~~LOCKHEED MISSILES & SPACE COMPANY~~

SCD-3

~~LMSC~~ MINI-CAMERA SYSTEM

SCD-3 is out number for MC-4

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1.0 Introduction

The SCD-3 camera has been designed and produced to acquire high-resolution photography that can be enlarged in excess of 100 times. High-resolution photography in this instance means photography with a resolution within the negative of more than 200 lines per millimeter (200 l/mm). This means that normal types of film are not adequate for obtaining high-resolution photography; that most cameras are not physically capable of taking high-resolution photography; and that special effort must be applied to the entire photographic process to meet a goal of 200 l/mm in the film plane.

The SCD-3 camera was designed and modified on a matched system basis. This means that every portion of the system was designed and tested to produce consistent results that exceeded the design goal of 200 l/mm. The different areas studie were: 1) camera body, 2) lenses, 3) film drive, 4) focus, 5) image smear, 6) film, 7) film processing, 8) human factors, and 9) operating techniques. All of these basic areas of the system were carefully studied and incorporated into a workable unit that integrates all the parts at or near their maximum potential. However, the ability of the system to deliver high resolution photography is dependent upon the operator's compliance with some basic rules and instructions. That is why this manual was written - to explain the development and unique features of the system so that the rules presented may be understood.

In addition to this manual there are individual equipment manuals published by the original manufacturer which provide detailed information on individual pieces of equipment.

2.0 List of Equipment

The SCD-3 camera system (Fig.) includes the following items:

2.1. Camera body, Nikon F2

2.2. Lens: 50mm focal length, f1.4 Nikkor
180mm focal length, f2.8 Nikkor

Both lens are mounted in a custom made acc ized lens barrel.
specialized

3. 250-exposure film cassettes (four) Nikon
4. Battery Pack
5. Film Drive
6. 250-exposure back, Nikon
7. View scope (sight)
8. Focus calibration sheet
9. Attache case
10. Battery charger

3.0 Essentials of the SCD-3 Camera

The SCD-3 camera can perform at the high-resolution numbers it acquires (200 1/mm) only when the operator follows the special rules that were devised for this system only. Should any of these rules be omitted or changed for any reason, the imagery quality will degrade to normal 35-mm camera quality (40 lines per millimeter or less). The rules are listed below, and the reasons for these rules are explained in the detailed sections of this document. Please read the rules, read the explanations, and they FOLLOW the rules as set down.

The SCD-3 camera must be locked into the continuous or high mode; this includes the battery drive switch, the camera mode switch, and the rate switch on the camera back. Lock the exposure at 1/1000 of a second and the camera lens at true focus distance. Lock the mirror into the up position and install the telescopic view finder (view scope) on the shoe on the left side of the camera body.

The camera can be used in its present configuration in a plane, in a helicopter, from a moving car, from a moving train, or from a moving ship; it can be hand held or mounted on a tripod on the ground. In all cases where the camera is to be used in a vehicle, the best and most consistent operation will be obtained when it is hand held.

The camera as described here is designed to provide high-resolution photography from a distance of about 100 feet to a distance of 18,000 feet. This camera can also be configured to take close-up pictures, but any camera can take an adequate picture close to the subject.

The camera is presently configured with only two lenses: a 5-mm focal-length, f1.4 Nikkor lens and a 180-mm, f2.8 Nikkor lens. The hyperfocal distance (hyperfocal distance is the nearest distance upon which a photographic lens may be focused to produce satisfactory definition at infinity) for the 5-mm lens is about 100 feet, and the hyperfocal distance for the 180-mm lens is about 800 feet. When these lenses are set for SCD-3 camera use they are for use outside the yperfocal distance of the lenses.

This camera has been used for distances beyond 18,000 feet but with generally longer lenses and faster films. At greater distances the faster film and the longer focal-length lenses at higher f-stop numbers prohibit the system from producing resolutions of 200 l/mm; however, this configuration will provide better imagery than other comparable camera-lens combinations because of the custom lens-body matching techniques applied to the system. Although the SCD-3 camera can be configured to provide excellent imagery at greater distances, the present configuration is with the two lenses as explained above.

During the production of the SCD-3 camera, each lens was accurately matched to the camera body and the camera-lens combination was checked to the accuracy required (better than 200 l/mm); the camera was then ready for operational use.

4.0 Instructions for use of the SCD-3 Camera

The camera operation is amazingly simple because the operational camera controls (Figure) are locked into fixed positions. Following is a check list to assist you: the operator:

Check color-coding to make sure lens is being used with correct camera body.

Lock the mirror in the up position. (See 7.7 Image Smear for explanation)

Lock the lens in the full open position.

Lock the lens in the true focus position.*

*50-mm lens focus should be set within 3/32 in. on the cursor scale. If effor is as much as 3/16 in. you will lose 50% or more of resolution. 180-mm lens focus should be set within 1/8 in. or the cursor scale. If error is as much as 3/16 in. you will lose 50% or more of resolution.

(TAKE NEW PICTURES)

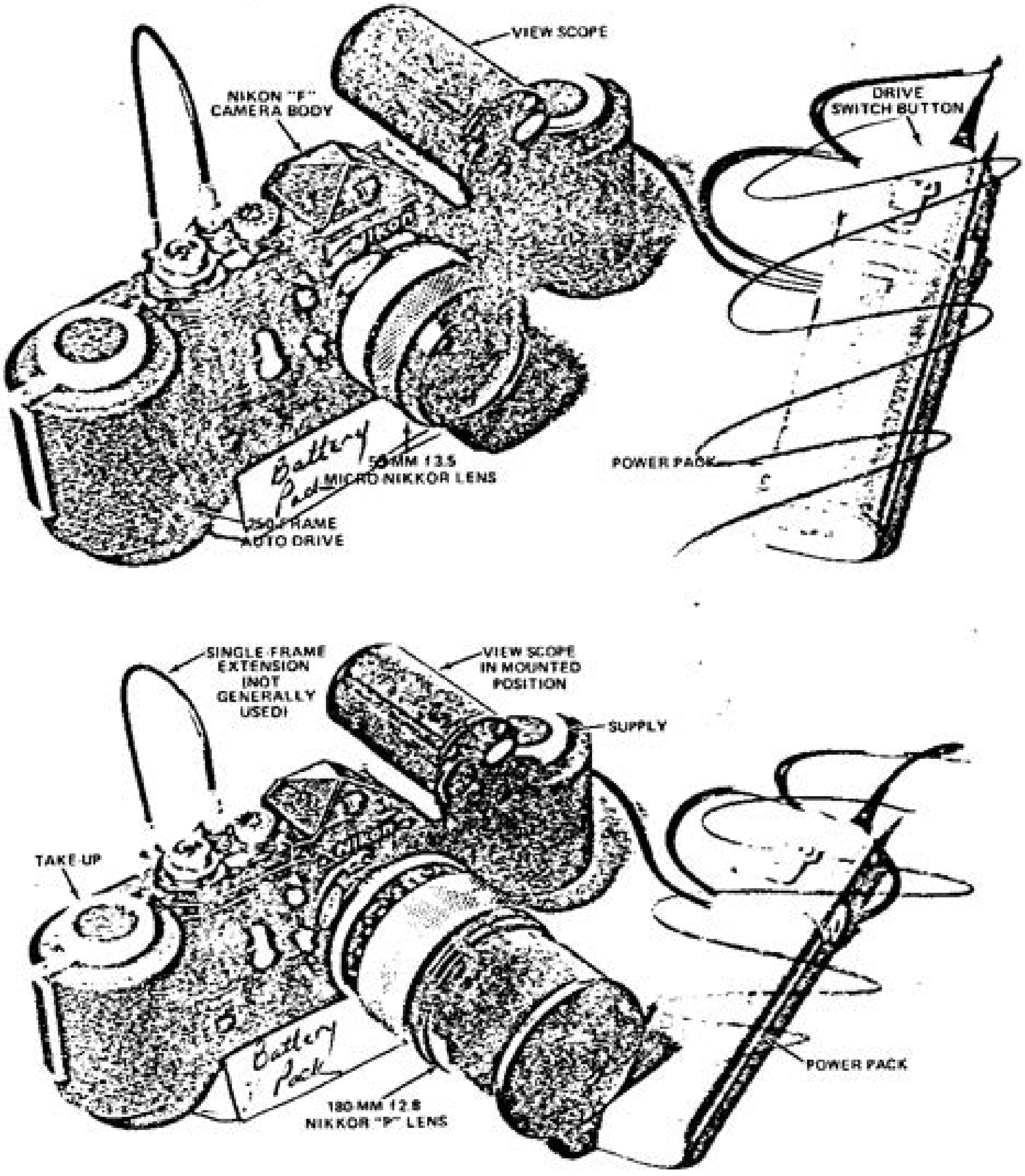
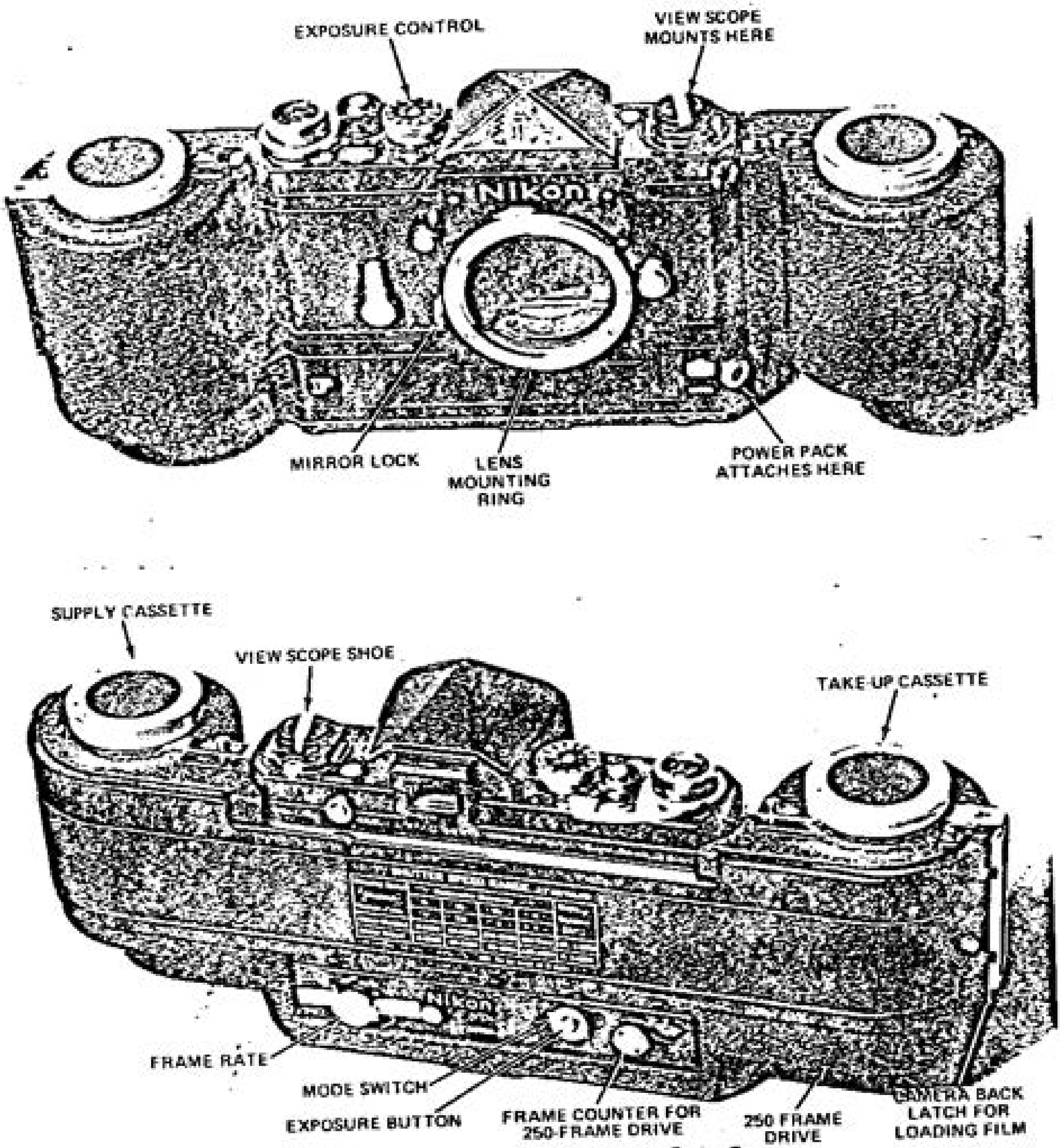


FIGURE SCD-3 [redacted] CAMERA [redacted] WITH 50 [redacted] mm, f[redacted] LENS (top view) AND WITH 180-mm, f2.8 LENS (bottom view)

(TAKE NEW PICTURES)



SCD-3

FIGURE [redacted] FRONT (top view) AND BACK (bottom view) OF [redacted] CAMERA [redacted] SHOWING OPERATIONAL CONTROLS

Lock the exposure time at 1/1000 second.

Lock the camera mode switch in the continuous position ("C").

Lock the frame rate switch on the camera in the high rate position ("H").

Install the small view scope on the left side of the camera to be used as a view finder and pointer.

Point the camera at the center of the area of interest and follow some identifiable portion of the target for the prescribed number of frames (10 or more).

Do not use the camera in a single-frame operation because the advantage of the high-resolution film is lost in this mode. The continuous mode provides full stereo photography when a moving ~~the~~ target is tracked by the camera operator or a moving operator continuously photographs a stationary target.

Hand-hold the camera when operating from a vehicle.

Always try to finish a roll of film each time the camera is used (remember, the film costs only about one cent per frame).

Expose the final few frames (15 or 20) on the 250 frame cassette with some scene of low importance; this allows the photo lab technician to use the tail of the roll for the inspection process in his quality control processing.

Be sure to write the average taking conditions on the film cassette.

Processing the special film used in the SCD-3 camera requires special photo lab procedures and chemical formulas which are described in detail in a subsequent section of this manual.

4.1 Special Tips

The camera should be kept free of vehicle vibration by holding the two film magazines without support from the window frame or other portion of the vehicle body which would transmit vibration to the camera.

The best operation of the camera can be obtained by shooting only through air. Therefore, if at all possible the vehicle window should be opened for all camera operations or the resolution will be limited. For example, 20/20 vision equates to 6 inch line and space GRD (ground resolved distance) per 1000 ft. of range for high contrast targets and aircraft windows or auto windshields degrade eye performance more than this limit. Therefore, the SCD-3 camera with a capability of 1.2 in. GRD per 1000 ft. with 180-mm lens and 1.2 in. GRD per 1000 ft. for 50-mm lens will be degraded to 6 in. GRD per 1000 ft. (or worse) when pictures are taken through an aircraft window, etc.

For the 50-mm lens, set focus at ∞ for range greater than 1000 ft. but for closer range judge the range the best way possible and set. For ranges less than 1000 ft. it is essential that the range be set accurately or a technique be used called "thru-focus flying". This simply means that the operator set a desired range on the camera and takes a long burst of frames as the aircraft approaches and departs the target area being sure that the range at the closest point of the flight is shorter than the range set on the camera. Some of the frames should be in focus if the other rules, noted above, are followed. Actual ranges must be set on the curser scale to better than 3/32 in. If error is as much as 3/16 in. you will lose 50% or more of resolution. For the 180-mm lens, set fucus at 5000 ft. and fairly good results will be obtained for ranges between 3000 ft. and ∞. For ranges less than 3000 ft. it is essential that the range be set accurately or a "thru-focus flight be made as described above. Actual ranges must be set on the curse-scale to better than 1/8 in. If the error is as much as 3/16 in. you will lose 50% or more of resolution.

Aircraft operation - through-focus photography should be used as described above and good pictures may be obtained to as close as 500 ft. range through a side or floor port on the aircraft. Do not take pictures through turbulent air or engine exhaust.

Helicopter operation - the through-focus photography technique can be used effectively but with many variations and to much shorter ranges. For example, the helicopter can move in and out sideways for a through-focus run to an extremely close range at low altitude. It has been found that main degradation is caused by incorrect focus rather than vibration from the ehlicopter (hand held without support from any portion of the helicopter). Successful photos have been made to better than 1/10 inch GRD at 150 ft. range with the 50-mm lens demonstrating what can be done.

Ground operation - standing or sitting without tripod. Focus is the main problem here. When not positive of the range, judge it to the best of your ability by comparison to some well used yardstick in your head such as the length of a football field, the 150 yd. marker from a golf hole, etc. then take a couple of shots and repeat with the range marker rotated about 1/4 inch on each side of your original guestimate. If the image is in motion it will still be less of a problem than in a flying operation so track with the scope and take a burst.

On all of the above operations, if time permits, the lock ring should be locked except when making a rapid thru-focus set of pictures.

The small view scope on top should be pointed at some easily identified portion of the target near the center of the desired coverage. When the camera has been stabilized on the object chosen as a target, the exposure switch on the camera should be depressed and held down until the desired number of exposures have been made. The camera operator should hold the camera on the chosen target during the entire sequence. Should the camera drift off the chosen target, the operator should swing the camera back to the proper pointing position instantly. This may smear one photograph in the sequence but will insure that the other photographs will be free of image motion from the camera repositioning.

The film cassettes will hold up to 250 frames, and in the continuous mode up to 30 frames can be taken in one flyby at an altitude of 2,000 feet. The continuous mode of operation will provide the best possibility of acquiring high-resolution photography. Because this camera system is extremely sensitive to image motion or smear the mirror should always be locked in the up position; ~~so that~~ therefore, the operator cannot see through the built-in view finder. The small view scope mounted atop the camera body operates as a view finder.

When loading and unloading film in the camera, follow standard instructions supplied with the Nikon camera.

5.0 Rationale of Operation

The basic rationale in the operation of this camera results in rules that must be fully understood and followed by the operator if he is to obtain the best results. Once the operator has accepted these basic rules he will have no problem taking pictures that consistently produce resolutions at or above the 200 1/mm-goal.

Rule 1. Smear in the image plane is the greatest hazard in taking high-resolution photography. As long as the image smear in a photograph is less than the grain size of the film in use, or is lower than the physical limit of the taking camera, the smear is not detected and does not affect the resulting photograph. If the grain size of the film is reduced or the lens-camera resolution is increased, the smear becomes detectable and apparent in the image plane. Smear, therefore, becomes the major stumbling block in taking high-resolution photography.

From this major assumption comes the idea of taking all photography at the shortest exposure time possible. With most 35-mm cameras this limit is 1/1000 of a second. Because grain size and speed of films usually do not permit a single exposure time under varying conditions, some special efforts had to be made in the development of the film and processing techniques that would offset this hindrance. This is discussed in the sections on film and processing techniques.

Rule 2.

move diagram and print about 3 lines above it before going to next page.

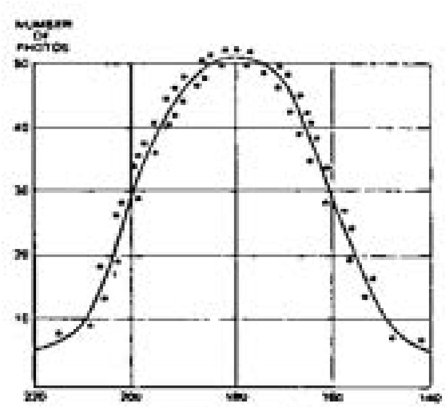


DIAGRAM 1. DISTRIBUTION OF PHOTOGRAPHIC RESOLUTIONS

Rule 2. If enough pictures are taken of the same scene to allow statistical averaging, the photographic resolutions will follow a bell-shaped probability (Gaussian) distribution (Diagram 1). This is only true when the smear component can be smaller than the grain size or lens-film resolution. A probability distribution of resolutions means that with a large enough sample there will always be some photos at the highest possible resolutions and equal number of poor or low-resolution photos. One-half of the photos will be above the mean or average resolution and one-half of them below this median resolution. In order to provide data for this rule, cameras were tested using as many as 150 pictures of the same scene; it was quickly found that ten to 15 pictures of the same scene had the same probability distribution as the large numbers. Therefore, it is suggested that every scene be photographed on at least ten frames and on 15 or more if time is available.

Rule 3. Film is the cheapest element in the entire camera system. Because the film presently used in this system costs about one cent per frame, it becomes readily apparent that it would take a long time to use a costly amount of film. Combining Rules 2 and 3 shows that the camera should always be operated in the continuous mode (four frames per second) and every burst should encompass ten or more frames.

Rule 4. A preselection of frames is necessary for exploitation. Because the frames all have differing resolutions and, therefore, differing values, a preselection of best and most valuable frames is necessary. It is usual to choose the three best frames from each scene and use these frames for exploitation. Sometimes a particular view angle or specific stereo angle requires the use of supplementary frames, but this occurs infrequently and is handled on an ad hoc basis.

Rule 5. The best photography can be obtained with the lens fully open. This rule is not fully true, some lenses show a slightly higher resolution at one-half to one stop away from the full open position. However, because the exposure time is kept at the minimum and the amount of available light diminishes as the lens is closed, the camera as a system will perform better with the lens fully open.

Rule 6. The human body is a better reducer of image motion than any equipment that could be built at the scale of this camera system. The body (mainly the muscles, tendons, and bones) can damp and remove much of the motion from a moving vehicle before the motion reaches the middle ear. If this were not true, continual vertigo (motion sickness) would occur every time a human body was put into contact with a moving vehicle. It is readily apparent from this that when a camera is held near the motion center of the body or close to the inner ear (in this case near the eye), the motion imparted from the moving vehicle is essentially damped and removed from the system by the interaction of the muscles and tissues of the body. Therefore, a hand-held camera will take a better picture from a vehicle than a mounted camera.

Because the statistical advantage of multiple photographs is used to increase the changes of obtaining a high-resolution photo, it is apparent that this same statistical advantage will occur when the camera is hand held. When the camera is operated at the high rate (four frames per second) over enough time (two and one-half or more seconds), some of the images will be blurred from motion of the body that has not been fully damped; however, most of the photography will be motion free and, therefore, smear free. This is true only when the camera is tracked against some constantly visible portion of the target and held on this same visible portion so that no apparent motion occurs. Actual photography is only occurring during a small percent of the time: the frame rate is four per second and the exposure time is 1/1000 second; the actual exposure time is 1/250 of the total time that pictures were being taken. It is very easy to hold a camera motionless for 1/1000 of a second and increasingly hard (the square of the change) with longer exposure times.

6.0 Technical Aspects

6.1 Camera Body

The camera body used in the SCD-3 camera is the Nikon "F2" standard motorized drive camera body with some modifications, i.e. rail alignment and lens screw mount instead of the standard bayonet mount. The rails that control the position of the film at the film plane must be in perfect alignment with the lens centerline to give the greatest resolution over the entire format. This alignment is critical to about 1/1000 of an inch. The rails are milled and polished to this accuracy and again checked for accuracy. When the required accuracy is achieved the lenses are then ready to be modified to the camera body.

The 250-exposure back for the Nikon F2 camera is individually fitted to the camera body with which it is to be used. Malfunctions in the shutter or film transport may result if the back is used with the wrong camera. If such malfunction occurs with a properly matched camera body and back, they should be returned to the nearest Nikon maintenance center for adjustment.

6.2 Lenses

Two lenses are furnished (Figure). The 50-mm-focal-length f1.4-Nikkor lens gives outstanding performance at long and short ranges. The 180-mm-focal-length f2.8 Nikkor lens has an advantage of a 3.3 times greater focal length, although image-plane resolution is less than for the 50mm lens. For long-range photography the net effect of these two factors on target resolution is to give an advantage of better than 2 to 1 in favor of the 180-mm lens if image smear is kept under control.

A considerable amount of work is involved in increasing the accuracy of the camera lenses in relation to the body-film combination. The most exacting requirement is to acquire true focus by determining the best focus position of the lens and setting the focus ring to allow the camera to take the best picture the lens is capable of taking.

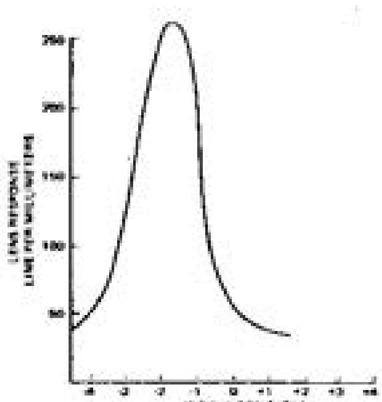


DIAGRAM 2. TYPICAL LENS RESPONSE AND FOCUS ERROR

The first task is to put the lens on a collimator and check the resolution capabilities (Diagram 2). The depth of true focus at infinity is very narrow and the lens must be set to an accuracy of within at least 1/1000 of an inch of true focus in order to record the resolutions the lens is capable of recording. The manufacturing company sets the lens focus on a short focal-length collimator to an accuracy of about 40 to 50 lines per millimeter. This short focal-length collimator (less than 30 inches) will allow focus to be set to about 1/200 of an inch. Because this satisfies the manufacturer's requirement for resolution, this is the extent of Nikon's test program.

The SCD-3 camera lenses are set to their required accuracy with a long collimator (100 inches) on which the minimum setting accuracy is approximately 1/2000 of an inch. A setting of better than 1/1000 of an inch is made with the lens on the camera body and film in the camera and acquiring multiple photos at several settings near the true focus position. This is accomplished on the collimator with targets in the collimator and after determination of where the true focus position lies. A range of true focus positions is established for different distances beyond the focus markings on the focus ring as delivered from the factory.

Each lens to be used with a particular camera body is made more accurate by this same technique. Each lens has been matched to one specific camera body; therefore, the components are color coded so that the specific lenses and bodies can be matched easily. Matching systems are also coordinated by serial numbers, but the color markings are easily seen and errors do not creep into the system when the color matching technique is applied.

Short focal-length lenses are less affected by smear than the longer lenses ~~and,~~ ; therefore, it is easier to build a smear-free system using short focal-length lenses. By changing the packing density to a much larger order of number (in this case resolution in lines per millimeter), it became feasible to use the shorter focal-length lenses. Because shorter lenses have small "f" numbers they can admit more light; this reduces the exposure-time problem as the focal length decreases.

6.3 BATTERY PACK AND CHARGER UNIT

The Nikon battery pack accomodates two Nikon power cells. Batteries should be checked after returning from a mission and recharged in the Nikon charger. The estimated life of fully charged Nikon power cells is as follows:

	36 frame roll	250 frame roll
Continuous use	___ rolls	___ rolls
Intermittent use	___ rolls	___ rolls

need data

6.4 Film Drives

There are two separate film drives available; a 36-frame drive and a 250-frame drive. Both these drives operate at the high cycle rate and operate basically in the same manner. The SCO-3 camera utilizes the 250-frame automatic drive for the obvious reason that it has a better capability to take numerous pictures and more target scenes without reloading. Any of the cameras can be outfitted with the smaller 36-frame drive if the operator prefers.

6.5 250-Exposure Film Cassettes

Damaged or improperly loaded film cassettes can cause total mission failure by preventing normal film transport.

New cassettes should be checked to determine that the inner shell rotates freely in the outer shell. If not, the interference can normally be eliminated by holding the outer shell in the left hand and rotating the inner shell inside the outer shell back and forth through the interference area under pressure of the right hand. Cassette parts should then be cleaned with a damp rag to prevent metal dust from getting into the camera.

Before loading with film, cassettes should always be checked for free rotation as above. Damaged cassettes should not be used.

In assembling and closing the cassette after loading it with film it is important to turn the inner shell clockwise only to the latching position. Turning it too far will leave it unlatched or will capture a full turn of film between the inner and outer shells.

In installing the cassettes in the 250-exposure back it is important to carefully follow the manufacturer's directions making sure the cassette snaps into place with the index mark on it properly lined up. If the cassette can be rotated in its socket, it is not installed properly. (Pressure exerted by foam pads inside the rear cover prevents such rotation when the rear cover is closed.) If a problem becomes apparent at any time during the process of installing the cassettes and checking for proper operation, start over at the beginning.

The 250-frame motorized back can also be used with commercially available 36-exposure rolls of High-Contrast Copy or other films. This involves releasing two thumb latches, removing the camera body from the motorized back and loading the 36-exposure roll of film in normal fashion (refer to the Nikon motor drive and camera body manuals), and then reinstalling the camera body in the motorized back and operating the same controls as with a 250-frame load. ck

6.6 Film

The basic film at present for taking high-resolution photography is emulsion 5069 high-contrast copy (HCC) film. This film was made for doing line drawings in the photo lab; however, it responds to POTA processing in such a way that processing essentially extends the speed of the film by a factor of three or more without changing the base fog by an appreciable amount. This film has an ASA rating of 64 under normal circumstances, but responds to POTA processing as if the speed were 180 or 200. This 5069 HCC film has the capability of recording 350 1/mm (medium contrast), considerably above the 200 1/mm goal for 5CD-3 camera uses.

6.7 Film Exploitation

The original negatives derived from this system are of better quality than that of most viewing equipment under normal use. The more exotic microscopes such as the B & L Zoom 240 are adequate for viewing this material. The material is also much better than most photo lab enlargers. The best available enlarger than can handle this quality material is the Beacon Printing Enlarger (the BPE) with the liquid gate platen. This material can be enlarged to 100 and 150 times with ease and still does not show the normal effects from such factors as grain size.

For proper exploitation of this material, it is suggested that the best quality optics available be used for viewing. When enlargements are desired, the enlarger should be the highes quality enlarger available. Duplicate positives of the original materials are usually made on 2430 duplicate stock in order to retain as much resolution as possible. The duplicate positives can then be viewed with the appropriate optics. Most viewing of the material is accomplished at 40X, 60X, or 100X. When viewing the material at a lower magnification much of the information is lost or unavailable.

6.8 Lens Cleaning Aids

How do you clean an optical surface? Carefully! The 50mm and 180mm lenses, and view scope have coated optical surfaces which can be scratched in the process of cleaning. Dusty or smudged areas on the surfaces of the lenses and viewscope optics will be out of focus and will have little effect on imagery unless the sun is shining directly on the dusty or smudged surfaces. For this reason it will normally be better to leave minor smudges untouched. Dust can be blown and/or brushed off optical surfaces with the blower brush. Since most dust will scratch glass and lens coatings, the blower brush should always be used as the first step in cleaning. If necessary to go beyond this step, a drop or two of lens cleaner on lens paper can be used to remove smudges. The lens paper should be formed into a mushroom shape and held by the stem. Under no conditions should the finger be used to apply pressure to the lens surface directly through a layer of lens paper.

7.0 ## PERFORMANCE DATA

The following performance data has been measured and/or computed for the optical components of the ~~mini~~ SCD-5 -camera as an aid to the selection of lenses for any given mission.

7.1 ### LENS FIELD-OF-VIEW AND RESOLUTION

Table 4 indicates the field-of-view for each lens as a function of range. It also indicates the resolution goals for the best frame out of one or more bursts. The ability of the system to deliver such resolution can be validated by static focus tests discussed in previous paragraphs. Getting similar performance on occasional frames in hand-held tests is evidence of full operator proficiency.

Table 4. Best-Frame Resolution Goals and Field-of-View for 50mm and 180mm Lenses

Range (ft)*	Ground-Resolved Distance (Target Resolution) (inches)**		Field Width (ft)***	
	50mm	180mm	50mm	180mm
500	0.55	0.22	325	100
1,000	1.1	0.44	650	200
1,500	1.7	0.66	975	300
2,000	2.2	0.9	1,300	400
2,500	2.8	1.1	1,625	500
3,000	3.3	1.3	1,950	600
4,000	4.4	1.8	2,600	800
5,000	5.5	2.2	3,250	1,000
7,500	8.3	3.3	4,875	1,500
10,000	10.9	4.4	6,500	2,000
15,000	16.5	6.6	9,750	3,000
20,000	21.8	8.8	13,000	4,000

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*These are slant ranges at altitudes between sea level and 5,000 feet barometric.

**Best frame, using High-Contrast Copy film, based on 200 lines per mm for a 50mm lens and 150 lines per mm for a 180mm lens, under best conditions. For mission planning, increase these values by the ratio of 3:2.

***Field in the 36mm direction of the format.

FIELD-OF-VIEW FOR VIEWSCOPES

Table 5 indicates the field-of-view for ~~each~~ the sight as a function of range.

Table 5. Field-of-View for 4X ~~and 7X~~ Viewscopes

Range (ft)	Diameter of Field-of-View (ft)
	4X Sight
500	73
1,000	147
1,500	220
2,000	293
2,500	365
3,000	440
4,000	586
5,000	730
7,500	1,095
10,000	1,470
15,000	2,190
20,000	2,940

These figures represent the following percentages of the field-of-view for lenses in the mini-camera I:

	4X Sight
50mm lens	
Vertical field	33.8%
Horizontal field	22.5%
180mm lens	
Vertical field	110%
Horizontal field	73%

Clearly, either viewscope will show most of the lens field when used with the 180mm lens. When the viewscope is used with the 50mm lens, the field-of-view is smaller than that of the 55mm lens. To insure proper coverage, center the target in the viewscope.

7.5 FULL-FIELD TARGET AREA FRAMING

Reflex mirror viewing can be accomplished without having the mirror operating during photography (which would degrade resolution). To obtain initial viewing of the target through the reflex mirror, move the mirror control to the ''down'' position and expose one frame to cause the mirror to come down for viewing. Then reset the mirror control to the ''up'' position and view the target. When the area of interest is properly framed in the viewfinder, note some feature at the center of the field, shift to the viewscope (sight), track the central feature, and take a burst of exposures. The mirror will go to the ''up'' position at the first exposure and stay up until the mirror control is next reset to the ''down'' position.

No.

7.4 WALL TARGETS (Investigate including a fold-out print of target in this manual.

Two 8- by 8-inch wall targets are provided* for use in field tests of resolution and focal position at a range of 50 feet. These targets are 11X enlargements of US Air Force Standard 1951 bar targets with medium contrast and have 42 steps at $\sqrt[6]{2}$ (1.1225) intervals, resulting in measurements from 0.00754 inch to 0.430 inch per cycle. Table 1 shows the image plane resolution corresponding to each step when the target is 50 feet from the camera. (The image plane mark on the camera body is set at 50 feet plus the focal length of the lens from the target.)

Table 1. Wall Target Calibration for USAF 1951, 11X, $\sqrt[6]{2}$ Bar Targets With Target at 50 Feet

Group	Element	Image Plane Resolution (Lines per mm With Target 50 Feet From Camera)	
		55mm Lens	180mm Lens
0	1	25.3	
	2	28.3	
	3	31.7	
	4	35.8	
	5	40	
	6	45	
1	1	51	15.5
	2	57	17.5
	3	63	19.8
	4	72	22.0
	5	80	24.5
	6	90	27.5
2	1	101	31
	2	113	35
	3	127	40
	4	143	44
	5	160	49
	6	180	55
3	1	202	62
	2	226	70
	3	251	79
	4	286	88
	5	320	98
	6	360	110
4	1	404	124
	2	452	139
	3	508	155
	4	572	175
	5	640	196
	6	720	220
5	1		248
	2		278
	3		311
	4		350
	5		392
	6		439

*In the space behind the foam liner in the top half of the attache case.

7.5 Field Focus Tests

The SDC-3 camera system is designed to provide a means by which the focus calibration and resolution performance of the system can be verified at any time in the field.

7.5.1 Static Focus Tests

Because focus accuracy is critical to system performance and may change as a result of use, provision has been made for field focus calibration by means of a through-focus run, according to the following procedure:

7.5.1.1. Load the camera with film and mount it on a tripod from which a 30-pound weight is hung for stability. Lock the reflex mirror in the "up" position. Mount the 55mm lens on the body and set the lens for f2.8 at 1/1000 second.

7.5.1.2. Tape a wall target* to an east-facing tripod (or wall) so that it will be illuminated by the direct early morning sun.

7.5.1.3. Use the sight to point the camera so the target is in the center of the field.

7.5.1.4. Starting from a position well beyond , turn the focus control knob counterclockwise until the 50-foot rotor index mark is at on the stator.

7.5.1 5. Expose one frame each with the 50-foot rotor index mark at , , etc., until the third division short of the 50-foot stator calibration mark (~~usually L-1, -2, -3, -4, or -5 for the~~ 50mm lens ~~and higher values for the~~ 180mm lens), as specified on the focus calibration sheet. Expose three frames each for the next seven successive stator divisions. Expose one frame for each of the remaining stator divisions, ending at "0". In case of overshoot at any division, go back to the start position and rotate the focus control knob counterclockwise again to the desired point. This action eliminates the effect of backlash in the internal focus thread of the lens.

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*In the space behind the foam liner in the top half of the attache case.

7.5.1 6. ~~When~~ After the film has been processed, the target images ~~will~~ may be read ~~out~~ to determine the best resolution in both directions for each frame. Plotting a curve of resolution in lines per mm vs rotor position will show the position in lines per mm (consult Table 1 for the wall target calibration).

7.5.1. 7. A similar procedure is followed with the 180mm lens.

These static focus tests ~~can~~ may be run at any time when there is reason to believe the focus of the camera/lens combination may have shifted. To aid in determining the cause of below standard mission imagery, it is recommended that an abbreviated through-focus test using the first 15 to 20 frames of the cassette be run prior to each mission, so that when the film is processed, the focus calibration ~~can~~ may be validated for that mission.

> Caution: After any through-focus run, be sure to reset the focus for the expected operational use, starting from a position well beyond   and turning the focus control knob counterclockwise until the desired rotor index mark is at the stator calibration point. revise

7.6 Hand-Held Tests

The ability of an operator to hold the camera steady can be verified at the time of the static focus test by having him use the camera, hand-held, to photograph the wall target at a 50-foot range, in one or more 15- to 30-frame bursts.

The ability of an operator to track a target from a moving vehicle can be verified by having him photograph the target in a 30- to 40-frame burst while being driven past ~~it.~~ the target. A speed of 2.5 miles per hour at a range of 50 feet simulates the angular tracking rate of an auto traveling 25 miles per hour at a 500-foot range or of an airplane at 100 miles per hour at a 2,000-foot range.

7.7 Image Smear

Because this camera system is extremely sensitive to image motion or smear, the internal mirror is locked into the up position and is not allowed to swing in and out of the view. This prevents the mirror slap from imparting a motion to the camera. This also eliminates viewing through the lens; ~~and~~ therefore, the camera is modified to allow target viewing with a small telescope or view scope ~~attached~~ mounted on top of the camera. The view scope has a magnification of 4X, 6X, or 8X according to the nominal distance at which the camera will be used. check ×

This view scope has several advantages for the operator. He has a better view of the target, and because he is looking at an exploded view of the target he can detect when he is not properly tracking the target and make adjustments to hold the target steady within his view. The view scope has crosshairs aligned with the optical axis of the camera so that a center of the target ~~can~~ may be chosen and used to eliminate motion.

With the extremely short exposure time mirror slap would occur during the exposure and add some smear to every picture. Elimination of smear is one of the reasons the camera attains the performance it does.

> Caution: In normal use of a through-the-lens viewfinder camera like the Nikon it is impossible to leave the lens cap on inadvertently during photography. However, In using the
> SCD-3 camera with a sight and the mirror locked up there is a possibility of leaving the lens cap on. The user should develop a routine and a check-list to prevent this from happening.

7.8 Precision Focus Settings and Depth-of-Field, 50mm Lens

Table 2. Precision Focus Settings and Depth-of-Field for Intermediate Values of Range to Target, Using the 50mm f1.4 ~~Micro-~~Nikkor Lens at Maximum Resolution (This data is for use where range to target is known -- that is, within the depth-of-field limits shown.)

Nominal Range (ft)	Rotor Index (ft)	Focus Settings (55mm Lens): Number of Divisions to Move Rotor Index to Left of Stator Calibration	Depth-of-Field* (ft): Near Field Limit	Depth-of-Field* (ft): Far Field Limit
50	50	0	47	54
55		1	52	60
61		2	57	67
68		3	64	76
76		4	71	85
86		5	80	97
100	100	0	91	113
120		1	105	138
150		2	124	184
200	200	0	160	268
300		1	218	440
500	500	0	320	840
840		1/2	420	1,000
∞	∞	0	840	∞

*There is an approximately 5% resolution loss at the near and far limits of the field.

79 Precision Focus Settings and Depth-of-Field, 180 mm Lens

Table 3. Precision Focus Settings and Depth-of-Field for Intermediate Values of Range to Target, Using the 180mm f2.8 Auto-Nikkor Lens at Maximum Resolution (This data is for use where range to target is known -- that is, within the depth-of-field limits shown.)

		Focus Settings (180mm Lens)	Depth-of-Field* (ft)	
Nominal Range (ft)	Rotor Index (ft)	Number of Divisions to Move Rotor Index to Left of Stator Calibration	Near Field Limit	Far Field Limit
500	500	0	470	530
550		1	510	590
620		2	570	680
710		3	650	780
840		4	750	930
1,000	1,000	0	880	1,140
1,250		1	1,080	1,480
1,750		2	1,380	2,100
2,000	2,000	0	1,600	2,650
3,500		1	2,300	5,600
5,000		1-1/2 (1 division from ∞)	3,000	15,000
9,000		2 (1/2 division from ∞)	4,500	20,000
∞	∞	0	9,000	∞

*There is an approximately 10% resolution loss at the near and far limits of the field.

8.0 Film Processing Techniques

Film processing is the single most important phase in using the SCD-3 camera to take high-resolution photography. The special film that is used in the SCD-3 camera requires special efforts in the photo lab to make the system perform at its highest potential.

Under normal photographic conditions, i.e., full sunlight and high sun angles, a simple POTA process using sodium sulphite (dessicated) and Graphadone "A" is used. This process is discussed fully in section 8.1 titled Simple POTA Process. When the photography has been exposed under other than ideal conditions, then a push POTA process is used.

When this push process is used, the film must be inspected under green light at intervals during the processing phase to insure that the proper processing level has been achieved. Because the film is being push-processed, the time of processing varies considerably with the changing light levels present when the photography was taken. The push process chemistry and mixing instructions are described in section 8.2 titled Push POTA Process.

Photography taken under fairly normal conditions such as clear days and medium sun angles will require approximately 11 minutes of processing at 80 degrees. Photography taken under the least desirable conditions--such as early-morning or late-evening low sun angle, or under full or pratial cloud cover, or low obliquity in high shadow areas--can take processing times of as much as 50 minutes at 90 or 95 degrees. Because of these variations, the operator taking the photographs must write on the film cassette the average taking conditions under which the film was exposed so that the laboratory will have guidance as to the amount of time needed to process the film.

These exacting techniques for the laboratory technician are required because the controls on the camera are locked into fixed positions to control the smear. These locked controls include: 1) the lens locked into the full open position, 2) the exposure time locked at 1/1000 of a second, 3) the camera controls locked into the four-frames-per-second mode, 4) the mirror locked into the up position.

Quality control in the laboratory is a necessity to insure that the quality of the imagery reaches the potential of the system. A Kodak safelight filter No. 3 dark green ~~can~~ may be used to inspect the film when processing has gone through approximately one-half of the normal processing level. With the special POTA processing used there is no discernible damage to the inspected film even when several inspections are required. The film will retain an excellent gray scale with no discernible base fog change over a very large range of processing times and temperatures.

8.1 Simple POTA Process

(Instructions for developing normally exposed emulsion 5069 film for very high resolution.)

8.1.1 Developer Preparation

While Stirring constantly, pour 3 grams of Graphadone "A" into one-half liter of water at 130°F. When chemicals are completely dissolved, add 30 grams of sodium sulfite (dessicated). When chemicals are completely dissolved, add cold water to make 1.0 liter of solution at 70°. Develop for 10 minutes with continuous agitation at 70°F.

This chemical process is adequate for all full-daylight exposures.

The chemical formula for low sun-angle and overcast photography is described in the extended response formulation that follows.

8.2 Push POTA Process

(Formulation for extending response of 5069 high-contrast copy film for under-exposed photography)

Developer Formula (quantity = one gallon)

Sodium Sulfite	379.0 grams
Graphadone "A"	0.76grams
Hydroquinone	19.0 grams
Borax	11.4 grams
Boric Acid	13.3 grams
Potassium Bromide	3.8 grams
Sodium Bisulfite	0.76grams

Note: Graphadone "A" will not go into solution at low temperature, it requires a temperature of 130°F. or more.

Mix above chemicals to maintain a temperature of 90°F. Nominal-exposure photography will require approximately 18 minutes in the above solution, while underexposed photography will take longer. Allow approximately 9 minutes extra for each stop of underexposure.

9.0 Equipment Operating Manuals

Manufacturer's manuals are provided for the camera body, 250-exposure motorized back, and lenses. Instructions are also provided for setting the combination lock on the attache case. These documents are behind the foam liner in the lid of the attache case.

10.0 Attache Case

The system is contained in an attache case with lockable latch.

11.0 Authorized Maintenance Support

Depending on the nature of the malfunction or repair requirement, maintenance may be performed in the field or by either the original equipment manufacturer or the system contractor who made equipment modifications and assembled and tested the final hardware.

In view of the importance of maintaining system optimization, it is recommended that only minor maintenance and adjustment be attempted in the field.

Problems with battery pack, motorized back and cassettes, camera body, or shutter may be referred to authorized Nikon maintenance centers, preferably those in the US listed here: EPOI, 362 Stewart Avenue, Garden City, N. Y. 11530; EPOI, 7000 North Ridgeway, Chicago, Ill. 60645; EPOI, 501 Folsom Street, San Francisco, Calif. 94105; EPOI, 355 South Douglas Street, El Segundo, Calif. 90245. Problems involving the lenses, the sights, their modifications, or optimum system performance should be referred to - - - .

12.0 Summary

The SCD-3 camera will provide 200 l/mm stereo photography when the camera is operated according to instructions.

The basic camera has been modified and, therefore, the camera-lens combinations MUST be kept together to insure that the lens matches the camera body.

The camera operator MUST follow the control locking instructions before taking any photos.

The camera operator must provide notations of photography taking conditions to assist the laboratory personnel.

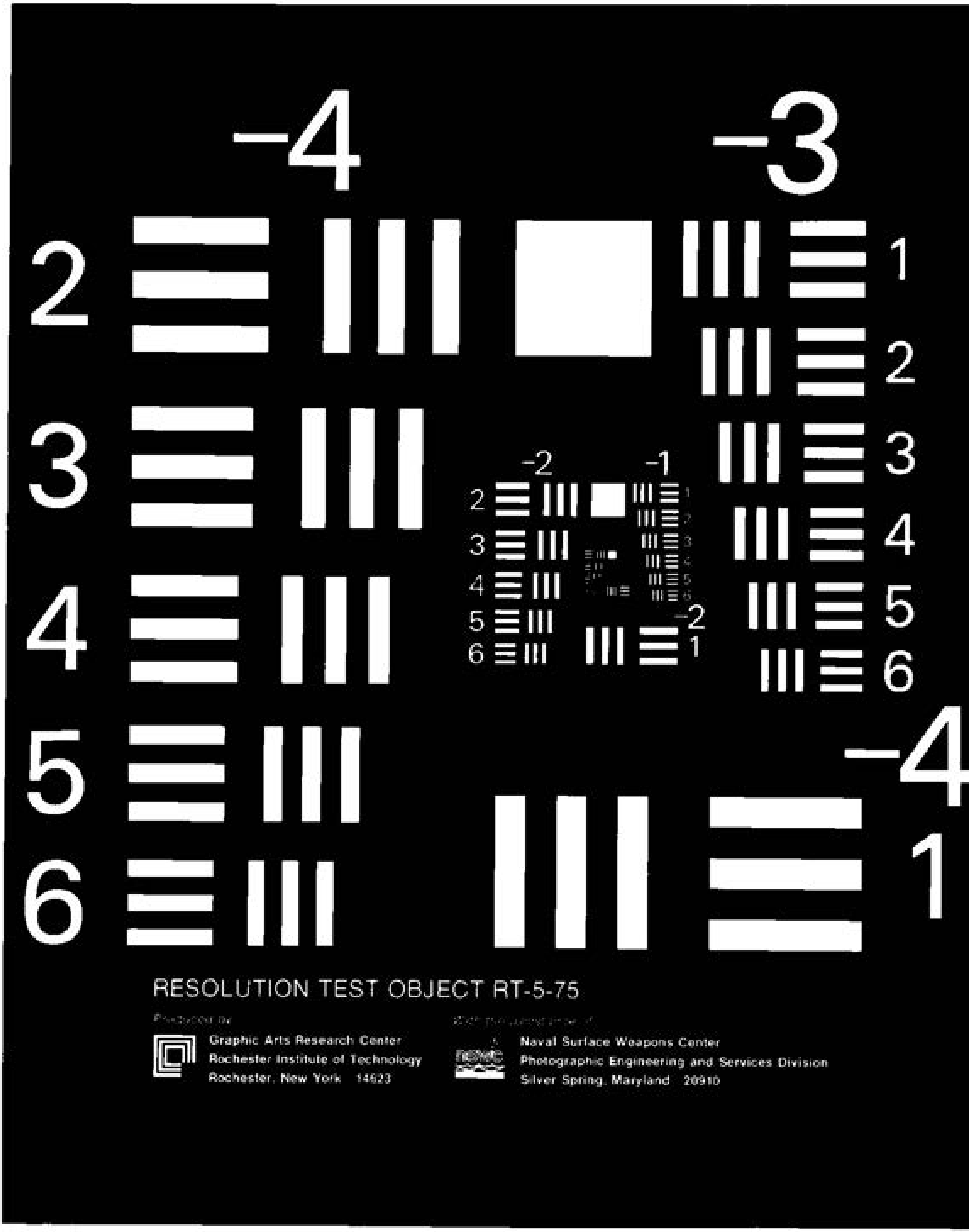
Film processing must be accomplished in a quality control environment or all the efforts to develop this highly accurate camera will be wasted.

The special chemical formulas MUST be used in developing the film to achieve consistent results of both 200 l/mm resolution and the full gray scale with no base fog.

Vic.

1. Omit cartoons
2. Be ~~consistant~~ on name of unit,
   SCD-, not mincom.
3. I'm not sure the explanation of why the focus adjustment is so critical is very clear - but wouldn't want to argue the point -
4. Section on the viewscope is fuzzy - what kind are we getting?

see individual pages.


RESOLUTION TEST OBJECT RT-5-75
Graphic Arts Research Center
Rochester Institute of Technology
Rochester, New York 14623
Naval Surface Weapons Center
Photographic Engineering and Services Division
Silver Spring, Maryland 20910