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Measurements of Fluctuating Pressures In and Behind the Born Bay of a Canberra Aircraft

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MEASUREMENTS OF FLUCTUATING PRESSURES IN AND BEHIND THE BOMB BAY OF A CANBERRA AIRCRAFT

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C. W. Skingle
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SUMMARY

The spectra of pressures at points in and behind the bomb bay of a Canberra aircraft have been obtained for a range of flight conditions. The primary objective of the flight measurement programme was to acquire data for comparison with pressure spectra obtained on a Wind tunnel model. This report describes the flight programme, and presents the results obtained. Comparison with wind tunnel experiments shows reasonably good agreement on rms pressure levels and spectrum shapes.

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*Replaces R.A.E. Technical Report 68086 - A.R.C. 30507

CONTENTS

1 INTRODUCTION

For many years, there has been interest in buffet in aircraft. In particular, the buffet caused by flying an aircraft with the doors of a bomb bay open has sometimes resulted in a high level of vibration, not only in the aircraft but in stores carried within the bomb bay. One of the problems in dealing with buffet is the difficulty of predicting the level and nature of the resulting vibration; a knowledge of this would be of great value, since if it is available during the design stage of the aircraft, steps may be taken to ensure that due allowance is made for the vibratory environment in assessing the operational capability of the aircraft under service conditions. Reliable prediction of aircraft response also allows remedial design action to be taken either to reduce the magnitude of the buffet pressures or to alter the structural response characteristics in critical areas.

A proposed technique for predicting vibration levels due to buffet (with particular reference to buffet in open bomb bays) consists of a two-stage procedure. In the first stage, a rigid model of the proposed design of aircraft is tested in a wind tunnel. The model is instrumented with pressure transducers, and the unsteady pressures due to buffet are recorded on magnetic tape. The second stage consists of setting up an electrical analogue of the aircraft and of using the measured wind tunnel pressures as a force input, by replaying, with appropriate scaling, the signals from the magnetic tapes into the analogue. The response of the analogue is then a measure of the response of the aircraft to the buffet pressures, assuming that aircraft motion does not modify the pressures, and the analogue response can be recorded and analysed so as to yield vibration levels and spectra.

At first sight, it might appear preferable to dispense with the second stage of the procedure by constructing a wind tunnel model which is dynamically similar to the aircraft, so that all that is necessary is to measure the response of the wind tunnel model to its own buffet, and to convert these measurements to the full scale aircraft. However, the construction of a dynamically accurate wind tunnel model would require modelling techniques of a very high order, and such a model would not easily lend itself to structural or aerodynamic modifications. In the two-stage technique, the wind tunnel model is effectively rigid (since it is unlikely that structural flexibility will significantly affect buffet pressures). The use of a rigid model enables modifications which affect the flow to be made easily, whereas this might be difficult, or even impossible, with a flexible model without altering the dynamic characteristics.

In order to assess the value of the proposed technique, a Canberra bomber was flown, and records taken of the unsteady pressures in and behind the bomb bay. A model of the aircraft was tested in a wind tunnel at the R.A.E. at conditions appropriate to the flight tests, and records were taken of unsteady pressures at a large number of points including the measurement points used in the flight tests'. In the flight tests, records of the response of the aircraft were also taken. It was intended that the wind tunnel pressure measurements should be used to compute, by means of an analogue, the response of the aircraft, so that the response measured in flight could be compared with the calculated response. Unfortunately, various circumstances made it impossible to complete the analogue stage of the exercise, and it has only been possible to compare the wind tunnel pressure measurements with the corresponding flight measurements. For this reason, the response measurements are not given in this report.

This report describes the flight test pressure measurements that were made, the results obtained, and gives a comparison of model and full-scale fluctuating pressure values. The comparison shows that reasonably good agreement was obtained, and this at least suggests that the first stage of the proposed technique of response prediction is valid. It is hoped that it may yet be possible to complete the second stage, but there is no immediate prospect of this, and any further work would be the subject of a separate report.

2 RANGE OF INVESTIGATION

The flight tests were made at heights of 1500 and 6000 m (5000 and 20000 ft). At each height, Mach numbers between 0.3 and 0.6 were investigated. These corresponded to Mach numbers investigated in the wind tunnel tests[1]. For each flight condition the aircraft was flown with the bomb doors open and shut, and records of the unsteady pressures at two stations within the bomb bay and two stations outside and aft of the bomb bay were taken.

The pressure records were analysed to yield pressure spectra for each point at each flight condition, and the spectra were then converted to non-dimensional form for direct comparison with the wind tunnel test results.

3 AIRCRAFT INSTALLATION

3.1 Measurement stations and transducers

The four pressure measurement stations are shown in Fig.1. The stations were chosen to be in a region where high fluctuating pressures would occur - these stations being selected on the basis of the results of the wind tunnel tests. A false roof was built into the rear of the bomb bay to eliminate possible unsteady flows arising from the local structure, which might render a comparison with the wind tunnel test results invalid. The false roof (bomb doors open) is shown in Fig.2. Although the instrumentation for the flight measurements was installed in a tray in the bomb bay Itself, a model of this tray was included in the wind tunnel model so that, geometrically, the model and aircraft bomb bays had no significant differences.

Unsteady pressures were measured by S.E. Laboratories' variable Inductance differential pressure transducers, type SE 150, having a pressure range up to 5000 N/m^2 (0.72 lbf/in^2). The transducers were mounted in boxes vented to atmosphere, as shown in Fig.3, so that no steady pressure differential would exist across the diaphragm. The vent consisted of a length of hypodermic tubing, the dimensions of which were chosen so that pressure fluctuations above 5 hertz at the atmospheric end of the tube would not be transmitted to the interior of the box, The installation of a pressure transducer in the roof Of the bomb bay is shown in Fig.4. The transducers were connected to transistorised ac bridge amplifiers.

The overall frequency response of the pressure transducers and amplifiers was flat within ±1 dB from 5-100 hertz.

3.2 Instrumentation

3.2.1 Calibration unit

Automatic calibration of three pressure measurement channels was provided. The calibration unit was interposed between the transducers and the ac bridge amplifiers. The unit operated when the main switch, controlling the recording system, was put to the "off" position at the end of a recording. Operation of the switch caused the calibration unit to disconnect the transducer and to substitute a dummy half-bridge circuit for a period of five seconds during which recording was continued. Transistor switches were used in the calibration unit to short circuit part of the resistance in one arm of the dummy half-bridge, as shown in Fig.5. The transistor switches were activated by oscillators (running at approximately 20 hertz) driving the base of the switch transistor both positive and negative. The positive swing is necessary to ensure that the alternating carrier applied to the dummy half-bridge will not switch the transistor on.

A second set of ac bridge amplifiers was included in the instrumentation to enable response measurements to be made from accelerometers. The results from these measurements are not covered in this report as explained in section 1, but they are mentioned here in order to clarify details of the instrumentation.

Because the carrier frequencies of the two sets of ac bridge amplifiers (pressure and response measurement) were different, both sides of the carrier supply were floating with respect to earth, the sets had to be isolated from each other and from earth; two oscillators were therefore required in the calibration unit, and these could not be driven directly by the aircraft supply. The oscillators were therefore driven by isolated Deac rechargeable cells fitted with self-regulating charging circuits as shown in Fig.6. The charging circuits were connected, by relays, to the aircraft supply when the calibration unit was inoperative.

3.2.2 Modulator unit

The modulator unit contained eight frequency modulators type IT I-6-57, a direct recording channel, a compensation channel which could be fed to two tape recorder heads in series, and power supplies for these items.

The modulators operated at 3 kHz with ±40 per cent deviation and a bandwidth from zero to 625 hertz. The outputs of four ac bridge amplifiers of each set were connected to the modulator unit.

The direct recording channel was connected to the aircraft telecommunication system so that a speech channel could be used for record identification.

3.2.3 Tape-recorder

The outputs of the modulator unit were fed to the recording head on a multi-channel tape recorder type IT 7-4-61. The recorder was fitted with a 16-track recording head giving a possible total of 16 recording channels of which 11 were utilised. Tape speeds of 0.0476, 0.0952 and 0.1905 m/s ($1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$ in/s) were available although most of the flight records were taken with a tape speed of 0.0952 m/s ($3\frac{3}{4}$ in/s).

3.2.4 Paper recorder

A photographic paper recorder was also installed as a check system. The recorder was a Mid-Western type 555 having twelve recording channels which were connected to the ac bridge amplifiers.

3.2.5 Installation

It was mentioned in section 3.1 that the instrumentation for the flight tests was installed in a tray in the bomb bay. The tray was mounted on the bomb beams at the forward end of the bay, and was designed for quick removal so that the installation could readily be taken from the aircraft to the laboratory for servicing end adjustment. A photograph of the installation is shown in Fig.7, The only components of the instrumentation not mounted in the tray were the transducers and the control unit. The latter was mounted near the observer's seat in the cockpit. A schematic diagram of the instrument tray wiring is shown in Fig.8.

4 FLIGHT TEST RESULTS

4.1 Pressure spectra

The notation for pressure spectra used in this report is the same as that used in the report giving the results of the wind tunnel tests'. Briefly, the notation is as follows: the rms pressure amplitudes are expressed in non-dimensional form as $p_\varepsilon/q\sqrt{\varepsilon}$ where:

p_ε is the rms value of the pressure fluctuations within the bandwidth of the analyser used to obtain the spectra

ε is the bandwidth ratio of the analyser, and is equal to the bandwidth divided by the centre frequency

q is the kinetic pressure.

Frequencies are expressed as a non-dimensional frequency parameter $n = \frac{f\,L}{U}$ where:

f is the bend centre frequency (hertz)

U is the forward speed (m/s)

L is the bomb bay length (6.6 metres).

It may be noted that, provided the variation of pressure spectral density with n is small within the bandwidth of the analyser, then $p_\varepsilon/q\sqrt{\varepsilon}$ is independent of the value of E, and in the limit ε may be replaced by dn/n so that the total mean square $\overline{p^2}$ of the pressure fluctuations is given by

$$\frac{\overline{p^2}}{q^2} = \int_{n=0}^{n=\infty} \left(\frac{p_\varepsilon}{q\sqrt{\varepsilon}}\right)^2 d\,(\log n) \quad .$$

The tape records of pressure fluctuations were **analysed** by passing each signal through a series of one-third octave bandwidth filters (E = 0.23) and measuring the rms value for each filter output (pa). The total **rms** value for each record ($\sqrt{\overline{p^2}}$) was also measured.

The positions of the four pressure **transducers** shown in Fig.1 **can** be expressed as fractions of the length of the bomb **bay** aft of the front lip of the bay (x/L, where **x** is the distance from the front lip of the bay to the transducer). The values of **x/L are** 0.84, 0.96, 1.05 and 1.20. The first three of these positions correspond to positions of pressure transducers in the wind tunnel tests. Flight tests were made at Mach numbers of 0.3 and 0.6 at both 1500 **and** 6000 m (5000 and 20000 **ft)** altitude. The **ias** for each of these conditions is given in Table 1.

The pressure spectra at the four measurement points are given in Tables 2-5, end are shown in graphical form in Figs.916.

It should be noted that in the following sections the term pressure refers to non-dimensionalised fluctuating pressure (i.e. either $(\sqrt{\overline{p^2}}/q)$ or $(p_\varepsilon/q\sqrt{\varepsilon})$as appropriate).

4.2 Effect of kinetic pressure and incidence

In order to assess the effect of kinetic pressure (q) and wing incidence (α) on the fluctuating pressures, flight measurements were made at Mach numbers of 0.3, 0.4, 0.5 and 0.6 at each of the two test heights. The total **rms** level of the pressure fluctuations was obtained for each transducer at each flight condition. The results are given in Table 6 in which the fluctuating pressures are expressed as percentage values of the kinetic pressure. A graphical presentation is shown in Figs.17 and 18.

5 COMPARISON WITH WIND TUNNEL MEASUREMENTS

5.1 Spectra of fluctuating pressures

A comparison of the pressure spectra measured in flight **and** in the wind tunnel is shown in Figs.19 **and** 20. In Fig.19 the comparison is made for two positions within the bomb bay, **and** one immediately aft of the **bay** at **M** = 0.3

and *M* = 0.6 at a height of 1500 m (5000 ft). In Fig.20, the same comparison is made at a height of 6000 m (20000 ft). Both figures show that there is reasonably good agreement in spectrum shape between the wind tunnel and flight results over the range of values of n for which the comparison can be made. For the spectra at x/L = 0.84, the two rather flat peaks that occurred in the wind tunnel tests, at n = 0.6 and n = 2 approximately, also occur in the flight tests, although they are less well defined. At x/L = 1.05, the single peak at approximately n = 4 occurs for both flight and wind tunnel experiments. Over most of the spectrum, however, there is a greater difference in level between M = 0.3 and M = 0.6 than was the case with the wind tunnel results. In flight, the higher spectral values were associated with the lower Mach number, and greater incidence.

5.2 Overall level of fluctuating pressures

5.2.1 Distribution in and behind the bomb bay

It is difficult to compare overall levels of pressure fluctuations in flight with those measured in the wind tunnel. The difficulty arises because, in the two experiments, differences of equipment resulted in the overall levels being measured for different frequency bandwidths. In all cases the range of frequency parameter n covered in the flight tests was less than that covered in the wind tunnel tests; it should perhaps be emphasised that the frequency range of the flight test equipment was chosen to cover the structural modes of the aircraft and, for this purpose, was more than adequate. The differences in pressure spectrum bandwidth would, of course, be unimportant if there were no significant pressure levels outside the bandwidth. This is not always the case, as may be seen in Figs.11 and 12, for example, in which the upper frequency end of the spectrum is cut off at points where the pressure level is high.

To obtain a valid comparison of flight and wind tunnel overall rms pressure levels, both sets of spectra have been integrated over the range of frequency parameter covered by the flight tests. The pressure levels given in Table 6 were obtained in this way *and thus* do not include components outside the bandwidth of interest.

It was shown in the wind tunnel tests that the pressure fluctuations are most intense in the vicinity of the rear bulkhead, and also on the roof of the middle of the bay where the flow is attached. In the flight tests, the pressures in the middle of the bay were not measured, and Figs.21 and 22 show the measure of agreement between wind tunnel and flight tests for pressures near the rear bulkhead. It will be seen that at both $M = 0.3$ and 0.6, maximum pressures in the wind tunnel tests occur within the bay and close to the rear bulkhead, and this was confirmed in the flight tests. At $M = 0.3$ the maximum aircraft pressures were somewhat lower than the maximum model pressures at $\alpha = 5.6^\circ$, but higher at $\alpha = 10.4^\circ$. At $M = 0.6$ the aircraft pressures were lower than the model pressures at both angles of incidence. Just aft of the bay, the aircraft pressures were higher than those of the model at $M = 0.3$, but were very similar at $M = 0.6$.

Although detail differences between the wind tunnel and flight test results have been noted, there is an encouraging level of agreement in general, not only in the position at which peak pressures occur but also in the variations of pressures on each side of the peak. It should also be remembered that, in the flight tests, some turbulence was present and aircraft response to both this and to the buffet pressures occurred whilst the measurements were taken. The level of pressure fluctuation for the points aft of the bomb bay was checked with the bomb doors closed and found to be less than 10% of the levels measured when the doors were opened.

5.2.2 Effect of Mach number and incidence

The limited data make it difficult to separate the effects of Mach number and incidence on the fluctuating pressures. From the results shown in Figs.17 and 18, it can be seen that at each height there is a tendency for the overall pressure level to rise at points on the fuselage aft of the bomb bay ($x/L = 1.05$ and 1.20) as the incidence is increased, whilst the level falls slightly at points within the bay ($x/L = 0.84$ and 0.95). In these figures, the increase of incidence is associated with a decrease in Mach number. It is possible to obtain some indication of the separate effects of Mach number and incidence by cross-plotting Figs.17 and 18 so as to obtain the variation of pressure with Mach number at constant incidence. This has been done in Fig.23 for $x/L = 0.95$ and 1.20. There are, of course, only two points for each line on the graph, and the incidence range is restricted, but it is clear from Fig.23 that there is a tendency for overall pressure levels to decrease with increase of Mach number. It can also be seen that increase of incidence at constant Mach number results in a decrease of pressure level for $x/L = 0.95$ but has little effect at $x/L = 1.20$.

6 CONCLUSIONS

The measurement of fluctuating pressures arising from buffet in the open bomb bay of a Canberra aircraft in flight have been shown to be in reasonably good agreement with corresponding pressures measured on a model in the wind tunnel. It is concluded that the use of wind tunnel pressure measurements as a force input in the calculation of aircraft response to bomb bay buffet loads is valid.

The flight measurements confirm that maximum fluctuating pressures occur close to the rear bulkhead of the bomb bay. The differences in overall rms pressures between aircraft and model depended on the flight conditions; for most conditions, the aircraft pressures within the bay were lower than the model pressures, Aft of the bay the aircraft pressures were higher than model pressures at the lower Mach numbers.

Comparison of the fluctuating pressure spectra from the aircraft and model tests shows that there was good agreement in spectrum shape and in the frequencies at which peaks occurred. Limitations of the equipment used for the flight tests prwented a comparison of spectrum shape being made over the full range of frequency covered by the wind tunnel experiments. However, the flight records adequately covered the frequency range of importance for a response calculation.

Within the limited range of Mach number and incidence covered by the tests, the fluctuating non-dimensional pressure levels tended to decrease as Mach number increased. It was also found that an increase of incidence resulted in a decrease of fluctuating non-dimensional pressure within the bomb bay near the rear bulkhead and in a negligible change in pressure Just aft of the bay.

ACKNOWLEDGEMENTS

We would like to express our appreciation of the assistance given on instrumentation problems by I & R Department, and by Mr. G.A. Taylor of Structures Department, and on the flight trials by Mr. R.F. Mousley of Structures Department.

Table 1

INDICATED AIRSPEEDS AT FLIGHT TEST CONDITIONS

Height		Mach number	
m	ft	0.3	0.6
1500	5000	185 kt	350 kt
6000	20000	140 kt	265 kt

Table 2

MEASURED VALUES OF PRESSURE SPECTRA

Flight condition:

Altitude: 1500 m (5000 ft)

ias: 185 kt

M (approx): 0.3

	Pressure spectra $\frac{p_\varepsilon}{q\sqrt{\varepsilon}}$			
x/L n	0.84	0.95	1.05	1.20
0.266	0.0202	0.0306	0.0297	0.0157
0.333	0.0239	0.0331	0.0298	0.0157
0.417	0.0272	0.0391	0.0346	0.0184
0.525	0.0326	0.0524	0.035	0.0204
0.667	0.0398	0.0635	0.0398	0.0246
0.833	0.0427	0.0683	0.0410	0.0277
1.07	0.0402	0.0627	0.0376	0.0272
1.333	0.0395	0.0678	0.0383	0.0308
1.667	0.0369	0.0635	0.0462	0.0364
2.08	0.0378	0.057	0.0584	0.0454
2.66	0.0442	0.0440	0.0878	0.0548
3.33	0.0347	0.0882	0.104	0.0614
4.17	0.0242	0.0702	0.0928	0.0583

Table 3

MEASURED VALUES OF PRESSURE SPECTRA

Flight condition:
Altitude: 6000 m (20000 ft)
ias: 140 kt
M **(approx):** 0.3

	Pressure spectra $\frac{p_\varepsilon}{q\sqrt{\varepsilon}}$			
n \ x/L	0.84	0.95	1.05	1.20
0.286	0.0228	0.0284	0.0332	0.0165
0.357	0.0242	0.0341	0.0364	0.0196
0.446	0.0239	0.0375	0.0397	0.0221
0.562	0.0277	0.0467	0.0405	0.0254
0.714	0.0306	0.0570	0.0445	0.0287
0.893	0.0384	0.0665	0.0443	0.0324
1.14	0.0411	0.0665	0.0445	0.0326
1.43	0.0398	0.0668	0.044	0.0341
1.785	0.0381	0.0617	0.050	0.0415
2.23	0.0396	0.0548	0.0595	0.0477
2.86	0.0433	0.0413	0.091	0.0635
3.57	0.0345	0.0281	0.115	0.0754
4.46	0.0256	0.022	0.1035	0.0724

Table 4

MEASURED VALUES OF PRESSURE SPECTRA

Flight condition:

Altitude: 1500 m (5000 ft)

ias: 350 kt

M (approx): 0.6

	Pressure spectra $\frac{p_\varepsilon}{q\sqrt{\varepsilon}}$			
n \ x/L	0.84	0.95	1.05	1.20
0.133	0.0234	0.0278	0.0163	0.008
0.167	0.0258	0.0333	0.0167	0.0093
0.208	0.0262	0.0335	0.0182	0.0096
0.262	0.0294	0.0382	0.02	0.0107
0.333	0.0351	0.0478	0.0218	0.013
0.416	0.0371	0.0553	0.0232	0.0137
0.533	0.0472	0.0717	0.0238	0.0156
0.666	0.0547	0.0922	0.0246	0.0167
0.833	0.045	0.0838	0.0248	0.0196
1.04	0.0459	0.107	0.024	0.0224
1.33	0.0377	0.0684	0.0272	0.0245
1.67	0.0397	0.052	0.035	0.029
2.08	0.0366	0.0362	0.0555	0.0356

Table 5

MEASURED VALUES OF PRESSURE SPECTRA

Flight condition:
Altitude: 6000 m (20000 ft)
ias: 265 kt
M (approx): 0.6

	Pressure spectra $\frac{p_\varepsilon}{q\sqrt{\varepsilon}}$			
x/L l	0.84	0.95	1.05	1.20
0.143	0.021	0.028	0.019	0.0092
0.179	0.0251	0.0348	0.0212	0.0104
0.224	0.0286	0.0365	0.022	0.0112
0.282	0.0296	0.0391	0.0239	0.0128
0.357	0.0329	0.0536	0.0277	0.0149
0.446	0.0365	0.0603	0.0281	0.016
0.572	0.0412	0.0742	0.0292	0.0172
0.715	0.0517	0.0948	0.0315	0.0195
0.893	0.0444	0.0905	0.0309	0.0232
1.12	0.0452	0.109	0.0278	0.025
1.43	0.047	0.0708	0.0325	0.0284
1.79	0.0476	0.0481	0.043	0.0327
2.24	0.0443	0.032	0.0678	0.041

Table 6

OVERALL PRESSURE LEVELS EXPRESSED AS PERCENTAGES OF KINETIC PRESSURE

					$\frac{\sqrt{\overline{p^2}}}{q} \times 100$			
Height m	(ft)	Mach No.	ias kt	α degrees	x/L = 0.84	0.95	1.05	1.20
1500	(5000)	0.3	185	5.6	5.94	10.09	9.40	6.09
		0.4	245	3.0	5.78	10.8	7.44	4.68
		0.5	300	1.8	6.37	12.2	5.66	3.87
		0.6	350	1.2	6.50	10.90	4.21	3.07
6000	(20000)	0.3	140	10.4	5.72	8.49	10.30	7.13
		0.4	180	5.6	5.94	8.79	7.41	4.83
		0.5	225	3.4	6.23	9.67	6.53	4.12
		0.6	265	2.2	6.62	11.26	5.16	3.51

REFERENCES

No.	Author	Title, etc.
1	J. E. Rossiter A. G. Kurn	Wind tunnel measurements of the unsteady pressures in and behind a bomb bay (Canberra). A.R.C. C.P.728(1962)

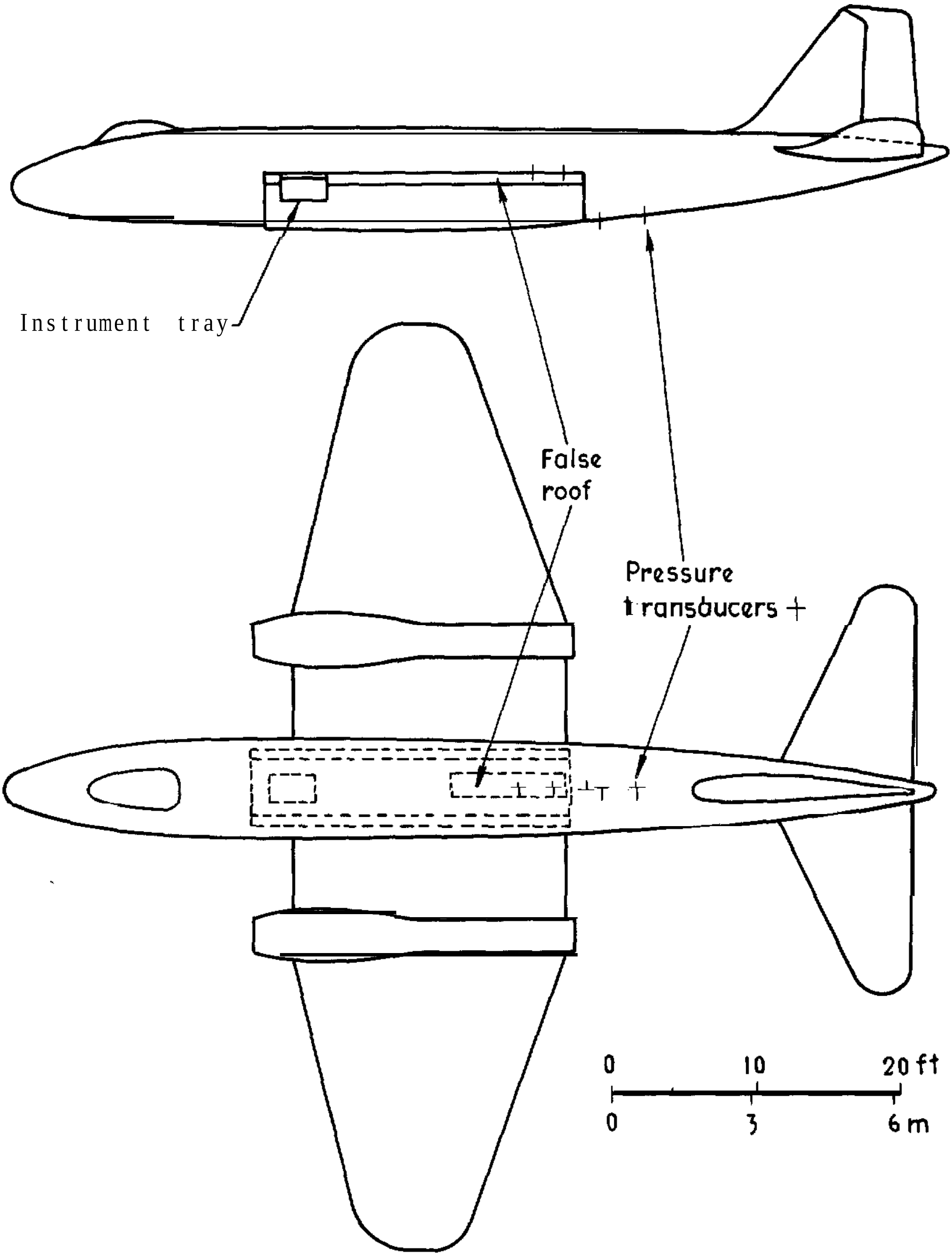

Fig I Transducer positions

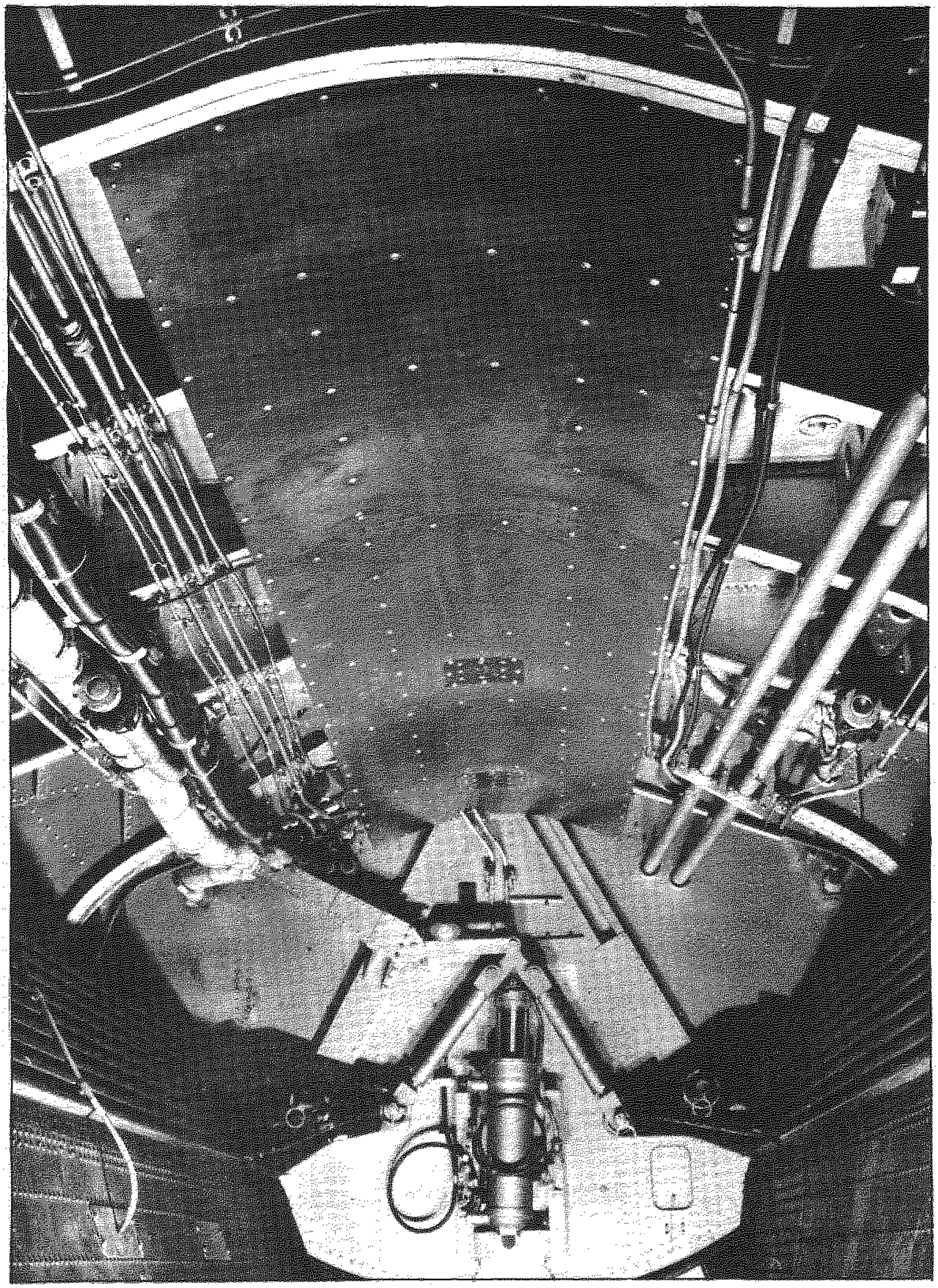

Fig.2 False roof to bomb bay, looking aft

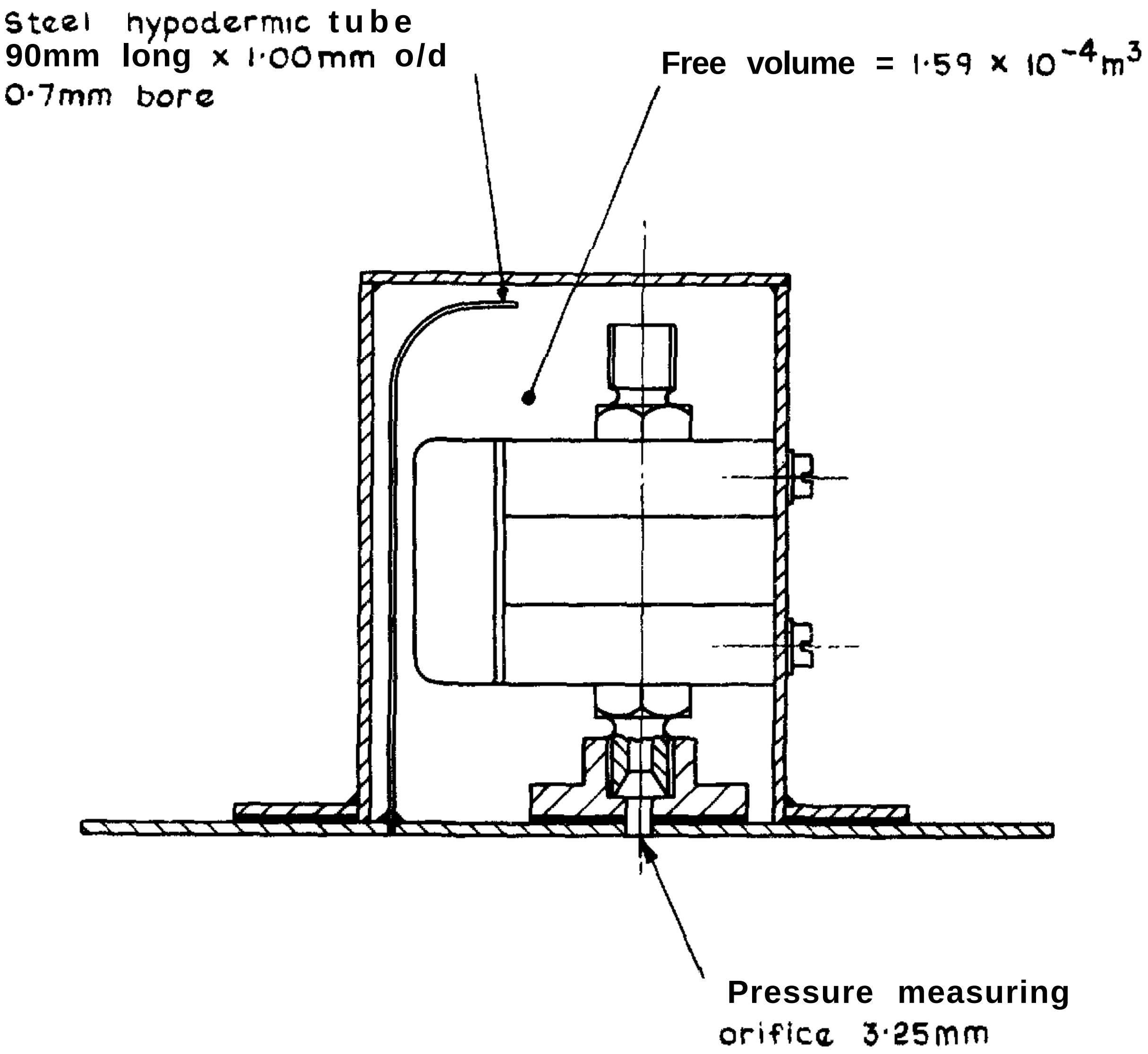

Fig. 3 Pressure transducer assembly

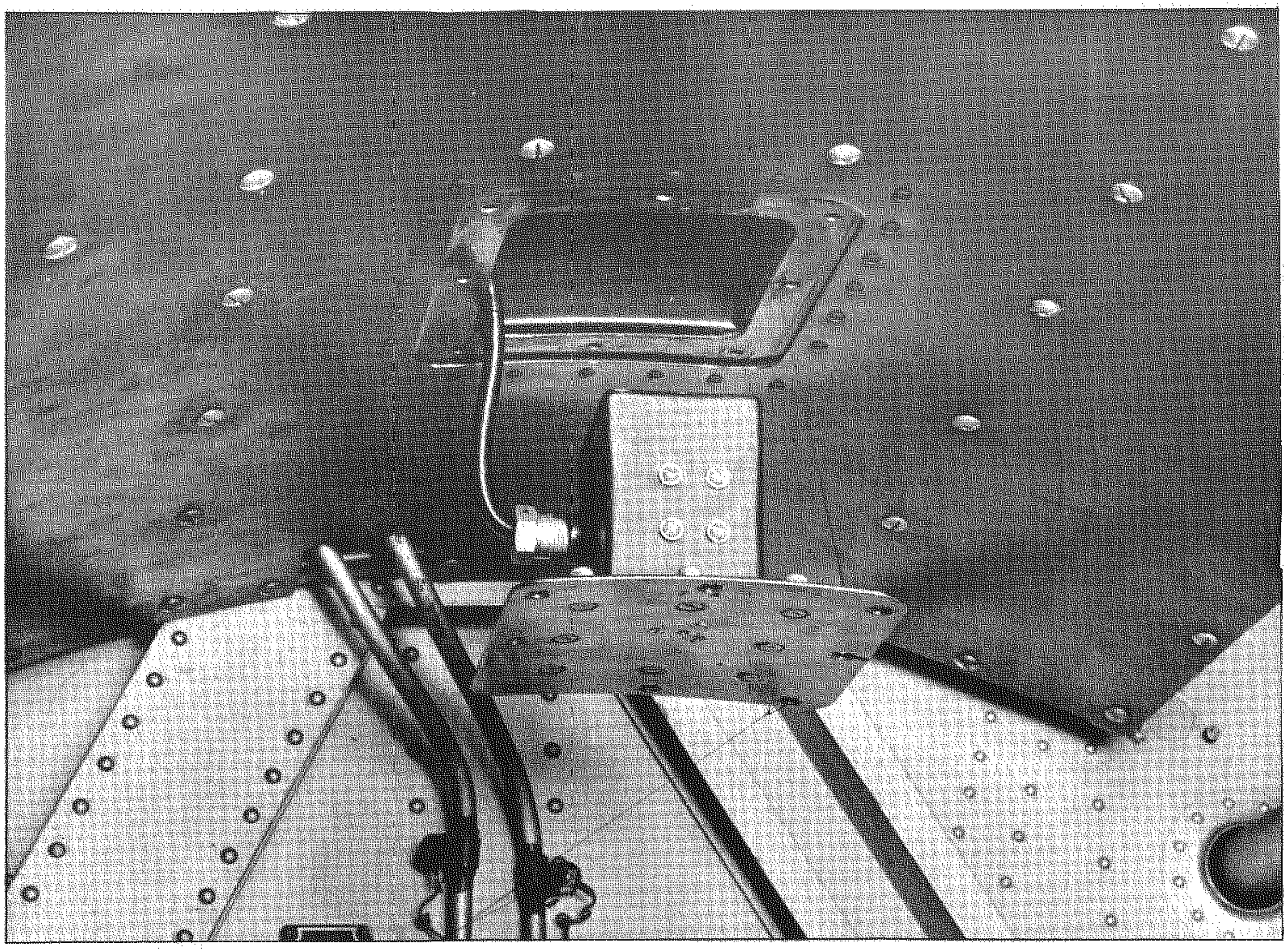

Fig.4 Pressure transducer installation

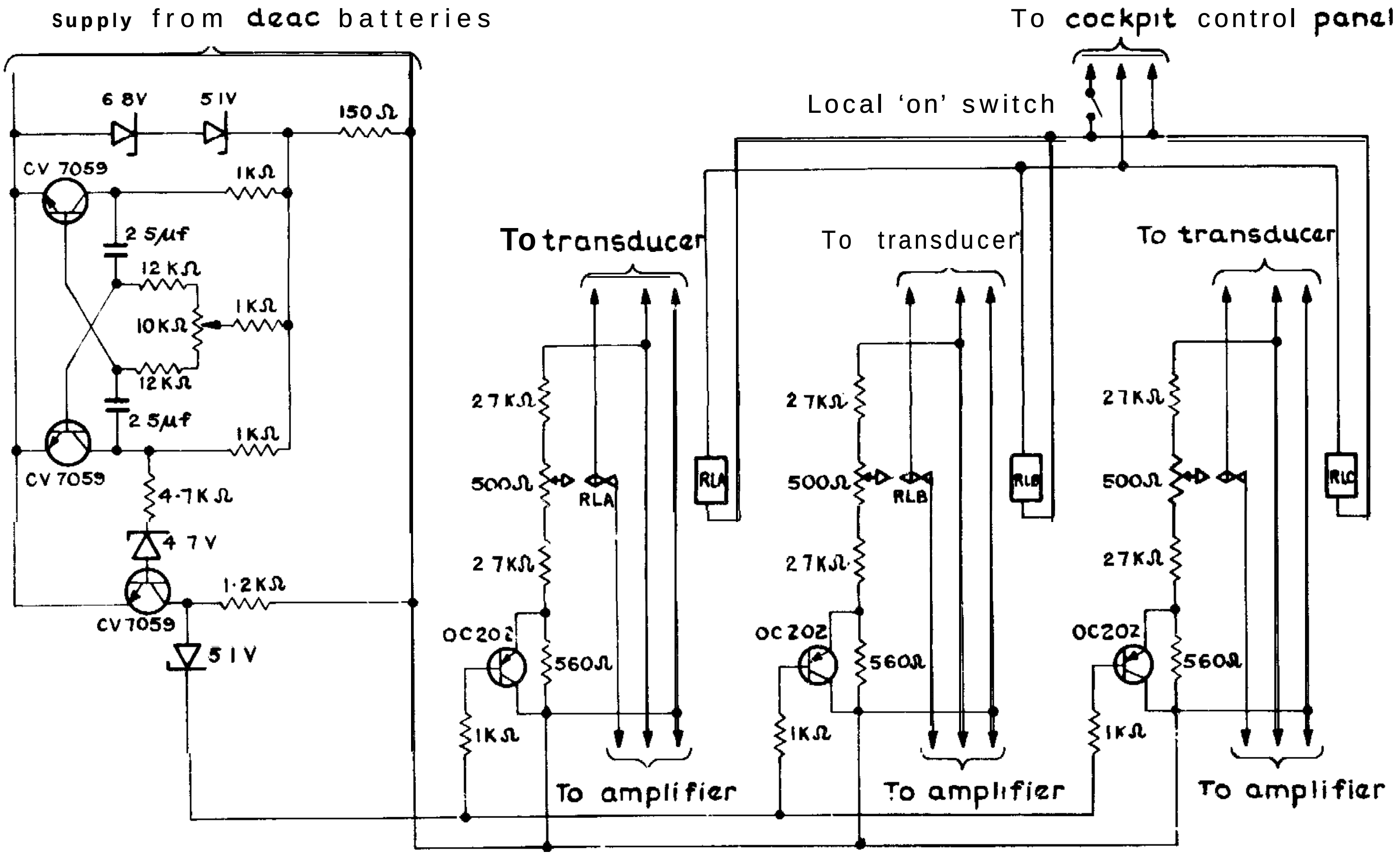

Fig. 5 Oscillator drive and three calibration bridges

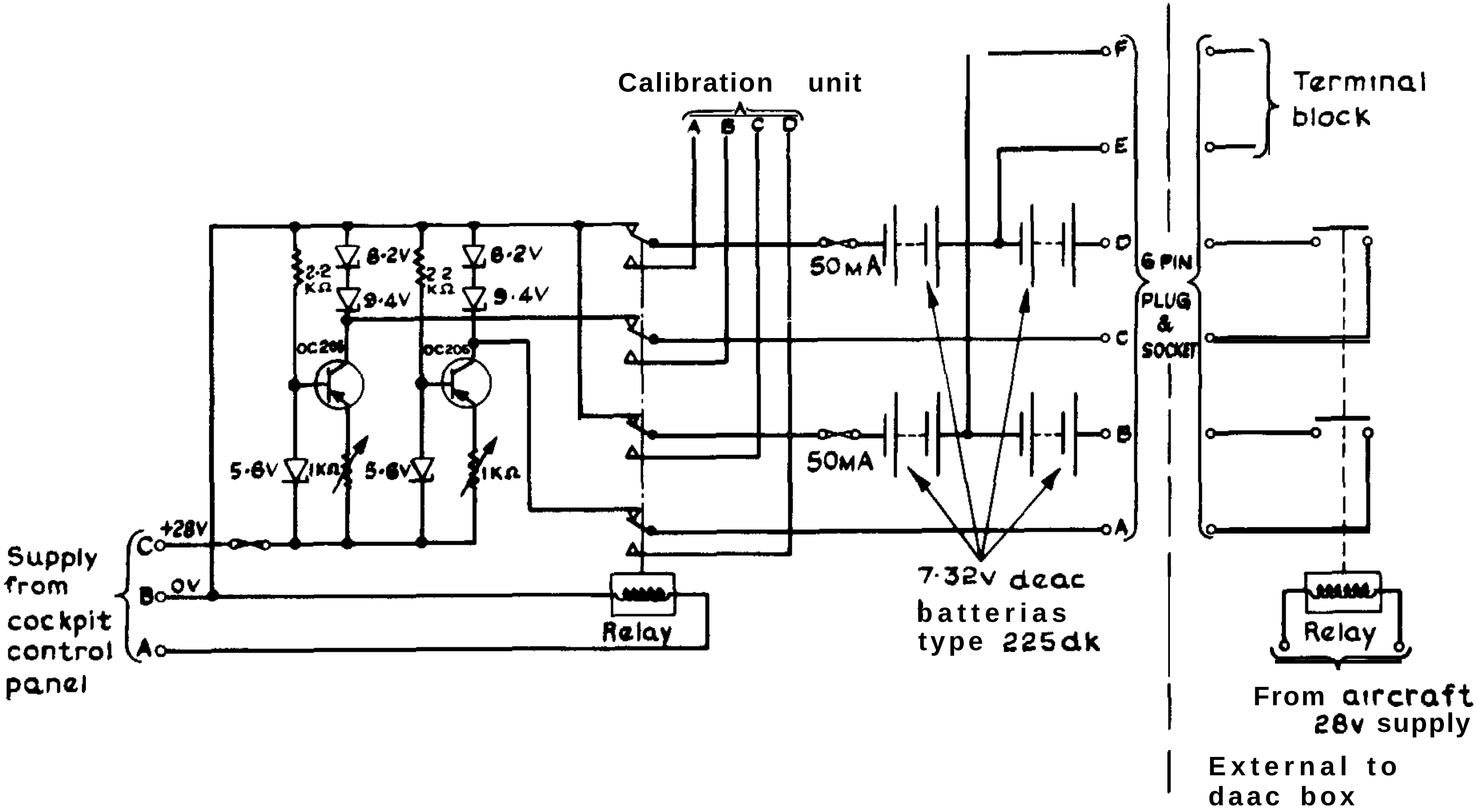

Fig. 6 Deac battery box

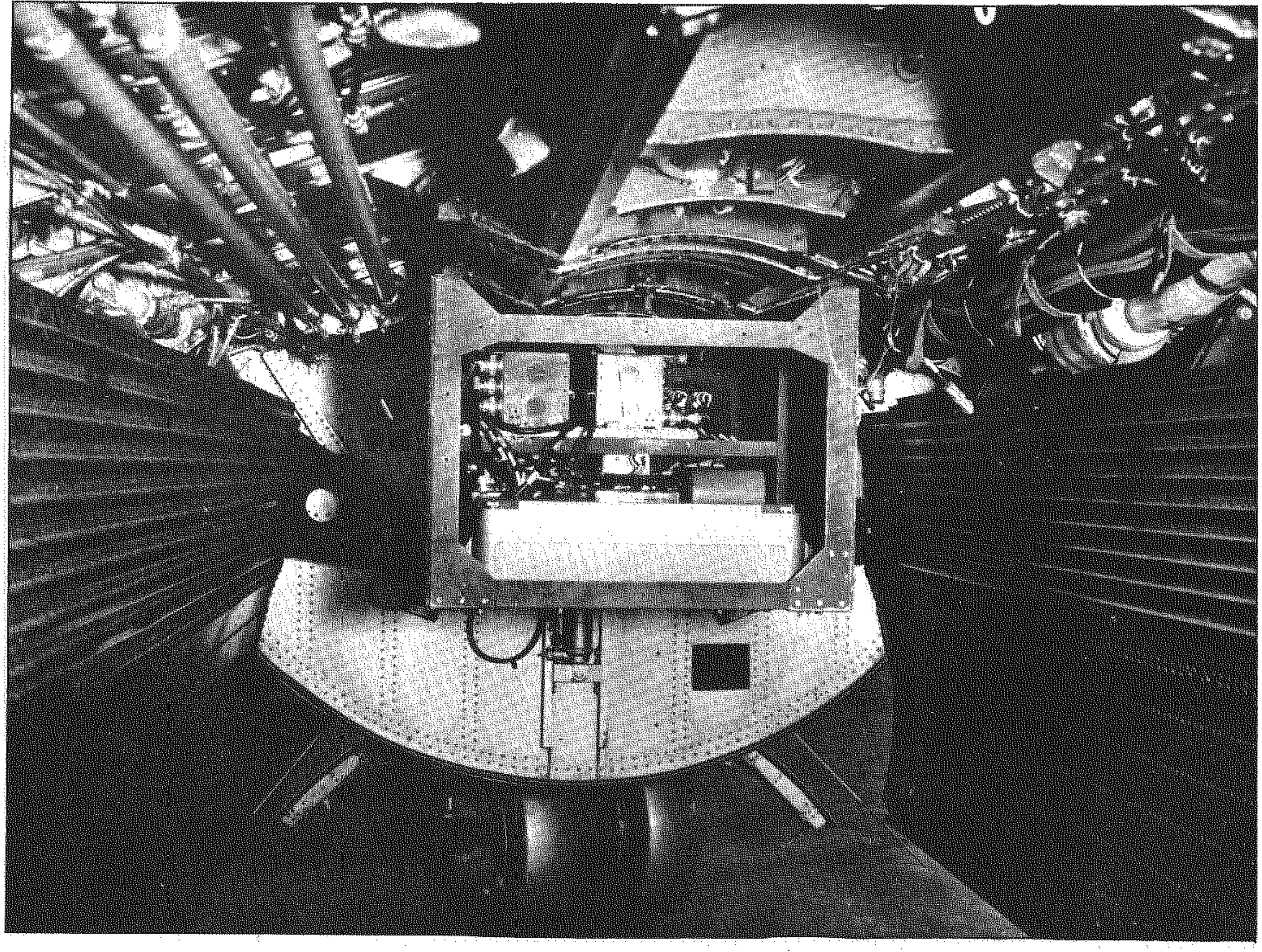

Fig.7 Instrumentation tray in bomb bay (false roof removed

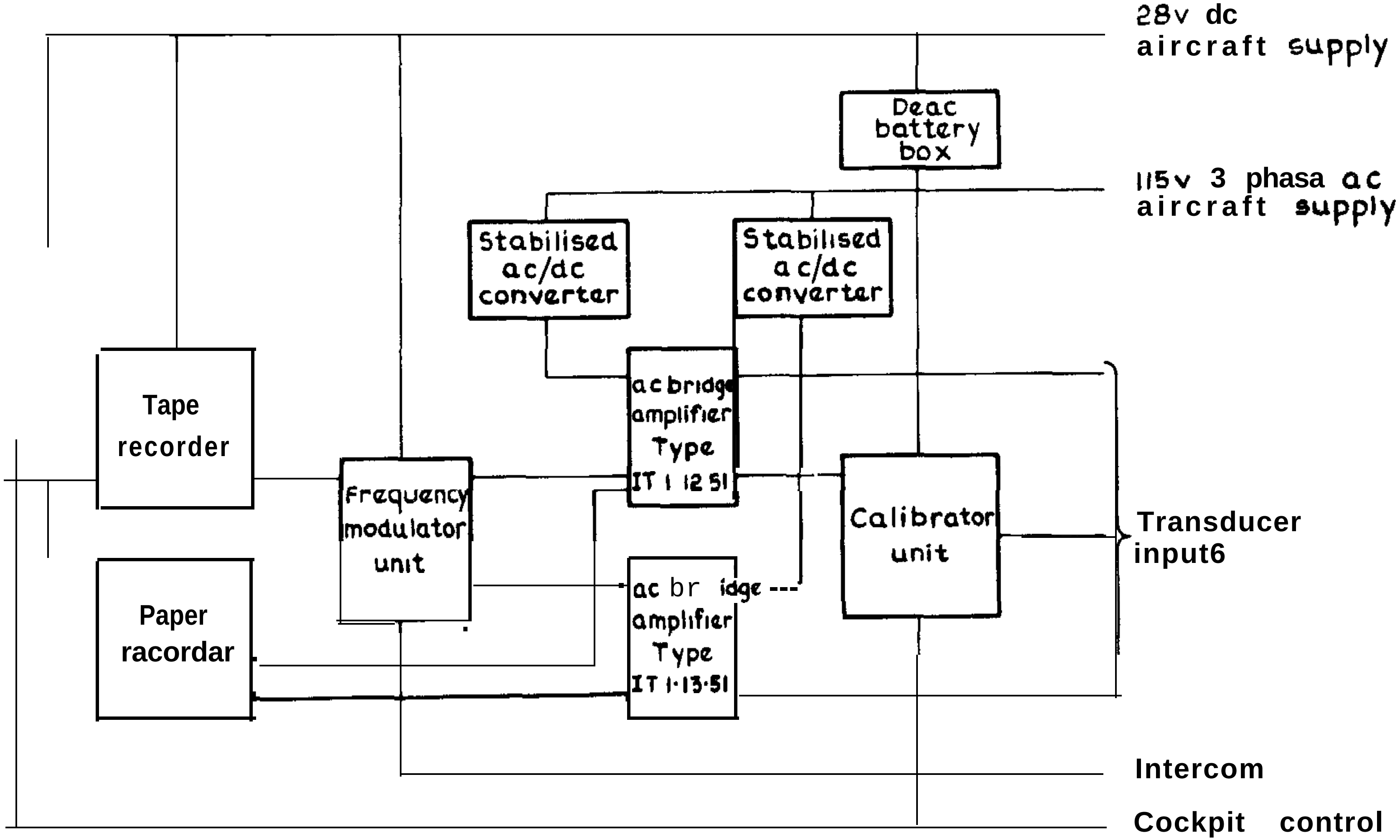

Fig. 8 Block diagram of instrument tray

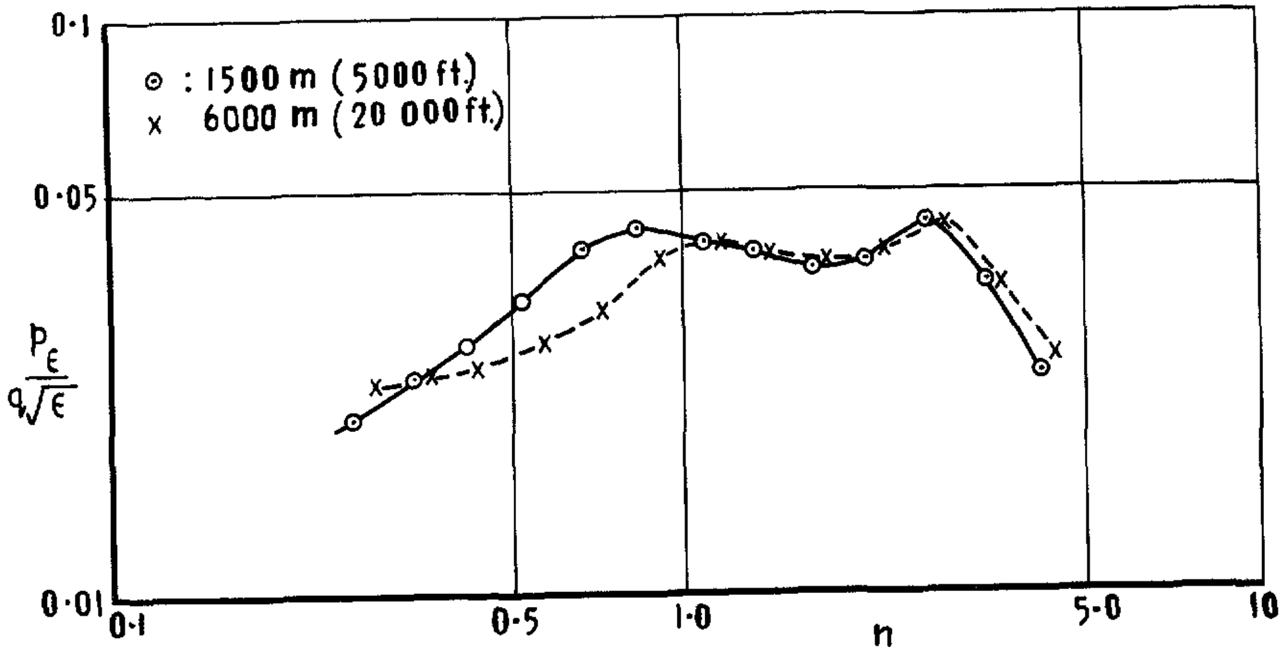

Fig. 9 Pressure spectra, M=0·3, x/L=0·84

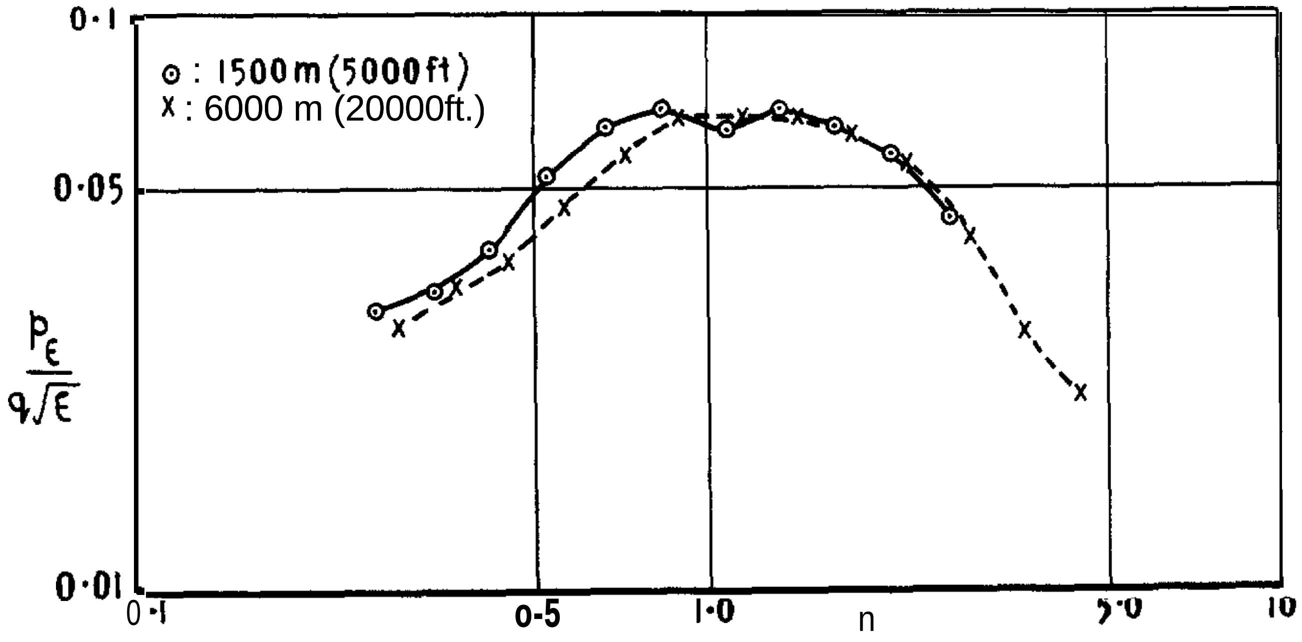

Fig. 10 Pressure spectra, $M = 0{\cdot}3$, $x/L = 0{\cdot}95$

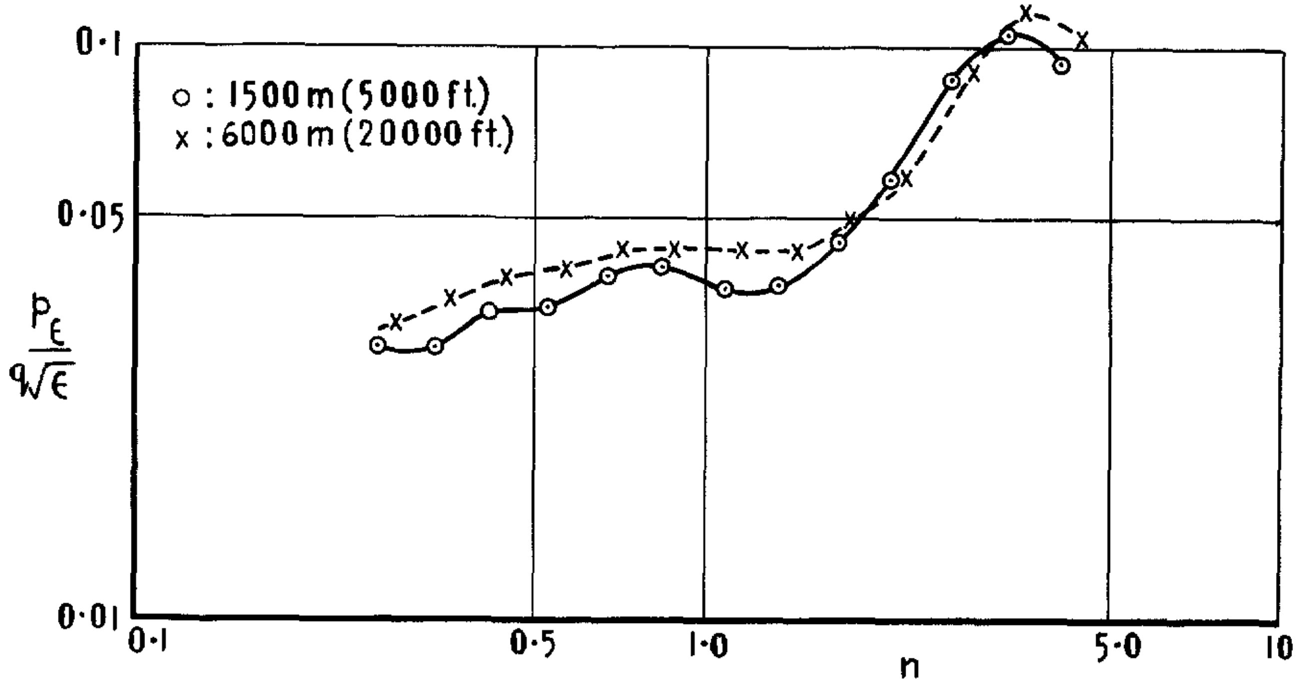

Fig. 11 Pressure spectra, $M=0{\cdot}3$, $x/L=1{\cdot}05$

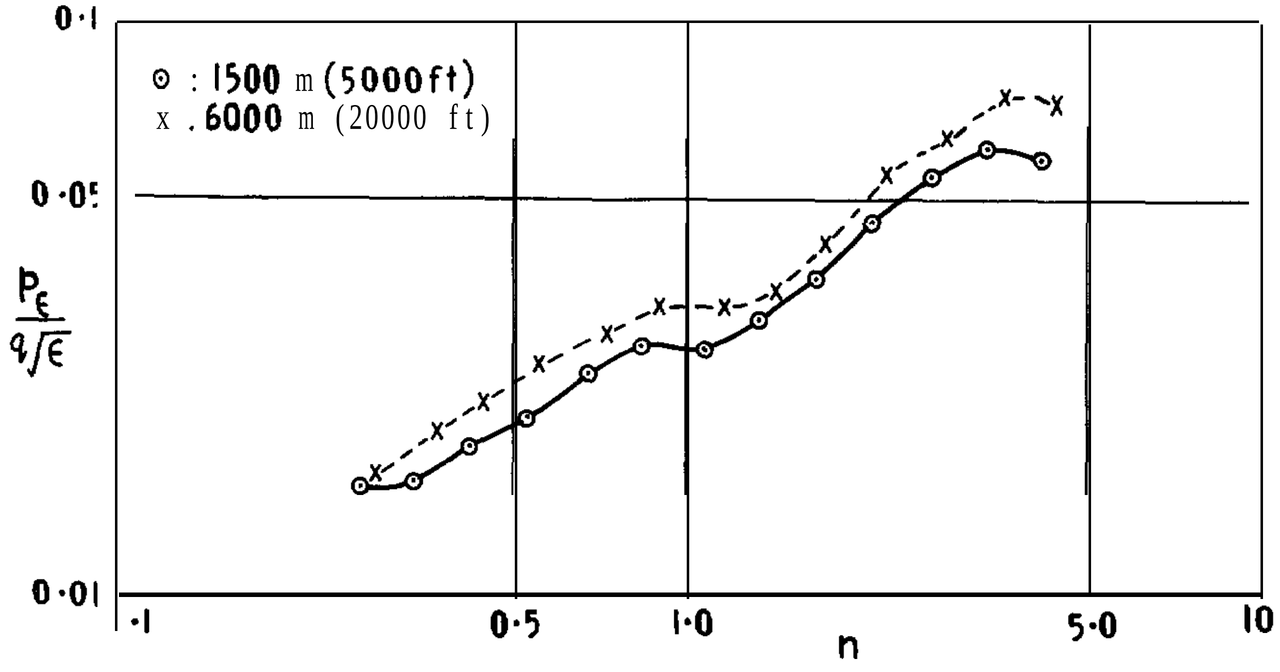

Fig. 12 Pressure spectra, $M=0\cdot3$, $x/L = 1\cdot20$

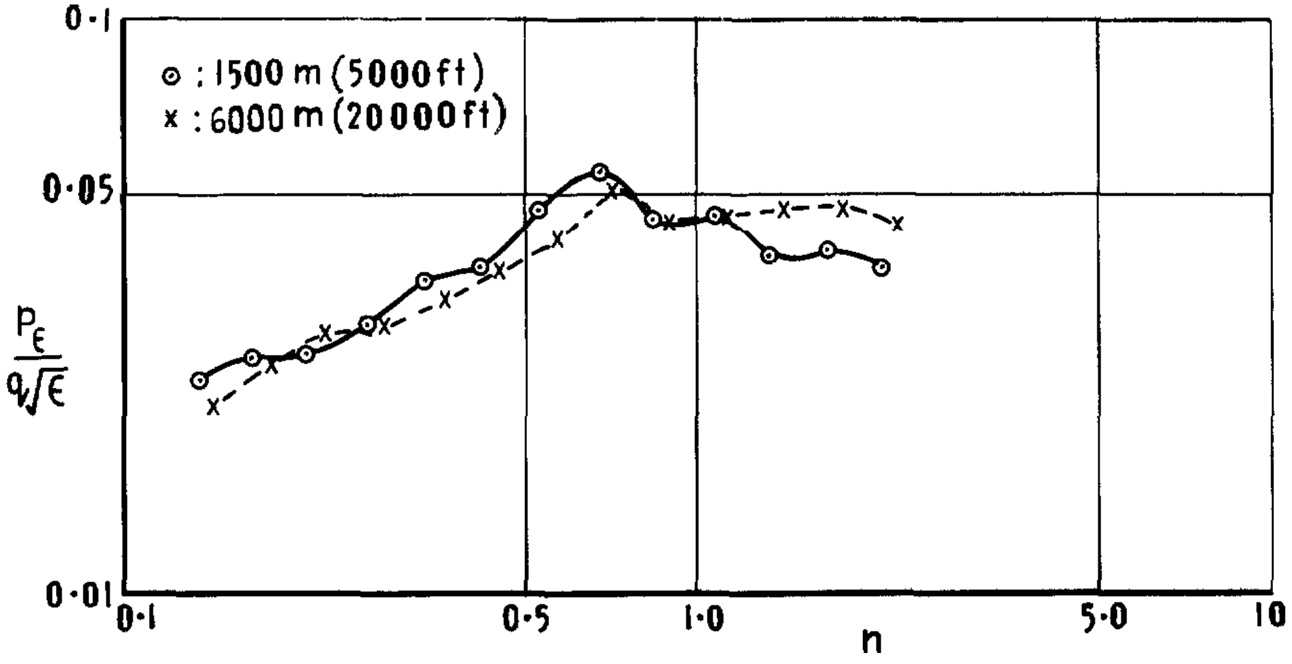

Fig. 13 Pressure spectra, $M=0{\cdot}6$, $x/L=0{\cdot}84$

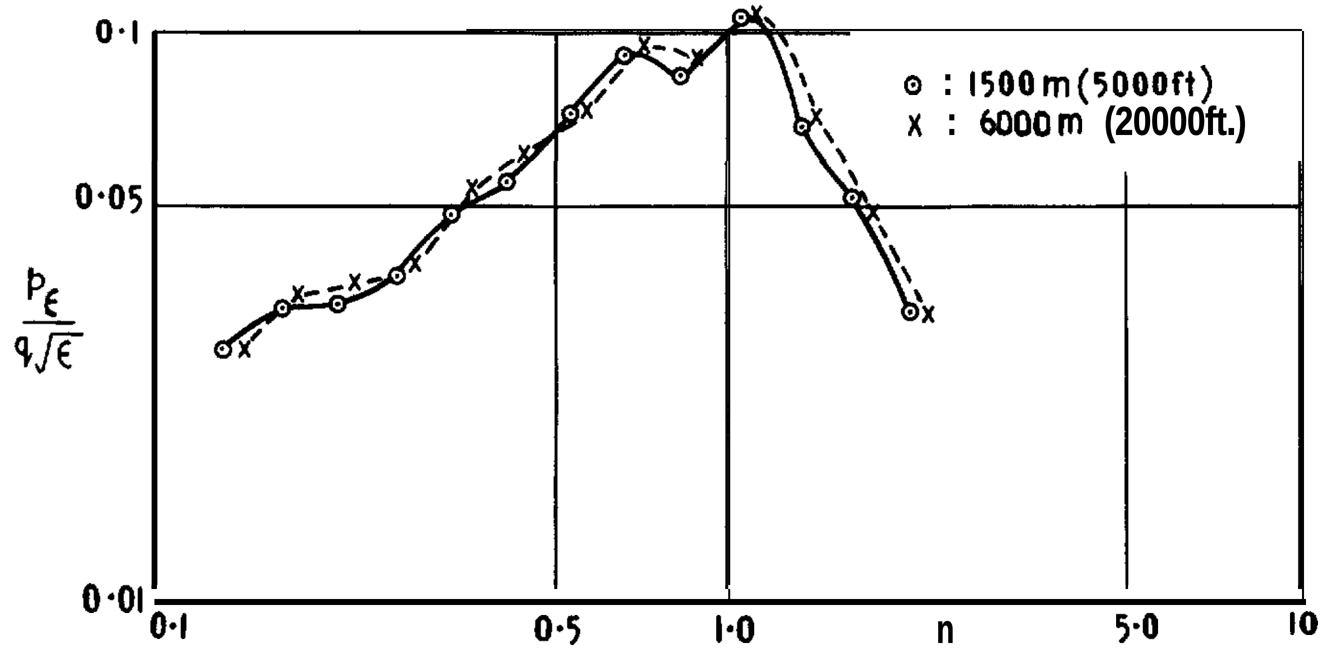

Fig. 14 Pressure spectra, $M=0{\cdot}6$, $x/L = 0{\cdot}95$

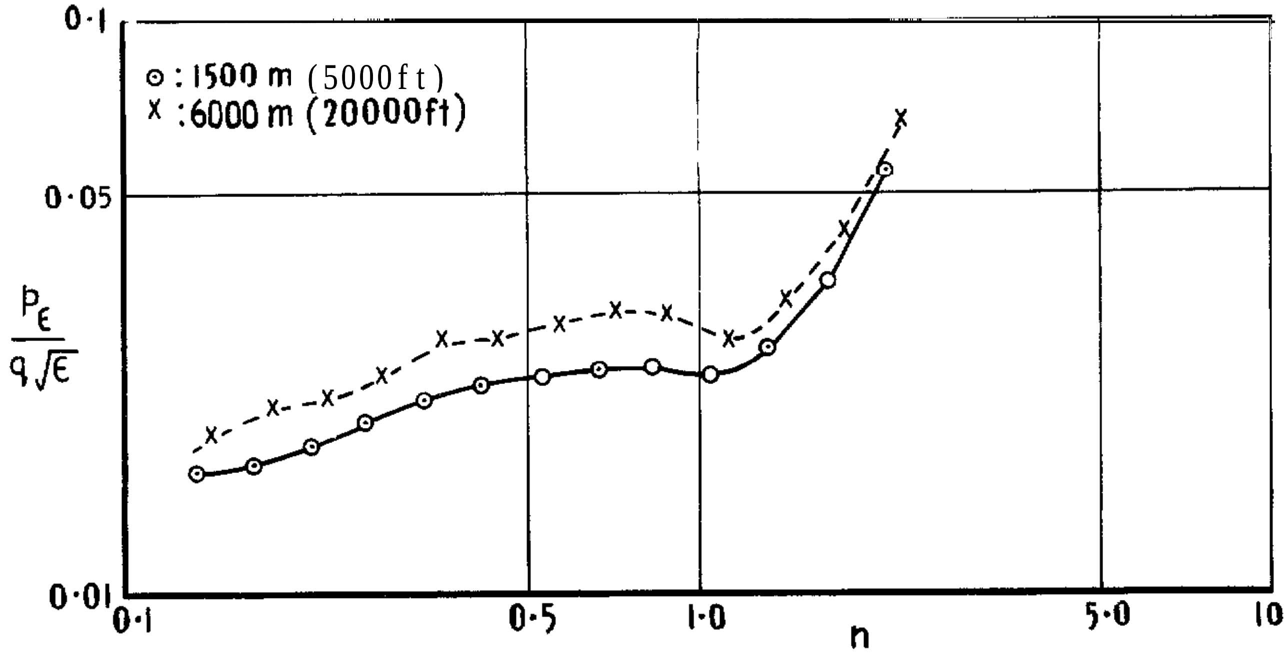

Fig. 15 Pressure spectra, $M=0{\cdot}6$, $x/L = 1{\cdot}05$

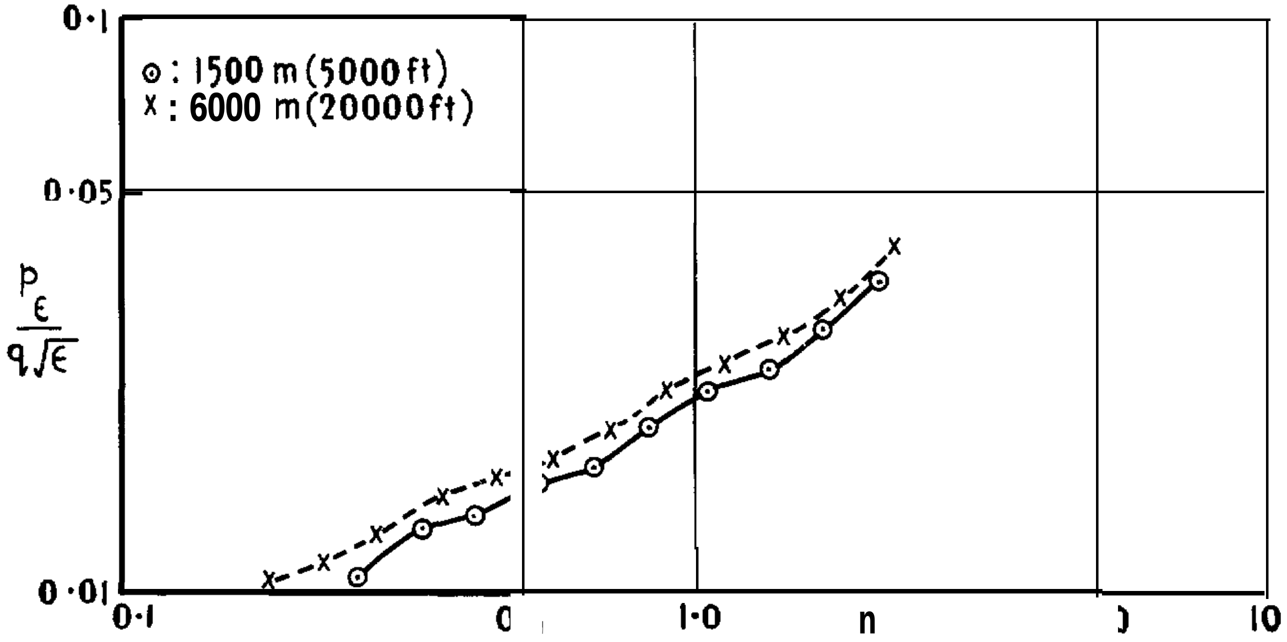

Fig. 16 Pressure spectra, $M = 0{\cdot}6$, $x/L = 1{\cdot}20$

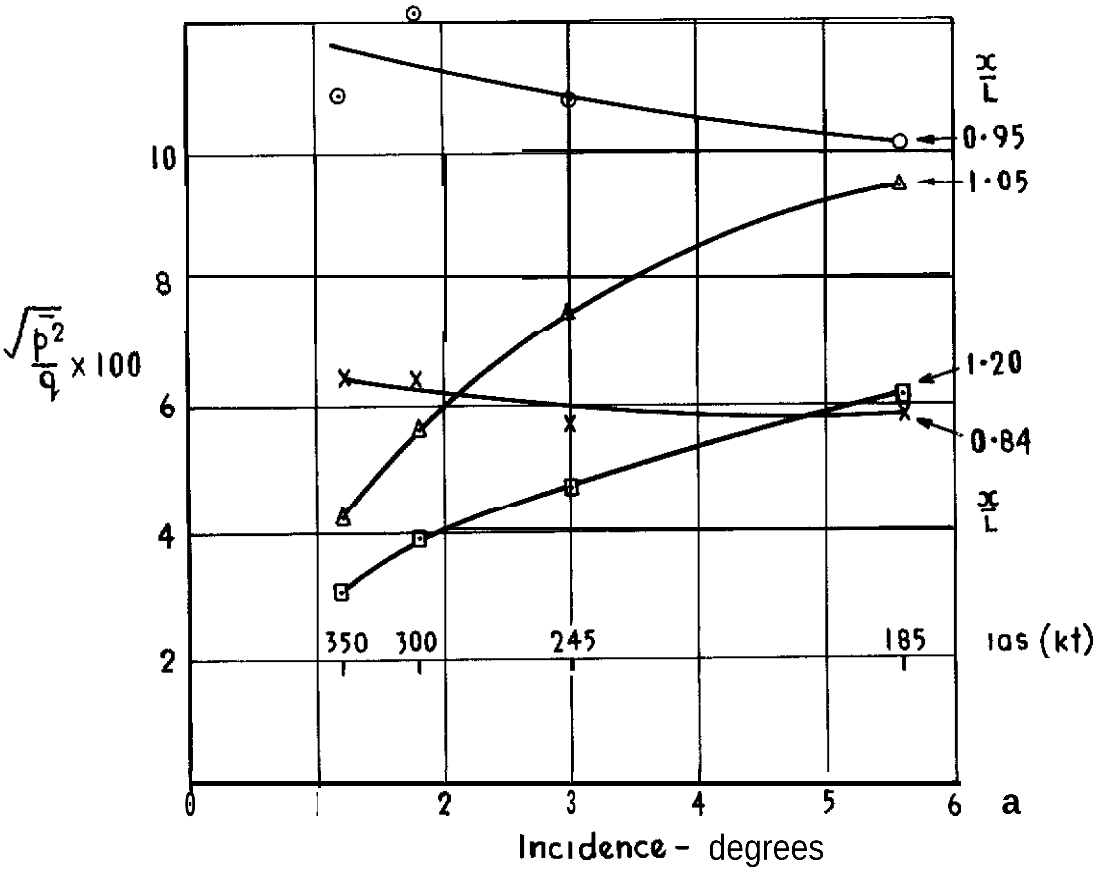

Fig.17 Effect of incidence on overall pressure level at 1500 m

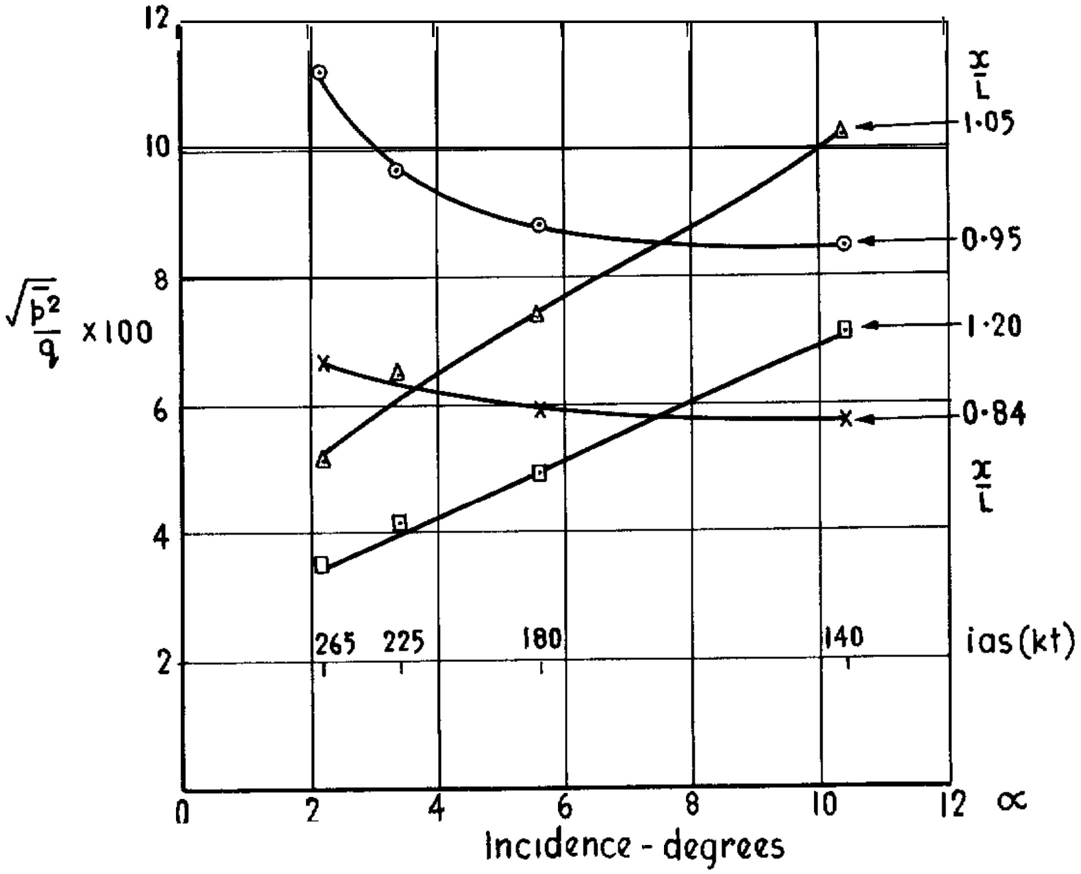

Fig.18 Effect of incidence on overall pressure level at 6000 m

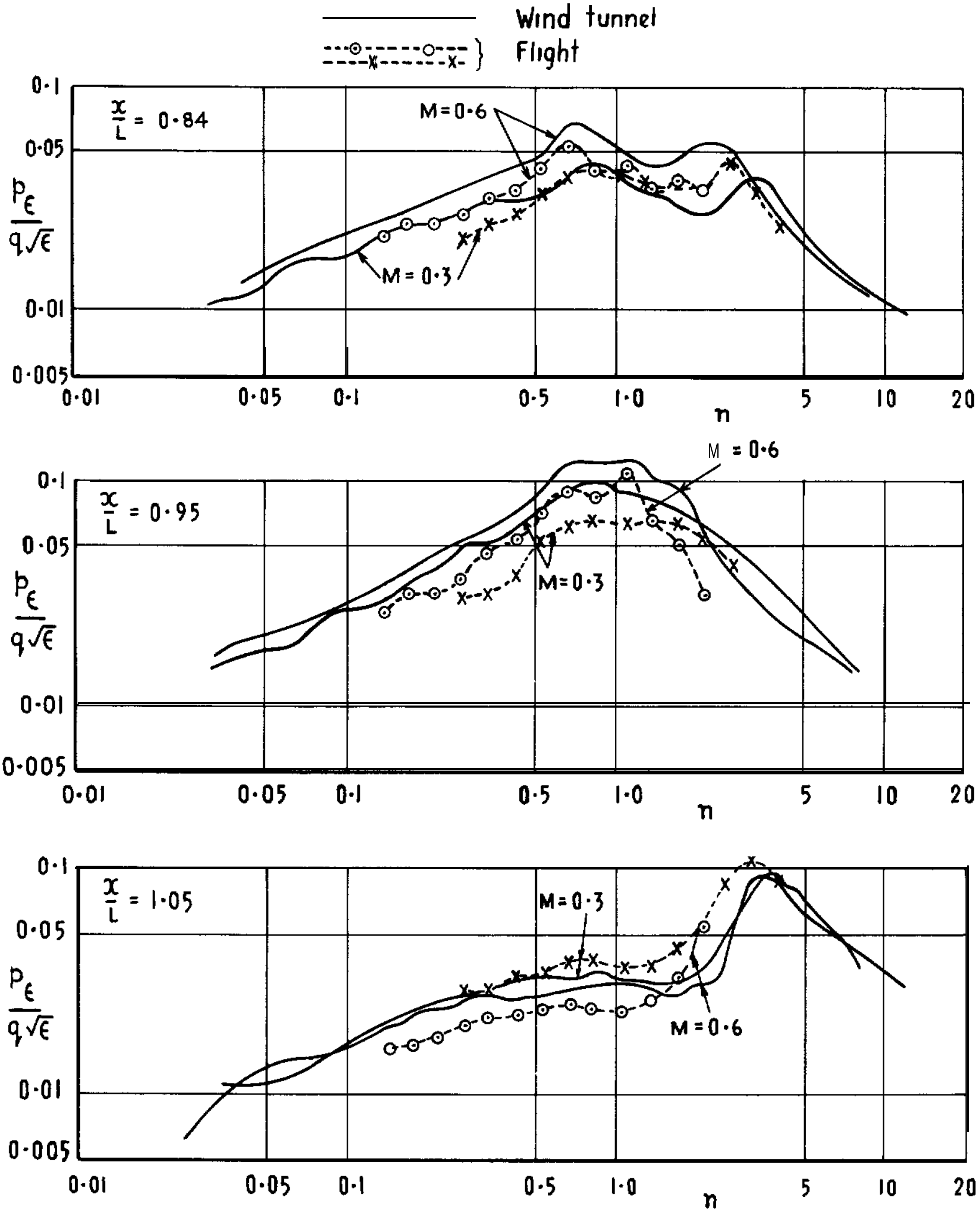

Fig 19 Comparison of wind tunnel & flight spectra at 1500m [5000 ft.]

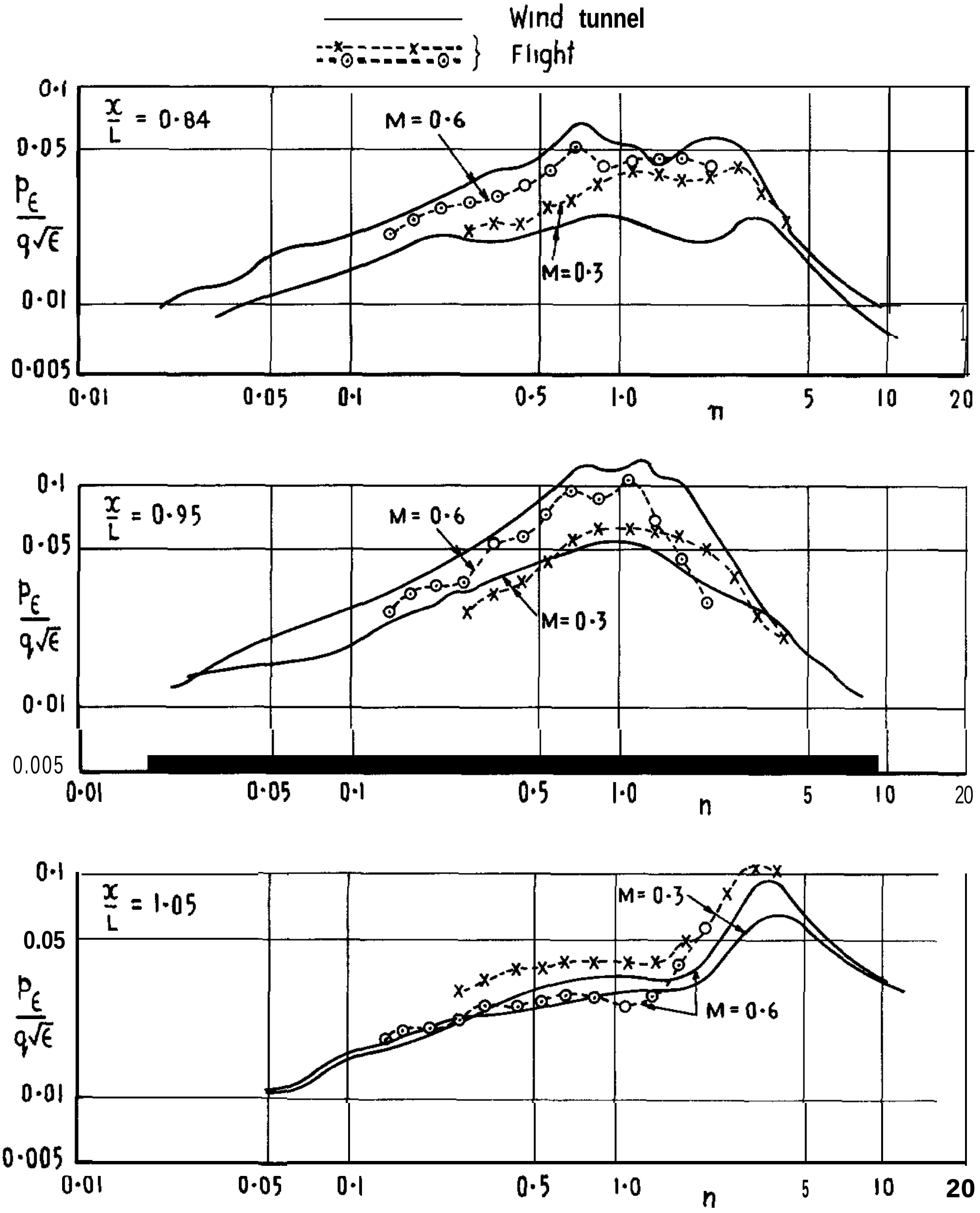

Fig. 20 Comparison of wind tunnel & flight spectra at 6000 m [20 000 ft.]

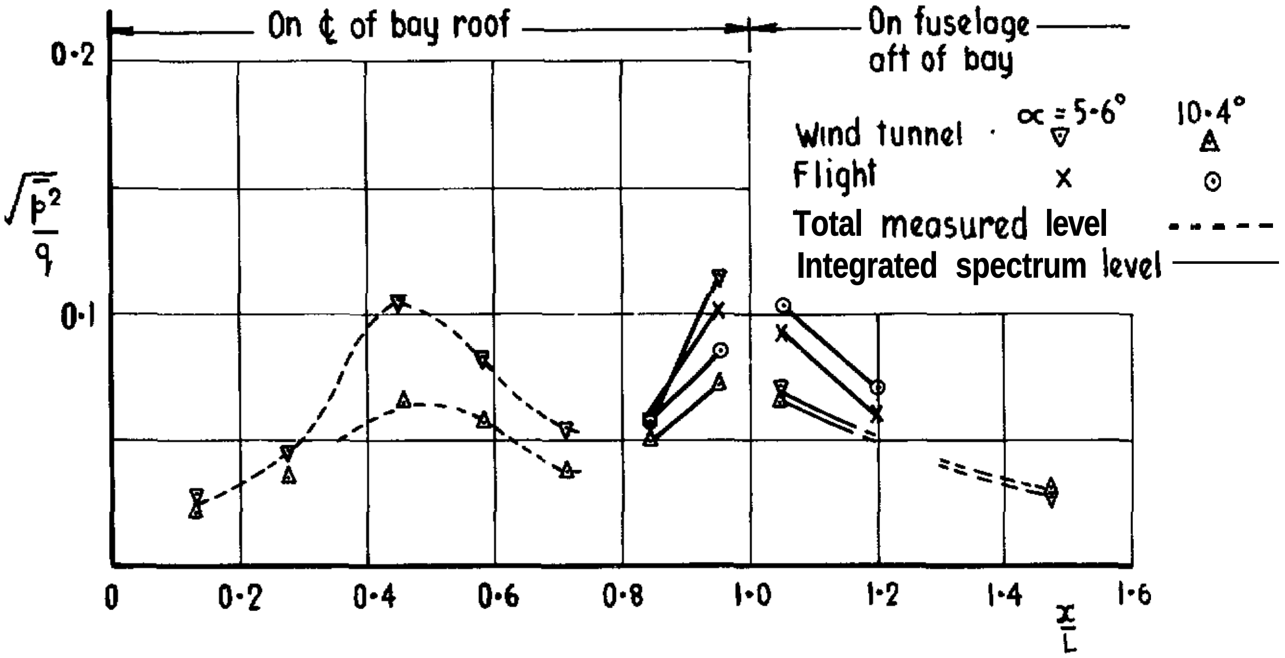

Fig.21 Comparison of wind tunnel & flight overall rms pressure levels M=0·3

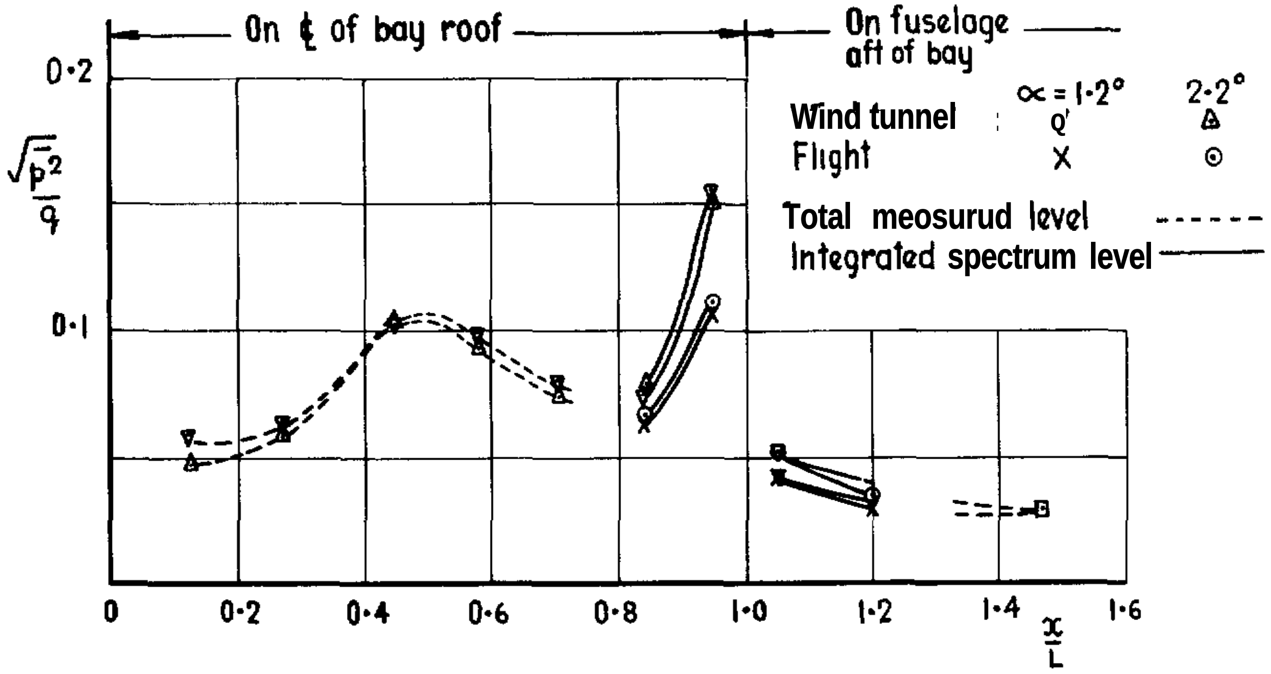

Fig.22 Comparison of wind tunnel & flight overall rms pressure levels M=0·6

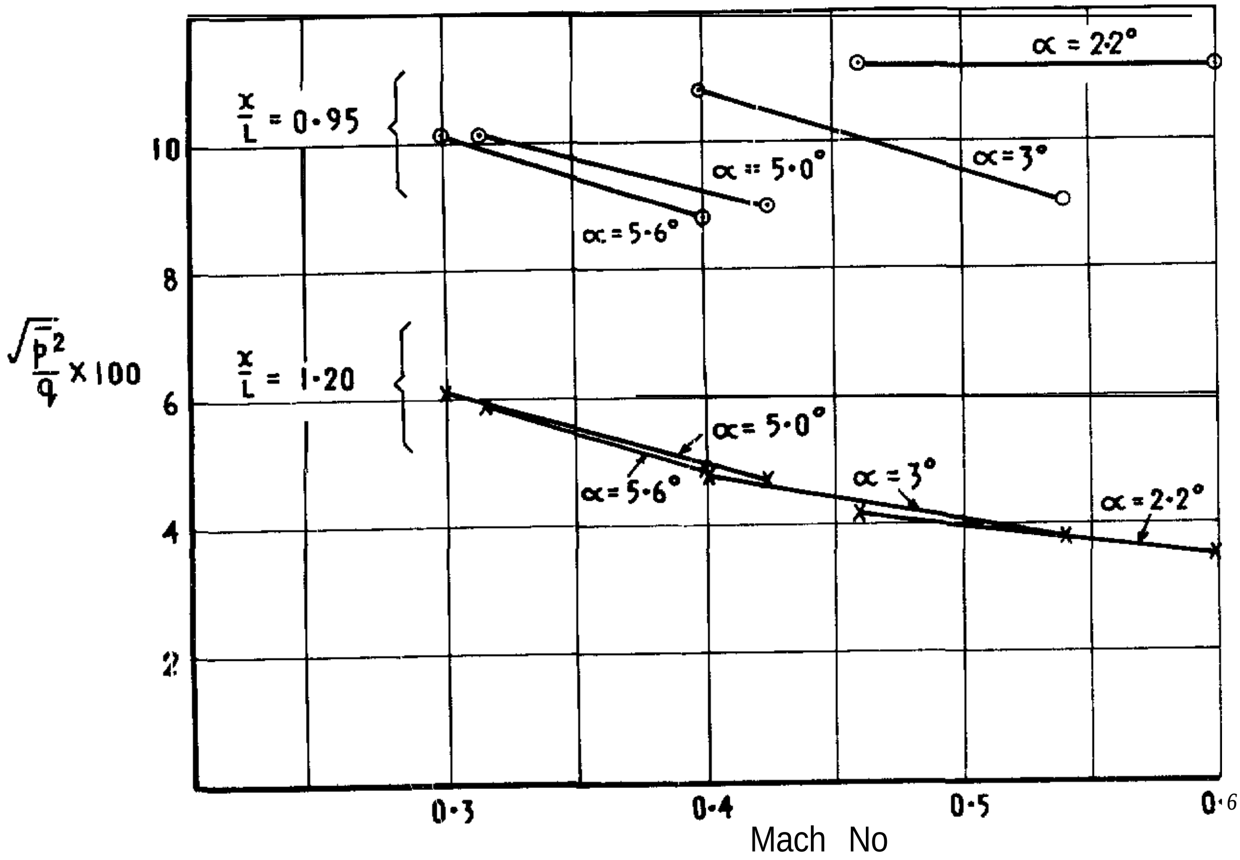

Fig. 23 Effect of Mach number on overall pressure level

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Gaukroger, D.R.

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