PRELIMINARY EXPERIMENTS ON NON-RIGID AIRSHIP "S.S.E.3 100,000," WITH A CONSIDERATION OF THE PERFORMANCE DATA OF VARIOUS TYPES OF S.S. AIRSHIP.

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Reports and Memoranda No. 693. *March*, 1920.

SUMMARY.—(a) *Introductory.* (*Reasons for Inquiry.*)—The experiments were carried out during a visit to Pulham Air Station when the trials of R.32 were temporarily interrupted. Other reports dealing with full-scale airship experiments are R. & M. 537, R. & M. 674, R. & M. 668 and R. & M. 675. A comparison is made between various ships of the S.S. type.

(b) *Range of the Investigation.*—The following experiments were carried out :—

Section (i).—Turning trials with rudders hard over ; course with rudders approximately amidships.

Section (ii).—Deceleration Trials. This section also includes a comparison between S.S.Z., S.S.E.3 90,000, S.S.T.14 and S.S.E.3 100,000.

Section (iii).—Airspeed for various engine combinations.

(c) *Discussion of the Results.*—Section (i).—With the rudder hard over the diameter of the turning circle is 615 ft. at 40 ft/sec. and 660 ft. at 25 ft/sec. ; the minimum turning coefficient is 3·7. For rudders amidships the maximum turning coefficient was 17, but this could probably be increased by the use of another rudder angle. After turning under full helm the angular motion of the ship can be stopped in two seconds.

Section (ii).—The mean resistance coefficient deduced from the first three experiments is 0·0245 ; but this value is probably too low. The later experiments shew marked change of the coefficient, which is thought to be due to unsatisfactory conditions.

The resistance coefficients for various S.S. ships has been calculated from their performance data. The figures shew that the saving due to the use of an envelope of the form of model U.721 is within 10 per cent. of what might have been expected from the rather inadequate information available from models, after making allowance for the fall of the resistance coefficient which may be expected for the S.S. envelope model on increase in the value of Vl.

The advantage due to envelope form " U.721 " is calculated from wind channel data as 15½ per cent. ; from the performance data the advantage is found to be less by the amounts stated.

Section (iii).—Airspeed is given for various rotational speeds of one or two engines. The highest average speed is 82 ft/sec. The airspeed is approximately proportional to the engine speed minus a constant.

(d) *Applications and Further Developments.*—These experiments are of a very incomplete nature, and if accurate information of the performance of this ship is required further trials will be necessary.

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The experiments described in this report were carried out at Pulham Air Station on October 18th and 21st, 1919, during visits for the purpose of carrying out flights in R.32. The experiments on " S.S.E.3 100,000 " were carried out on two occasions when it was not possible to fly in R.32. " S.S.E.3 100,000 " is a twin-engined non-rigid airship, whose car and power units are similar to those of an earlier ship known as E.3, but whose envelope is of the form referred to later as type " U.721."

The only apparatus employed was the ship's compass and a pressure tube anemometer with a flying head, for the turning trials ; and a cinematograph camera mounted on a stand with the indicator of the anemometer and a stop watch, for deceleration. The anemometer has been fully described in R. & M. 675.

The method of reduction of the results has also been described in R. & M. 675, and it will here suffice to say that the turning coefficients* for various positions of the rudder have been calculated from the slopes of the curves in Fig. 3 and the mean speed.

It may be convenient to recapitulate the method employed for calculating the resistance coefficient C from the curves of Fig. 6. Over the range where the resistance varies as the square of

* Equal to the diameter of the turning circle, divided by the length of the ship.

the speed, the reciprocal of the speed plotted on a time base will give a straight line, the slope of which is equal to $dV/dt \times l/V^2$. Neglecting the effect of acceleration on the resistance, we may write

$$T - R = M\frac{dv}{dt} \quad . \quad . \quad . \quad . \quad (1)$$

where T is the thrust, R the resistance, M the mass, V the speed and t the time. During a deceleration trial $T = 0$, and the resistance coefficient C will be equal to

$$-M\frac{dV}{dt} \times \frac{1}{V^2} \times \frac{1}{\rho l^2} \quad . \quad . \quad . \quad . \quad (2)$$

where ρ is the current density of the air, and l the cube root of the volume of the airship. Calling the slope of the $1/v$ — time curve (see Fig. 6) S equation (2), may be written.

$$C = -MS \times \frac{1}{\rho l^2} \quad . \quad . \quad . \quad . \quad (3)$$

But since the airship is in equilibrium

$$M = \rho l^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

So that (3) becomes

$$C = Sl \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

In the deceleration trials on the first flight observations were taken visually; in those of the second flight the cinematograph camera was employed.

The angle of the rudders when the helm was hard over to port was measured in the shed after the experiments, by Flight-Lieut. R. A. Cochrane. It was found to be 38° when a force was applied to the rudder to represent the air pressure.

The nominal volume of the envelope was 100,000 cu. ft., but in view of the increase in volume which usually takes place, due to stretch of the fabric, an attempt has been made to determine the volume at the time of the experiments. The overall length of the envelope was measured by Flight Lieut. Cochrane after the experiments, and a photograph giving a side view was taken on the day of the experiments; end views of the envelope were also taken in the shed, and used to estimate the mean diameter of the envelope, the cross-section of which is not circular in form.

DISCUSSION OF THE RESULTS.

Turning Trials, Section (i).—*Full Helm.*—The compass readings for these experiments are plotted on a time base in Fig. 3; the slopes of the lines and the turning coefficients deduced from them are given in Table 2. The high speed curve in Fig. 3 shews to a marked degree the sinuous form which has been noticed in previous compass observations during turning; the same effect is noticeable to a lesser degree in the turns at lower speed. In the present experiments several complete turns were made during each trial, so that the accuracy in determining the slope is not appreciably less than if the observations lay on a straight line.

The turning coefficients deduced from the slopes of these lines are given in Table 3 and are plotted in Fig. 4 on a speed base. The variation of the turning coefficient with speed is 7 per cent. for a speed range of 1·6 to 1 ; but the coefficient falls with increase of speed, which effect is opposite to that observed on R.33. This result is possibly due to heeling of the main plane under the forces which act on it during rapid turns at high speed.

Helm Amidships.—Experiments with the rudders amidships are rendered difficult by the general flexibility of the ship, unless special apparatus be employed. It was not possible in the preliminary trials now described to fit any device for holding the rudders at a given angle to the fixed fin, so that, due to slackness in the rudder lines and absence of a rudder angle indicator, the rudders were not always accurately amidships. The deviation could be observed by looking from the car along the fixed fin ; this uncertainty, therefore, limits the accuracy of the observations. Further, both airscrews rotate in the same direction, and this has been frequently found to necessitate setting the fixed plane at an angle to the axis of the ship in order to avoid constant use of the rudders on one side of amidships. Accurate determination of the turning coefficients would necessitate turns both to port and starboard, and in experiments to determine the *maximum* turning coefficient it would be necessary to employ in turn a number of rudder angles of small magnitude.

Three trials with the rudder approximately amidships were carried out at speeds of 40, 42 and 54 ft/sec. The results shew a marked speed effect in the same direction as observed on R.33, viz., a higher coefficient (possibly corresponding with reduced instability) as the speed increases. The turning coefficient changes by as much as 37 per cent. for a speed range of 1·4 to 1.

The maximum turning coefficient observed is less than 17, which is near the value deduced for R.33 at 60 ft/sec. (R. & M. 668) ; but on R.33 this value became practically infinite at 87 ft/sec. S.S.E.3 appeared to have a distinct preference for turning to starboard (*see* Expt. No. 7, Fig. 5, in which the direction changed from port to starboard) and it is probable that had the rudder been fixed slightly to port a larger coefficient would have been obtained.

It should be noted that the experimental data upon which the foregoing suggestions are based are very meagre.

In concluding this section of the report it may be of interest to record some measurements of controllability carried out at the suggestion of Flight Lieut. R. A. Cochrane.

After securing a sufficient number of observations with the rudders hard over (38°) to port to define the rate of turn, the rudders were changed hard over to starboard. An observer with a watch noted the time when the lower rudder passed through the amidships position, and again when the airship was in the act of changing its direction of turn from port to starboard. Observations of this type were carried out at four speeds ranging from 25 to 40 ft./sec., and the time interval between rudders amidships and change in the direction of turn varied between one and two seconds.

A further tribute to the controllability of this ship is contained in the statement by Captain S. E. Taylor that, during the speed trials of October 21st, he was able to manipulate the helm so as to prevent changes in the compass reading greater than about one degree.

Resistance. Section (ii).—*Deceleration.*—The observations of deceleration are plotted in Fig. 6, and the resulting slopes are given in Table 3. It was anticipated that it would be much more difficult to secure steady conditions on a non-rigid airship than on one of the rigid type, and this difficulty is probably in part responsible for the unusual features exhibited by the values plotted in Fig. 6.

Expts. 8, 9 and 10 were carried out during the flight on October 18th, the Ogilvie indicator being observed visually. Straight lines representing the estimated mean slopes have been drawn, and though the points deviate from these lines the departure does not appear to be systematic. The mean of the coefficients calculated from these three lines is 0·0246, from which value the maximum difference is slightly more than 1 per cent.

On October 21st, the deceleration trials were repeated (Expts. 11, 12 and 13), a cinematograph camera being employed for observing the airspeed indicator. Reference to Fig. 6 shews that these curves are all concave upwards throughout their whole range, though a straight line has been drawn to indicate the average slope over the early portion of the curve. Owing to lack of sufficient observers* a full record of angle of inclination, elevator angle, and height was not secured during the trials ; but from approximate observations it was found that the angle of pitch in Expt. 11 amounted to 10° during a part of the experiment, so that this trial may be regarded as less accurate than Nos. 12 and 13, and it will be neglected in the considerations which follow.

The resistance coefficients calculated from the average slopes during the early parts of Expts. 12 and 13 are respectively 0·0306 and 0·0269, giving a mean value of 0·0287. This later figure is 1·17 times the mean value for Expts. 8, 9 and 10. It should be

* Of the five persons carried, three were required to navigate the ship, and a fourth was a wireless operator ; the fifth only was *quite* free for observing.

noted that the airscrews were at rest in Expts. 11, 12 and 13; but in Expts. 8, 9 and 10 the engines were "ticking round." The rotational speed of the screw under this condition would probably be about 300 r.p.m.

From an approximate calculation based on experiments with models the difference between the resistance of the airscrew rotating slowly and at rest should be small, at least during the early portion of a trial; but the difference in the character of the two curves for the two days is suggestive.

With regard to the concave form of the curves, it has been pointed out by Flight Lieut. F. M. Rope that this effect might be expected if the airship was not in equilibrium or was statically out of trim, since as the speed fell a greater angle of pitch would be required to maintain a constant height, or if the axis of the ship was horizontal the path would become inclined and the airship, therefore, inclined in pitch. The author was not, however, during the flight aware of any marked departure from steady conditions. The same tendency would be manifest as the result of placing the elevators at increasing angles as the speed fell.

That the results of Expts. 12 and 13 are spurious seems highly probable, since the coefficients calculated from the average slopes of the upper portions of the curves is about 0·045, and it is difficult to believe that scale effect can account for so much change, especially as at the highest value of Vl in experiments on a model of the hull (about 0·08 of the Vl of the ship at 20 ft/sec.), the resistance coefficient was practically constant.

A possible source of error, which is being investigated, lies in the lag of the anemometer. Observations have been made on the damping in the tubes employed; but the conditions appear to be complicated and experiments are being carried out with a view to constructing an anemometer in which the lag will be negligible. If accurate data of the performance of this airship are required it is essential that further experiments of a more complete character be carried out.

Comparison of Performance of various "S.S." Airships.—The form of envelope employed on the present S.S.E.3* was designed in the course of a series of experiments on models R. & M. 607, and is intended to be identical in form with model U.721. The resistance coefficient of this model was lower than that of any other model examined, and the position of the maximum ordinate offered certain advantages in rigging the car, over that of the original form of S.S. envelope. Its chief disadvantage is that owing to the reduced distance between the centre of gravity of the ship and the fins, the moment due to unit area of the latter is less. Though complete data is not available from experiments on models, an approximate estimate may be made of the relative

* The name is the same as that of an earlier ship, which had an "S.S.Z. 90,000" envelope.

resistances of S.S.E.3 100,000, and airships with the original form of S.S. envelope.

At the highest value of Vl obtained in the wind channel the resistance coefficient for a model of the "S.S.Z." envelope is 0·0130; but since the value is falling rapidly it may be assumed that C for the full-scale value of Vl will probably be as low as 0·01 or less (*see* R. & M. 607); the value of C for model U.721 at the highest value of Vl (75 ft^2/sec.) is approximately constant at 0·0069. Since there is no evidence as to the variation of the coefficient for the latter model at values of Vl higher than 75 ft^2/sec., this value (0·0069) must be employed for estimating full-scale performance. The resistance of the "S.S.Z." envelope on full scale is, therefore, assumed to be 1·45 times that of the "721" envelope for the same volume.

In experiments on a model of "S.S.Z." (R. & M. 457) the envelope was found to be responsible for 35 per cent. of the total resistance, so that, assuming this proportion on full scale (though it may well be lower), changing the "S.S.Z. 90,000" envelope of airship No. 2 (Table 4, page 244) for an envelope of the "721" form, should result in a reduction of the resistance coefficient for the ship of about 15½ per cent.

An impression appears to exist in British and American airship circles that in practice the use of an envelope of the form of "U.721" in place of the original envelope did not, other things being equal, produce a faster ship. In order to make possible a comparison of the various types of S.S. airship, information as to the performance data of these ships was supplied, at the author's request, by the Director of Research.

In this connection the writer wishes to tender his thanks to Flight Lieut. Rope for his assistance and for supplying practically all the data given in Table 4. The various quantities employed in the calculation are derived as follows :—

(*a*) *Volume.* Nos. 1, 2 and 3 (Flight Lieut. Rope) by volume of gas required to fill the envelope; No. 1 is the more accurate, as it is the mean of the values for many envelopes. No. 4 (N.P.L.) estimated from photographs, and an actual measurement of length taken at the time of the present experiments; the non-circular form of the cross-section was taken into account.

(*b*) *Power.* (Flight Lieut. Rope.) Nos. 1 and 3, Dyak engines; from bench tests of the actual units fitted on the ship; accuracy about ± 3 per cent. Nos. 2 and 4, Hawk engines; mean values for the type; accuracy about ± 5 per cent.

(*c*) *Speed,* by flying head and specially calibrated Ogilvie indicator. Nos. 1, 2 and 3 (Flight Lieut. Rope). The first is a mean value from results for many ships ; the results for Nos. 2 and 3 are deduced from several observations, all of which were taken on one ship only. No. 4 (N.P.L.) from present experiments. Accuracy of measurement is probably about ± 1 per cent. ; but changes in the attitude of the ship may reduce the speed.

(*d*) *Airscrew Efficiency*. (Flight Lieut. Rope.) Taken as equal to that of a blade element at 0·7 maximum radius, taking account of advance per revolution and inflow velocity.

Perhaps the most striking feature of the resistance coefficients deduced from the foregoing figures (given in Table 4) is the low value obtained for "S.S.Z." (No. 1) as compared with that for "S.S.E.3 90,000" (No. 2), viz., 0·018 and 0·025 respectively. The chief points of difference between airships No. 1 and No. 2 are :—

(1) No. 2 has two engines instead of one, and the resistance of the supporting structure will consequently be *higher*.*

(2) The car of No. 2 has a larger cross-sectional area than that of No. 1 and the personnel sit abreast instead of in line ; but the car of No. 2 has a form which should give a lower resistance coefficient so that its actual resistance is unlikely to differ widely from that of No. 1.*

From these considerations values of the same order might be expected for the resistance coefficients of the two ships ; but the coefficient for No. 2 is given as 1·4 times that for No. 1. None of the quantities upon which the calculations are based appear to be liable to sufficient uncertainty to account for the difference.

Experiments on a model of "S.S.Z." (R. & M. 457) give a value of the resistance at 40 ft/sec. corresponding to a coefficient of about 0·04. Observations are only available at one speed ; but the resistance coefficient will probably fall with increase of scale and speed, so that, since the full scale Vl is about 50 times that on the model, an accurate prediction of the resistance of the actual ship cannot be made from these wind channel experiments.

Airships "S.S.E.3 90,000"† (No. 2) and "S.S.T.14" (No. 3) differ mainly in the car and envelope.

(1) The cars are of similar form, but No. 3 is much larger (1·25 times) cross-sectional area, and consequently *higher* resistance, than No. 2.

(2) The envelope of No. 3 is of the "721" form, which, judging from experiments on models, should have a *lower* resistance.

* *Note*.—Possible increases of resistance under these heads are reduced in the coefficient by the larger volume of the envelope of No. 2.

† Airships Nos. 2 and 4 are both known as S.S.E.3.

TABLE 4. (See Fig. 2.)

PARTICULARS OF VARIOUS S.S. AIRSHIPS.

No.	Name of Ship.	Envelope. Type.	Envelope. Vol. (cu. ft.).	Car, Approximate Dimensions (feet).	No. of Fins and Area (sq. ft.).	Power Plant. Type.	Power Plant. Power.	Rotational Speed (r.p.m.).	Speed (f/s.).	Air-screw Efficiency.	Thrust (lbs.).	Resistance Coefft.
1	S.S.Z.	"70,000"‡ Lgth/diam. 4·7.	71,000	Zero 2·7 × 4·3 × 17·3.	3 1 Vert. 225 2 Hor. 288 Total 513	Rolls Royce, "Hawk."	One of 82 h.p. (± 5%).	1,350	72·6	0·62	385	0·0179
2	S.S.E.3*	"90,000." Similar in form to "70,000."	95,000	Original E.3, 4·6 × 4·6 × 21·6.	3 1 Vert. 225 2 Hor. 322 Total 547	Sunbeam, "Dyak." (Same engines as on No. 4.)	Two of 114 h.p. (± 3%).	1,340	87·9	0·67	956	0·0251
3	S.S.T.14	"100,000" (U.721), Lgth/diam. 4·6.	109,000†	Extra large E.3 type, 5·1 × 5·1 × 24.	3 1 Vert. 275 2 Hor. 300 Total 575	Rolls Royce, "Hawk."	Two of 85 h.p. (± 5%).	1,400	77·6	0·64	770	0·0237
4	S.S.E.3*	"100,000" (U.721). Lgth/diam. 4·6.	111,000†	Original E.3. As No. 2.	4 2 Vert. 300 2 Hor. 300 Total 600	Sunbeam, "Dyak." (Same engines as on No. 2.)	Two of 111 h.p. (± 3%).	1,300	82	0·65	972	0·0265

* Both airships known as S.S.E.3.

† Two different envelopes nominally of the same form.

‡ The nominal volume of an envelope is often used to designate that particular form.

The resistance coefficient for No. 3 is only 0·94 that of No. 2, so that the use of envelope " 721 " appears to have reduced the coefficient for the ship by 6 per cent. *plus* the amount due to the difference between the large and small cars. This difference compares with an approximate estimate from experiments on models (*see* p. 242) of 15½ per cent.

Coming to airship " S.S.E.3 100,000 "* (No. 4 of Table 4) upon which the present experiments were carried out, comparison with the other airships is rendered difficult by the fact that No. 4 has an upper fin and rudder in addition to those on Nos. 1, 2 and 3.

The best evidence as to the resistance due to the additional fin appears to be contained in R. & M. 457, where it is stated that the removal from a model of " S.S.Z." of a pair of elevator planes (the type employed for all the planes of S.S.E.3) caused a reduction of resistance equal to 0·18 times that of the fully rigged model, or for one elevator 0·09 times.

In considering the application of this result to the similar fin on airship " S.S.E.3 100,000 " it appears that, owing to the large scale effect on wires of small diameter at wind channel speeds, the proportion of the resistance due to the fin will be less than the amount given in R. & M. 457 ; but if the envelope of No. 4 has a lower resistance coefficient than that of No. 2 the fin resistance will be relatively more important. These two effects appear to be the ones of greatest importance, and since they produce opposite effects it may be hoped that the value given in R. & M. 457 may be applied to full scale without serious error.

Assuming, then, in the absence of more precise information, that the results obtained on a model of " S.S.Z." may be used for estimating the resistance of the upper stabilizing surface on " S.S.E.3 100,000," this quantity is found to be 9 per cent. of the fully rigged ship.

Reference to Table 4 shews that the two " S.S.E.3 " airships, Nos. 2 and 4, differ only in the envelope and in the presence of an upper vertical fin on the latter ship. The increase of resistance due to the additional fin has just been estimated as 9 per cent., while the reduction which might be expected due to use of an envelope of the " 721 " form in place of the " S.S.Z. 90,000 " cu. ft. envelope has been shewn to be 15½ per cent. The resistance coefficient of airship No. 4 should therefore be 6½ per cent. lower than that of No. 2. Reference to Table 4 shews that the resistance coefficient of airship No. 4, calculated from the full-scale performance, is 5 per cent. higher than that for airship No. 2.

To sum up, therefore, it may be said that the resistance coefficients of airships " S.S.E.3 100,000 " and " S.S.E.3 90,000," as determined from performance data, are, within 12 per cent., related in a manner which might have been predicted from data available from models.

* Airships Nos. 2 and 4 are both known as " S.S.E.3."

In view of the uncertainty on the various full-scale quantities, and the possible magnitude of the correction in passing from model to full scale, the accuracy of this agreement is as good as could be expected.

It may be urged that the necessity for fitting the fourth fin, which causes the increase of resistance, arises from the use of the "721" form envelope; but it should be noted that airship No. 4 is markedly more controllable, and probably less unstable, than Nos. 1, 2 or 3. Several experienced pilots are of the opinion that "S.S.T.14," which had an envelope of the "721" form and 3 fins only, was no more difficult to control than "S.S.Z." A patrol flight of 52 hours' duration was made in "S.S.T.14" by Captain G. F. Meager and Captain S. E. Taylor, and it may be assumed that this would not have been possible had the navigation of this ship entailed more than the ordinary degree of fatigue.

From the foregoing discussion it appears evident that no accurate comparison can be made without suitable full-scale experiments, and it is urged that, if possible, an airship with an envelope of the "S.S. 60,000," or "S.S.Z.," form should be secured for comparison with "S.S.E.3 100,000."

It is unfortunate that accurate information has not been obtained as to the performance of each of these types of airship. There is a tendency to regard as useless, airships which are obsolete from the point of view of service requirements; but unless the performance of such ships is recorded there is the risk of losing the valuable experience which is to be gained from comparison of different types.

Airspeed for Various Combinations of Power Units. Section (iii).—Observations of speed are given in Table 5, and plotted on a base of rotational speed of the engine in Fig. 7. It will be noticed that the continuation of a straight line through the points does not pass through the origin, as it should if the speed were throughout proportional to the rotational speed of the engines, but cuts the axis of engine speed. Two causes suggest themselves in explanation of this behaviour—(1) the resistance does not vary as the square of the speed, or (2) the ship may not be statically in equilibrium or in trim, or (3) both causes may operate.

The small number of observations in the present experiments precludes the possibility of any definite conclusions being based upon them. Flight Lieut. Rope has a number of similar observations taken on several airships of the C star class, and except in one case a line through any of these sets of points cuts the base line; but the range of speed in these experiments is less than two to one, so that no accurate deductions can be drawn from them.

There appears to be little hope of determining the change in the resistance coefficient from the evidence at present available, but it should be possible to carry out experiments in which the ship is in trim, over a range of speed of approximately three to one. Such evidence would afford information as to the change in the resistance coefficient, which would be valuable for comparison with the results of deceleration trials.

In conclusion the author wishes to tender his thanks to Captain R. A. Cochrane, who arranged the flights, and acted as pilot on both occasions ; Captain S. E. Taylor rendered valuable assistance in taking observations on each flight. The writer is also indebted to Mr. A. H. Bell for assistance in reducing the observations.

TABLE 1. (See Fig. 1.)

PARTICULARS OF "S.S.E.3 100,000."

Displacement of hull. (Nominal 100,000 cu. ft.) ...	111,000 cu. ft.
Overall length...	167 ft.
Maximum diameter	37 ft.
Power plant :—Two, Sunbeam "Dyak" engines of 100 h.p. (rated).	
Airscrews :—Two, Coventry Pope. Left-handed. Diameter, 8 ft. 2 ins.	
Stabilizing surfaces :—Four similar fixed fins and four similar control surfaces.	
Total fixed vertical or horizontal area, about	330 sq. ft.
Total movable vertical or horizontal area, about	70 sq. ft.

Deduced from Present Experiments.

Maximum speed	82 ft/sec.
Minimum diameter of turning circle (to port), at 40 ft/sec.	615 ft.
Minimum turning coefficient at 40 *ft/sec.*	3·7

TABLE 2. (See Figs. 3, 4 and 5.)

EXPERIMENTS ON S.S.E.3. TURNING TRIALS.

Calculation of Turning Coefficient, &c.

Expt. No.	Time. Hr.	Time. min.	Rudder Angles.	Engines (r.p.m.).	Mean Speed V (ft/sec.).	Rate of Turn. Deg/min.	Rate of Turn. Rad/sec.	Diameter of Turning Circle (ft.).	Turning Coefficient.	Mean Inclination (degrees).
	(Oct. 11th).									
1	15	23	38° port	Both 1,000	39·7	443·6	0·129	615	3·68	—
2	15	16	,, ...	,, 900	35·2	389·2	0·113	621	3·72	—
3	15	10	,, ...	,, 700	28·4	305·0	0·0887	640	3·83	—
4	15	31	,, ...	,, 600	24·8	259·0	0·0754	660	3·95	—
	(Oct. 18th).									
5	11	28	Amidships (approx.)	,, 900	54·1	133·0	0·0387	2,800	16·75	+ 1·1
6	11	06	,, ,, ...	,, 700	41·7	130·2	0·0379	2,200	13·18	+ 2·0
7	11	17	,, ,, ...	,, 700	39·8	144·0	0·0419	1,900	11·38	+ 1·9

Fig. 1.

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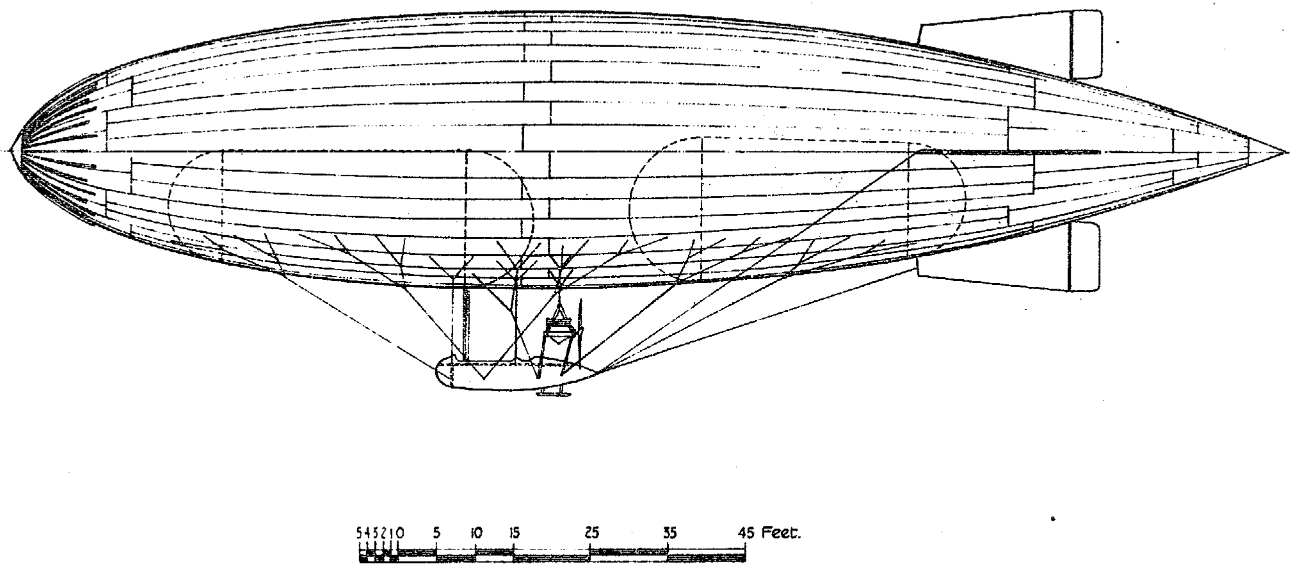
General Arrangement of S. S. E.3 – 100,000.



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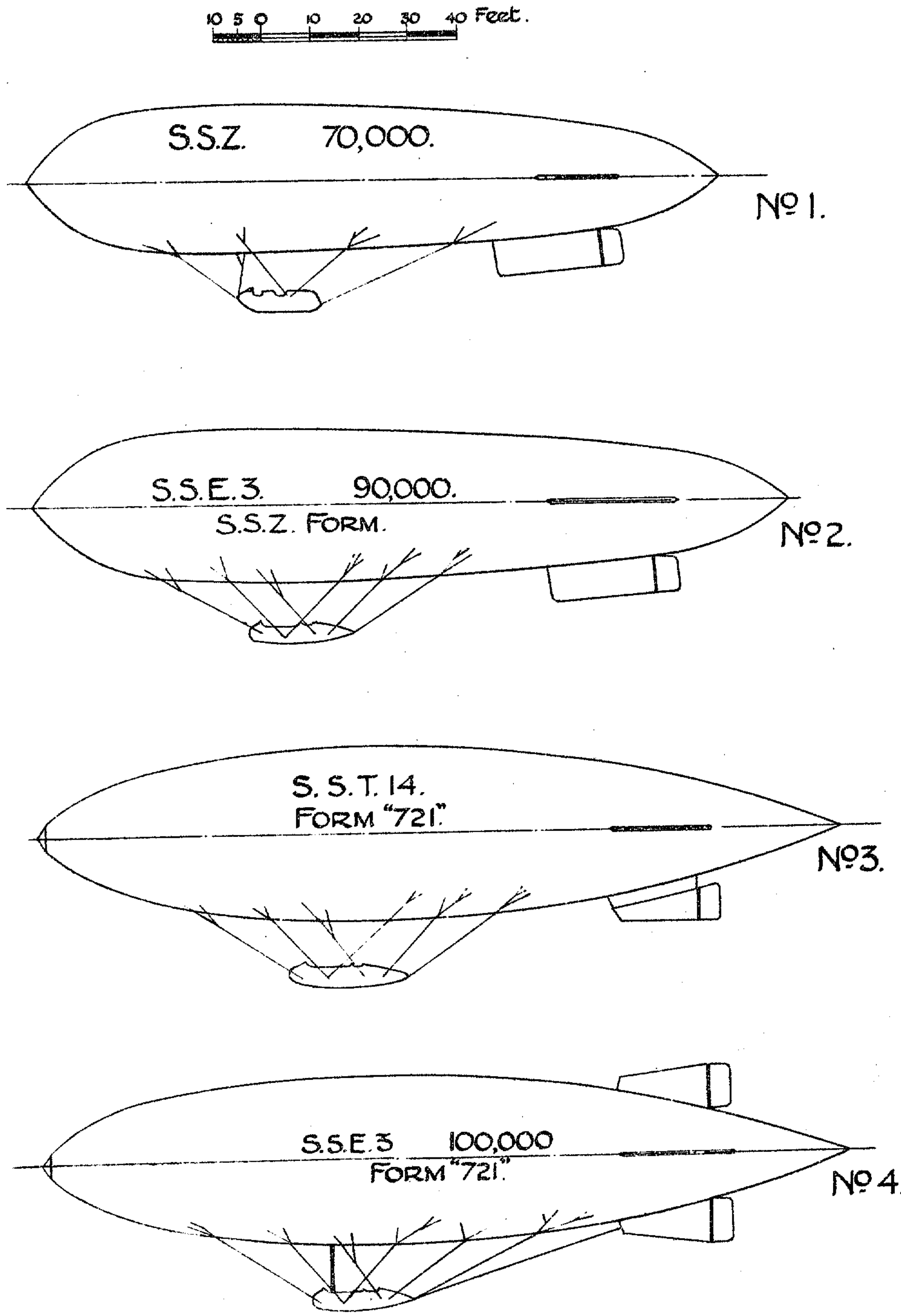
Types of S. S. Airship

Fig. 2.
See Table 4.

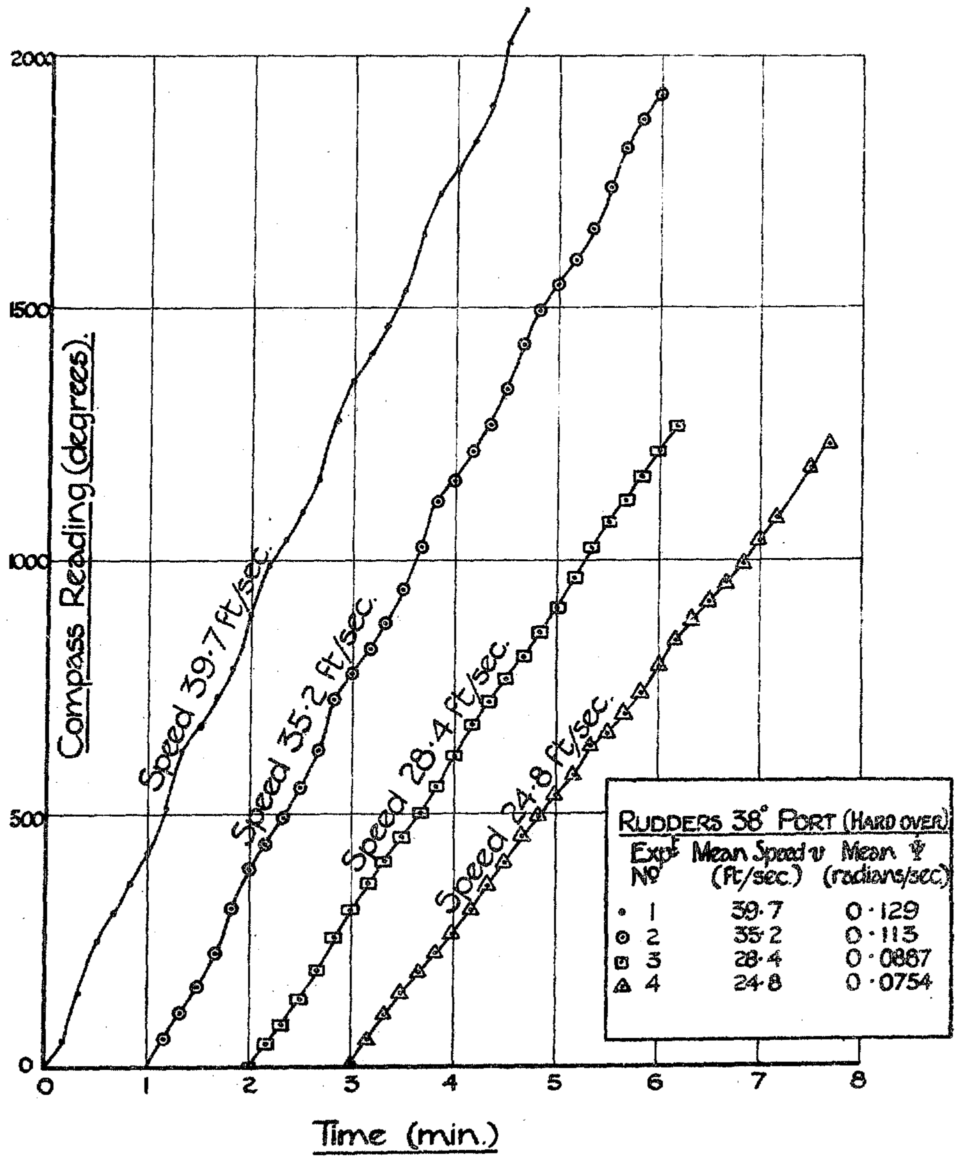


Report Nº 693. Fig. 3.

Experiments on Airship S.S.E.3.

Turning Trials.

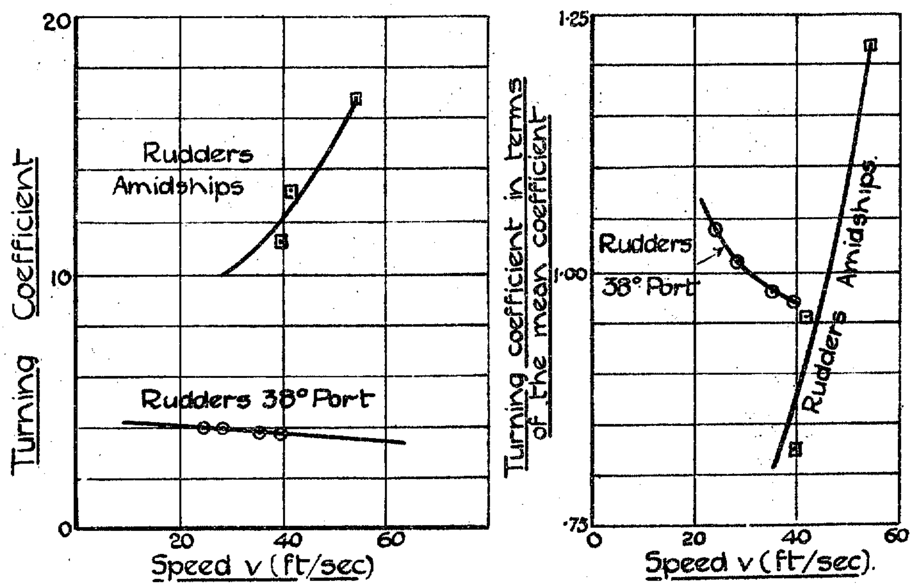
Rudders held at 38° Port (Hard over).



EXPERIMENTS ON AIRSHIP S. S. E3.

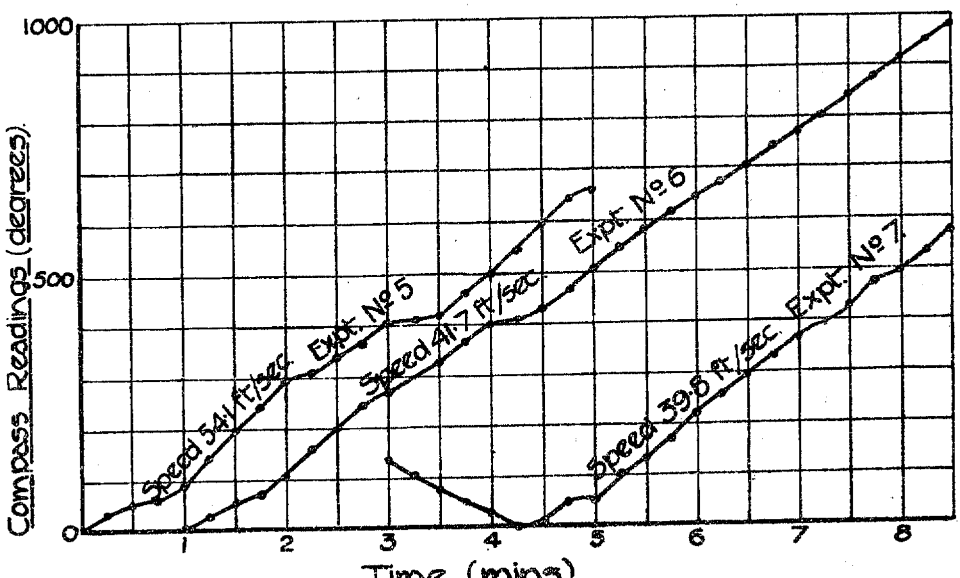
FIG. 4.
See Table 2.

VARIATION OF TURNING COEFFICIENT WITH SPEED.



PATH WITH RUDDER HELD AMIDSHIPS (APPROX)

FIG. 5.

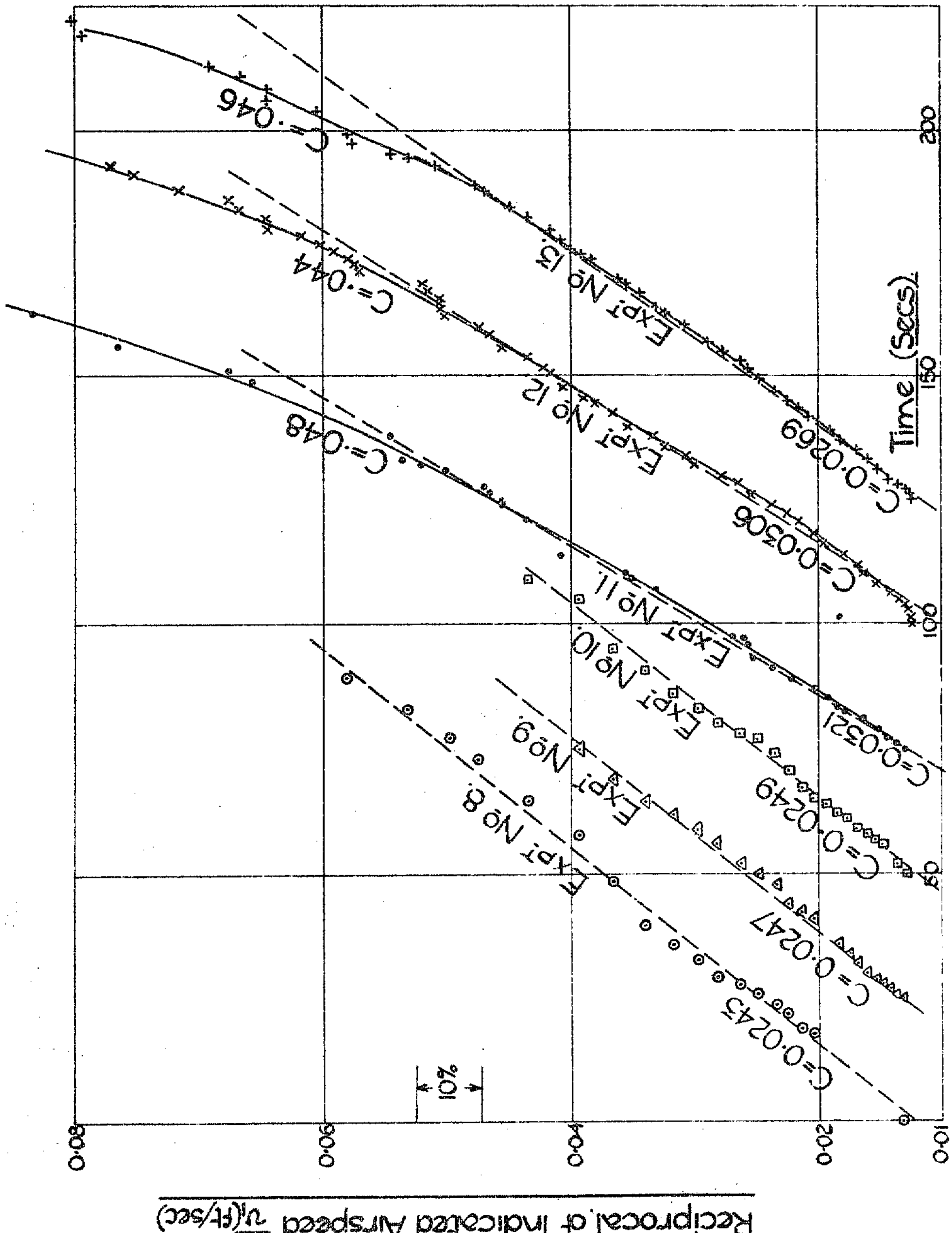


REPORT Nº 693.

EXPERIMENTS ON AIRSHIP S.S.E.3.

FIG. 6.
(See Table 3.)

DECELERATION TRIALS.



9/203/127. 1/21.1275. C& R. LTD-345.

EXPERIMENTS ON AIRSHIP S.S. E3.

VARIATION OF AIRSPEED WITH ROTATIONAL SPEED OF ENGINE.

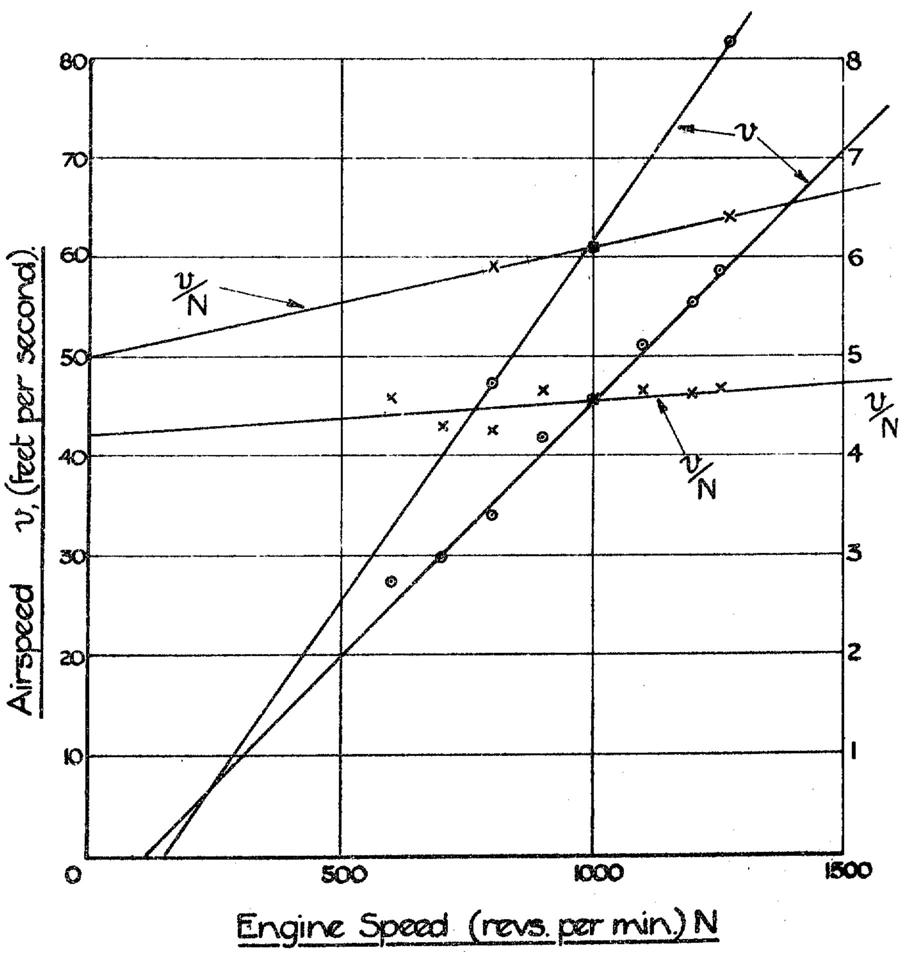


TABLE 3. (See Fig. 6.)

RESISTANCE COEFFICIENTS CALCULATED FROM DECELERATION TRIALS.*

Expt. No.	S.†	Coefficient C.‡
8	$5 \cdot 05 \times 10^{-4}$	0·0243
9	5·14	0·0247
10	5·17	0·0249
11	6·67	0·0321
12	6·37	0·0306
13	5·60	0·0269
Mean of Expts. 8, 9 and 10		0·0246

† $S = \frac{1}{V^2} \times \frac{dV}{dt}$.

‡ $R = C\rho V^2 l^2 = Sl$.

$l = \text{vol.}^{1/3}$.

* For discussion of errors see page 241.

Table 5. (See Fig. 7.)

FORWARD SPEEDS FOR VARIOUS ENGINE COMBINATIONS.

Expt. No.	Date.	Time.		Engines (r.p.m.).		Speed (ft/sec.).		$\frac{v}{N}$	Mean Inclination.	No. of Observations of Speed.
		Hr.	min.	Port.	Starboard.	Extremes.	Mean.			
14	18th October ...	11	56	1,000	1,000	63·0—54·0	60·9	0·0609	+ 2·2°	8
15	,, ...	11	53	800	800	48·8—44·9	47·2	0·0590	—	9
16	21st October ...	15	49	1,255	0	58·9—58·3	58·6	0·0467	—	4
17	,, ...	15	48	1,200	0	55·6—55·2	55·3	0·0461	—	5
18	,, ...	15	46	1,100	0	51·9—49·6	51·0	0·0464	—	7
19	,, ...	15	45	1,000	0	46·2—44·6	45·5	0·0455	—	6
20	,, ...	15	43	900	0	42·2—40·7	41·8	0·0465	—	8
21	,, ...	15	41½	800	0	34·8—32·8	34·0	0·0425	—	6
22	,, ...	15	40	700	0	30·5—29·4	30·0	0·0428	—	8
23	,, ...	15	38	600	0	27·6—27·3	27·4	0·0456	—	7

Note.—In Expt. No. 12 (Deceleration trial) highest speed touched was 81·7 ft/sec., the engine speeds being 1,275. (v/N = 0·0642.)