TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 271

FULL SCALE DRAG TESTS ON VARIOUS PARTS OF SPERRY MESSENGER AIRPLANE

By Fred E. Weick
Langley Memorial Aeronautical Laboratory

Washington
January, 1928

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL NOTE NO. 271.

FULL SCALE DRAG TESTS ON VARIOUS PARTS OF SPERRY MESSENGER AIRPLANE.

By Fred E. Weick

Summary

The drag of a Sperry Messenger airplane with the wings removed, and also the drag of its various component parts, was measured in the 20-foot air stream of the N.A.C.A. propeller research tunnel at air speeds from 50 to 100 M.P.H. It was found that the three-cylinder radial air-cooled engine nearly doubled the drag of the bare fuselage, and the drag of the landing gear was about the same as that of the fuselage and engine combined.

Introduction

Heretofore, measurements of the drag of airplane fuselages, landing gears, and other large parts have been limited by the size of available wind tunnels to tests on relatively small models. It has been necessary to calculate the full scale drag from the results of the model tests upon the basis of the principle of mechanical similitude. Since all of the conditions of this principle are not fulfilled in the model tests, the calculated full scale drag is at best more or less an approximation. The approximation may become very poor for bodies having complicated shapes such as air-cooled engine cylinders and landing gears in which the model cannot easily be made similar in all details to the full size object. It is desirable, therefore, to test these objects at full scale. This is now possible in the 20-foot air stream of the new propeller research wind tunnel of the National Advisory Committee for Aeronautics.

The Sperry Messenger airplane was originally mounted in the tunnel for propeller tests. This note describes a series of tests made on the drag of various parts of the airplane without wings. Since the wings have about the same span as the diameter of the air jet their drag as measured in the tunnel would not be the same as their drag in flight. The tests were therefore confined to drag measurements with the wings and wing bracing removed. The drag of the whole airplane without wings was obtained for air velocities of from 50 to 100 M.P.H., and the drag due to the landing gear, tail surfaces, windshield, cockpit, and the radial air-cooled engine, were measured at velocities from 50 to 80 M.P.H.

Methods and Apparatus

The Sperry Messenger airplane with the wings removed, as shown in Figure 8, was mounted on the balance in the test chamber, with the thrust line horizontal and in the center of the air stream. Figure 1 is a general view of the test chamber showing the entrance cone and the mounting of the airplane which was supported at two points on the axle and one at the tail of the fuselage. With this arrangement the wheels were displaced 3 inches outward as compared with their proper position to allow room for the attachment of the faired supports.

The air force measurements are read on commercial scales located at ground level, one of which indicates the thrust or drag directly. A detailed description of the balance as well as the rest of the propeller research tunnel will be published in the near future.

In running the tests, the total drag of the airplane without wings but including the supports was first obtained at air speeds from 50 to 100 M.P.H. The airplane was then disconnected from the supports and held in place with slight clearance by means of wire cables from the sides and top of the test chamber, and the drag of the supports obtained over the same range of air speeds. For the third run the landing gear was disconnected from the fuselage and refastened to the supporting structure and the total drag of the landing gear and supports obtained in the presence of the fuselage, which still remained suspended from the sides and top of the test chamber. This and subsequent tests were not run over 80 M.P.H. because the power plant was not yet in condition to be operated regularly at the higher speeds. For the fourth test the airplane was again mounted on the landing gear and balance supports, and the tail surfaces with their bracing and control wires were removed. Figure 1 is a view of the set-up for this test. Removing the rudder left a hollow-grooved section in the rear of the tail post which was faired as shown in the picture. The chain shown on the outside of the fuselage at the pilot's cockpit was for lowering a suspended flight angle and air-speed recorder in flight tests and is not part of the standard equipment of the airplane. It was left on for these tests in order to make them comparable with other experiments. For the fifth run the windshield and the roll of upholstering around the edge of the cockpit were also removed as shown in Figure 2. The sixth run was made with the cockpit covered over with a piece of sheet metal as shown in Figure 3, the engine still being in place; and the last run was made with the engine removed and the cylinder and carburetor holes in the cowling covered smoothly by means of sheet metal, carrying out the shape of the nose.

Results

The results observed are plotted on Figure 5. Nearly every reading comes within 1 pound of a faired curve through the points, and it is therefore thought that the faired results are accurate to within about 1/2 pound.

As shown in the illustrations, during all of the runs in which the windshield was in place, a pilot sat in the cockpit. In one test the pilot placed his head on either side of the cockpit, in the center, and down inside out of sight. The position of his head was found to have no noticeable effect on the drag readings.

In Figure 6 the drag in pounds due to the various parts is shown for speeds from 50 to 80 M.P.H. These values are also given in Table I, together with the absolute drag coefficients,

$C_D = \frac{D}{\frac{1}{2} \rho V^2 S}$, where S is the wing area (148 sq.ft.).

In general, the drag coefficients are constant throughout the speed range within the limits of accuracy of the tests. The additional drag due to the air-cooled engine, however, seems to be subject to some scale effect, the drag coefficient decreasing with increase in speed. This is not unnatural since the engine is made up of a number of comparatively small parts which, considered by themselves, were tested at very low values of Reynolds Number; and at these low values of Reynolds Number scale effect is quite pronounced. The coefficient of the increased drag due to the cockpit also decreases considerably with increase of speed, but the actual forces involved were so small that the accuracy of these measurements was not very great, especially at the low speeds. The coefficient of the drag due to the tail surfaces falls off at the lowest speeds, but this also is within the limits of accuracy of the experiments in the low speed range. The forces are naturally much greater at the higher speeds and the accuracy correspondingly better.

The relative drag of the various parts is shown more clearly in Figure 7. The outstanding feature of the chart is the proportionately high drag of the landing gear, this being about 40 per cent of the total drag of the airplane without wings. The landing gear evidently affords one of the most promising possibilities for the reduction of drag. The landing gear of the Sperry Messenger airplane is not of particularly clean design, but, on the other hand, it is probably not far from average. Another point of interest is that the increased drag due to the three-cylinder radial engine in the nose of the fuselage is nearly as large as the drag of the bare fuselage itself. The possibility of reducing the drag due to radial air-cooled engines is no doubt worth investigating.

Conclusions

These experiments indicate that for the Sperry Messenger airplane without wings, by far the largest possibility of improvement is in reducing the drag of the landing gear and the air-cooled engine.

Further full-scale research on the reduction of the drag of landing gears and on the cowling of air-cooled engines is recommended.

TABLE I.

DRAG AND DRAG COEFFICIENT FOR PARTS OF SPERRY MESSENGER AIRPLANE AT VARIOUS AIR-SPEEDS.

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 S}, \qquad S = 148 \text{ sq.ft.}$$

Airspeed, M.P.H.		50	55	60	65	70	75	80	100
Drag of complete airplane without wings	D, lb. C_D	25.64 .02723	31.10 .02727	37.14 .02733	43.48 .02731	50.17 .02709	57.38 .02705	65.26 .02708	101.00 .02680
Drag of bare closed fuselage	D, lb. C_D	6 .00637	7.25 .00636	8.75 .00644	10.40 .00654	12.20 .00661	14.05 .00663	15.95 .00662	
Increased drag due to engine	D, lb. C_D	5.3 .00563	6.0 .00526	6.95 .00511	7.95 .00500	9.05 .00491	10.2 .00481	11.3 .00469	
Increased drag due to cockpit	D, lb. C_D	1.11 .00118	1.20 .00105	1.28 .00094	1.40 .00088	1.47 .00080	1.70 .00080	2.00 .00083	
Increased drag due to windshield and upholstering	D, lb. C_D	.88 .00094	1.20 .00105	1.51 .00111	1.72 .00108	1.85 .00100	1.98 .00093	2.00 .00083	
Increase in drag due to tail surfaces	D, lb. C_D	2.35 .0025	3.15 .00276	4.00 .00294	4.93 .00310	5.92 .00321	6.95 .00328	8.00 .00332	
Drag of landing gear	D, lb. C_D	10.00 .01061	12.30 .01079	14.65 .01079	17.08 .01071	19.68 .01066	22.50 .01060	26.00 .01079	

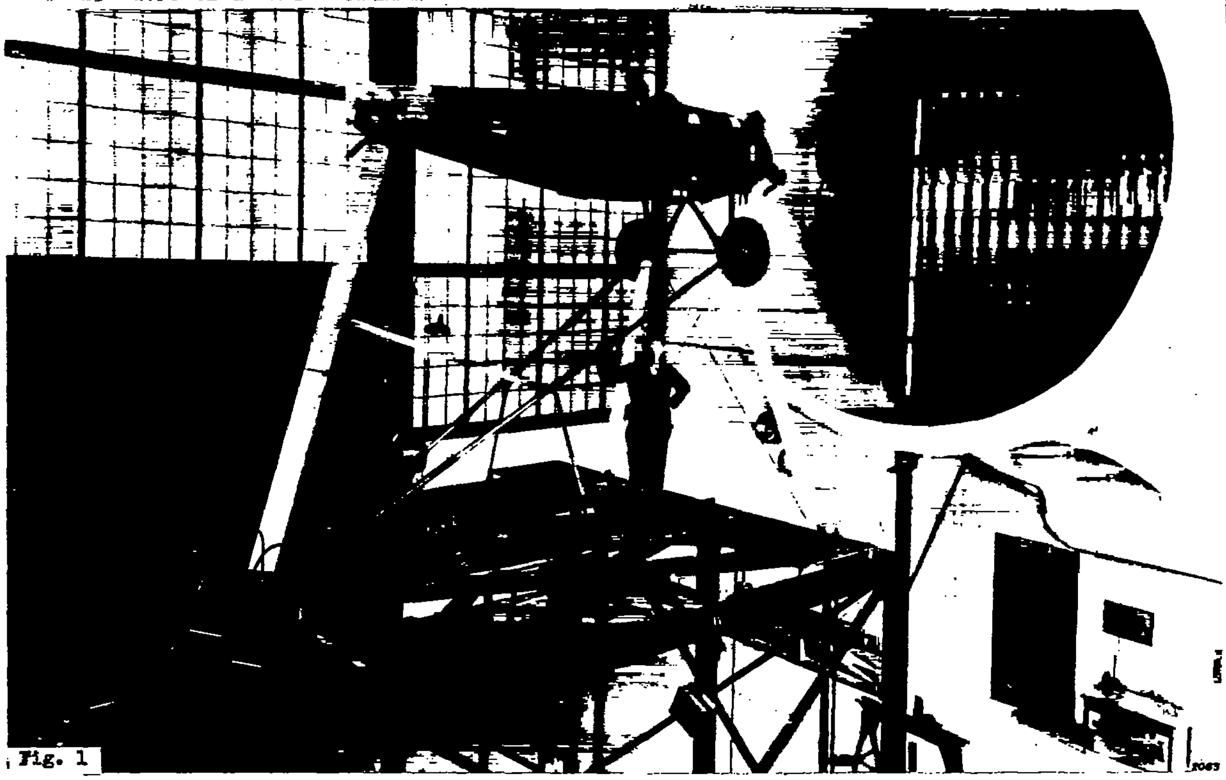

Fig. 1

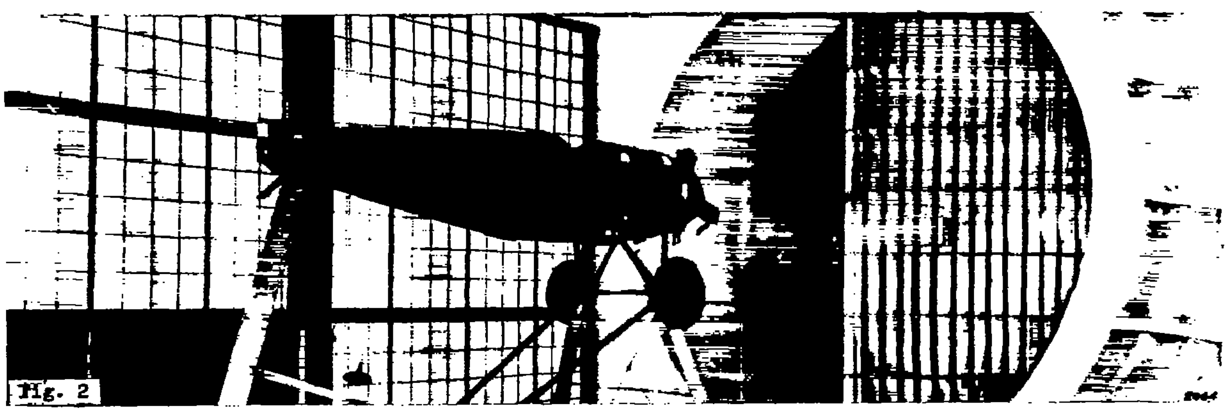

Fig. 2

Fig. 3

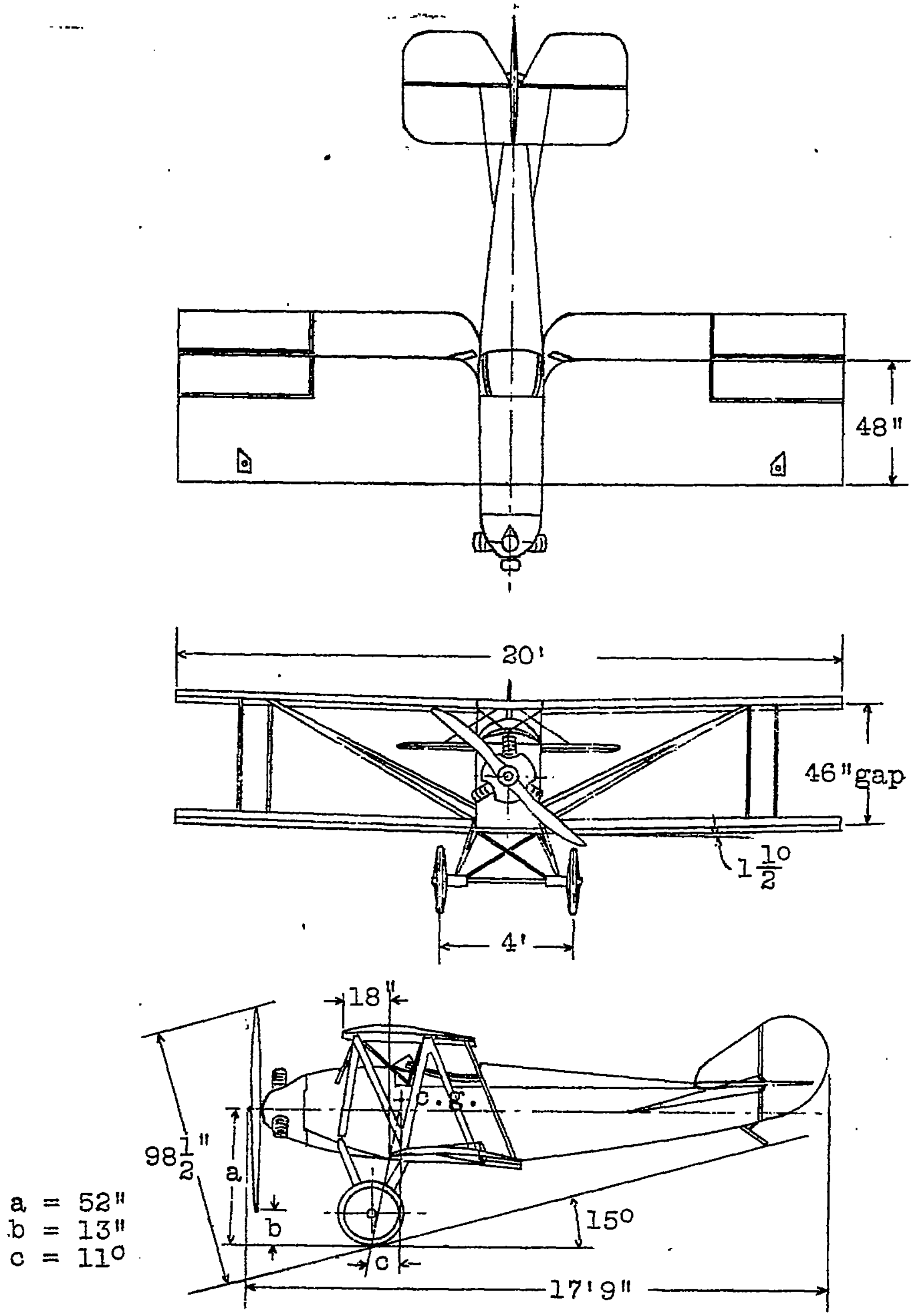

Fig.4 General arrangement drawing of Sperry Messenger airplane.

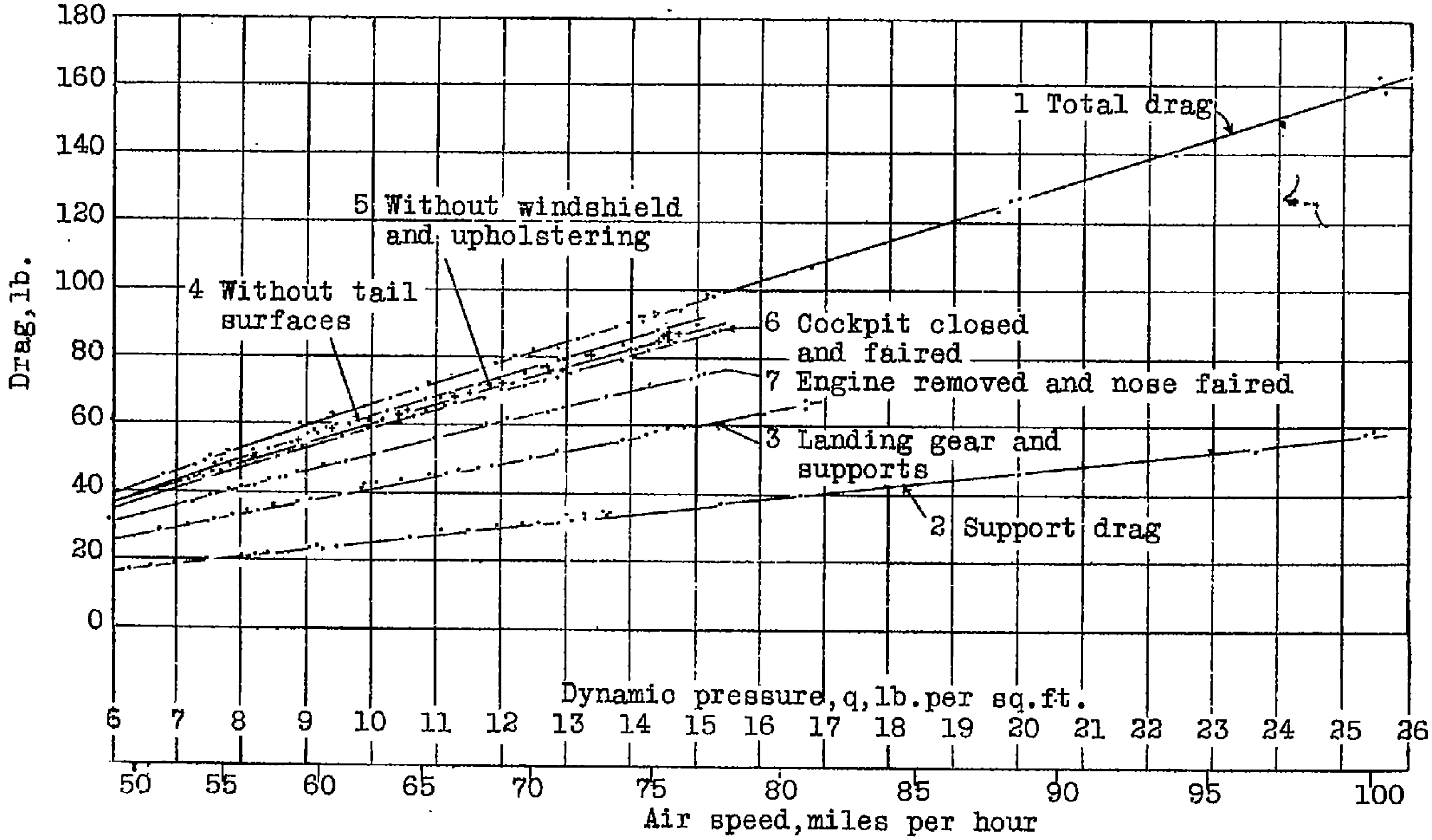

Fig.5 Drag of Sperry Messenger without wings or propeller.

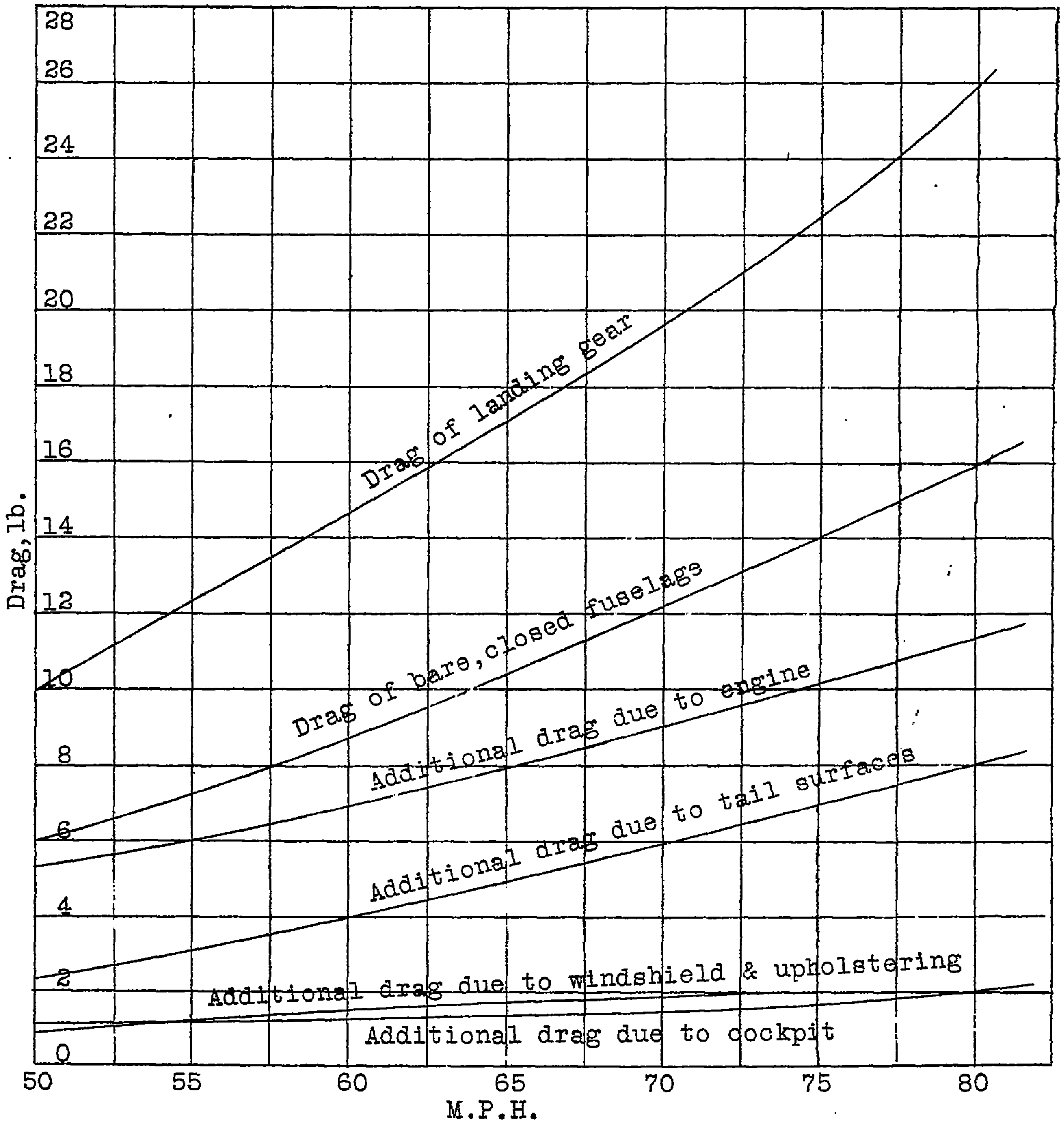

Fig.6 Drag due to component parts of Sperry Messenger airplane without wings, at various air speeds.

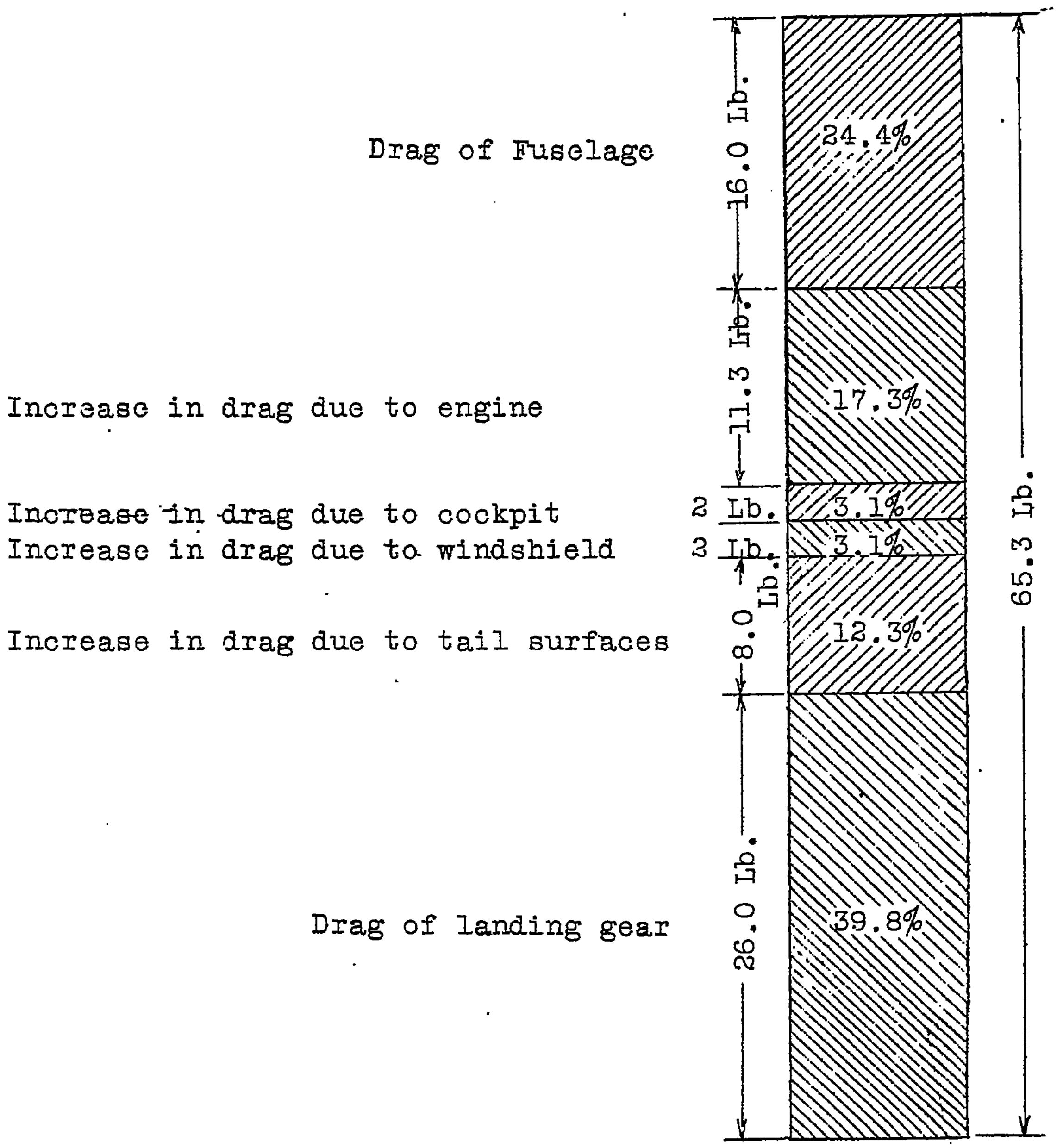

Fig.7 Drag due to various parts of Sperry Messenger airplane without wings at an airspeed of 80 M.P.H.

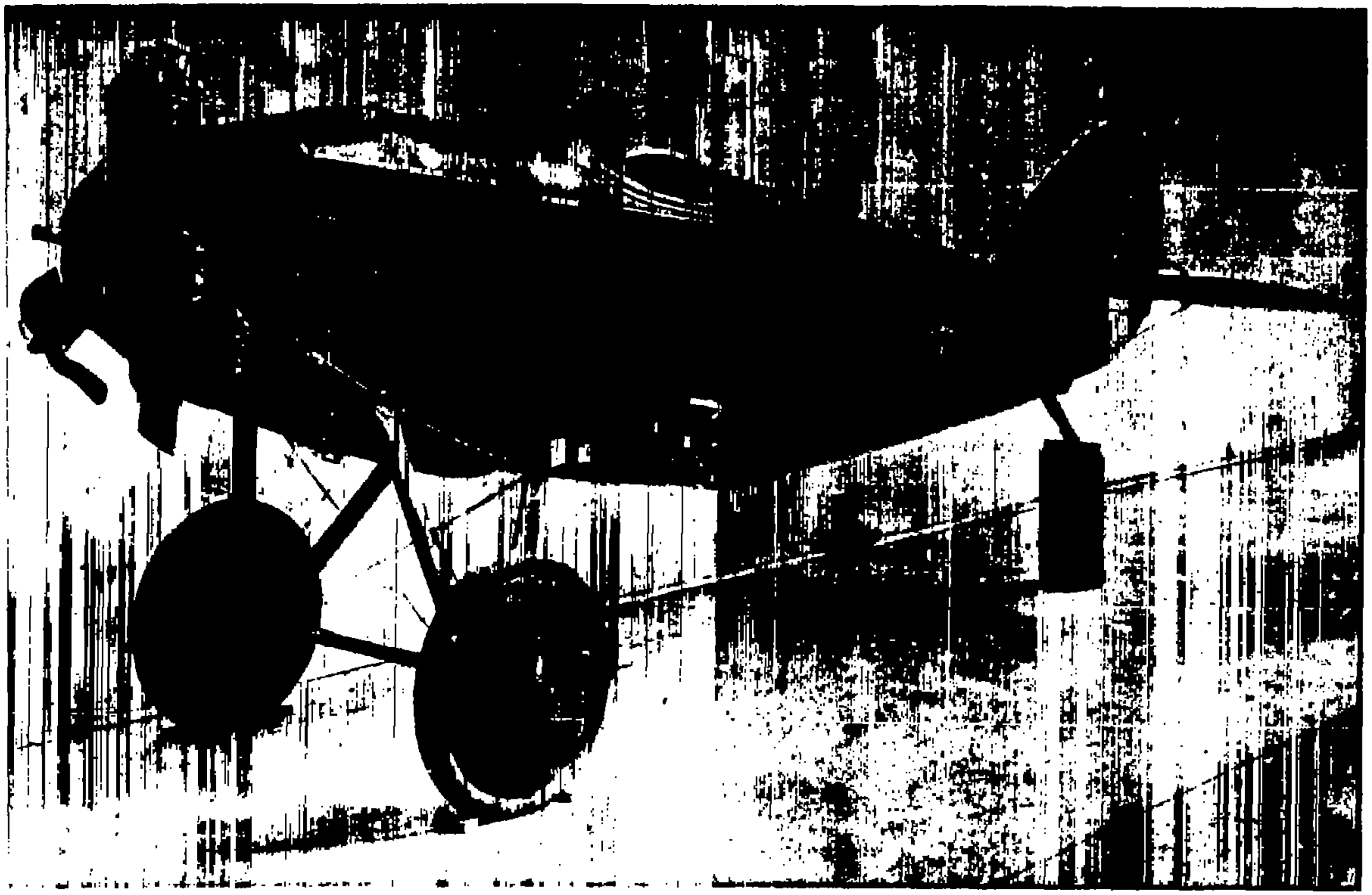

Fig. 8