CHAPTER 2

EJECTION SEATS

CONTENTS

Introduction

1. Ejection seat development has been a continuous process since the first live ejection in 1946. The earliest type of seat provided only a means of ejecting the occupant from the aircraft; when clear, it was then necessary to undo the seat harness and manually deploy the parachute. Current ejection seats operate automatically following initiation by the operation of the seat pan handle; no further action is required until descending on the parachute.

2. The present range of ejection seats is very large, and quite beyond the scope of this chapter. Therefore, two typical types of Martin-Baker seat will be covered—the Type 4 (as in the Jet Provost) and the Type 10 (as in the Tornado). The Annex lists the types and marks of seat fitted to aircraft currently in service. Information on other ejection seats is contained in the AP109B series.

MARTIN-BAKER TYPE 4 EJECTION SEAT

Principle of Operation

3. On ejection initiation, a Type 4 P seat as fitted to the Jet Provost is designed to operate in the following manner:

a. The aircraft canopy is jettisoned or disintegrated.

b. The seat is ejected upwards. This occurs after a delay of 1s (0.6s in some installations), or immediately when miniature detonating cord (MDC) is fitted to provide canopy disintegration.

c. During the ascent of the seat, the occupant's legs swing back and are retained (by the leg restraint cords) against the seat pan. At the same time, the main oxygen and RT connections are broken and the emergency oxygen supply is operated.

d. Two drogues develop in turn to stabilize the seat and reduce its speed.

e. If ejection has occurred below 10000 ft, a barostatic time-release unit (BTRU) operates after 1.25s to free the drogues which open the main parachute pack; the harness and the leg restraining cords are simultaneously released. A *g*-stop prevents the mechanism operating if the speed is too high for safe parachute deployment.

f. If ejection has occurred above 10000 ft, a barostat prevents the BTRU, referred to in sub para e above, operating until that altitude is reached.

General Description of the Seat

4. The Type 4 P seat is illustrated in Figs 1 and 2 and described in the following paragraphs.

5. In order that the seat is as light as possible, the main structure is made almost entirely of light alloy. Two drogues and a face screen are housed in a container at the top of the seat. Two firing handles are fitted: the main handle is situated on the seat pan between the occupant's knees (the seat pan handle) and the other one attached to the face screen (the face screen handle). Operation of either handle operates the sears of the canopy jettison firing unit and the breach (time-delayed) firing unit of the ejection gun. The seat begins to rise after the firing pin of the breech firing unit detonates the primary explosive cartridge—this occurs after the delay given in para 3b.

6. The ejection gun consists of three telescopic tubes, with a combined stroke of 1.85m; the outer tube being attached to the aircraft floor. The ejection velocity is 24.5m/s (80ft/s). There are two secondary cartridges which are ignited in turn by the hot gases of the primary cartridge; the first after the seat has risen 400mm, and the second after the seat has risen a further 240mm. At the end of the stroke, the intermediate and inner tubes separate, the inner tube remaining attached to the seat at the top latch.

7. The BTRU and the drogue gun are located below the drogue container on opposite sides of the seat. As the seat moves up the guide rails during ejection, a static rod trips the drogue gun time delay mechanism. After a delay of 0.5s the drogue gun fires and extracts the controller drogue; this in turn develops the main drogue, which stabilizes the seat and checks its speed. At the same time, a second static rod trips the BTRU; the time delay of 1.25s commences immediately if the ejection is below 10000 ft, provided that the *g*-stop is not in operation. When ejection takes place above 10000 ft, the barostat prevents operation of the time delay by inserting a pin in the gear train of the mechanism. The *g*-stop ensures that man/seat separation does not occur until the speed has dropped to a value safe for parachute deployment.

8. Two leg restraint cords prevent the legs from flailing during ejection. From attachments in the cockpit floor, these cords pass upwards and then forward through snubber units. During strapping-in, the free ends are threaded through rings on the leg garters and plugged into quick-release sockets on the front of the seat pan; the right cord crossing to the left leg and returning to the right socket and vice versa. More free cord may be available by pulling the rings on the snubbing units. As the seat rises on ejection, the legs swing back and the cords are pulled through the snubbers, restraining the legs against the front of the seat pan. A rivet in each floor attachment shears at a predetermined load: cord run-back being prevented by snubbing units.

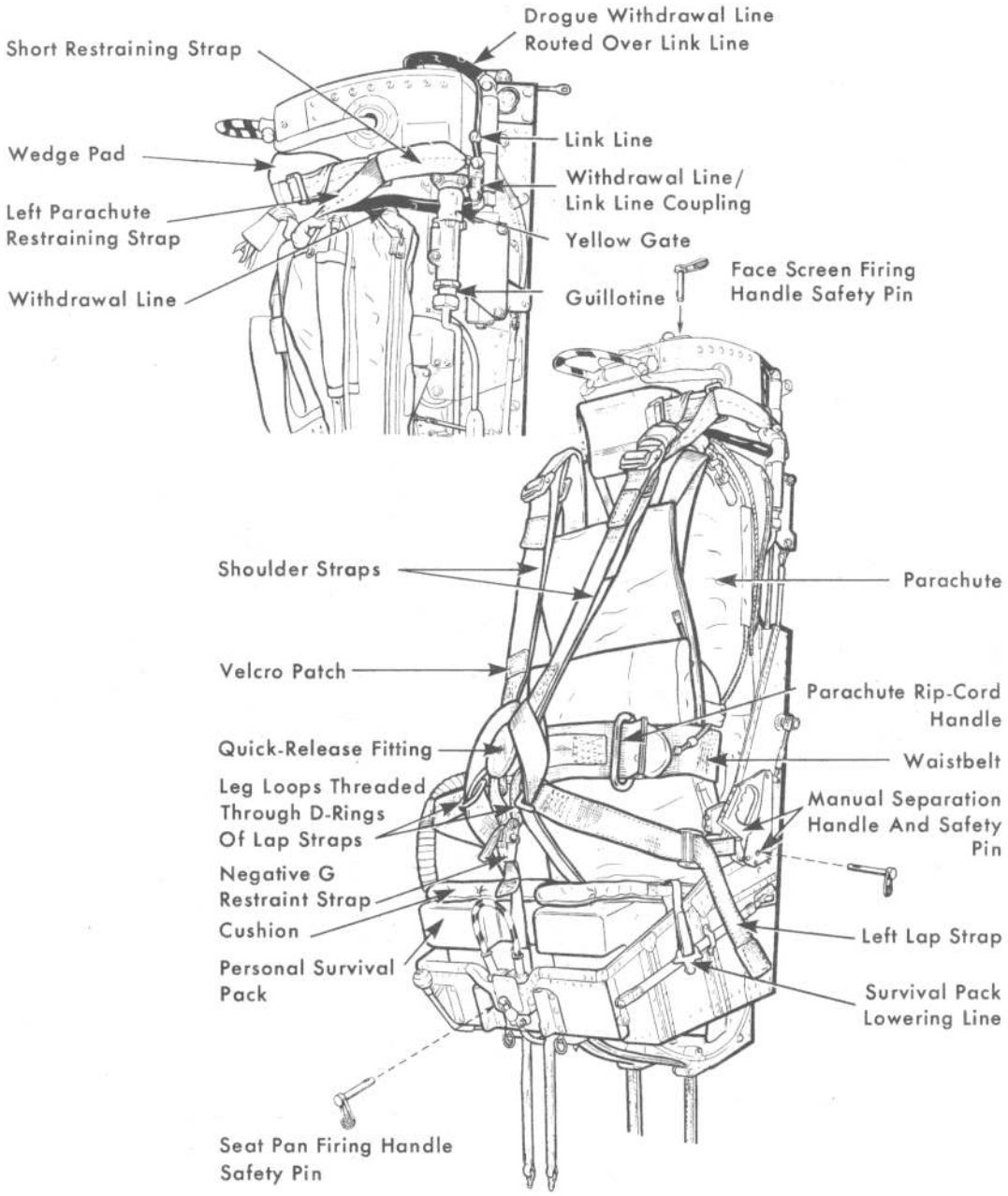

Fig 1 Martin-Baker Ejection Seat Type 4P Left Hand View

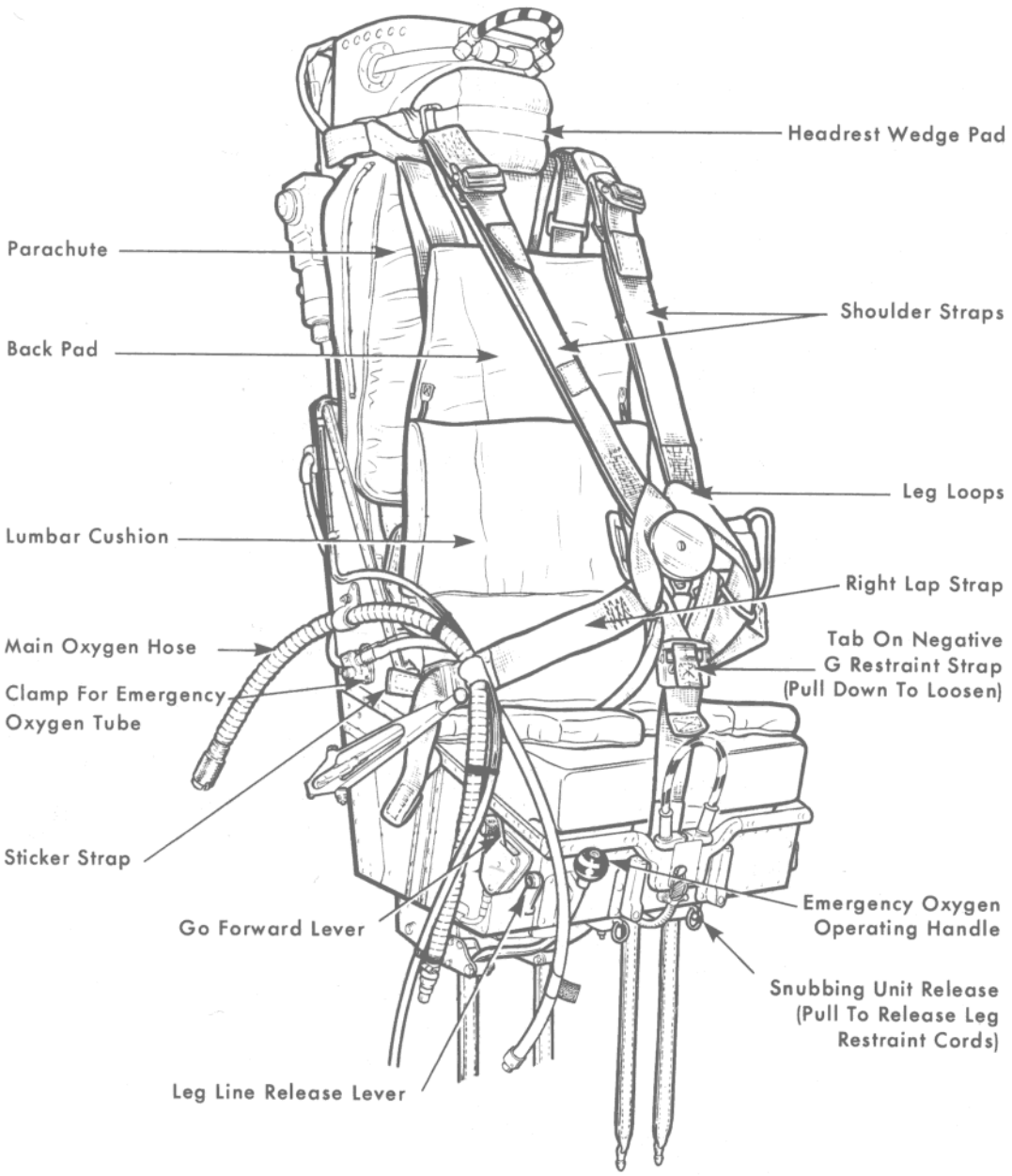

Fig 2 Martin-Baker Ejection Seat Type 4P Right Hand View

9. A combined seat/parachute harness is fitted to the seat. This harness is attached to the seat at three points; two points on the seat pan secure the lap straps, and one upper point secures the shoulder straps. The connection to the upper point is *via* a spring loaded go-forward mechanism. The spring prevents any slack in the straps; forward movement of the shoulders is normally restrained by a lever controlled snubber. The snubber release lever is situated on the outboard side of the seat pan, immediately aft of the leg restraining cord release.

10. The lower harness fixing points also anchor one end of a negative *g* strap; the other end rises behind the seat pan firing handle, terminating in loops through which the lap straps pass before entering the quick release fitting. The negative *g* strap provides improved vertical restraint in turbulence or inverted flight; it may be adjusted by pull tabs below the loops.

11. The upper harness fixing point also anchors two parachute pack restraint straps. The pack is horse-shoe shaped and rests on a support below the drogue container. The apex of the parachute canopy, and the pack closure pin, are attached by a link line to the drogue within its container. The line is secured to the seat by a scissor shackle controlled by the BTRU.

12. A lumbar cushion is provided on the front of the back pad. In order to achieve the correct seating posture, it is essential that this cushion is placed in the small of the back, and the buttocks pressed firmly backwards, before the lower harness is tightened.

13. The seat pan can be adjusted for height by operating a handle on the outboard side of the seat. The seat pan moves relative to the headrest so that aircrew with different body lengths can be accommodated, and the head is located in the best position for vision and ejection. A hard shell Personal Survival Pack (PSP) Type ZE is located in the seat pan.

14. A manual separation lever is located on the side of the seat, adjacent to the left elbow. If the automatic operation of the seat fails, operation of this lever will:

a. Fire a small cartridge, the gases from which operate a guillotine, thus severing the line between the drogues and the parachute.

b. Release the anchorage points of the harness and the leg restraining cords; the occupant is then free from the seat. The RT, normal and emergency oxygen connections will automatically disconnect as man and seat move apart.

Note: The escapee will then have to open his parachute manually by pulling the ripcord handle.

15. A spring-loaded top latch prevents the seat from sliding up its guide rails when negative *g* is applied. The top latch is correctly aligned when the ends of the housing and both inner and outer plungers are all flush with one another.

16. Quick-release connections for RT and main oxygen are provided on the seat, both for ejection and man/seat separation. In addition, a separate emergency oxygen supply is fitted to the seat, the primary function of which is to provide a source of oxygen for the escapee in the case of a high level ejection. This emergency supply can also be operated in flight if the main supply becomes unserviceable; the actuation is by a black/gold knob on the front of the seat pan, below the right thigh.

Seat Safety

17. In order to minimize the possibility of inadvertent ejection of the seat when the aircraft is on the ground, safety pins are provided to prevent operating the firing handles and the manual separation lever. With these pins in place, the aircraft is "Safe

for Parking". In order for the seat to be "Safe for Servicing", pins have to be placed in the sears of the main and guillotine guns. Note that safety pins are also required for canopy jettison/disintegration handles/sears.

Seat Limitation

18. The seat has a ground level ejection capability, provided that the airspeed is at least 90 kt and the aircraft is in level flight. If the aircraft is descending with wings level, height approximately 10% of the rate of descent is required. Thus at a descent rate of 3000 ft/min, the minimum height for ejection is approximately 300 ft agl. Gross exceptions occur to the 10% rule if the aircraft is diving or banked, when height required may be much greater—*eg* an aircraft inverted in straight and level flight would need to be at 300 ft agl minimum, and one in a vertical dive at 260 kt would have to be abandoned by 2500 ft agl.

MARTIN-BAKER TYPE 10 EJECTION SEAT

Introduction

19. The Type 10A ejection seat, as used in the Tornado, is a fully automatic cartridge-operated, rocket-assisted seat. It is designed to provide safe escape for most combinations of height, speed, attitude and flightpath within the envelope of zero speed to 650 kt IAS from ground level (in a level attitude) to 50000 ft. Alternative breech time-delay firing units (varying only in delay setting) and rocket packs with divergent trajectories are provided to make the seat compatible with both front and rear cockpit positions.

Operation of the Escape System

20. In the Tornado, the two seats and the canopy form an integrated escape system. In the event of an emergency which requires abandonment with minimum delay, the pilot can initiate crew ejection by pulling his firing handle. This causes the canopy to be jettisoned immediately; the navigator is ejected 0.3s afterwards, and the pilot follows 0.45s later. The divergent nozzles of the rocket packs will veer the seats to starboard and port respectively to ensure lateral separation. If the navigator is ordered to eject alone, he can do so by pulling his firing handle; in this case, the sequence will stop after his own ejection. Should the pilot be incapacitated and unable to eject himself, the navigator must move the lever of the command selector valve to the dual position before initiating ejection; the sequence will then be as before, *ie* canopy—navigator—pilot.

21. A single firing handle—on the front of the seat pan—is fitted to the Type 10 seat. On pulling this handle, a cartridge in the seat pan is fired; the gases from this actuate the following:

a. The harness retraction unit, which draws the occupant back to the correct posture for ejection.

b. The selector valve of the seat sequencing system to jettison the canopy (and, if appropriate, to initiate ejection of the other seat).

c. The withdrawal of the sear from the breech time delay firing unit, which fires the primary cartridge after the appropriate delay.

22. As the seat moves up the guide rails:

a. Trip rods withdraw the sears from the drogue gun and BTRU.

b. The command firing system is disconnected.

c. The seat adjusting actuator circuit is disconnected, and the transponder and crash recorder are actuated.

d. The aircraft portion of the personal equipment connector (PEC) is disconnected.

e. The emergency oxygen is tripped on.

f. The leg and arm restraint cords tighten to draw in and restrain the occupant's limbs. When the cords are taut, a rivet in each floor attachment shears at a predetermined load; cord run-back being prevented by snubbing units.

g. Just before the ejection gun reaches the top of its stroke, the static line of the remote rocket initiator becomes taut, withdrawing its sear. The hot gases from the initiator cause the rocket propellant to be ignited; the rocket pack then sustains the upward thrust of the ejection gun.

23. The drogue gun fires 0.5s after the seat rises. The drogue bullet withdraws the securing pin and opens the flaps of the drogue/parachute pack and deploys the drogues.

24. The BTRU commences to function when the seat is below a barometric altitude of 10 000 ft. The mechanism runs for 1.5s before a cartridge is fired; gas from this cartridge removes the restraint from the scissor shackle, thus allowing the drogue shackle to become free. The harness release system is simulataneously operated. The occupant is momentarily held in the seat pan by the sticker straps. A barostatic *g*-stop prevents the BTRU functioning if the seat is above 6000 ft and the speed is too high for safe parachute deployment.

25. When released, the drogues withdraw the parachute from the pack. As the parachute develops, it lifts the escapee and the PSP from the seat, pulling the sticker straps from their clips; this ensures that collision with the seat after separation is unlikely.

26. A particular feature of the Type 10A seat is the provision of automatic operation of the personal locator beacon (PLB) on man/seat separation and the inflation of the liferaft contained in the PSP on water entry.

General Description of the Seat

27. The basic construction of the seat is similar to that of the Type 4—*ie* light alloy construction, 3 cartridge ejection gun with telescopic tubes and top latch assembly. The seat is illustrated in Figs 3 and 4 and the various seat systems are described below.

28. The hard shell PSP contains a single-seat liferaft and survival aids; the liferaft is inflated automatically on water entry by means of a water activated battery, the sealing plugs of which are removed on man/seat separation. This battery detonates a small explosive charge; the gases from which operate the head of a CO_2 cylinder and open the PSP. The PLB is also operated on separation by the PSP lowering line before it is pulled from its sticker clip. During the parachute descent, only one of the quick-release connectors on the parachute harness need be operated to lower the PSP.

29. The parachute and harness assembly consists of a 5.2m GQ aeroconical parachute packed together with 1.5m main and 560mm controller drogues in a rigid head box, a backpad and a simplified combined harness. The harness consists of two adjustable lap straps, two adjustable shoulder straps, two fixed length leg straps, and a quick-release fitting (QRF) attached to a fixed length negative *g* strap. A harness go-forward lever is located on the port side of the seat pan. When strapping in, the leg loops are passed through the D-rings of the lap straps and then the shoulder straps are passed down through the leg loops before the lugs enter the QRF. The front face of the headbox is shaped to provide helmet location on ejection; it also is fitted with touch-and-stick tape to stow the parachute lift webs, which are an integral part of the harness assembly.

30. An electric actuator is used to raise and lower the seat pan to cater for occupants of varying back length. The correct position for the seat pan is when eyes of the occupant are

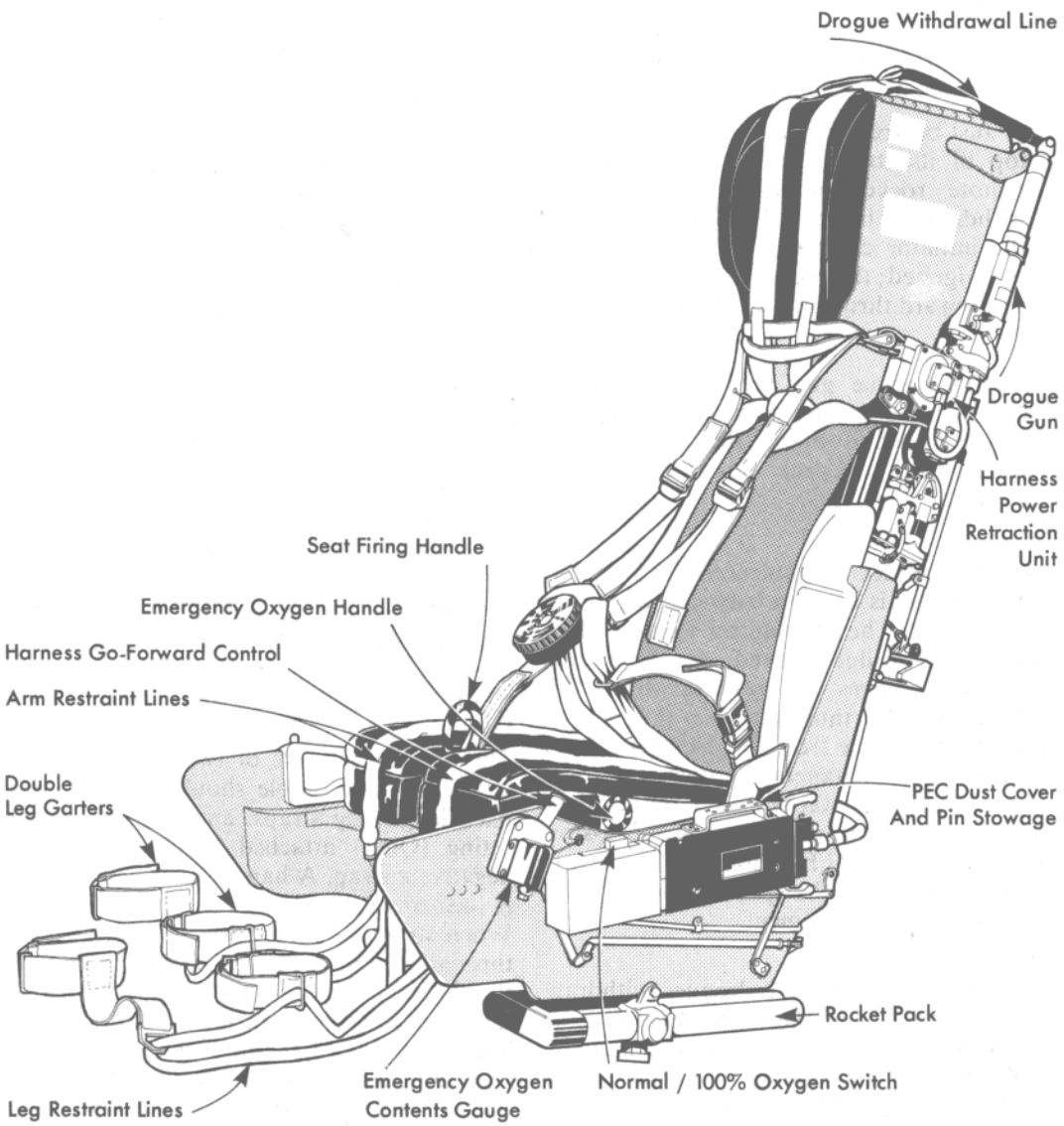

Fig 3 Martin-Baker Type 10A Ejection Seat Left Hand View

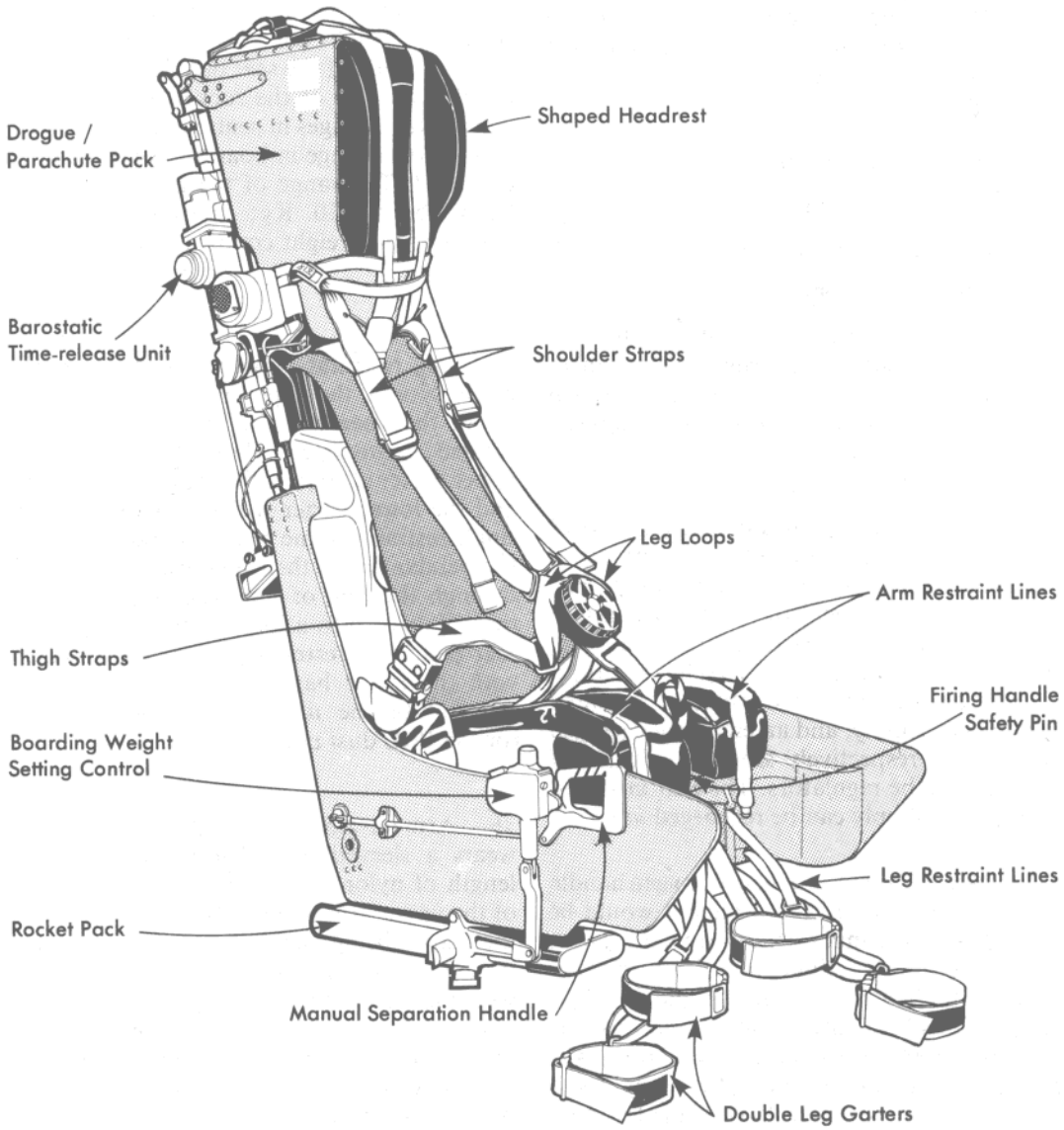

Fig 4 Martin-Baker Type 10A Ejection Seat Right Hand View

at the eye datum position of the cockpit. The actuator is controlled by a switch on the left side of the cockpit console.

31. Services are connected to the occupant by a PEC, which is located on the port side panel of the seat pan. The services supplied are as follows:

a. Main oxygen.

b. Emergency oxygen.

c. RT and intercom.

d. Air ventilated suit supply.

e. Anti-*g* suit supply.

A dust cover, incorporating a storage for seat and canopy safety pins, is provided to protect the PEC when the seat is unoccupied. When the seat is occupied, this dust cover is stowed on the cockpit wall.

32. An oxygen tray is situated forward of the seat portion of the PEC. Essentially it consists of two miniature regulators, one optimized for normal (*ie* airmix) operation and the other optimized for 100% oxygen, and a slide change-over switch. A gauge, indicating the contents of the seat mounted emergency supply, and an emergency oxygen handle are respectively situated forward of and beside the regulators. The seat mounted emergency supply can be recharged *in situ*.

33. Normally, the emergency oxygen handle would be down and the occupant would be supplied with airmix *via* the normal regulator. In event of a malfunction of the normal system the handle would be pulled. This action transfers the main supply to the standby (100%) regulator and trips the emergency supply. The standby supply will only be used if no oxygen flows from the main supply; this would be shown on the emergency contents gauge. If the malfunction disappears, the emergency oxygen handle can be pushed down and the sortie continued. If required, 100% oxygen can be selected by use of the slide changeover switch.

34. A multi-tubed rocket pack is situated under the seat pan. The rocket pack fitted to the front seat has the two starboard nozzles, and that to the rear seat the two port nozzles, enlarged to provide divergent trajectories of the seats, particularly at low forward speed. A pitch control, situated on the starboard side of the seat pan, is used to vary the thrust angle of the rocket pack to compensate for changes in centre of gravity of the seat due to change in boarding weight of the occupant. The range of the pitch control is from 65 to 110 Kg; clockwise rotation decreases the weight compensation and vice versa.

35. Leg restraint is achieved by a double garter system, the upper garter being located above the knee and the lower garter being located immediately above the boot. The upper garter is fitted with a ring on a pendant and the lower garter with a sewn-in ring. A single restraining line passes forward through the pendant ring, then inboard to outboard through the ring of the lower garter and is then plugged into a lock on the front of the seat pan. The restraining lines are released with the lower harness on ejection, or on removal of the man portion of the PEC (or the PEC dust cover).

36. Arm retraint is also fitted. The occupant wears a sleeved life preserver (Mk 19); a length of nylon tape is stitched to the front of the upper arm and wrist, the remainder of the tape being held by touch-and-close fastener. The tape passes through a ring, which incorporates the male part of a quick-release connector (QRC), retained to the upper arm by a light tie. Arm restraint lines are fitted to break rivets in the cockpit floor, pass through snubber units on the seat and are connected to the life preserver by mating the QRC on strapping-in. The normal method of disconnecting the lines is by pulling on the barrel of the QRC; following ejection, the lines are cut by a guillotine near the snubbers on man/seat separation.

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37. If a malfunction occurs in the automatic operation of the seat the manual separation handle should be pulled; the handle is situated on the right of the seat pan. Operation of this handle restarts the automatic release sequence, *ie* drogue gun fires, drogues deploy, personal parachute deploys and man/seat separation takes place; no manual ripcord is required. It is vital to note that, if the seat has been command ejected, the manual separation handle cannot be pulled until the seat firing handle has been pulled from its housing.

Seat Safety

38. The seat is safe for parking when one safety pin is fitted to prevent the seat firing handle being pulled. The seat is safe for servicing when pins are placed as follows:

a. Through the main ejection gun sear.

b. Through the remote rocket initiator sear.

c. Through the drogue gun sear.

d. Through the BTRU sear.

With aircraft safe for parking, these pins are stowed in the top of the PEC dust cover. Note that a further safety pin, through the operating lever of the canopy breech unit, is necessary to make the canopy jettison system safe.

EJECTION SEATS FITTED TO SERVICE AIRCRAFT

Aircraft Type and Mark		Seat Type and Mark
Buccaneer	S Mk 2B	Martin-Baker Type 6MSB1 (Front) Martin-Baker Type 6MSB2 (Rear)
Canberra	T Mk 4	Martin-Baker 3CT1 Mk 3 (Left) Martin-Baker 3CT2 Mk 3 (Right) Martin-Baker Type 2CA2 Mk 4 (Rear)
	PR Mk 9	Martin-Baker Type 3CS2 Mk 1 (Pilot) Martin-Baker Type 4QS Mk 2 (Nav)
	Other Mks	Martin-Baker Type 2CA1 Mk 2 (Pilot) Martin-Baker Type 2CA2 Mk 4 (Nav)
Gnat	T Mk 1	Folland Type 4GT/1 (Front) Folland Type 4GT/2 (Rear)
Harrier	GR Mk 3	Martin-Baker Type 9A Mk 2
	T Mk 4	Martin-Baker Type 9D1 (Front) Martin-Baker Type 9D2 (Rear)
Hawk	T Mk 1	Martin-Baker Type 10B1 Mk 1 (Front) Martin-Baker Type 10B2 Mk 1 (Rear)
Hunter	F Mk 6	Martin-Baker Type 2H or 3H
	T Mk 7	Martin-Baker Type 4HA
	T Mk 8	Martin-Baker Type 4HA (N)
	F Mk 9	Martin-Baker Type 2H or 3H

AIRCRAFT TYPE AND MARK		SEAT TYPE AND MARK
Jaguar	GR Mk 1	Martin-Baker Type 9B Mk 2
	T Mk 2	Martin-Baker Type 9B1 Mk 2 (Front) Martin-Baker Type 9B2 Mk 2 (Rear)
Jet Provost	T Mk 3, 3A, 4	Martin-Baker Type 4PA1 Mk 2 or 3 (Left) Martin-Baker Type 4PA2 Mk 2 or 3 (Right)
	T Mk 5, 5A	Martin-Baker Type 4PB1 Mk 2 or 3 (Left) Martin-Baker Type 4PB2 Mk 2 or 3 (Right)
Phantom	FGR Mk 2	Martin-Baker Type 7A1 Mk 2 or 3 (Front) Martin-Baker Type 7A2 Mk 2 or 3 (Rear)
Tornado		Martin-Baker Type 10A1 Mk 1 (Front) Martin-Baker Type 10A2 Mk 1 (Rear)
Victor	K Mk 2	Martin-Baker Type 3LS1 Mk 2 (Left) Martin-Baker Type 3LS2 Mk 2 (Right)
Vulcan	B Mk 2	Martin-Baker Type 3KS1 (Left) Martin-Baker Type 3KS2 (Right)