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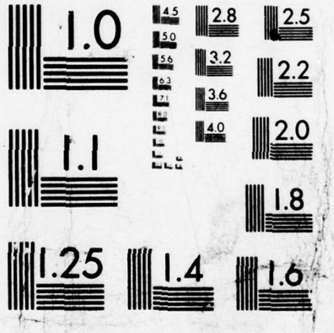

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HELICOPTER CANOPY INTERNAL REFLECTION INVESTIGATION

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report identifies a promising technique for reducing or eliminating aircraft canopy reflections from instrument panel light sources that impact on safe night flight of commercial and military aircraft. The concept involves the selective application of a light control film over the various cockpit light sources such that the aircrew can see the lighted instrumentation; however, the light is unable to reflect from the canopy because of microlouvers built into the material. A kit for the AH-1S helicopter, using this technique, was fabricated during this program and it will be field tested to verify effectiveness of the concept.

Earl C. Gilbert of the Aeronautical Systems Division served as project engineer for this effort.

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→ The reflections on helicopter canopies from instrument panel light sources adversely affect night flight operations. A program objective was to investigate the application of Light Control Film, such as 3M or equivalent material, as a technique for eliminating helicopter canopy reflections in the AH-1S from instrument panel lighting which cause the pilot and copilot night flight operational problems. A mock-up of the AH-1S was used to test and

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evaluate the reflection conditions. Light control technology was reviewed to uncover corrective techniques or materials. The most promising approach was to apply 3M Light Control Film on the face of instruments and control panels. Most reflections were eliminated using this technique. A few problem areas still remain which appear to be treatable by applying a soft glare shield extension that enshrouds the cockpit.

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BACKGROUND

Internal canopy and windshield reflections from cockpit lighting have been a problem for helicopter and fixed-wing pilots for most of modern aviation history. Simply stated, the light emitted from instruments and control panels during night flying "bounces" off the windshield or canopy and is seen by the cockpit crew as a reflected image. These reflections are distracting, interfere with external vision, and can be confused with light signals from the ground. The requirement for U. S. Army helicopters to use night terrain flight for threat avoidance and staying power gives the canopy reflection problem increased importance. The reflections that previously were an annoyance are now a serious hazard and degrade mission performance. Previous research has identified a technique for reducing this problem that involves the selective application of a light control film developed by the 3M Company. This program was to explore this technique as it applies to the attack helicopter, specifically the AH-1S (production). The AH-1S attack helicopter has quite a number of reflections that are intensified by the flat-plate canopy configuration. This flat-plate canopy, whose main purpose was to reduce sun glint signature, intensified the internal reflections seen on the canopy at night. The canopy was later modified for production with a slight curvature in the side transparencies to reduce the problem; however, reflections remain but are less distinct. To enhance safety of flight and increase mission effectiveness, this program was initiated to develop a means of reducing or eliminating the canopy internal reflection problem in the AH-1S.

PROGRAM OBJECTIVE

The objective of this program is to investigate the application of Light Control Film, such as 3M or equivalent material, as a technique for eliminating and/or reducing helicopter canopy reflections from instrument panel lighting in the AH-1S (production) which cause the pilot and copilot night flight operational problems.

SCOPE

The helicopter canopy internal glint control contract was divided into the following tasks.

Phase I - Problem Identification
Phase II - Cockpit Change Development
Phase III - Canopy Reflection Elimination Kit

The technology application being developed here is applicable to any aircraft with windshield or canopy internal reflections however, the scope of this contract is specifically limited to the reflections of the AH-1S (production) helicopter.

Internal canopy and windshield reflections from cockpit lighting have been a problem for helicopter and fixed-wing pilots for most of modern aviation history. Simply stated, the light emitted from instruments and control panels during night flying "bounced" off the windshield or canopy and is seen by the cockpit crew as a reflected image. These reflections are distracting, interfere with external vision, and can be confused with light signals from the ground. The requirement for U. S. Army helicopters to use night terrain flight for threat avoidance and staying power gives the canopy reflection problem increased importance. The reflections that previously were an annoyance are now a serious hazard and degrade mission performance. Previous research has identified a technique for reducing this problem that involves the selective application of a light control film developed by the 3M Company. This program was to explore this technique as it applies to the attack helicopter, specifically the AH-1S (production). The AH-1S attack helicopter has quite a number of reflections that are intensified by the flat-plate canopy configuration. This flat-plate canopy, whose main purpose was to reduce sun glint signature, intensified the internal reflections seen on the canopy at night. The canopy was later modified for production with a slight curvature in the side transparencies to reduce the problem; however, reflections remain but are less distinct. To enhance safety of flight and increase mission effectiveness, this program was initiated to develop a means of reducing or eliminating the canopy internal reflection problem in the AH-1S.

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PROBLEM IDENTIFICATION - PHASE I

AH-1S CANOPY REFLECTIONS

The AH-1S (production) helicopter is a single rotor attack helicopter with a tandem seating arrangement. The front seat is occupied by the gunner whose principal tasks involve target detection and the management/operation of weapons systems. The gunner's instrument panel contains communications and weapons system control panels, as well as flight and aircraft subsystems instruments. The rear seat for the pilot has mainly flight, navigation, aircraft subsystems, and communications controls/displays. Red integral lighting is used throughout. The canopy is made up of seven transparent panels. The three panels on top and front are flat plates. The four side panels have a slight curvature. Figure 1 gives general views of the canopy configuration.

To identify the specific canopy internal reflection problems, an AH-1S was placed in a darkened hangar and the cockpit lighting system was energized. Figure 2 shows the pattern of the canopy reflections seen from each seat. The shaded areas indicate the places where lighted control panels or displays cause reflections. All of the observed reflections were caused by light exiting the instrument panels. None were found to be caused by control panels on the side consoles. The three panels shown in the rear seat view of Figure 2 that do not appear in the front seat view are those that are behind the gunner's head and therefore could not show reflections. Figure 3 illustrates reflections seen by the gunner.

The dimming controls for the lighting system were exercised as an attempt at eliminating the reflections. A familiar pattern evolved where dimming the displays reduced the severity of the reflection, but eliminating the reflection rendered the display too dim to be readable. However, it should be noted that the display lighting showed good uniformity within each display, and good balance between displays. This has probably resulted in reducing the severity of the reflection problem. In general, the light sources causing the reflections were the instruments and control panels on the gunner's and pilot's instrument panel. The control panels on the side consoles did not appear to contribute any reflections.

MOCK-UP MODIFICATIONS

The test bed used in this program to conduct some experimentation in developing possible solutions to the internal reflection problem was a Government-supplied mock-up of the AH-1S

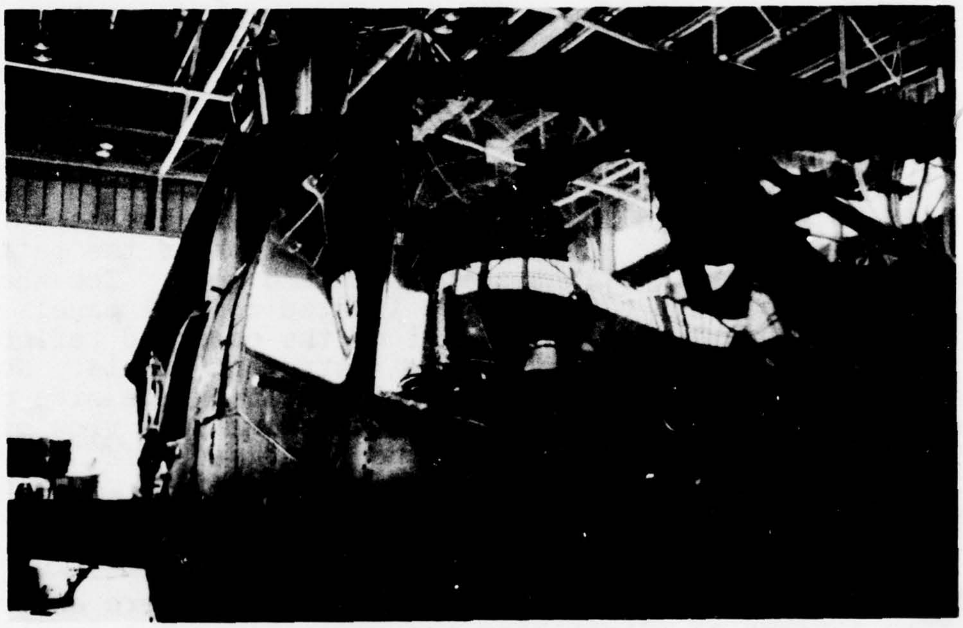


Figure 1. AH-1S (production) canopy.

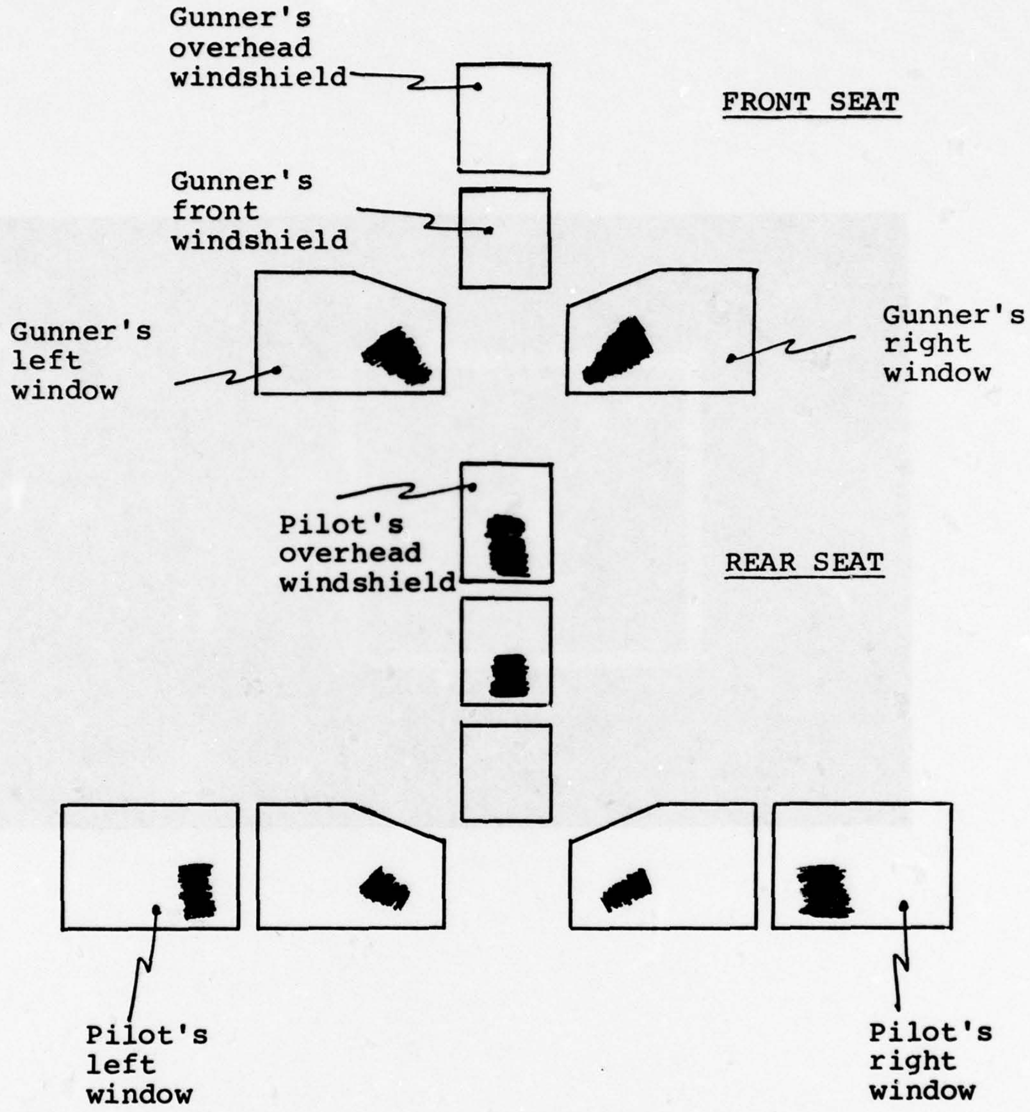


Figure 2. AH-1S canopy reflection map.

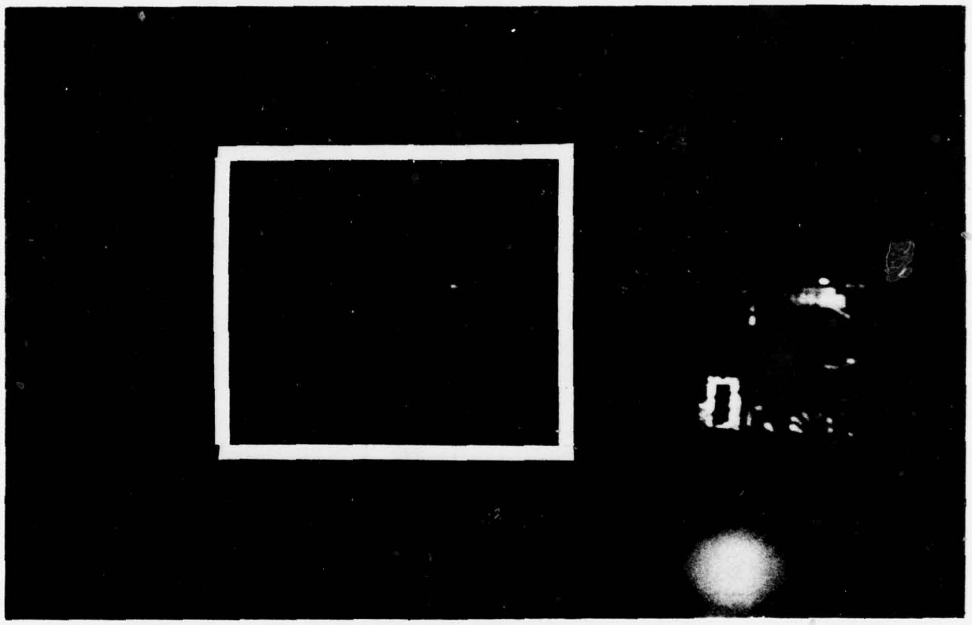


Figure 3. Example of lighted control panels and reflections (in box) seen by gunner.

canopy and cockpit section. As can be seen in Figure 4 the mock-up has a totally flat plate canopy. However, it was felt that this would present a "worst case" situation and that if the reflections could be prevented in the mock-up, the technique could be successfully transferred to the AH-1S aircraft.

The mock-up was modified by adding instrument panels, glare shields and side consoles. Red integrally lighted instruments and control panels similar to those used in the AH-1S were added to act as light sources. Figure 5 shows the interior of the mock-up after modification. AH-1S drawings and measurements from an actual aircraft were used to make the modifications so that cockpit geometry would be as correct as possible. No attempt was made to install components that had no role in the crew-canopy reflection-light source interaction.

LIGHT CONTROL TECHNOLOGY REVIEW

To eliminate the reflections, a number of approaches are possible.

- Block or absorb light rays from displays that would strike transparencies
- Bend light rays from displays so that all light exiting the displays is directed toward the crewman's eye
- Treat transparent panels with anti-reflection chemical coating
- Polarizing emitted light

Figure 6 presents graphical illustrations of these approaches.

To conduct the technology review vendors of light control materials, other airframe manufacturers who have attempted to deal with canopy reflections, and developers of anti-reflection coatings were contacted. A computerized literature search was also used to survey activity in the area of combating canopy or windshield reflections. The purpose of the review was to determine which of the approaches mentioned earlier was feasible for use on an existing production aircraft, and determine state of the art for each approach.

Existing Canopy Reflections

It may be helpful to review the problem that is the object of attention during this contract. Cockpit lighting is diffused light exiting an array of instruments and control

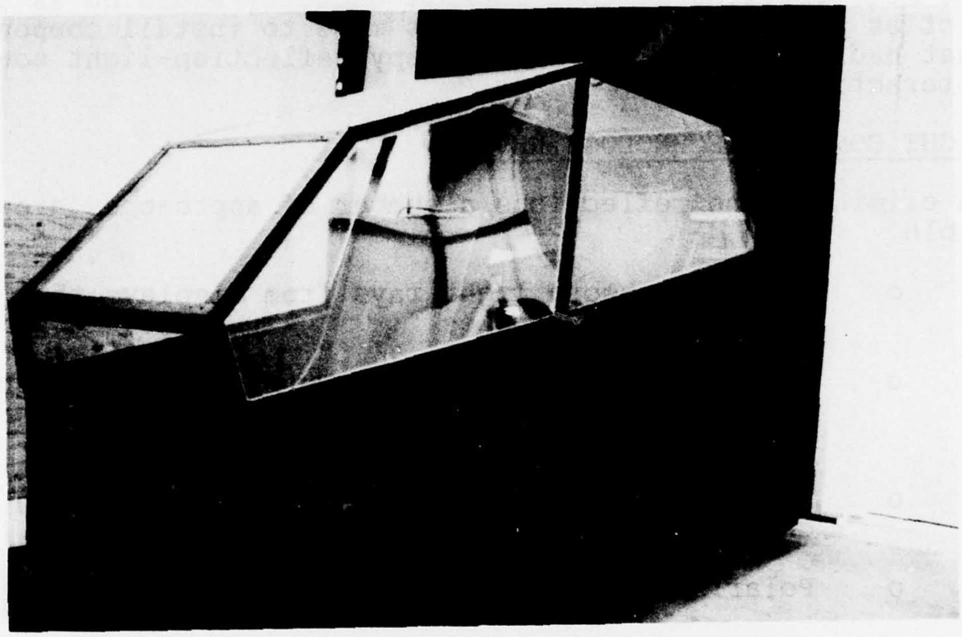


Figure 4. Government-supplied mock-up.

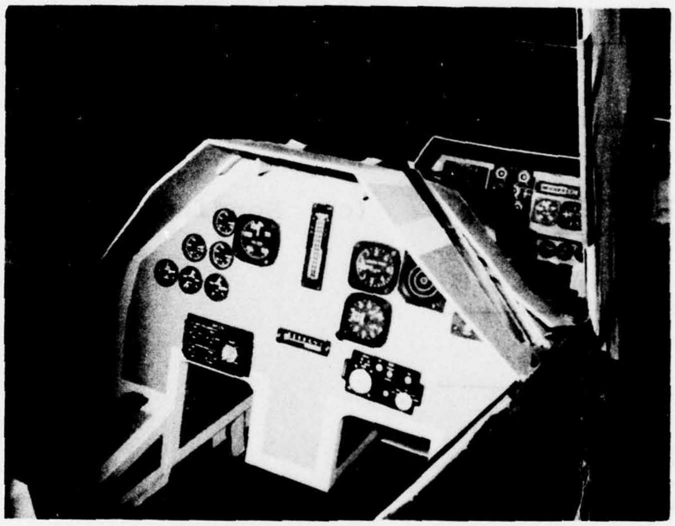
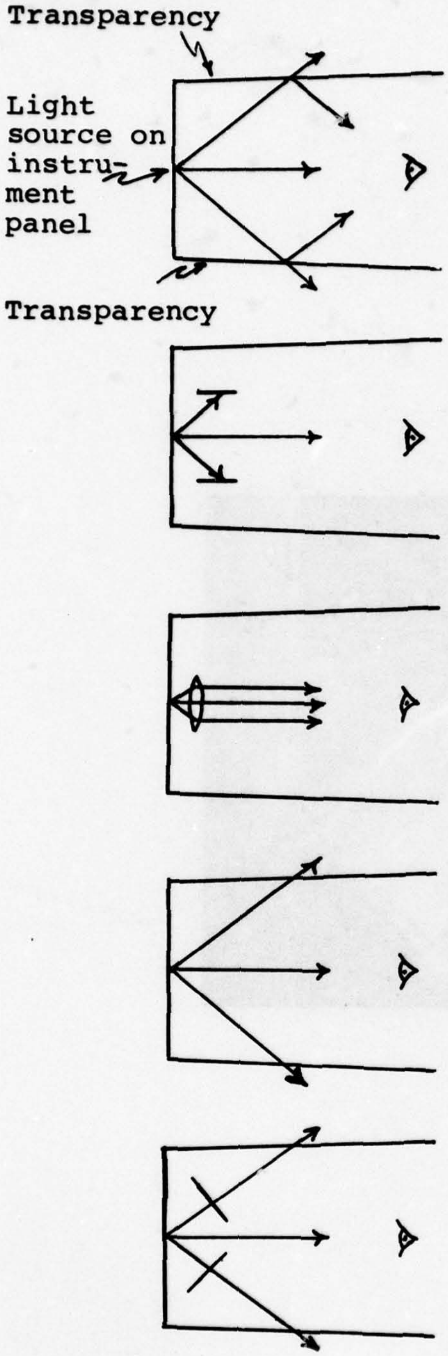


Figure 5. Modified mockup.



(a) Existing situation with canopy reflections.

(b) Blocking (absorbing)

(c) Bending

(d) Antireflection coating on transparency

(e) Polarizing emitting light

Figure 6. Approaches to eliminate reflections.

panels that cover a relatively large area in front of the crewman, oriented perpendicular to his straight-ahead line of sight. Some of the light from the illuminated displays is directed at the crewman's eye which allows him to read the information. The rest of the light is not useful and heads toward other areas of the cockpit, including the canopy or windshield that forms the transparent enclosure. Those rays strike the canopy and are reflected into the crewman's eye, which tends to obscure the view through the canopy. Figure 6a shows in plan view how light exits from an arbitrary point on the instrument panel in diffused form. One ray illustrated is seen by the crewman. The other two strike the canopy, with some of the energy being transmitted or absorbed and the remainder being reflected. The objective is to eliminate the reflected image which appears on the surface of the canopy.

Blocking or Absorbing Approach

The first approach that was considered used some mechanical means of blocking the unwanted light rays from getting to the canopy by placing an opaque, light-absorbing barrier in their path. Recognizing the fact that light exits from across much of the surface of the instrument panel, many such barriers are needed. They must be of sufficient depth and closely spaced so that only those rays heading toward the crewman are allowed to escape. Yet, readability of the displays is an important issue, so the barriers must not obstruct the crewman's view of an instrument face.

Large barriers running vertically adjacent to displays on the instrument panel that were a few inches deep had been tried with little success. Mock-up testing during this program also showed that large barriers were less than an optimum solution. The size of the barriers, or fences, tended to obscure some instrument faces when the crewmembers' head is moved. The direction then taken was toward using very small, thin barriers closely spaced and placed over the displays. Two products were found to fit this description. The first material is much like a black honeycomb laminated between glass or plastic outer layers. The honeycomb material called MICRO-MESH acts as the light barrier and has been found to be very effective in enhancing contrast on a CRT in high ambient light conditions. Placing this material over an instrument face or other display would probably work in the desired way; however, the cost of the material at $400-$500 for one ship's set is considered quite high. Also, a 12-month lead time for delivery, a transmittance of 30%, and a thickness of .25 inch were detrimental to the application.

Another material is made by 3M called Light Control Film (LCF). This is a set of microlouvers laminated in plastic that act as light barriers much like a venetian blind. This construction makes LCF well suited for application over integrally lighted controls and displays. The LCF is readily available with a number of viewing angles, louver slant, colors, and surface treatments. Material cost is about $100 for the amount needed in a ship's set. Thickness is either .030 or .050 inch. LCF has been successfully used for a comparable application involving integral lighting with some success.

No other materials that could act as light barriers were uncovered during this technology review. Of the two materials cited above, the LCF is considered superior in this specific application when taking the approach to absorb light that would be incident to the canopy.

Light Bending Approach

A second approach considered to eliminate canopy reflections was to bend any light that would be incident to the canopy so that it would be directed at the crewman instead. As Figure 6c shows, this must be accomplished by placing a lens or other optical system in front of the light emitting surface. The cockpit display system of the F-18 Hornet, composed mainly of CRT's, uses a field lens with a CRT for this very purpose. The effect is that all light exiting the CRT is directed, or collimated, toward the pilot, rather than diffusing toward all areas of the cockpit.

In place of a relatively bulky field lens, it was felt that a thin fresnel lens could be used as the instrument cover glass to accomplish the same thing. However, in pursuing this line of thought, two problems arose. First, this program is dealing with existing aircraft instruments. This means that extensive modification of the instrumentation package is impractical. Second, no commercially available fresnel lenses were found with a sufficiently short focal length. Also, the grooves in the fresnel lens tended to distort the instrument face to an unacceptable degree.

After a limited amount of investigation and experimentation involving the readability of instrument faces with fresnel lenses and the ability of the fresnel lens to prevent stray light from reaching the transparencies, this approach was abandoned. Further research was beyond the scope of this program, but this concept may be worthy of research by others with interests in optics or instrument construction.

Anti-Reflection Coating on Transparency

For quite a number of years lenses for optical devices such as telescopes and cameras have been coated with anti-reflection compounds to increase transmissivity and decrease specular reflections. Aircraft instruments have made use of this technology by treating the cover glass to enhance the readability of the instrument face. These coatings are very efficient across most of the visible spectrum, but do tend to reflect small percentages of light at the higher frequencies. Extensive work has been done recently to make a "second generation" anti-reflection coating that is more efficient and durable. However, all the coatings that were encountered were most efficient when light struck the surface at small angles to the normal. Since the reflections in the AH-1S have an angle of incidence of 30° to 80°, the anti-reflection coatings were found to be ineffective for use on the canopy transparencies.

Polarizing Light

The light which exits a cockpit display contains a mixture of waves linearly polarized in a large number of transverse directions. When this light strikes the canopy (a reflecting surface) there is a preferential reflection for those waves in which the electric vector is vibrating perpendicular to the plane of incidence. It was originally thought that a polarizing filter could be used over the cockpit displays to absorb the light waves that vibrate perpendicular to the plane of the canopy, thereby eliminating a large part of the reflection. However, the light is emanating from a relatively large area and the canopy is far from perfectly flat. Therefore, the impact of polarizing filters on canopy reflections would be minimal. This contention was verified during the mock-up investigation when circularly and linearly polarized filters were placed over displays on the gunner's and pilot's instrument panel. The filters had no impact on preventing canopy reflections.

COCKPIT CHANGE DEVELOPMENT - PHASE II

Using the modified mock-up as a test bed, tests were conducted to provide a comprehensive understanding of the canopy reflection problem. The critical data that needed to be generated involved the geometric relationship of light source, canopy planes, and crew members' eye points. Figures 7, 8 and 9 show these interactions in various views. For purposes of clarity, only three light sources on each instrument panel are shown. Since the cockpit and crew seating is symmetrical about the centerline of the aircraft, only the right side reflections will be analyzed in this report. Testing has verified the fact that canopy reflections are duplicated on the left side.

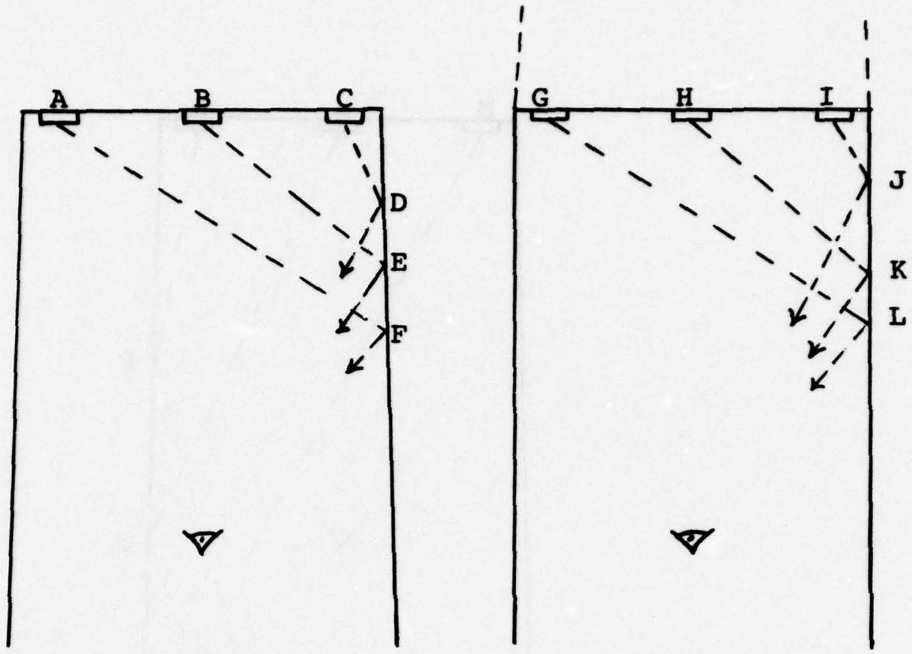
Table 1 shows the approximate exit angles (from the normal to the instrument panel surface) of light leaving lighted displays that cause canopy reflections. Also included is the viewing angle from the display to the crew member's eye. An inspection of this data reveals that reflections for the first two cases (gunner's eye - gunner's lights and pilot's eye -pilot's lights) are caused by exit angles greater than 30°, while viewing those displays requires approximately 20°. Since the crew can be realistically expected to move their heads during flight, expanding the viewing angle requirement to 30° would not be unreasonable. Therefore, blocking light exiting a lighted display at greater than 30° should prevent reflections, while allowing each crewman to read his own instruments.

In the third case, reflections seen by the pilot caused by gunner's displays, the exit angles are less than 30°. This means that blocking these reflection-producing light rays will not allow the gunner to see his own instruments.

Overhead reflections were found to be present only for the pilot, as shown in Figure 9. Exit angles causing reflections are approximately 35° in the vertical plane. Reflections in the side transparencies discussed earlier were in the horizontal plane. Eliminating reflections in both planes entails restricting the pilot's view of the displays to a cone shaped projection. The inclination of the cone must also change as his viewing angle changes from the top of the instrument panel to the bottom.

LIGHT CONTROL FILM TESTING IN MOCK-UP

As mentioned during the discussion on technology review, the most promising candidate material for reflection reduction was 3M Light Control Film (LCF). LCF is a thin plastic sheet

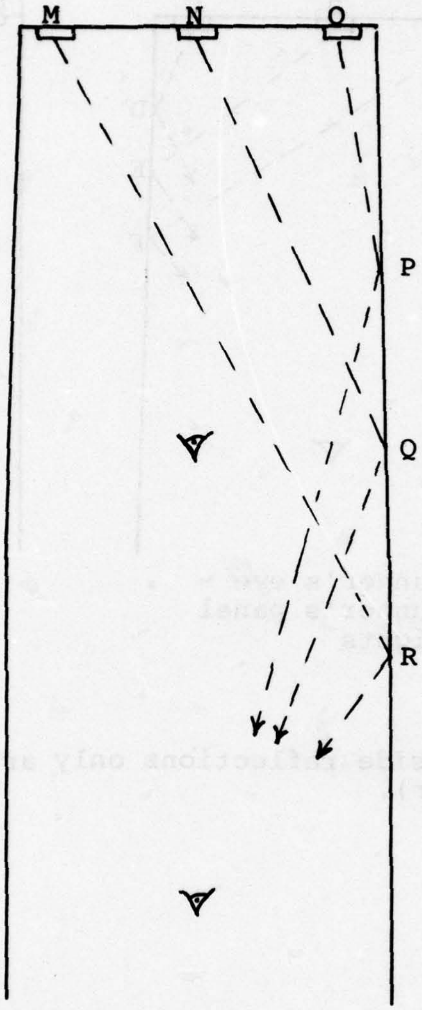


Gunner's eye -
gunner's panel
lights

Pilot's eye -
pilot's panel
lights

(Right side reflections only are shown. Left side is similar).

Figure 7. Plan view of canopy reflection geometry.



Pilot's eye -
gunner's panel lights

(Right side reflections only are shown. Left side is similar).

Figure 8. Plan view of pilot's reflections from gunner's instrument panel.

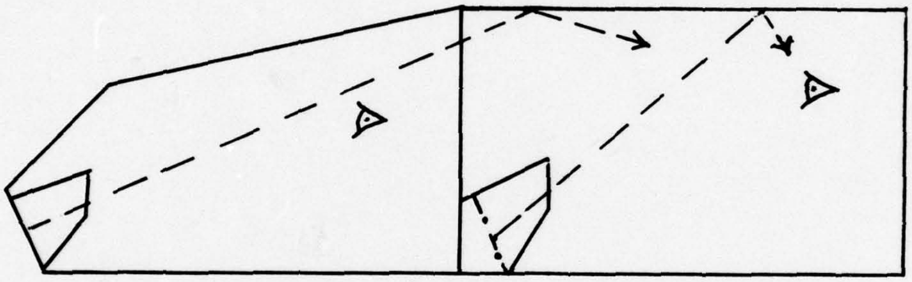


Figure 9. Side view of canopy reflection geometry.

TABLE 1. EXIT AND VIEWING ANGLES FOR AH-1S INSTRUMENT PANELS

		Exit Angle	Viewing Angle
Gunner's Eye - Gunner's Lights	A-F	45°	+20°
	B-E	41°	0°
	C-D	36°	-20°
Pilot's Eye - Pilot's Lights	G-L	54°	+22°
	H-K	45°	0°
	I-J	30°	-22°
Pilot's Eye- Gunner's Lights	M-R	27°	
	N-Q	24°	
	O-P	12°	

(.030 in.) incorporating black microlouvers to control the viewing angle of a display. Figure 10 shows the basic mechanics of LCF.

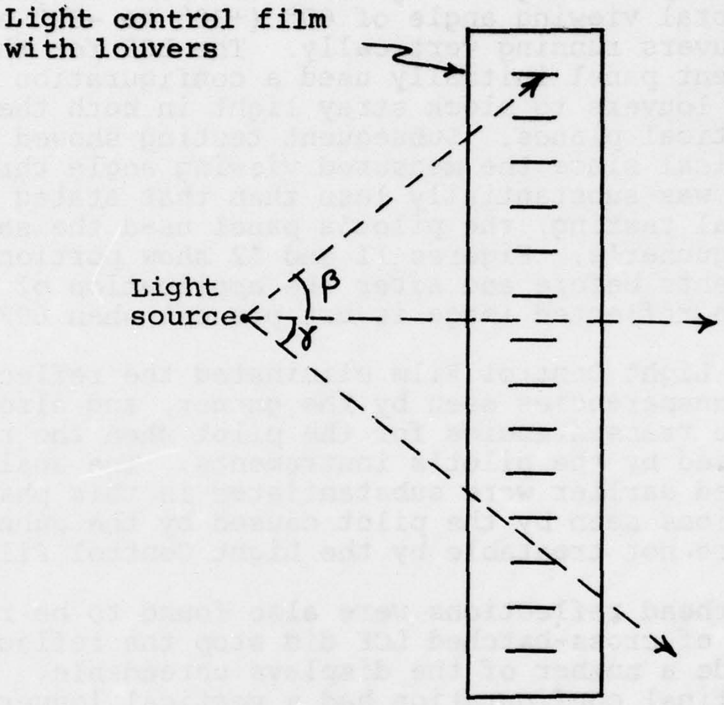
LCF is available commercially in a number of configurations that vary the distance between louvers to affect the viewing angle, and also with various louver slants.

For mock-up testing the LCF selected for the gunner's panel had a total viewing angle of 60° (+30° to -30° exit angle) with louvers running vertically. The LCF for the pilot's instrument panel initially used a configuration with cross-hatched louvers to block stray light in both the horizontal and vertical planes. Subsequent testing showed this to be impractical since the measured viewing angle through the louvers was substantially less than that stated by the vendor. For final testing, the pilot's panel used the same material as the gunner's. Figures 11 and 12 show portions of lighted instruments before and after the application of LCF. Note that the reflected image is not present when LCF is used.

The 60° Light Control Film eliminated the reflections in the side transparencies seen by the gunner, and also those in the side transparencies for the pilot when the reflections are caused by the pilot's instruments. The analytical efforts described earlier were substantiated in this phase. The reflections seen by the pilot caused by the gunner's instruments are not treatable by the Light Control Film method.

The overhead reflections were also found to be residual. The use of cross-hatched LCF did stop the reflections, but also made a number of the displays unreadable. The LCF used in the final configuration had a vertical louver orientation and did not affect the overhead reflections. However, these reflections are almost directly over the pilots head, and probably do not pose an obstruction of external vision under most flight conditions.

Photometric measurements of light exiting cockpit displays were made using a Pritchard 1980A photometer. The light was measured on a lighted display at an exit angle that would result in a side canopy reflection for the gunner. Display brightness was 1.152 foot lamberts at 5 volts. With the 60° light control film installed, display brightness at the same exit angle was reduced to .0062 foot lamberts. When viewed normal to the instrument face, the light control film attenuates 20-25% of the light. Since aircraft instruments are rarely used at their full rated voltage, the small amount of attenuation can be compensated by increasing the lighting rheostat setting.



Light rays exiting at angles less than γ pass through LCF.

Light rays exiting at angles greater than γ (such as β) are blocked.

Figure 10. Light control film (LCF) mechanics.

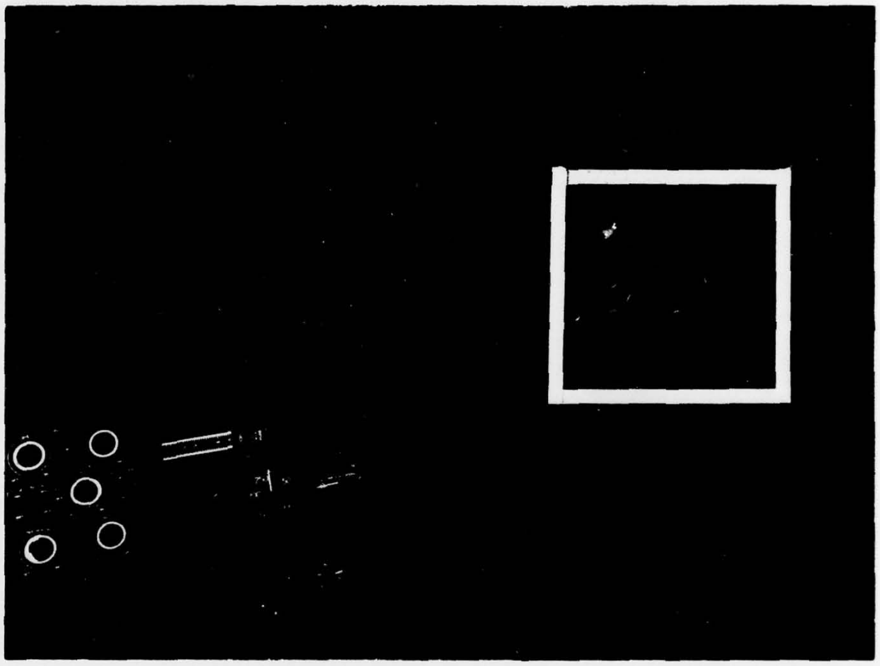


Figure 11. Darkened AH-1S mock-up with lighted displays showing reflections on side transparencies (without LCF).

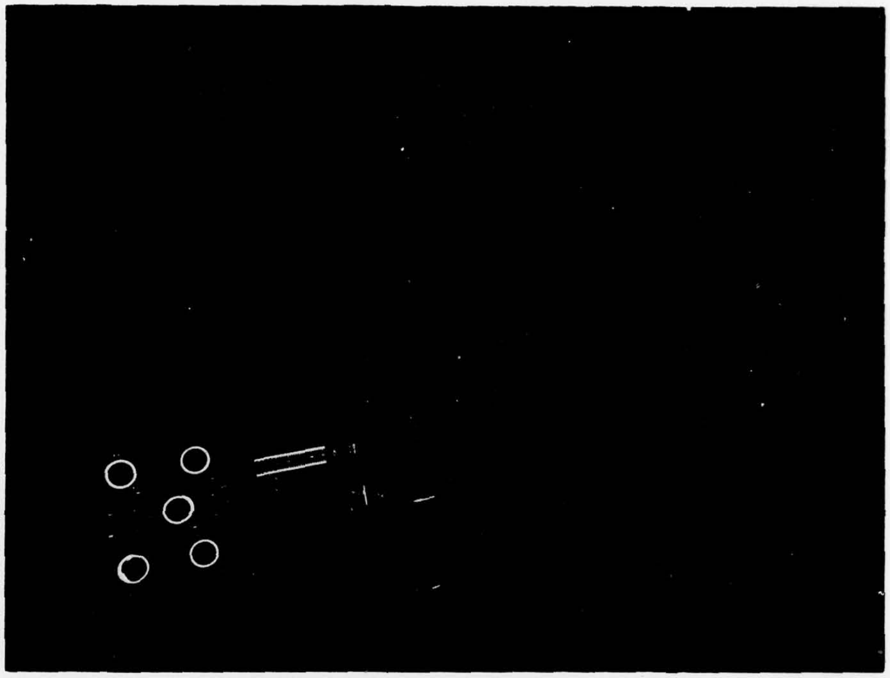


Figure 12. Darkened AH-1S mockup showing lighted displays with reflections absent (with LCF).

OTHER COCKPIT CHANGES

A review was also made of other potential changes or alterations to the instruments, glare shield, test material or cockpit area that would enhance effectiveness of the light control film concept and improve field of view considerations. Attempts were made to reduce glare shield sizes to increase external vision, but readability of the instruments in sunlight was found to be compromised. Fences (light barriers) at the instrument panel, recessing instruments, and fences between pilot and gunner were all tried without success. These techniques either did not prevent canopy reflections, or obscured the faces of some instruments.

The one option that met with success was a type of soft glare shield extension involving a fabric that enshrouds the cockpit. The fabric (which should be black nomex or other flame resistant cloth) is stretched down the cockpit length to connect the front and rear glare shields at the sides with an appearance similar to a kayak. Figure 13 is a sketch of this concept installed in the AH-1S. If installed properly, the shroud should pose no obstruction to external vision. Fastening it with hook and pile fasteners (Velcro) will assure that it will not impede emergency egress or rescue. When tested in the mock-up, the "kayak" technique reduced reflections to a very large extent, and greatly enhances the light control film application. The sides of the "kayak" shroud greatly reduced the reflections in the side transparencies. The forward section of the "kayak" that extends the top of the glare shield greatly reduces overhead reflections seen by the pilot that are caused by both instrument panels, if a shroud is used in the rear cockpit as well. It should be noted that a "kayak" around the gunner's seat was the only means found that prevented the pilot from seeing residual reflections caused by the gunner's instruments, even after the application of Light Control Film.

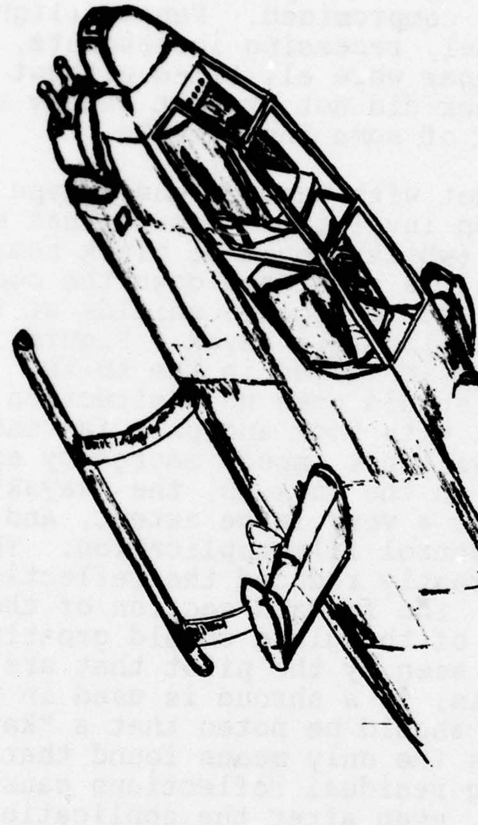


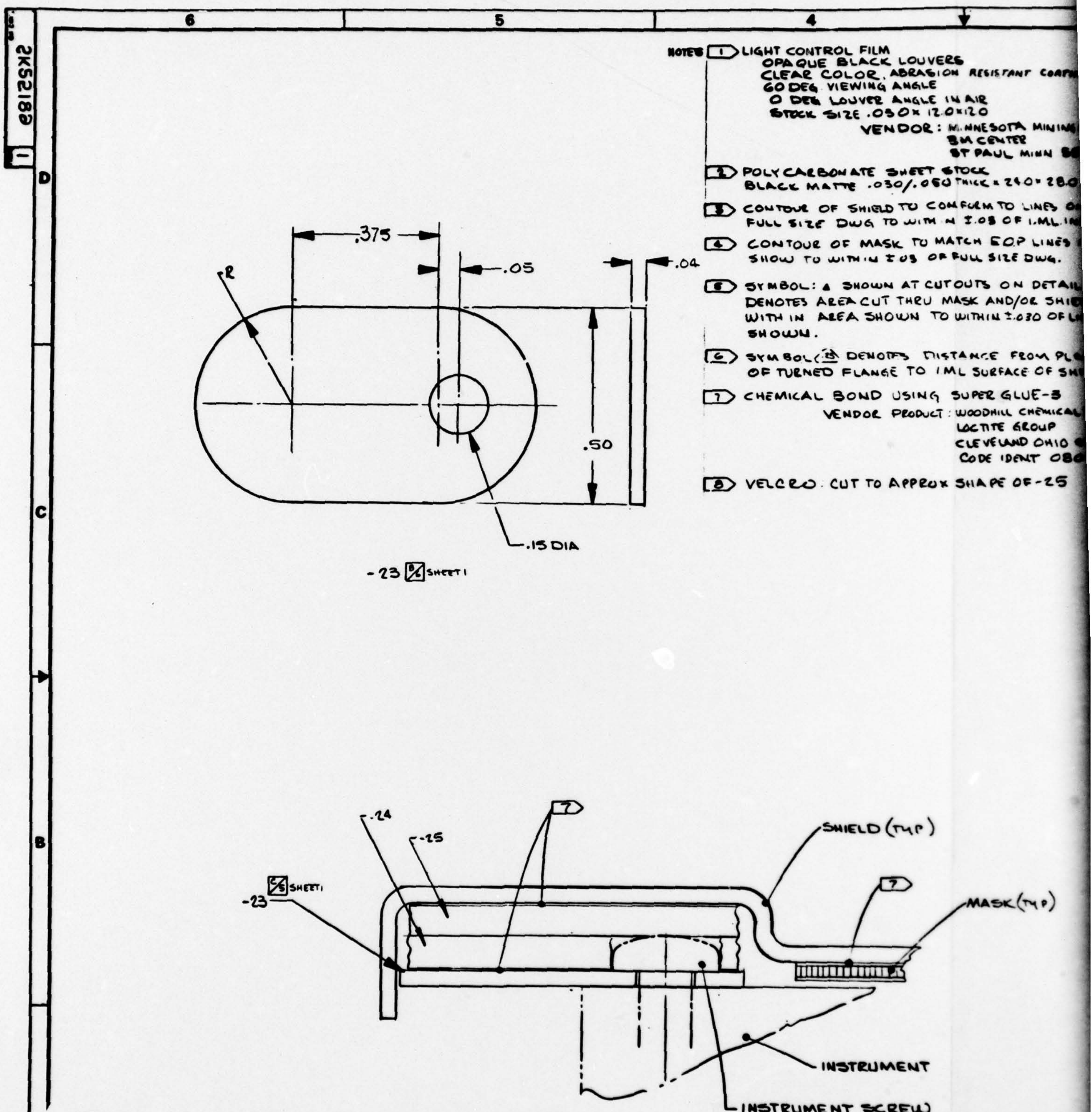
Figure 13. Soft glare shield extension to enhance light control film installation.

CANOPY REFLECTION REDUCTION KIT

KIT DESIGN

Once the configuration of light control film and where it was to be applied was decided, the major remaining task was to design a kit that allows the crew to easily place LCF on the instruments for night flying. Placing individual pieces of LCF over each instrument would obviously not be an acceptable method of applying LCF in the cockpit since it would be very time consuming to prepare for a night flight and require the flight crew to keep track of a large number of pieces of hardware. The kit design that was used to minimize the number of items to be manipulated involved plastic masks that fit over sections of the instrument panels. The drawings for the kit (light incidence controlled emission panel assemblies) fabrication are presented in Figure 14. A set of molds were made that duplicated the contours of the displays and controls on the instrument panels to be treated. Polycarbonate plastic was heated and vacuum-draped over the molds to form the mask body. Holes were cut in the masks for viewing the displays and to provide clearance for controls. LCF was then bonded to the masks so that all light exiting displays and control legends were treated by LCF. The masks are then fastened to the instrument panel using Velcro tabs for easy application and removal.

The kit consists of five masks (two for the gunner and three for the pilot) as shown in Figure 15. The surfaces of the mask must be a low reflectance black to be compatible with night vision goggles and fit in with the cockpit furnishings of the AH-1S.



NOTES 1 LIGHT CONTROL FILM
OPAQUE BLACK LOUVERS
CLEAR COLOR, ABRASION RESISTANT COATI
60 DEG VIEWING ANGLE
0 DEG LOUVER ANGLE IN AIR
STOCK SIZE .030 × 12.0×12.0
VENDOR: MINNESOTA MINING
3M CENTER
ST PAUL MINN

2 POLYCARBONATE SHEET STOCK
BLACK MATTE .030/.050 THICK × 24.0 × 28.0

3 CONTOUR OF SHIELD TO CONFORM TO LINES O
FULL SIZE DWG TO WITHIN ±.03 OF I.ML. IN

4 CONTOUR OF MASK TO MATCH E.O.P LINES
SHOW TO WITHIN ±.03 OF FULL SIZE DWG.

5 SYMBOL: ▲ SHOWN AT CUTOUTS ON DETAIL
DENOTES AREA CUT THRU MASK AND/OR SHI
WITH IN AREA SHOWN TO WITHIN ±.030 OF L
SHOWN.

6 SYMBOL (.25) DENOTES DISTANCE FROM PL
OF TURNED FLANGE TO IML SURFACE OF SH

7 CHEMICAL BOND USING SUPER GLUE-3
VENDOR PRODUCT: WOODHILL CHEMICAL
LOCTITE GROUP
CLEVELAND OHIO
CODE IDENT 08

8 VELCRO CUT TO APPROX SHAPE OF -25

Figure 14. Light incidence controlled emission panel assemblies.

HOLDING DEVICE DETAIL (TYP)
10X SIZE

3 2 1

ING BOTH SIDES

N & MFG CO.

5101

O

ON
INDICATED.

AS

IL PARTS
IELD
LINES

LANE
SHIELD.

AL SALES CO

) 44128
3028

REV STATUS					

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ALL ZONES REVISED	3/16/73	

D

C

B

-7	-6	-5	-4	-3	QTY REQD -2	QTY REQD -1	FSCM	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	FT WT	CALC UNIT WT	ACT UNIT WT	REV LTR
1	2	2	2	2				-25	VELCRO UPPER	B5 1	8						
1	2	2	2	2				-24	VELCRO LOWER		8						
1	2	2	2	2				-23	MTG PLATE	B6 1	2						
1								-22	MASK	B6 3	4 1						
1								-21	MASK	D5 3	4 1						
	1							-20	MASK	B3 3	4 1						
				1				-19	MASK	B3 2	4 1						
		1						-18	MASK	B6 2	4 1						
		1						-17	MASK	C6 2	4 1						
			1					-16	MASK	D4 2	4 1						
			1					-15	MASK	A5 2	4 1						
	6	3	1	4				-14	MASK	C3 2	4 1						
				1				-13	MASK	C3 2	4 1						
								-12	SHIELD	B5 3	3 2						
								-11	SHIELD	B3 3	3 2						
		1						-10	SHIELD	B5 2	3 2						
			1					-9	SHIELD	B4 2	3 2						
				1				-8	SHIELD	B3 2	3 2						
					1			-7	ASSY MASK	B6 3							
					1			-6	ASSY MASK	B4 3							
						1		-5	ASSY MASK	A5 2							
						1		-4	ASSY MASK	B3 2							
						1		-3	ASSY MASK	B2 2							
								-2	PANEL ARRANG	A5 3							
								-1	PANEL ARRANG	A5 2							

PARTS LIST

A

BOEING VERTOL COMPANY
PHILADELPHIA PENNSYLVANIA 19142

LIGHT INCIDENCE
CONTROLLED EMISSION
PANEL ASSEMBLIES

F.T. Wilson 3/4/73

SIZE	FSCM NO	
J	77272	SK 25189

SH 1 OF 3

SK 25189

3 2 7430 1

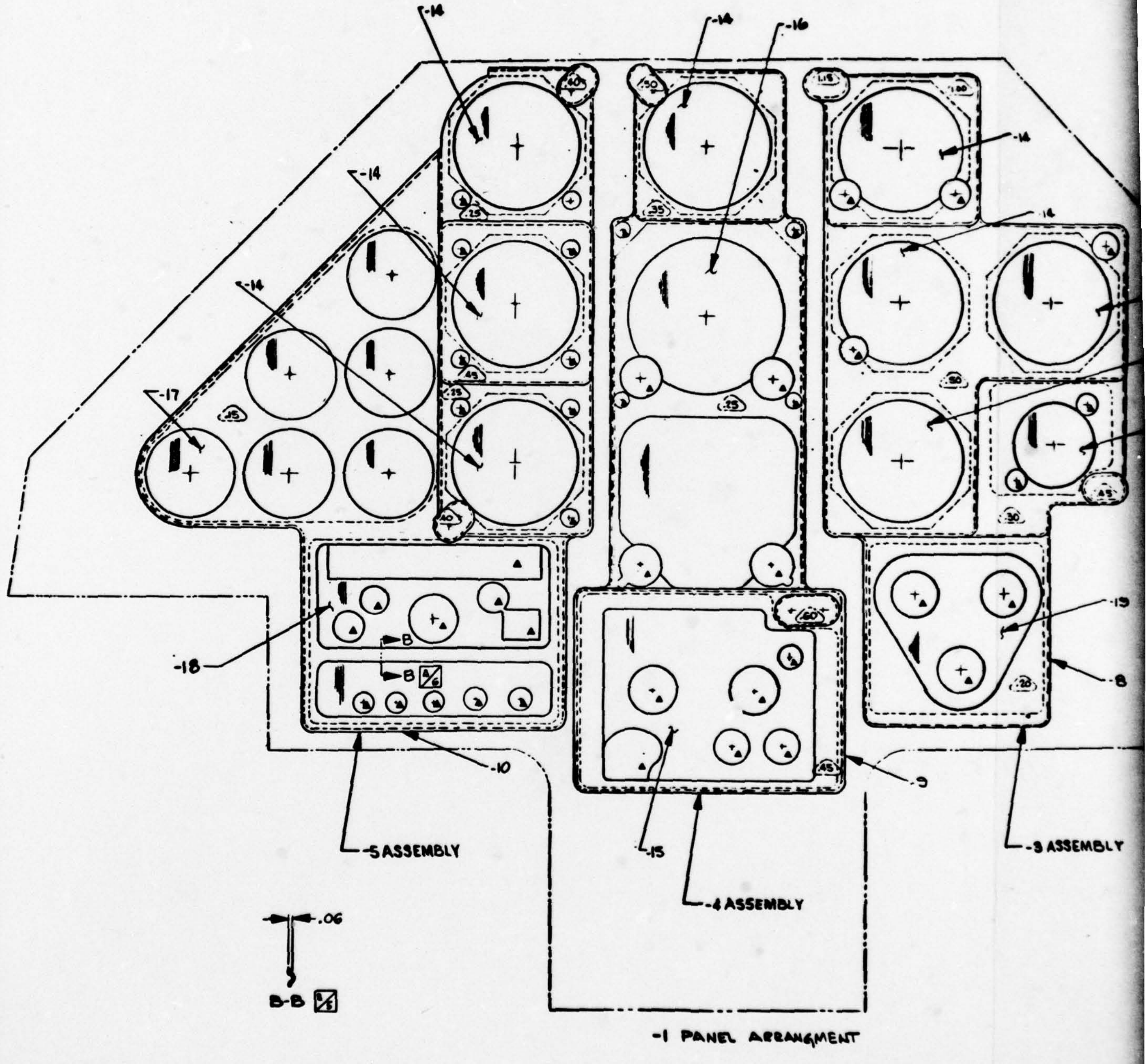
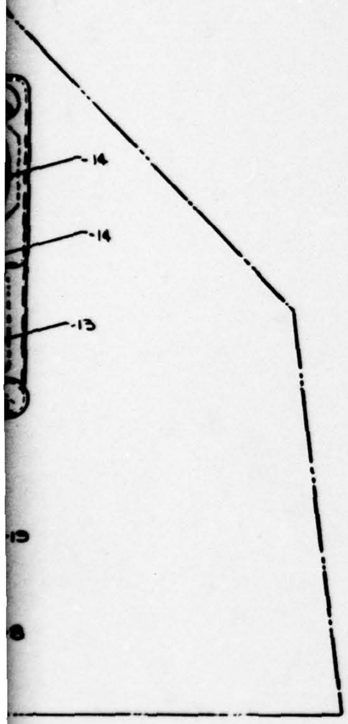


Figure 14. Continued.

	REVISIONS		
LTR	DESCRIPTION	DATE	APPROVED
A	ALL ZONES REVISED	3/14/79	



PARTS LIST

BOEING VERTOL COMPANY
PHILADELPHIA PENNSYLVANIA 19142

LIGHT INCIDENCE
CONTROLLED EMISSION
PANEL ASSEMBLIES

BALLENTINE 3-14-79

PROJECT APPROVAL W. T. W[illegible] 3/14/79

J 77272 SK 25189

SCALE FULL

SH 2 OF 3

SK 25189 A

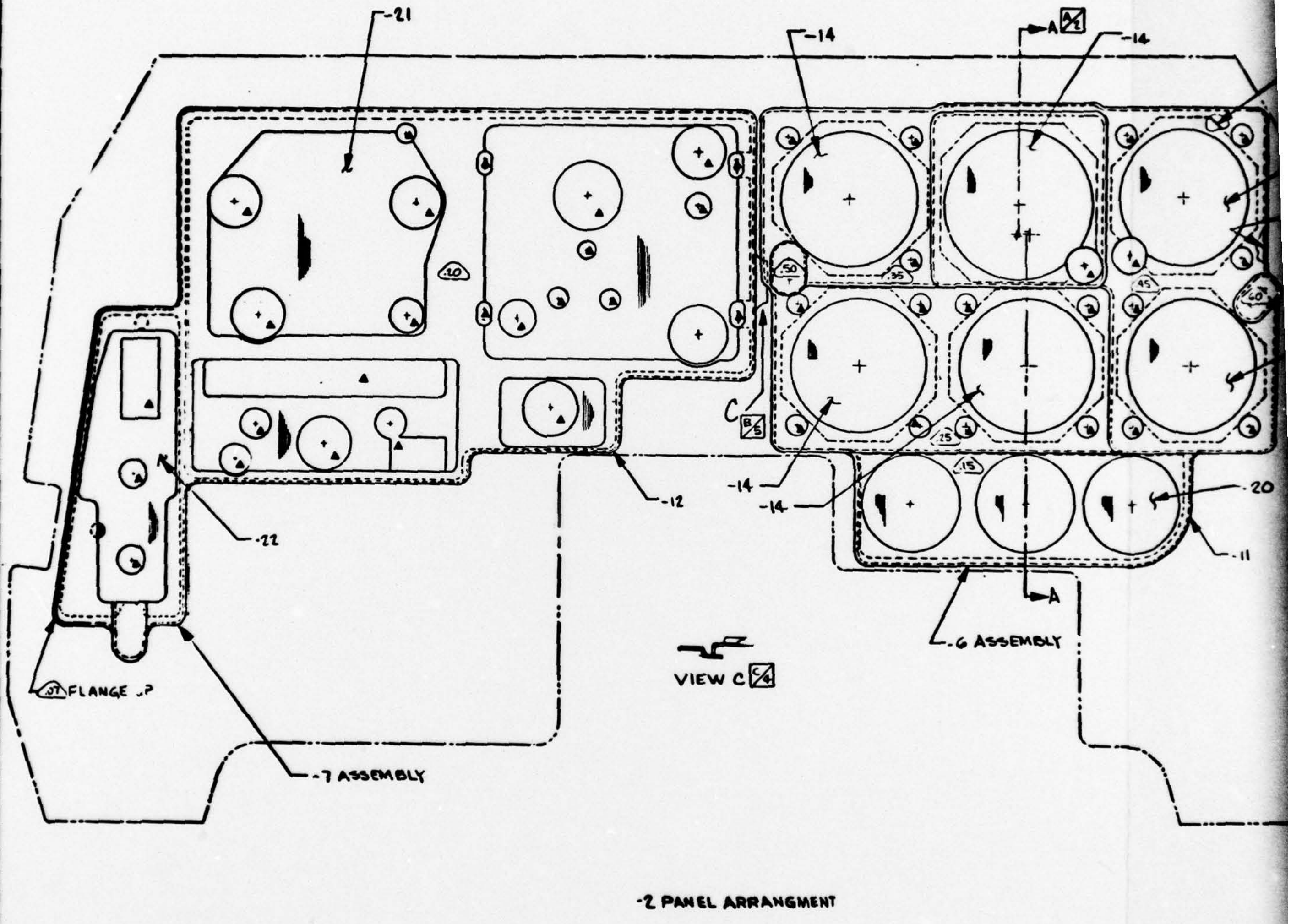
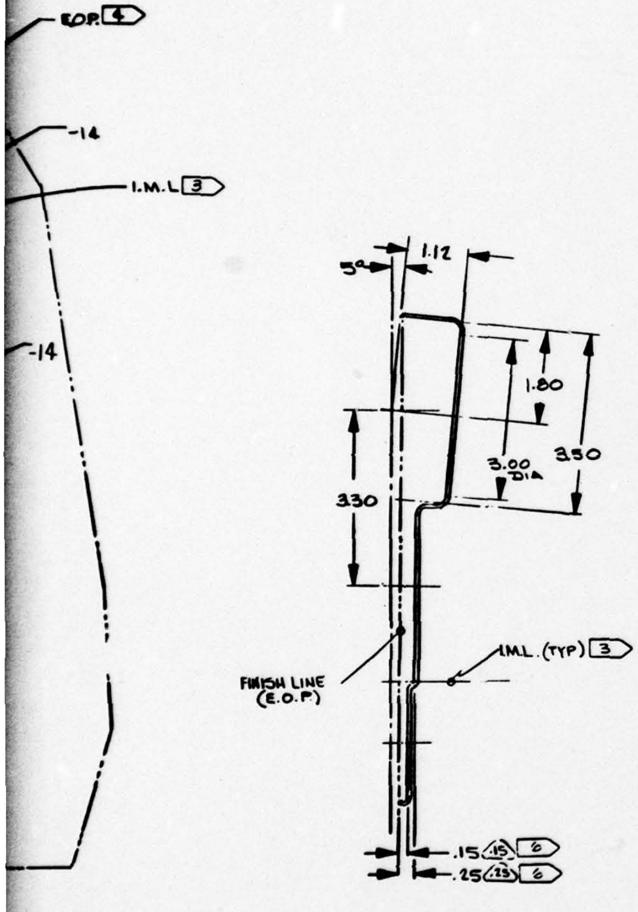


Figure 14. Continued.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ALL ZONES REVISED	3/14/79	



A-A 3/4 SHEET 3

PARTS LIST

BOEING VERTOL COMPANY
PHILADELPHIA PENNSYLVANIA 19142

LIGHT INCIDENCE
CONTROLLED EMISSION
PANEL ASSEMBLIES

J 77272 SK 25189

SH 3 OF 3

FASTENER CODES

2. 7930

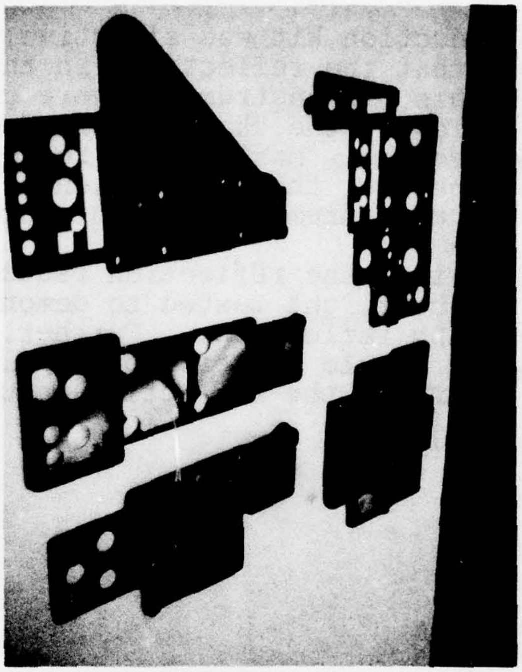


Figure 15. AH-1S reflection reduction kit.

CONCLUSION AND RECOMMENDATION

The reflection reduction kit using Light Control Film (LCF) was effective in reducing the reflections seen by the gunner in the side transparencies caused by his lighted displays. A few reflections were residual due to the inability to put LCF over every lighted legend. An example is the bank of switches on one ICS panel that has a number of plastic fences between switches. This area could not accept a LCF overlay, and therefore still caused reflections. These cases, however, are minimal.

The reflection reduction kit was effective in the same way for the pilot in that the reflections in the side transparencies caused by his own instruments were greatly reduced. A trial installation of the "kayak" shroud greatly enhanced the kit's effectiveness. Most of the reflections were eliminated, but concerns over the obstruction of external vision and portions of the instrument panel are present.

It is recommended that the reflection reduction kit concept as defined herein be flight tested to demonstrate its effectiveness in reducing reflections. Further, the concept for the "kayak" shroud should be refined for flight evaluation as a means of enhancing the reflection reduction kit.