processing . . . . Page 1-21

The tank method of processing . . . . Page 1-22

From page 1-20

The temperature of the water surrounding the tanks governs the solution temperature, true enough, but the name of the method is derived from the three stainless steel insert tanks and the large tank into which they fit. It's the TANK method of processing.

The tank method has two important advantages over any other. One has already been mentioned — the control of solution temperature by controlling the temperature of the water surrounding the tanks.

Turn to the next page.

The three steel insert tanks give the most common, most efficient method of film processing — the tank method — its name. Good.

This method of film processing offers several important advantages over other methods. One advantage, inseparable from efficiency, is speed.

The tank method permits____________________temperature control of the developer, stop bath, and fixer.

Simultaneous . . . . Page 1-23

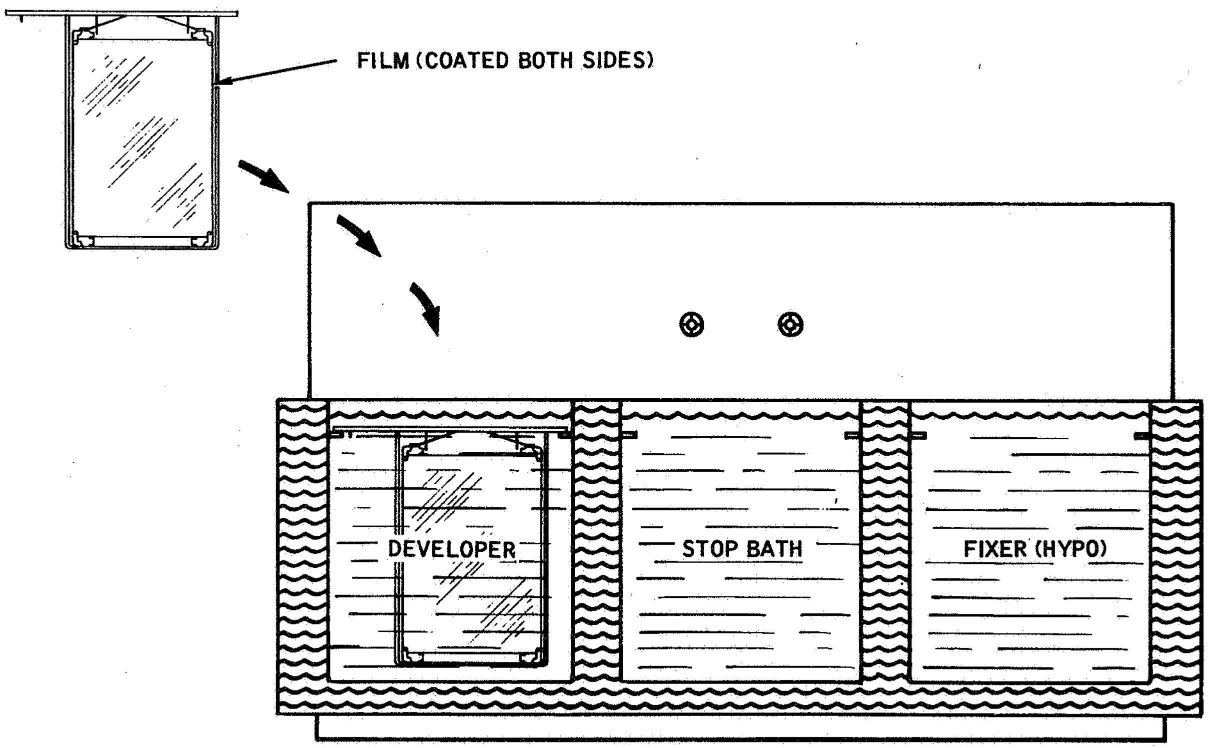
Separate . . . . Page 1-24

From page 1-22

That's it. The tank method permits SIMULTANEOUS (and thus fast) control of the developer, stop bath, and fixer. You have the point.

Water temperature can be raised or lowered by simply regulating the hot or cold water valves as required. Since the solutions (in tanks) are immersed in this water, their temperatures are established and maintained simultaneously by the surrounding water temperature — a fast, efficient method.

Another advantage of the tank system lies in the depths of the tanks and in film makeup. Radiographic film consists of a thin piece of acetate with an identical coating on both sides.



The solution tanks are deep enough for the film (on hangers) to be suspended vertically. The advantage here of the tank method of processing over some other methods is:

The film can be completely immersed . . . . Page 1-25

The solutions have free access to both sides of the film . . . . Page 1-26

[redacted])

The tank method permits simultaneous temperature control of the three solutions, not separate control. Look at it this way: The three insert tanks are, so to speak, all in the same watered nest. A change in nest water temperature means a corresponding change in all three solution temperatures. The method is faster than separate temperature control of each solution would be.

Turn to page 1-23.

There is no denying that film must be completely immersed in the solutions during processing, but this is true for any method of processing. It is therefore not the advantage of tank processing over other methods.

Remember that the emphasis was on tank depth and film makeup. It has been stressed that radiographic film has an identical coating on both sides. The advantage here is that tank depth permits vertical suspension which, in turn, permits free and continuous solution access to both sides.

Turn to page 1-26.

From page 1-23

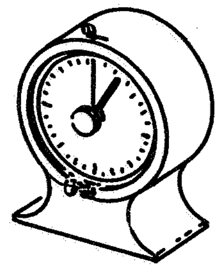
When the tank method of film processing is used, the solutions have free and continuous access to both sides of the film, correct. Since both sides of radiographic film have identical coatings, the solutions are able to act equally on both sides at once; a distinct advantage over, say, the tray method in which one side of the film may not receive the same chemical action as the other.

It's almost time to leave the darkroom for awhile. However, before going let's take a look at some of the small but essential items of equipment found here. These items will vary from fancy built-ins in some darkrooms to simple hand held equipment in others. Degree of complexity doesn't matter. Accuracy and utility do.

Turn to the next page.

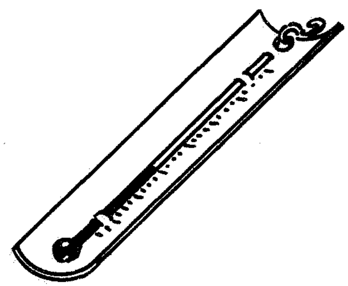
[redacted]

TIMER



As you will learn, time is critical in film processing. After dialing the desired time, this device becomes your personal timekeeper complete with alarm.

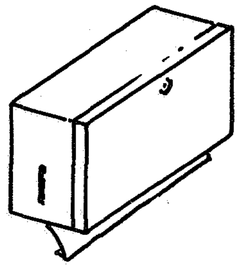
THERMOMETER



In film processing, time and temperature are inseparable. In the "good old days" finger testing often sufficed. Today a thermometer is necessary to ensure that the required temperature is achieved and maintained. There is no room for guesswork.

Turn to the next page.

PAPER TOWEL DISPENSER

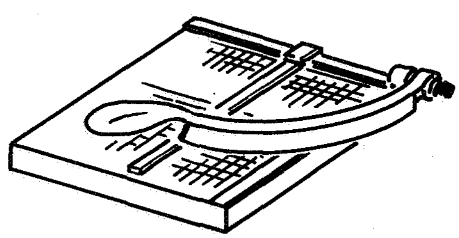


This prosaic item might hardly seem worth mentioning but its importance in the darkroom is not to be underestimated. Although lint-free cloths can perform the same clean-up tasks, they don't match the paper towel's utility.

STIRRERS,
MIXERS,
CONTAINERS

These items vary considerably and are pretty well self-explanatory with the exception of containers. Containers made of most metals cannot be used since they will contaminate the solutions. Acceptable container materials are: glazed earthenware, enamelware, stainless steel (the material of the tanks), glass and hard rubber.

FILM CUTTER

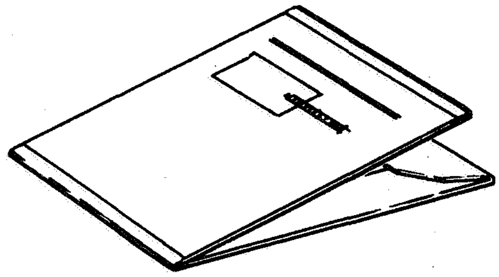


The film cutter is simply a paper cutter, its title notwithstanding. It is merely used to trim film to size as needed.

Turn to the next page.

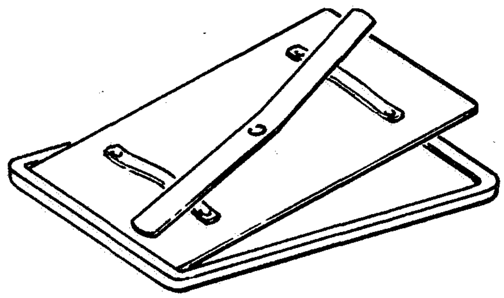
From page 1-28

FILM HOLDERS



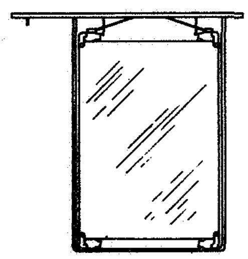
A film holder's primary function is to maintain the film's lighttight environment during radiographic exposures. Film holders are usually constructed of cardboard or plastic and may be quite flexible.

CASSETTES



It is the function of cassettes also to maintain a lighttight environment for film. But cassettes have a more rigid and permanent construction.

FILM HANGERS



Film hangers have the job of holding the film rigid during film processing.

Turn to the next page.

The darkroom orientation is at an end. It's a small room and didn't take too long to explore.

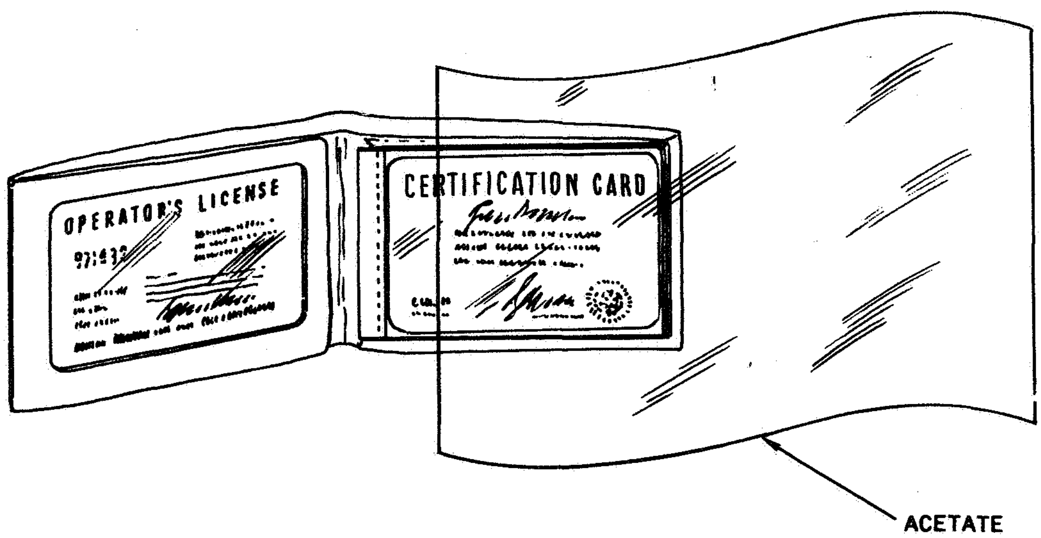
However, before we leave, remember this: outside of actually making the radiographic exposure itself, whatever happens to the film, good or bad, almost without exception happens in the darkroom.

Turn to page 2-1.

Now that we've examined the darkroom, let's take a look at radiographic film - how it's constructed and some of its properties.

Although similar in appearance, there is considerable difference between photographic film and radiographic film. Radiography is a highly specialized technique which requires the recording of interior images over a wide range of film densities. It follows that a specialized film is needed for this purpose. And since radiographic film is the base on which all radiography stands, it also follows that an understanding of this film and of the way in which it is processed is essential to obtain the desired result - high sensitivity in radiographs.

In the beginning most film-to-be is nothing but a transparent plastic such as cellulose acetate, similar in appearance to a wallet window. The material is clear and flexible. It has no sensitivity. It can record nothing.

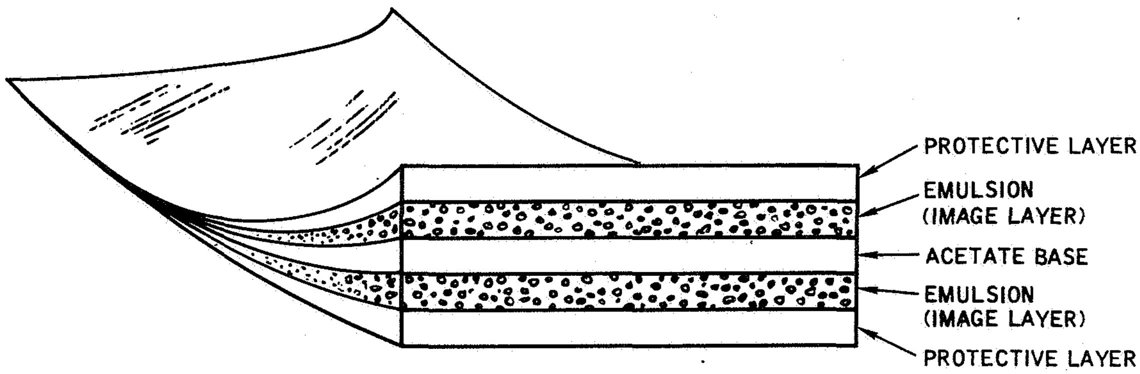


Turn to next page.

[redacted]

The clear cellulose acetate or similar plastic material is used as the support for radiographic film - it is the base to which other materials are applied. Coated with a light (or radiation) sensitive emulsion, this base becomes a radiographic film.

Most (but not all) radiographic film has a sensitive emulsion on both sides of the base as depicted in this illustration (shown thick only for clarity).



Although, technically, radiographic film is comprised of four layers and a base, for a practical understanding it is useful to think of it as a transparent base evenly coated on both sides with a gelatin emulsion. In total thickness the film is roughly comparable to the wallet window previously mentioned.

Acetate makes an excellent film base for the specialized purpose of radiography. It is flexible, transparent, compact, light, unbreakable. Which, in your opinion, is the most important quality of acetate when it is used as a radiographic film base?

Flexibility . . . . Page 2-3

Transparency . . . . Page 2-4

[redacted]

Flexibility, although an extremely vital property in radiographic film, is not the blue-ribbon property. Transparency takes first place, for a radiograph must transmit light or it is useless.

In the infant days of photography, glass, a nuisance in many respects, was used as a film base. Mathew Brady, the great Civil War photographer, lugged his bulky, heavy, inflexible, breakable - but transparent - glass plates to every important battlefield of the war. Glass plates are in use even today. The emulsion-coated bases on which astronomers photograph the stars, for instance, are made of glass.

This is not to detract from the importance of the flexibility of acetate. Without flexibility, many of the parts and seams which can be radiographed today would be beyond the scope of radiography. But without the transparency which allows a film to transmit light, there would be no radiography at all.

Turn to page 2-4.

From page 2-2

Right, transparency is the property which is indispensable, for radiographic film must be capable of transmitting light.

Most of today's X-ray film is pre-cut into standard size sheets by the manufacturers. But there is available wide, uncut rolls from which the user can cut various-size sheets to suit his requirements. Darkrooms have cutters with which to trim film to convenient sizes.

Radiographic film is usually pale yellow in color and glassy-appearing. Will it be glassy on one or two sides?

Both sides will be glassy appearing . . . . Page 2-5

Only one side will be glassy . . . . Page 2-6

Of course. Since one side is glassy appearing, the other will logically be glassy since most radiographic film has emulsion on both sides.

The glassy appearance of film is caused by its gelatin coating. Gelatin, a term derived from a Greek word meaning "gummy," is made from the finely ground bones and skins of animals. It is of particular value in film making because of these properties: it shrinks when drying, it dissolves in warm water and, in relatively cold water it will absorb the water and swell. These are valuable properties in film making and processing.

During film making, the base is coated with thin gelatin solutions or emulsions which, upon drying shrink, forming smooth, glassy layers. The outside protective layers of the film are an especially hardened gelatin which prevents the softer emulsion layers from being scratched or scraped.

The very word "emulsion," however, implies that there is more to these gelatin layers than meets the eye, for an emulsion holds something in suspension.

Turn to page 2-7.

That "Only one side will be glassy" is not the desired answer. But, neither is it an entirely incorrect answer since most, but not all radiographic film will be glassy on both sides.

The glassy appearance is caused from the gelatin coating. Since in most radiographic film each side is a duplicate of the other, a glassy surface on one side would mean a glassy surface on the other.

Turn to page 2-7.

Although the protective layer of a film has the extremely important function of protection, it is simply a hardened gelatin. It contains nothing. Held in suspension throughout the emulsion (the image layer), however, are countless microscopic grains of silver bromide - a chemical compound.

During film manufacture, silver bromide is added to a solution of dissolved gelatin. When the gelatin hardens the grains are held suspended throughout the emulsion.

Obviously, since these grains are invisible to the naked eye and yet are suspended in the emulsion, they must be extremely small. They range in size up to approximately 1/10,000th of an inch across, which is why they can't be seen without a high-powered microscope.

Carefully now, since you haven't been specifically told the correct answer, but which of the two statements below do you presently agree with?

Silver bromide is a chemical term only. Silver is not included in the makeup of emulsion . . . . Page 2-8

The compound, silver bromide, includes pure silver . . . . Page 2-9

The people who make (and those who use) film probably wish that you were right, but you aren't - silver <u>is</u> part of the makeup of film emulsion. The silver, in combination with bromine, makes up the chemical compound silver bromide which possesses desirable photographic properties to an extent thus far found in no other substance. Otherwise silver would not be used in the film emulsion since it is expensive.

Turn to page 2-9.

Your choice is sterling. Pure silver is part of the chemical compound - silver bromide.

During manufacture, film is protected from such things as dirt and dust, pressure, heat, moisture, X-rays, gamma rays and light rays. It is then packed into lighttight boxes which maintain this protective environment until the film is ready for use. Such conditions as cleanliness, coolness, dryness, darkness, then, are part of a film's natural environment and anything which changes that environment is going to cause a change in the film. In short, film is sensitive, to a great many things.

Suppose a sheet of film was removed from its lighttight box in a normally lighted room. Exposure would be immediate and total although there would be no apparent change in the film. However, if this same film were developed, the silver grains within the emulsion would undergo a change and become visible. All grains within the film would be affected to the same degree and, on development, the film would turn solid...

Black . . . . Page 2-10

White . . . . Page 2-11

Solid black is right. Why? The entire film was subjected to an environmental change - light. No useful image resulted since the light was not focused and all of the grains were exposed. When exposed grains are developed they change to black, metallic silver.

It may at first seem strange but it is true - although there is an image within an exposed photograph or radiograph, prior to developing, it remains invisible or LATENT.

A latent image is caused when the silver bromide grains within a film's emulsion become ionized by exposure to X-rays, gamma rays, or light. Each grain that has become ionized can be reduced or developed to form a grain of black, metallic silver - a visible image.

Which of these statements is true?

Upon exposure, reduction of the grains of silver bromide to black, metallic silver is instantaneous . . . . Page 2-12

Exposure is the first step in reducing the grains of silver bromide to black metallic silver . . . . Page 2-13

The fully exposed film would, upon being developed, turn not white but solid black. The black part of a negative is nothing more than exposed silver bromide grains which have been reduced to black, metallic silver.

An exposed and developed grain will turn completely black, there are no partially black grains. The totally black part of any negative is an area in which all of the grains have been exposed and reduced to silver. The gray areas in a negative are simply areas in which only a part of the grains have been exposed. The darker the area the greater the degree of exposure at that location.

Turn to page 2-10.

[redacted]

The statement, "Upon exposure the final step in reducing the grains of silver bromide to black metallic silver is accomplished" is not right.

It would be convenient if there were a film in which the first step, exposure, would also be the final step, image development. The nearest thing to this arrangement is the Poloroid process. But even this process involves development, however speedy. Radiography isn't so compact a package, however, it requires film exposure (step 1) and film processing of some length (step 2).

Turn to page 2-13.

[redacted]

From page 2-10

Precisely. Once a film has been exposed, only the first step in reducing the grains to black metallic silver is completed. Briefly:

- Exposure causes ionization of the silver bromide grains suspended throughout film emulsion.
- Immediately following exposure the change that has taken place in the grains cannot be seen - the image is latent.
- To be made useful, latent images must be made visible by the developing process.
- The visible image in a film is the sum total of countless black grains of silver.
- A film containing an image has within it blacks, varying shades of gray, and areas that (after final processing) are transparent.

There is no partial exposure of individual silver grains. If the grains have been exposed they turn black when developed. What, then, makes the shades of gray within an image? Simple. Assume that one area of a film was completely exposed. Assume also that an area immediately adjoining the completely exposed area received exactly one-half as much exposure. Upon development, the completely exposed area will turn completely black, all grains within the area having absorbed rays. The adjoining area, however, will be only one-half as black, since only half as many grains were exposed and developed.

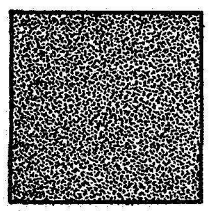
Exactly what happens to unexposed grains will be discussed in the chapter on processing. But they do not turn black when the latent image is developed.

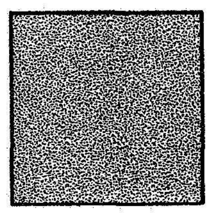
Turn to page 2-14.

Although there are so many grains within a film emulsion as to be incomprehensible, it is due to this huge quantity of grains working together that film reacts as it does.

For instance, one grain, or a few dozen grains, or even a few hundred grains, exposed and developed would not be visible. Individually, or even in relatively small groups, they are so tiny as to be insignificant. But when those grains, together with millions of others in their immediate vicinity are exposed, they are going to make themselves seen. And the more thousands that are exposed, the more visible they are going to be.

Grains are small in size, large in quantity, and it takes a lot of them working together to make a dent in density. Despite all this talk about small grain size, if improperly exposed or developed, the image on a radiograph can be made grainy. Graininess means exactly what it says - the film has a grainy appearance.



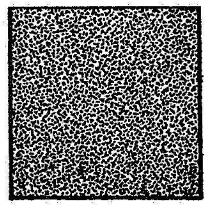


It is obvious which of these radiographs is the most grainy. In the grainy film are you seeing individual grains of developed metallic silver?

Yes . . . . Page 2-15

No . . . . Page 2-16

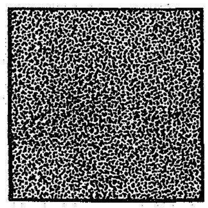
No, you are not seeing individual grains. Look again,



The graininess you see above is not comprised of individual silver grains but of visible clumps of grains. It is a natural inclination to believe that the grains you are seeing result from individual grains of metallic silver because the clumps themselves are extremely small. This is one of the reasons for stressing the microscopic size of the grains.

Turn to page 2-16.

"No" is correct - it must be reasoned that microscopic silver grains are not going to be visible individually whether the film has been developed or not. Their size precludes this possibility. Instead, when you see "grains" in a grainy film, you are seeing tiny "clumps" comprised of many grains - enough that the clumps themselves become visible.



Any developed film is going to exhibit some graininess since the radiographed image itself is comprised of metal grains. But if correct exposure and developing procedures are used, graininess will not be sufficient to affect the image. The clumps themselves will be so small as to go unseen.

Obviously, since graininess makes the outline of an image less sharp, it is an undesirable condition. In those portions of a radiograph which receive complete exposure, graininess...

Is not apparent because of film density . . . . Page 2-17

Becomes a serious problem . . . . Page 2-18

Of course, graininess would not be apparent "because of film density," in those portions of a radiograph which received complete exposure. Those areas are completely black!

It is the gray portions of an image that are adversely affected by the clumping of grains within an emulsion. Silver grains have an affinity for each other; that is, like birds they want to flock together.

The extent to which grains desire the company of other grains has been demonstrated in tests. The results have shown that even unexposed grains may become developed and join a clump just from being near an exposed grain.

The natural (and unwanted) tendency of grains to clump can be increased by radiation, use of fluorescent screens and improper developing procedures.

Turn to page 2-19.

From page 2-16

There may be grainy problems in other portions of a radiograph but not in those parts which receive complete exposure.

Remember that in any portion of film receiving complete exposure all the grains are going to be ionized. Upon developing, these grains are going to turn to metallic silver leaving a completely black or dense area through which no light can be transmitted.

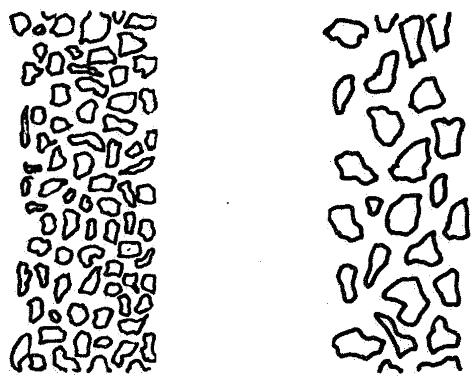
In those parts of a radiograph which are most dense, then, graininess is not going to be visible - nor is anything else.

Turn to page 2-17.

[redacted]

In large part the differences in various films are due to grain size. Like most things, silver bromide grains come in various sizes. (Be aware, however, that grain size is relative, even the largest grains are microscopic.)

Choice of film depends on a combination of factors such as the type of material to be radiographed and its thickness, the radiation source, volume of work, required degree of sensitivity, etc. In selecting a film for a particular use, the governing factor is, in general, the size of grains within the film.



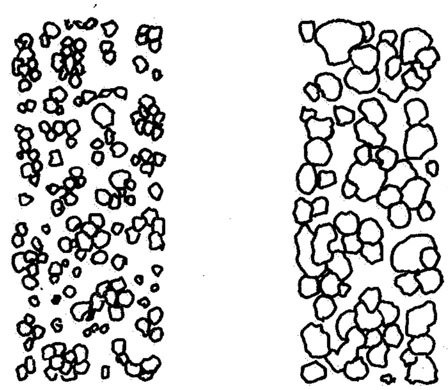
All factors being equal, which of these drawings, representing fine-grained, and coarse-grained film, would result in the least sharp image? The clue is in the clumping.

The finest-grained film . . . . Page 2-20

The coarsest-grained film . . . . Page 2-21

From page 2-19

The finest grain would not result in the least sharp image but instead would comprise the sharpest image of the two (assuming correct exposure and processing). Perhaps these drawings which depict clumped grains will better explain why.



It becomes clear that, given the same number of grains in each clump, the finer grains make the smallest clump.

Fine grains, even when clumped, are able to resolve more detail than coarse grains. Thus, the image formed by the coarse grains would be less sharp than one in fine-grained film.

Turn to page 2-21.

From page 2-19

Correct, the coarse-grained film would result in the least sharp image. Graininess (visible clumps of grains) is present to a greater or lesser degree in all processed film. But clumps of coarse grains, being larger than clumps of fine grains, are going to be more easily seen. This graininess makes the image less sharp.

Do not assume that coarse-grained film has no place in radiography. Obviously it does or it wouldn't be manufactured. Each grain size has its advantages, its disadvantages. Coarse-grained silver bromide, for example, has an advantage which lies in the larger amount of silver contributed to its emulsion, allowing energy to be more readily absorbed than with finer grains. This means that coarse-grained film is ______________ than fine-grained film.

Slower . . . . Page 2-22

Faster . . . . Page 2-23

[redacted]

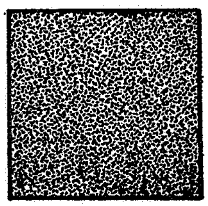
Slower? No. In coarse-grained film the larger amount of silver within the individual grains of silver bromide causes "...energy to be more readily absorbed than with finer grains." Given the same amount of exposure as a fine-grained film, a coarse-grained film will generally be faster. Or in other words, in a coarse-grained film the desired latent image will be formed faster and require less exposure than in a fine-grained film.

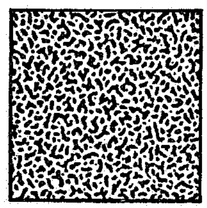
Turn to page 2-23.

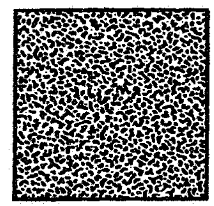
5[redacted])

Faster, right. Being relatively large and therefore exposing more silver to the rays per grain, coarse grains react faster to form a latent image. Speed is the advantage of coarse-grained film; lack of ability to resolve fine detail - its disadvantage.

The advantages and disadvantages of fine-grained film are exactly opposite those of an emulsion containing relatively coarse grains. The finer the grain, the slower the film speed but the finer the detail.







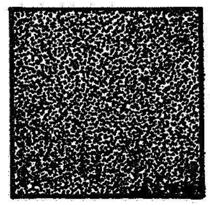
Select from the above drawings (representing degrees of grain coarseness) the grain which, all other factors being equal, would result in relatively fine detail and a reasonable film speed.

Number 1 . . . . Page 2-24

Number 2 . . . . Page 2-25

Number 3 . . . . Page 2-26

The finest-grained film (number one, repeated below) wouldn't meet <u>both</u> the requirements of relatively fine detail <u>and</u> film speed.



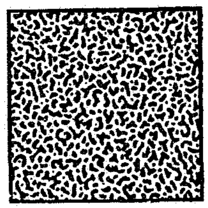
True, it would provide good detail. In fact, the best detail of the three films because it has the finest grain of the three. But, it is also the slowest.

Return to page 2-23 and select the film which meets <u>both</u> the stated detail and speed requirements.

[redacted]

From page 2-23

The coarsest film (number two), shown again below, would not meet both requirements - relatively fine detail and film speed.

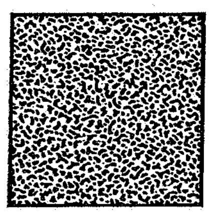


Since it would have the fastest speed of the three it does meet one of the requirements. But only one.

Return to page 2-23 and choose the film which would meet both requirements - reasonably fine detail and speed.

From page 2-23

Number three, the medium-grained film, meets both the stated detail and speed requirements.



The film having the finest grain (number one) would provide excellent detail but it would also be slowest. The number two film (the coarse grain) would meet the speed requirement but would be the grainiest of the three. To meet the middle-road course of detail and speed, a film emulsion having grain of a medium size is required.

When a film is said to be fine grained this is not to suggest that it is entirely free of graininess. All processed film is more or less grainy - coarse and fine alike. Some graininess is inescapable since the image itself consists of silver grains. But the degree of graininess is, to an extent, controllable.

Turn to the next page.

Exposure time and fluorescent screens are two possible causes of graininess. These aspects of graininess are controlled in part by use of the characteristic film chart taught in Volume IV and are beyond the scope of this study. We assume that exposure has been correct.

Even with this assumption, however, a film can look grainy because of improper developing technique.

Do you recall that silver grains have an affinity for each other, that they like to flock together? Their suspension in the hardened emulsion (gelatin) prevents this. However, when the film is processed, the once hard gelatin absorbs the chemicals in which it is immersed and begins to swell. In a word, it <u>softens</u>. Upon drying it contracts. This swelling and softening, drying and contracting of the emulsion...

Can cause graininess by allowing the grains themselves to swell . . . . Page 2-28

Can cause graininess by allowing the grains to move . . . . Page 2-29

The silver bromide grains do not change size. They do not swell, they do not contract despite the amount of liquid absorbed by the emulsion. The grains visible on the surface of a film are not grains which have grown in size, nor are they individual grains. Rather, they are grains which have "gotten together". They have clumped.

To do this musn't they have moved?

Turn to page 2-29.

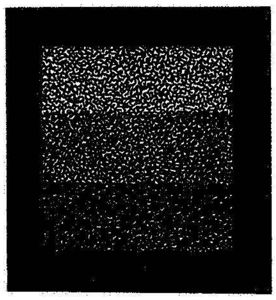
Right, disturbance of the emulsion due to swelling and contracting "frees" the silver grains, however slightly, allowing many of them to clump together. The degree of clumping and thus of graininess, depends on the extent of emulsion disturbance.

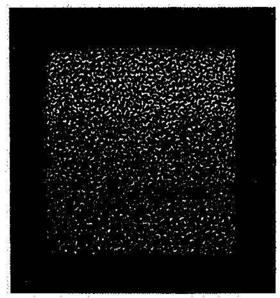
If a film is correctly exposed and correctly developed, it will have no more graininess than is inherent in the film itself. Proper exposure <u>and</u> developing are both necessary to achieve minimum graininess for a given film.

Another unwanted characteristic of exposed film is its susceptibility to increased density.

Turn to page 2-30.

Sad but true, the density of an otherwise perfectly exposed film <u>can</u> be accidentally increased.





The radiograph on the left was correctly exposed. The areas of high exposure are quite dense. Areas of less exposure are seen as varying shades of gray depending on the amount of exposure received.

However, following exposure, density could have been increased past the point of maximum effectiveness as shown on the right. Additional grains could have been accidentally exposed. Film emulsion, remember, is sensitive to many things.

Assuming correct film development, what do you believe could be a practical cause of this additional, unwanted, film density?

Safelights . . . . Page 2-31

Left too long between fluorescent screens . . . . Page 2-32

"Safelights" is the correct choice since these lights "...are only as 'safe' as sensible handling of the film makes them." Although a film <u>can</u> become fogged when left too long between fluorescent screens, <u>practically</u> speaking, it is not going to be left that long before being removed.

Fogging from improper handling under safelights <u>can</u> result at any time the film is removed from its totally dark environment. This can happen before exposure as well as <u>after</u>.

An explanation of the emphasis on the latter is in order. <u>Exposed film is more sensitive than unexposed film</u>. The reduction process from silver bromide to metallic silver would eventually take place during development even without exposure. But development will take place 10 to 100 times faster with exposure than without it.

To recap:

Unexposed film cannot be developed . . . . Page 2-33

Exposed film has increased sensitivity . . . . Page 2-34

From page 2-30

Technically, too long a time between screens before developing will cause fogging, very true. BUT, practically speaking, the film isn't about to be left the length of time it would take to cause this problem.

Film is sensitive to all changes in environment. Safelights, although providing an environment close to films' natural one, are nonetheless a change in environment for film. Subjected too long to this change in environment, the unexposed silver bromide grains are going to begin to ionize - the film will begin to fog.

Turn to page 2-31.

From page 2-31

Strange though it may seem, an unexposed film, a film which has not been removed from its environment since manufacture, can be developed if it is processed long enough. Of course this would not result in anything but a completely useless, dense piece of acetate.

In a film containing a latent image, there are grains that have been exposed and ones that have not been exposed. During normal processing the grains which have been exposed will turn black, those which have received no exposure will be removed from the film base. The fact that unexposed grains can be turned to metallic silver (developed) is an important consideration in handling and processing of exposed film.

Turn to page 2-34.

[redacted]

From page 2-31

That is the point - "Exposed film has increased sensitivity." Remember that an image contains blacks and various shades of gray depending on the exposure received by a particular area. When the specimen has been properly shot the latent image contains precisely the desired number of exposed grains. However, the surrounding unexposed grains are now more sensitive to ionization than they normally would be. Very little additional exposure will ionize these surrounding grains.

Because of increased sensitivity the possibility of unexposed grains becoming exposed from improper handling or processing is now a danger. The latent image then will contain more exposed grains than desired resulting in what is termed "fog" in the visible image. Safelights can be a cause of fog. The same degree of handling under safelights which might have been OK before radiographic exposure could prove to be too long after exposure because of the increased sensitivity.

Fogging is only one of the undesirable effects that can be introduced into sensitive film. Improper handling of film can result in undesirable film effects called ARTIFACTS. The dictionary definition of the word artifact is: "A product of human workmanship." Archeologists carefully dig for artifacts, darkroom technicians don't dig them at all, artifacts must be avoided. The next chapter will explain how.

Turn to next page.

In this chapter you will learn the basic film handling techniques to insure best radiographic film results. To a large degree, these techniques can be lumped under one simple statement -

HANDLE WITH CARE AND CLEANLINESS

It is lack of care and cleanliness that causes most film processing headaches: fog, spots, stains, streaks, finger prints, etc. You can use the best shooting techniques and use technically accurate processing techniques; but, careless handling in the darkroom can cancel all your efforts.

One of the first considerations in darkroom housekeeping is dust. The remedy for ordinary, shoe-tracked dust is a good daily mopping of the floor.

For the housewife dust merely spells annoyance. For the darkroom technician it spells a-r-t-i-f-a-c-t-s. Dust must be kept to an absolute minimum. When dust settles on film and screens the finished radiograph will record it as light spots or areas. You will then have one of those unwanted film indications that are generally lumped together under the term ________________.
(fill in the blank)

Turn to the next page.

From page 3-1

ARTIFACT, right.

Any of that group of film imperfections which result from lack of care or cleanliness is called an artifact - a product of human workmanship.

The shoe-tracked variety of dust isn't really the worst of the lot, a daily floor scrubbing can pretty well keep it under control. A potentially worse offender is chemical "dust."

Although you must try to avoid splashing or dripping chemicals on the floor or walls, it will inevitably occur. If left to evaporate, the resultant minute chemical particles will float free in the darkroom with the same consequences as dust. The cure to this ill is reassuringly simple - <u>wipe up spilled chemicals</u>.

The next step toward good darkroom housekeeping is in the direction of that citadel of <u>all</u> good housekeeping - the sink. Darkroom cleanliness must be extended to thorough washing of each item which comes in contact with the processing solutions, such as thermometer, funnels, mixing vessels, pails, etc.

If not thoroughly washed following each use, chemicals that dry on the equipment could cause contamination during subsequent use. The result would be film artifacts.

And, before being refilled with fresh solutions, even the processing tanks themselves must be scrubbed clean. Scum on tank walls and tired chemicals must be thoroughly removed before adding fresh solutions.

Processing schedule permitting, a diluted bleach (about five percent bleach) should be used to sterilize the tanks. The bleach should be allowed to remain overnight, then drained and the tanks rinsed thoroughly the following morning.

Whether overnight sterilization is possible or not, processing tanks must be cleaned:

Once a month . . . . Page 3-3
With each fresh solution . . . . Page 3-4

From page 3-2

No, cleaning of the processing tanks does not necessarily depend on a schedule such as monthly intervals although a schedule may be established. The basis on which such a schedule would be set up would be the work load of a particular radiographic laboratory. And, regardless of the schedule, the tanks will be cleaned each time the solutions are changed.

Turn to page 3-4.

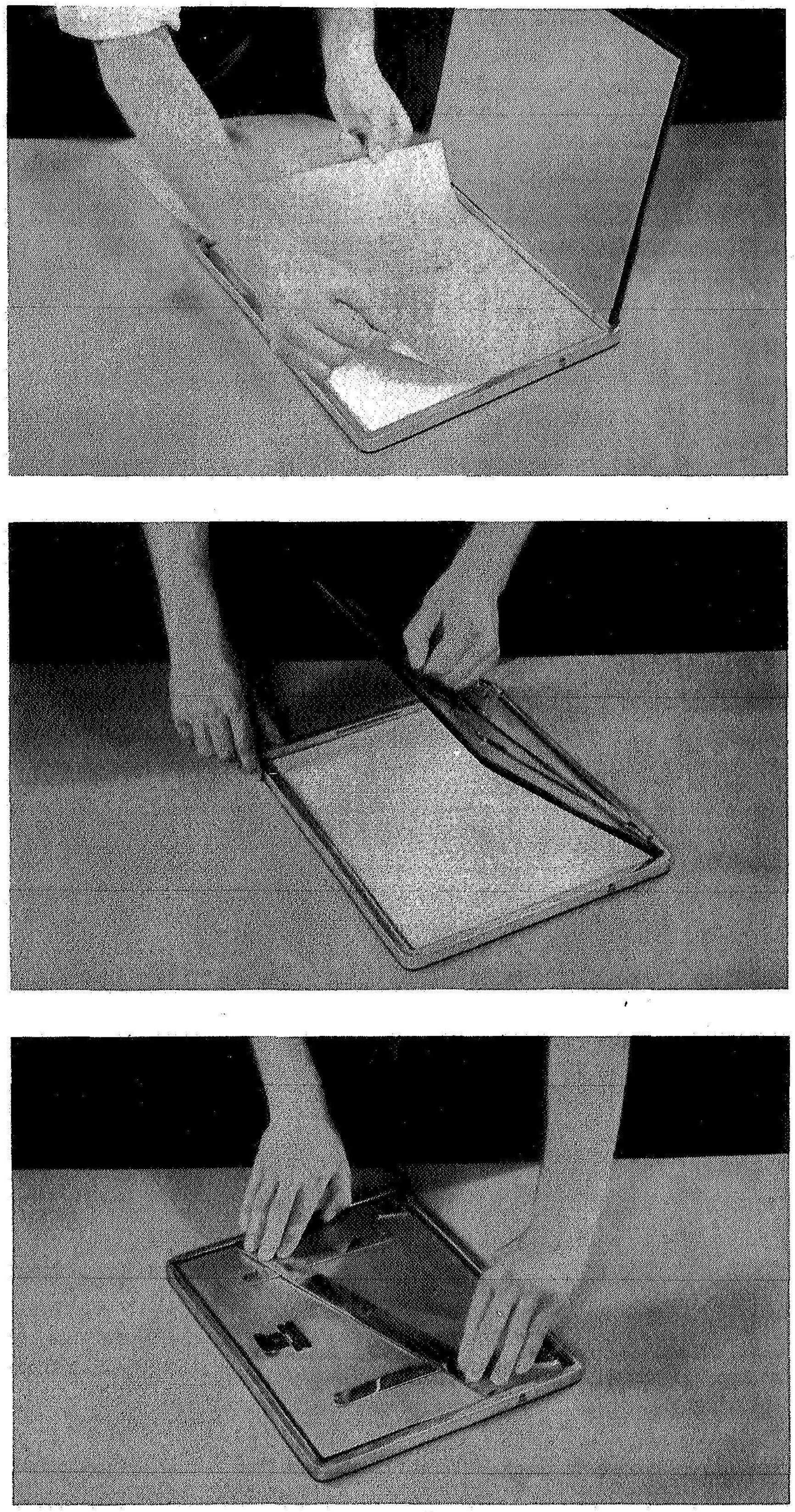
From page 3-2

Processing tanks must be cleaned with each fresh solution, yes. The interval of solution changes will vary from lab to lab. It may be on a precise schedule, perhaps not. But whenever the solutions are changed, the tanks should be cleaned.

Scrubbing, washing, cleaning. All are extremely important in the prevention of film artifacts. But these comprise only one aspect of artifact prevention. The other aspect which can cause or prevent artifacts is film handling.

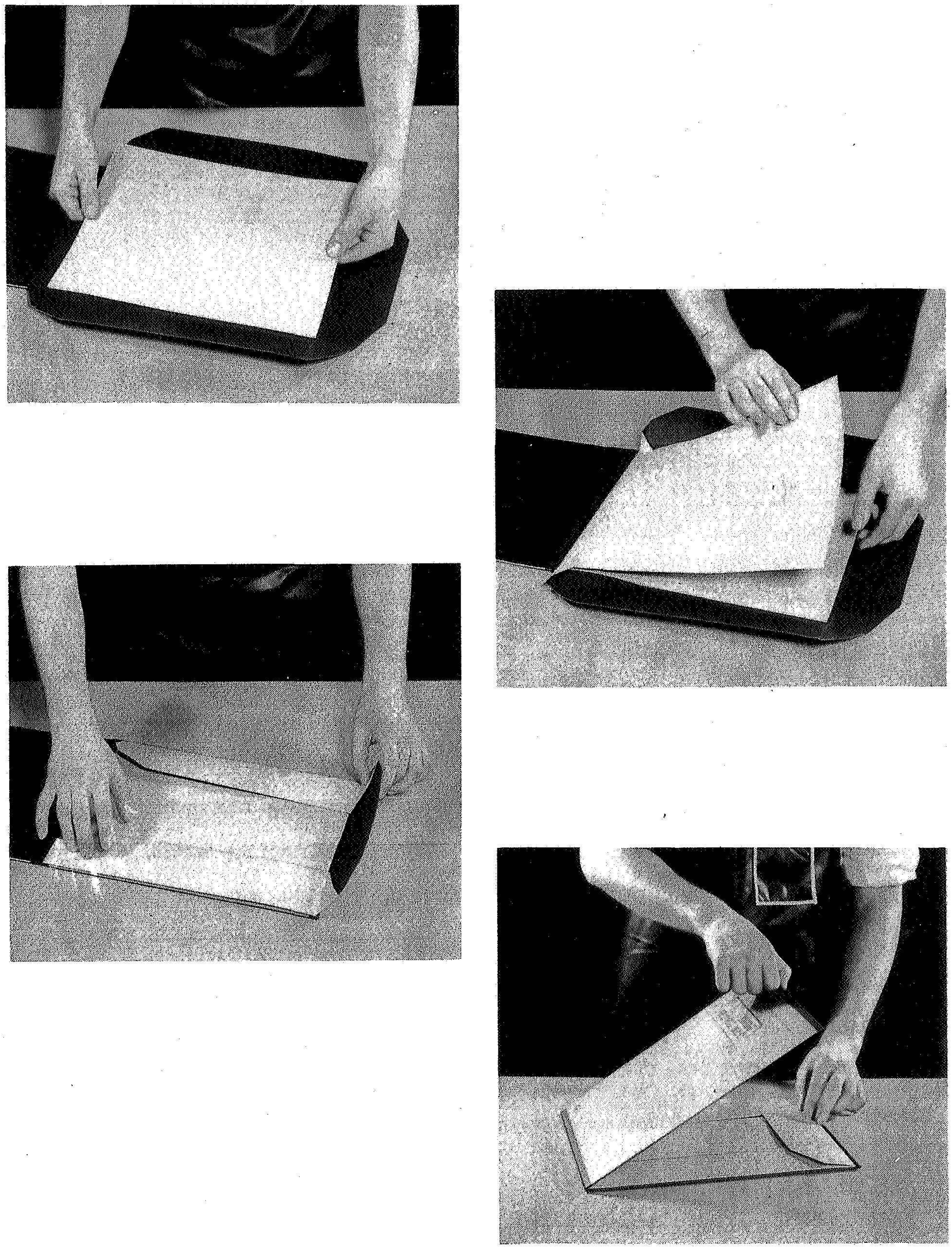
On the next three pages, we present a step-by-step procedure for loading film. Study the procedures carefully. And remember, all handling of film is done under darkroom safelights.

Turn to the next page.



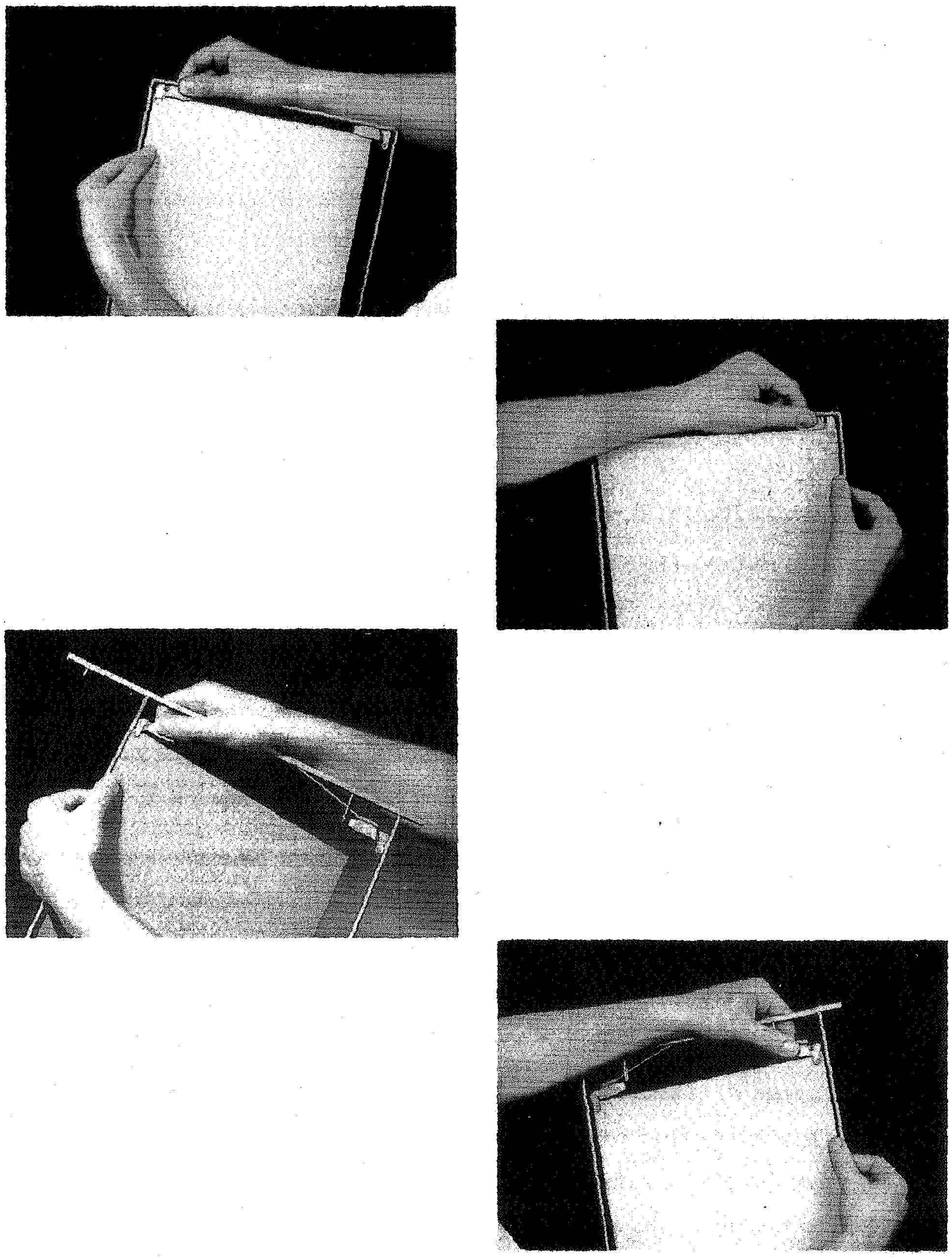
"COURTESY RADIOGRAPHY MARKETS DIVISION, EASTMAN KODAK COMPANY"

Method of Placing Film in a Cassette



"COURTESY RADIOGRAPHY MARKETS DIVISION, EASTMAN KODAK COMPANY"

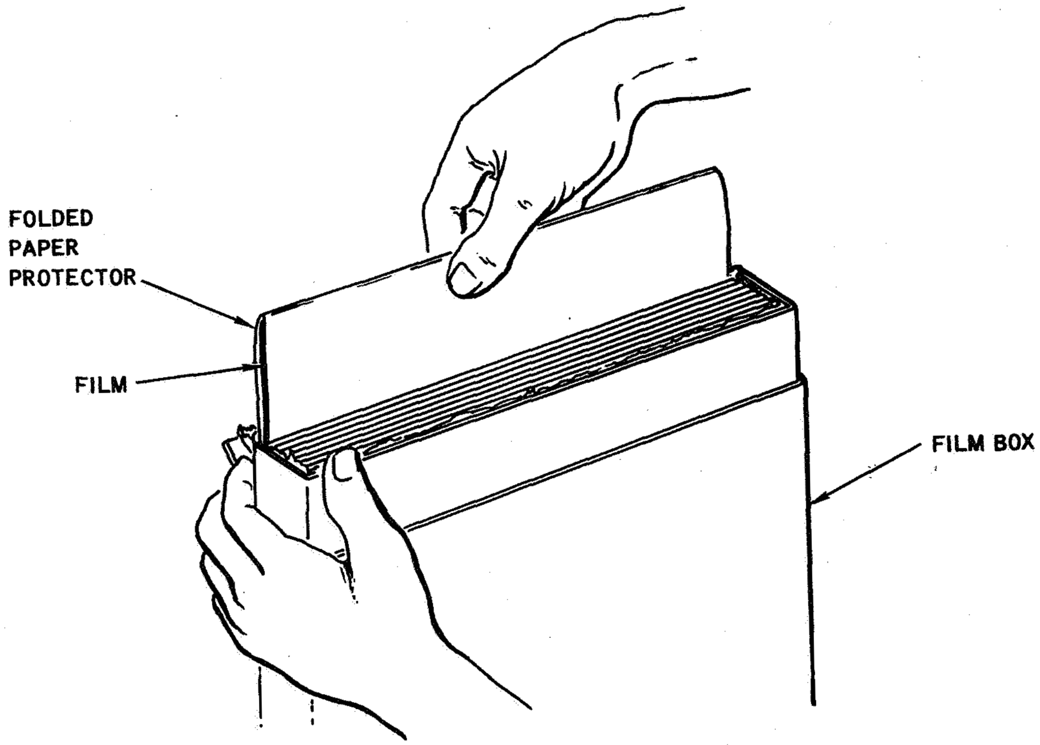
Method of Loading Film Holder



"COURTESY RADIOGRAPHY MARKETS DIVISION, EASTMAN KODAK COMPANY"

Fastening Film on Developing Hangers

For protection the individual sheets of film within the film box are sandwiched between a folded paper.



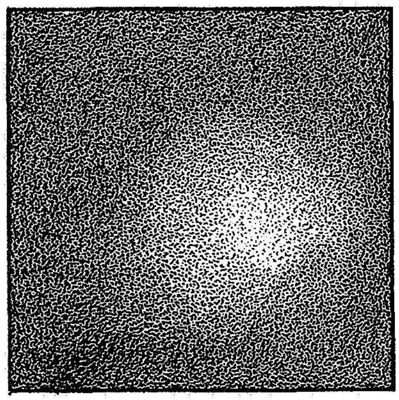
Your first contact with the film will be when you gingerly grasp the folded end of the protective paper with one end of the film it contains. Although fingerprints must be avoided, at this point they are no problem since you are grasping the protective paper. But even during this first contact there are considerations in avoiding creation of artifacts.

When pulling the paper and film from the film box, you must:

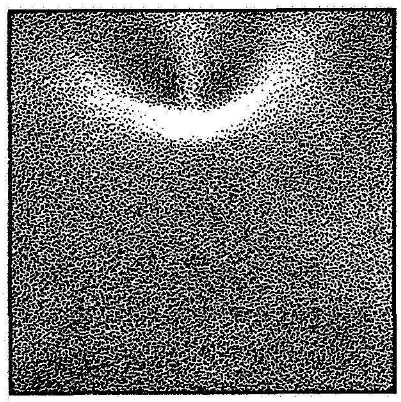
Avoid undue pressure on the film . . . . .Page 3-9
Pull rapidly to avoid dislodging other sheets . . . . Page 3-10

That's right.

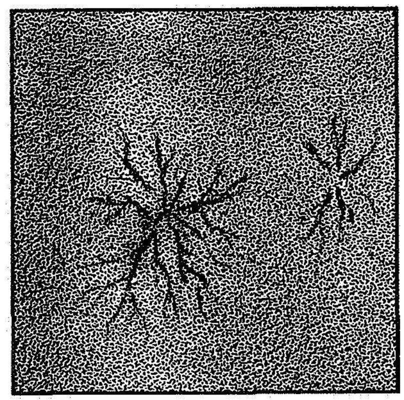
Too much pressure on a film could easily result in pressure marks or, because of the rough treatment it suggests, the film could be crimped. Pulling a film rapidly from its container or dragging it over any surface and thereby causing friction is also likely to cause static marks. Each of these examples of mishandling add up to...



PRESSURE MARKS



CRIMP MARKS



STATIC MARKS

But of course your technique will be beyond reproach, the film will be removed without causing tell-tale artifacts. Following removal from the box, the film will be loaded into:

A film hanger .... Page 3-11

A film holder .... Page 3-12

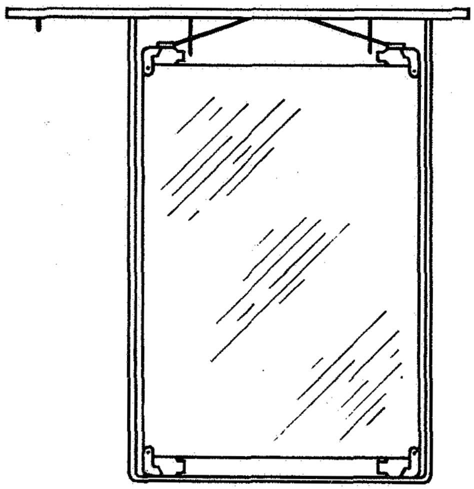
From page 3-8

The discussion, remember, was about avoiding creation of artifacts and the avoidance of undue pressure on the film is the answer which fits the discussion.

Pulling the film rapidly from its box, on the other hand, would not avoid artifacts but would be apt to cause them. At the end of this chapter you will find a chart which lists cause, effect, and remedy of artifacts so it won't be necessary to detail them here. Be aware, however, that sliding a film over any surface fast or with pressure, can cause static electricity. When created within the proximity of sensitive film emulsion, static electricity is about as useful to the film as a match is to a gas leak. The electricity causes tree-like artifacts in the emulsion.

Turn to page 3-9.

By loading the film onto a film hanger at this time, you are getting somewhat ahead of the game.

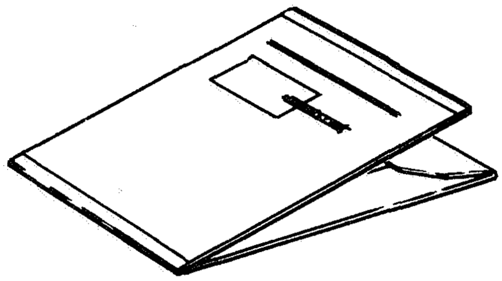


Film hangers hold film taut during the developing process and are open so that the processing chemicals have access to the exposed film. At the moment, however, the film has not been exposed and a lighttight environment must be maintained. So, load it into a film holder or a cassette.

Turn to page 3-12.

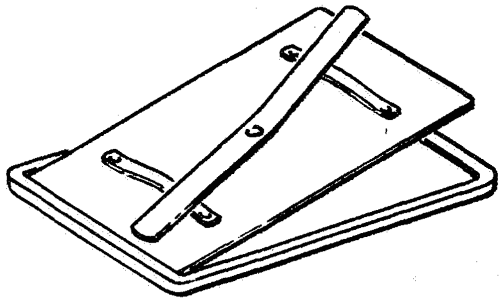
From page 3-9

After removal from its box a film will be loaded into a film holder, correct. It is possible the receptacle of the film might be a cassette rather than a film holder depending on the objective. Either one of these will maintain a lighttight environment for the film.



FILM HOLDER

CASSETTE



The purpose of film holders and cassettes is to provide an environment which is free of light. It is advisable to check them periodically for defects (light leaks). There is another responsibility which you must fulfill prior to loading the film. And that is simply to ensure the cleanliness of the film holder or cassette which is to receive the film.

Turn to the next page.

The remedy to dust or lint in film holders or cassettes is simply to remove it with a clean, lint-free cloth. There is one technique, however, which must not be used for cleaning film holders or cassettes; and that is: Do not remove dust or lint by blowing it away. Moisture particles may be blown onto the holder or cassette.

The cleaning of screens is another matter. There are, you will recall, two basic kinds of intensifying screens - fluorescent and lead. When used, they are in direct contact with the film and must be clean if artifacts are to be avoided.

Since the two types of screens require different cleaning techniques, let's handle them separately, starting with fluorescent.

Fluorescent screens should not be handled with bare hands as fingerprints may show in the radiograph. Cleaning of these screens is simply a matter of following the manufacturer's recommendations. Many common cleaning chemicals, such as hydrogen peroxide, cannot be used since traces of the chemical may, during the screen's later use, react with some of the grains within the film emulsion causing,

Graininess . . . . Page 3-14

Fog . . . . Page 3-15

Graininess is not likely to be caused by the action of cleaning chemicals on some of the silver bromide grains within the emulsion. Graininess is caused by the clumping of grains into a texture-like pattern on the film. In this case we are talking about a general effect of the undesirable cleaning chemicals on the silver bromide grains, not on a movement or grouping of the grains.

The condition in this case causes added film density and is known as: FOG.

Turn to page 3-15.

From page 3-13

Fog, yes. Common cleaning chemicals are apt to contaminate the screen, causing the film to fog when it is placed next to the screen. The remedy to this is simply to follow the manufacturer's instructions on cleaning the screen.

Lead screens can be cleaned with a commercially available chemical called carbon tetrachloride, usually shortened to "carbon tet."

WARNING

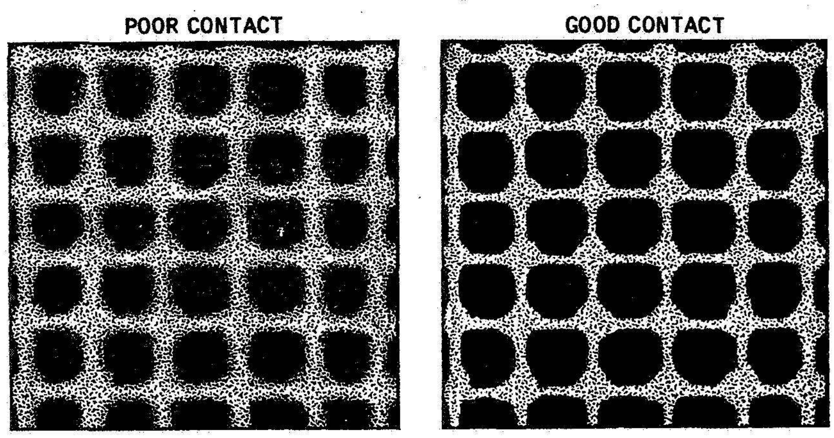
> The fumes from carbon tetrachloride are toxic. Do not breathe them.

Carbon tet is particularly useful for removing grease. Another means of cleaning lead screens is the use of steel wool, an abrasive. As you can probably guess, the steel wool should be the finest grade and scouring pressure must be light to avoid scratches other than minor surface ones. Of course, if there is any question about the quality of a lead screen, it is cheaper to replace it than to try to salvage it.

Leaving film in contact with lead screens for too long a period can cause fogging. This potential hazard is aggravated by comparatively recent cleaning of the screens with an abrasive. To preclude this, avoid prolonged contact between film and screen for 24 hours after cleaning the screen with an abrasive.

Turn to the next page.

It should almost go without saying that good contact between screens and film is essential to prevent the spreading of the intensifying rays.



WIRE MESH TEST OBJECT

When rigid cassettes are used, unless the cassettes themselves are damaged in some way, good contact is assured. In flexible film holders it's another matter. These film holders are flexible in order that they may be used on irregular objects.

What do you think of this statement?

Clamping a flexible film holder to irregular objects assures uniform contact between film and screens.

True . . . . Page 3-17
False . . . . Page 3-18

No, it is not true that clamping a film holder to irregular objects assures uniform contact between film and screens. Nor does weight of the specimen or contouring of the folder to fit the object assure adequate, even, contact between screens and film. There may still be areas in which contact is inadequate, resulting in a fuzzy image in those areas.

Be aware of the possibility of poor contact when using flexible film holders. The method used to avoid this condition is dependent on the specimen being radiographed. Weight, clamping, contouring can all be used to advantage in promoting uniform contact but there is no positive assurance.

Turn to page 3-18.

You are right, clamping a film holder to a specimen does not assure uniform contact between film and screens. Depending on the specimen, clamping might contribute to good contact, so might the weight of the specimen and contouring of the film holder to fit irregular shapes. But no one of these nor all of them combined assure the desired contact.

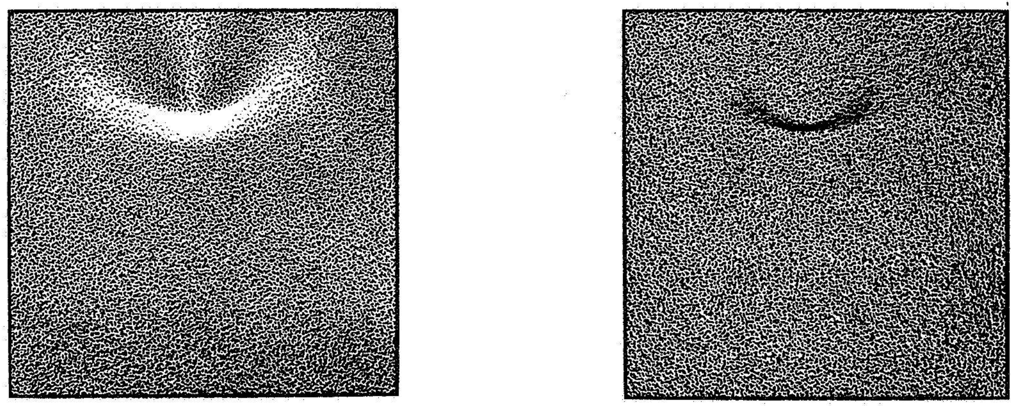
Assuming that your film holders and screens are in good condition, this is not a problem that you can solve in the darkroom. However, you should be aware of the results of uneven contact between film and screen, so that you won't attribute the problem to some other cause.

Flexible film holders present another problem which may become apparent in the darkroom. When using flexible film holders there is always the possibility of pressure marks resulting from pressing of the film against a protrusion on the specimen. Too much pressure against such an object on the specimen would cause an ______________ in the finished radiograph.

Fill in the missing word and turn to page 3-19.

ARTIFACT is the missing word which describes the result of too much pressure between film and specimen.

Let's look at some more artifacts.



CRIMP MARKS BEFORE AND AFTER EXPOSURE

These are crimp marks, the result of rough handling. Although both of these artifacts result from the same cause, one is light and one is dark. The one on the left occurred when the film was being loaded into a film holder; the crimp mark on the right occurred when the film was being placed on a film hanger.

From this it can be concluded that: Artifacts which occur prior to exposure are generally light in appearance, those which occur after exposure are generally dark.

True . . . . Page 3-20

False . . . . Page 3-21

Correct. Although a generalization, light artifacts usually are traceable to prior-to-exposure causes. Conversely, dark artifacts are generally those which were caused in the exposed - but still sensitive - film.

This isn't a foolproof method of determining whether artifacts occured before or after exposure but it is a starting point for your sleuthing. Before - light. After - dark.

The last few pages of this chapter are devoted to artifacts - what they look like, what causes them, how they can be prevented.

Turn to page 3-22.

You are on this page because of a wrong answer, but it isn't too serious a mistake. Although the statement that artifacts caused before exposure will be light and those caused after exposure will be dark was the desired answer, it is merely a generalization. It doesn't hold true in all cases.

Regardless of the statement's generality, it can be a handy starting point from which to pick up a clue to the cause of many artifacts.

Turn to page 3-20.

[redacted]

From page 3-20

ARTIFACT CAUSES AND REMEDYS

ARTIFACT	PROBABLE CAUSE	REMEDY
Fog	Light leaks in darkroom.	With darkroom unlighted, turn on all lights in adjoining rooms, seal any light leaks noted.
	Exposure to safelight.	Check safelight filters. Check safelight lamps for correct wattage.
	Stored film not protected from radiation.	Attach a strip of lead to a loaded film holder and place in film storage bin. Develop the film after 2 or 3 weeks. If image of strip is evident, improve protection in storage area.
	Exposure to heat, humidity, or gases.	Store film in cool, dry place away from gases and vapors.
	Overdevelopment.	Check darkroom timer. Check for high developer temperature.
	Developer solution.	Check developer solution for incorrect mixing or contamination. Replace if necessary.
	Exposure during processing.	Do not inspect film during processing until adequately fixed.
Finely mottled fog.	Stale film.	
Fog on edge or corner.	Defective cassette or film holder.	

From page 3-20

ARTIFACT CAUSES AND REMEDYS (CONT)

ARTIFACT	PROBABLE CAUSE	REMEDY
Yellow stain.	Depleted developer.	Replace developer solution.
	Failure to use stop bath or rinse.	Use stop bath or rinse thoroughly.
	Depleted fixer.	Replace fixer solution.
Dark circular marks.	Film splashed with developer prior to immersion.	Use care in immersing film in developer.
Dark spots or marblelike areas.	Lack of fixation.	Use fresh fixing solution and correct fixing time.
Dark branched lines and spots.	Static discharge.	Remove film slowly and carefully from wrapper. Avoid friction. Avoid clothing that produces static electricity.
Dark fingerprints.	Touching undeveloped film with chemically contaminated fingers.	
Dark spots or streaks.	Film contamination by metallic salts.	Insure that developer solution is not contaminated by container.
	Contaminated hangers.	Insure that wash water covers hangers.
	Uneven development.	Agitate film at regular intervals.
Cresent-shaped dark areas.	Film crimps after exposure.	Handle film carefully.
Crescent-shaped light areas.	Film crimps before exposure.	Handle film carefully.

From page 3-20

ARTIFACT CAUSES AND REMEDYS (CONT)

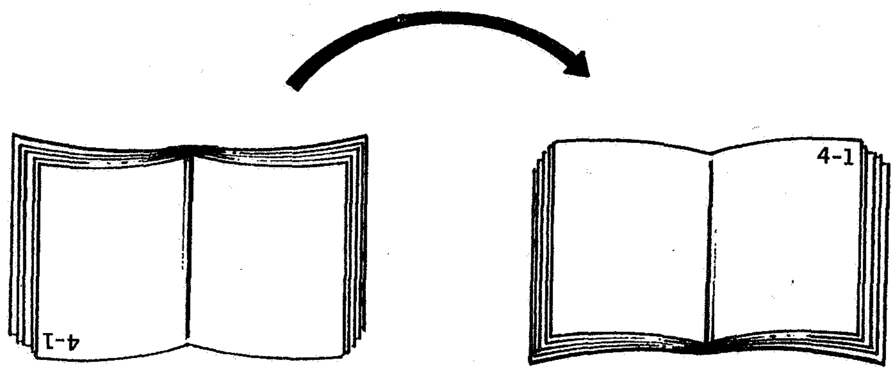
ARTIFACT	PROBABLE CAUSE	REMEDY
Light circular patches.	Air bubbles on film during development.	Agitate immediately upon immersion of film in developer.
	Pressure points or blows to film before exposure.	Avoid excessive pressure or the dropping of objects on film or film holder.
Light fingerprints.	Touching undeveloped film with oily or greasy fingers.	
Well defined circular light spots.	Splashes of stop bath or fixer prior to development.	Avoid splashing of solutions. Keep film clean and dry before development.
Light spots or areas.	Dust or other foreign matter between screens and film.	Keep screens clean.
Wavy marblelike marks.	Non-uniform development.	Agitate film at regular intervals during development.
Reticulation. (leather grain appearance)	Temperature differences in processing solutions.	Maintain all processing solutions at some constant temperature.
Filling (loosening of film emulsion from film base).	Overly warm processing solutions.	Maintain recommended temperature range.
	Exhausted fixer solution.	Replace fixer solution frequently.

Turn to page 3-25.

From page 3–24

Now you are ready to start back through the book and read those upside-down pages.

TURN OR ROTATE THE BOOK 180° — LIKE THIS



READ PAGE 4–1 AND CONTINUE AS BEFORE.

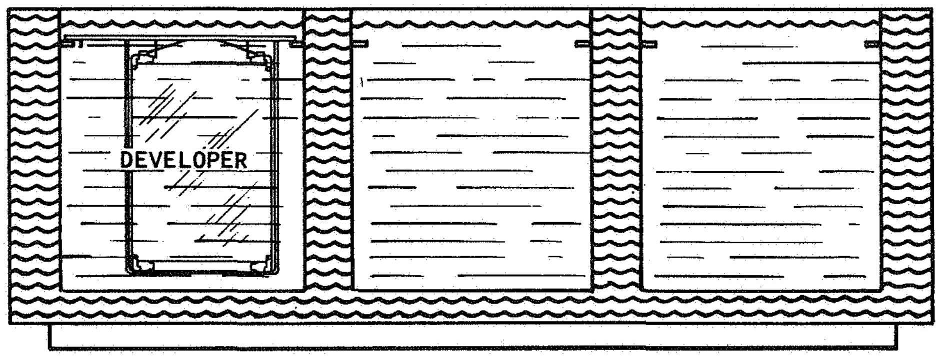
In this chapter, you will not learn how to mix the chemical solutions used in processing film; those directions accompany the powder or liquid chemicals themselves. You will not learn the exact chemical composition of these solutions, for that knowledge, however useful elsewhere, is of no practical value here. What you will learn is how the various chemical solutions react on the film, during processing.

Each chemical, each solution, has a completely different effect upon the film, the total of which produce permanent radiographic images.

There are three processing solutions that must be used in turn to convert an exposed film to a useful radiograph. These are the developer, the stop bath, and the fixer. We will discuss the action of each of them in their sequence of use.

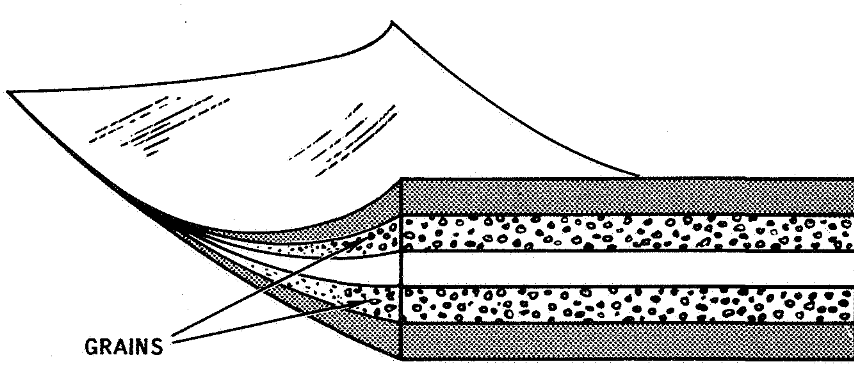
Turn to next page.

[redacted])



The first darkroom chemical solution with which you will be concerned is the DEVELOPER. As the name implies, its purpose is to develop - to make visible - the latent image that the film contains.

A special chemical within the developer acts on the latent image in an exposed film by reducing the exposed silver bromide grains to black metallic silver. But before the reducing agent can begin its function the developer must first penetrate the outer protective layer, enter the emulsion (image layer) and make contact with the grains.

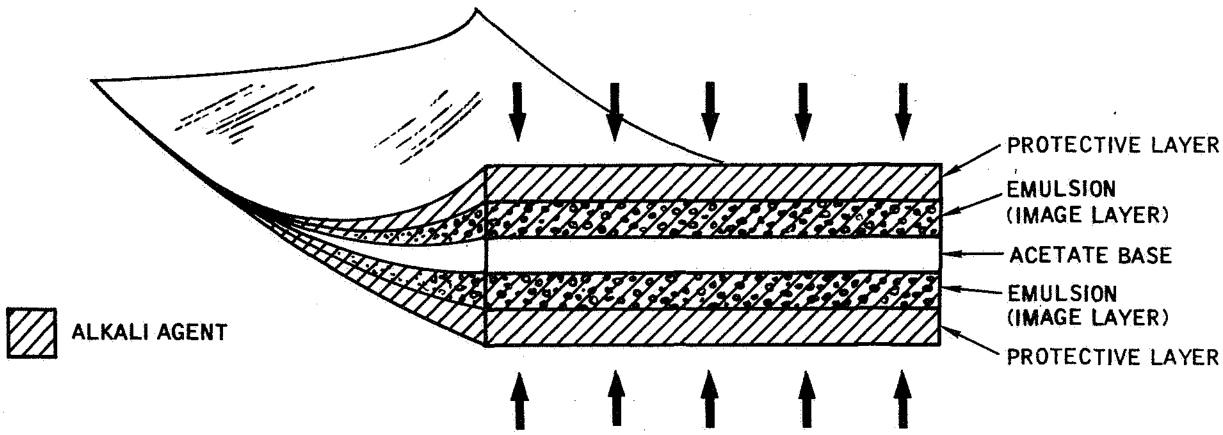


Turn to the next page.

[redacted])

The developer is a solution, a combination of chemicals, each of which, like members of an infantry squad, has a particular and vital function. Acting as a team, these chemicals accomplish the developer's objective - reduction of exposed silver bromide grains to silver.

Although a detailed chemical analysis isn't necessary, it is of practical importance to know <u>and to remember</u> that one of the chemicals in the developer is an alkali! The alkali's sole purpose is to speed up penetrating action, permitting <u>another</u> of the developer's ingredients - the reducing agent - to enter the protective layer and then the emulsion.



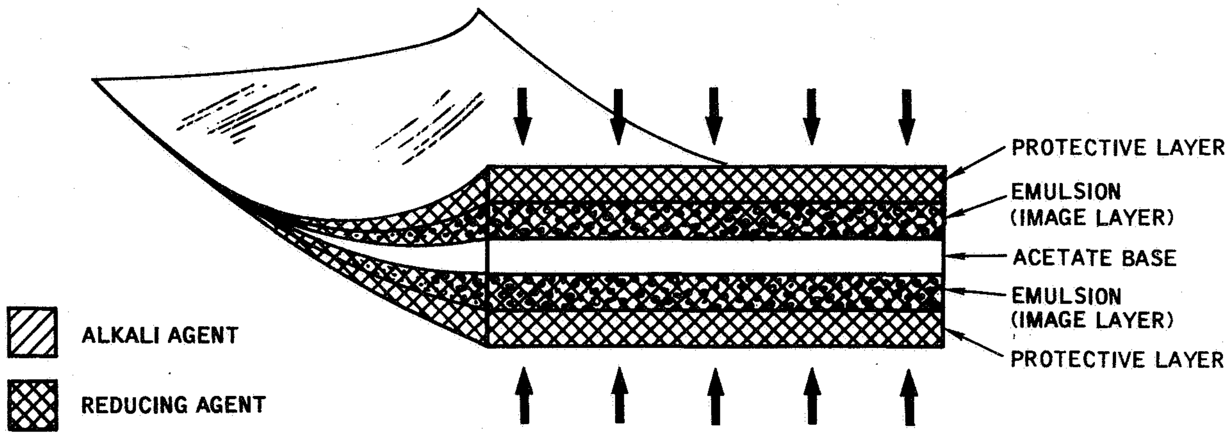
Because of its ability to swiftly penetrate, to "lead the way in," the chemical which performs this function is called an <u>accelerator</u>. But of more practical importance is the knowledge that this ingredient:

Makes the developer an alkaline solution . . . . Page 4-4

Reduces the silver bromide grains . . . . Page 4-5

Exactly. The presence of alkali in the developer solution makes the developer an alkaline solution. The importance of this is going to be demonstrated shortly. For now, tuck away the fact that the developer is alkaline in nature.

Once the alkali has opened the way into the emulsion, the reducing agent (metol or hydroquinone, etc.) takes over. Its function is to reduce the exposed (ionized) silver bromide grains to black metallic silver to produce a useful image.



Since the reducing agent acts to reduce the silver bromide, why doesn't the entire film turn completely black when developed?

Unexposed grains cannot be developed . . . . Page 4-6

Developers can distinguish between exposed and unexposed grains . . . . Page 4-7

From page 4-3

The alkaline chemical that "leads the way in" through the protective layer is not the same chemical that reduces the silver bromide grains. It is only present in the developer solution because of its ability to get through the protective layer fast, to accelerate the developing process.

Once the alkali has penetrated the protective layer then another chemical - the reducing agent - takes over the task of reducing silver bromide grains to black silver.

Turn to page 4-4.

[redacted]

From page 4-4

In selecting "Unexposed grains cannot be developed," you are forgetting that even unexposed grains can be developed if they are left in the developer long enough. Remember?

Therefore, the reason that a properly exposed film doesn't turn completely black when developed is not because unexposed grains cannot be developed. The true reason is "selectivity," the ability of the developer to distinguish and go to work first on those grains which have been exposed.

Turn to page 4-7 and learn that...

[redacted]

A handful of reducing agents are able to distinguish between exposed and unexposed grains. TRUE. However, "handful" is a qualifier which must be included since, of hundreds of agents capable of reducing silver bromide, only a few have the critical ability to judge whether a grain has been exposed.

But even the most selective reducing agents (of which metol and hydroquinone are two) have limitations. Although they select exposed grains to reduce first, if an agent is left too long in contact with the emulsion, it will begin to reduce unexposed grains.

The longer a film remains in the developer, the greater the degree of development; and degree of development affects degree of density. Therefore, one of the critical functions of film development (and thus density) is ______________________________!

Write in the missing word and turn to the next page.

[redacted]

TIME! The longer a film remains in the developer, the more silver bromide that is developed and the denser the film becomes. Through use of a timer, the period of immersion can be regulated exactly and one critical aspect of development controlled.

The activity of most chemical reactions is affected by temperature. This is also true of the film developing process. The speed at which the alkali accelerator penetrates and with which the reducer develops is also a function of the developer's temperature.

As an exaggerated example, assume that the temperature of a developer is a chilly 35°F. The developer will have little or no effect on the film at that temperature. In theory, the higher the temperature rises from this icy level, the more active the developer chemicals will become. In practice they are not going to become usefully active until the developer temperature reaches at least the low 60's.

Which of the two developing schedules below would produce the least dense negative?

68°F for six minutes . . . . Page 4-9

60°F for six minutes . . . . Page 4-10

From page 4-8

Actually, sixty-eight degrees at six minutes might be an acceptable developing schedule. But, of the two choices listed it is not the one which would produce the least dense negative. Density, as you know, is degree of blackness which, in turn, is determined by the number of silver bromide grains reduced (developed) to metallic silver.

In developing, remember that degree of film development (density) is a function of both time and temperature. In the two schedules just listed, the times were equal. With equal times then, temperature of the solution will determine the density.

Temperature helps determine the speed with which grains are reduced. As the temperature increases so does the speed of the developing action. And the opposite is true. As the temperature decreases so does the speed of the developing action.

Turn to page 4-10.

Sixty degrees at six minutes would produce the least dense negative, correct. Since the times were the same, the difference had to be in the temperature. Density, which is simply the degree of blackness, is governed by the number of silver bromide grains reduced to silver by the developing action. Since degree of developing is dependent on both time and temperature, the lowest temperature would develop the least number of grains in a given time.

Now, which of the following schedules would produce the most density?

68° at eight minutes . . . . Page 4-11

68° at five minutes . . . . Page 4-12

From page 4-10

Sixty-eight degrees at eight minutes would produce more density in a film than would the same temperature for a shorter time - "you've got it."

The point stressed in the past few pages has been the effect of time and temperature upon a film in a developing solution. Both of these factors, time and temperature, have an effect on the film's density.

The entire purpose of developing film by exact timing and precise temperature is to produce consistent negative density.

If a dozen films were exposed the same way and developed the same length of time at the same developer temperature, each negative should have the same density.

But assume a 13th negative is exposed the same way as the preceding 12 but must be developed at a higher temperature. This change in routine is obviously going to cause a more dense negative than the other 12 - if everything else remains the same as before.

However, from our discussion, you know that there is a method of compensating for this increase in temperature. It is simply a matter of...

Diluting the developer . . . . Page 4-13

Reducing developing time . . . . Page 4-14

[redacted]

From page 4-10

Wait a minute! By this time you should be convinced that, given equal temperatures, an increase in time is going to cause added density because more grains will be developed. Therefore, a film developed for eight minutes is going to be more dense than if it were developed for five minutes.

Turn to page 4-11.

Dilution should never be considered as a means of compensating for increased temperature. The relationship is between TIME and temperature. It is this relationship which determines the course of action.

Darkroom procedures are based on routine. For the bulk of work, temperature and time are standardized. But should a change in routine, such as the higher temperature just mentioned be necessary, compensation must be made in the other half of the relationship - in this instance, time.

Turn to page 4-14.

An increase in developer temperature can be compensated for by reducing the development time - right. The time must be adjusted if the thirteenth negative is to have the same density as the preceding twelve. The higher temperature of the developer will cause faster development. Therefore, the film need not remain as long in the developer. The exact opposite, of course, is also true; lower temperature, longer development.

All development is based on this combination, TIME-TEMPERATURE relationship! Film manufacturers provide charts such as the one below listing these relationships. By following their recommendations, consistent development and maximum sensitivity will be achieved.

Developer Temperature Degrees F	Development Time in Minutes
60	8-1/2
65	6
68	5
70	4-1/2
75	3-1/4

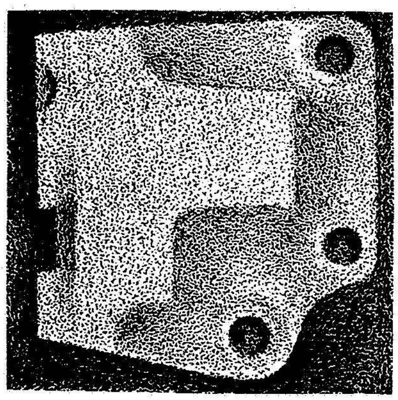
Also, by following the recommendations on these charts a check on exposure is possible. Assuming proper developer activity, if the time-temperature relationship has been followed it will be known that underexposure or overexposure is the result of improper shooting technique.

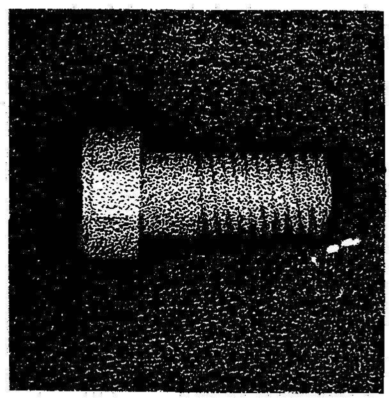
Turn to the next page.

The usefulness of the time-temperature relationship is only valid so long as the developer's strength is maintained.

When a developer is fresh, its strength is enough to produce the desired sensitivity at a specified time and temperature. But developers can become weakened. Their ability to develop diminishes. One cause of weakened developer is oxidation from exposure to air. This cause of weakened developer is partly eliminated by simply keeping a lid on the developer tank.

But oxidation of the chemical solution by air is not the major cause of developer exhaustion. Like you and I, developers weaken with work – with developers its the work involved in developing each film.





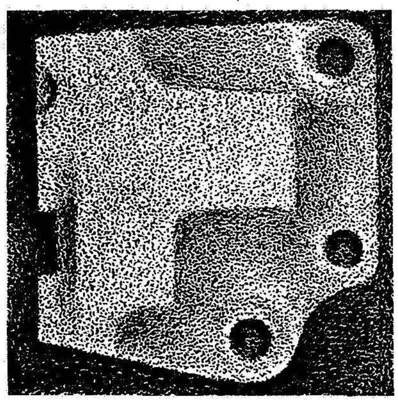
Select the radiograph which would cause the greatest exhaustion in a developer.

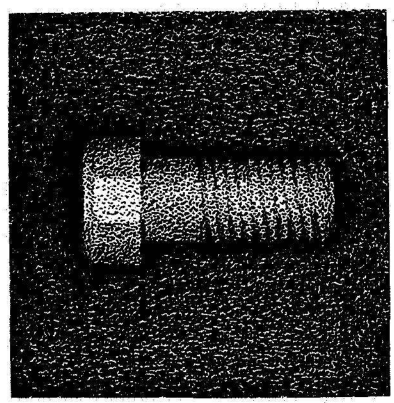
Film on the left . . . . Page 4-16

Film on the right . . . . Page 4-17

From page 4-15

Bluntly speaking, no. Take another look at the two choices.





The greater density of the film on the right will require more developer activity, therefore will exhaust more of the developing chemicals.

Turn to page 4-17.

From page 4-15

Right, correct. This film (the most dense) would cause the greatest exhaustion in a developer.

Developing chemicals become exhausted from the effort of removing the bromine from exposed silver bromide grains and changing them to silver. Naturally, the more dense the film the more exhausted the developer is going to become from that particular film.

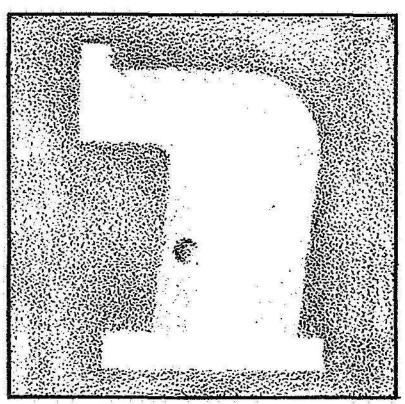
Film size is another major factor in exhausting the developer. A larger film has a larger area to be developed.

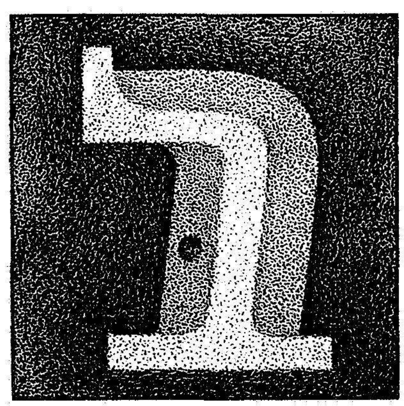
It should be obvious, also, that a certain amount of developer is going to be removed with each film. For example, when a film is removed from the developing tank it will carry the absorbed developer with it plus any that clings to the film surface.

Also, as a film is lifted from the tank the developer which clings to its surface becomes oxidized from increased exposure to air and becomes, in effect, "dead" developer. Inevitably, some of this "dead" developer will drip back to further decrease developer strength.

To emphasize the effect of developer exhaustion, assume some 200 film have been developed in the same developer. All received the same exposure. The 200th film was developed at the same temperature for the same period of time as the first film.

A





B

Which of these radiographs would you assume to be the 200th film?

Radiograph A . . . . Page 4-18

Radiograph B . . . . Page 4-19

Radiograph A, of course. A weakened developer will turn out an underdeveloped negative, it won't have the strength to do otherwise. To ensure consistent results, something must be done to compensate for this progressive decrease in developer strength. Leaving the film in the developer for a longer period of time (time-temperature relationship) is one method of compensation. This method of increasing development time to compensate for loss of developer strength is effective but obviously time consuming.

The second method of dealing with this situation is REPLENISHMENT. Replenishment is just as effective as additional developing time and has the advantage of being faster. The replenishment method is precisely what the name indicates. Chemicals are added to replenish a weakened developer solution to maintain its original strength.

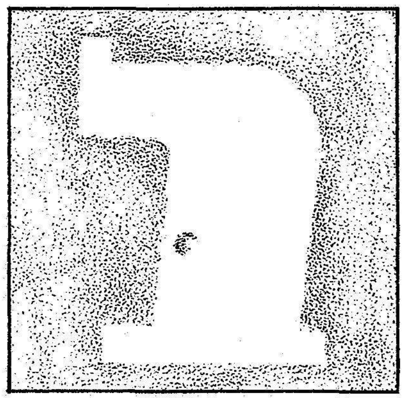
Neither of these methods, additional time or replenishment, can be applied haphazardly. They both rely on a combination of record-keeping and testing. An accurate log should be kept on exhaustion factors — number of film developed, their size and average density. Is this log all that is necessary to determine how much to increase developing time or how much replenisher to add?

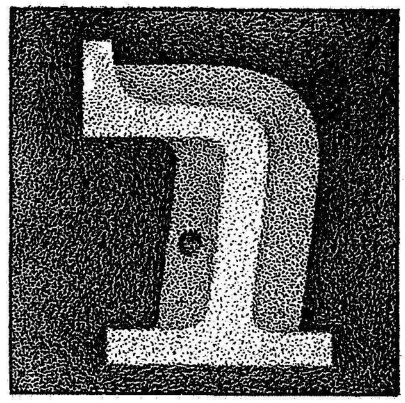
Yes . . . . Page 4-20

No . . . . Page 4-21

Nope. You chose "Radiograph B." In comparing the two, radiograph B has more density.

A





B

The facts: All the film received the same exposure; all the film was developed at the same temperature; all the film was developed for the same period of time. The only thing that changed was developer strength — it was getting pretty old, worn-out and used up. Somewhere in the course of developing these 200 radiographs, the film is going to become noticeably underdeveloped. Comparatively, this condition is indicated by the least dense radiograph which is...

Turn to page 4-18.

Although an important guideline by which to add developing time or replenisher, record-keeping is only one of the two tools you have available. For the other one return to the page indicated. Reread the last paragraph, particularly the underlined portion, and turn to the right answer.

Return to page 4-18.

"No" is correct. Record-keeping, although an important guideline to the adding of time or replenisher, cannot do the job alone. The mention of a "...combination of record-keeping and testing," specifies another factor — testing.

Chemically, there is no simple, effective method of testing developer strength. The most direct way is to develop a piece of film and compare it to a standard.

Here is the technique. You begin by exposing a piece of film, usually more than one at a time, through a stepwedge. The variations in thickness of the stepwedge should cover most if not all of the density range encountered in everyday practice. Do not use a screen since it will affect the exposure of the top film more than the other lower films — each film should receive the same exposure.

After exposure take the film into the darkroom and cut it into strips. (The exposure of several films at once ensures a quantity of strips having the exact same exposure.) Each strip must contain the full range of stepwedge densities.

Store the cut strips in a lightproof bin or drawer in the darkroom except for one which is developed in <u>fresh</u> developer according to established time and temperatures. This strip becomes the <u>control strip</u>, known to have the proper density and thus maximum sensitivity.

This control strip is the standard you will use to check the strength of the developer. The remainder of the stored strips are developed one at a time at regular intervals and checked against the control strip. If the difference in density between the two strips is too great, then replenisher must be added to the developer until the density of a developed test strip agrees with the control strip.

When using this strength control method, each time the developer solution is changed...

Retain the control strip for the discarded developer . . . . Page 4-22
A new control strip must be processed . . . . Page 4-23

[redacted]

No, once the developer in which the control strip was developed is replaced by a fresh solution, the control strip becomes useless. It should be discarded along with the old developer.

This means that a brand new control strip should be developed in each fresh batch of developer. For further information on this process:

Turn to page 4-23.

[redacted]

Exactly. A new control strip must be processed each time the developer is changed. The entire purpose of the control strip is to provide a standard against which to measure the strength of the solution in which it was developed.

Although tables similar to those of the time-temperature type are published as a guide to replenishment, they are necessarily only a guide since they can only be based on average conditions.

Regular, frequent checks with test strips is the best means of maintaining proper developer strength. Tolerances have been established. A difference in density, between the newly developed strip and the control strip, which is greater than the tolerance necessitates a change in the rate at which replenisher is added or a change of developer.

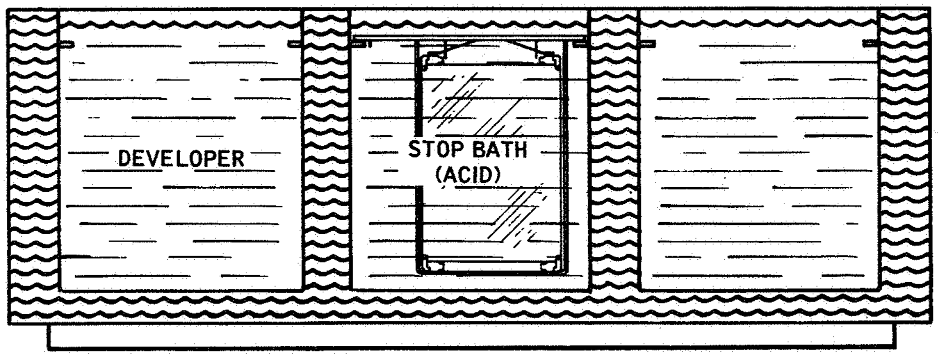
Also, replenishment at frequent rather than prolonged intervals, eliminates large density variations in your radiographs.

You may be wondering whether replenishment can go on indefinitely. The answer is no. Like all good things it too must come to an end. However, there is a new beginning with the discarding of the old developer and its replacement by a fresh batch. When the amount of replenisher added is equal to about two or three times that of the original developer, then the developing tank is ready for a solution change.

From the developing tank to the second chemical in the processing routine is but a few inches in the darkroom and a turn of the page here.

Turn to page 4-24.

From page 4-23



Before getting into the acid stop bath here is a simple, direct, important statement:

When combined, alkalis and acids neutralize each other!

When removed from the developing tank, the film carries with it some of the alkaline developer absorbed within its swollen emulsion. Still active, this developer continues to work toward reduction of the silver bromide.

Since removal from the developer means the desired degree of development has been achieved, reduction must be quickly stopped. Immersion in the stop bath accomplishes this by:

Drawing developer from the film's emulsion .... Page 4-25
Neutralizing the alkaline developer .... Page 4-26

[redacted]

From page 4-24

The stop bath, functioning as its name implies, stops development quickly alright, but not by drawing the developer from the film's emulsion.

Remember, we said that the developer is alkaline and the stop bath is acid.

Alkalis and acids neutralize each other.

Turn to the next page.

From page 4-24

Excellent selection.

The acid stop bath does stop developing action quickly by "neutralizing the alkaline developer." Therein of course lies the importance of the fact that, "When combined, alkalis and acids neutralize each other." The porous emulsion, which is swollen with still active alkaline developer, also absorbs the acid stop bath.

One alternative to using a stop bath is washing the film in clean, running water. But since this method is inferior to the stop bath method it is mentioned only as a point of interest.

You now know that developer is alkaline in nature; that the stop bath is an acid solution. The chemical used in the stop bath is acetic acid. Acetic acid can be obtained in two forms — a diluted solution which is relatively mild, and a highly concentrated form called glacial acetic acid. Glacial acetic acid is highly caustic and if improperly handled can cause severe burns.

Mixing directions, giving proportions to use, will accompany the acid; however, there is a very important technique that you should know when mixing the highly caustic glacial acetic acid. Very simply it is this: Always add the acid to the water.

When using glacial acetic acid to mix a stop bath solution always:

Add the glacial acetic acid to the water .... Page 4-27

Add the water to the glacial acetic acid .... Page 4-28

[redacted]

From page 4-26

Always add acid to the water, correct! This is the method which should keep you from getting burned. If it were the other way around, the water contacting the glacial acetic acid would cause it to boil and spatter, resulting in possible acid burns to your skin or clothing.

In addition to adding the acid to the water, and not vice versa, proper technique demands that you pour slowly and stir constantly during the mixing process.

ADD acid to water. Pour slowly. Stir constantly.

Follow these three rules in mixing a stop bath solution with highly caustic glacial acetic acid, and you should never be spattered and burned during the mixing process.

Turn to page 4-29.

From page 4-26

You elected to add the water to the acid. A dangerous selection!

Glacial acetic acid is caustic; it will burn. If you put acid in the stop bath tank first and then add water, it is quite likely the acid will spatter. If it spatters on your skin it's going to burn.

To repeat, the answer is simple: always put the <u>water</u> in the tank <u>first</u> and then, stirring constantly, slowly add the acid. Just remember, ADD THE ACID TO THE WATER.

Turn to page 4-27.

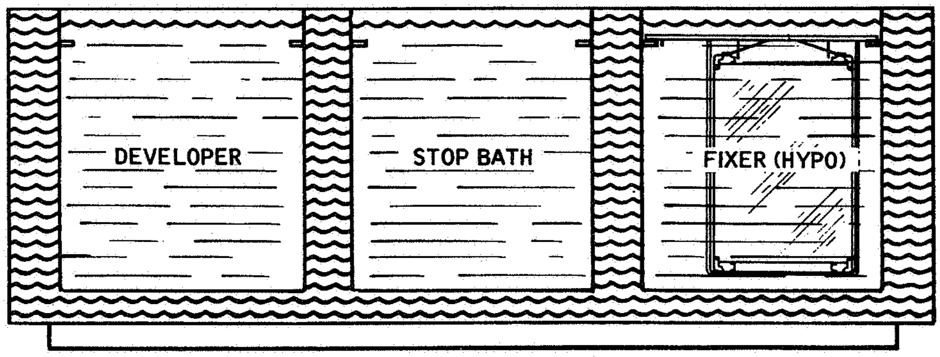
From page 4-27

A stop bath solution actually has two functions, the first of which — to stop development within the film — is indicated by its name: STOP BATH.

The second stop bath function plays not quite so dramatic a part in film processing but you should be aware that immersion of the film into the bath protects the fixer (into which the film goes next). By neutralizing the alkaline developer, the stop bath prevents carryover of alkali into the fixer solution, thus extending the fixer's life.

The fixer itself is acid in nature. For this reason, the stop bath could be bypassed and the fixer could, by its acidity, neutralize the alkaline developer. But <u>before</u> it could begin its real purpose, the fixer would first have to stop the developing action, thereby lengthening the immersion time required in the fixer. In addition, the alkali would shorten the life of the acid fixer. The stop bath prevents these shortcomings. Now let's see what happens in the fixer solution.

Turn to the next page.



To develop the latent image the film was placed in the developer. To stop development quickly and to prevent carryover of developer, the film was then immersed in the stop bath. Both solutions have names which describe their functions. The <u>fixer</u> is no exception — it permanently <u>fixes</u> the image on the film.

The exposed silver bromide grains were reduced to metallic silver but have you wondered what became of the <u>unexposed</u> (and unreduced) silver grains. Well, thus far, nothing. They are still within the film emulsion causing the emulsion, wherever they occur, to have a swollen, milky-yellow appearance.

Like the other processing chemicals, the fixer becomes less effective with use. Its processing value diminishes with each film it fixes. From a purely dollars and cents viewpoint, however, its value <u>increases</u> with each developed film.

This is a round-about way of saying that the fixer removes all unexposed silver bromide grains.

True . . . . Page 4-31

False . . . . Page 4-32

Absolutely true! Although not the pot at the end of the rainbow, there are firms which find it is profitable to reclaim used fixing solution. Why? Because the fixer removes and retains all the unexposed silver bromide grains of all films which have been fixed in it.

After development and before being placed in the fixer solution, the unexposed areas of the film are swollen and milky-yellow in appearance.

The first task of the fixer in fixing an image is to dissolve the unexposed grains. As the grains dissolve, the swollen, milky-yellow areas become less prominent until, finally, they become clear.

The first of the two fixing stages derives its name from this physical change and is called:

The removal time . . . . Page 4-33

The clearing time . . . . Page 4-34

The people who make a profit by reclaiming used fixer solution would agree that you have just selected the wrong answer. The answer is not false but true. The increase in monetary value of used fixer means the fixer removes all unexposed silver bromide grains.

After all, the grains which were not exposed and not reduced are, in part, comprised of silver. The more films that are fixed the more silver that is removed in the form of unexposed silver bromide grains and the more valuable the used fixed becomes to someone who can reclaim it.

Turn to page 4-31.

No, "removal time" is not the name given the first stage of the two-stage fixing process. Although in the first stage the grains are dissolved they are not removed.

The fact that the milky-yellow areas become clear during this initial period in the fixer, gives this stage of fixing the name "clearing time."

Turn to page 4-34.

From page 4-31

That's it. A fixing solution accomplishes its task in two stages. The first stage is the length of time it takes for the undeveloped grains to dissolve and for the areas containing those grains to become clear. The name given this clearing time is, appropriately, the clearing time.

Two agents in common use for dissolving undeveloped silver (sodium thiosulphate and ammonium thiosulphate) are generally lumped together under the name "hypo." The fixer itself is often referred to as the hypo.

It is during the clearing time that the fixer or hypo dissolves the undeveloped silver grains and the swollen, milky-yellow condition clears. This clearing action can be seen and the time it takes to occur can be recorded. If the time between immersion of the film and the time to clear is four minutes then the film has a clearing time of four minutes. But, at this point the job of the fixer is only half finished. In this case the film must remain in the fixer a total of eight minutes. Had the clearing time been three minutes, total time required in the fixer would have been six minutes.

The rule for length of immersion in the fixer is seen to be...

Turn to page 4-35

From page 4-34

. . . . . . twice the clearing time. This rule requires a total immersion time of ten minutes for a clearing time of five minutes, etcetera.

During this second stage (e.g., during the second five minutes of the instance just stated) the grains which were dissolved during the first five minutes are diffused or removed from the emulsion. In addition to removal of dissolved grains there is another reason for this additional five minutes. It is during this period that the film becomes thoroughly hardened for the commercial life which it will lead.

Radiographic films are subject to more frequent handling and must be preserved in better condition for a much longer period than ordinary film. To achieve this objective a hardening agent (potassium alum) is included in the fixing solution. This agent hardens the emulsion for protection against handling, scratches and the warm temperatures of the film dryer.

Turn to page 4-36.

Although the stop bath extends the fixer's life by neutralizing the alkaline developer so that the fixer won't have to do this job, the fixer nonetheless will eventually become exhausted.

It becomes exhausted by the silver grains which it accumulates within it. It also becomes weakened from the diluting action of stop bath or rinse water which may be carried into it. When the fixer loses its acidity or the clearing time exceeds the established time, the fixer has lost its usefulness.

To maintain fixer strength, there is a special solution which has the same name (but not ingredients) as that solution which is used to maintain the developer strength. Its name? REPLENISHER.

Fixer exhaustion must be avoided to preclude harmful effects to the radiograph. Loss of acidity in a fixer is likely to cause brown stains in the radiograph. Of course, the longer time required in a weakened fixer is also a drawback. And, importantly, an exhausted fixer will not adequately perform its vital second stage job, thus leaving the film emulsion...

Milky-yellow . . . . Page 4-37

Insufficiently hardened . . . . Page 4-38

Clearing of the milky-yellow color from the film is the first stage action of the fixer. With an exhausted fixer solution, this clearing time may be excessively long and possibly not complete.

However, the second stage action we asked for is the hardening of the film emulsion. Unless the fixer is relatively active, the film emulsion will be soft and subject to damage.

Turn to page 4-38.

An exhausted fixer will leave the film emulsion insufficiently hardened, exactly.

Insufficient hardening of film emulsion could have immediate (and unwanted) results. A fingernail could quite easily scratch the emulsion. The temperature of the warm air dryer in which the film will be dried could cause the too soft emulsion to pull away from its base. Or, the results of such a condition could be long range, with the film discoloring while in storage.

Whenever the results of insufficient hardening occur, they are unwelcome in radiography. As always, of course, an ounce of prevention is worth a pound of cure and in this instance the ounce of prevention is simple: Frequent replenishment. With fixer strength constantly maintained, film removed from the fixer will be properly fixed and hardened.

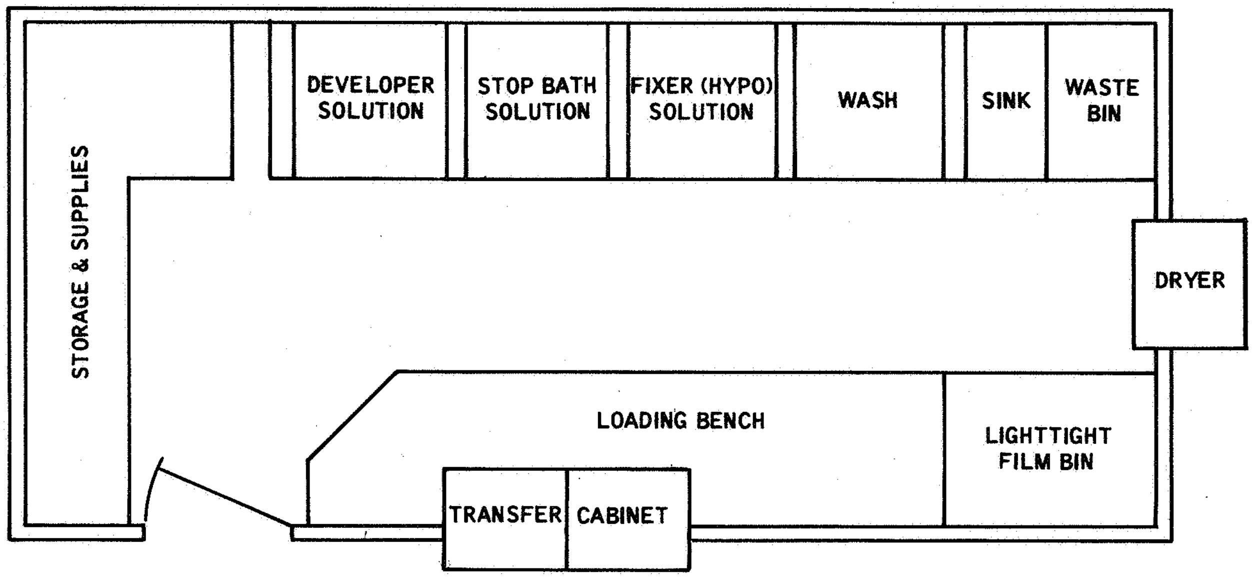
The time has come for us to talk of film processing, for you to bundle up your new-found knowledge about the darkroom, about film and its handling, about processing chemicals, and put it to use.

Turn to next page.

This is the payoff, the chapter which will bring all previous information together for the complete picture. Although there is nothing magic about producing an image from an exposed film, the error margin is narrow. The job must be accomplished with knowledge and skill if the image is to be sensitive enough to do the task for which it is intended.

Perhaps the best way to step into this chapter is to backtrack ground already covered. To this end the next four pages each provide a recapitulation of the preceding four chapters. No response is required on these pages, they are merely refreshers which should prove helpful in learning the Film Processing material.

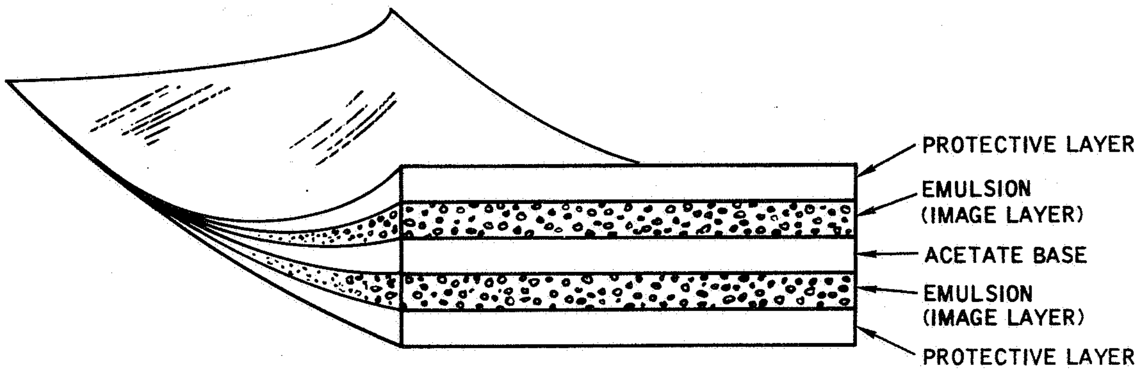
Turn to the next page.



A clean darkroom is absolutely vital in preventing film artifacts. Its purpose is to provide environmental protection for film during storage, loading, unloading and processing, keeping from it such things as dust, light, X and gamma rays, moisture and heat. Safelights, the "seeing eye" of the darkroom are only as "safe" as sensible handling of film makes them. They enable one to "see" in a darkroom. The "dry" side of the darkroom includes facilities and equipment for loading and unloading film, provides towels, storage facilities, etc. On the "wet" side are the processing tanks containing chemicals into which the film can be immersed and which are themselves immersed in water for temperature control of solutions. The <u>tank</u> developing method allows total immersion and chemical access to both sides of the double-coated film and equal temperatures for all solutions. Washing requires a high volume of water (we'll discuss this more in this chapter). The warm-air dryer completes the processing equipment.

Turn to the next page.

RADIOGRAPHIC FILM (Recapped)



Radiographic film consists of a transparent acetate base (which permits light transmission) emulsion-coated on both sides. The countless microscopic silver bromide grains which the gelatin-emulsion holds in suspension makes it extremely sensitive.

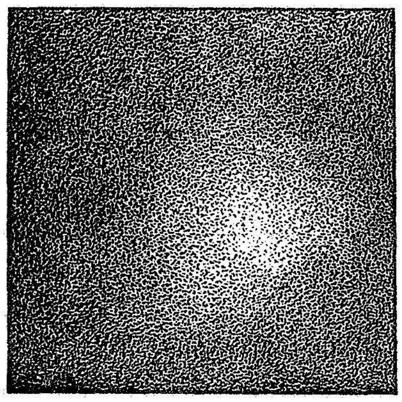
An exposed, undeveloped film contains a "latent image" — an image that is there but not detectable by the eye.

When an exposed film is developed, the latent image becomes visible. Bromine is released from exposed grains only, leaving behind tiny, black, metallic silver grains. The greater the exposure in an area the blacker or more dense that area will be when developed. The image itself is comprised of varying degrees of density or blackness ranging from totally black to shades of gray; non-image areas are transparent.

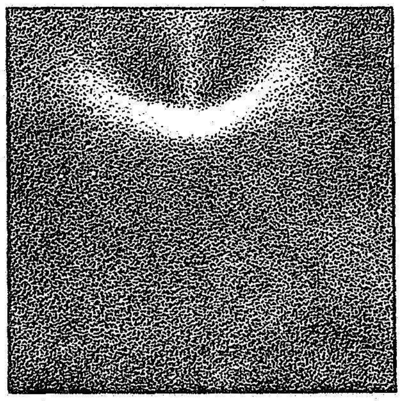
Visible graininess in a film is the clumping action of many microscopic grains. This unwanted condition can be aggravated by the swelling and contracting action of the gelatin emulsion. Fogging, another unwanted effect, can result from developing grains which have not been exposed.

Turn to the next page.

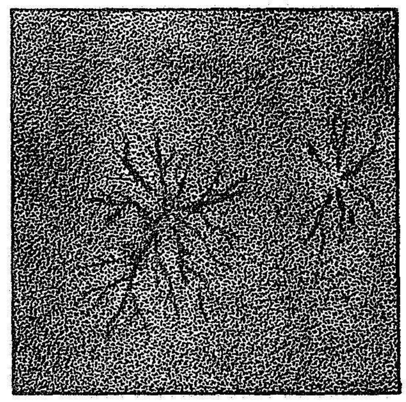
From page 5-3



PRESSURE MARKS



CRIMP MARKS



STATIC MARKS

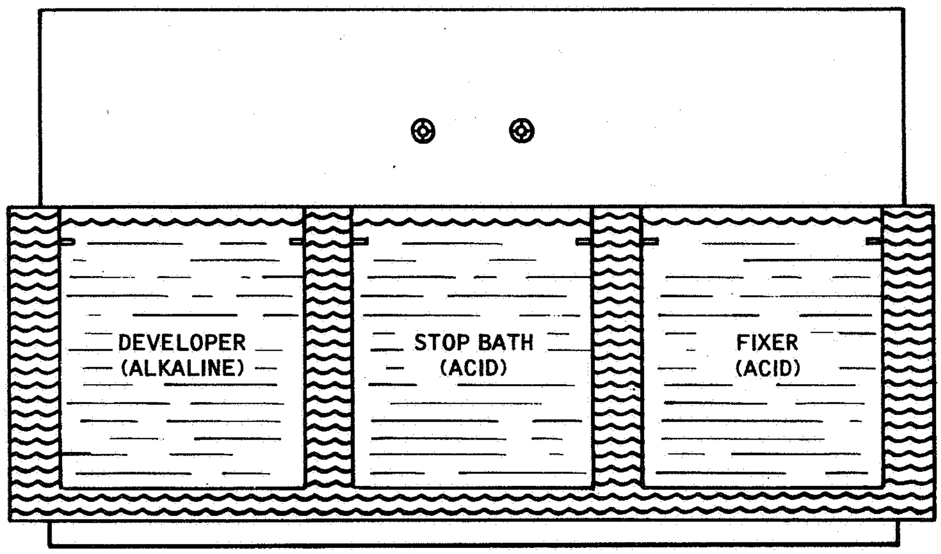
Great care must be used in the handling of radiographic film to avoid false indications and to prevent loss of sensitivity in the finished film. Cleanliness is of prime importance — frequent mopping to remove dust and immediate removal of contaminating chemicals can prevent many problems.

False indications that are caused by faulty film handling or lack of care are known as artifacts. Chemical stains, foreign body images (from dirt, etc.), pressure marks, crimp marks, and tree-like marks (from static discharges) are some of the common types of artifacts.

Film holders, cassettes, and screens must also be maintained in good condition to prevent artifacts.

Turn to next page.

From page 5-4



Since you have just covered this material the review will be brief. The alkaline developer reduces exposed grains from silver bromide to metallic silver leaving the unexposed grains within the emulsion unaffected. The acid stop bath stops development immediately by neutralizing the alkaline developer so that the acid fixer (hypo) won't have to do this job. The fixer, therefore, can begin immediately to accomplish its primary functions: 1) the dissolving of the unexposed grains and 2) the removal of those grains and hardening of the film emulsion.

Now that the refresher course is out of the way, you can begin to develop film.

Turn to the next page.

From page 5-5

Assume that you have just entered the darkroom for your days work. The white lights are on at this point while you make your inspection to see that the room and equipment are properly cleaned and ready to use. They should be — that is the responsibility of the last user.

Your first task is going to be:

Begin processing the film backlog . . . . Page 5-7

Check the temperature of the processing solutions . . . . Page 5-8

You're off to a bad start.

As with most operations, success depends on advance preparation. So it is with film processing. You will recall from the preceding chapter that temperature is vitally important in the developing process. The higher the temperature of the chemicals, the faster the film is developed. Conversely, a low temperature retards development.

Your first step in preparing for film processing is to check the temperature of the processing chemicals.

Turn to page 5-8.

Your first task is to check the temperature of the processing chemicals, certainly.

Since in the tank method of development, all solutions have the same temperature as the surrounding water, a temperature check is a simple matter. Ideally, the temperature of the water should be 68°F and an attempt should be made to maintain this temperature.

However, if the temperature is within a few degrees of 68°F, development time can be compensated by referring to the film manufacturer's time-temperature correction charts. The temperature tolerances and time corrections differ between film types and manufacturers, so we won't set any rules here.

To get back to our own situation, if you find that the tank water temperature is not acceptable to begin film processing, it must be corrected by using the hot and cold water inlet valves. Allow enough time for all temperatures to stabilize.

Now that you have the correct temperature in the processing tank, what is the next step?

Begin processing film backlog . . . . Page 5-9

Develop a test film strip . . . . Page 5-10

Remember the control strip? It was developed when the developer in the tank was fresh and new. It is the standard that is used to determine if the developer is still up to strength or needs replenishing.

One of your first tasks is to determine if the developer strength is within acceptable tolerances.

Turn to page 5-10.

From page 5-8

Very good. You develop a test film strip using accurate processing times and procedures.

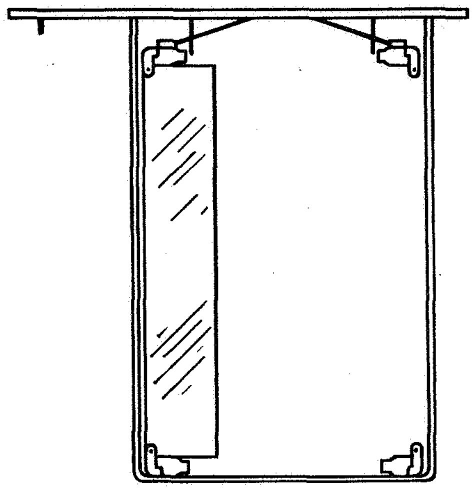
This <u>test film strip</u> can then be compared to the <u>control strip</u> that was developed when the developer solution was new. If the density variation is approaching or outside the acceptable limit, then the developer must be replenished.

But perhaps we are getting ahead of ourselves. We told you to process a test strip, but as yet we haven't been through a complete cycle of processing. So let's use the test strip as the example and process it just as we would any other piece of film.

So turn off the white lights and remove one of the undeveloped test strips from the storage bin.

Turn to the next page.

Since we are going to process the film test strip, let's mount it in a film hanger. This is done on the dry side of the darkroom to prevent any chemicals from coming in contact with the film before processing begins. Also, handle the film carefully, don't bend it unnecessarily, and handle the corners only to prevent fingerprints or pressure marks.



The film hanger provides a rigid support for the film during processing.

Now stir the developer for a few seconds to thoroughly mix the chemicals and you're ready to put the film in the developing tank.

You know what the developer temperature is (it should be at or close to 68°F), but there is one thing remaining to be done either immediately before or immediately after immersing the film. Can you pick it out?

Stir the developer for a few seconds . . . . Page 5-12

Set the timer for the required development time . . . . Page 5-13

Since you have already stirred the developer, you should not logically be on this page.

Remember the relationship between developer temperature and developer time? There is a certain development time that must be used for the developer temperature. This is particularly critical when developing the test strip, otherwise, the comparison to the control strip will not be valid.

Turn to page 5-13.

From page 5-11

Right, when you slowly and carefully immerse the test strip in the developer the timer must be set for the period of development time recommended in the time-temperature chart for the film.

On immersion it is possible for tiny air pockets — called air bells — to form on the film surface. These air bells will prevent developer from contacting and penetrating the emulsion in those areas.

Two or three sharp finger taps on the hanger's top will serve to:

Make certain the hanger is properly seated . . . . Page 5-14
Dislodge air bells . . . . Page 5-15

From page 5-13

Film hangers are of relatively simple design. A hanger is lowered into a tank until two metal arms protruding from each side contact and come to rest on the tank edges. There is no question of film hangers being properly seated.

And since the finger tapping is not a display of nervous energy, the other alternative — dislodging air bells — must be the answer.

Turn to the next page.

From page 5-13

The finger taps dislodge air bells, correct. If these air pockets aren't removed from the film's surface, the film will not be properly developed at those spots.

Now let's see what's happening to the film. The alkaline developer solution is working its way through the film's protective layers so that the exposed silver bromide grains in the emulsion layers can be reduced to silver. As soon as the developer penetrates the emulsion layer it starts removing the bromine from the exposed grains.

The bromine will collect on the surface of the film and will, if left long enough, flow or cascade down the film surface as it settles to the bottom. It should be obvious that this situation is not desirable because it interferes with the action of the developing solution. Unless some action is taken to remove the bromine as it collects, the film will be streaked and unevenly developed.

To remove the bromine, you must...

Agitate the film in the developer solution . . . . Page 5-16

Carefully wipe the film occasionally . . . . Page 5-17

Absolutely. Agitate the film while it is developing. Do not attempt to wipe the film — you may damage the soft emulsion.

By moving the film up and down or side to side, the bromine is removed from the film surface and fresh developer replaces it.

When and how long should you agitate?

The initial period in the developer is the most critical so it is recommended that you agitate the film for at least 30 seconds immediately after immersing it. Additional agitation for about 10 seconds after every minute of additional development should take care of the bromine. Since the average development time will be about 5 minutes, you will agitate the film 4 or 5 times for 10 seconds after the initial 30 seconds.

When the timer indicates that the development period is over, you must remove the film promptly from the developer to prevent overdevelopment.

Drain the film for a second to two and then place it in the...

Fixer . . . . Page 5-18

Stop bath . . . . Page 5-19

Very definitely not. You didn't have much to go on for this one; however, remember that the film emulsion is very susceptible to mechanical damage.

You have been very careful up to this point in handling the film — let's not spoil it now.

Turn to page 5-16.

You're rushing it a little. However, it's only fair to tell you that you are not completely wrong.

In our discussion of processing chemicals we said that the fixer can do the same job as the stop bath because it is an acid solution that will serve to neutralize the alkaline developer. But the consequences of such action are not usually acceptable. The stopping action of fixer on the absorbed developer is not as fast and sure as a stop bath and the practice will result in very fast exhaustion of the fixer strength.

With these thoughts in mind, your next step with the developed film is the...

Turn to page 5-19.

From page 5-16

Stop bath. Very good.

The stop bath, if you remember, will stop the action of the absorbed developer in a minimum of time. Time in the stop bath need not be great — 30 to 60 seconds is sufficient — but again, you will need to agitate the film moderately in order to keep active solution in contact with the film.

The temperature of the stop bath must be within the same narrow range as the developer temperature, close to 68°F. In the example we are working with here, the stop bath will have the same temperature as the developer because we are using the tank method in which all solutions have the same temperature as the surrounding water.

From the stop bath the film goes immediately into the...

Fixer solution .... Page 5-20

Wash water .... Page 5-21

From page 5-19

Very good. The film now goes into the fixer solution or "hypo" as it is often called.

The prime purpose of the fixer solution is to dissolve and remove all of the undeveloped silver bromide from the emulsion.

If you recall from Chapter 4, the action of the fixer in removing the unexposed grains is a two-step process. The first action is to dissolve the grains within the emulsion. This results in a "clearing" of those areas on the film that have a large number of unexposed grains. The time it takes these areas to clear is called the clearing time.

It is during this clearing time that you will get your first good look at the film you are processing. When the film is first placed in the fixer, agitate it vigorously for 30 seconds or so then an additional 10 seconds every 2 minutes after that. After the first minute in the fixer, the film may be lifted out and viewed under the safelight to determine the degree of clearing. Depending on the type of film, type of fixer, temperature of fixer, and freshness of the fixer, the clearing time may vary from one to several minutes. By occasional viewing of the film, you can tell what the clearing time is. It is important that you know, because...

The film should not be left in the fixer for a longer period . . . . Page 5-22

The film must be left in the fixer for an additional period at least equal to the clearing time . . . . Page 5-23

Sorry, you skipped a very important step in the processing procedure.

The film will eventually be washed, but before that, the image must be fixed. The radiograph would be worthless without the fixer bath, both from the viewing standpoint, since it is a milky-yellow color in the areas that should be clear, and from the standpoint of permanence.

From the stop bath the film should go into the fixer solution.

Turn to page 5-20.

You're forgetting that the fixer solution has another important function to perform before the film can be removed.

The <u>first</u> function, accomplished during the clearing stage, is to dissolve the unexposed silver salts that remain in the emulsion. However, at the end of the clearing time, these dissolved salts still remain in the emulsion. The <u>next</u> function of the fixer is to remove these dissolved salts from the emulsion.

Turn to page 5-23.

From page 5-20

Excellent. You remember from Chapter 4 that the dissolved silver bromide must be removed from the emulsion by leaving the film in the fixer for an additional period of time.

And what is the additional time? Normally, the same as the clearing time, although if the time exceeds that figure, no harm will be done provided the time doesn't run into hours.

So, the time in the fixing bath should be a minimum of twice the clearing time.

There is an auxiliary function performed by the fixing solution. Do you remember what it is?

Turn to page 5-24.

[redacted]

From page 5-23

Certainly. The fixer hardens the emulsion to make it more durable. Without this hardening action the finished film would be susceptible to scratches and other damage in normal handling.

Now you're ready to wash the film in fresh, running water. In order to do an adequate job of washing, the rate of water flow through the wash tank must provide for a complete change of water from four to eight times an hour.

Another requirement for proper washing is time. Again, time is dependent on the film being processed and you should follow the manufacturer's recommendations. Recommended time will generally be twenty minutes or more in order to adequately remove all traces of fixer chemicals from the emulsion.

When processing a series of films, place the first film next to the drain end of the wash tank. As you introduce additional films into the tank move the first films toward the inlet end. By doing this —

— you first wash the films in partially contaminated water and finally in clear water.

True . . . . Page 5-25

False . . . . Page 5-26

True. Film number two is placed at the drain end in the location just vacated by moving film number one toward the inlet end. Film number two, therefore, is first washed in number one's fixer-contaminated water. Film number three, in turn, is first washed in water contaminated by film numbers one and two.

By the time each film reaches the inlet end of the tank, it is being washed in water fresh from the inlet.

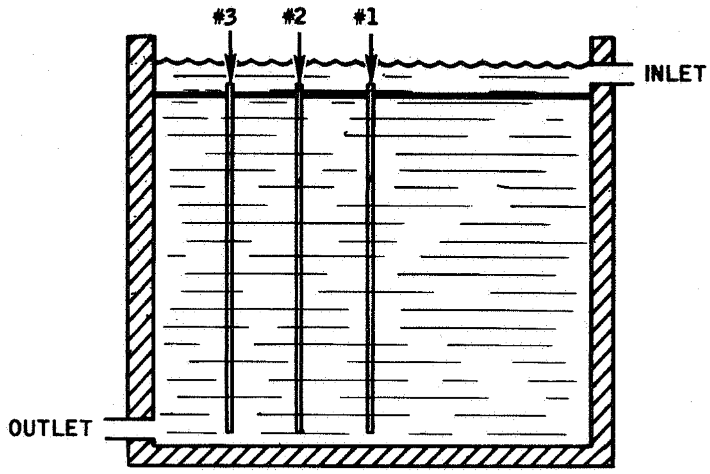
During the washing period the tops of the film hangers should be covered by the water.

The purpose of this is to:

Wash the hangers as well as the film . . . . Page 5-27

Assure complete coverage of the film . . . . Page 5-28

Your "false" answer is incorrect, the films are first washed in partially contaminated water. Let's look at the wash tank.



There are three films being washed. Number one was moved forward to accommodate number two. Number two was moved forward to accommodate number three. Excepting the initial film, each film is first washed in water contaminated by the preceding film. But by the time each film reaches the inlet end of the tank, it is being washed in clear water. True?

Turn to page 5-25.

From page 5-25

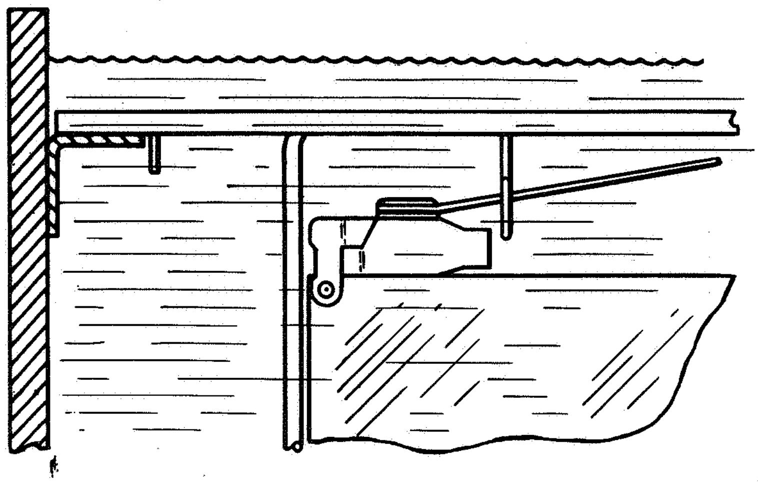
Of course. The purpose of maintaining a water level sufficient to cover the hanger tops is to wash them free of chemicals. Without this precaution chemicals will dry on the hangers. When the hangers are used again the chemicals will contaminate the solutions, causing streaks on the film.

When the two requirements for adequate film washing — time and plenty of water — have been satisfied, remove the film.

Your film is almost ready for the warm air dryer. But before starting the drying process there is something you can do to increase the dryer's effectiveness and decrease the possibility of water spots.

Turn to page 5-29.

Sorry. Covering the hanger tops with water is <u>not</u> for the purpose of assuring complete coverage of the film. As shown, the film is well covered before this level is attained.



So, maintaining a water level higher than the film hanger tops can only be for the purpose of washing the hangers as well as the film.

Turn to page 5-27.

On removing a film from the wash tank you will inevitably find drops of water clinging to its surface. If the film is immediately placed in the dryer, water spotting could result.

It would happen this way: The emulsion not covered by water drops would dry more rapidly than the emulsion beneath the drops. This uneven drying would cause the drop-covered part of the emulsion to distort. The distortion would cause a slight change in density and a visible spot on the finished radiograph.

How to prevent water spots? Easy. Make the water so slick it won't cling to the film's surface. Get rid of the cause — water drops — and you are rid of the effect — water spots. The same principle is used in household dishwashers when a solution is added to prevent dish spotting.

Here are the processing steps we have discussed so far:

1. Developing solution
2. Short stop solution
3. Fixer (hypo) solution
4. Washing
5. ____________________

What is the desireable fifth step?

Drying . . . . Page 5-30

Spot preventing solution . . . . Page 5-31

Well, you can go directly to the dryer, however, there's a good chance that the finished radiograph will have troublesome spots on it. Better rinse it in a spot preventing solution first.

Turn to page 5-31.

A film would be immersed in a spot preventing solution after washing and before drying — correct. This solution, in effect, relieves the surface tension of the water so that it does not cling so readily to the film's surface.

The film should be immersed in the solution one or two minutes, drained for one or two minutes and then placed in a dryer.

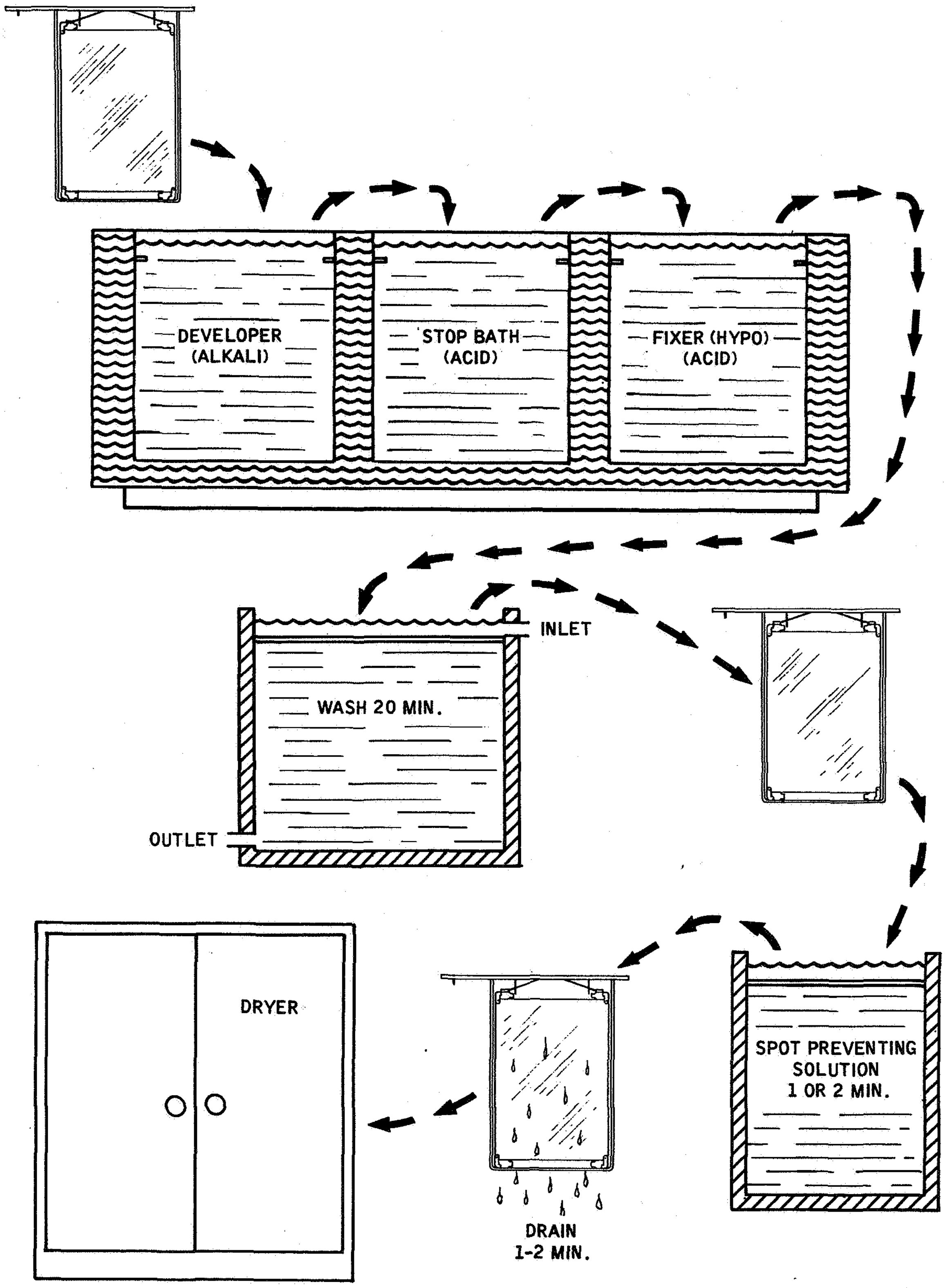
In addition to the obvious benefit of preventing water spots, use of this solution provides a bonus benefit — decreased drying time. Use of a spot preventing solution saves many valuable minutes because of the more complete removal of water from the film before it is placed in the dryer.

As a review, the next page contains a flow chart of the processing routine from start (developer) to finish (dryer).

Turn to the next page.

From page 5-31

PROCESSING FLOW CHART



Turn to the next page.

That's it. You have immersed, agitated, waited, and agitated some more. Now the test strip is in the dryer and you can relax a bit.

It must be emphasized that exact times and procedures (except for a fairly standard temperature of 68°) vary with films and conditions. You should carefully check the film manufacturer's recommendations.

The film which emerges from the darkroom is the result of your skill, knowledge and care; there can be no guess-work, no slipshod techniques if you want consistent results.

Now you can remove the test strip from the dryer and compare it with the control strip. If temperatures were within limits, your chemicals were fresh, you agitated properly and you left your film in the solutions the required time, the test strip should be within acceptable tolerances. If not, it is an indication that the developer needs replenishment.

Well, that's just about it. We've covered the subject in a broad sense to give you the major guide lines. So much depends on the type of film you are working with and the facilities you have. Always look to the film manufacturer's instructions for details of the processing requirements.

Before we leave the subject of film processing, turn the page for a short discussion that should be of interest to many of you.

A discussion of film processing would not be complete without mentioning automatic processors. If you are fortunate enough to have such a unit available, many of your processing problems are over.

Of course, you still have to load your film into cassettes or film holders and, after exposure, you will have to unload the film. The automatic processor will not help in these functions. And during loading and unloading you must still exercise all the care and cleanliness possible to avoid artifacts.

However, from the point where you insert the exposed film in the automatic processor, you have many advantages over the hand processing method. Your radiographs will be consistently better due primarily to the very accurate control of time, temperature, and solution strengths.

Because time is so carefully controlled, the processing temperatures can be higher without the normal danger of over- or under-development, and processing time is shortened accordingly. Constant agitation and accelerated washing and drying contribute additional time savings. All these factors, taken together, result in finished radiographs in less than one fourth of the time it takes by hand processing.

High quality radiographs in one fourth of the time!

Great, isn't it? However, it's only fair to tell you that it isn't all gravy. Like any other piece of delicate machinery, the automatic processor will only function properly so long as it is properly serviced and maintained. And like any delicate equipment, you can't fiddle with it unless you are trained and know what you are doing.

A final word. Even if an automatic film processor is available, don't ignore the fact that on occasion you may find it necessary to hand process your film. It isn't hard to visualize such occasions - working away from the lab area, processor down for maintenance, etc. So, don't lose touch with the basic procedures of processing film by hand.

Turn to the next page.

You have just completed the fifth volume of the programmed instruction course on Radiography.

Now you may want to evaluate your knowledge of the material presented in this handbook. A set of self-test questions are included at the back of the book. The answers can be found at the end of the test.

We want to emphasize that the test is for <u>your own</u> evaluation of <u>your</u> knowledge of the subject. If you elect to take the test, be honest with yourself - don't refer to the answers until you have finished. Then you will have a meaningful measure of your knowledge.

Since it is a self evaluation, there is no grade - no passing score. If you find that you have trouble in some part of the test, it is up to you to review the material until you are satisfied that you know it.

Now rotate the book and flip to page T-1 at the back of the book.

RADIOGRAPHIC TESTING - VOLUME V - FILM PROCESSING

Self-Test

1. The primary function of a darkroom is the protection of sensitive film by control of:

   a) dust
   b) light
   c) humidity
   d) density

2. The most efficient method for hand processing large numbers of radiographs is:

   a) the tray method
   b) the wet method
   c) the tank method
   d) the automatic method

3. Which of the following is not used to control light in the darkroom?

   a) timer
   b) safelight
   c) film storage bin
   d) transfer cabinet

4. The darkroom is often divided into two areas for control of chemical contamination, the (choose two):

   a) wet side
   b) bright side
   c) dim side
   d) dry side

5. Which of the following is a possible source of danger to undeveloped film?

   a) safelights
   b) chemical dust
   c) pressure
   d) all of above

6. What is the one requirement that every radiographic film base must have?

   a) flexibility
   b) transparency
   c) toughness
   d) fine grain

7. In order for a film to record an image, the base must have, as a minimum:

   a) an emulsion layer on one side
   b) an emulsion layer on both sides
   c) an emulsion layer plus a protective layer

8. The emulsion or image layer of the unexposed film contains grains of:

   a) black silver
   b) hypo
   c) alkali
   d) silver bromide

9. All other factors being equal, which two types of film would give the sharpest images?

   a) fine-grained
   b) coarse-grained
   c) fast
   d) slow

10. The grays and blacks in a radiographic image are composed of:

    a) tiny grains of black silver
    b) grains of gray silver and black silver
    c) thin silver and thick silver
    d) petrified X-rays

11. The "density" of a radiographic image refers to:

    a) the thickness of the film
    b) the weight of the film
    c) the degree of blackness

12. The phenomena in which grains of silver clump together is known as:

    a) graininess
    b) density
    c) transparency
    d) contrast

13. Processing tanks should be thoroughly cleaned every time the solutions are changed.

    a) True
    b) False

14. It is acceptable to wait five minutes before wiping up spilled chemicals, but no longer.

    a) True
    b) False

15. An artifact is a film defect that results from lack of cleanliness, or improper film handling or processing.

    a) True
    b) False

16. Film should be removed rapidly from its container to avoid build-up of a static charge.

    a) True
    b) False

17. Excessive pressure on the film should be avoided.

    a) True
    b) False

18. Clamping of a flexible film holder to the specimen will assure proper film-to-screen contact.

    a) True
    b) False

19. The proper way to remove dust or lint from film holders or cassettes is to blow carefully.

    a) True　　　b) False

20. Each utensil that is used to handle or mix processing solutions must be (choose one):

    a) inventoried　　　c) washed
    b) plastic　　　d) transparent

21. Generally speaking, artifacts that occur before the film is exposed are:

    a) always dark　　　c) always light
    b) usually dark　　　d) usually light

22. The developer solution is:

    a) acid　　　c) icy
    b) alkaline　　　d) silvery

23. During development, the film releases:

    a) silver bromide　　　c) bromine
    b) silver

24. After a film has been exposed, the remaining unexposed silver bromide grains cannot be developed.

    a) True　　　b) False

25. Film processing is based on the relationship between time and temperature.

    a) True　　　b) False

26. All other factors being equal, a film developed for 5 minutes at 68° will be more dense than one developed for 5 minutes at 70°.

    a) True　　　b) False

27. The best method of raising or lowering solution temperature is by adding warm or cold water to the solution.

    a) True　　　b) False

28. An exhausted or weakened developing solution will turn out an underdeveloped film.

    a) True　　　b) False

29. The activity of processing solutions increases as the solutions become warmer.

    a) True
    b) False

30. What is the proper day-to-day method of maintaining developer strength?

    a) replacement
    b) raising the temperature
    c) replenishment

31. What is the one choice below that does not affect developer strength?

    a) exposure to air
    b) film grain size
    c) density of films
    d) number of films processed

32. Too much difference in density between the control strip and the test strip indicates that the developer:

    a) is exhausted
    b) needs replenishment
    c) both of above

33. A new <u>control</u> strip must be developed each time the developer:

    a) is replenished
    b) is changed
    c) temperature changes
    d) is used

34. Number these random-listed processing steps in their correct sequence.

    _______ Stop bath
    _______ Wetting agent
    _______ Developing
    _______ Fixing
    _______ Washing
    _______ Drying

35. What is the purpose of the developing solution?

    a) To remove the unexposed grains.
    b) To develop the exposed grains.
    c) To remove the exposed grains.

36. How does the stop bath stop the developing action?

    a) by catalytic action
    b) by osmosis
    c) by neutralization

37. When mixing the stop bath using glacial acetic acid, always:

    a) add the acid to the water
    b) add the water to the acid
    c) pour them both in at once

38. An acid stop bath will stop developing action in the shortest practical time:

    a) True
    b) False

39. As a rule of thumb, a film should remain in the fixing solution for twice the clearing time.

    a) True   b) False

40. The fixing solution (choose two):

    a) removes the unexposed grains
    b) develops the exposed grain
    c) hardens the emulsion
    d) removes all chemicals from the emulsion

41. When a film is initially inserted in the developer, the hanger should be tapped several times to eliminate;

    a) uneven development   c) fog
    b) air bells

42. What one action will best prevent uneven development?

    a) stir the solution   c) agitate the film
    b) maintain correct temperature

43. Put these processing steps in correct numerical sequence for the first film of the day.

    ____ Set timer and immerse film   ____ Agitate film
    ____ Stir developer   ____ Tap hanger
    ____ Check developer temperature

44. A good temperature for all solutions is:

    a) 68°   c) 64°
    b) 75°

45. When a film is first placed in the developing solution, it must be agitated for:

    a) one minute   c) thirty seconds
    b) ten seconds

46. Assuming the darkroom is clean, the first major task of the day is to:

    a) process the film backlog   c) change the solutions
    b) process a test strip

47. Bromine is released in greatest quantities from those areas of the film that received the most exposure.

    a) True   b) False

48. During processing, if a film is examined too soon under the safelights, it might become fogged.

    a) True b) False

49. A film should remain in the stop bath for 30 to 60 seconds.

    a) True b) False

50. A film should be moved directly from the developer to the fixer.

    a) True b) False

51. When washing a film, it doesn't matter if the film hanger is not covered by the water.

    a) True b) False

52. As each film is washed, it is first placed in the outlet end of the wash tank.

    a) True b) False

53. The film should be agitated in the stop bath and fixer as well as in the developer.

    a) True b) False

54. A wetting agent is sometimes used after fixing and before washing.

    a) True b) False

55. Too great a difference in density between the test strip and the control strip indicates that the developer should be replenished or replaced.

    a) True b) False

ANSWERS FOR SELF-TEST

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