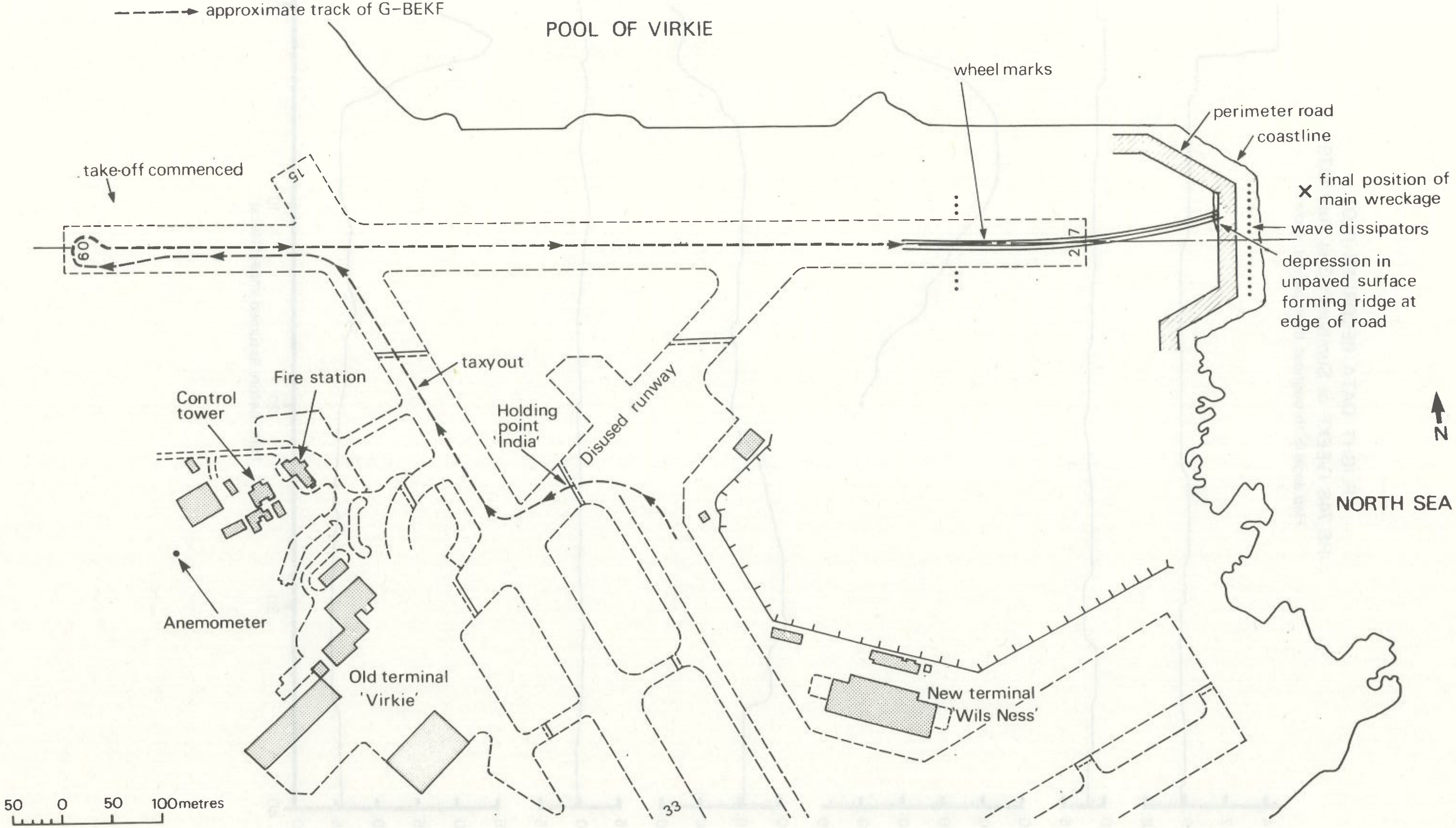
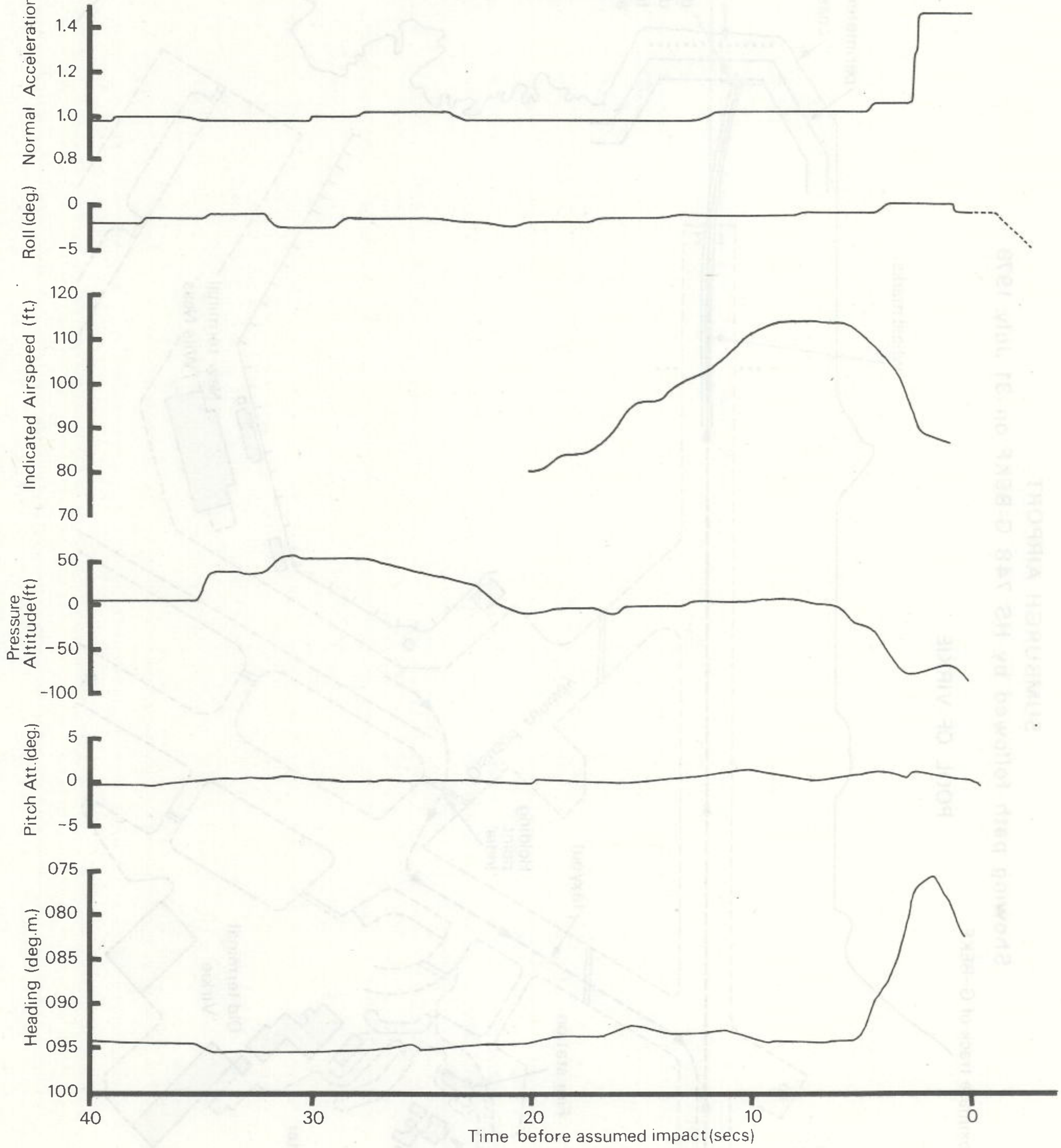
SUMBURGH AIRPORT
Showing path followed by HS 748 G-BEKF on 31 July 1979



FLIGHT DATA RECORDER PLOT

HS 748 G-BEKF at Sumburgh, 31st July 1979

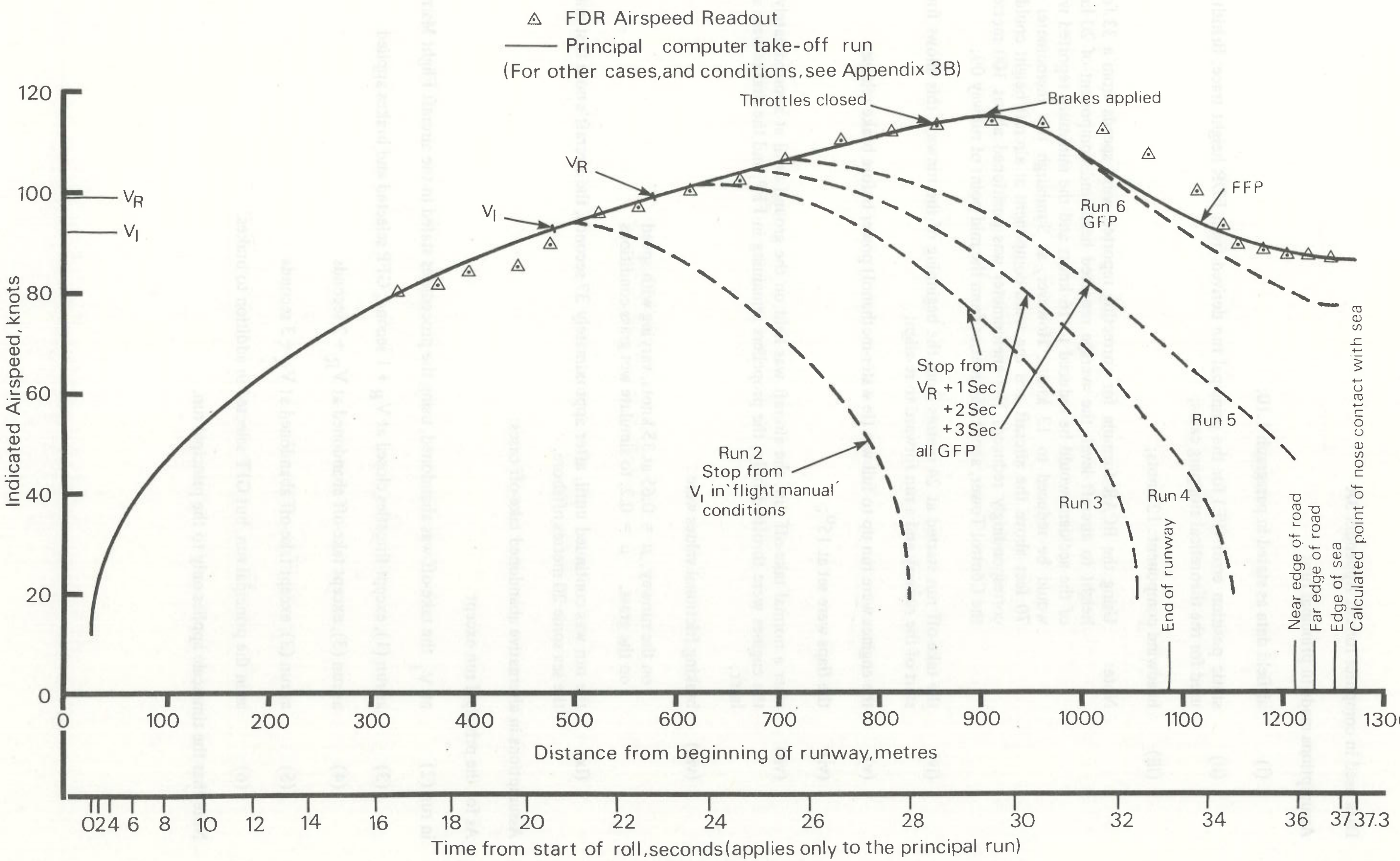
Flap angle 15° throughout time period shown



CALCULATED ACCIDENT RUN & STOPPING DISTANCES COMPARED WITH FDR AIRSPEED READ-OUT

HS 748 G-BEKF at Sumburgh, 31st July 1979

15°Flap, water-methanol on
12 Knot headwind at aircraft level



Data used in computer runs at Appendix 3A

Assumptions made in principal run:

(i) airfield data as stated in paragraph 1.10;

(ii) static position error (PE) for the principal run derived from FDR height trace; British Aerospace PE's used for the theoretical stopping cases;

(iii) headwind component: 12 knots;

Note: Using the BCAR formula for correcting reported wind speeds from a 33 foot anemometer height to aircraft level, the average reported headwind component of 20 knots at the time of the accident would be reduced to 16 knots and the minimum reported wind of 16 knots would be reduced to 13 knots. However, at Sumburgh the anemometer height averaged 70 feet above the aircraft and the wind component at aircraft height could well have been correspondingly reduced. The anemometer was positioned about 100 metres south-west of the Control Tower, about 550 metres from the mid point of runway 09;

(iv) the take-off run started at 24 metres from the beginning of the runway; this allows for a turn near the start of the runway and a run forward to re-align;

(v) the engines were run up to full wet (ie water-methanol) power before brake release;

(vi) the flaps were set at 15^{o};

(vii) after a normal take-off run, the aircraft was held on the ground until at approximately 113 knots IAS the engines were throttled fully, the propellers remaining in FFP, and the brakes were applied 1 second later;

(viii) braking frictional values were:

on the runway, μ = 0.65 at 35 knots, varying with speed
on the grass, μ = 0.2, to simulate wet grass conditions

(ix) the run was continued until, after approximately 37 seconds, the aircraft's nose first made contact with the sea some 20 metres offshore.

Assumptions in alternative abandoned take-off cases:

As for the principal run except

in run (2) at V_1 the take-off was abandoned, using the procedures stated in the aircraft Flight Manual

(3) as run (1), except throttles closed at V_R + 1 second, GFP selected and brakes applied

(4) as run (3), except take-off abandoned at V_R + 2 seconds

(5) as run (3), except take-off abandoned at V_R + 3 seconds

(6) as in the principal run, but GFP selected in addition to brakes.

Note that the timescale applies only to the principal run.

HISTORY OF OTHER RELEVANT ACCIDENTS AND INCIDENTS

A summary of reports of accidents and incidents which may be relevant to this accident is given below.

A *Incident to HS 748 LV-HHH at Concordia, Argentina, on 21 March 1967*

The aircraft overran the runway on take-off and came to rest in loose sand. No damage or casualties were reported. The pilot had abandoned the take-off after finding the elevator locked in the fully down position as he approached rotation speed. He was adamant that he had checked all control surfaces before the start of the take-off run. The report of the manufacturer's representative who went to the scene shortly afterwards is summarised below:

1 When moving the gust-lock lever from OFF to ON, 50% of lever travel was used before anything happened; then all the locks engaged satisfactorily in the correct order.

2 When moving the lever from ON to OFF, it was found to be easily possible to put it in an apparent OFF position which released both ailerons and rudder but retained the elevator locked. This lever position was approximately 0.2″ short of full travel and was made possible by a very badly worn locking slot at the OFF position. The incorrect selection of locks OFF was intermittent, in fact sometimes difficult to obtain,but then, in others, all too easy. It was noticeable that if a fast selection were made to OFF, the fault never showed.

3 The gust-lock lever was then left in this incorrect lever OFF position while a physical check was made on all locks at the control quadrants. The check showed the ailerons and rudder locks to be fully released, but that the locking arm assembly at the elevator quadrant had only moved 0.25″ from the fully locked position. When a correct selection was made the locking arm assembly was seen to move approximately 2″ away from the fully locked position.

4 In due course a rigging check was carried out at base, and a number of defects were noted and corrected. Most notable was that the locking arm assembly at the elevator quadrant was overtightened at its pivot, thus restricting free movement and operation of the release spring.

5 The above faults were corrected, and 'a reinforcement was fitted to the locking slot at the console lever by rather crudely cutting through the top of the (throttle) box to gain access and then chobert rivetting a stainless steel strip into place. This strip then formed the new locking slot for the lever'.

6 It was concluded as follows:

(a) that the whole system had been badly neglected;

(b) that the principal defects were the worn gate and the overtightened pivot at the elevator lock;

(c) that all the small defects made some contribution to accumulate a major one;

(d) that the pilot failed to check the elevator's movement prior to take-off.

Subsequent action taken by the manufacturer was as follows:

1 The operator's attention was drawn to a modification (Mod 967) introducing a detachable gate plate.

2 A requirement was introduced into the Maintenance Schedule to lubricate the pivot every 750 hours.

3 Modification 2617 was introduced to prevent overtighteneing of the pivot.

B *Accident to HS 748 VT-DXO at Rajkot, India, on 7 March 1975*

The aircraft was reported to have overrun the runway during a take-off attempt and was damaged.

The manufacturer never received a copy of the Indian Inspector of Accident's report, but in an extract from it which they did receive via the operator concerned, the Inspector commented on the possibility of leaving the gust-lock lever short of the 'off' detent so that the elevator only remained locked and went on to consider the effectiveness of the throttle interlock under these circumstances. He noted that on carrying out a spot check on 9 aircraft, the interlock was effective on 7 of them. On the remaining 2 aircraft, however, it was possible to arrive at an operating lever position which allowed the FFPS to engage and thus free the throttles while the elevator lock was still engaged.

At the time, the manufacturer, in correspondence with the aircraft operator, did not agree that the situation described above could have caused the elevators to be locked. They stated that in their opinion the throttle baulk would have limited the throttle movement during the take-off attempt if the gust-lock lever had been left in an *intermediate* position. After further investigation into the accident, the manufacturer amended the Maintenance Manual to reduce the backlash in, and thereby improve the effectiveness of, the throttle interlock.

Until shortly after the accident to G-BEKF, the manufacturer believed that the accident in India could have been the result of the pilot attempting the take-off with full nose-down trim applied. At the time it was believed that the pull force required to rotate the aircraft on take-off in this condition would have been excessive.

C *Incident to Dan-Air HS 748 G-BEBA at Leeds-Bradford on 18 May 1977*

On rotation at a V_R of 106 knots the commander found the control column 'frozen' fully forward and abandoned the take-off. The crew stated that the gust-lock lever had been moved to the OFF position before lining up on the runway. The co-pilot checked the ailerons and elevators for 'full and free' movement and this was confirmed visually by the commander. After the take-off had been abandoned, the aircraft was taxied off the runway, the crew checked the elevator control, found 'full and free' movement, re-cycled the gust-lock lever, and could not reproduce the fault. A detailed inspection of the elevator control, gust-lock, elevator trim and autopilot systems showed no defect, and, according to the operator, no adjustment to any system was made. The aircraft was put back into service without further trouble. The manufacturer first became aware of the incident when it received the CAA's Mandatory Overhaul Digest on 3 June. The Mandatory Occurrence Report (MOR) was not received until 13 June.

Following the accident to G-BEKF, the gust-lock system on G-BEBA was re-inspected but no malfunction or abnormality was found.

D *Accident to HS 748 HS-THG at Chiang Rai, Thailand, on 21 June 1980*

The aircraft overran the runway on take-off and sustained substantial damage; two of the crew and one passenger were seriously injured. An investigation is being undertaken by a Thai Government Accident Investigation Committee. The United Kingdom appointed an accredited representative who was able to visit the accident site, assisted by a representative of the manufacturer.

It was clear that the runway length available was more than sufficient to permit a normal take-off under the reported conditions. There were indications that the aircraft was still on the ground when it left the side of the runway at high speed some 100 metres from the far end, and that it had continued along the ground for approximately another 500 metres before coming to rest in a river. There was no indication of engine failure. The handling pilot is reported as saying that during the take-off run the elevator and rudder controls felt very stiff.

It was apparent that the gust-lock lever gate plate had an elongated detent at the 'locked' position, with the result that the distance between the 'locked' and 'unlocked' detents was 1.37 inches. The minimum distance for this dimension prescribed in the manufacturer's Alert Telex Service Bulletin issued in August 1979 is 1.95 inches.

There is evidence that the operator concerned had received this Bulletin and also the follow-up Bulletin issued in March 1980.

The Thai Government report has not yet been received.

AN EXPERIMENT DESIGNED TO MEASURE RESPONSE TIMES OF PILOTS TO A LOCKED ELEVATOR CONDITION AT ROTATION SPEED

THE ROYAL AIR FORCE INSTITUTE OF AVIATION MEDICINE
R G GREEN R J SKINNER

METHOD

Apparatus. The experiment was carried out in a Redifon 101 flight simulator (configured as a small twin engine jet such as an HS 125) provided with a simple computer generated visual world. The simulator had been modified such that the control column could be locked electro-mechanically from the instructor's console at any time and in any position. When locked, the control column was not totally immobile, but presented the sort of resistance which could be encountered in stretching cables in an aircraft with locked controls. Toe-brakes with microswitches were also fitted to enable remote monitoring of the onset of brake application. Other aspects of the pilot's behaviour could be monitored using a low light television camera mounted in the roof of the simulator.

Subjects. All eight subjects were transport pilots in current flying practice, and all were drawn from a UK airline with the exception of one RAF pilot. Their experience varied from a first officer with 1500 hrs to a training captain with 12000 hrs. The aircraft types on which they were current were Trident, Boeing 737, Devon, and BAC 1-11. All subjects were volunteers.

Procedure. Subjects were told that the experiment concerned measuring response times to various emergencies (the natures of which were not specified). They were then given a briefing in which they were told that all of the flying in the experiment was circuit flying and this would not be complicated by weather, air traffic control, hills, changes of altimeter setting or wind. The briefing also included details of handling the aircraft under normal and asymmetric conditions and lasted for approximately one hour.

The subjects were then installed in the simulator and given two visual circuits under instruction with an instructor in the cockpit, where they were familiarised with speeds, power settings and so on. The instructor then left the cockpit but continued, on intercom, to act as a first officer calling out check lists, and speeds during the takeoff roll (at 50 kts, 80 kts, V_1 and V_R).

Checks were carried out:

- Pre start
- Start
- Pre take-off
- After take-off
- Pre landing
- Final approach

These checks were always carried out diligently including the pre take-off check, part of which ensured full and free movement of the controls.

The subject then carried out an uneventful solo flight consisting of a take-off (TO), climb to 3000 ft, 10 mile downind leg for a full ILS approach.

The following flights containing the specified emergencies were then flown.

1. Engine failure at V_2 + 15 kts (140 kts) followed by single engine circuit and visual approach.
2. Engine failure on the runway below V_1 (100 kts).
3. Engine failure immediately after (ie within 5 kts) of V_2 (125 kts).
4. TO, normal circuit with ILS approach.
5. Control column was locked shortly before V_R (110 kts).

The pilots' actions were videotaped, and it was this videotape which was analysed to determine the time between the call 'Rotate' made by the instructor and the subjects initiating both a power reduction and braking.

The visual simulation was arranged so that the action of closing the throttles and fully applying the brakes, if initiated approximately 3 seconds after passing V_R, would bring the aircraft to a halt at the far end of the runway.

RESULTS

Response times in seconds between the call 'Rotate' and the pilot's hand touching the throttle are given in the second column of Table 1 and response times from 'Rotate' to the onset of brake pedal pressure are given in the third column. The nature of the experiment dictated that only one data point could be elicited from each subject.

Subject	*RT to Power Off*	*RT to Brakes*
A	2.0	3.0
B	4.0	7.0
C	3.0	3.0
D	1.5	1.8
E	1.8	2.2
F	3.0	3.0
G	3.0	3.5
H	3.0	4.0
	$\bar{x}$ 2.7	$\bar{x}$ 3.4

DISCUSSION

There are many aspects of the real emergency which could not be simulated in this experiment; ideal flying conditions prevailed, the pilot was flying alone, and he was, of course,.expecting some sort of emergency, though he did not know what. Because, in simulator flying, experienced aircrew inevitably expect emergencies it was decided not to attempt to pretend that emergencies would not be given, but to accept that the pilot would be expecting them, and would thus respond more quickly than he would in a real aircraft.It must therefore be acknowledged that any results found represent the minimum possible times required to appreciate the problem and take action.. The same emergency occurring in a real aircraft could take very much longer to be responded to. Two interesting points arise from the results. The first is that the response times are relatively long; it is difficult to estimate precisely how much of this time is taken in identifying the problem (what is sometimes terms 'cognition time'), but it is certainly a material fraction of it. Secondly, it may be observed that while two pilots applied the brakes and reduced power simultaneously, all the other pilots took considerably longer to apply the brakes than to reduce the power.

It is unfortunate that time constraints prevented more subjects from being tested; nevertheless it is felt that this small experiment does provide some realistic idea of the minimum time required to respond to emergencies of this nature.

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CONTROL LOCK OPERATING SYSTEM IN UNLOCKED POSITION

CONTROL LOCK OPERATING SYSTEM IN LOCKED POSITION

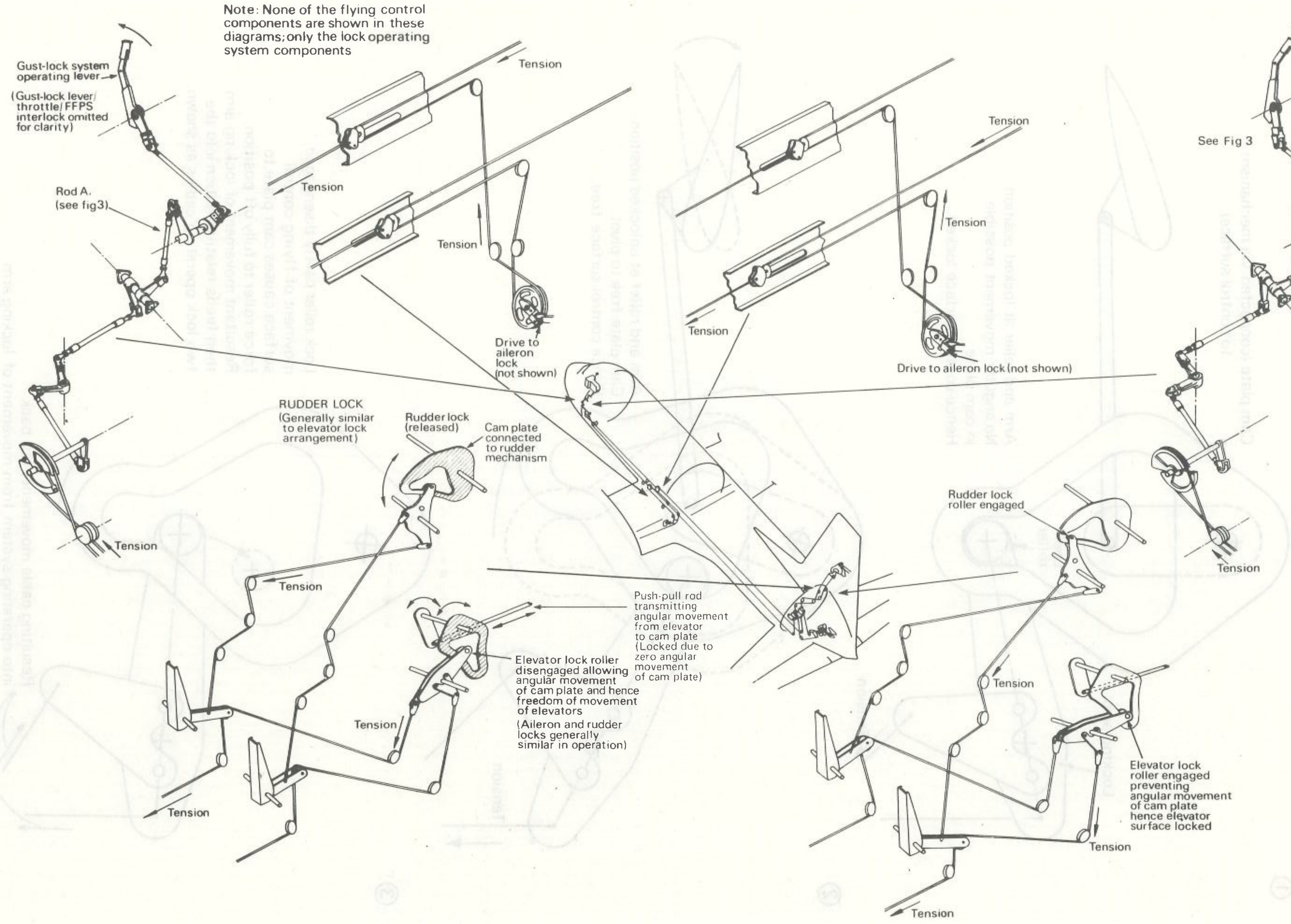


FIGURE 1

FIGURE 2

METHOD OF OPERATION OF INDIVIDUAL GUST-LOCKS

(ELEVATOR LOCK SHOWN, AILERON AND RUDDER GENERALLY SIMILAR)

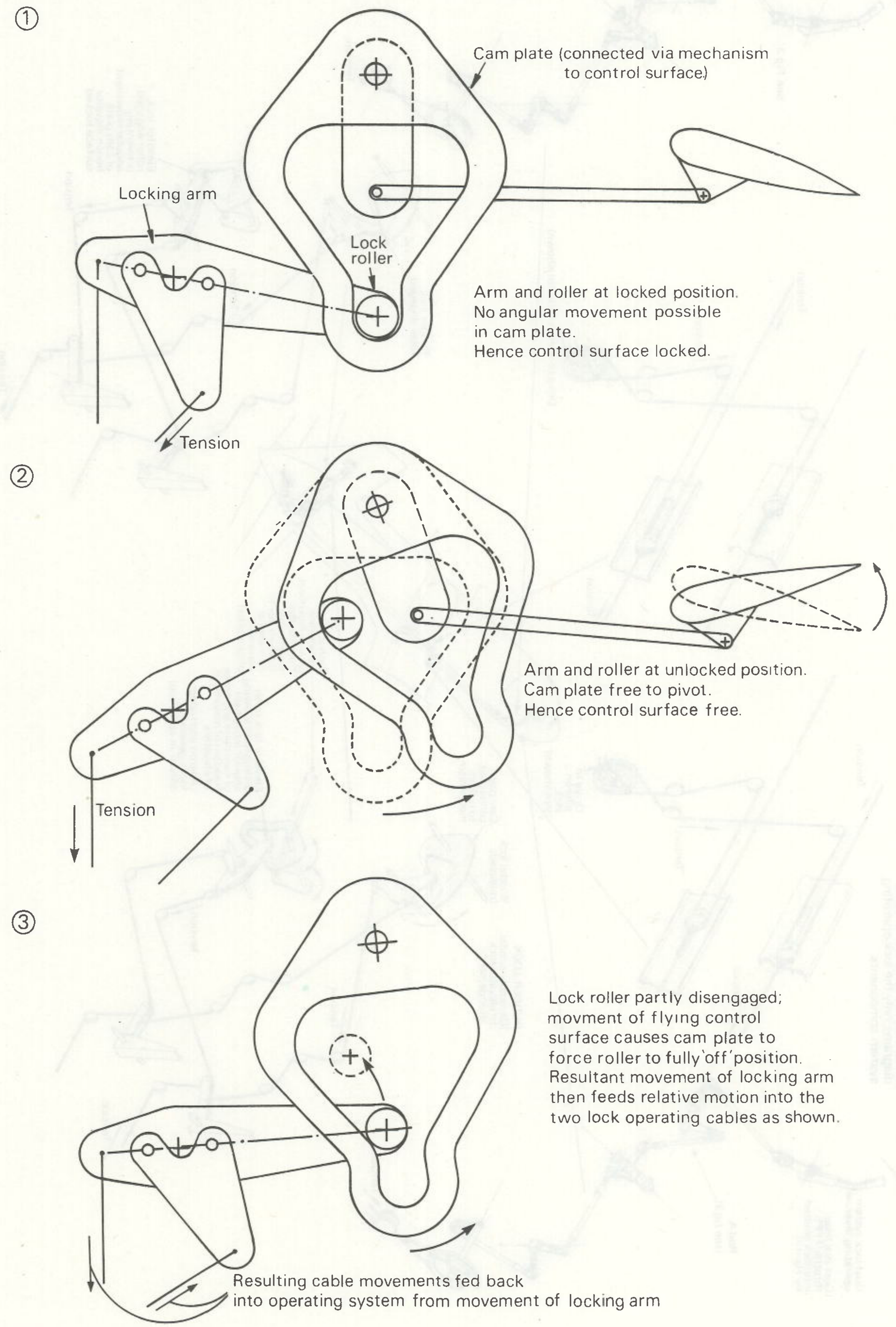


FIGURE 3

THROTTLE, FLIGHT-FINE-PITCH STOP GUST-LOCK INTERLOCK MECHANISM IN CONTROL CONSOLE
(Throttles omitted for clarity)

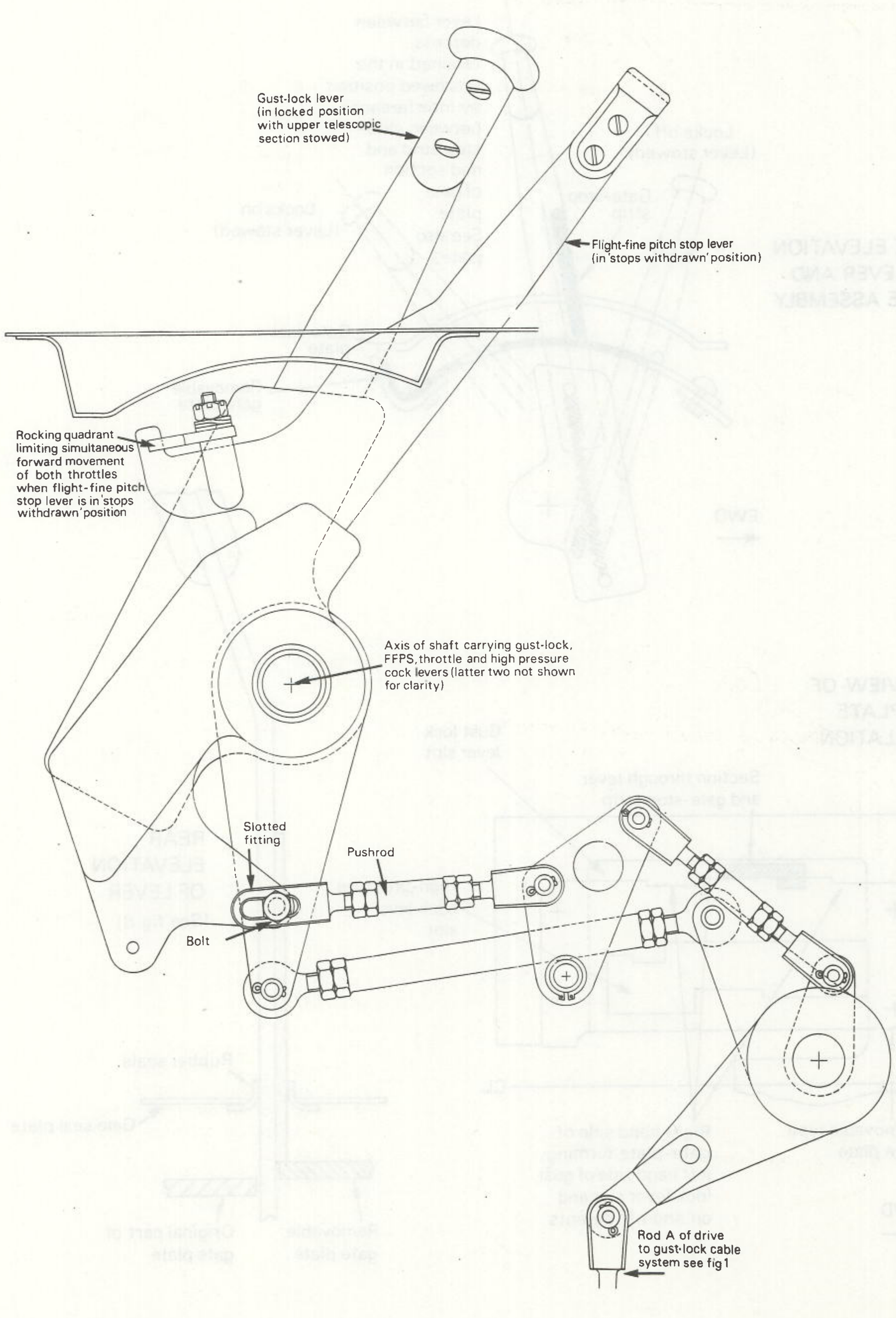


FIGURE 4

ARRANGEMENT OF GUST-LOCK LEVER AND GATE PLATE IN CONTROL CONSOLE (Recent production modification standard)

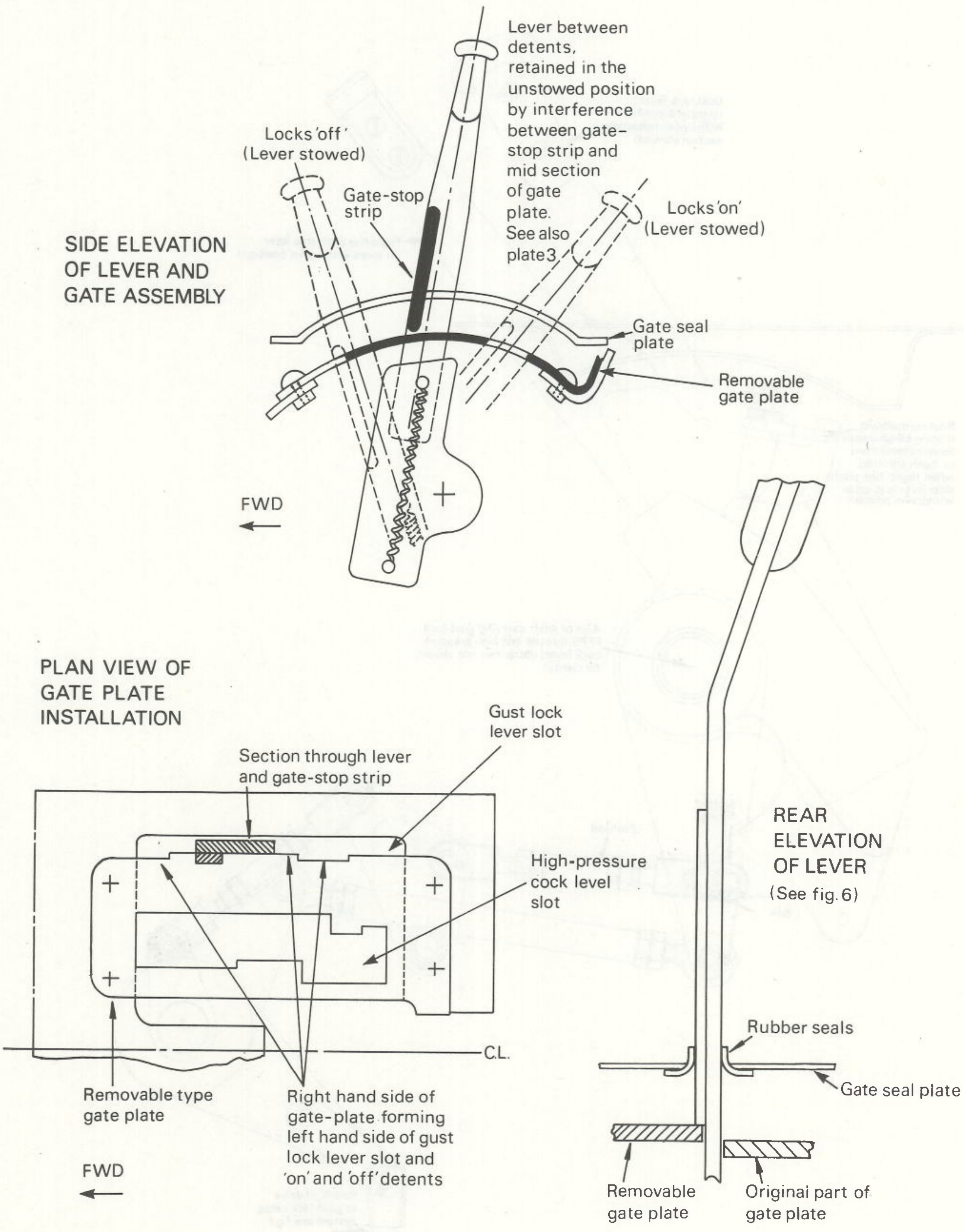


FIGURE 5

SITUATION OF GUST-LOCK LEVER AND GATE PLATE IN CONTROL CONSOLE AS DEMONSTRATED ON G-BEKF

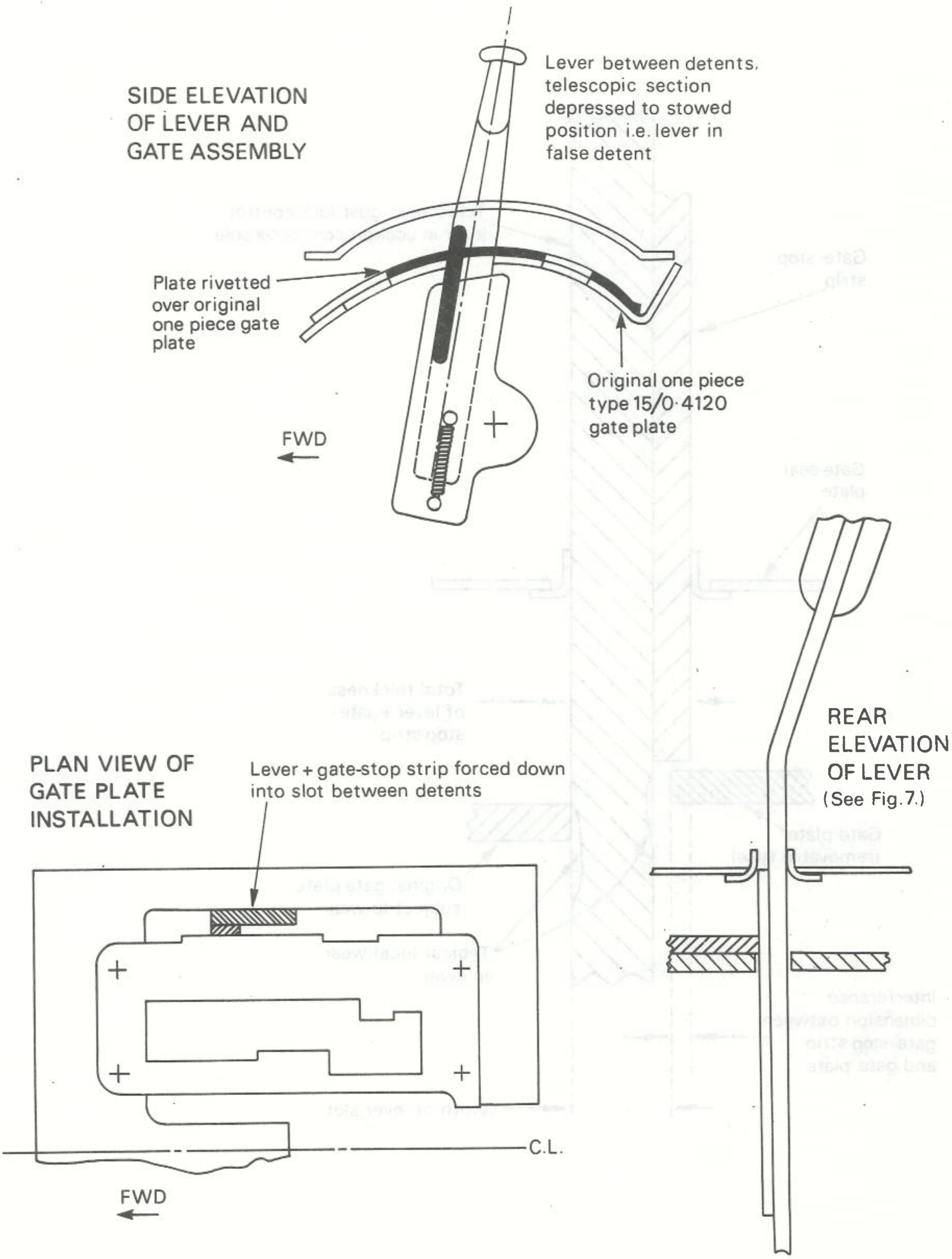


FIGURE 6

SECTION THROUGH TYPICAL GUST-LOCK LEVER AND GATE-STOP STRIP, SHOWING INTERFERENCE WITH GATE PLATE (LOOKING FORWARD)

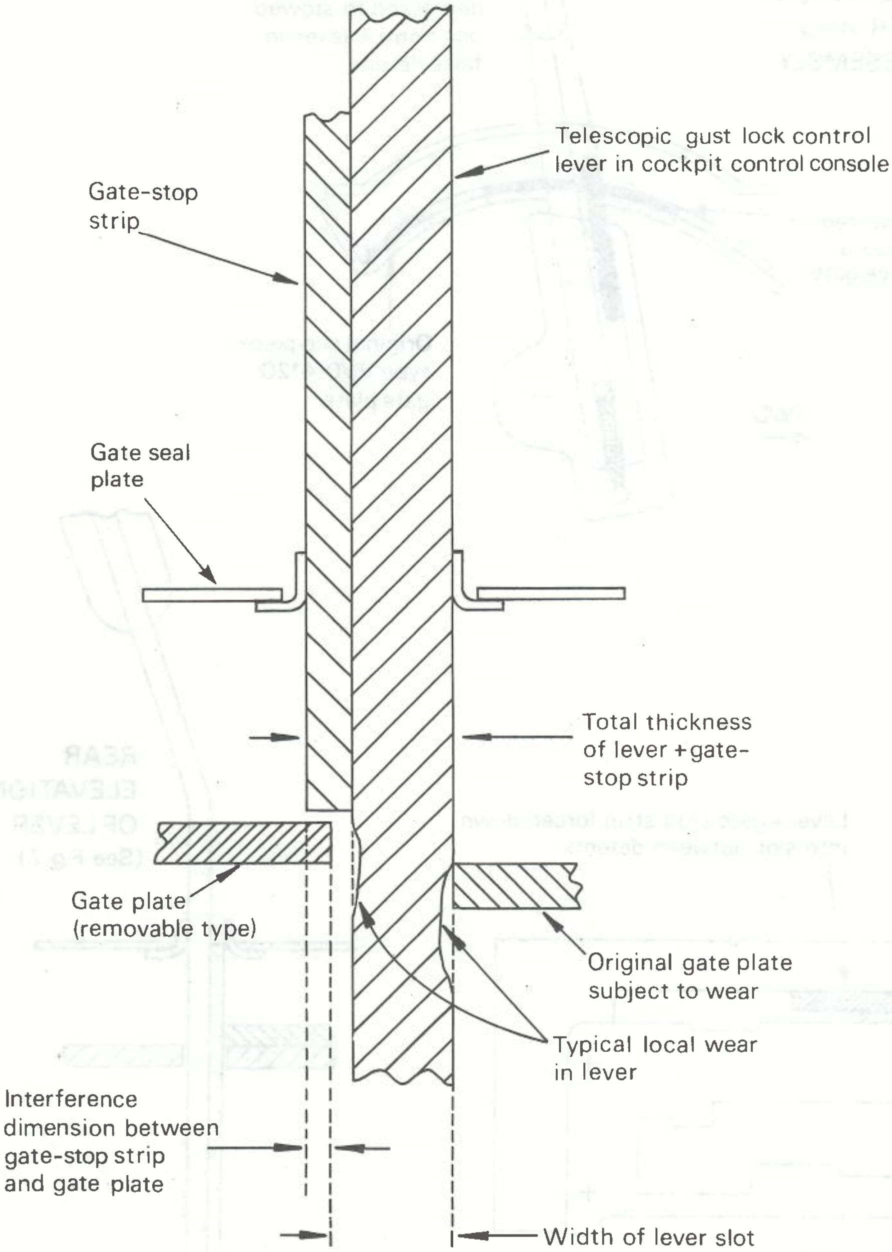
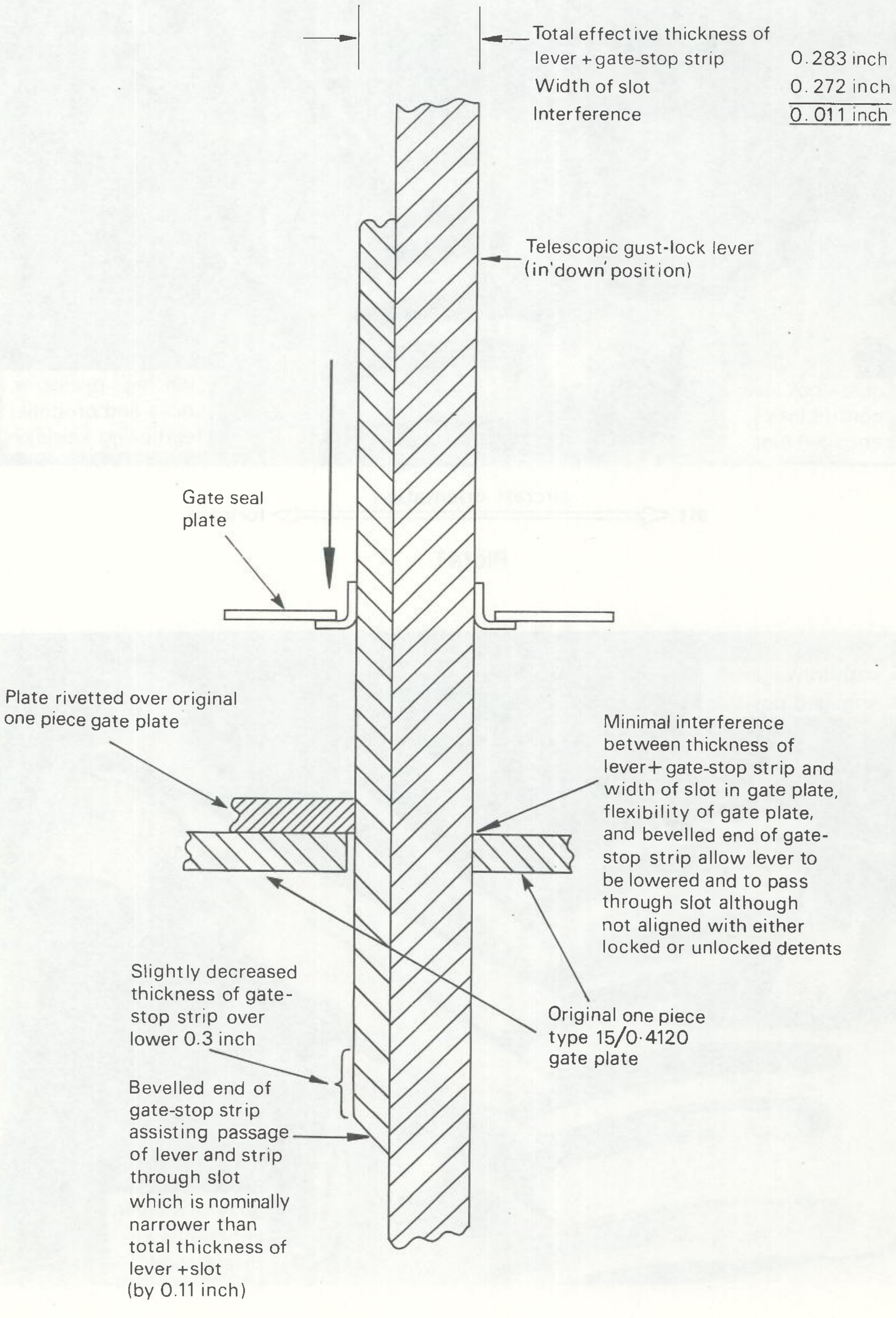
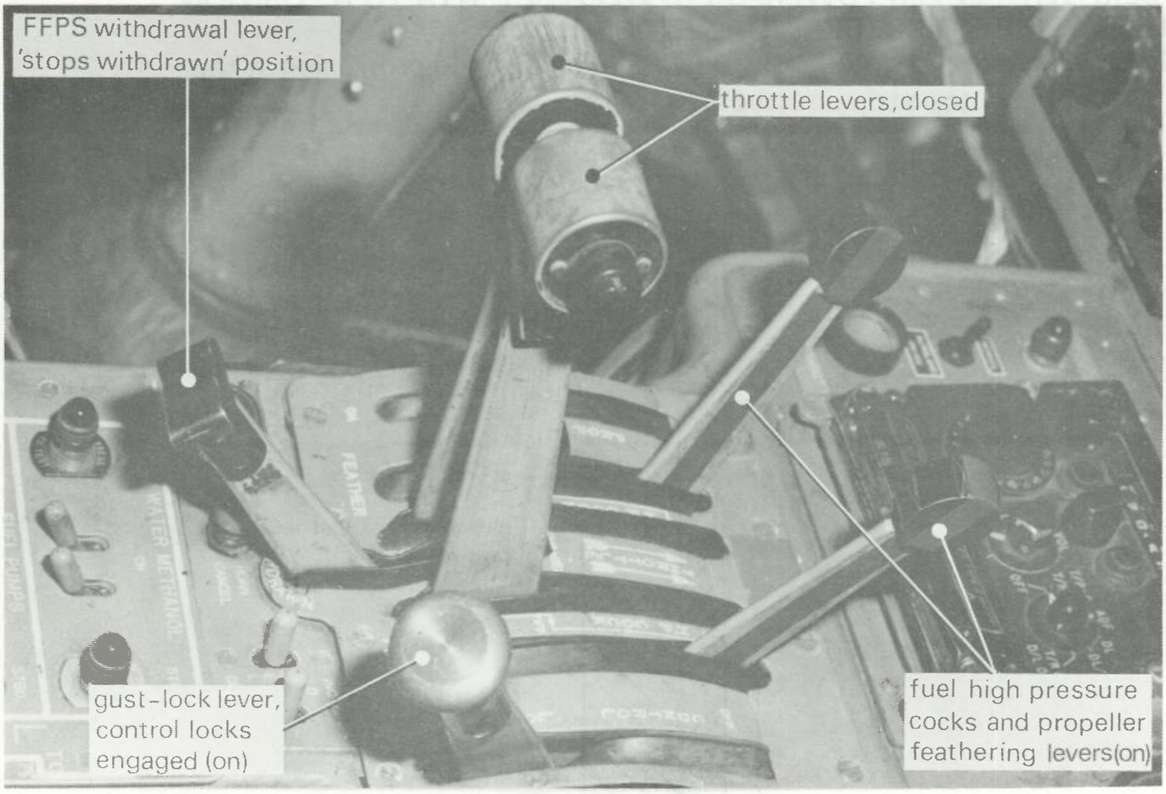


FIGURE 7

DIAGRAM OF SECTION THROUGH GUST-LOCK LEVER, GATE PLATE AND GATE-STOP STRIP, SHOWING SITUATION DEMONSTRATED ON G-BEKF, WITH LEVER LOWERED BETWEEN DETENTS TO A POSITION RESEMBLING 'LOCKS DISENGAGED' POSITION
(Note: loose steel strip on right hand side of slot and protrusion at top of gate-stop strip omitted for clarity)



Cockpit controls-centre pedestal



aft ⟺ aircraft orientation ⟹ forward

Plate 1

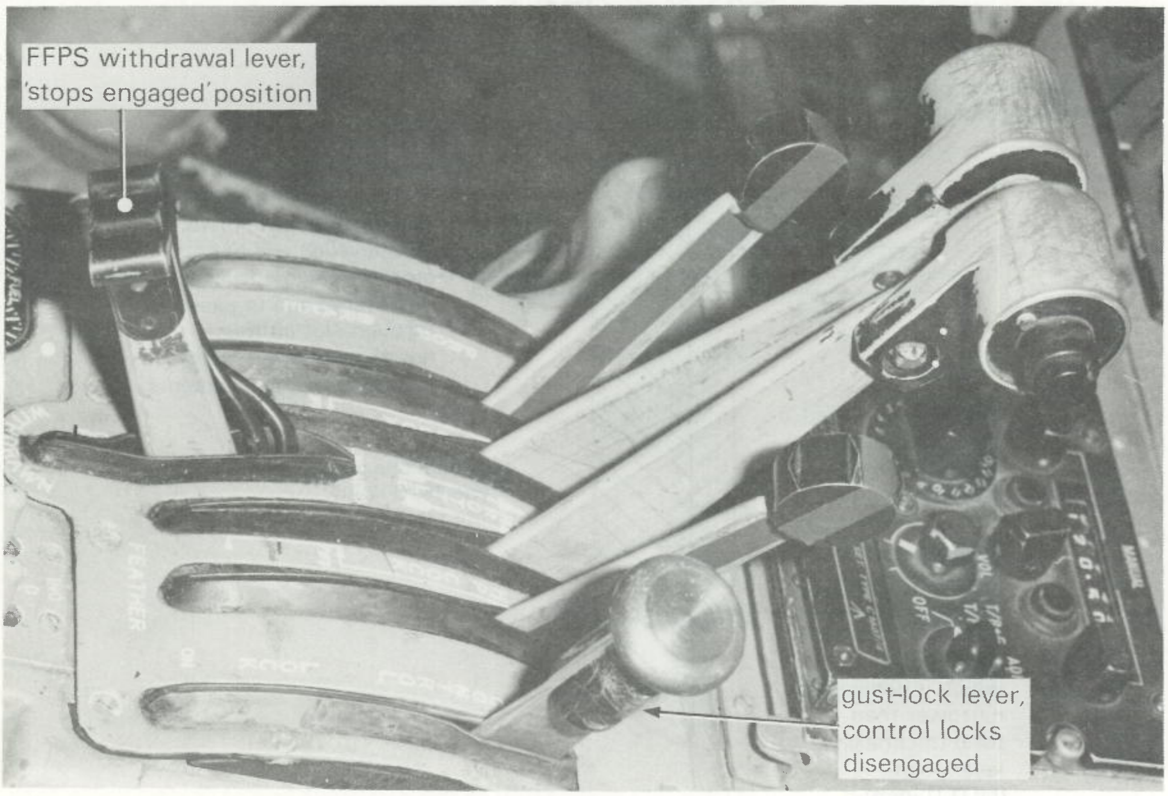
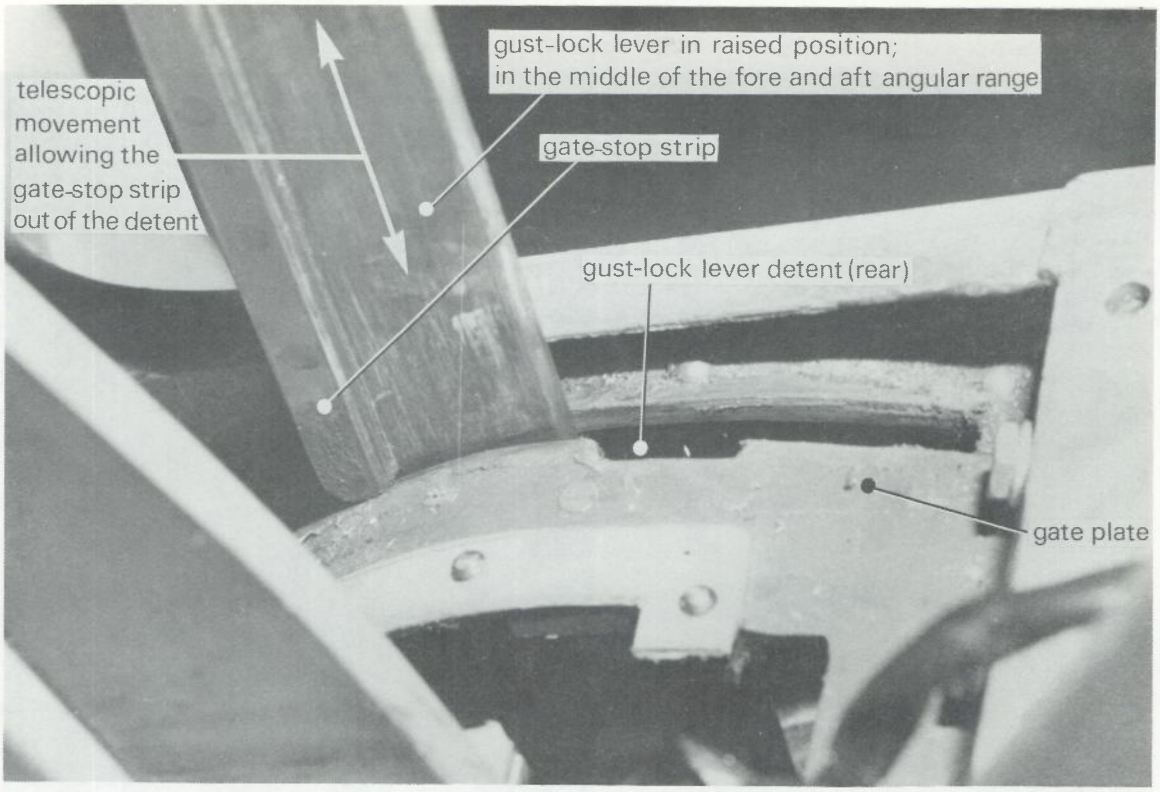
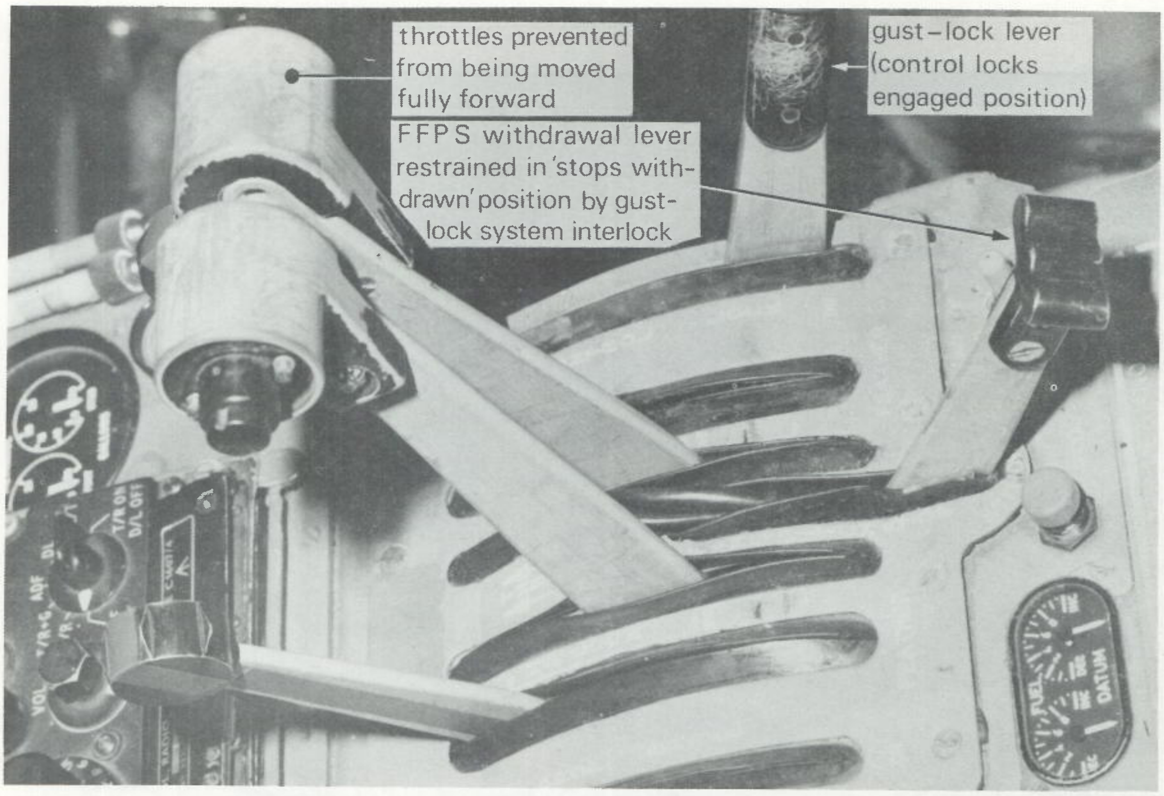


Plate 2



aircraft orientation
forward ⟺ aft

Plate 3 : gate seal plate removed



aircraft orientation
forward ⟺ aft

Plate 4 : throttle position when baulked by the interlock

Cockpit controls-centre pedestal
Gust-lock lever approximately 30% back from 'off' detent, in false detent position.
Throttles closed

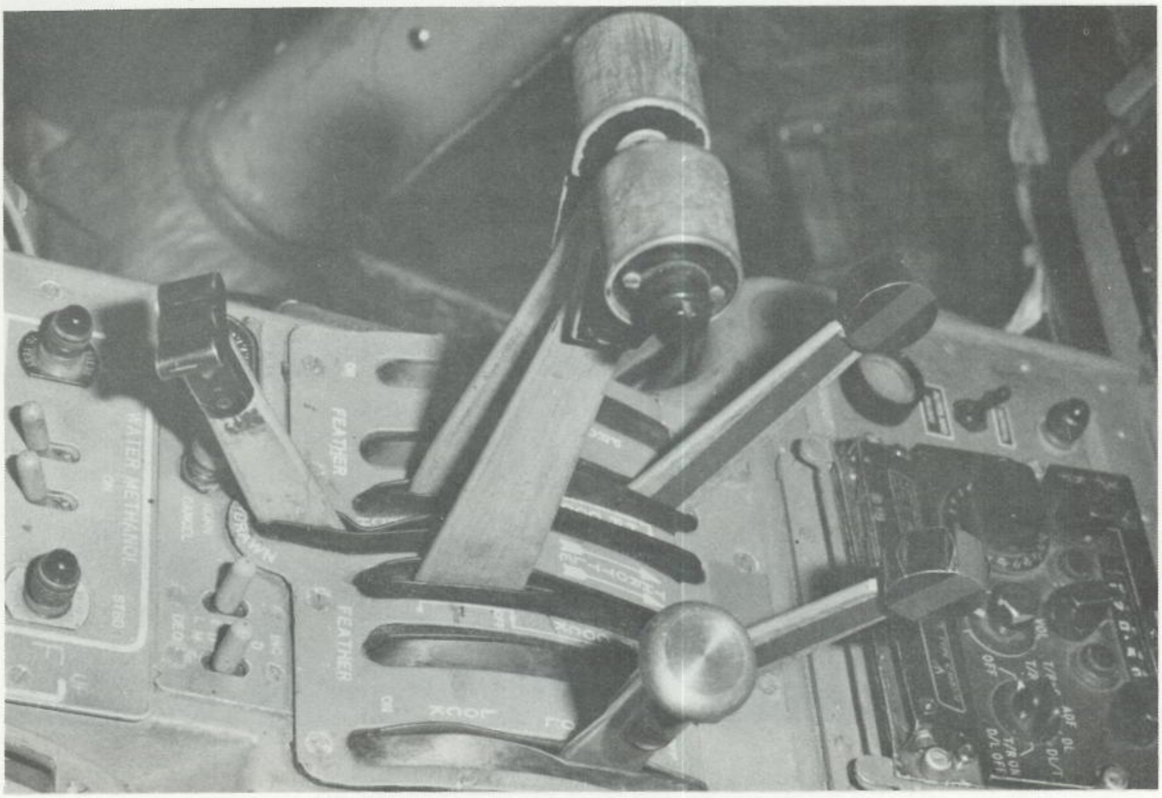


Plate 5 : approximately as viewed from the co-pilot's position

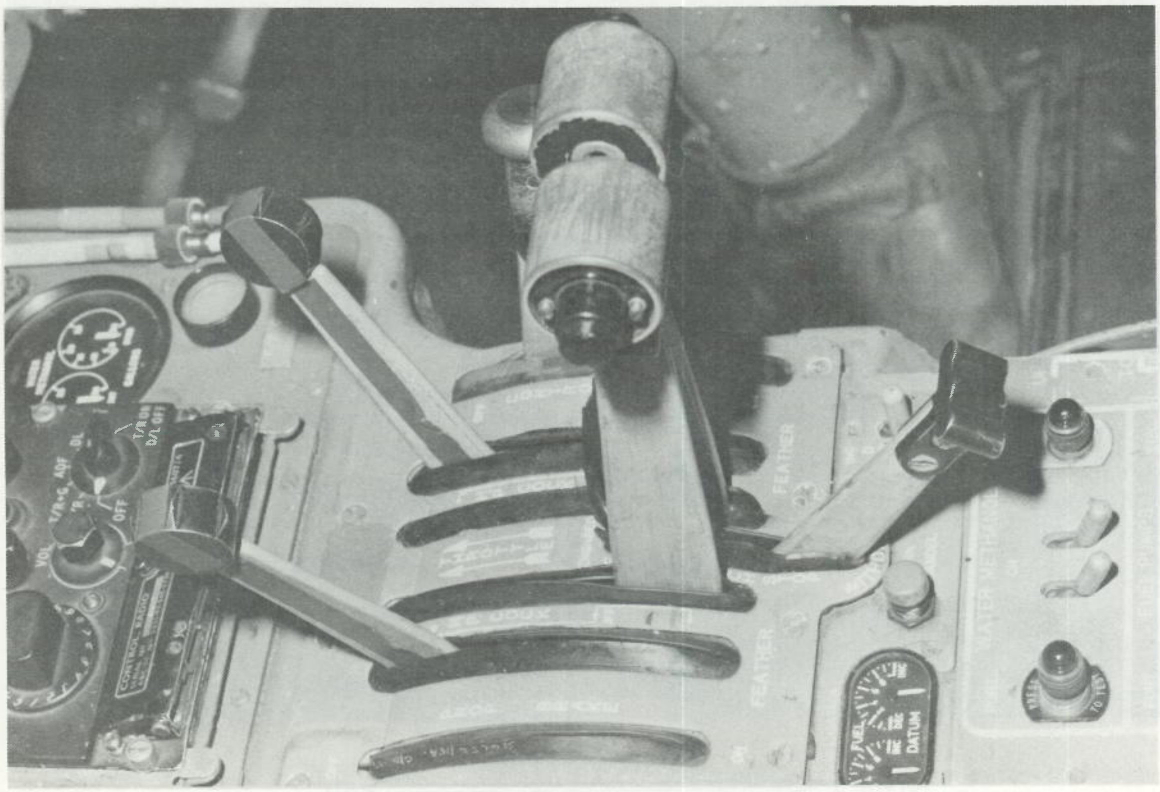


Plate 6 : approximately as viewed from the commander's position

Topography at eastern end of overrun area

Plate 7 : the sea defences, viewed from the perimeter road

Plate 8 : the step up to the perimeter road, viewed along aircraft track