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Calibration of the Royal Aircraft Establishment 24-ft Wind Tunnel

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Summary.—Reasons for Enquiry.—Evidence from several check experiments indicated that the results of the preliminary calibration of 1935 were in error. The object of the described experiment was to investigate this and to calibrate the wind tunnel in greater detail than previously.

Range of Investigation.—The velocity distribution across the jet in three planes has been found at several tunnel speeds. The distribution of static pressure throughout the jet and the relation between the dynamic head at various positions in the tunnel and the hole-in-side pressure has been investigated. A complete list of all previous calibrations together with results and reasons for the discrepancies is included.

Conclusions.—A new tunnel calibration is given in Tables 1 and 2. The plane of reference is taken as 12·5 ft from the jet face, and the mean velocity over the section is greater than the standard value used up to the present by about ½ per cent at high speeds and 2 per cent at low speeds.

The mean velocity falls as the jet face is approached, and a correction factor for this is given in Table 2.

The revised corrections will be incorporated in all reports issued after 30th June, 1942.

1. *Introduction.*—A preliminary calibration of the airflow in the wind tunnel was made in 1935[1]. Several check calibrations have been made subsequently for individual experiments, although these have necessarily been of a limited extent, and it was thought advisable to make a more complete investigation to substantiate these results. The tests were made during October and November, 1941.

2. *Range of Investigation.*—Complete traverses across the jet were made in three planes at 3 ft, 7 ft 5 in., and 12 ft 6 in. from the jet face. Measurements in each plane were at 3-ft intervals vertically and horizontally. In addition the tunnel centre-line values were measured from just inside the jet to the end of the balance house. A view of the pitot-static mast is shown in Fig. 1, and details of the experimental procedure are given in Appendix I.

The tests were designed to give the following information :—

(*a*) Velocity distribution contours over the 3 ft, 7 ft 5 in., and 12 ft 6 in. planes at tunnel speeds from 80 to 170 ft/sec.

(*b*) The static pressure along and across the working section.

(*c*) The relation between the dynamic head and the controlling hole-in-side pressure.

* R.A.E. Technical Note No. 965 (Large Tunnel), received 20th July, 1942.

3. *Results*.—3.1. *Velocity Distribution* (Figs. 2, 3 and 4).—These curves are drawn so that the observer faces upstream into the nozzle. They indicate that the maximum variation of local velocity from the mean within a 20-ft diameter circle is $\pm$ 2 per cent. The corresponding value for the flow through a 12-ft diameter circle is $\pm$ 1 per cent. There is in general a continuous increase of velocity across each section from the side nearer the return circuit to the hangar side.

3.2. *Static Pressure* (Figs. 5, 6 and 7).—The static pressure $(S - A)$ along the tunnel centre-line is shown in Fig. 5 as a fraction of the total head $(P - A)$. This ratio was found to be independent of speed. It is seen that the static pressure falls rapidly for the first 10 ft from the jet face, is almost constant over a considerable portion of the working section and rises rapidly again on approaching the fan (*see* experiment F, Appendix II and Fig. 5). In determining the longitudinal buoyancy correction the static-pressure gradient is needed; Fig. 6 gives this value as a fraction of the dynamic head.

The average values of the static pressure over the 20-ft diameter circle are given in Table 5. The magnitude is about 0·01 less than the centre-line value but the gradient is identical. The longitudinal buoyancy correction can thus be safely applied to bodies of a range of cross-sectional areas.

The static pressure across the jet is shown in Fig. 7. This appears to be distributed symmetrically over a 12-ft diameter circle.

The effect of the ventilating fans on the velocity distribution and the static pressures could not be detected. It would be expected that their maximum effect would occur at the lowest tunnel speed. Comparative values with and without fans at 60 ft/sec were identical within the limits of experimental accuracy.

3.3. *Dynamic Head*.—3.31. Mean values.—The mean velocity over the 12-ft and 20-ft diameter circles is shown in Tables 2 and 3 as the ratio of the dynamic head ($\frac{1}{2}\rho V^2$) to the hole-in-side reading $(H - A)$. The 20-ft diameter mean values tend to be about 0·5 per cent higher than the 12-ft diameter values for planes 3 ft and 7·4 ft from the jet face, and the two are sensibly equal at the 12·5-ft plane. Since the normal position of models is in the vicinity of this latter plane it is seen that the mean value at this section will be applicable to the majority of tests. Taking the mean between the 12-ft and 20-ft diameter circles at this plane the relation between the hole-in-side reading and the mean velocity is given in Table 1 below.

TABLE 1

Mean velocity in 12·5-ft plane (ft/sec)	Hole-in-side reading (in. water)	$\frac{\frac{1}{2}\rho V^2}{H - A}$	
		Present	Previous
40	0·337	1·083	
60	0·773	1·065	1·026
80	1·400	1·047	1·022
100	2·208	1·037	1·018
120	3·182	1·033	1·020
140	4·340	1·033	1·028
160	5·660	1·032	1·021
170	6·400	1·031	1·025

The velocity at a given hole-in-side reading is greater than that in use at present (*see* Table 7, calibration B) for two reasons.

(*a*) The previous calibration was based on measurements made chiefly at a cross-section 7·4 ft from the jet face.

(*b*) Although the total head measurements agree very well with the previous calibrations, the static head is considered to be lower than previously owing to a revised correction factor. This is dealt with in Appendix II.

Regarding (*a*) above, it is seen from Tables 3, 4 and 5 that the velocity for a given hole-in-side pressure increases from the jet face towards the collector. The increase is rapid at first but reaches a steady value just after the 12·5-ft station. The reason for this change is the drop in static pressure over this region, as the total head is sensibly constant. Hence if the model under test is positioned some distance in front of the 12·5-ft plane a correction should be applied to the proposed standard calibration given above. The mean values of the ratio of the velocity (V) at the required section to the velocity (V_s) at the 12·5-ft section is shown in Fig. 10 and tabulated below.

TABLE 2

Distance from jet face (ft) ..	0	2·5	5·0	7·5	10	12·5	15	20
V/V_s	0·964	0·977	0·987	0·993	0·997	1·000	1·002	1·003

3.32. *Centre-line values of dynamic head.*—A comparison of Table 3 with Tables 4 and 5 shows that although the mean values of $\frac{1}{2}\rho V^2(H - A)$ fall in a regular manner as the speed increases, the centre-line value shows a fairly well marked kink over the range 120 to 160 ft/sec. The cause of this was originally thought to be a change of flow past the hole-in-side, but further experiments have shown the variation to occur in the local total head of the airstream.

In view of the non-linear variation of $\frac{1}{2}\rho V^2$ and $(H - A)$ it was suggested that as an alternative to the controlling hole-in-side pressure the total head at the last cascade should be used. To investigate this a total head tube was mounted in the centre of the cascade of deflectors at the last corner. The total head here was found to vary in the same manner as the centre-line total-head values along the working section. This result seemed to confirm doubts of the hole-in-side pressure readings. The evidence of the average values, however, indicated that the disturbance is local and does not affect the tunnel calibration.

Results from an experiment on the effect of thrust and drag on the controlling pressures have led to the same conclusions. Further experiments to investigate this phenomenon are being carried out.

4. *Conclusions.*—It is considered that the standard calibration of the tunnel should be altered in the following particulars.

(1) The standard plane of reference should be 12·5 ft from the jet face.

(2) The standard wind speed for a given hole-in-side reading should be taken as the values given in Table 1, which are greater than those previously taken by about 2 per cent at 60 ft/sec, 1 per cent at 100 ft/sec and about $\frac{1}{2}$ per cent at greater speeds.

(3) The correction factor for wind speed at sections other than the standard section is as given in Table 2. The correction should be applied only when the model position is appreciably different from the standard.

(4) The value of the static-pressure coefficient is about 0·02 greater than given previously, but the gradient ds/dl is sensibly unchanged.

The changes will be incorporated in all R.A.E. 24-ft Wind-Tunnel reports issued after 30th June, 1942.

APPENDIX I

1. *Experimental Methods and Apparatus.*—The static pressure and total head were measured by means of nine aircraft type Mark IV pressure head instruments mounted on a 30-ft vertical beam (as in Fig. 1). The instruments were spaced 3 ft apart along the beam and the beam was mounted in seven positions at 3-ft intervals across the plane. With this arrangement 37 spot values within the 20-ft diameter circle were obtained. The beam was of streamlined section built up of a $3\frac{1}{2}$-in. diameter steel tube with hollow wooden tail fairing. The copper pipe connections from the pitot-static tubes were conveniently accommodated within the fairing. The pressures were photographically recorded on an inclined multitube manometer using alcohol. The tunnel centre-line pressures were also read on Chattock manometers capable of reading to greater accuracy. These readings formed a useful check on the calibration of the multitube manometer.

The multitube manometer was carefully calibrated against a Chattock gauge several times throughout the experiments, as a change of $\frac{1}{2}$ deg in the inclination of the tubes would lead to an error of 1 per cent in the reading.

During initial experiments an occasional discrepancy was found to exist between the Chattock and multitube manometer readings. This was due to the heating of the alcohol in the latter by a lower strip light which was used while photographs were being taken. This caused errors up to 6 per cent at the lowest speeds. The difficulty was overcome by using an upper light, *i.e.* away from the main volume of alcohol, keeping this alight for the minimum time and taking a photograph of the zero levels both before and after each test.

The film negatives were projected in an enlarger and the observations were read off directly in inches of water from a carefully graduated scale.

2. *Corrections Applied.*—The presence of the calibrating beam increases the static pressure in the plane of the recording static holes. To determine this correction a 7-ft beam of the same cross-section and mounting the same type of pitot-static head was tested in the $11\frac{1}{2} \times 8\frac{1}{2}$-ft tunnel.

The reading of the tunnel static as given by this arrangement was compared with that measured by a standard N.P.L. type head placed in the same position in the tunnel in the absence of the beam.

It was found that the measured static exceeded the true undisturbed value by 0·030 of the dynamic pressure.

Let S be true static pressure,

S' be the measured static pressure,

P be the total head pressure,

A be the atmospheric pressure.

Then
$$S' - S = 0\cdot03\ \tfrac{1}{2}\rho V^2 = 0\cdot03\,(P - S)$$

whence
$$\tfrac{1}{2}\rho V^2 = \frac{P - S'}{0\cdot97} = \frac{1}{0\cdot97} \times \text{(uncorrected dynamic head).}$$

3. *The Soundproofing of the Balance House and its Effect on the Tunnel-speed Controlling Manometer.*—The tunnel wind speed is maintained within close limits of a given speed by means of an automatic manometer which operates the fine speed control of the fan driving motor.

The controlling pressure used for the automatic manometer is that of a hole in the outer side wall midway up and at the position of the maximum cross-sectional area. There the velocity is slowest and the static pressure is only slightly less than the dynamic head in the working section. The datum pressure in which the manometer works is approximately that of the stationary air in the hangar. Originally it was in the unsoundproofed balance house.

The excessive noise set up during airscrew tests at high tip speeds make working in the balance house difficult. To overcome this the balance house has been soundproofed*. As most leak holes were sealed up the air enclosed in the balance house was subject to oscillations causing the controlling manometer to hunt badly.

During the series of calibration experiments the datum atmospheric pressure was taken from the hangar, the maximum difference between this pressure and that of the newly soundproofed balance house being up to 3 per cent of the dynamic pressure, as is shown below.

Nominal speed (ft/sec)	80	100	120	140	160	170
Difference between hangar and balance house static pressure (in. water).	0·005	0·008	0·012	0·023	0·029	0·036

After the soundproofing of the balance house the automatic manometer was removed to the tunnel operator's cabin. It was housed in a separate box effectively isolated from the cabin itself and connected by a bleed pipe to the hangar atmosphere. This method gave satisfactory stability for the automatic control, and the datum pressure is now the same as previously.

APPENDIX II

A Summary of 24-ft Tunnel Calibrations and a Comparison of Results

Introduction.—All calibration experiments performed from 1935 to date are listed as calibrations A to M in Table 6. They are arranged in chronological order, and details of the experiments are given together with results obtained.

The preliminary calibration experiments were made in early 1935, the results of experiments reference A, B and D being incorporated in R. & M. 1720[1]. From that date until 1941 only short calibration experiments of limited range were made.

Certain discrepancies were found to exist among these results mainly in the static-pressure value, but also in the relation between the controlling hole-in-side pressure and the dynamic head. An opportunity occurred in the Summer of 1940 to check the calibration in the working plane in more detail. The conclusion from this experiment (reference I and J) was that sufficient difference existed to warrant a more thorough investigation.

With this in mind the present calibration (experiments reference L and M) was commenced, the series of experiments lasting over a period of about 10 weeks.

An indication of the discrepancies can be obtained from the table below, which gives mean speeds at the same hole-in-side pressure obtained from three calibration experiments in the plane 7·4 ft from the jet face.

$H - A$ (in. water)	. . . . . .	0·804	1·430	2·232	3·215	4·374	5·503
Speed, ft/sec	Experiment B, original . .	60·5	80·4	99·5	119·5	140·2	156·0
	Experiment J, check calibration	61·1	81·3	100·5	120·8	140·8	157·3
	Experimental M, final . .	61·9	81·4	101·1	120·6	140·4	154·5

The first and last are strictly comparable, as the speeds are averages for the 20-ft diameter circle and show the original speeds to be about 1·2 per cent lower than the present. The speed obtained from check calibration J, although agreeing well with M, is a mean of readings from two vertical rows near the centre-line only.

* The major changes are the replacement of the steel framed windows and steel panelled sides by a brick wall with a lining of sound absorbing felt and plaster board. The partition wall between the operating room and the balance was also bricked in.

Fig. 8 shows the values of $\frac{1}{2}\rho V^2/(H - A)$ used up till the present calibration plotted against $H - A$ and compared with the present results. Percentage discrepancies between the present and past values are seen to vary from -1 to $+2$ per cent for the two representative curves chosen. This discrepancy is not constant throughout the speed range as it would wholly be produced by a change in the static-pressure correction. There was considerable scatter among the plotted points used for obtaining the curves shown for experiment B, and part of the disagreement would thus seem to lie with the accuracy of measurement of the original experiment.

Causes for this discrepancy may be either with the measurement of the total head or of the static pressure. Fig. 9 shows that the change in mean $(P - A)/(H - A)$ from experiment B to experiment M is only about $\frac{1}{2}$ per cent. The discrepancy can thus be traced to the change in static pressure, comparative values for which are given in the following table.

Measurements of Static Pressure/$\frac{1}{2}\rho V^2$ on the Centre-line 7·4 ft from Jet Face

Experiment	Apparatus	Actual reading	Correction	Corrected reading
A	25 ft beam along axis	0·027	None	0·027
B	30 ft beam horizontal	0·075	−0·014 (measured)	0·061
C	15 ft beam vertical	0·031	−0·015 (calculated)	0·016
J	15 ft beam with outrigger	0·030	+0·006 (measured)	0·036
M	30 ft vertical	0·072	−0·030 (measured)	0·042

The fact that the previous value of $(S - A)/\frac{1}{2}\rho V^2$ was 0·061 and is now taken as 0·042 is sufficient to account for the disagreement.

The measuring pitot-static tubes have been mounted on different beams for these experiments and the measured statics have different corrections in consequence. The corrections applied are shown in the foregoing table.

The actual readings for the same apparatus from experiments B and M agree well. The corrections applied are, however, 1·5 per cent different, and it is this fact that accounts for the errors in static pressure and hence in the velocity readings.

The correction applied in C was calculated from potential-flow theory, it being assumed that the static holes read the true increased pressure ahead of the supporting beam. This is certainly unjustified, as there is evidence to show that these read up to 1·6 per cent in error.

The fairly close agreement between the later experiments J and M is noteworthy, considering that different beams requiring different corrections were used.

All results of static-pressure measurements are shown in Fig. 5. The static pressure gradient as determined by experiments C and F agrees well with that of the present calibration. On this account little error has been introduced in the longitudinal buoyancy correction.

The static gradient as found by experiment A is shown to differ from the latest value owing to inevitable inaccuracy of the apparatus used. Its use was purely comparative in determining the best nozzle tab size.

REFERENCE

No.	*Author*	*Title, etc.*
1	Jennings, Terry and Pearsall	Preliminary Calibration of the 24 ft. Wind Tunnel R.A.E. with a Short Description of the Tunnel. R. & M. 1720. 1936.

TABLE 3

Centre-line Values

(For symbols see foot of page 8)

Nominal velocity (ft/sec)	40	60	80	100	120	140	160	170
				1 ft Inside Nozzle				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	0·986	0·972	0·959	0·952	0·951	0·955	0·937	0·939
$\frac{P - A}{H - A}$ ..	1·116	1·097	1·081	1·075	1·073	1·076	1·059	1·059
$\frac{S - A}{P - A}$ ..	0·116	0·114	0·113	0·114	0·114	0·112	0·115	0·114
k	65·6	65·2	64·75	64·5	64·5	64·6	64·0	64·1
				3 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·032	1·021	1·009	0·998	0·996	1·001	0·990	0·992
$\frac{P - A}{H - A}$ ..	1·105	1·090	1·078	1·066	1·064	1·070	1·058	1·060
$\frac{S - A}{P - A}$ ..	0·066	0·062	0·064	0·064	0·064	0·064	0·064	0·064
k	67·15	66·8	66·4	66·0	66·0	66·2	65·8	65·9
				7·4 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·062	1·050	1·038	1·029	1·027	1·031	1·017	1 016
$\frac{P - A}{H - A}$ ..	1·108	1·094	1·082	1·071	1·070	1·072	1·059	1·059
$\frac{S - A}{P - A}$ ..	0·041	0·040	0·041	0·039	0·040	0·038	0·039	0·040
k	68·2	67·8	67·4	67·0	67·0	67·1	66·6	66·6
				8·9 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·067	1·054	1·042	1·031	1·029	1·035	1·021	1·022
$\frac{P - A}{H - A}$ ..	1·116	1·097	1·082	1·074	1·070	1·074	1·060	1·058
$\frac{S - A}{P - A}$ =	0·044	0·039	0·037	0·039	0·038	0·036	0·036	0·033
k	68·3	67·9	67·5	67·2	67·0	67·2	66·8	66·8

TABLE 3 (*contd.*)

Nominal velocity (ft/sec)	40	60	80	100	120	140	160	170
				12·5 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{P-A}$ ..	1·073	1·062	1·050	1·044	1·043	1·047	1·034	1·033
$\frac{P-A}{H-A}$ ..	1·122	1·100	1·082	1·073	1·071	1·075	1·059	1·059
$\frac{S-A}{P-A}$ ..	0·044	0·034	0·029	0·026	0·026	0·025	0·024	0·024
k	68·5	68·1	67·7	67·6	67·5	67·6	67·2	67·2
				15 ft. from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·082	1·074	1·055	1·048	1·048	1·054	1·038	1·037
$\frac{P-A}{H-A}$ ..	1·109	1·099	1·083	1·075	1·074	1·077	1·061	1·060
$\frac{S-A}{P-A}$ ..	0·024	0·022	0·025	0·025	0·024	0·021	0·022	0·021
k	68·8	68·5	67·9	67·6	67·6	67·8	67·4	67·3
				19·8 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·075	1·064	1·052	1·047	1·048	1·056	1·042	1·044
$\frac{P-A}{H-A}$ ..	1·121	1·100	1·081	1·071	1·072	1·076	1·061	1·062
$\frac{S-A}{P-A}$ ..	0·041	0·032	0·026	0·022	0·022	0·018	0·017	0·016
k	68·5	68·2	67·8	67·6	67·6	67·9	67·5	67·6
				24 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·077	1·069	1·051	1·046	1·046	1·055	—	—
$\frac{P-A}{H-A}$ ..	1·114	1·096	1·076	1·066	1·068	1·073	—	—
$\frac{S-A}{P-A}$ ..	0·032	0·024	0·023	0·018	0·020	0·016	—	—
k	68·6	68·4	67·8	67·6	67·6	67·9	—	—
Standard $H-A$ in 12·5-ft plane	0·337	0·773	1·400	2·208	3·182	4·340	5·660	6·400

$H-A$ Hole-in-side minus atmospheric pressure,

$P-A$ Total head minus atmospheric pressure,

$S-A$ Static minus atmospheric pressure.

Velocity V, in feet per second given by $V = k\sqrt{(H-A)}$ when $H-A$ is expressed in inches of water.

TABLE 4

Mean Values, 12-ft Diameter Circle

(For symbols see foot of Page 8)

Nominal velocity (ft/sec)	40	60	80	100	120	140	160	170
				Plane 3 ft. from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·044	1·026	1·009	1·000	0·998	0·998	0·997	0·998
$\frac{P-A}{H-A}$ ..	1·120	1·100	1·069	1·066	1·068	1·065	1·065	1·063
$\frac{S-A}{P-A}$ ..	0·069	0·070	0·060	0·061	0·063	0·063	0·061	0·063
k	67·6	67·0	66·4	66·1	66·0	66·0	66·0	66·0
				Plane 7·4 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·068	1·050	1·033	1·023	1·020	1·020	1·020	1·019
$\frac{P-A}{H-A}$ ..	1·102	1·090	1·080	1·068	1·064	1·065	1·061	1·063
$\frac{S-A}{P-A}$ ..	0·035	0·036	0·039	0·040	0·040	0·038	0·038	0·039
k ..	68·5	67·75	67·2	66·9	66·8	66·8	66·8	66·7
				Plane 12·5 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H-A}$ ..	1·084	1·067	1·048	1·037	1·032	1·033	1·031	1·030
$\frac{P-A}{H-A}$ ..	1·111	1·092	1·078	1·068	1·062	1·059	1·056	1·059
$\frac{S-A}{P-A}$ ..	0·027	0·026	0·030	0·028	0·029	0·025	0·025	0·026
k	69·0	68·3	67·7	67·3	67·2	67·2	67·1	67·1

TABLE 5

Mean Values, 20-ft Diameter Circle

(For symbols see foot of Page 8)

Nominal velocity (ft/sec)	40	60	80	100	120	140	160	170
				Plane 3 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·046	1·028	1·014	1·004	1·003	1·007	1·007	1·007
$\frac{P - A}{H - A}$ ..	1·095	1·084	1·065	1·060	1·061	1·059	1·061	1·062
$\frac{S - A}{P - A}$ ..	0·048	0·057	0·050	0·052	0·052	0·050	0·050	0·052
k	67·6	67·0	66·6	66·2	66·2	66·3	66·3	66·3
				Plane 7·4 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·072	1·055	1·040	1·032	1·029	1·028	1·028	1·026
$\frac{P - A}{H - A}$ ..	1·092	1·085	1·070	1·063	1·062	1·060	1·060	1·060
$\frac{S - A}{P - A}$ ..	0·015	0·025	0·027	0·030	0·031	0·029	0·030	0·031
k	68·4	67·9	67·4	67·2	67·0	67·0	67·0	66·9
				Plane 12·5 ft from jet face				
$\frac{\frac{1}{2}\rho V^2}{H - A}$ ..	1·082	1·063	1·046	1·037	1·033	1·032	1·033	1·031
$\frac{P - A}{H - A}$ ..	1·095	1·072	1·062	1·054	1·052	1·050	1·050	1·050
$\frac{S - A}{P - A}$ ..	0·008	0·007	0·015	0·016	0·017	0·016	0·016	0·016
k	68·8	68·2	67·6	67·3	67·2	67·2	67·2	67·15

TABLE. 6.

REFERENCE & DATE	APPARATUS	RANGE OF INVESTIGATION	CORRECTIONS APPLIED TO MEASURED STATIC PRESSURE	TUNNEL STATIC PRESSURE AND VELOCITY DISTRIBUTION	HOLE-IN-SIDE/DYNAMIC-HEAD RELATIONSHIP	REMARKS
A FEBRUARY 1935	25FT BEAM HORIZONTAL ALONG CENTRE LINE. 6 STATIC TUBES MOUNTED ON TOP. $\frac{1}{2}\rho V^2$ MEASURED BY AIRCRAFT TYPE A.S.I. AND PITOT-STATIC HEAD MOUNTED IN JET FACE. PRESSURES READ VERTICALLY ON MULTITUBE ALCOHOL MANOMETERS.	STATIC-PRESSURE GRADIENT ALONG CENTRE LINE FOR DIFFERENT SPEEDS & TAB SIZES.	NONE. THE STATIC TUBES MOUNTED BEHIND EACH OTHER WOULD PRODUCE SERIOUS WAKE EFFECTS, WHICH TOGETHER WITH EFFECT OF BEAM ITSELF WOULD CAST DOUBTS ON THE ACCURACY OF THE RESULTS.	EFFECT OF THE SIZE OF THE TABS INVESTIGATED; OF COMPARATIVE USE ONLY.		
B EARLY 1935	9 AIRCRAFT TYPE PITOT-STATIC HEADS MOUNTED ON 30FT HORIZONTAL BEAM. PRESSURES MEASURED IN MULTITUBE MANOMETERS PHOTOGRAPHICALLY RECORDED.	FULL VELOCITY DISTRIBUTION. RELATION BETWEEN H-A & $\frac{1}{2}\rho V^2$	ORIGINALLY NO CORRECTION MADE FOR EFFECT OF BEAM. VELOCITIES LATER INCREASED BY 1% BEFORE INCLUSION IN R&M 1720 AS RESULT OF EXPERIMENT D TO ALLOW FOR THE PRESENCE OF THE BEAM.	VELOCITY DISTRIBUTION AT ALL TUNNEL SPEEDS IN PLANE 7·4 FT FROM JET & FOR SEVERAL PLANES ALONG WORKING SECTION AT SPEED OF 140FT/SEC.	STANDARD MEAN SPEED OF TUNNEL OVER WHOLE JET. NOM. VEL. — CHATT. — VF/SEC. — $\frac{1}{2}\rho V^2/_{H-A}$ 60 — 0·798 — 59·92 — 1·026 80 — 1·400 — 79·17 — 1·022 100 — 2·172 — 98·42 — 1·018 120 — 3·156 — 118·73 — 1·020 140 — 4·377 — 140·36 — 1·028 160 — 5·699 — 158·24 — 1·021 171·5 — 6·437 — 170·02 — 1·025	IN GENERAL USE TILL 1941.
C MARCH 1935	15 FT VERTICAL BEAM WITH STANDARD SHARP-NOSED N.P.L. PITOT-STATIC HEAD.	PITOT STATIC MEASUREMENTS FOR ALL CONTROLLED TUNNEL SPEEDS ON CENTRE LINE & 18" ABOVE AT 3·5', 5·5', 9·5', 14·5', & 20' FROM JET FACE.	STATIC CORRECTION CALCULATED. (NEGLECTING ERROR IN STATIC HOLE READING) CORRECTION $S'-S=0{\cdot}015\times\frac{1}{2}\rho V^2$.	$\frac{S-A}{P-A}=0{\cdot}016$ AT 7·4FT PLANE FOR ALL SPEEDS.		
D OCTOBER 1935	7FT SAMPLE BEAM OF SAME CROSS-SECTION AS 30FT BEAM USED IN 7FT ENCLOSED SECTION TUNNEL.	CHECK OF STATIC CORRECTION FOR BEAM AS USED IN B. TUNNEL SPEEDS 60 & 85 FT/SEC	RESULT $V=66{\cdot}6\sqrt{P-S'}$ GIVING THE 1% INCREASE IN SPEEDS i.e., THE 2% CHANGE IN STATIC MENTIONED IN B.	NONE.		
E JUNE 1936	15 FT BEAM VERTICAL IN JET FACE.	MEASUREMENTS OF TOTAL HEAD & VEL. DISTRIBUTION AS AFFECTED BY AIRSCREW THRUST IN THE AIRSTREAM.	STATIC CORRECTION CALCULATED AS IN C.	NONE.	CHANGE IN TOTAL HEAD WITH AIRSCREW WORKING AT VARIOUS THRUST COEFFICIENTS ACROSS VERTICAL DIAMETER OF JET NO 'SHADOW' PRESENT, ALTHOUGH TOTAL HEAD CHANGES OF 2% RECORDED.	
F SEPTEMBER 1937	15 FT BEAM VERTICAL. PRESSURES MEASURED BY CHATTOCKS.	CENTRE LINE MEASUREMENTS OF PITOT & STATIC PRESSURES AT 28·5 FT, 33·5 FT, 38·5FT, & 43 FT FROM JET FACE.	STATIC CORRECTION CALCULATED ONLY, AS IN C.	FOUND THAT STATIC PRESSURE INCREASED NEAR THE FAN REACHING A VALUE OF 0·112 OF $\frac{1}{2}\rho V^2$, 43 FT FROM JET FACE.		
G OCTOBER 1938	15 FT BEAM VERTICAL. PRESSURES MEASURED BY CHATTOCKS.	LOW SPEED CALIBRATION CENTRE-LINE VALUE AT 8·9 FT FROM JET FACE.	STATIC CORRECTION AS IN C $S'-S=0{\cdot}015\times\frac{1}{2}\rho V^2$	NONE.	VEL. — (H-A) — $\frac{1}{2}\rho V^2/H\text{-}A$ — K. 19·9 — 0·09 — 1·005 — 66·4 29·9 — 0·199 — 1·026 — 67·0 45·9 — 0·460 — 1·045 — 67·7 60·2 — 0·799 — 1·035 — 67·3 79·2 — 1·400 — 1·022 — 66·9	THESE RESULTS INDICATE THAT THE PROGRESSIVE RISE OF $\frac{1}{2}\rho V^2/H\text{-}A$ WITH DECREASE OF SPEED REACHES A MAXIMUM AT 40F/SEC. THEN FALLS RAPIDLY. ACTUAL MAGNITUDE IN GOOD AGREEMENT WITH PRESENT VALUE ALLOWING FOR THE KNOWN 2% ERROR IN STATIC READING.
H OCTOBER 1939		SPOT VALUES IN CONNECTION WITH HURRICANE & WHIRLWIND EXPERIMENTS.				
I JULY 1940	4'6" BEAM OF SAME CROSS SECTION AS THE 15 FT BEAM. ONE N.P.L. TYPE PITOT-STATIC HEAD MOUNTED ON OUTRIGGER.	CHECK OF STATIC-PRESSURE CORRECTION IN 5 FT OPEN-JET TUNNEL.	MEASURED VALUE $S'-S=-0{\cdot}006\times\frac{1}{2}\rho V^2$.	NONE.		
J AUGUST 1940	15 FOOT VERTICAL BEAM WITH OUTRIGGER AS IN I.	VELOCITY & PRESSURE MEASUREMENTS AT 7·4 FT FROM JET FACE.	AS FOUND IN EXPERIMENT I.	SPOT VALUES AT POINTS ON CENTRE LINE & 2FT ABOVE & 3FT BELOW.	SPOT VALUE OF DYNAMIC HEAD 3FT BELOW CENTRE LINE. NOM. VEL. — $\frac{1}{2}\rho V^2/H\text{-}A$. 60 — 1·188 80 — 1·053 100 — 1·040 120 — 1·048 140 — 1·047 160 — 1·030	THE EFFECTS OF FANS & PLATFORM POSITION ON VELOCITY & PRESSURE WAS NEGLIGIBLE. THE OBSERVED CHANGE OF VELOCITY WHICH WAS <·2% AT 100F/S & -·15% AT 140 INDICATES THAT ANY CHANGES NOT DETECTABLE WITH APPARATUS USED.
K FEBRUARY 1941	30FT BEAM VERTICAL 4 CHATTOCKS USED ON THE 9 PITOT-STATIC HEADS.	VELOCITY DISTRIBUTION ON 3 VERTICALS AT 7·4 FT FROM JET FACE. HOLE-IN-SIDE SPEED RELATIONSHIP.	$S'-S=0{\cdot}02\times\frac{1}{2}\rho V^2$ WAS USED AS FOUND IN EXPERIMENT D ABOVE.	STATIC PRESSURE DISTRIBUTION ACROSS JET ALONG VERTICAL DIAMETER. DISTRIBUTION LITTLE AFFECTED BY SPEED. VALUES AGREE WELL WITH M	SPOT VALUES OF CENTRE LINE $\frac{1}{2}\rho V^2$ NOM. VEL. — $\frac{1}{2}\rho V^2/H\text{-}A$. 60 — 1·076 80 — 1·028 100 — 1·01 120 — 1·01	VELOCITY AT TOP OF SECTION FOUND TO TO BE 3% LESS THAN THAT AT THE BOTTOM EXPERIMENT M INDICATES VALUE OF 1¼%.
L AUGUST 1941	15 FT BEAM WITH OUTRIGGER.	LOCAL VALUES FOR STIRLING EXPERIMENT.	AS FOUND IN EXPERIMENT I.	VALUES OF STATIC PRESSURE AT 12·5 FT & 16·5 FT FROM JET FACE.		WITHIN 1% OF PRESENT VALUE.
M OCTOBER NOVEMBER 1941	30FT BEAM VERTICAL PRESSURES ON MULTITUBE MANOMETERS PHOTOGRAPHED. CENTRE LINE VALUES ALSO READ ON CHATTOCKS.	VELOCITY DISTRIBUTION ACROSS THREE PLANES DOWN SECTION AT ALL CONTROLLED TUNNEL SPEEDS FROM 80-170 FT/SEC STATIC PRESSURE ALONG & ACROSS JET. RELATION BETWEEN $\frac{1}{2}\rho V^2$ & H-A FOR CENTRE LINE & ALSO MEANS FOR 12 FT & 20FT CIRCLES.	$S'-S=0{\cdot}030\times\frac{1}{2}\rho V^2$ WAS MEASURED IN A CHECK TEST OF 7FT BEAM (AS IN D) IN 11FT TUNNEL. THREE OF THE 9 PITOT-STATIC HEADS TESTED FOUND TO AGREE WITHIN ·2% ON STATICS.	COMPLETE VELOCITY CONTOURS FOR VARIATIONS OF FLOW WITHIN 20FT CIRCLE ALSO STATIC-PRESSURE GRADIENT CALCULATED FOR CENTRE LINE.	COMPLETE RESULTS GIVEN IN MAIN REPORT.	

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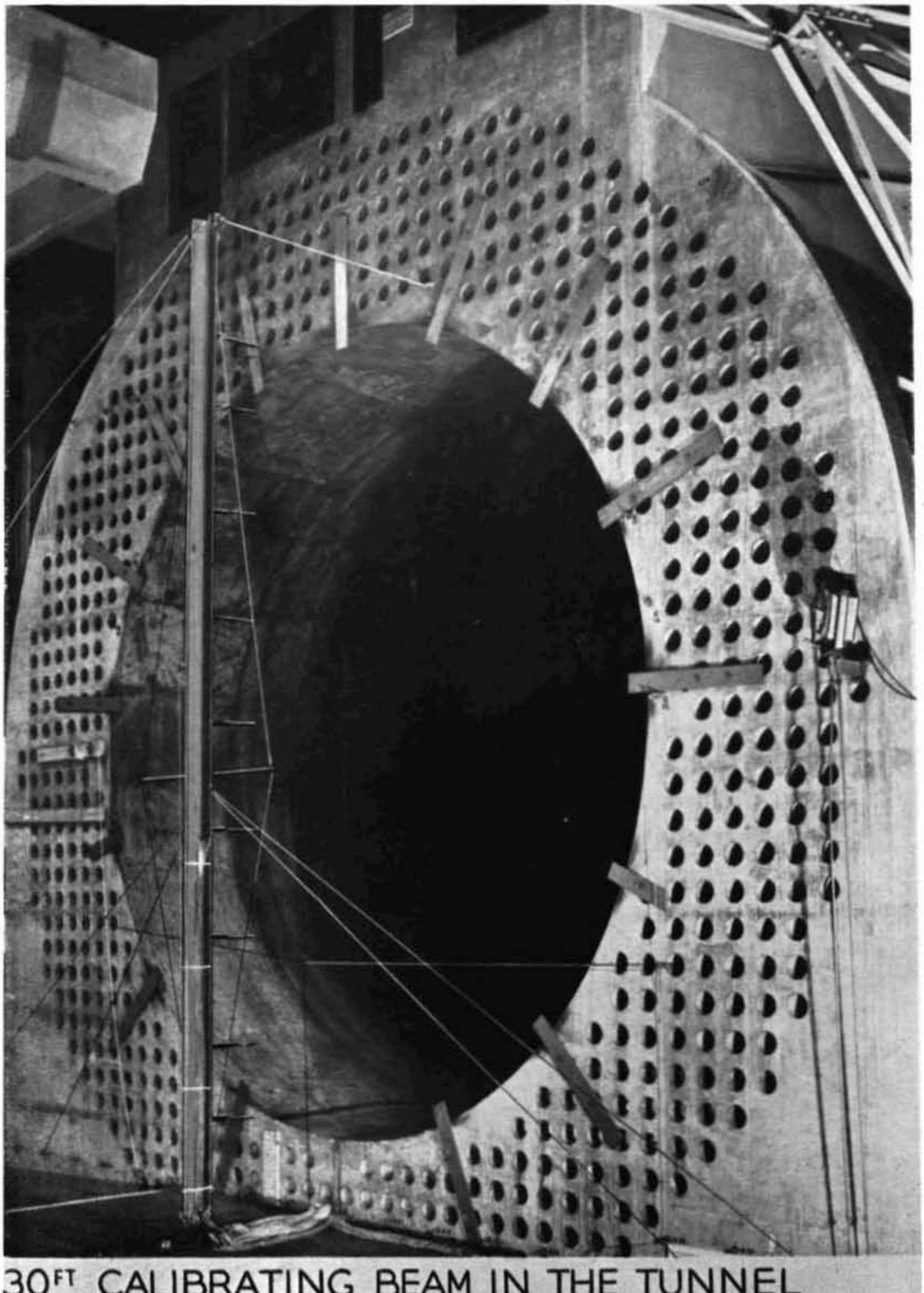
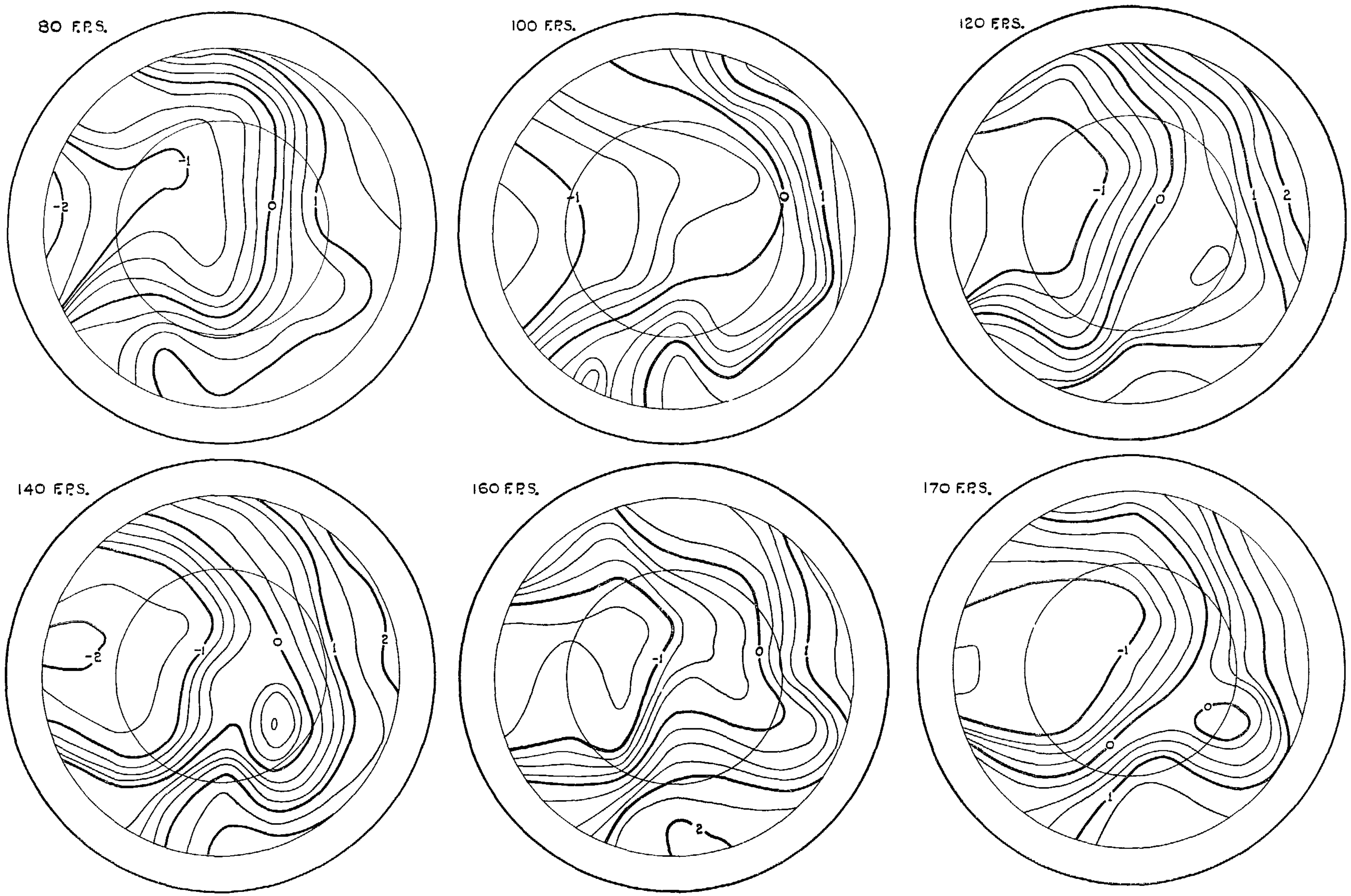


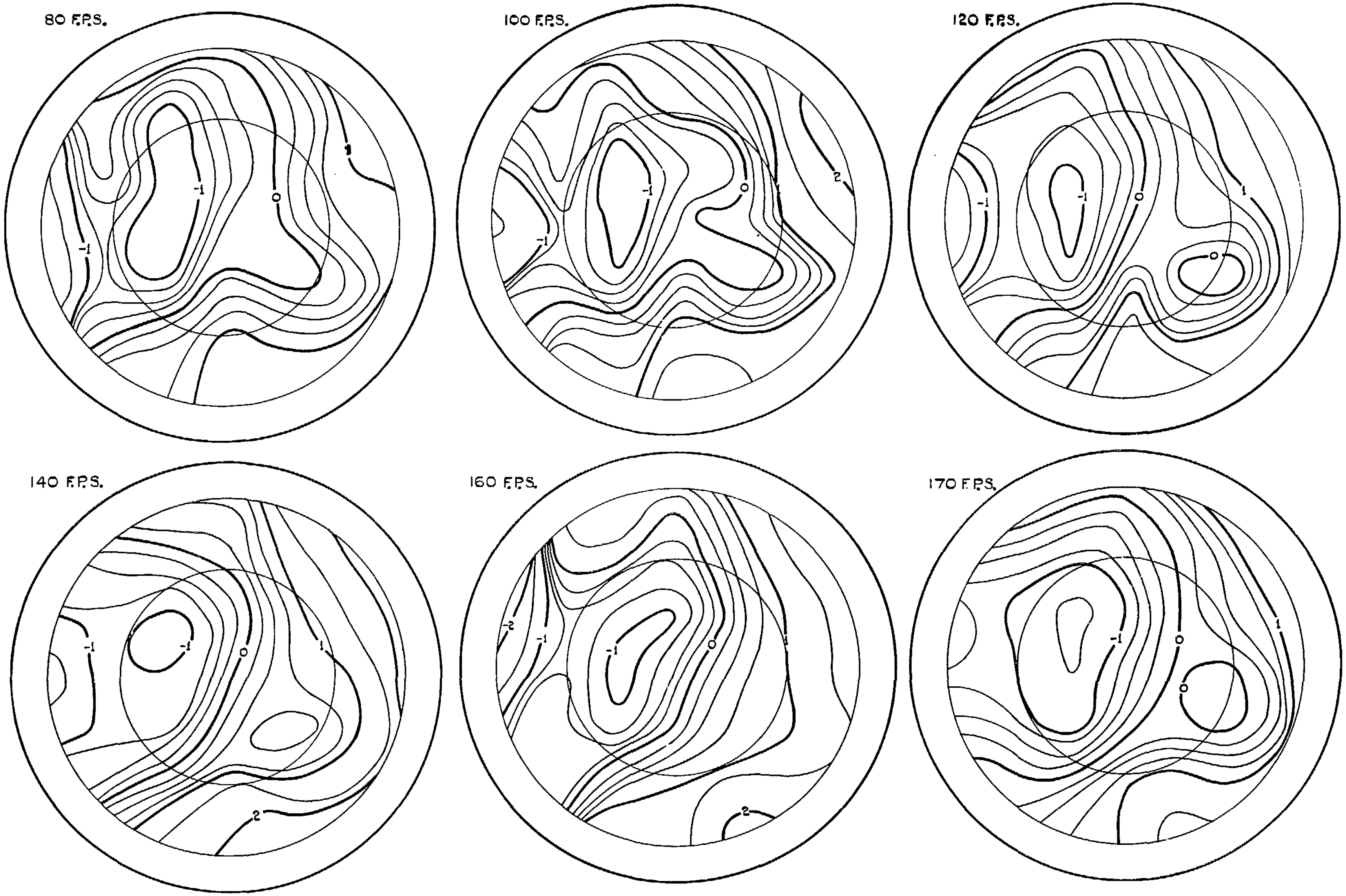
FIG. 1.

(91985)



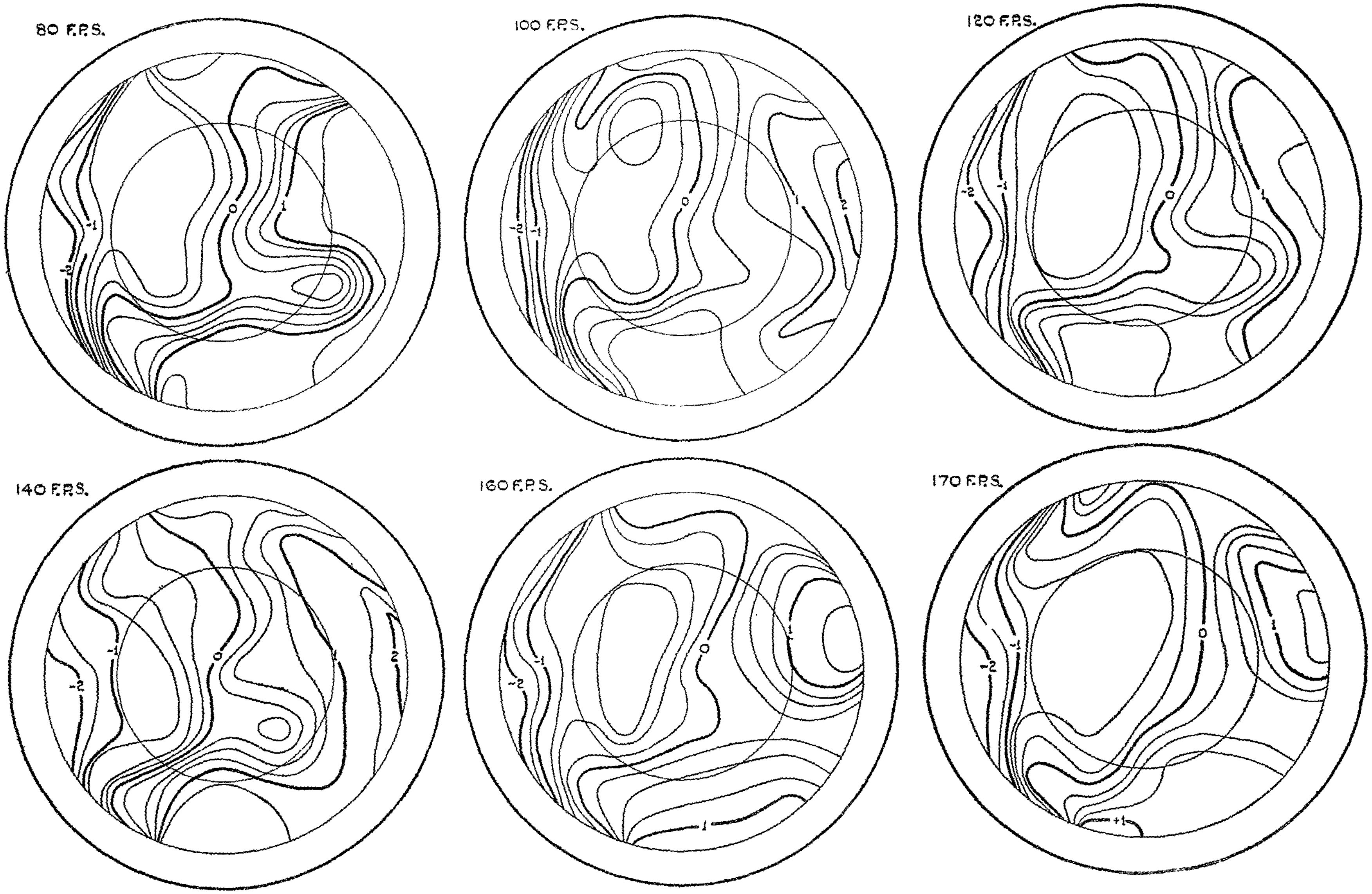
The Contours show the Variation of Local Velocity from the Mean within a 20 ft. Diameter Circle and are spaced as follows:
Each $\frac{1}{4}\%$ between $+ 1\%$ and $- 1\%$; Each $\frac{1}{2}\%$ for Variation $> 1\%$ and $< - 1\%$.

FIG. 2. Velocity Distribution in Plane 3·0 ft. from Jet Face, Looking Upstream.



The Contours show the Variation of Local Velocity from the Mean within a 20 ft. Diameter Circle and are spaced as follows :
Each $\frac{1}{4}$% between $+1$% and -1%; Each $\frac{1}{2}$% for Variation > 1% and < -1%.

Fig. 3. Velocity Distribution in Plane 7·4 ft. from Jet Face, Looking Upstream.



The Contours show the Variation of Local Velocity from the Mean within a 20 ft. Diameter Circle and are spaced as follows:
Each $\frac{1}{4}$% between +1% and −1%; Each $\frac{1}{2}$% for Variation $>$ 1% and $<$ −1%.

FIG. 4. Velocity Distribution in Plane 12·5 ft. from Jet Face, Looking Upstream.

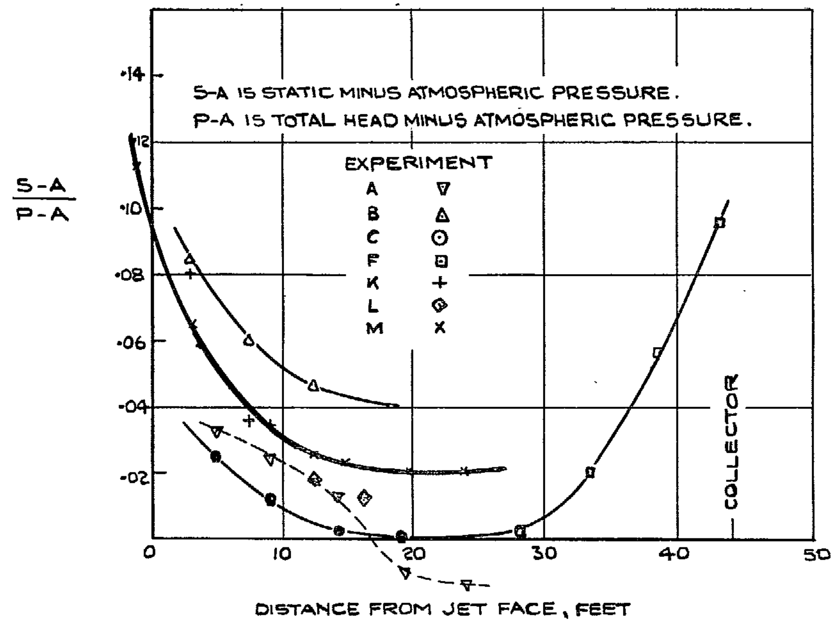


FIG. 5. Static Pressure along the Tunnel Centre Line as Measured in the Calibration Experiments from 1935 to 1941.

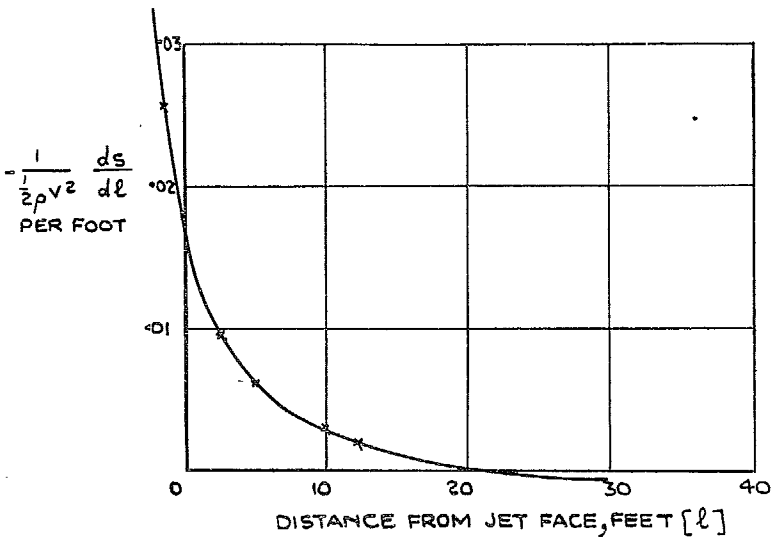


FIG. 6. Centre-Line Static-Pressure Gradient.

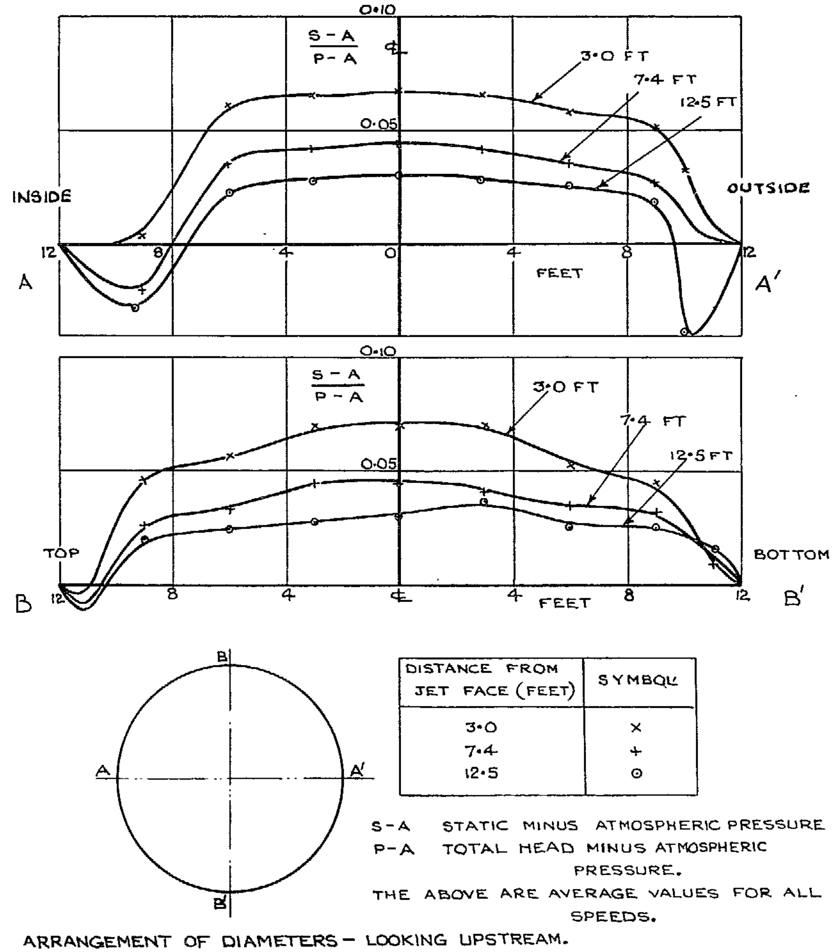


FIG. 7. Distribution of Static Pressure across the Jet.

(94985) Wt. 14/806 K5. 2/51 Hy.

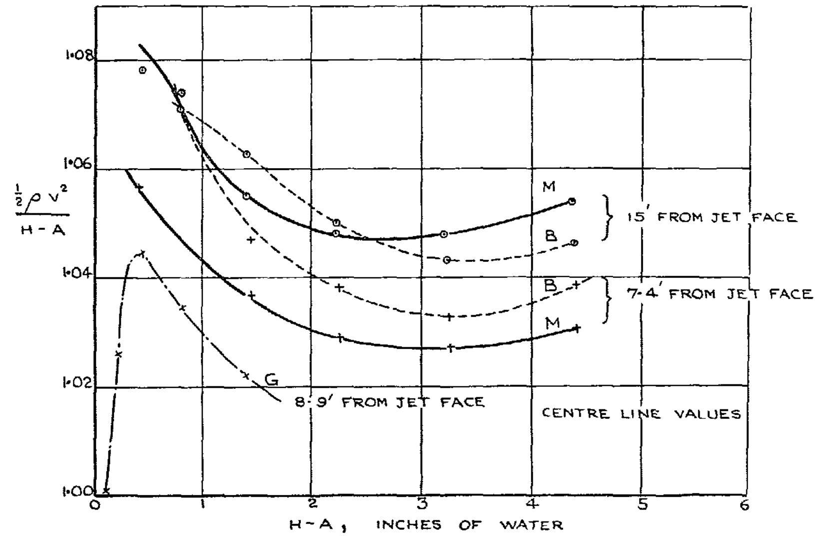


FIG. 8. Comparative Dynamic-head/Hole-in-side Curves.

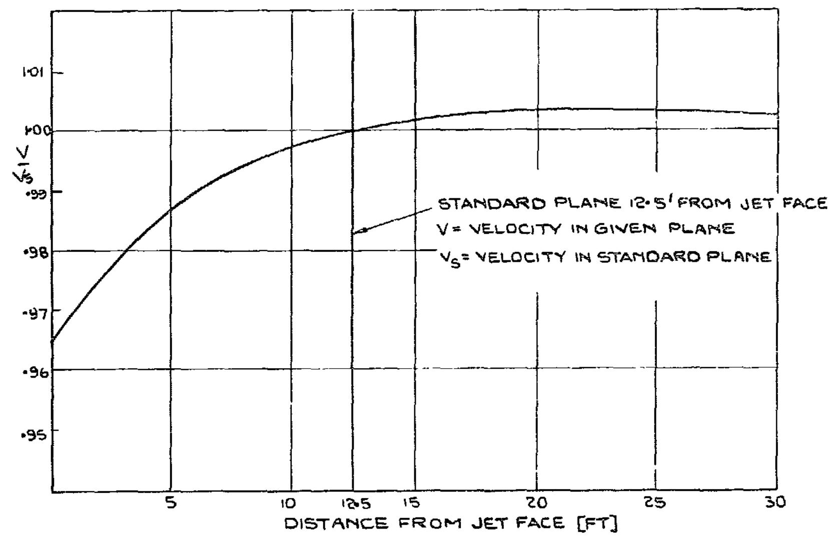


FIG. 10. Variation of Velocity along Working Section.

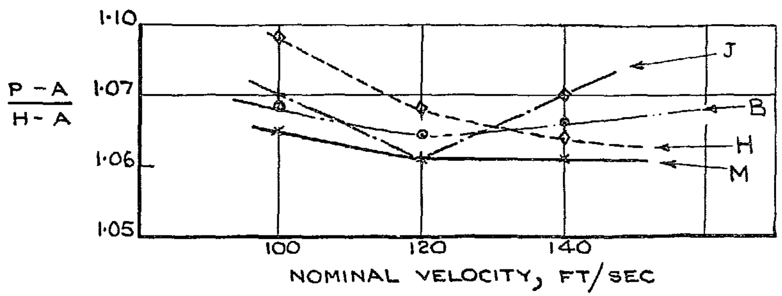


FIG 9. Comparison of Total-head/Hole-in-side Ratio at 7·4 ft. from Jet Face as Given by Different Experiments.

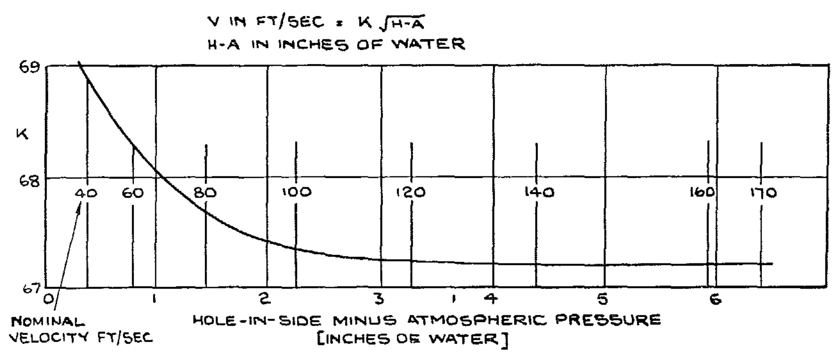


FIG. 11. Velocity / Hole-in-side Curve for Standard Plane 12·5 ft. from Jet Face.
(This applies to both 12 ft. and 20 ft. circles).

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