ACCOUNT OF SOME EXPERIMENTS ON RIGID AIRSHIP R.26.

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SUMMARY.—The Report gives experimental results obtained on four flights on R.26 during the period November, 1918—January, 1919.

The following earlier Reports are quoted in the text :—R. & M. 668 (Airship R.33) ; R. & M. 537 and R. & M. 619 (23 Class Airships) ; R. & M. 460 and R. & M. 475 (Airscrew Thrust).

Range of the Investigation.—The experiments may be classified under the following headings.

(1) Unsuccessful attempt at pressure measurement over the horizontal stabilizing surfaces.

(2) Turning trials with the rudders at 12° and 18°, port and starboard, for one speed only. See Tables 2 and 3, Figs. 2 and 3.

(3) Deceleration tests from full speed. See Table 4, Fig. 4.

(4) Airspeed for a number of combinations and rotational speeds of the engines. See Table 5.

(5) Preliminary observations of airscrew thrust by the method suggested by Dr. Stanton in R. & M. 460. See *Appendix* and Tables 6 and 7, Figs. 5 and 6.

Conclusions. Section (2).—For rudder settings between 5° and hard over the mean turning diameters range in the case of R.26 from 30 to 50 per cent. higher than the figures corresponding with R.33. The percentage reduction of forward speed due to turning with the rudders at a given angle, instead of flying a straight course at the same engine r.p.m., is appreciably smaller with this class of airship than with the 33 Class.

Section (3).—The values of resistance coefficient derived from the deceleration experiments differ from the mean C = 0·0247 by not more than 1 per cent.

Section (4).—The highest observed speed was 70 ft./sec. (41·5 knots). The few speed observations available confirm satisfactorily the dependence of head resistance upon the square of forward speed.

Section (5). (*Appendix.*)—The results of the preliminary thrust measurements present anomalous features, for which hitherto no satisfactory explanation has been suggested. The observations secured at the after airscrew, when plotted, appear to group themselves into five points agreeing satisfactorily with the model and into two curves falling markedly below the expected range. The former group was secured on occasions when the port amidships engine was not running, and the latter group when all engines were stated to be running satisfactorily.

INDEX TO TABLES, DRAWINGS AND CURVES.

	Table.	Figure.	Page. Text.	Page. Table.
Various Particulars of Airship R.26 ...	1	1	—	194
Observations during turning trials with rudders at 12° and 18°, port and starboard.	—	2	—	—
Values of turning coefficients, diameters of turning circles.	2	3	188	195
Observations during deceleration ...	—	4	—	—
Mean airspeed for various engine combinations.	3	—	190	195
Pressure difference at after airscrew ...	4	5	192	196 (Appendix).
Pressure difference at amidships and forward airscrews.	5	—	—	199
Thrust coefficient at various values of v/nD, predicted from model of after airscrew.	—	6	—	—

INTRODUCTORY.

Programme of Experiments.—During the summer of 1918 certain full-scale experiments on rigid airships were arranged in conjunction with the Airship Design Department, Admiralty. The original proposals included an investigation of pressure distribution over the stabilizing surfaces of a rigid airship, with a view to locating the positions on these surfaces where maximum stresses were likely to be encountered during flight. Airship R.26 was allocated for the purpose, and a preliminary series of pressure holes was fitted on one of the horizontal surfaces. After discussion with an experienced pilot a horizontal surface was chosen in preference to a vertical surface, since it was hoped that by appropriate alteration both of trim and equilibrium of the airship during flight, manœuvres might be undertaken which would furnish higher stresses over the horizontal fins than would be secured over the vertical fins by turning manœuvres.

A semi-circular photo-manometer (containing 32 tubes) similar in principle to the instrument described in R. & M. 287 was loaned from the R.A.E. for these special experiments, and installed in the gun position at the tail. Suitable arrangements were also made to measure, by aid of an instrument similar to a yawmeter mounted horizontally at the keel cabin, the pitch of the airship.* A special protractor was fitted to the elevator under test, so that the true elevator angle at any stage could be observed directly from the tail by means of a telescope.

* This angle is not given by the ordinary inclinometer unless the flight path is horizontal.

It may be stated at the outset that, owing to bad weather and to the low disposable lift of airships of this class, these experiments were abandoned. Some photographs of pressure distribution were taken on one flight; but as the ship was flying very approximately in trim the pressures recorded were insignificant. The captain considered it unsafe to attempt any manœuvres which would give high pressures on the fins, and it was eventually agreed to postpone these special tests until a ship of a later class became available.

During this period Dr. T. E. Stanton, F.R.S., and Miss D. Marshall, B.Sc., were carrying out experiments in a wind channel on a new method of measuring airscrew-thrust. These experiments are reported upon in R. & M. 460 and R. & M. 475, where it is concluded that a close approximation can be made to the airscrew-thrust, as measured on a wind channel balance, from observations of the difference of pressure between two pitot tubes, mounted in certain positions before and behind the airscrew disc. The possibility of estimating ultimately by this method the total airscrew thrust of any airship was at once evident, and at Dr. Stanton's suggestion appropriate pitot tubes were mounted at the airscrews of R.26, with a view to a preliminary comparison between the thrust of the full-scale airscrew and that predicted by a similar method from a scale model.

Unfortunately, those few experiments on R.26 which were performed in this connection remained uncompleted, and the results, as they stood, were found to present very anomalous features.

Since the completion of the trials of R.26, and as a result of the experience gained in them, special apparatus has been designed for Airship R.32; and the preliminary experiments recently conducted with the later class airship do not appear to exhibit the anomalous behaviour observed on R.26. It is, therefore, thought desirable, for purposes of reference, to present the earlier observations in the form of an Appendix to the present report. It is hoped that in due course a satisfactory explanation of the outstanding discrepancies will be discovered.

Deceleration tests and a number of turning experiments completed the schedule of trials on R.26; these results serve as a check on those reported earlier. (R. & M. 537.)

The observations were taken during four flights from Pulham Air Station, in Norfolk, on the following dates: Nov. 20th and Dec. 22nd, 1918, and Jan. 23rd and 24th, 1919. It may be remarked that the weather conditions obtaining during the flights, and the limited number of useful flights, were not favourable for completing the programme of experiments satisfactorily.

DESCRIPTION OF APPARATUS.

Anemometer.—The flying head used for purposes of speed measurement was substantially that already described in detail in R. & M. 668 (Experiments on R.33). The head was lowered some 45 ft. below the forward car or the keel, and gave a pressure difference of $1/2\rho^*V^2$, which was observed by means of an Ogilvie indicator, in the usual manner.

Control Surfaces.—Reference has already been made in the Introductory Section to certain apparatus which was installed for pressure measurement over the horizontal stabilizing surfaces. As these particular tests proved abortive, it is thought that any further account of the arrangements made in this connection is unnecessary. It is hoped to report shortly on analogous experiments on R.32, when the equipment will be described in the requisite detail.

In connection with the turning trials it should be explained that recent experience with R.33 has shown the desirability of clamping the rudders at the after end of the airship during a turn at any specific rudder angle, if the most accurate results are to be obtained. This precaution has uniformly been followed in conducting turning trials on the later class airships, since a considerable movement of the rudders has been observed when the helm in the forward car is held steadily in any given position, in virtue of the strain in the great length of the cables operating the rudders. The experiments on R.26 were conducted at a stage when experience of full-scale requirements was relatively limited, and the advisability of clamping the rudders had yet to be appreciated. The assumption was also made that the angle of the rudders was the same as that on the indicator in the forward car. Whilst the results of the turning trials on R.26 are open to the errors associated with helm control (though, owing to the reduced length of cable, probably to a less extent than on R.33) and are consequently of doubtful accuracy for purposes of stability comparison with values from model, it is thought that they define sufficiently closely the turning performance of the 23 Class of airship from the standpoint of design.

REDUCTION OF THE OBSERVATIONS.

Turning Trials.—Methods for the reduction of the various trials have been formulated in some detail in R. & M. 668 with reference to experiments on R.33. It is shown there that the

* Throughout the report ρ denotes the current value of air density. The values of ρ for the flights reported on are as follows :—

Nov. 20th, 1918	$\rho = 0 \cdot 00245$ slugs /ft.^{3}
Jan. 23rd, 1919	$\rho = 0 \cdot 00250$,,
Jan. 24th, 1919	$\rho = 0 \cdot 00251$,,

radius R of the turning circle for any given rudder setting is sufficiently accurately given by

$$R = V/\dot{\psi} \quad . \quad . \quad . \quad . \qquad (1)$$

where V denotes the speed in feet per second as measured on a flying head suspended from the forward car, and where $\dot{\psi}$ denotes the angular velocity of the airship during the turn, in radians per second. The quantity $\dot{\psi}$ is readily derived by measurement of the slopes of lines specifying variation of compass reading with time.

Deceleration Tests.—For the reduction of the deceleration trials, it is convenient to utilise a graph connecting the reciprocal of the forward speed during deceleration with the corresponding times. (Fig. 4.) Over ranges where the head resistance varies as the square of the speed, the observations so plotted fall on a straight line, whose slope S determines the non-dimensional resistance coefficient C in the following terms :—

$$C = \frac{MS}{\rho l^2} \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

where M denotes the mass of the airship, and l the cube root of the volume. In this approximation the effects of acceleration upon resistance are neglected, pending more precise information on the allowances for virtual mass.

If the airship is assumed to be in equilibrium in air whose density is ρ, it follows that $M = \rho l^3$, whence :—

$$C = lS \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

DISCUSSION OF RESULTS.

Turning Trials.—The observations of compass angle taken with the rudders maintained at various angles by use of the forward control wheel are plotted in Fig. 2. Corresponding with each turn the mean angular velocity $\dot{\psi}$, expressed in radians per second, has been calculated from the diagram, and tabulated in Table 2. The angle of yaw was not observed.

During each turning experiment all engines were running at 1,200 r.p.m., corresponding with a forward speed 58·9 ft/sec., when the rudders were amidships, and with a speed 56·4 ft. per second for rudders at 18° starboard. It is of some interest in this connection to compare the reductions of forward speed brought about by turning at various rotational speeds of the engines for airships of Classes 23 and 33.

AIRSHIP R.26.

Engine r.p.m.	All Engines 1,400 r.p.m. (From R. & M. 537.)				All Engines 1,200 r.p.m. (Present Report.)	
Angle of rudders ...	5°S	10°S	15°S	15°P	Amidships	18°S
Speed, ft/sec. ...	67·2	66·6	66·2	64·3	58·9	56·4

AIRSHIP R.33 (From R. & M. 668).

Engine r.p.m.	No. 1 stopped 2, 3, 4, 5 at 1,800 r.p.m.				All Engines 1,200 r.p.m.				
Angle of rudders	5°S	5°P	10°P	15°P	5°S	10°S	5°P	10°P	15·5°P
Speed, ft/sec. ...	65·5	64·9	58·6	56·4	48·9	45·5	48·4	46·0	44·0

Examination of these figures shows that the reduction of forward speed due to turning at any given engine speed is relatively greater with the later class of airship. In the case of R.26 the reduction of forward speed appears to be in general of the order 2 per cent., per 10° of rudder angle ; whilst with the stream-line shape (R.33) the corresponding reduction amounts to as much as 10 per cent.

In Table 2, the values of diameter of turning circle and the corresponding turning coefficients* are calculated for the four turning trials carried out, viz., 12° and 18° port and starboard. The table includes values derived from a number of similar experiments which were reported upon in R. & M. 537.

Owing to the short time available for the trials, it was impossible to carry out the turns at more than a single speed for each rudder angle ; the speed effect upon diameter of turning circle thus remains somewhat uncertain. It has, however, in the case of R.33 been shown (see R. & M. 668) that the variation of diameter from the mean with speed for turns at the higher rudder angles is relatively small, amounting to not more than 3 per cent., for rudders at 10° or 15°, and to about 7 per cent. at 5° rudder. The effect of speed was found to be even less on R.29, whose hull was designed to include a great proportion of cylindrical body, in common with R.26. It is legitimate to infer that the speed effect upon diameter of turning circle cannot be pronounced in the case of R.26.

The results of the present turning trials and those available from R. & M. 537 have been collated in the form of a curve representing for the 23 Class the variation with rudder angle of the mean turning coefficient (see Fig. 3). An analogous curve, corresponding with airships of Class 33, has been added to the diagram.

In facility of turning it is seen that the R.33 Class shows to very marked advantage, inasmuch as for rudder settings between 5° and hard over the mean turning coefficients range between 0·39 and 0·57 of the corresponding values obtained with airships of 23 Class. Unfortunately, extrapolation of the curves of Fig. 3 over the region of small rudder angles cannot be attempted with

* The turning coefficient for any particular rudder setting on an airship is defined in R. & M. 668 as the diameter of the turning circle divided by the length of the airship.

confidence, owing to the possible appearance in this neighbourhood of an appreciable speed effect on turning diameter. From the standpoint of stability it is regrettable that time was not available for some investigation of the behaviour of R.26 when the rudders were amidships and at small angles. It is, however, not unreasonable to anticipate from the general divergence of the two curves of Fig. 3 at the smaller rudder angles, the greater stability of the earlier class airship.

Deceleration Experiments.—Two deceleration tests were made on the flight of January 24th, the observations taken being plotted in Fig. 4.

Corresponding with the two trials, the values of S and C, as calculated by the method described on page 188, are as follows :—

	S.	C.
Expt. 5a	$2 \cdot 44 \times 10^{-4}$	$0 \cdot 0249$
Expt. 5b	$2 \cdot 40 \times 10^{-4}$	$0 \cdot 0245$

Thus the values of C derived from these two experiments differ from the mean value $C = 0 \cdot 0247$ by not more than 1 per cent., and it is thought that this figure should be considered more reliable than the coefficient $C = 0 \cdot 022$ quoted in R. & M. 537.

It will be noticed that at the lower speeds the slopes of the curves in Fig. 4 become more steep, though the change depends upon one or two observations, and cannot be regarded as established. Curvature in this direction would be expected if a speed effect were present, and all further deceleration tests conducted will be closely examined for such a result. At present there is no evidence of a consistent departure from a straight line.

A full discussion of the significance of these results in the prediction of the resistance of an airship of 23 Class from data available from experiments on a model is given in R. & M. 619. In the report quoted it is shown that, whilst the resistance predicted from models amounts to $1 \cdot 2$ times the value determined by deceleration of the actual airship, the discrepancy can be accounted for by the behaviour of the "scale-effect" curve for the model of the hull, which exhibits an appreciable slope at the highest wind channel values of Vl.

Forward Speed for Various Engine Combinations.—A few measurements of speed were made, with the engines running under various conditions. These figures, which are added for purposes of reference in Table 3, are not sufficiently complete, however, for any serious attempt at speed prediction on the basis sketched in R. & M. 668. The highest observed speed was 70 ft/sec. This table also contains the speeds recorded in R. & M. 537.

In the case of various combinations of engines running at a like speed three types of speed observation are comparable, viz., those taken with all engines running at 1,400, 1,300 and 1,200 r.p.m. For combinations of this type the following table has been compiled :—

ALL ENGINES RUNNING AT A LIKE SPEED (N).

Value of N. r.p.m.	Mean Forward Speed V (ft /sec.).	Mean V /N.
1,400	69·0	0·0492
1,300	64·3	0·0494
1,200	58·9	0·0491

It is shown in R. & M. 668 that these values of V /N should be constant over ranges where the head resistance varies as the square of the forward speed. The conclusions to be drawn from the above figures are thus in good agreement with what may be inferred from the linearity of the deceleration curves.

Distribution of Velocity below Forward Car.—An opportunity was taken at the close of the last flight to make some measurements of speed at various distances below the forward car. The increase of speed locally over the true forward speed was found appreciable when the suspended length of tubing to the flying head was less than 25 ft. ; this increase amounted approximately to 9 per cent. of the true forward speed when this distance was reduced to 5 ft.

The writers wish to express their indebtedness to Major W. H. Watt, the Commanding Officer of R.26, for his skill and judgment, and for the numerous facilities he offered in connection with the experiments ; also to all officers and men who assisted in the navigation of the airship.

Captain S. E. Taylor and Captain G. F. Meager co-operated closely with the N.P.L. representatives, and assisted in taking observations. Acknowledgment is also due to Mr. L. F. G. Simmonds, B.A., of the N.P.L. Staff for his assistance on the flight of December 22nd, 1918.

APPENDIX.

MEASUREMENT OF AIRSCREW THRUST.

After Airscrew.—Following a discussion with Dr. Stanton, arrangements were made to investigate the distribution of pressure difference across the disc of the after airscrew.

The method of thrust measurement proposed by Dr. Stanton (R. & M. 460), consists in deriving air thrust grading curves by measuring along a typical radius, by aid of a pair of pitot tubes, the distribution of difference of total head between the inflow and outflow sides of the airscrew disc. If $(p_1 + \rho V_1^2/2)$, $(p + \rho V_2^2/2)$ represent the values of total head as measured by pitot tubes A, B, supported in close proximity to the airscrew disc at a common radius r from the shaft on the inflowing and outflowing sides respectively, then the difference observed at each point amounts to $(p_1 - p_2) + \frac{1}{2}\rho(V_1^2 - V_2^2)$, which under the ordinary hypothesis of theory that the column of air passes through the screw without change of velocity, reduces to $(p_1 - p_2)$. Denoting by D the diameter of the airscrew, the non-dimensional thrust coefficient is readily derived as the area of the graph obtained by plotting the quantity $(2\pi/\rho V^2) \times (r/D) \times (p_1 - p_2)$ on a base of r/D. In the experiments on the model quoted it was shown that the total head $(p_1 + \rho V_1^2/2)$ did not vary appreciably in the inflowing stream, and it was consequently assumed that for the purposes of thrust measurement it would be sufficient to maintain the pitot tube "A" clamped forward of the airscrew at some convenient position throughout the experiment.

Fixed Pitot Tube A.—For the full-scale experiments, a pitot tube "A" was fixed at a point which measured 8 ft. forward of the airscrew disc, 6 ft. below the bottom of the keel and 4 ft. laterally from the port side of the after car. A length of tubing served to connect this head to the suction side of the Ogilvie pressure indicator in the keel. (See Fig. 1.)

Exploring Pitot Tube B.—A stream-lined strut was lashed securely to a pair of keel-girders aft of the airscrew, and projected vertically downward some 7 ft. below the keel into the slipstream. (See Fig. 1.)

A length of copper tubing, gripped to the leading edge of the strut by a pair of rings fitted on the upper part of the strut, was bent at its lower extremity to constitute the exploring pitot tube "B," and was connected at its upper extremity within the keel by a length of rubber tubing to the pressure side of the indicator. The constraint of the rings was such that the copper tube with its pitot head could be made to slide vertically. It was possible by this means to travel the head parallel to the vertical exploring radius of the airscrew disc, from an extreme position corresponding with zero radius from the airscrew axis, to within 8 ins. of the bottom of the keel (neighbourhood of tip of airscrew). The mouth of the exploring tube was in all positions situated 3 ft. behind the airscrew disc.

Amidships and Forward Airscrews.—A number of observations of pressure difference were also taken at the amidships and forward pairs of airscrews, but only with the pitot tube "B" clamped at 0·7 of the airscrew radius in each case. Observations were taken in this manner in view of the very limited time at disposal; the preliminary observations on model airscrews gave hope that it might be possible to determine the thrust from such measurements, but the method was ultimately found to be not capable of general application.

It is hoped that these isolated observations may eventually prove useful for comparison with model results, should the latter become available.

Analysis of the Results.—The observations taken are reproduced in Tables 4, 5, Fig. 5, and the results may be summarised under the following headings :—

AFTER (FARRINGDON) AIRSCREW. (Table 4, Fig. 5.)

(a) *November 20th,* 1918.—Five measurements of pressure difference corresponding with $r/\mathrm{D} = 0\cdot35$ and $\mathrm{V}/n\mathrm{D} = 0\cdot260$, $0\cdot229$, $0\cdot221$, $0\cdot218$. These points are found to be consistent with values estimated from experiments with a $\frac{1}{8}$th full-sized model of the airscrew, in the presence of a model keel and radiator. (See Fig. 6.) The port amidships engine was not running during these experiments.

(b) *January 23rd,* 1919. 9.10 a.m.—Measurement of pressure distribution over the tabulated range of values of r/D, for $\mathrm{V}/n\mathrm{D} = 0\cdot314$. This curve, on integration, gives a thrust coefficient $\mathrm{T}_c = 0\cdot14$ which is less than half the value ($\mathrm{T}_c = 0\cdot385$) to be expected from the model experiments. (See Fig. 6.) All engines were running satisfactorily.

(c) *January 23rd,* 1919. 9.45 a.m.—A set of observations corresponding with $r/\mathrm{D} = 0\cdot35$, $\mathrm{V}/n\mathrm{D} = 0\cdot315$, leading to a point compatible with the model experiments. Port amidships engine not running.

(d) *January 24th,* 1919. 9.15 a.m.—Experiments with $r/\mathrm{D} = 0\cdot35$, $\mathrm{V}/n\mathrm{D} = 0\cdot342$, furnishing a point markedly lower than the prediction, but confirming measurements immediately following. (See section (*e*)). All engines running satisfactorily.

(e) *January 24th,* 1919. 9.20 a.m.—Determination of pressure distribution over a range of r/D, for $\mathrm{V}/n\mathrm{D} = 0\cdot342$. Results comparable with sets (b) and (d) but differing notably from predicted values. All engines running satisfactorily.

AMIDSHIPS AND FORWARD AIRSCREWS. (Table 5.)

(f) In the case of each of the remaining airscrews, pressure difference was measured at $r/\mathrm{D} = 0\cdot35$ only, for two values of $\mathrm{V}/n\mathrm{D}$.

No comparisons are at present possible, since experiments with the appropriate models have not yet been undertaken.

The results of the experiments at the after airscrew, present anomalous features, for which the writers have been unable to find any adequate interpretation. On reference to the summary of these observations it is seen that on the occasions when agreement with model predictions was secured, the port amidships engine was not running ; whilst with all engines running normally, the full-scale values fell markedly below the expected figures.

It does not appear, however, that any satisfying explanation is to be anticipated in the running performance of the port amidships airscrew.

Two distinct effects at the after airscrew are possibly due to the slipstream from the port amidships airscrew.

(1) The inflow velocity may be augmented appreciably above the forward speed of the airship, as measured by the flying head. Under such conditions the tabulated full scale values of $\mathrm{V}/n\mathrm{D}$ are too low.

It appears, however, that the increase of speed to be expected due to the slipstream from the port amidships airscrew is insufficient altogether to account for the observed discrepancies. The distance between the two airscrews was approximately 11 diameters of the amidships airscrews.

(2) The slipstream effect may be very local, and, whilst not changing the overall inflow velocity at the after airscrew, may increase the datum head in the upstream pitot tube " A," which was fitted on the port side of the after car.

The increase of speed required (about 70 ft/sec.) appears, however, far in excess of what might be expected from the amidships airscrew ; under these circumstances this explanation is untenable.

It is thought unlikely that the errors were introduced owing to a leak in a connecting tube, since the experiments, in chronological sequence, furnished alternately the high and low figures.

The writers submit the results quoted in the Appendix with considerable diffidence. When measurements of this nature have to be undertaken in a very limited time it is difficult to take cognizance of all circumstances likely to affect any given experiment; it is a matter for regret that further experiments could not be arranged on another airship of this class.

The importance of establishing this method of thrust-measurement cannot be over-estimated, since satisfactory results would eventually provide figures for head-resistance independent of any allowance for "virtual mass."

Table 1.

VARIOUS PARTICULARS OF AIRSHIP R.26.

Hull.

Length ...	535 feet.
Maximum diameter ...	53 ,,
Gas bags, 18 in number, with a total capacity of ...	985,000 cu. ft.
Total displacement of airship ...	1,054,000 cu. ft.
Gross lift at N.T.P. ...	28 tons.
Disposable lift, about ...	6 tons.

Power Units.

Forward car.—One 250 h.p. Rolls Royce engine, driving two four-bladed "Integral" airscrews of diameter 10·04 ft., both swivelling. Ship controlled from forward part of this car.

Amidships car.—Two 250 h.p. Rolls Royce engines, each driving one four-bladed "Beardmore" airscrew of diameter 11·08 ft.

After car.—One 275 h.p. Rolls Royce engine, driving a two-bladed Farringdon airscrew of diameter 13·54 ft.

Gearing of Airscrews.

Forward gear ratio ...	$\frac{820}{1,600}$
Amidships gear ratio ...	$\frac{1,000}{1,600}$
After gear ratio ...	$\frac{1,024}{1,600}$

Stabilizing Surface.

Vertical Surfaces.	Top fin ...	725 sq. ft.	1,339 sq. ft.
	Bottom fin ...	614 ,,	
	Top rudder ...	240 ,,	450 ,,
	Bottom rudder ...	210 ,,	
	Total ...		1,789 ,,

Horizontal Surfaces.	Fins, 700 sq. ft. each ...	1,400 sq. ft.
	Elevators, 240 sq. ft. each ...	480 ,,
	Total ...	1,880 ,,

TABLE 2.

TURNING TRIALS.

Estimation of Diameter of Turning Circles.

Experiment No.	Angle of Rudders. (Degrees.	Engine Speed. (r.p.m.)	Angular Velocity $\dot{\psi}$ (Radians per sec.)	Approx. Speed V (Ft. per sec.)	Diameter* of Turning Circle. (Feet.)	Turning Coefficient.	Angle of Yaw at C.G. of Airship. (Degs.)
1	12° stbd.	All 1,200	0·0167	57·6	7,700	14·4	—
2	12° port.	Do.	0·0161	57·6	8,000	15·0	—
3	18° stbd.	Do.	0·0200	56·4	6,300	11·8	—
4	18° port.	Do.	0·0181	56·4	6,900	12·9	—
Figures from R. & M. 537.	5° stbd.	All 1,400	—	67·2	15,780	29·5	1·5
	10° stbd.	Do.	—	66·6	9,380	17·5	3·3
	15° stbd.	Do.	—	66·2	6,900	12·9	4·0
	15° port.	Do.	—	64·3	5,075	9·5	3·9

* $2v/\dot{\psi}$.

TABLE 3.

AIRSPEED FOR VARIOUS ENGINE COMBINATIONS.

Expt. No.	Date.	r.p.m. of Engines.				Forward Speed V Ft /sec.	No. of Observations Speed. of	Mean* Speed V Ft /sec.
		Forward. 1.	Stbd. Amids. 2.	Port Amids. 3.	Aft. 4.			
6	Jan. 23	1,400	1,500	1,500	1,500	68·2	15	68·2
7	Jan. 24	1,400	1,400	1,400	1,400	70·0	4	69·0
8	,,	,,	,,	,,	,,	69·6	3	
9	,,	,,	,,	,,	,,	69·0	21	
10	,,	,,	,,	,,	,,	66·4	3	
11	Jan. 24	1,400	1,300	1,300	1,300	65·8	3	64·3
12	,,	,,	,,	,,	,,	64·6	3	
13	,,	,,	,,	,,	,,	64·3	7	
14	,,	,,	,,	,,	,,	63·9	5	
15	Jan. 23	1,300	1,300	0	1,300	58·9	5	58·9
16	,, 24	1,200	1,200	1,200	1,200	58·9	5	58·9
From R. & M. 537.	Apr. 22 1918.	1,550	1,650	1,650	1,600	—	—	76·5
	,,	1,550	1,650	1,650	0	—	—	62·5
	,,	1,550	0	0	0	—	—	39·3

* The mean speed, when several sets of observations for one type of engine combination are available, is calculated as the summed products of speed and number of observations, divided by total number of observations.

Table 4.

EXPLORATION OF PRESSURE DISTRIBUTION AT AFTER AIRSCREW.*

No. of Experiment.	Date and Time of Experiment.	Value of r/D.	Difference of Total Head $(p_1 - p_2)$. Lbs/ft².	Mean Forward Speed V Ft/sec.	Value of $\frac{2\pi}{\rho V^2}\times\frac{r}{D}\times(p_1-p_2)$.	Mean Value of V/nD.	Thrust Coefficient. Full Scale.	Thrust Coefficient at same V/nD (Model).	Remarks.
17	7.48 a.m. (Nov. 20)	0·35	9·18	50·4	3·24	0·229	—	—	Port amids. engine not running.
18	7.49 a.m. (Nov. 20)	0·35	8·90	50·4	3·15	0·221	—	—	
19	7.58 a.m. (Nov. 20)	0·35	8·27	49·1	3·08	0·218	—	—	
20	8.16 a.m. (Nov. 20)	0·35	6·53	42·2	3·30	0·260	—	0·6 (approx.)	
21	8.25 a.m. (Nov. 20)	0·35	6·53	42·2	3·30	0·260	—	,,	
6	9.10 a.m. (Jan. 23)	0·00	—	Mean 68·2	0·000	0·314	0·14	0·385	All engines running as normally.
		0·15	−1·92		−0·154				
		0·15	−1·64?		−0·131?				
		0·22	+3·58		+0·428				
		0·22	3·53		0·422				
		$0·29_5$	2·66		0·425				
		$0·29_5$	2·80		0·446				
		0·35	3·85		0·730				
		0·35	3·85		0·730				
		0·35	3·85		0·730				
		0·37	4·20		0·842				
		0·37	3·69		0·738				
		0·37	4·20		0·842				
		0·44	2·56		0·612				
		0·44	2·41		0·580				
		0·48	1·76		0·468				

* For Notation see text (Appendix).

R.&M. 674.

9.203/127. 4/20. 1275.

EXPERIMENTS ON R. 26.

SCALE DRAWING OF AIRSHIP.

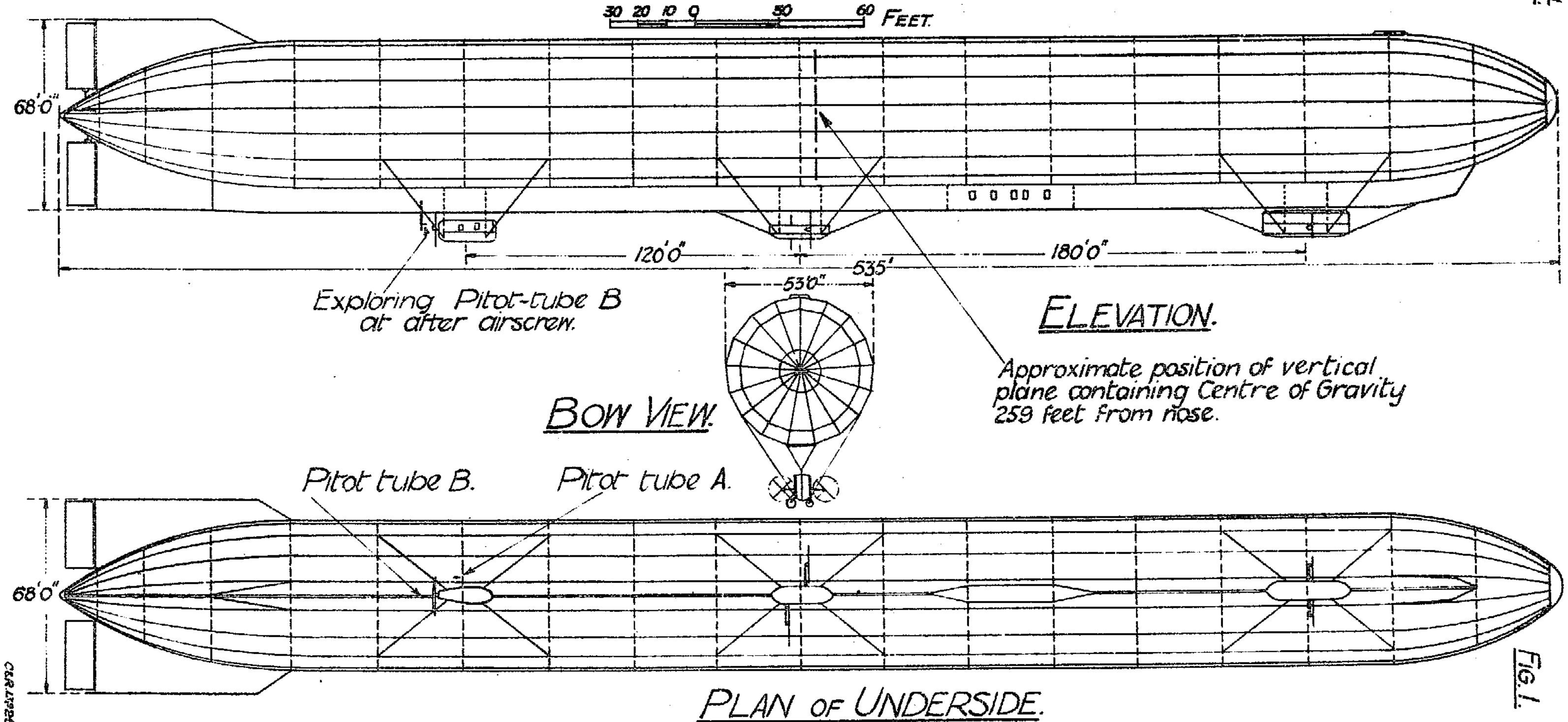

FIG. 1.

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FIG. 2.

EXPERIMENTS ON R. 26.

TURNING TRIALS.

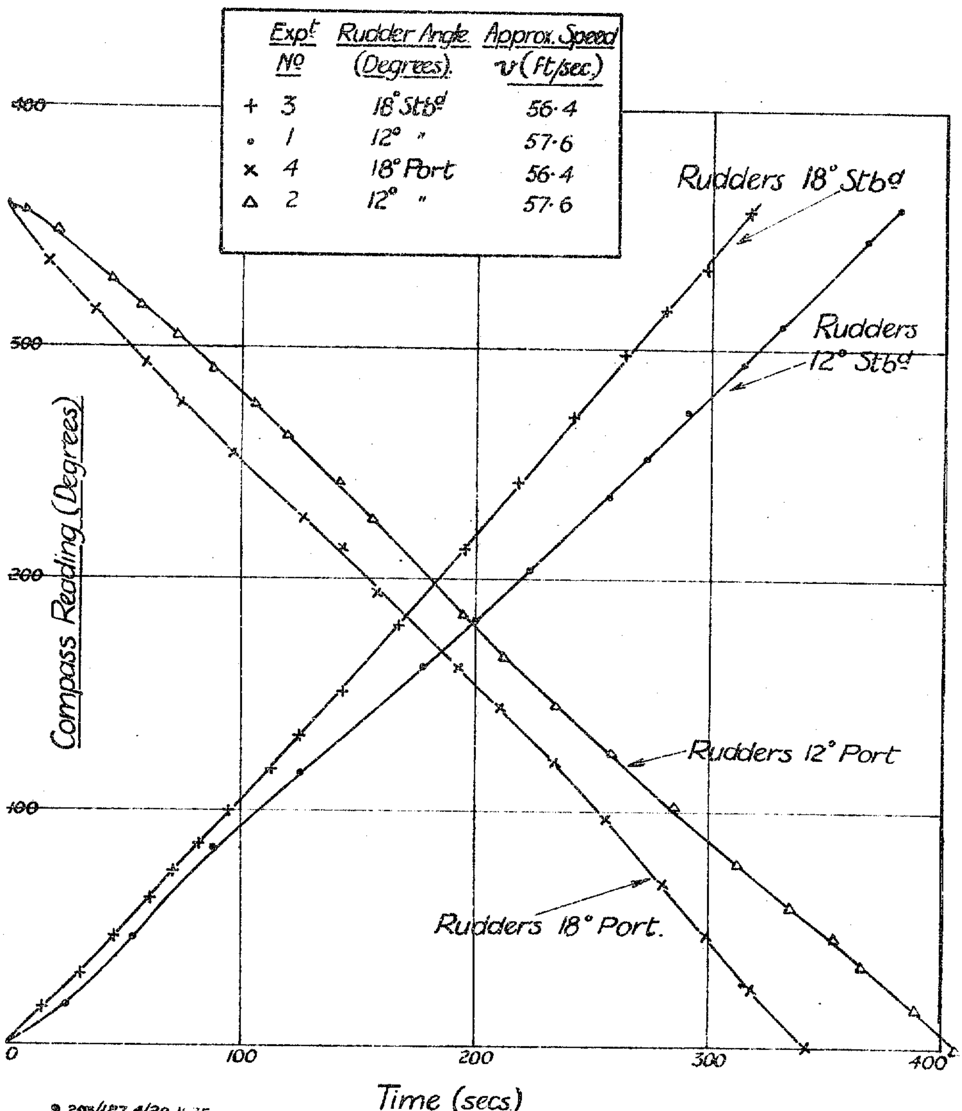
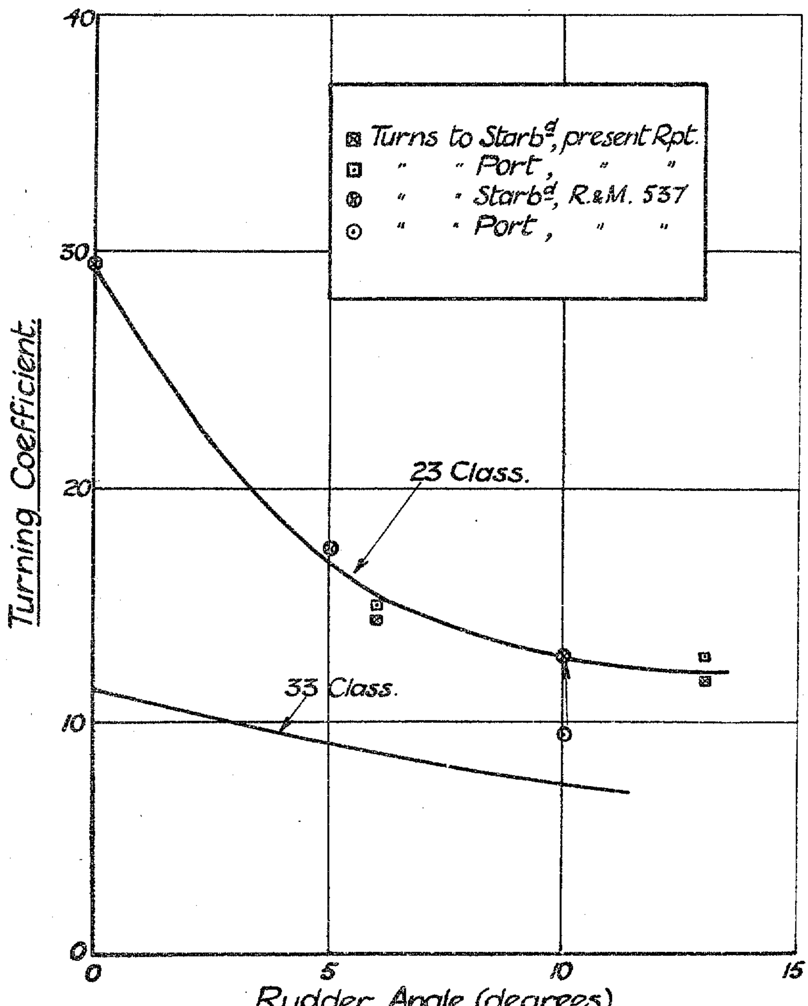


FIG. 3.

EXPERIMENTS ON R.26.

VALUES OF TURNING COEFFICIENT.



5. 203/127. 4/28. 1275.

C&R.Ltd 256.

FIG. 4.

EXPERIMENTS ON R.26.

DECELERATION TESTS.

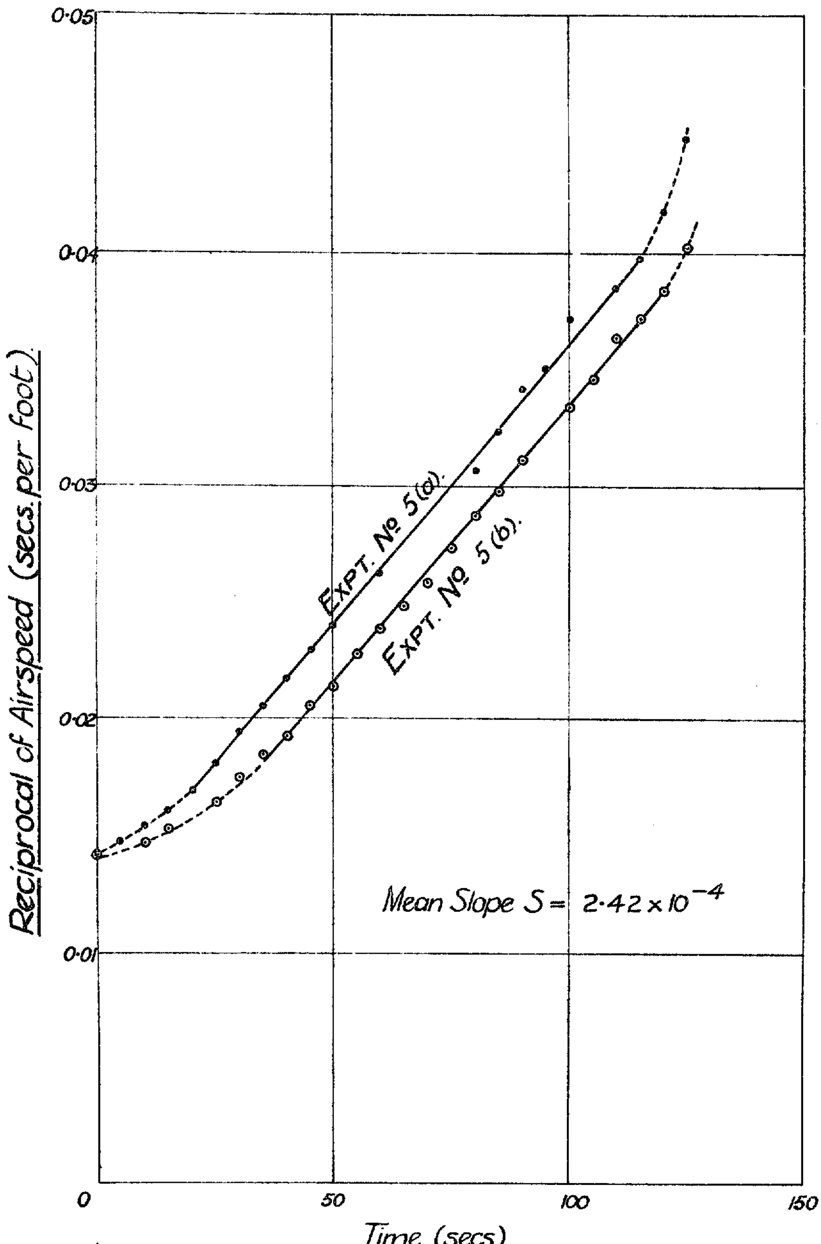


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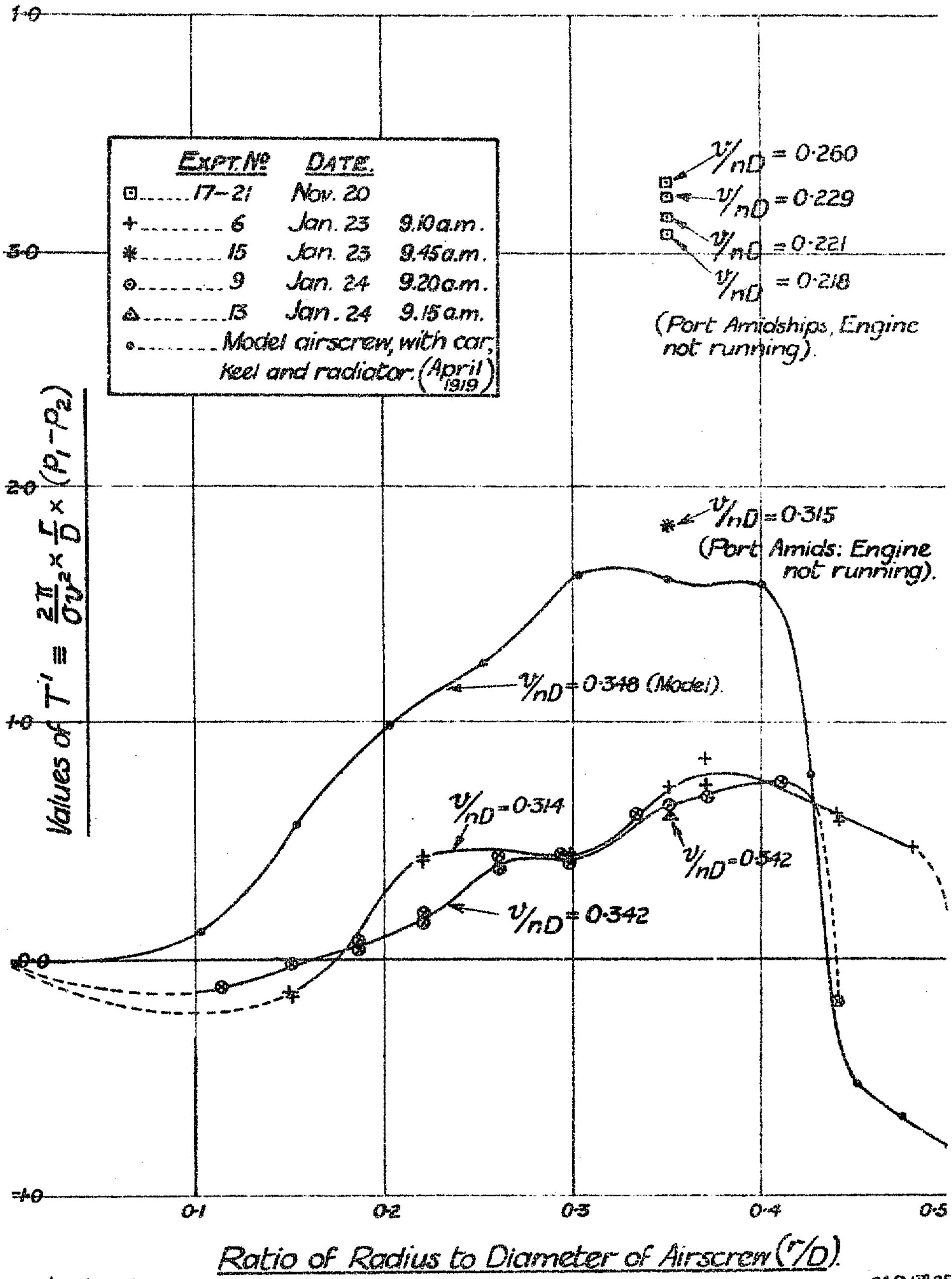
Fig. 5.

Experiments on R. 26.

Thrust Grading Curves (After Farringdon Airscrew).



9/203/127.4/20. 1275.

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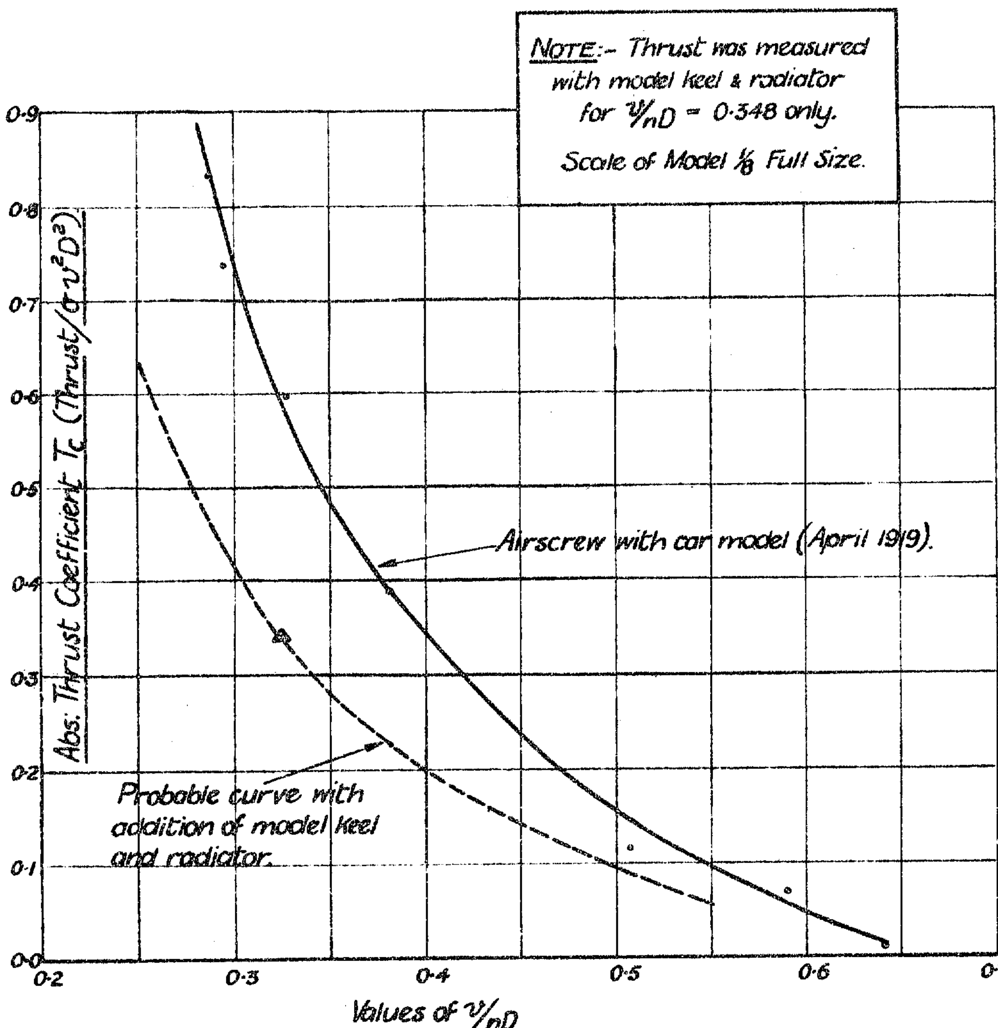
R. & M. 674.

FIG. 6.

EXPERIMENTS ON R. 26.

ABSOLUTE THRUST COEFFICIENT FOR MODEL OF AFTER AIRSCREW.



9.203/187. 9/20. 1275.

C&R. LTD 256

TABLE 4 (*contd.*).

No. of Experiment.	Date and Time of Experiment.	Value of r/D.	Difference of Total Head $(p_1 - p_2)$. Lbs/ft^2.	Mean Forward Speed V Ft/sec.	Value of $\frac{2\pi}{\rho V^2} \times \frac{r}{D} \times (p_1 - p_2)$.	Mean Value of V/nD.	Thrust Coefficient. Full Scale.	Thrust Coefficient. at same V/nD Model.	Remarks.
15	9.45 a.m. (Jan. 23)	0·35	8·08 7·86 7·04 6·64 6·64 Mean 7·25	58·6 58·6 59·1 59·1 59·2 Mean 58·9	Mean 1·83	0·315	—	0·385	Port amids. engine not running.
13	9.15 a.m. (Jan. 24)	0·35	3·22 2·41 2·67 2·93 3·22 2·98 2·93 Mean 2·91	65·3 63·8 62·9 64·0 63·3 65·3 65·3 Mean 64·3	Mean 0·615	0·342	—	0·345	All engines running as normally.
9	9.20 a.m. (Jan. 24)	0·00 0·11 0·15 0·15 0·18$_5$ 0·18$_5$ 0·18$_5$ 0·22 0·22	— −2·00 −0·16 −0·16 +0·83 0·48 0·83 1·76 1·36	69·0	0·000 −0·109 −0·012 −0·012 +0·079 0·045 0·079 0·198 0·157	0·342	—	0·345	All engines running as normally.

TABLE 4 (*contd.*).

No. of Experiment.	Date and Time of Experiment.	Value of r/D.	Difference of Total Head $(p_1 - p_2)$. Lbs/ft².	Mean Forward Speed V Ft/sec.	Value of $\frac{2\pi}{\rho V^2} \times \frac{r}{D} \times (p_1 - p_2)$.	Mean Value of V/nD.	Thrust Coefficient. Full Scale.	Thrust Coefficient at same V/nD Model.	Remarks.
9	9.20 a.m. (Jan. 24)	0·26	2·87	69·0	0·385	0·342	—	0·345	All engines running as normally.
		0·26	3·22		0·346				
		$0{\cdot}29_5$	2·89		0·439				
		$0{\cdot}29_5$	2·68		0·408				
		0·33	3·52		0·614				
		0·33	3·52		0·614				
		0·35	3·52		0·653				
		0·37	3·52		0·689				
		0·41	3·52		0·751				
		0·44	−0·82		−0·187				

TABLE 5.

PRESSURE DISTRIBUTION AT AMIDSHIPS AND FORWARD AIRSCREW.

Value of r/D was chosen 0·35 in each case.

No. of Experi-ment.	Date and Time of Experi-ment.	Particulars of Airscrew.	Difference of Total Head $(p_1 - p_2)$. Lbs/ft².	Forward Speed V Ft/sec.	Value of $\frac{2\pi}{\rho V^2} \times \frac{r}{D} \times (p_1 - p_2)$.	Mean Value of V/nD.
12	Jan. 24	Stbd. amids. ...	8·19	Mean	Mean	0·430
		Do. ...	7·98	64·6	1·70	
		Do. ...	8·08			
12		Port. amids. ...	6·81	Mean	Mean	0·430
		Do. ...	6·81	64·6	1·42	
		Do. ...	6·61			
10		Stbd. amids. ...	9·57	Mean	Mean	0·412
		Do. ...	9·81	66·4	1·93	
		Do. ...	9·62			
10		Port amids. ...	8·79	Mean	Mean	0·412
		Do. ...	8·60	66·4	1·74	
		Do. ...	8·79			
14		Stbd. forward ...	1·36	Mean	Mean	0·530
		Do. ...	0·99	63·9	0·24	
		Do. ...	1·07			
		Do. ...	0·99			
14		Port forward ...	4·12	Mean	Mean	0·530
		Do. ...	4·56	63·9	0·89	
		Do. ...	4·26			
		Do. ...	4·12			
		Do. ...	4·68			
8		Stbd. forward ...	2·18	Mean	Mean	0·580
		Do. ...	2·18	69·6	0·40	
		Do. ...	2·18			
8		Port forward ...	4·26	Mean	Mean	0·580
		Do. ...	4·48	69·6	0·80	
		Do. ...	4·48			