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SUMMARY

This report presents the results of tests of a Powerplus supercharger and a comparison of its performance with the performance previously obtained with an N.A.C.A. Roots-type supercharger. The Powerplus supercharger is a positive displacement blower of the vane type having mechanically operated vanes, the movement of which is controlled by slots and eccentrics. The supercharger was tested at a range of pressure differences from 0 to 15 inches of mercury and at speeds from 500 to 2,500 r.p.m. The pressure difference across the supercharger was obtained by throttling the intake of a depression tank which was interposed in the air duct between the supercharger and the Durley orifice box used for measuring the air.

The results of these tests show that at low pressure differences and at all speeds the power required by the Powerplus supercharger to compress a definite quantity of air per second is considerably higher than that required by the Roots. At pressure differences from 10 to 14 inches of mercury and at speeds over 2,000 r.p.m. the power requirements of the two superchargers are practically the same. At a pressure difference of 15 inches of mercury or greater and at a speed of 2,500 r.p.m. or greater the performance of the Powerplus supercharger is slightly better than that of the Roots. Because the Powerplus supercharger cannot be operated at a speed greater than 3,000 r.p.m. as compared with 7,000 r.p.m. for the Roots, its capacity is approximately one-half that of the Roots for the same bulk. The Powerplus supercharger is more complicated and less reliable than the Roots supercharger.

INTRODUCTION

The experimental work in this country on aircraft engine superchargers has been confined principally to the development of the centrifugal and the Roots-type superchargers. Little attention has been given to the development of either the reciprocating or the vane-type superchargers, because of their greater weight, bulk, and complicated operating mechanism.

As the geared centrifugal supercharger has a high adiabatic efficiency and can be conveniently built integral with a radial engine, it is at present used more than any other type of supercharger. It is considered highly satisfactory for maintaining ground level pressures to low critical altitudes but is not as satisfactory for high critical altitudes. At least two gear ratios must be used between the engine and the supercharger or a large amount of throttling will be necessary at low altitudes to prevent overcharging of the engine.

The use of the turbocentrifugal supercharger is particularly attractive for high altitude where its performance is superior to any other type. It is not used extensively except for special purposes because, among other factors, the large amount of piping required makes a very combersome installation.

The Roots supercharger is a simple machine but it's use on aircraft makes a more bulky installation than the geared centrifugal. It operates on a "square" card resulting in high power requirements at large pressure differences as compared with superchargers operating with an adiabatic compression.

A knowledge of the comparative performance of the different types of superchargers under various operating conditions is essential in order to select the supercharger best suited for a particular condition of service. The National Advisory Committee for Aeronautics has conducted several investigations on superchargers to obtain this information. (References 1, 2, 3, and 4.) Recently the Bureau of Aeronautics, Navy Department, submitted a Powerplus vane-type supercharger to the Committee for testing. The performance of the supercharger was determined for pressure differences of 0, 3, 6, 9, 12, and 15 inches of mercury and at speeds of 500, 1,000, 1,500, 2,000 and

2,500 r.p.m. This report presents the results of these tests and a comparison of the performance of the Powerplus vane-type supercharger with that of the N.A.C.A. Roots-type supercharger.

DESCRIPTION OF THE POWERPLUS SUPERCHARGER

The Powerplus supercharger is a vane type with mechanically operated vanes having a restricted movement. This movement is governed by slots and eccentrics so that there is always a small clearance between the tips of the vanes and the supercharger case. The assembled supercharger with oil pump and oil lines in place is shown in Figures 1 and 2.

The operating principle of the supercharger is as follows: Air enters the supercharger at A (fig. 3) and is trapped between two successive vanes. As the drum B revolves, the air is compressed because the space between the drum and the case C diminishes, the drum being mounted eccentrically in the case. The compressed air is discharged through the outlet D. As the drum revolves it exerts a side pressure on the vanes, causing the eccentrics upon which the vanes are mounted to revolve and hold the proper clearances between the vanes and the case.

An exploded view of the supercharger with the parts designated for convenience is shown in Figure 4. The casing 1 is made of elektron (a magnesium-base alloy) for lightness and is ribbed for strength and cooling.

The assembly 2 of the vanes and eccentrics on the layshaft is shown. Two sets of vanes of air-hardened nickel-chrome steel operate in the drum at right angles to each other. Each set consists of two vanes and extends across the case. The hubs of each set are integral with the vanes and are provided with case-hardened steel bushings which serve as bearing surfaces for the bronze eccentrics. There are two eccentrics at each end of the layshaft which are bolted together 180° out of phase. They turn on the layshaft and in the hardened steel bushings and regulate the movement of the vanes so that the proper clearance is maintained between the tips of the vanes and the case. The layshaft does not rotate, but serves as a support for the vanes and eccentrics when assembled in the case.

On each end of the layshaft is a bearing 3, a bronze bearing housing 4, and a mild steel nut 5 which screws on the bearing housing and holds the bearing in position. The assembly of these parts fits up against the eccentric and acts as a thrust bearing to hold the vanes in the proper axial position.

Parts 6, 7, 8, and 9, the four quadrants of the drum, are made of duralumin and are of skeleton construction for lightness. Note the five bronze pads, 10 in each quadrant, to reduce the wear on the vanes and to reduce the friction where the vanes contact with the drum. Each quadrant of the drum fits between two vanes. The four quadrants are held in place by two steel rotor-end rings 11, one of which is bolted to each end of the drum assembly. Only the ring on the antigear end can be seen in Figure 4, the one on the gear end being assembled to the intermediate plate 13 on the opposite side to that shown. The brass oil ring 12 fits in the rotor-end ring 11.

The drum is held in the proper position in the case 1 by two ball bearings, one on each end. These ball bearings cannot be seen because one is on the opposite side of rotor-end ring 11 and the other on the opposite side of intermediate plate 13. The inner race of each bearing is fitted over a flange on each of rotor-end rings 11; the outer race of the bearing on the antigear end fits in the end plate 18 and the one on the gear end in intermediate plate 13. Bear in mind that the shaft supports the vanes and the eccentrics and does not provide any support for the drum. The driven gear 14 of air-hardened nickel-chrome steel is bolted to the steel rotor ring 11. A shoulder on the driven gear fits in the ball bearing which is held in place by the steel retaining ring 15. A brass oil retaining ring is shown as part 16.

The end plate 19 is bolted to the intermediate plate 13. It supports the driving shafts for the drum and the Bosch pump and one end of the layshaft. This plate, like plates 13 and 18, is made of elektron. It has bearing housings in it for one of the bearings of the drum driveshaft and for the bearing of the pump driveshaft. Two ball bearings and the driving gear 21 are mounted on the driveshaft 20. The driving gear is made of air-hardened nickel-chrome steel, and has 65 teeth. The driven gear 14 has 39 teeth which makes a gear ratio of 1.66. One bearing on the shaft fits in the bearing housing of the end plate 19 and the other bearing fits in housing 22 in the intermediate plate 13. The pump 23 is mounted on the support 24 and is driven by a shaft in the end plate. The pump speed is 3.25 times that of the driving shaft of the supercharger. The nuts 25 and 26 are screwed on each end of the layshaft and they serve to locate the drum in the case.

The operation of the supercharger is as follows: The gear 21 drives the gear 14, which is bolted to the rotor-end ring. The drum is also bolted to the rotor-end ring and will therefore rotate when gear 14 rotates. The drum in rotating carries the vanes with it, and the vanes in turn actuate the eccentrics. The eccentrics rotate twice as fast as the vanes and always maintain the latter in the correct position with respect to the case.

Some physical constants of the supercharger are:

Displacement	0.544 cubic foot per revolution
Fixed compression ratio	1.53
Maximum speed of drum	3,000 r.p.m.
Weight	119 pounds

The supercharger is lubricated with castor oil by an oil system independent of that of the engine to which it may be attached. The Bosch pump which distributes the oil is provided with one intake and six discharge openings. One of the discharge openings is connected by an oil duct to a pressure gauge and five are connected by oil ducts to the supercharger at the following points (fig. 4): one on each end of layshaft, one on the end plate 19, and two at 27 on the end plate 18. The connection on end plate 19 is so located that the oil can flow over the gears in the gear case. The oil is drained from the case through a connection at the bottom.

The L-shaped connection 27 in end plate 18 is so located that the oil in entering falls on the portion of the brass oil ring 12 that is shaped to catch the oil. The oil is then thrown out by centrifugal force into the oil grooves in the ring. This oil then passes through holes running lengthwise in the drum quadrants and thence through holes in the bronze bearing pads. This oil lubricates the surfaces between the moving vanes and the drum.

The eccentric bearing surfaces are lubricated through the oil connections on each end of the layshaft. Passages are provided in the shaft and in the eccentrics to convey the oil to the bearing surfaces. The oil is thrown out by centrifugal force, after leaving the surfaces, against the inside of the drum quadrants. Passages are provided in the quadrants to carry the oil back to the gear case. However, as only a small amount of oil was drained from the case and a large amount passed out through the discharge it seems that most of the oil escaped through the spaces between the vanes and bearing pads in the quadrants.

In order to supply 4 pints of oil per hour to the supercharger, the amount specified by the manufacturers as essential for proper lubrication, the oil tank must be kept under a pressure head. A connection is provided on the supercharger case so that under service conditions the pressure on the oil tank is maintained by the supercharger.

TEST PROCEDURE, EQUIPMENT, AND METHODS

Before any tests were conducted on the supercharger the Bosch pump was tested separately to determine what pressure head should be maintained on the pump and also whether it delivered the required 4 pints of oil per hour. In these tests the pump was driven by an electric motor. The motor was provided with variable resistance so that pump speeds of 1,050, 3,000, 4,200, and 5,000 revolutions per minute could be obtained. The rate of discharge was determined for these speeds with 0, 20, 40, 60, and 80 pounds of pressure per square inch on the supply tank. The duration of each run was 1 hour.

Because the supercharger was new it was "run in" at speeds up to 2,200 r.p.m. before any performance tests were made. Its performance was then determined for speeds of 500, 1,000, 1,500, and 2,000 r.p.m. at pressure differences of 0, 3, 6, 9, 12, and 15 inches of mercury for each speed. These tests were followed by further running-in tests up to a speed of 2,800 r.p.m. whereupon its performance at a speed of 2,500 r.p.m. was determined for each of the above pressure differences. No test was made at its maximum drum speed of 3,000 r.p.m. because the supercharger never attained a speed over 2,800 r.p.m. without seizing. Trouble was experienced from time to time with the vane clearances, as is explained later.

The supercharger was driven by an electric dynamometer and the torque indicated by a Kron scale. The horsepower absorbed by the supercharger was computed from the scale reading and the dynamometer speed. The amount of air delivered by the supercharger was measured by means of the Durley orifice box. From the measurement of the pressure drop across the orifice and the temperature of the air entering the orifices the weight and consequently the volume of air could be calculated. Pressure difference across the supercharger was obtained by throttling the intake of a 72-cubic-foot depression tank placed in the air duct between the supercharger and the orifice box.

The data for the Roots supercharger of 0.509-cubic-foot displacement per revolution were taken from N.A.C.A. Technical Report No. 284 (reference 1) and were corrected to the same displacement as that of the Powerplus by multiplying the values by 0.544/0.509, the ratio of the capacities of the two superchargers. For further information on the method of conducting the tests and calculating the results, see references 5 and 6.

RESULTS AND DISCUSSION

The results of the Bosch pump tests are shown in Figure 5. The amount of oil delivered by the pump increased both with the increase of speed and primary pressure but the increase with the pressure was not very large. However, it was decided always to have a primary pressure of not less than 40 pounds per square inch on the tank owing to the fact that at 20 pounds per square inch the amount of oil delivered fell off considerably at the higher speeds. A pump speed of 3,500 revolutions per minute had to be attained before the pump delivered 4 pints of oil per hour. However, throughout the tests it was noted that the supercharger had sufficient oil at low speed, even though 4 pints were not used; the 4 pints per hour specified must, therefore, refer to the higher supercharger speeds.

In order that the performance of the Powerplus supercharger at various conditions of pressure and speed may be more fully appreciated it has been compared with the performance of a Roots supercharger for the same operating conditions. The pressure-volume cards for the Roots and the Powerplus superchargers are shown in Figure 6. The Roots supercharger operates on a square card, the air being compressed within the supercharger by the back flow of the compressed air. The Powerplus supercharger has a fixed compression ratio of 1.53. All air taken in is therefore reduced in volume to 1/1.53 of the intake volume before it comes in contact with the discharged air, after which its pressure is either increased or decreased, depending on the pressure at the supercharger exit. If the exit pressure is higher than the pressure of the compressed air within the supercharger the discharged air will rush back and further compress the air within the supercharger; whereas, if the pressure at the exit is lower than that in the supercharger, as in Figure 6, the compressed air will rush out until the pressure within the case is equal to the pressure at the exit.

The pressure-volume cards in Figure 6 are based on a pressure difference across the supercharger of 8 inches of mercury and the volume displaced by one of the four vanes or lobes. A compression exponent of 1.407 was assumed for the Powerplus supercharger. Note that for the intake and discharge pressures given in Figure 6 that the pressure within the case of the Powerplus supercharger is 39.87 inches of mercury just before the air between two successive vanes starts to flow through the discharge opening. The energy used in compressing the air to a pressure higher than the discharge pressure is wasted. This energy is represented by the area A. The area B represents the amount of unnecessary work done by the Roots because the air rushes back and must be expelled again. From a theoretical consideration of the power requirements of the two superchargers, it is obvious that the Powerplus supercharger is better than the Roots for all conditions where the area A is less than the area B. It is also obvious that the power requirements are in favor of the Powerplus when the pressure differences across the supercharger are large and that they are most favorable to the Roots when the pressure differences are small.

The performance data obtained in the laboratory test of the Powerplus supercharger are given in Table I.

TABLE I

PERFORMANCE DATA FOR THE POWERPLUS VANE-TYPE SUPERCHARGER

Run No.	Super-charger speed (r.p.m.)	Pressure difference (in.Hg)	Pressure ratio	Temperature ratio	Horse-power	Air weight (lb.per sec.)	Volumetric efficiency (per cent)	Adiabatic efficiency (per cent)
				TEST 1				
2	493	3.10	1.115	1.020	1.85	0.2293	77.5	72.4
3	473	6.15	1.255	1.042	3.09	,1641	65.1	66.0
4	505	.20	1.006	1.007	.67	.3127	92.9	17.0
5	487	8.85	1.415	1.070	4.48	.1260	54.7	54.0
6	528	12.22	1.679	1.106	6.39	.0183	9.6	9.3
				TEST 2				
7	1023	.34	1.011	1.011	2.42	.6045	88.5	13.76
8	1016	2.97	1.110	1.024	4.19	.5177	84.8	70.4
9	995	5.90	1.243	1.040	6.51	.4226	79.0	77.4
10	1005	8.94	1.420	1.082	9.13	.3352	71.2	71.8
11	992	11.90	1.650	1.126	11.60	.2395	59.9	59.0
12	1005	14.85	1.966	1.204	14.40	.1612	47.7	44.6
				TEST 3				
13	1505	.38	1.012	1.019	5.06	.8861	89.8	9.7
14	1513	2.95	1.109	1.030	7.93	.7959	88.2	55.8
15	1520	5.94	1.245	1.054	11,70	.6803	84.2	69.9
16	1506	8.97	1.422	1.085	15.10	.5520	78.9	72.5
17	1500	12.20	1.676	1.149	19.30	.4698	79.7	72.4
18	1481	15.15	2.007	1.201	23.10	.3187	65.5	56.6
				TEST 4				
19	2012	.71	1.024	1.027	9.11	1.1765	89.0	16.5
20	2018	3.05	1.111	1.043	12.30	1.0450	85.6	47.9
21	2002	6.08	1.252	1.062	16.60	.9160	85.5	67.4
22	1998	9.05	1.427	1.101	20.90	.7763	83.0	73.3
23	1950	12.00	1.660	1.143	25.10	.6364	81.4	73.1
24	1944	15.00	1.990	1.190	29.80	.4993	76.9	67.5
27	2009	6.00	1.250	1.054	16.20	.8900	83.9	66.8
				TEST 5				
28	2530	.80	1.027	1.029	14.79	1.4260	87.4	14.1
29	2510	3.00	1.111	1.039	18.78	1.3138	88.4	40.1
30	2500	6.08	1.254	1.056	23.10	1.1245	85.7	60.3
31	2503	*9.09	1.435	1.066	28.04	.9670	85.8	71.4

*No test data obtained at high pressure difference for this speed because of contacting of the vanes with the case.

The curves in Figure 7 show the horsepower required to operate the Powerplus supercharger and a Roots supercharger at various conditions of pressure difference and speed. The curves show that the Roots supercharger requires less power at the low pressure differences, especially when operating at high speeds, but at the high pressure differences the power requirements of the Powerplus supercharger are less for all speeds. These results substantiate the results presented in the preceding paragraph. Bear in mind that these curves alone do not indicate which supercharger is the more efficient; they show the horsepower required to operate the superchargers at these various speeds and pressure differences; whereas, to determine which is the more efficient supercharger the amount of air each delivers at the same operating conditions must be known. It may be well to mention here that the Powerplus supercharger cannot be operated at drum speeds over 3,000 revolutions per minute; whereas, the Roots supercharger can be operated at impeller speeds up to 7,000 revolutions per minute. The curves in Figure 7 show that the power requirements of the two superchargers are equal at pressure differences of 4, 6.7, and 8 inches of mercury at drum speeds of 1,000, 2,000, and 2,500 revolutions per minute, respectively. The variation of these pressure differences with the speed is due to the difference in mechanical and volumetric efficiency for these conditions.

The weights of air delivered by the Powerplus supercharger and a Roots supercharger at various speeds and pressure differences are shown in Figure 8. With no pressure difference the Powerplus supercharger delivers less air than the Roots and the difference in air weight increases with increase of speed. At 12 inches of mercury pressure difference the Powerplus supercharger delivers approximately 0.10 pound of air per second less than the Roots at the low speeds and 0.14 pound per second less at the high speeds. On the basis of air weights given in Figure 8 and the horsepowers given in Figure 7 the power required by each supercharger to compress a definite weight of air can be obtained. At a speed of 2,500 revolutions per minute and a pressure difference of 12 inches of mercury 32.8 horsepower is required by the Powerplus to deliver 0.835 pound of air per second and 38.3 horsepower is required by the Roots to deliver 0.97 pound of air per second. Assuming that the power varies directly as the weight, then for these conditions of pressure and speed the power required to compress one pound of air per second by the Powerplus and Roots is 39.3 and 39.5 horsepower, respectively. In a similar manner the power required by each supercharger to compress a pound of air per second at other conditions of pressure difference and speed was determined and is presented in the following table.

TABLE II

HORSEPOWER REQUIRED BY EACH SUPERCHARGER TO

DELIVER ONE POUND OF AIR PER SECOND

Supercharger Speed - 1,000 r.p.m.			
Pressure difference, in. of Hg	0	12	15
N.A.C.A. Roots supercharger, hp	0.294	42.6	64.5
Powerplus supercharger, hp	3.84	49.6	90.6
Supercharger Speed - 2,000 r.p.m.			
Pressure difference, in. of Hg	0	12	15
N.A.C.A. Roots supercharger, hp	0.954	39.7	57.1
Powerplus supercharger, hp	6.57	39.55	59.8
Supercharger Speed - 2,500 r.p.m.			
Pressure difference, in. of Hg	0	12	15
N.A.C.A. Roots supercharger, hp	1.342	39.5	57.6
Powerplus supercharger, hp	9.00	39.3	56.7

A study of Table II shows that below 12 inches of mercury pressure difference the results are more favorable to the Roots supercharger whereas from 12 to 15 inches of mercury pressure difference the performances are about equal at speeds of 2,000 revolutions per minute and above. At high pressure differences (above 15 inches of mercury) the performance of the Roots supercharger is superior to that of the Powerplus except at speeds of 2,500 revolutions per minute or higher where the performance of the latter is slightly better. As designed, this supercharger would be most satisfactory for conditions where the pressure difference was from 12 to 15 inches of mercury. The supercharger can, however, be designed for other pressure differences.

The comparative volumetric efficiencies of the superchargers are shown in Figure 9 and the slip speed for each is shown in Figure 10. The slip speed is a measure in terms of supercharger speed of the quantity of air that slips back, at various pressure differences, between the moving parts and the case of the supercharger. The slip speeds for the Roots supercharger were determined by operating it at various pressure differences with the intake blocked. The values for the slip speeds obtained by this method on a Roots-type supercharger should check the speed for zero air delivery at various pressure differences in Figure 8. The method used for determining the slip speed of the Roots supercharger is not satisfactory for determining the slip speed of the Powerplus because even when there is no difference in pressure between the intake and discharge there is a certain amount of slip in the Powerplus which is caused by high pressure air leaking back between the vanes and the case. From the curves in Figure 8 for zero pressure difference the weight of air that slips back in the Powerplus supercharger at various speeds can be obtained by subtracting the air weight given for the Powerplus from the weight given for the Roots. Note that the difference decreases gradually as the speed is decreased.

The slip speeds of the Powerplus supercharger can be determined from the volumetric efficiency curves in Figure 9. For instance, at a pressure difference of 15 inches of mercury and a speed of 1,000 revolutions per minute the volumetric efficiency of the supercharger is 46.5 per cent. The slip speed must, therefore, be 53.5 per cent or 535 revolutions per minute. The slip-speed curves in Figure 10 for the Powerplus supercharger were computed according to this method. Note that, unlike the Roots supercharger, the slip speeds for the Powerplus increase with speed up to a pressure difference of about 12 inches of mercury. The slip-speed curves for a speed of 2,500 revolutions per minute may be slightly high because the method of computing these results neglects the effect of charging losses that may enter at this speed. However, on the basis of other tests conducted with a Roots-type supercharger at speeds up to 6,000 revolutions per minute it is believed that the charging losses would be negligible at a speed of 2,500 revolutions per minute.

A comparison of the adiabatic efficiencies of the Powerplus and the Roots superchargers is shown in Figure 11. The adiabatic efficiency of both superchargers decreases with increase of speed at low pressure differences, the effect being more noticeable in the case of the Powerplus supercharger. At high pressure differences the efficiency increases with increase of speed. The Powerplus supercharger is more efficient than the Roots at the high pressure differences, but at the low pressure differences the results are more favorable to the Roots. These efficiencies bear out what already has been stated with respect to the horsepower required by each supercharger for various operating conditions.

The Powerplus supercharger is more complicated and less reliable than the Roots. In these tests difficulty was experienced with the vanes contacting with the case, which placed an excessive load on the eccentrics. This contacting of the vanes was eliminated at speeds up to 2,500 r.p.m. by scraping the case. At higher speeds the vanes contacted even after approximately 0.006 to 0.010 inch of metal had been removed. It is believed that the contacting is due to distortion of the case and that the design could be modified to eliminate or reduce it. With this exception this is a well-designed and constructed supercharger and indicates that the manufacturers have exercised great care and paid considerable attention to details of lubrication and weight reduction.

CONCLUSIONS

1. At low pressure differences the power required by the Powerplus supercharger to compress a definite quantity of air per second is greater at all speeds than that required by the N.A.C.A. Roots supercharger. At pressure differences from 10 to 14 inches of mercury and speeds above 2,000 r.p.m. its performance is about equal to that of the Roots. At a pressure difference of 15 inches of mercury, or greater, and a speed of 2,500 r.p.m., or greater, the performance of the Powerplus supercharger is slightly better than that of the Roots.

2. The Powerplus supercharger is not equal to the Roots supercharger in reliability.

3. A Powerplus supercharger of the same capacity as a Roots supercharger would be considerably more bulky.

4. This supercharger as designed would be most satisfactory for conditions where the discharge pressure was about 30 inches of mercury, absolute, and the pressure difference was from 12 to 15 inches of mercury. However, the supercharger can be designed for other pressure differences.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 14, 1932.

REFERENCES

1. Ware, M., and Wilson, E. E.: The Comparative Performance of Roots Type Aircraft Engine Superchargers as Affected by Change in Impeller Speed and Displacement. T.R. No. 284, N.A.C.A., 1928.

2. Schey, O. W., and Gove, W. D.: The Effect of Supercharger Capacity on Engine and Airplane Performance. T.R. No. 327, N.A.C.A., 1929.

3. Schey, O. W., and Young, A. W.: Comparative Flight Performance with an N.A.C.A. Roots Supercharger and a Turbocentrifugal Supercharger. T.R. No. 355, N.A.C.A., 1930.

4. Schey, O. W.: Comparative Performance of Superchargers. T.R. No. 384, N.A.C.A., 1931.

5. Ware, Marsden: Description and Laboratory Test of a Roots Type Aircraft Engine Supercharger. T.R. No. 230, N.A.C.A., 1926.

6. Ware, Marsden: Effect of the Reversal of Air Flow upon the Discharge Coefficient of Durley Orifices. T.N. No. 40, N.A.C.A., 1921.

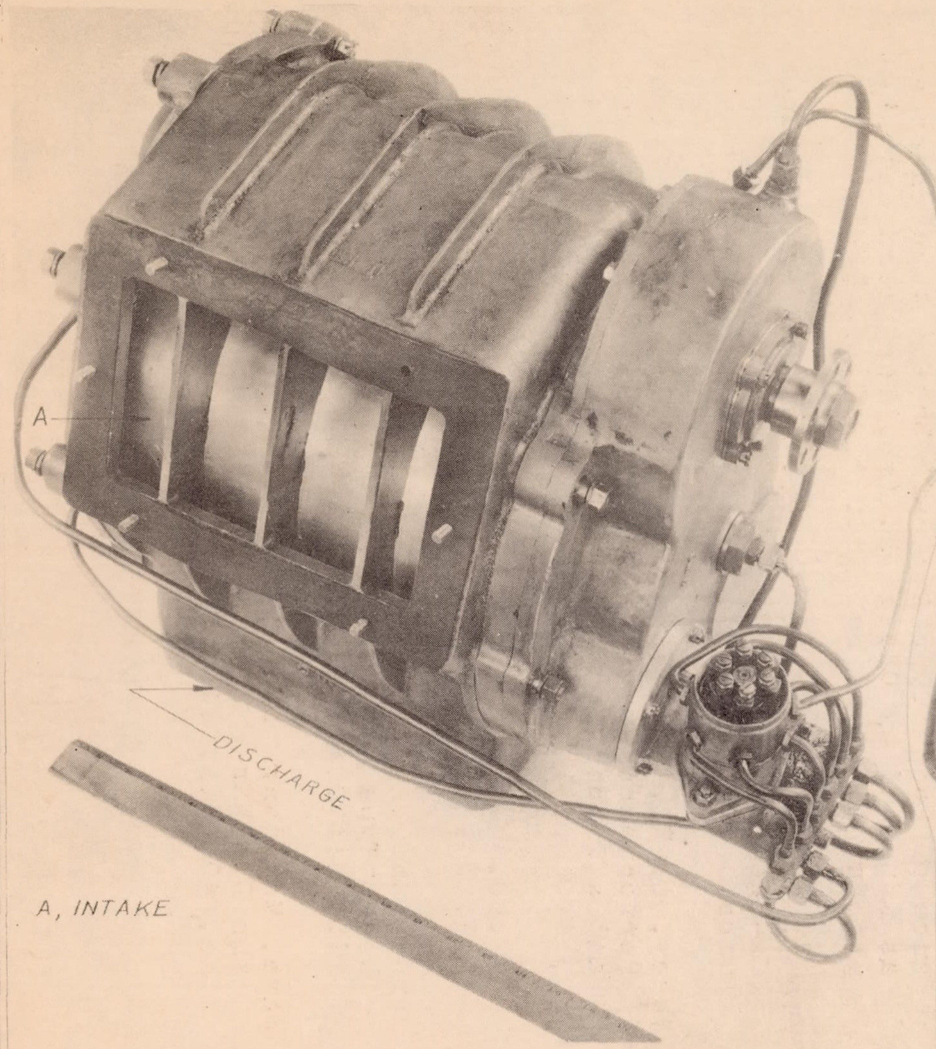


Fig.1 Powerplus vane-type supercharger with Bosch pump attached.

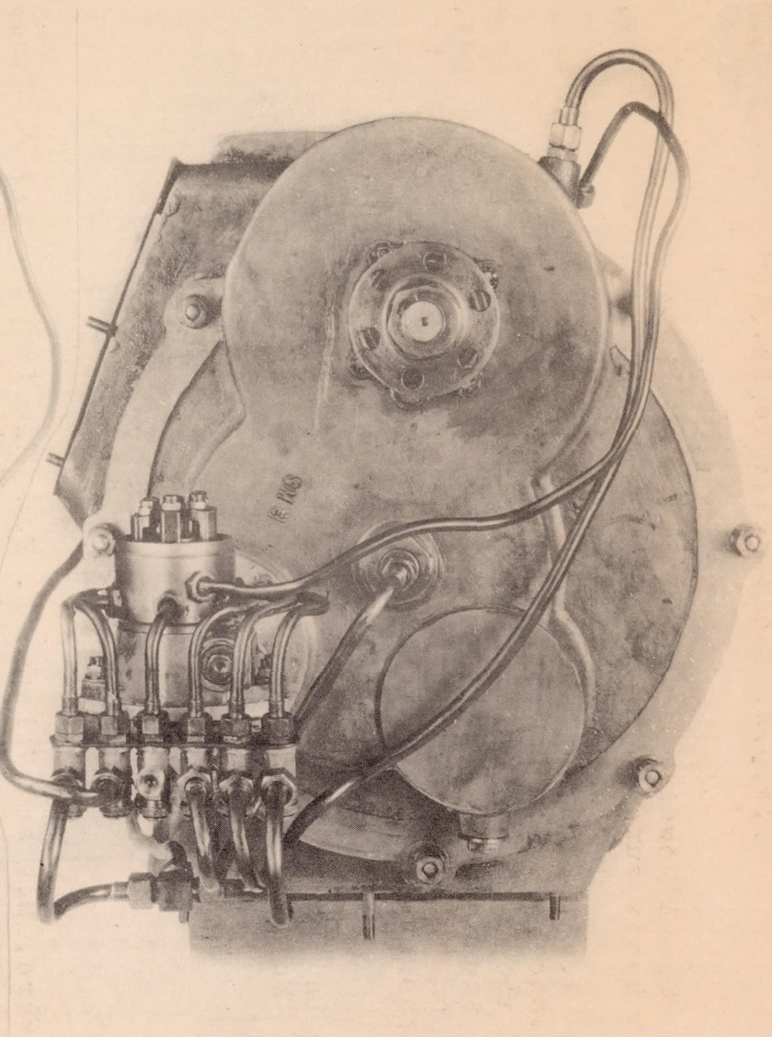


Fig.2 End view of Powerplus vane-type supercharger.

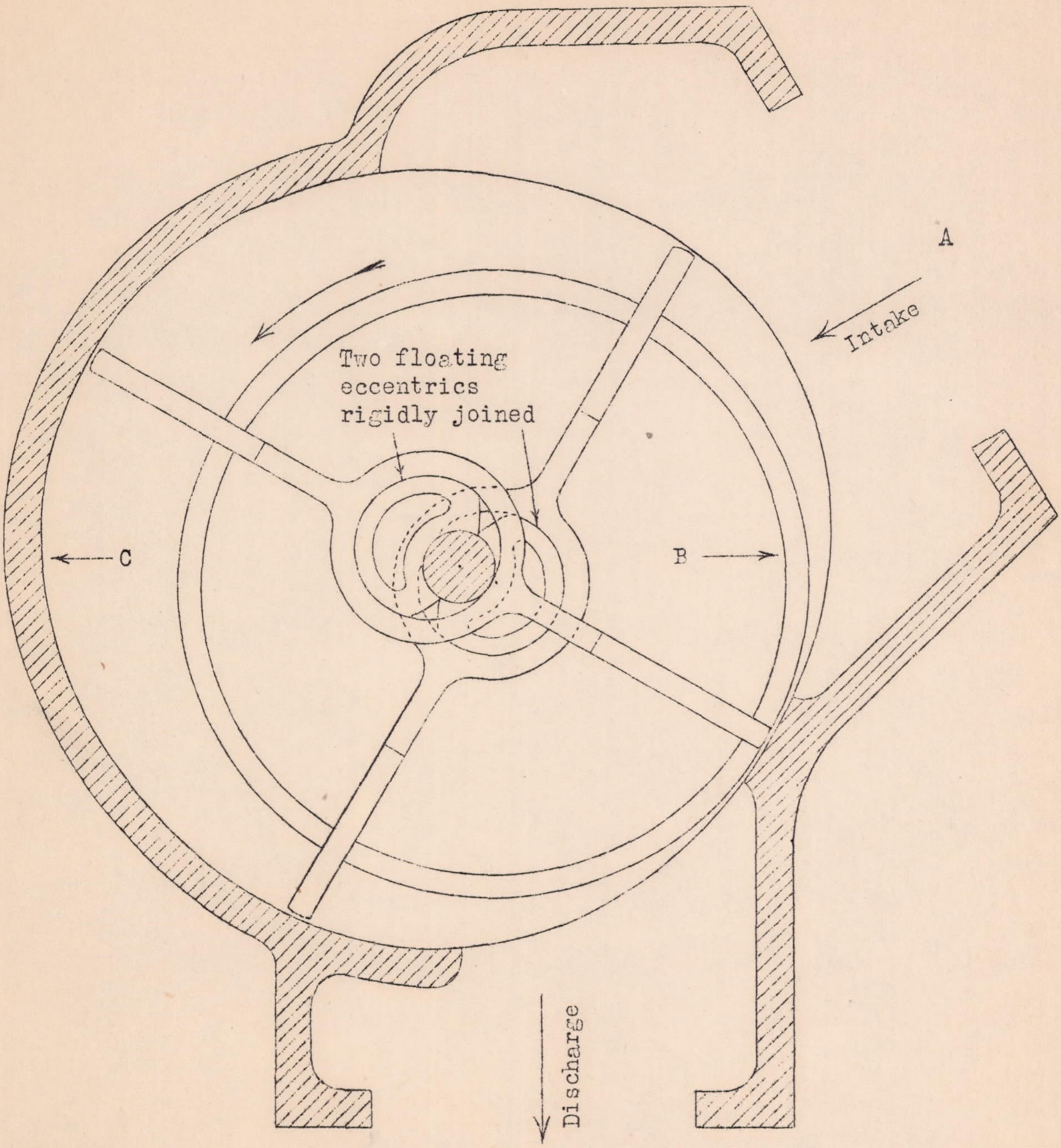


Fig. 3 Sketch of Powerplus vane-type supercharger.

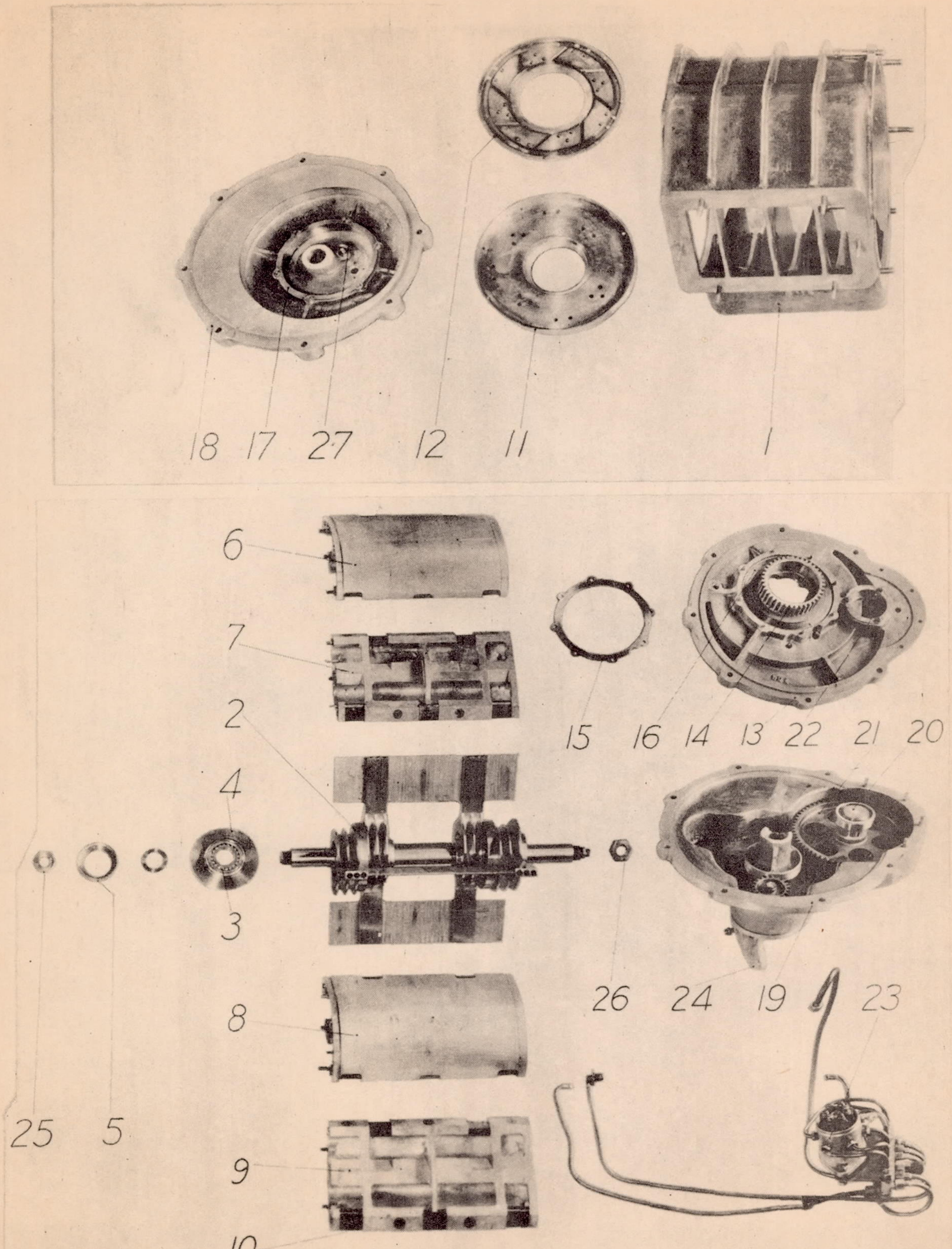


Fig.4 Exploded view of Powerplus vane-type supercharger.

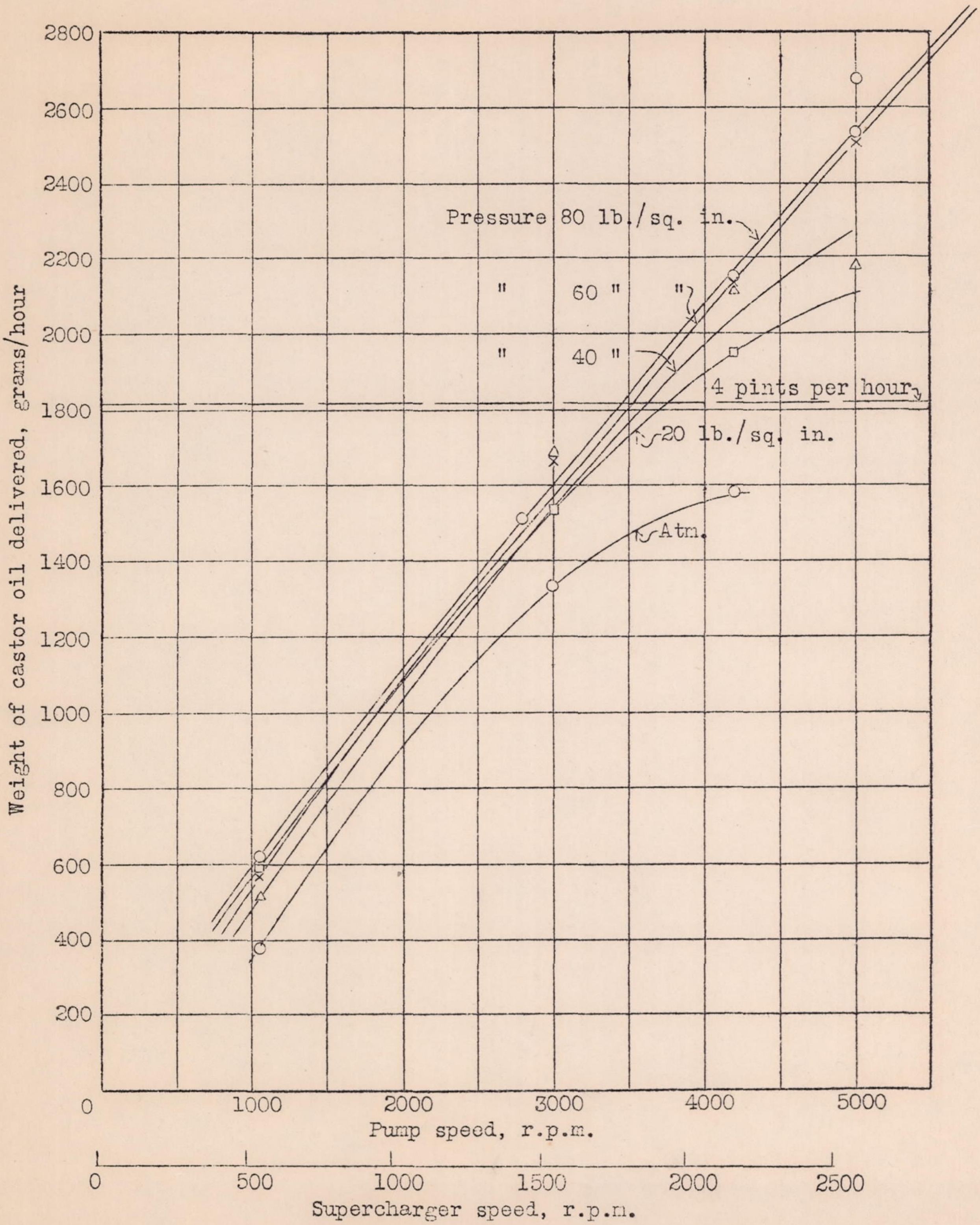
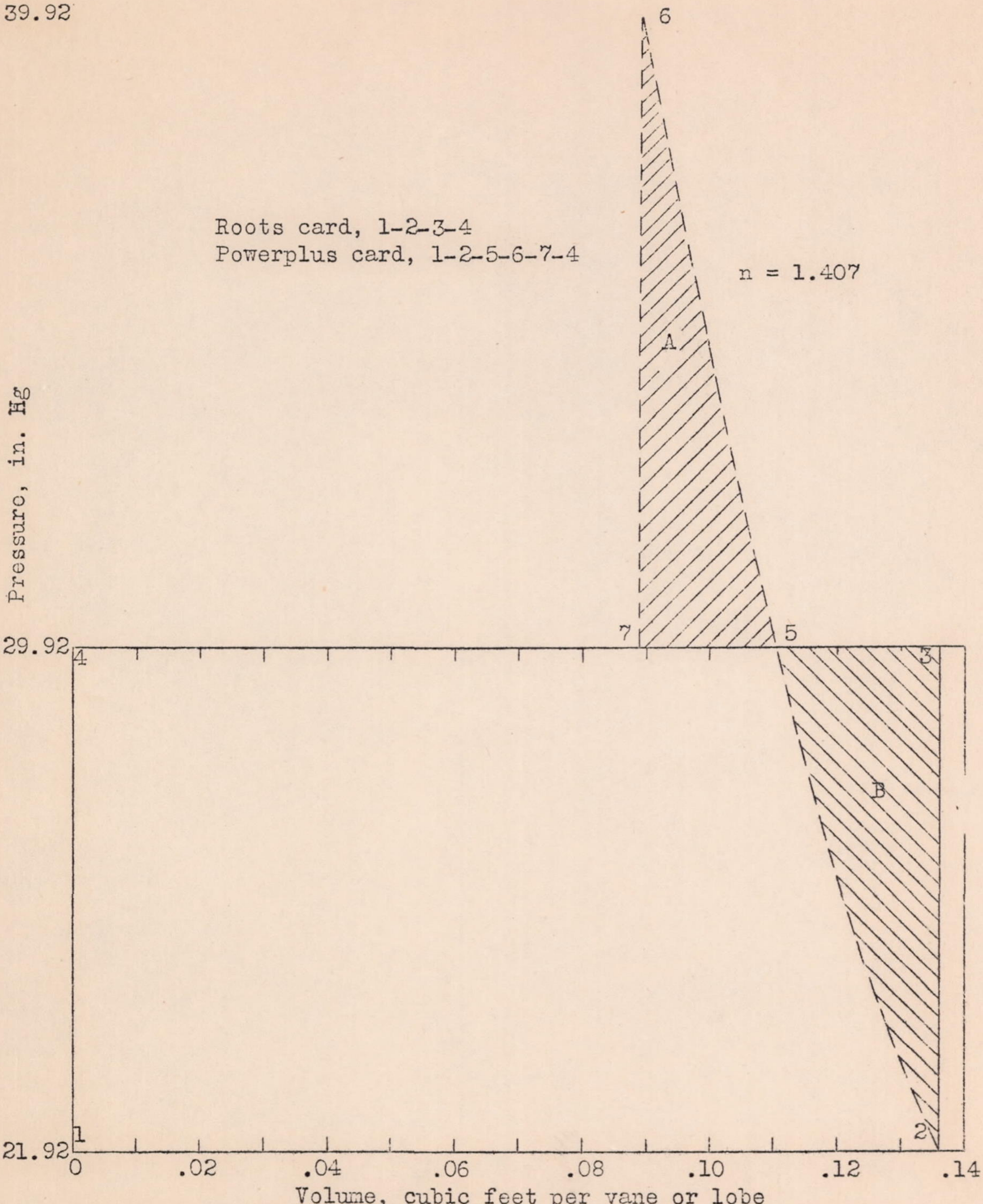


Fig.5 Rate of discharge of Bosch pump at various speeds and with various pressures on supply tank.



Displacement of each supercharger = 4 × 0.136 = 0.544 cu.ft./rev.

Fig.6 Comparison of pressure-volume cards of Powerplus and N.A.C.A. Roots superchargers neglecting slip.

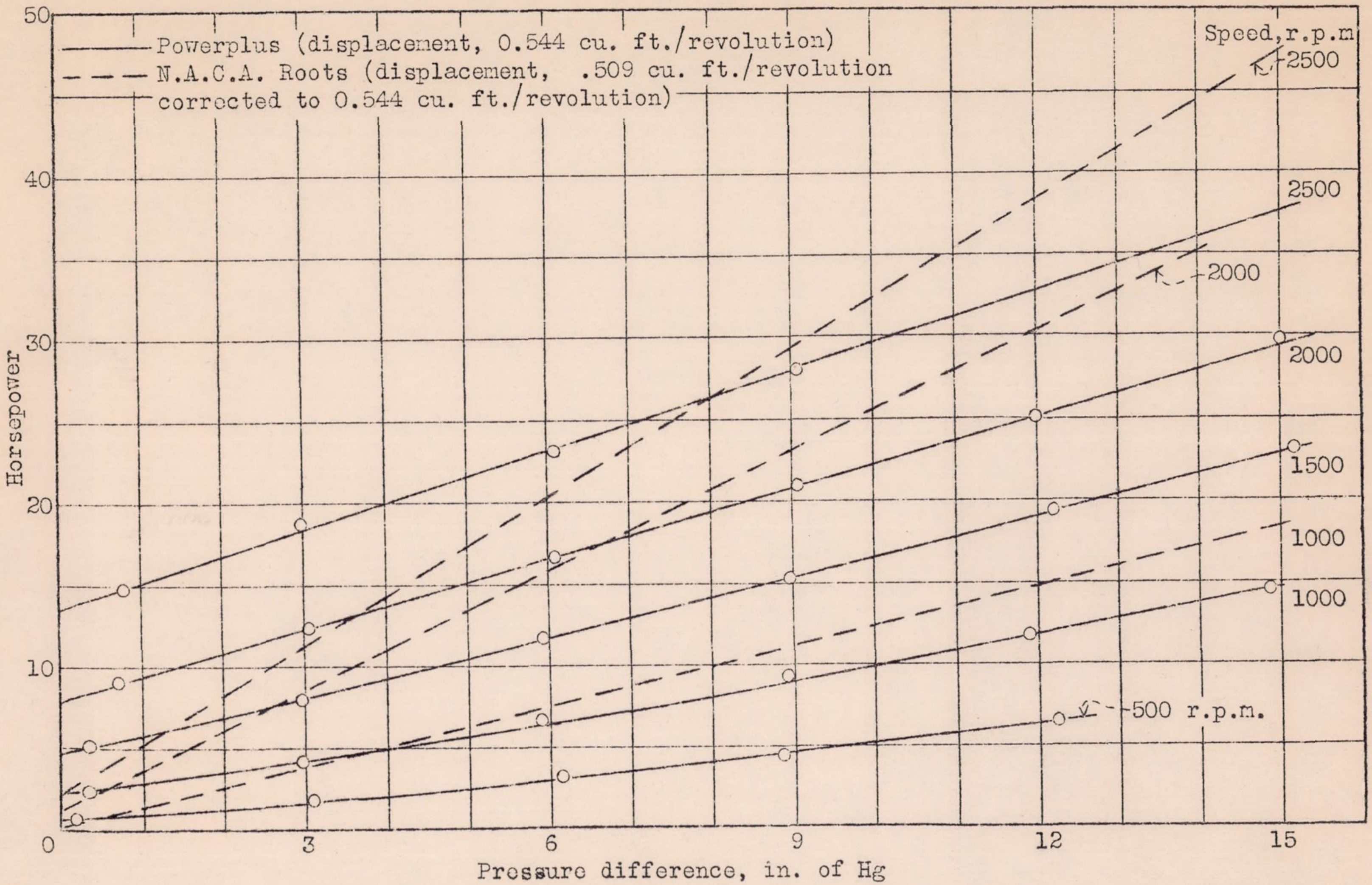


Fig.7 Horsepower required by Powerplus and N.A.C.A. Roots superchargers at various speeds and pressure differences.

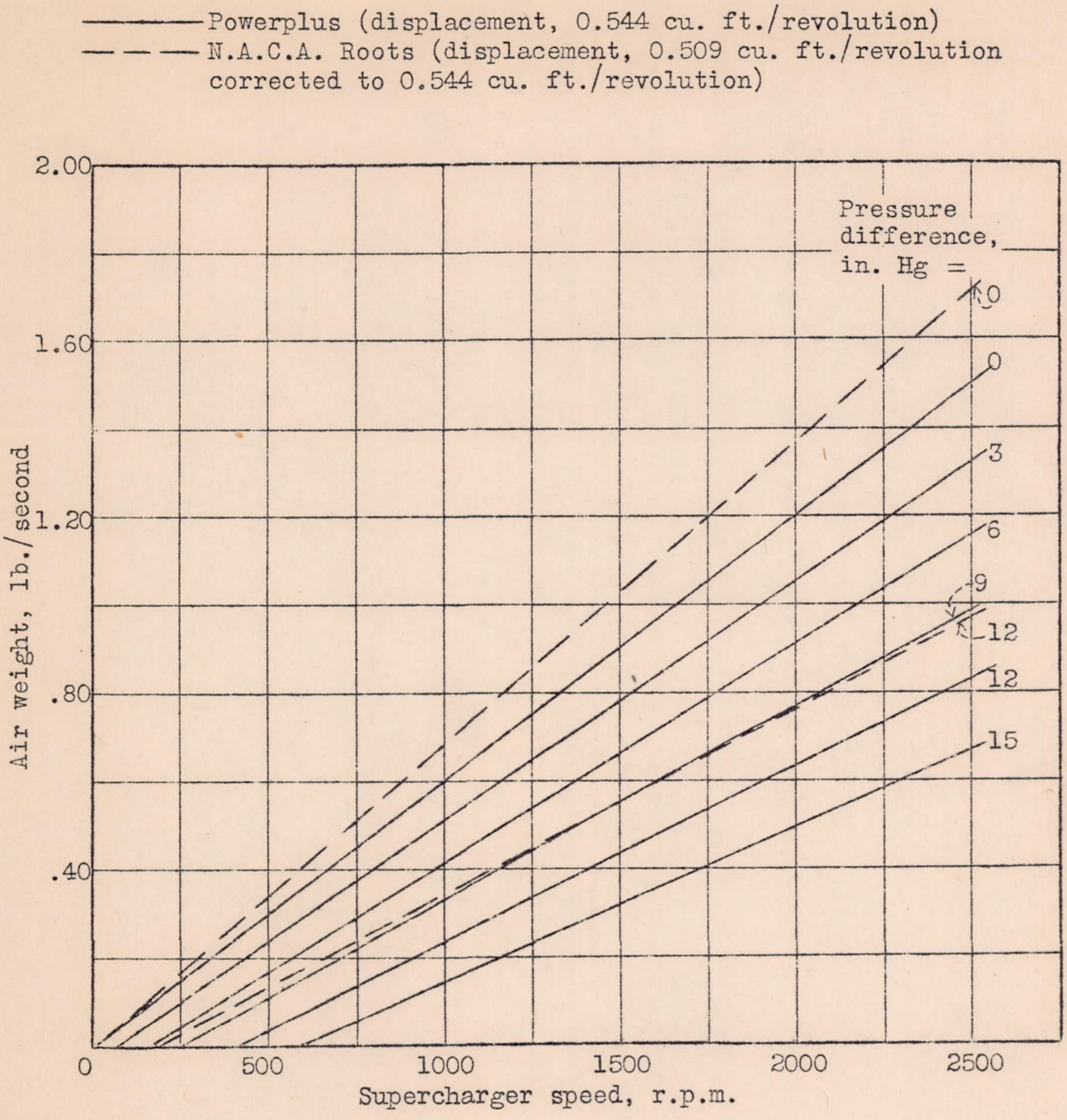


Fig.8 Weight of air delivered by Powerplus and N.A.C.A. Roots superchargers at various speeds and pressure differences. Discharge pressure at sea level.

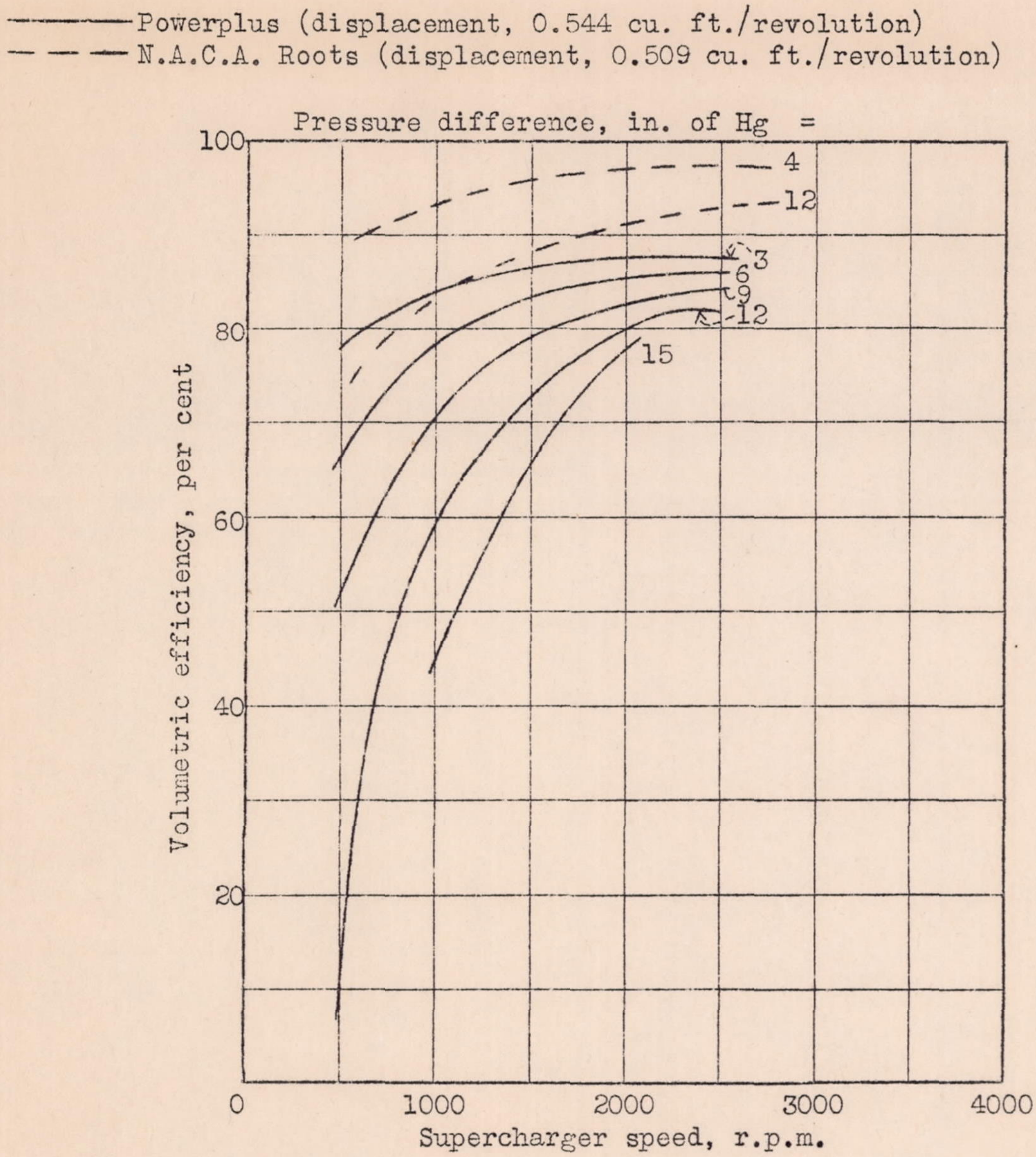


Fig.9 Volumetric efficiency of Powerplus and N.A.C.A. Roots superchargers at various speeds and pressure differences.

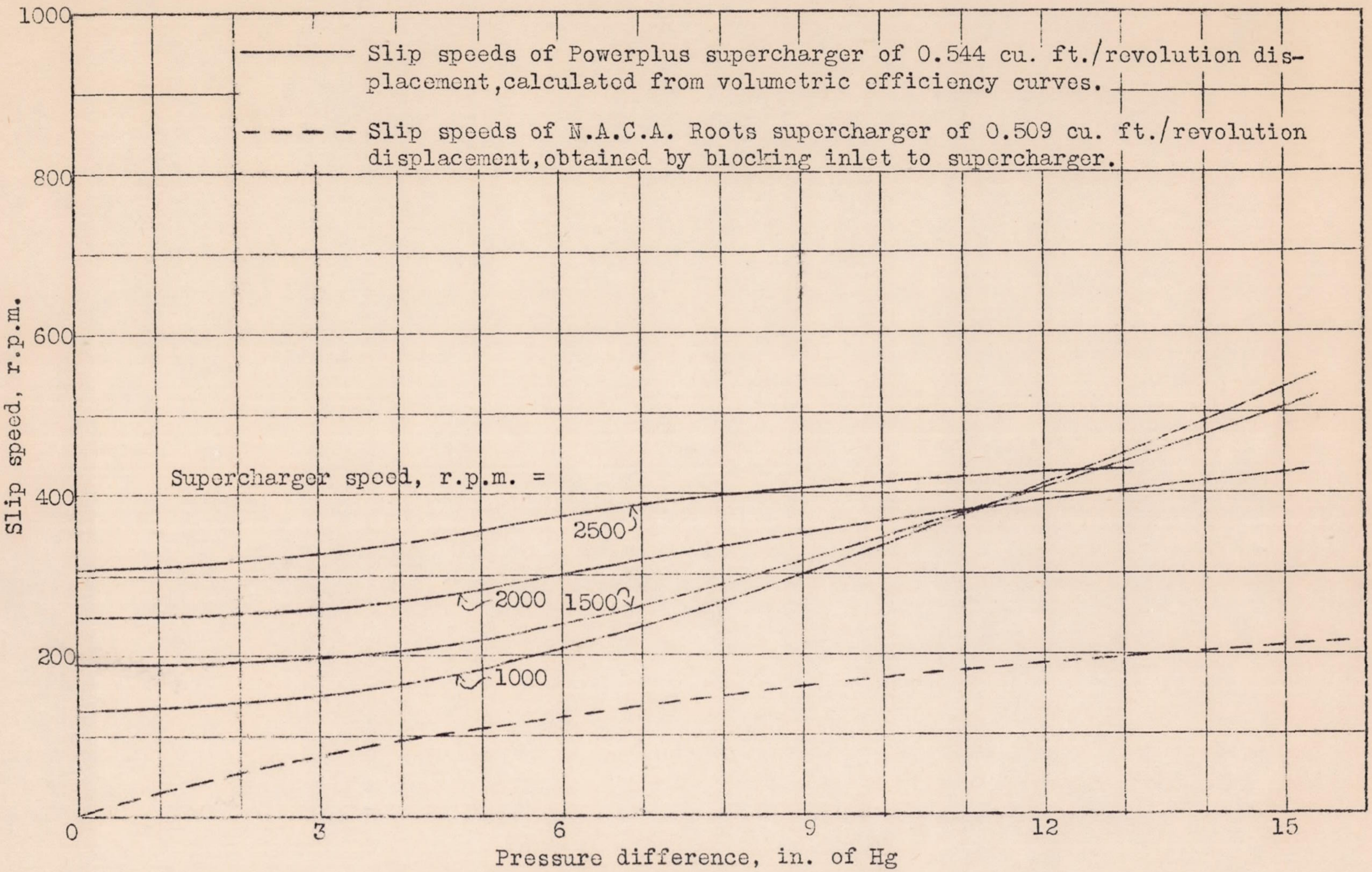
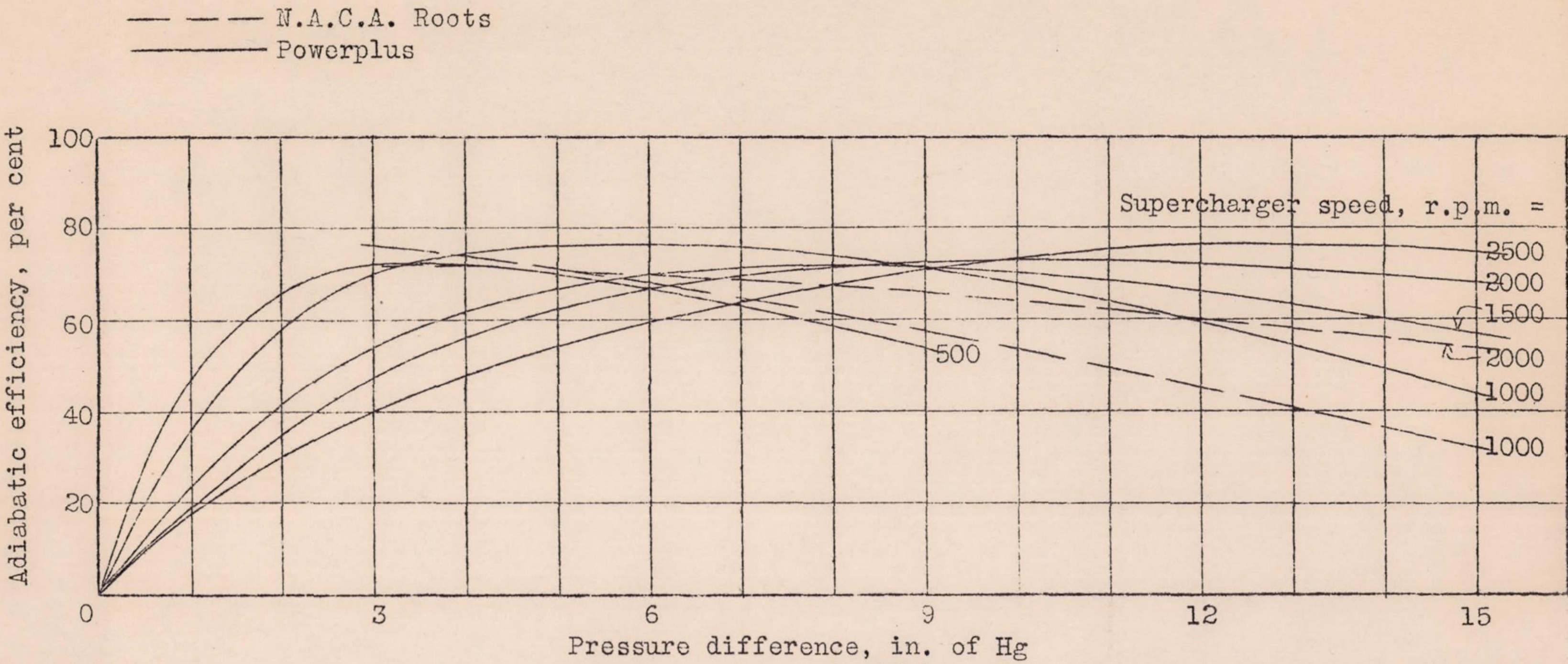


Fig.10 Slip speeds of Powerplus and N.A.C.A. Roots superchargers at various speeds and pressure differences.



$$\text{Adiabatic efficiency} = \frac{K \times \frac{1.407}{1.407-1} P_1V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{1.407-1}{1.407}} - 1\right]}{\text{Gross hp. of the supercharger}}$$

Fig.11 Adiabatic efficiancy of Powerplus and N.A.C.A. Roots superchargers at various speeds and pressure differences.