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**ARROW 2
ESCAPE SYSTEM**

REPORT No. 72/ENG. PUB./2

ENGINEERING DIVISION

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ARROW 2 ESCAPE SYSTEM

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This brochure is intended to provide an accurate description of the system(s) or service(s) for purposes of the Arrow 2 Mock-up Conference, and is not to be considered binding with respect to changes which may occur subsequent to the date of publication.

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TABLE OF CONTENTS

CHAPTER	PARA	PAGE
1	Introduction	1
2	Design Objectives	2
3	General Description	3
4	Detailed Description	5
	4.1 Ejection Seat	5
	4.2 Crew's Equipment and Harness	7
	4.3 Firing Mechanism	7
	4.4 Canopy Opening Mechanism	8
	4.5 Bail-Out Warning	10
	4.6 Distress Warning Facility	10
5	Ejection Sequence	11
6	Equipment List	13

LIST OF ILLUSTRATIONS

FIGURE	PAGE
1 Martin-Baker MK. C-5 Automatic Ejection Seat	14
2 Canopy Emergency System	15
3 Front and Rear Canopies	16
4 Canopy Emergency System Controls	17
5 Canopy Actuation Mechanism - Geometry	18

1. Introduction

This brochure describes the Escape System for the Arrow aircraft. The system provides automatic emergency ejection for both crew members, using interconnected canopy opening and ejection seat firing. A Martin-Baker fully automatic ejection seat is provided for each crew member.

The escape system is designed for maximum reliability and efficiency under all conditions. Extensive ground tests of the canopy opening mechanisms have been carried out and further functional tests, plus rocket sled testing of the complete system, are being undertaken.

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2. Design Objectives

The design objectives for the Arrow escape system are:

- (1) To provide automatic escape from the aircraft for both crew members in an emergency.
- (2) To ensure that both crew members are safely separated from the aircraft, and ejected clear of the structure, over a full range of aircraft speeds.
- (3) To provide a reliable canopy opening and ejection seat firing mechanism.
- (4) To locate the firing control so that it may be operated under all conditions.
- (5) To ensure that the action of firing the ejection seat also provides a clear ejection path.
- (6) To provide emergency canopy opening for each crew member, without ejection seat firing.
- (7) To provide emergency canopy opening actuated by an external control.
- (8) To provide a bail-out warning system and an automatic distress signal transmission facility.
- (9) To meet ground servicing and safety requirements.
- (10) To provide a system which will meet the requirements of specification AIR 7-4 and the design requirements of CAP 479 (Manual of Aircraft Design Requirements for the RCAF) and ARDCM 80-1 (Handbook of Instructions for Aircraft Designers).

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3. General Description

The Escape System consists essentially of a firing unit and operating mechanism for emergency opening of the two split clam-shell type canopies, two Martin-Baker Mk. C-5 ejection seats and a bail-out warning system.

Each canopy is normally opened and closed by means of an electrically driven screw-jack and locked or unlocked by a manual latch control lever, which is disconnected from the latches when in the closed position. Interconnected emergency canopy opening and seat ejection is initiated by pulling the face blind handle. This action fires the canopy actuating cartridge causing the canopy to unlatch and open, over-riding the normal screw-jack. At the same time the seat ejection gun is primed. When the canopy is sufficiently extended, beyond the normal open position, the ejection gun is automatically fired, a radio distress signal being initiated as the seat is ejected. An alternative firing handle is provided on the front of the seat pan should the crew member for some reason be unable to reach the face blind. A bail-out warning system, operated by the pilot from the front cockpit, warns the observer of the necessity for escape.

An emergency oxygen cylinder, which is attached to the underside of each ejection seat, is automatically connected to the occupant's supply system on ejection. A composite quick-disconnect coupling, also attached to the seat, provides an effective means of breaking

4. Detailed Description

4.1 Ejection Seat (Refer to Fig. 1)

The ejection seat employed in the Arrow 2 escape system is of the Martin-Baker Mk. C-5 fully automatic light-weight type, weighing a total of approximately 100 lb. This seat incorporates the following features:-

- (1) A 72" (long stroke) ejection gun, giving an ejection velocity of 83 feet per second, to make safe escape from low level practicable.
- (2) A strengthened, light weight seat pan without thigh guards or foot rests.
- (3) A single, combined seat and parachute harness. The parachute harness is attached to the seat at three points, thus also serving as seat harness.
- (4) A "D" shaped ejection handle, of conventional type, attached to the face blind, which is stowed in the head-rest. Cables from the blind are connected to the sears of the ejection gun and the canopy firing unit.
- (5) An auxiliary ejection handle, in the form of a "D" ring, situated at the forward upper edge of the seat pan, between the crew member's knees. Operation of this handle fires the ejection mechanism in the same manner as the face blind, thus providing for the case where the occupant is unable to raise his hands to the blind.

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the crew member's various supply leads from the aircraft as the seat is ejected. The occupant is released from the seat at or below the correct altitude and safe 'g' load by means of a barostatic and 'g' controlled time release unit.

There are two emergency methods of opening the canopy without firing the seat gun. The first of these may be used by both members of the crew to open their respective canopies. Operation of the emergency canopy control lever removes the sear from the canopy firing unit causing the canopy to open without firing the seat gun, which can only be primed by the ejection handles. The second method is by means of an external control, which has the same function as the internal control lever with one difference, in that it operates both canopies simultaneously. Independent canopy and ejection controls are provided for each crew member.



- (6) A barostatic and 'g' controlled time release unit which disconnects the occupant's harness and equipment from the seat at an altitude of 5000 metres, approximately 16,400 feet (with a unilateral tolerance of +3000 feet), or below, provided the loads on the seat are less than the specified limit.
- (7) A snubber unit on the underside of the seat pan, through which passes the leg restraining cord. A hand-wheel on the right-hand side of the seat pan is used to release the cord under normal conditions.
- (8) A composite quick-disconnect on the right-hand side of the seat, providing connections for oxygen, pressure suit, visor de-misting, anti-g suit and telecommunication. By means of this unit, automatic disconnection (on ejection of seat) or manual disconnection of these services between the crew, seat and aircraft are provided.
- (9) Manual release of the leg restraint, seat harness and quick disconnect, in one movement, by use of a manual override lever on the right-hand side of the seat pan.
- (10) A further lever on the left-hand side of the seat pan controlling a reel to which is attached the combined seat and parachute harness. Operation of this lever provides freedom of movement for the occupant while seated in the aircraft.
- (11) The seat raising handle on the left-hand side of the seat pan.
- (12) Safety pins for the face blind and auxiliary firing mechanism.

to prevent inadvertent operation on the ground. These are removed by the crew member on entering the aircraft.

4.2 Crew's Equipment and Harness

Each crew member is equipped with a standard, 21 feet per second rate of descent, parachute which is mounted to the back of the seat, and a survival pack in the seat pan. These items are an integral part of the combined harness which is attached to the seat at three points. A nylon leg restraining cord is passed from an anchorage on the front of the seat pan, through a ring on the side of a garter strap attached to each of the crew member's legs below the knee. From there through the snubber box on the underside of the seat pan to a bracket on the cockpit floor, which retains the end of the cord by means of a shear pin. The emergency oxygen cylinder is fitted to the underside of the seat and is operated, on ejection, by a lanyard attached to the aircraft structure. (Refer to Fig. 1).

4.3 Firing Mechanism (Refer to Fig. 2)

Twin cables attached to both the face blind and the auxiliary firing handle, withdraw the sears from both the seat ejection gun and the canopy firing unit when either of the handles is operated. This action fires the canopy cartridge but only primes the ejection gun, which is prevented from firing by a pin inserted through its striker. When the canopy has reached an angle of 41° from the closed position, the pin is withdrawn by a telescopic rod connected

through a lever arrangement to the left-hand portion of the canopy, thus detonating the ejection gun. After the pin is withdrawn the telescopic rod reaches its limit of extension, at which point a shear pin in the rod fails, disconnecting it from the lever mechanism.

A cockpit control lever is provided for emergency opening of each canopy without sequenced firing of the ejection seat gun, and is positioned on the right-hand side at the forward end of each cockpit. When this lever is pulled aft, being connected to the sear by a cable, it fires the canopy cartridge but does not prime the ejection gun. A cable from the external control performs the same function, but operates both canopies simultaneously. The exterior end of this cable is stowed in a quick access cavity on the right-hand side of the aircraft, forward of the intake ramp. (Refer to Fig. 4).

4.4 Canopy Opening Mechanism (Refer to Fig. 3)

Each canopy is normally actuated by an electrically driven screw-jack at the rear of the cockpit, attached directly to the left-hand half of the canopy. Normal operation of each canopy is controlled by two, three position (OPEN - OFF - CLOSE) switches, one located on the left-hand console and the other on the exterior left-hand side of the aircraft between the two canopies. The screw jack incorporates a separation device which fails during emergency operation, disconnecting the jack from the canopy to permit rapid opening and overtravel. A mechanism consisting of an idler link

and two push rods is situated at the rear of each cockpit. The push rods connect the ends of the idler link one to each side of the canopy, ensuring that rotation of the idler opens both halves of the canopy simultaneously. The canopy opens through an angle of 31° under the action of the normal screw-jack. (Refer to Fig. 5).

The emergency canopy operating jack has its ram attached to one end of the idler link. When the canopy cartridge is fired, the resulting gas is piped to a latch operating jack (or sequence valve), the piston of which impinges on a bellcrank, which in turn strikes the canopy latches open before permitting the passage of gas to the emergency operating jack. Pressure then builds up in the emergency operating jack until it is sufficient to cause the normal screw-jack separation device to fail, allowing extension of the operating jack and hence rotation of the idler link; thus causing the two push rods to open the canopy. A recuperator, which is situated on the right-hand side of the cockpit and is connected by piping to the emergency operating jack, supplies oil to the low pressure side of the piston. As the operating jack is extended it forces the oil through a restriction back into the recuperator, thus restraining the impact of rapid opening of the canopy. This recuperator is of the floating piston type, being spring loaded to obtain sufficient pressure for charging the emergency operating jack with oil. The canopy is fully open at an angle of 45° from its closed position. At this point a pin on one end of the idler link engages with a spring

loaded catch, retaining the canopy in the open position and obviating any tendency to close due to aerodynamic loading. (Refer to Fig. 2).

4.5 Bail-Out Warning System

The bail-out warning system comprises a green light in the front cockpit and a red light and warning horn in the rear cockpit. Operation of a switch in the front cockpit illuminates both warning lights and sounds the horn. As the rear seat is ejected from the aircraft it operates a micro-switch, which de-energizes the green light in the front cockpit, thus informing the pilot that the observer has been ejected.

4.6 Distress Warning Facility

A micro-switch in each seat installation, operated by ejection of the seat, switches the UHF communication transmitter to transmit on the emergency frequency and the air-to-ground IFF transponder to transmit in the emergency mode. These emergency functions of the UHF and IFF may be tested by means of an override switch in the front cockpit.

5. Ejection Sequence

When emergency ejection becomes necessary the sequence of operations is as follows:

- (1) The occupant carries out the pre-ejection procedure, which is yet to be determined.
- (2) The ejection seat blind is pulled down over the face, or alternatively the auxiliary firing handle is pulled vertically up between the knees, to initiate the escape sequence.
- (3) The canopy opens and, having moved through an angle of 41° , fires the seat cartridge.
- (4) As the seat leaves the aircraft the occupant's legs are pulled back and together by the leg restraining cord. The cord, which is attached to the cockpit floor by a shear pin, is drawn through the snubber unit until the load is sufficient to cause failure of the shear pin. The snubber unit prevents the cord slackening until it is released.
- (5) Movement of the seat also breaks the quick disconnect between the seat and aircraft, primes the drogue gun and the time release mechanism by removing their respective sears, and opens the emergency oxygen cylinder by means of a lanyard.
- (6) Half a second after leaving the aircraft the drogue gun is fired and the controller drogue extended. Then the main drogue is withdrawn, retarding the forward movement of the seat.
- (7) When the load on the seat is within the limit the time release

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unit commences to operate (provided the seat is below 16,400 ft). After an interval of 1.3 seconds, by means of a linkage from the time release mechanism, the harness is automatically released from the seat, the leg restraint is released and the composite services quick-disconnect between seat and occupant is broken. In addition, a restraint is removed from the scissor shackle which attaches the main drogue to the seat, causing the drogue to be released. Attached to the drogue is a link line which has its opposite end secured to the occupant's parachute rip-cord. The configuration of the back of the seat causes the occupant to be tipped forward when the harness is released and the seat then falls away. The drogue provides sufficient drag to deploy the auxiliary parachute and subsequently the main parachute.

6. Equipment List

Description	Qty.	Avro Drg. No.	Spec.	Manufacturer and Part No. where Applicable
Ejection Seat	2)			Martin-Baker
Mk. C-5)			Aircraft Co. Ltd.
)			
Seat Ejection Gun	2)	7-2852-12	E 365	Martin-Baker
)			(MBEU. 5001)
)			
Canopy Cartridge	2)			Martin-Baker
Firing Unit)			
Emergency Canopy Operating Jack	2	7-1052-1037	E 299	Martin-Baker
Latch Operating Jack	2	7-1052-1038	E 299	Martin-Baker
Recuperator	2	7-1052-6589	E 299	Martin-Baker
Normal Canopy Operating Screw- Jack	2	7-1152-9	E 277	Airborne Accessories

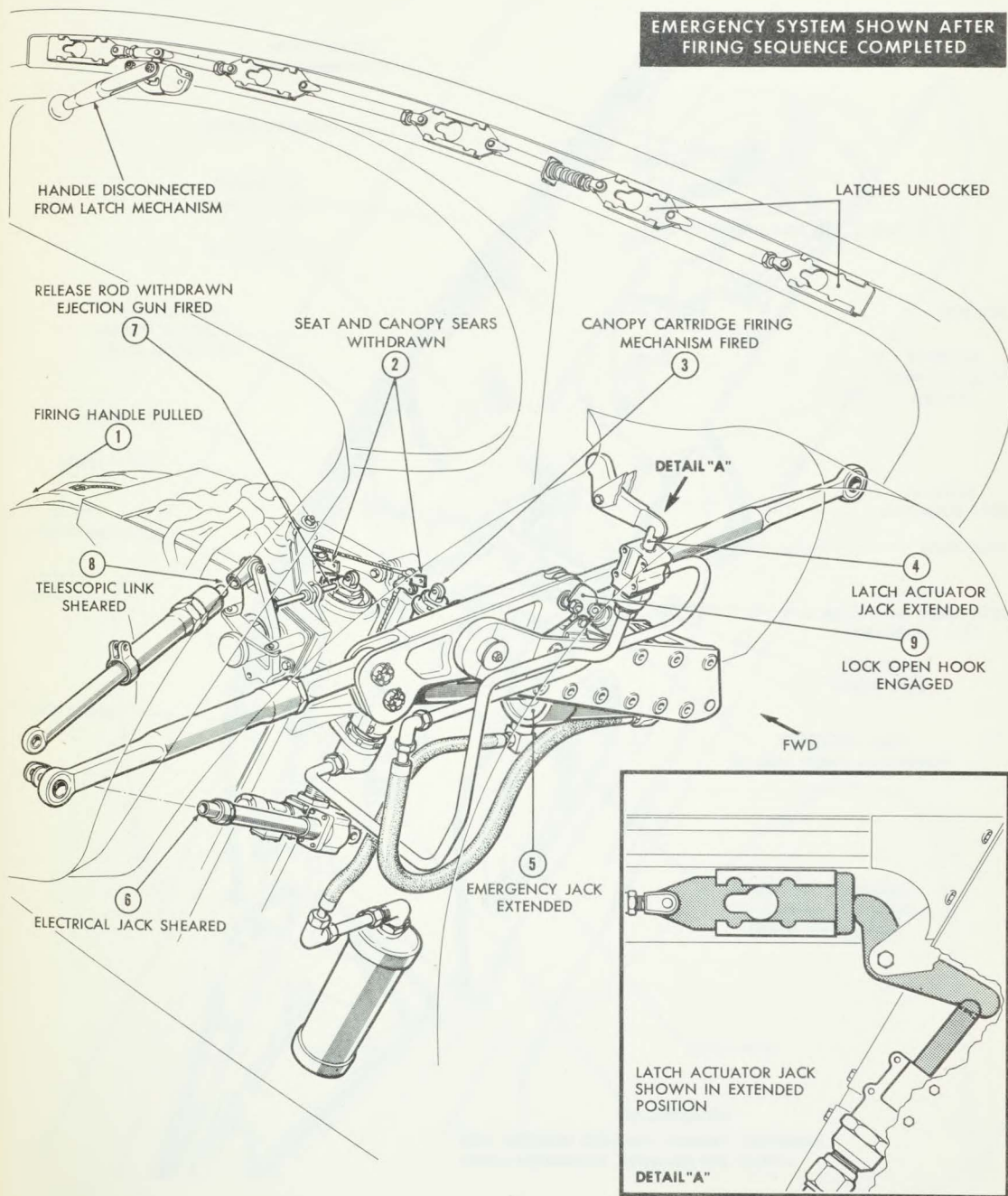


FIG. 2 CANOPY EMERGENCY SYSTEM

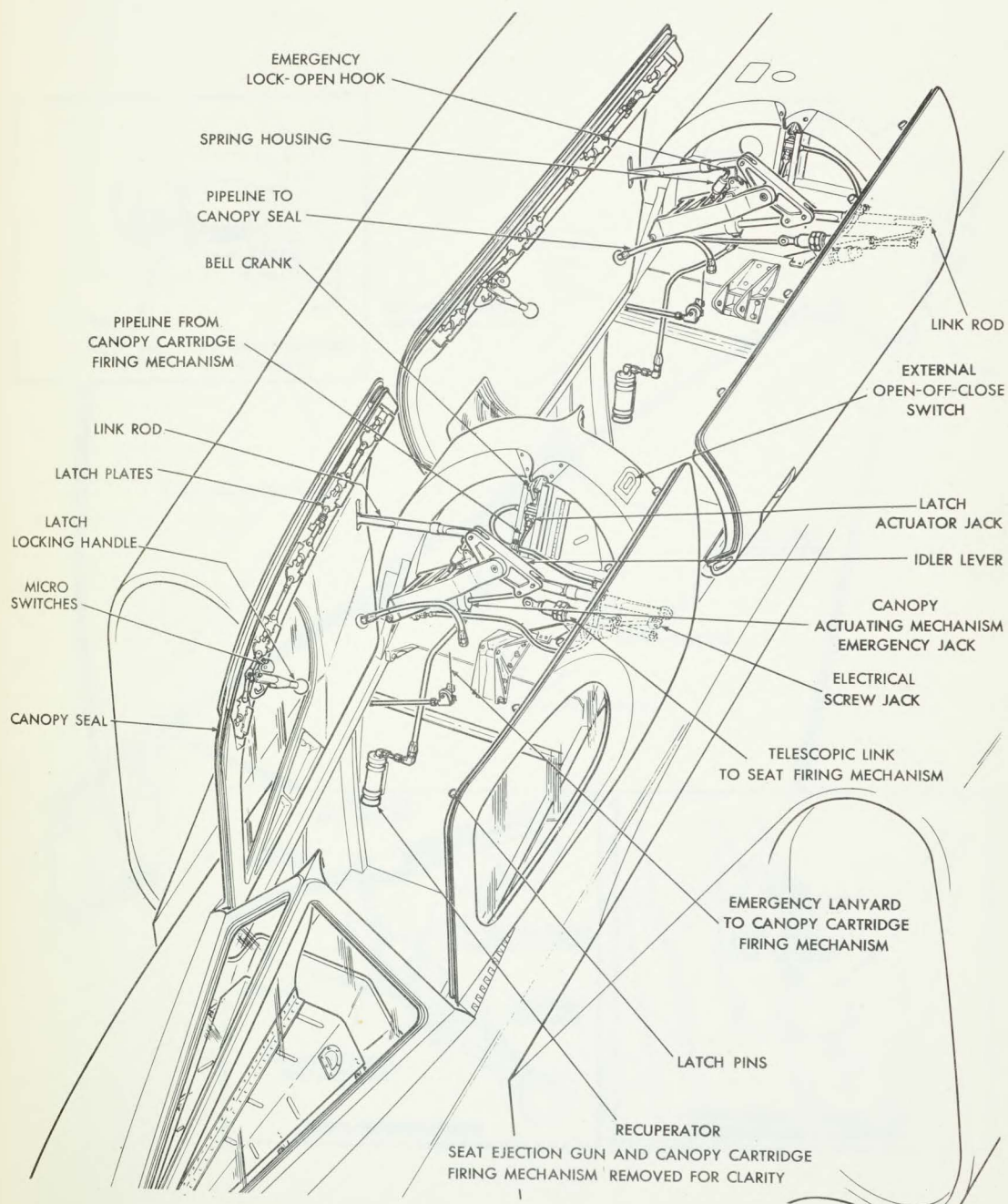


FIG. 3 FRONT AND REAR CANOPIES

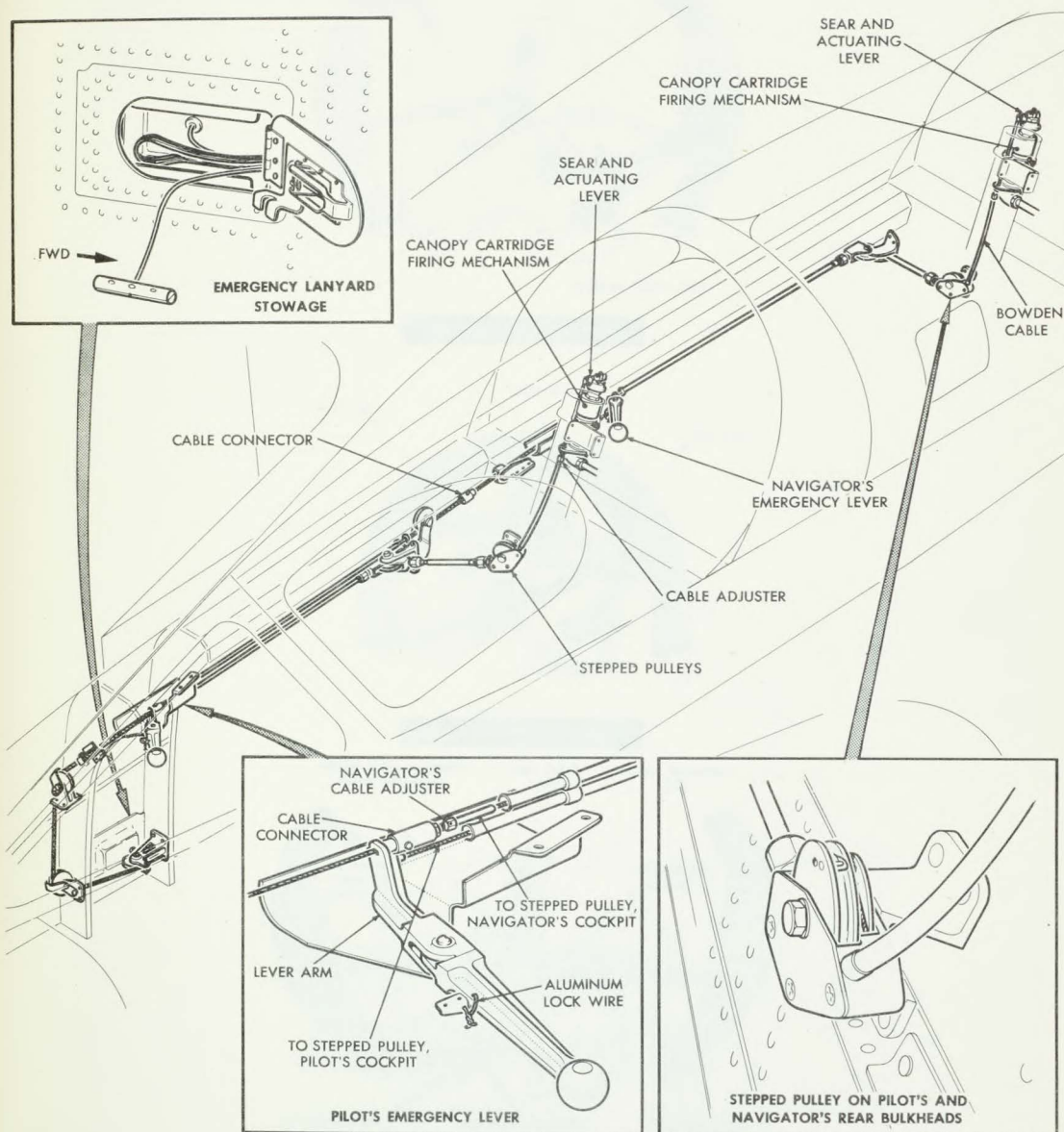
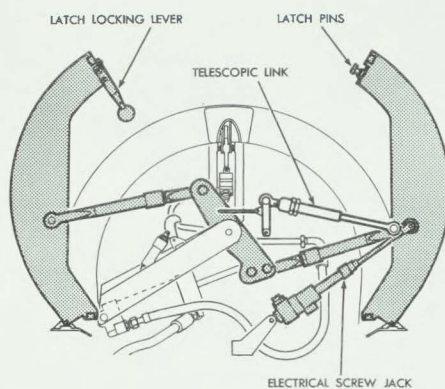
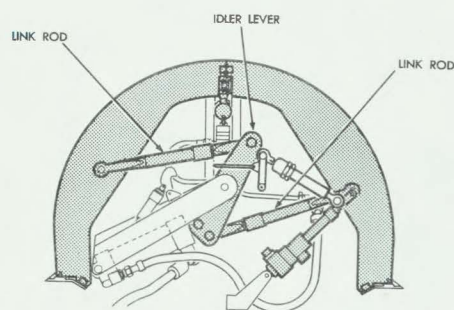


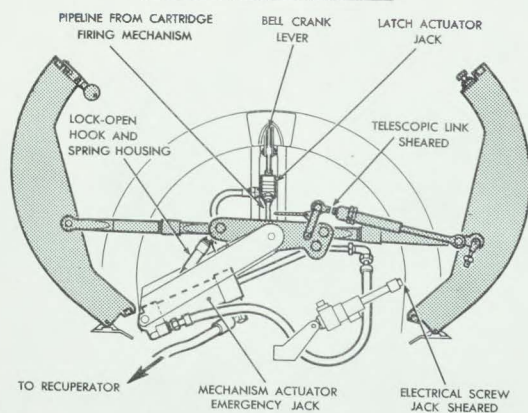
FIG. 4 CANOPY EMERGENCY SYSTEM CONTROLS



NORMAL OPERATION—OPEN



CLOSED AND LOCKED



EMERGENCY OPERATION—OPEN

FIG. 5 CANOPY ACTUATION MECHANISM—GEOMETRY

