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FLIGHT INVESTIGATION OF NACA D_S COWLINGS ON THE XP-42 AIRPLANE. IV - HIGH-INLET-VELOCITY COWLING TESTED IN CLIMB WITH AND WITHOUT PROPELLER CUFFS AND IN HIGH-SPEED LEVEL FLIGHT WITHOUT PROPELLER CUFFS

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WASHINGTON

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I ANC [redacted] REPORT

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FLIGHT INVESTIGATION OF NACA D_S COWLINGS ON THE XP-42 AIRPLANE. IV - HIGH-INLET-VELOCITY COWLING TESTED IN CLIMB WITR AND WITHOUT PROPELLER CUFFS AND IN HIGH-SPEED LEVEL FLIGHT WITHOUT PROPELLER CUFFS

By J. Ford Johnston and T. J. Voglewede

SUMMARY

Hesults are presented of flight measurements of the performance and cooling characteristics of a short-nose high-inlet-velocity cowling on the XP-42 airplane for conditions of climb with and without propeller cuffs and for high speed without cuffs. This cowling is one of a series being tested at LMAL.

The airplane speed was approximately 1 mile per hour greater witnout propeller cuffs than the previously measured value with cuffs. The pressure recovery on the front of the engine averaged 0.74 airplane impact pressure at high speed without cuffs as compared with 0.80 airplane impact pressure with cuffs.

In full-power climb, at 140-miles-per-hour indicated airspeed, the pressure recoveries averaged 0.70 impact pressure with cuffs and 0.60 impact pressure without cuffs.

Oil-in and spark-plug-elbow temperatures were critical in the ground run without cuffs.

INTRODUCTION

The MACA is conducting an extensive flight investigation of several types of cowling for radial aircraft engines. The conditions so far investigated are given as follows:

Test	Type of cowling and flight condition
1	Long-nose high-inlet-velocity cowling with propeller cuffs and small cowl flaps; high speed
2	Loiig-nose high-inlet-velocity cowling with cuffs and modified cowl. flaps; climb
3	Short-nose high-inlet-velocity comling with cuffs and small cowl flaps; high speed
4	Short-nose low-inlet-velocity cowling with spinner-mounted axial-flow fan, cuff 1, and small cowl flaps; high speed
5	Short-nose low-inlet-velocity cowling with fan, cuff 1 and modified cowl flaps: climb
6	As in test 4, cuff 1 except with modified cowl flaps: high speed
7	As in test 6, but with baffle seal strips at base of cylinders removed; high speed
8	Short-nose low-inlet-velocity cowling with fan only; high speed
9	As in test 8; climb
10	Short-nose low-inlet-velocity cowling without fan or cuffs; climb
11	As in test 10; high speed
12	Short-nose low-inlet-velocity cowling with cuff 1, without fan; high speed
13	As in test 12; climb
14	Short-nose low-inlet-velocity cowling with cuff 2, without fan; climb
15	As in test 14; high speed
16	Short-nose high-inlet-velocity cowling with propeller cuffs; climb
16A	Short-nose high-inlet-velocity cowling without cuffs; climb
16B	Short-nose high-inlet-velocity cowling without cuffs; high speed

Where not otherwise noted, the tests were made with the modified cowl flaps.

The results of tests 1 and 2 are reported in reference 1. The results of test 3 are presented in reference 2; of tests 4 to 7, in reference 3; and of tests 8 to 15, in reference 4.

The present paper covers the results of tests 16, 16A, and 16B. In conjunction with reference 2, it represents a completion of the investigation contemplated for the short-nose (D_S) high-inlet-velocity cowling.

The design of the cowling and engine installation was a project of the Air-Cooled Engine-Installation Group stationed at the Laboratory. The portion of this group associated witn this project included Mr. Howard S. Ditsch, of the Curtiss-Wright Corporation, Mr. Peter Torraco, of the Republic Aviation Corporation, Mr. William S. Richards, of the Wright Aeronautical Corporation, and Mr. James R. Thompson, of Pratt & Whitney Aircraft. The Materiel Command, Army Air Forces, sponsored the investigation and supplied the XP-42 airplane. The airplane division of the Curtiss-Wright Corporation handled the construction as well as the structural and detail design of the cowling and supplied personnel to assist in the servicing and maintenance of the airplane and cowling during the tests. Pratt & Whitney Aircraft; prepared the engine and torque meter for the tests and assisted in the operation and servicing of the engine. The propeller, cuffs, and spinner were supplied by the propeller division of the Curtiss-Wright Corporation.

This paper was originally issued as a memorandum report for Army Air Forces, Materiel Command.

XP-42 AIRPLANE WITH SHORT-ROSE HIGH-INLET-VELOCITY COWLING

The airplane, engine, and cowling mere the same as described in reference 2 except that the cowl skirt had been cut for the addition of extra cowl flaps, of which the position could be changed on the ground only. The airplane. with the modified cowl flaps fixed open is shown in figure 1.

TEST APPARATUS AND PROCEDURE

The installation of the test equipment was described in reference 2. The method used for making the climb cooling tests was the same as described in references 3 and 4. For the cowling with cuffs, full-power climbs were made at indicated airspeeds of 155 and 140 miles per hour in automatic rich and at 140 miles per hour in full rich. For the cowling without cuffs, the climbs were limited to one at 155 miles per hour in automatic rich and one at 140 miles per hour in full rich.

The high-speed tests were conducted as described in reference 2 and ground cooling tests, as described in reference 4.

SYMBOLS

bhp brake horsepower

σ density ratio

η propulsive efficiency

S wing area, square feet

C_D drag coefficient

P observed pressure above free-stream static pressure, inches of water

q_c airplane impact pressure, inches of water

RESULTS

The data obtained during the high-speed runs and during the climbs are presented in tables I and II. In addition, the chief climb-test data are shown in figures 2 and 3 in the form of time histories of the climbs.

It will be noted that all temperature data for the 155-mile-per-hour climb with cuffs (flight 16-1) are missing. Analysis of the data from this flight indicated that cold-junction temperatures had not stabilized and that temperatures were uncertain within a range of about 15° F.

A leak in one of the 12 pressure-selector switches invalidated some of the engine cooling-air pressure data, as indicated by omissions in table I(a).

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DISCUSSION

Maximum Speed

The values of maximum speed and power observed during the full-throttle level runs without cuffs are plotted against density altitude in figure 4. The figure also includes the parameters $\left(\frac{V}{\sigma}\right)^{1/3}$, representative of the effective power, and $52.73\left(\frac{\eta}{C_D S}\right)^{1/3}$, representative of the airplane cleanness, as explained in references 1 and 2. The product of these two parameters is the speed of the airplane. The installation having the highest value of the parameter of airplane cleanness will evidently have the highest speed at a given power and altitude.

It was shown in reference 3 that the installation of the modified cowl flaps in the closed position caused an increase of form drag, resulting in a decrease of approximately two-thirds of 1 percent in the parameter $52.73\left(\frac{\eta}{C_D S}\right)^{1/3}$. This increase in drag is attributed to air leakage around the modified flaps and would not be present in a well-designed flap installation. Hence, for comparison with the results of previous tests with the original cowl flaps, it is desirable to increase by two-thirds of 1 percent the values of speed and $52.73\left(\frac{\eta}{C_D S}\right)^{1/3}$ obssrved in the present tests. Values corrected in this way are shown by the dashed lines of figure 4. Comparison of the corrected value of the cleanness faotor with that obtained from reference 2 for the cowling with cuffs shows an increase of approximately one-third of 1 percent, or 1 mile per hour, due to removal of the cuffs.

Pressures and Temperatures

The cooling-air pressures on the front of the engine in full-power level Plight without cuffs averaged approximately $0.74q_c$ as compared with $0.80q_c$ with cuffs for the same locations of pressure measurement. The distributions of the cooling-air pressures for each case are shown in figure 5. The pressure distributions for the cowling with cuffs are taken from reference 2. It is evident from this figure that the pattern of pressure distribution is the same in either case except for slight dissimilarities behind the engine resulting from the change in cowl flaps.

The distributions of cooling-air pressures for the full-power-climb condition are shown in figure 6, in which the points are taken from individual runs in the 140-mile-per-hour climbs at approximately 16,000 feet. Here, again, there is no apparent change in distribution due to the cuffs,

It is to be noted, particularly, that either with or without cuffs, the pressure recovery on the front of the engine in climb was less than that observed for the high-speed condition, For the runs plotted in figure 6, the pressure recovery was $0.70q_c$ with cuffs and $0.59q_c$ without cuffs. The pressure loss between the survey in the annulus and the front of the engine de-pends upon the air flow, For this reason, the loss through the annulus, in terms of q_c, is higher in the climb condition. When cuffs are used, this increased pressure loss is usually more than offset by the increased cuff loading at the lower velocity. In the present case, however, although the cuffs caused high pressures in the carburetor and oil-cooler scoops, the pressure increment at the annulus was comparatively small. The boundary layer on the spinner is believed to have blanketed an appreciable part of the narrow annular opening. This condition resulted in an energy absorption from the incoming air and *a* consequent pressure loss at the inlet, Further pressure losses were introduced by gaps between the spinner and the roots of the cuffs. At the low-pitch angles for climb, the gaps between the spinner and the trailing edges of the cuffs extended almost halfway across the annular opening.

Typical distributions of the cylinder head and barrel temperatures are shown in figure 7 for the high-speed level-flight ccndition without cuffs and in figures 8 and 9 for the climb condition with and without cuffs. The temperature-distribution patterns are evidently similar and bear little

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apparent relation to the cooling-air pressure-distribution patterns. The engine temperatures observed during these tests are of doubtful significance since the pilot reported rough engine operation at and near full throttle and the power developed, especially during the climbs, was relatively low,

Ground Cooling

Representative temperatures observed during the ground-cooling tests are shown on figure 10 for the run with cuffs and on figure 11 for the run without cuffs. It is apparent that the use of cuffs materially reduces the engine and accessory temperatures. The difference in cooling is probably greater than is indicated since excessive indicated oil-in temperatures caused the operator to throttle back to idling only 5 minutes after the start of the run without cuffs, when cylinder temperatures had not yet stabilized, Under these conditions, only the oil-in temperature exceeded the Army limit, but it is probable that the spark-plug elbow would also have gone over the Army limit after cut-off if the engine had been run at 1.400 rpm for the full 10 minutes. Of the six elbows for which temperatures were recorded, the front elbow of cylinder 11 and the rear elbow of cylinder 1 reached the same maximum of 215° F during the run without cuffs. The rear elbow was hottest during the idling period and the front elbow was hottest after out-off.

Cylinder head and barrel temperatures did not closely approach their limits in either test.

CONCLUSIONS

1. The maximum speed of the XP-42 airplane with the short-nose high-inlet-velocity cowling was about 1 mile per hour greater without propeller cuffs than with the cuffs.

2. The cooling-air pressure recoveries on the front of the engine in full-power climb at 140-miles-per-hour indicated airspeed averaged about 70 percent of airplane impact pressure with cuffs and 60 percent without cuffs, The corresponding pressure recoveries in high-speed level flight were 80 percent and 74 percent airplane impact pressure.

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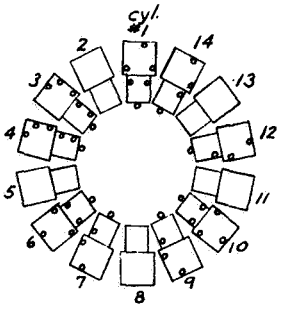
Table I(a) – Pressure Data

XP-42 Airplane

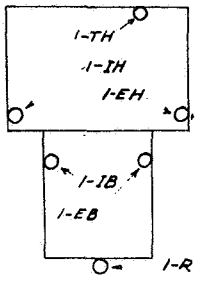
Short-Nose High Inlet Velocity Cowling

Test No - Flight No. / Run No.	16A-1					16A-2				
	1	2	3	4	5	1	2	3	4	5
True Airspeed mph	328	331	332	331	327	330	328	327	330	328
q_c impact pressure in H_2O	34.4	33.7	32.8	31.4	29.6	33.5	32.1	30.8	30.1	28.8
Atm pressure in Hg	17.13	16.38	15.69	15.07	14.47	16.38	15.75	15.10	14.47	13.92
Ambient Air Temp., °F	20	17	14	11	8	16	13	10	9	6
σ, density ratio	.619	.596	.574	.555	.536	.597	.578	.557	.535	.518
Density Altitude ft	15500	16650	17750	18800	19800	16650	17550	18700	19850	20800
R P M.	← - -				2680					→
Bhp	895	872	840	811	770	862	820	798	770	737
Manifold pressure in Hg	40.3	38.9	37.5	36.1	34.6	38.9	37.5	36.0	34.7	33.3
	← High Speed Without Cuffs →									

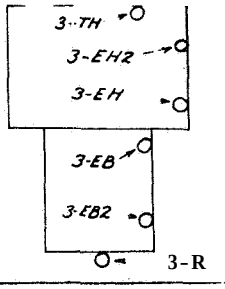
Engine Pressure Tube Locations



Cylinder no. 1



Cylinder no. 3



Method of designating tube locations for typical cylinders

		16A-1					16A-2				
		pressure ratio P/q_c									
1-R	sheltered tubes behind engine	.29	.29	.28	.28	.27	a%	. a	am	.29	.as
3-R		.28	.28	.28	.28	.27	28	a0	.27	.28	.a0
4-R		.28	28	.27	.28	27	28	28	.27	.28	ai
6-R		30	30	.30	30	.29	30	30	30	.31	30
7-17		30	.30	.30	.30	.29	.30	30	30	31	30
9 R		.32	.31	.31	.32	.31	.31	32	3a	32	.32
10-R		32	.31	.31	32	31	31	.32	32	32	.32
ia- R		.30	30	.29	.29	.28	.28	.29	.28	.29	.29
I4-R		.29	.29	.28	.28	.27	.28	.28	.28	.29	.28
L-ED	exhaust side of barrel	80	79	79	78	79	79	80	80	80	79
3-EB		.62	.61	.61	.61	.60	.62	.62	62	.62	.62
4 ED		73	72	72	72	72	72	73	72	73	72
6-EB		80	79	78	78	79	79	79	79	79	79
7-EB		72	72	72	72	72	72	73	72	73	72
9-EB		.80	79	79	79	79	80	.80	79	.80	79
10·EB		73	72	72	72	72	72	73	72	74	72
12·EB		73	72	73	72	72	72	72	72	73	72
14-EB		.71	.71	.72	71	.71	.71	.71	71	.71	.70
1 EH	exhaust side of head	83	.82	82	83	.82	.82	.83	.82	.82	81
3 EH		73	72	72	72	72	.72	72	71	72	71
4· EH		82	.82	82	81	.82	.81	81	.81	82	81
6 EH		73	72	72	72	72	71	71	72	73	71
7 EH		78	77	78	78	77	.77	77	78	78	76
9· EH		76	76	76	76	75	.76	75	76	76	76
10·EH		84	82	83	.82	.81	.82	83	.83	82	81
12·EH		.80	79	79	79	78	.78	79	78	79	78
14·EH		.79	.78	77	.77	.78	.77	.78	.77	.78	.77
1 TH	top of head	70	.69	.69	70	.69	.69	.69	.69	70	70
3·TH		71	71	70	71	71	70	70	70	71	70
4 TH		.65	.64	.65	.65	.65	.64	.65	.65	.65	.65
6·TH		.66	.65	.65	.66	.66	.65	.66	.65	.66	.66
7 TH		76	75	76	76	75	75	75	74	76	75
9 TH											
10·TH											
12·TH											
14·TH											
1 IH	intake side of head										
6-IH											
10 IH											
1 IB	intake side of barrel	.69	69	.69	.68	.69	.68	.68	70	71	70
6 IB		80	79	.80	80	79	79	79	.80	79	78
10·IB		76	75	.14	.74	.73	.74	.74	.74	75	.73
3-EH2		78	78	77	78	77	78	77	77	78	77
4-EH2		.80	79	79	79	79	79	79	79	79	79
3 EB2		54	54	55	.55	.54	54	.55	.56	56	.56
4 EB2		.63	.63	.65	.65	.64	.64	.64	.65	.65	.66

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Table I(a) (concluded)

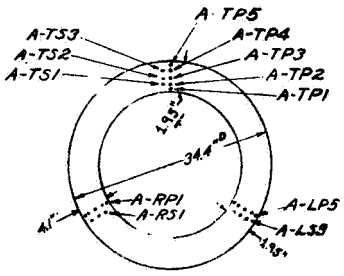
	16B-1				16B-2				16-1				16-2				16-3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Indicated Airspeed mph	158	155	155	154	140	140	138	138	156	156	157	158	143	142	140	140	139	142	138	138
q_c	12.3	11.8	11.8	11.6	9.7	9.7	9.4	9.4	12.0	12.0	12.2	12.3	10.0	9.9	9.6	9.7	9.5	9.9	9.4	9.3
Pressure Altitude Range ft	4900-5900	8800-9700	15700-16400	19450-20000	8650-9400	13850-14300	16950-17300	19200-19500	6950-7950	10950-11900	14650-15450	19400-19750	8750-9700	11950-12800	16150-16900	18450-19100	4250-5450	8750-9750	15200-15800	19150-19850
Av. Free Air Temp °F	49	37	16	3	39	24	13	4					39	27	16	8	61	41	20	7
Av. bhp	820	860	770	675	875	760	665	610	870	890	810	705	830	860	765	710	890	830	740	610
Av. Manifold Pressure	39.8	40.0	34.5	30.0	42.3	36.3	32.3	29.5	40.0	39.8	36.1	30.5	38.8	38.7	34.0	31.2	43.0	40.0	35.0	29.5
R P M	2530								2520				2525				2500			
	Auto Rich Climb				Full Rich Climb				Auto Rich Climb								Full Rich Climb			
	Without Cuffs								With Cuffs											
Tube designation	*pressure ratio, P/q_c*																			
Sheltered tubes behind engine — 1-R	-.32	-.34	-.33	-.34	-.38	-.34	-.37	-.37	-.31	-.28	-.29	-.28	-.32	-.30	-.30	-.30	-.38	-.36	-.38	-.39
3-R	-.28	-.30	-.31	-.29	-.33	-.32	-.35	-.35	-.27	-.25	-.26	-.25	-.28	-.27	-.28	-.28	-.31	-.32	-.31	-.33
4-R	-.29	-.31	-.33	-.31	-.35	-.34	-.37	-.37	-.29	-.27	-.27	-.27	-.27	-.28	-.27	-.27	-.34	-.34	-.33	-.33
6-R	-.19	-.20	-.24	-.22	-.26	-.25	-.28	-.28	-.17	-.16	-.16	-.16	-.18	-.16	-.18	-.18	-.19	-.20	-.22	-.26
7-R	-.19	-.20	-.22	-.22	-.26	-.25	-.28	-.28	-.16	-.16	-.17	-.16	-.18	-.16	-.17	-.18	-.19	-.21	-.22	-.23
9-R	-.20	-.22	-.24	-.22	-.26	-.25	-.28	-.28	-.20	-.19	-.18	-.18	-.22	-.21	-.21	-.21	-.26	-.25	-.26	-.26
10-R	-.22	-.24	-.24	-.23	-.28	-.27	-.30	-.30	-.20	-.20	-.19	-.19	-.24	-.21	-.21	-.23	-.27	-.27	-.28	-.29
12-R	-.32	-.34	-.33	-.31	-.38	-.37	-.40	-.37	-.31	-.28	-.28	-.27	-.32	-.29	-.30	-.30	-.36	-.36	-.36	-.36
14-R	-.32	-.34	-.33	-.31	-.38	-.37	-.37	-.37	-.31	-.29	-.29	-.28	-.32	-.30	-.30	-.29	-.36	-.36	-.36	-.39
exhaust side of barrel — 1-EB	.74	.75	.71	.71	.75	.69	.67	.69	.82	.81	.78	.78	.77	.78	.79	.77	.80	.73	.78	.73
3-EB	.38	.36	.37	.36	.36	.35	.34	.34	.34	.48	.46	.45	.48	.48	.48	.47	.52	.42	.44	.41
4-EB	.61	.59	.58	.60	.62	.58	.55	.55	.65	.62	.62	.62	.68	.68	.66	.67	.72	.65	.66	.63
6 EB	.76	.75	.73	.75	.77	.76	.71	.71	.78	.75	.73	.75	.78	.76	.78	.76	.80	.75	.76	.78
7 EB	.65	.61	.58	.60	.64	.61	.57	.57	.78	.79	.74	.69	.79	.80	.78	.75	.80	.79	.78	.76
9 EB	.80	.78	.75	.75	.77	.78	.74	.74	.73	.76	.74	.73	.78	.78	.84	.76	.76	.73	.73	.73
10-EB	.61	.59	.58	.60	.62	.63	.57	.57	.67	.69	.67	.63	.73	.73	.75	.72	.71	.69	.66	.68
12 EB	.62	.60	.58	.62	.58	.57	.53	.53	.73	.72	.69	.66	.82	.84	.76	.73	.85	.73	.76	.66
14-EB	.65	.62	.60	.62	.64	.63	.58	.58	.72	.69	.71	.65	.72	.76	.74	.72	.80	.67	.72	.67
exhaust side of head — 1 EH	.74	.73	.71	.72	.69	.65	.63	.68	.85	.77	.80	.78	.72	.74	.74	.74	.78	.70	.74	.72
3 EH	.60	.56	.53	.56	.60	.57	.53	.51	.73	.68	.68	.64	.70	.72	.68	.69	.76	.71	.68	.62
4 EH	.77	.75	.73	.75	.78	.74	.70	.70	.84	.84	.79	.80	.85	.85	.86	.83	.90	.85	.83	.83
6-EH	.63	.64	.58	.62	.62	.59	.58	.58	.73	.72	.68	.66	.68	.68	.66	.63	.70	.65	.66	.64
7-EH	.74	.73	.68	.69	.73	.70	.65	.68	.83	.80	.78	.77	.82	.83	.83	.79	.83	.82	.78	.77
9-EH	.70	.70	.69	.68	.70	.69	.64	.64	.66	.67	.68	.68	.68	.72	.73	.69	.71	.64	.69	.63
10-EH	.80	.80	.75	.78	.81	.80	.76	.73	.95	.91	.90	.86	.93	.88	.96	.91	1.05	.94	.96	.92
12 EH	.72	.70	.69	.70	.68	.66	.64	.66	1.02	.96	.90	.83	1.16	1.13	1.09	1.05	1.24	1.07	1.05	1.00
14-EH	.80	.75	.74	.76	.84	.82	.81	.73	.86	.87	.84	.80	.92	.92	.91	.89	.97	.89	.85	.80
top of head — 1-TH	.57	.55	.53	.55	.55	.56	.52	.52	.62	.59	.62	.59	.73	.63	.58	.62	.69	.62	.60	.60
3 TH	.61	.57	.55	.57	.59	.58	.55	.52	.64	.63	.60	.59	.62	.62	.66	.64	.67	.64	.63	.63
4-TH	.48	.46	.44	.47	.47	.44	.46	.46	.53	.53	.52	.50	.53	.56	.56	.52	.53	.52	.51	.51
6 TH	.50	.48	.46	.49	.45	.44	.46	.46	.53	.54	.51	.50	.51	.54	.56	.53	.52	.49	.49	.49
7-TH	.72	.70	.66	.68	.70	.66	.62	.64	.77	.74	.74	.72	.74	.74	.74	.73	.78	.76	.70	.72
9-TH									.78	.77	.78	.75	.82	.80	.83	.82				
10-TH									.58	.54	.59	.56	.57	.60	.62	.58				
12-TH									.59	.58	.62	.58	.68	.66	.66	.65				
14-TH									.52	.53	.55	.50	.62	.62	.59	.57				
intake side of head — 1-IH									.80	.82	.81	.78	.87	.88	.90	.88				
6-IH									.82	.80	.86	.81	.83	.85	.88	.84				
10-IH									.93	.92	.94	.90	1.01	.98	.98	.96				
intake side of barrel — 1 IB	.58	.59	.54	.56	.62	.61	.58	.54	.70	.69	.70	.68	.75	.76	.74	.73	.74	.65	.70	.64
6 IB	.79	.78	.76	.77	.79	.78	.74	.77	.83	.80	.80	.78	.80	.85	.83	.80	.91	.77	.85	.81
10-IB	.62	.59	.58	.61	.60	.59	.52	.56	.76	.72	.73	.71	.80	.80	.78	.76	.83	.72	.74	.72
3-EHR	.69	.67	.64	.66	.64	.63	.61	.61	.74	.69	.41	.68	.70	.72	.66	.72	.76	.70	.71	.71
4-EHR	.69	.67	.65	.66	.69	.63	.63	.61	.77	.75	.76	.72	.77	.79	.78	.75	.78	.74	.76	.73
3-EBR	.28	.27	.25	.27	.27	.28	.24	.24	.34	.34	.34	.34	.32	.37	.37	.35	.37	.29	.32	.31
4-EBR	.52	.50	.48	.52	.53	.50	.49	.51	.47	.45	.48	.49	.52	.52	.53	.52	.50	.49	.50	.51

Table I(b) - Pressure Data

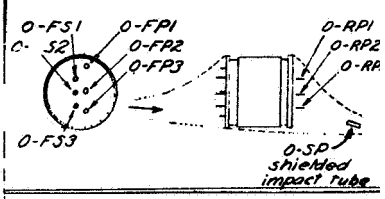
XP-42 Airplane

Short-Nose High-Inlet-Velocity Cowling

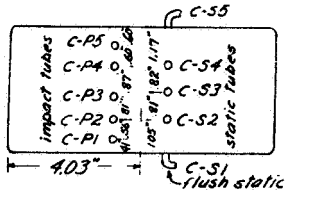
Test No - Flight No. / Run No.	16A-1 1	2	3	4	5	16A-2 1	2	3	4	5
True Airspeed, mph	328	331	332	331	327	330	328	327	330	328
q_c, impact press, in H_2O	34.4	33.7	32.8	31.4	29.6	33.5	32.1	30.8	30.1	28.8
Atm Pressure, in H_2O	17.13	16.38	15.69	15.07	14.47	16.38	15.75	15.10	14.47	13.92
Ambient Air Temp °F	20	17	14	11	8	16	13	10	9	6
σ, density ratio	.619	.596	.574	.555	.536	.597	.578	.557	.535	.518
Density Altitude, ft	15500	16650	17750	18800	19800	16650	17550	18700	19850	20800
R P M	2680									
Bhp.	895	872	840	811	770	862	820	798	770	737
Manifold Press., in. Hg.	40.3	38.9	37.5	36.1	34.6	38.9	37.5	36.0	34.7	33.3
	High Speed Without Cuffs									



Location of Pressure Tubes in Annulus



Oil Cooler Pressure Tube Locatio



Carburetor Scoop

Pressure ratio, p/p_c

			16A-1 1	2	3	4	5	16A-2 1	2	3	4	5
A TP1	impact tubes	Top Survey Rake	.86	.86	.86	.85	.86	.86	.86	.86	.87	.85
2			.95	.94	.94	.94	.94	.93	.93	.93	.93	.93
3			.93	.93	.92	.92	.92	.92	.92	.92	.93	.91
4			.90	.89	.89	.89	.88	.88	.88	.88	.89	.87
5			.72	.71	.71	.70	.70	.70	.69	.70	.71	.70
A-TS1	static tubes		.62	.62	.62	.62	.62	.62	.62	.62	.64	.62
2			.59	.59	.59	.59	.59	.59	.59	.60	.61	.60
3			.64	.64	.64	.64	.65	.63	.64	.63	.65	.65
A-RP1	impact tubes	Right Survey	.70	.69	.70	.71	.70	.70	.70	.69	.70	.70
2			.84	.83	.83	.84	.84	.82	.83	.82	.82	.82
3			.90	.89	.89	.89	.90	.90	.89	.89	.90	.88
4			.92	.91	.92	.91	.90	.91	.91	.91	.91	.91
5			.83	.83	.82	.82	.83	.82	.81	.82	.81	.81
A-RS1	static tubes		.62	.62	.62	.62	.62	.61	.62	.62	.63	.62
2			.64	.64	.63	.64	.64	.63	.64	.64	.64	.64
3			.67	.67	.66	.67	.67	.66	.66	.66	.67	.66
A-LP1	impact tubes	Left Survey	.74	.73	.73	.73	.73	.72	.73	.73	.73	.72
2			.84	.85	.84	.85	.84	.83	.83	.83	.85	.83
3			.94	.94	.93	.94	.93	.94	.93	.94	.94	.92
4			.96	.95	.95	.95	.95	.95	.95	.96	.96	.95
5			.87	.87	.85	.87	.86	.86	.86	.86	.87	.85
A-LS1	static tubes		.67	.67	.67	.67	.67	.67	.67	.67	.68	.67
2			.65	.65	.66	.65	.65	.64	.65	.65	.66	.65
3			.64	.64	.64	.64	.64	.64	.63	.63	.64	.64
O-FP1	impact tubes	Front Survey	.96	.96	.96	.95	.95	.95	.95	.94	.96	.95
2			1.00	.99	.99	.99	.99	.99	.98	.99	1.00	.98
3			1.00	.99	.99	.99	.99	.98	.99	.99	.98	.98
O-FS1	static tubes		.86	.84	.84	.84	.84	.84	.84	.84	.84	.83
2			.90	.89	.89	.89	.89	.89	.89	.88	.89	.88
3			.90	.89	.90	.90	.90	.90	.89	.89	.90	.89
O-RP1	impact tubes	Rear Survey	.65	.65	.64	.65	.64	.65	.64	.64	.66	.64
2			.60	.60	.59	.59	.59	.59	.60	.60	.61	.59
3												
O-SP			.57	.57	.56	.57	.57	.56	.57	.57	.58	.57
C-P 1	Impact tubes		.98	.97	.97	.97	.97	.96	.97	.96	.97	.96
2			.99	.98	.98	.97	.98	.98	.97	.97	.99	.97
3			1.01	.99	.99	.99	.99	.98	.98	1.00	1.00	.98
4			1.01	1.00	1.00	1.00	1.00	.99	.99	1.00	.99	.98
5			1.01	1.00	.99	1.00	1.00	.99	.99	.99	1.00	.98
C-S 1	Static tubes		.81	.81	.82	.81	.81	.81	.81	.81	.81	.81
2			.79	.78	.79	.79	.78	.78	.78	.77	.79	.78
3			.77	.77	.77	.77	.77	.76	.76	.76	.77	.76
4			.76	.76	.76	.76	.76	.76	.75	.75	.76	.76
5												
C-TH	Impact pressure in carb throat		.81	.81	.82	.81	.81	.81	.80	.80	.82	.80

L-285

Table I(b) (concluded)

Test No. - Flight No. / Run No.	16D-1				16D-2				16-1				16-2				16-3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Indicated Airspeed, mph	158	155	155	154	140	140	138	138	156	156	157	158	143	142	140	140	139	142	138	138
q_c	12.3	11.8	11.8	11.6	9.7	9.7	9.4	9.4	12.0	12.0	12.2	12.3	10.0	9.9	9.6	9.7	9.5	9.9	9.4	9.3
Pressure Altitude	4900-	8800-	13700-	19450-	8650-	13850-	16950-	19300-	6850-	10950-	14650-	19400-	8750-	11950-	16150-	18450-	4250-	8750-	15200-	19150-
Range, ft	5900	9700	16400	20000	9400	14300	17300	19500	7950	11950	15450	19750	9700	12800	16900	19100	5450	9750	15800	19850
Average Free Air Temp, °F.	49	37	16	3	39	24	13	4					39	27	16	8	61	41	20	7
Average bhp	820	860	770	675	875	760	665	610	870	890	810	705	830	860	765	710	890	830	740	610
Average Manifold Press.	39.8	40.0	34.5	30.0	42.3	36.3	32.3	29.5	40.0	39.8	36.1	30.5	38.8	38.7	34.0	31.2	43.0	40.0	35.0	29.5
R P M.	2530								2520				2525				2500			
	Auto Rich Climb				Full Rich Climb				Auto Rich Climb								Full Rich Climb			
	Without Cuffs								With Cuffs											
Tube designation	pressure ratio, P/q_c																			
Annulus — Top Survey — A-TP1	85	.85	.81	.84	.86	.82	78	78	.92	.92	.90	.87	.88	.91	.90	.88	.92	Ti	91	.as
2	94	91	91	.90	93	.89	.87	.87	1.05	1.01	1.02	1.00	.99	1.02	1.01	1.01	1.12	1.00	1.03	99
3	.93	91	.89	90	.94	93	88	.88	1.01	98	.94	.94	.98	9%	97	98	1.09	99	.98	1.00
4	.89	.86	.83	84	.87	.86	.81	.81	93	.91	.89	.88	.90	92	93	.91	.sa	90	90	.89
5	.61	.59	.58	.58	.60	.59	.56	.56	.62	.60	.62	.60	.58	.bD	.62	.60	,hi	54	.56	58
A-TS1	.42	.42	.40	43	.42	.43	43	.40	.49	.52	.50	.49	.sa	.55	54	53	.55	.50	.47	4%
2	.35	34	.34	37	34	.37	.34	.34	.40	.40	.43	.41	.41	42	.45	.43	.37	39	39	.39
3	.43	.46	.44	.47	.45	.4b	.44	.44	.54	.53	.50	.53	.57	.56	.54	.54	.60	.53	.53	.53
Annulus — Right Survey — A-RP1	72	70	.66	.68	72	.66	,b4	.66	.%4	.80	76	14	79	77	73	73	92	.80	.84	74
2	91	.88	86	87	90	87	.83	85	1.07	9%	1.00	94	1.00	97	97	96	L13	98	1.03	99
3	97	92	91	90	96	.95	.88	.90	1.10	1.10	1.02	.97	1.00	1.03	1.04	98	1.14	1.10	1.06	1.09
4	94	.95	92	.93	1.00	.95	90	90	94	1.06	1.03	1.01	1.07	1.00	1.05	1.01	1.14	1.07	1.07	1.03
5	79	75	73	75	77	.74	72	72	.86	.a5	85	aa	87	.87	87	.83	45	79	83	81
A-RS1	.44	.42	.40	.43	.40	.41	40	.38	.41	.39	41	.41	31	.39	40	40	.36	33	34	3b
2	46	.45	.43	45	.42	.45	.43	43	.44	41	.43	.43	.40	.41	44	.42	35	35	.37	.39
3	.48	.48	.48	.49	.50	.48	.48	.46	.4m	.40	.49	.48	.46	.44	.48	.46	.44	.4b	.41	.49
Annulus — Left Survey — A-LP1	76	79	74	76	.76	.80	78	76	15	79	81	79	.82	1.02	85	1.01	82	76	82	77
2	94	92	91	93	97	.96	95	.89	96	96	93	92	.96	.95	93	93	.98	98	93	94
3	1.02	1.02	98	97	1.02	1.03	1.00	98	1.01	1.04	1.03	1.00	1.02	1.04	1.07	1.02	1.08	1.04	1.04	1.05
4	1.00	1.02	.96	97	1.02	1.01	98	4b	1.01	1.01	1.02	1.01	1.04	1.08	1.08	1.04	1.12	1.00	1.03	1.00
5	79	76	76	78	77	73	77	72	.87	.85	.82	.82	86	.85	83	82	90	85	.81	81
A-LS1	.51	.48	.49	.50	,S0	.47	.47	.45	.58	.56	.54	.55	.57	.57	50	57	.46	54	.55	.55
2	.47	.47	.43	.47	.44	.45	.34	.43	.56	.54	.54	.54	.56	.58	.58	56	.46	52	.50	53
3	.43	.42	.41	.44	.39	.40	.39	.39	.49	.51	.52	.53	.46	.49	.51	.48	.48	.48	.49	.47
Oil Cooler — Front — O-FP1	.84	.86	.83	87	.85	.81	79	79	1.12	1.17	1.14	1.10	1.25	1.28	1.23	1.16	1.26	1.18	1.18	1.08
2	.87	.88	.86	.89	.85	.86	.82	.82	1.17	1.21	1.18	1.12	1.28	1.34	1.30	1.22	1.35	1.20	1.23	1.15
3	.87	.88	.86	.89	.87	.86	.84	.84	1.19	1.21	1.18	1.12	1.28	1.32	1.27	1.19	1.40	1.22	1.21	1.17
O-FS1	.67	.65	.65	69	.65	.63	.61	.61	95	.98	.98	.92	1.02	1.03	1.05	.97	1.01	1.01	91	.95
2	72	70	.70	72	.69	70	.68	.68	94	97	98	.93	1.02	1.04	1.04	.99	1.05	1.00	99	.9b
3	.70	.70	.70	.72	.69	.70	.68	.68					1.06	1.09	1.07	1.01	1.06	1.02	1.01	.9b
Oil Cooler — Rear — O-RP1	.as	as	.27	.28	.27	.26	.24	.24	.50	.46	.45	.41	50	.49	.48	47	.53	4b	.45	41
2	.21	.20	.20	.22	.21	.20	18	18	.33	.34	.33	.29	.35	.37	.38	33	.35	35	.32	3a
3																				
O-SP	.18	.18	.1b	.19	.16	.16	.13	.13	.32	.34	.33	.27	.37	.39	.38	.35	.35	.33	.3a	.30
Carburetor Scoop — impact tubes — C-P1	9%	95	93	96	91	92	.89	.89	1.23	1.17	1.17	1.17	1.14	1.17	1.16	1.11	1.23	1.17	1.11	L0?
2	98	.98	.97	97	95	94	93	.93	1.25	1.21	1.21	1.21	1.19	1.22	1.17	1.15	i.30	1.19	1.19	1.1(
3	.98	.98	.97	.97	91	.96	93	.93	1.28	1.21	1.21	1.21	1.22	1.25	1.22	1.19	i.37	1.19	1.20	1.1[illegible]
4	98	.98	.99	99	95	96	.95	.93	1.31	1.21	1.21	1.21	1.22	1.25	1.23	1.20	1.40	1.19	1.20	1.1[illegible]
5	.98	.95	.97	.97	.95	.96	.93	.95	1.29	1.21	1.21	1.21	1.25	1.25	1.23	1.21	1.39	1.19	1.18	1.1[illegible]
Carburetor Scoop — static tubes — C-S1	.67	.61	.61	.67	.45	.46	.48	.48	94	.80	.80	.80	78	75	.76	75	91	76	73	71
2	.63	.53	.58	61	38	.42	.44	.46	87	74	74	74	.71	.68	71	72	.83	.55	.67	.66
3	.b0	51	.53	.59	.35	.38	.40	.45	.88	73	73	73	.66	.64	.65	.66	76	.68	.60	.64
4	.60	49	.51	.59	.35	36	.37	40	.85	73	73	73	70	.60	.65	.64	74	6%	.60	62
5																				
C-TH	.b?	.59	58	.67	.41	.44	.44	48	93	81	.80	78	.79	73	73	73	.Is	77	I0	68

Table I.. Temperature Data

Short-Nose-High-Inlet Velocity Cowling	Run No.	1	2	3	4	5	16A-2 1	2	3	4	5
	True Airspeed mph	328	331	33a	331	327	330	328	327	330	328
	q_c, impact press, in H_2O	34.4	33.1	32.8	31.4	29.6	33.5	32.1	30.8	30.1	28.8
	Atm Pressure, in Hg.	17.13	16.38	15.69	15.07	14.4'	16.38	15.75	15.10	14.47	13.92
	Ambient Air Temp °F	20	17	14	11	8	16	13	10	9	6
	σ, density ratio	.619	59b	574	555	.536	.597	578	.557	.535	518
	Density Altitude ft	15500	16650	17750	18800	19900	16650	17550	18700	19850	20800
		2680									
	Manifold Press, in Hg	895	872	840	811	770	862	820	798	770	737
		40.3	38.9	37.5	36.1	34.6	38.9	37.5	36.0	34.7	33.3
		High Speed Without Cuffs									
Cylinder No. - Point of Measurement		Temperature °F									
1 - gasket thermocouple at rear spark plug		356	351.	361	367	31%	37d	373	378	382	393
2 -		359	359	367	372	385	382	384	386	391	400
3 -		367	367	372	374	387	384	384	389	391	400
4 -											
5 -		384	385	389	391	400	400	402	402	404	411
6 -		356	359	3C3	365	3b9	3b9	371	313	31b	382
7 -		387	396	393	393	398	404	402	404	404	411
8 -		374	369	314	37b	383	3Sb	386	3U9	391	398
9 -		372	376	378	380	387	3ab	386	389	393	too
10		391	391	398	400	407	395	404	40b	409	415
11		383	383	387	395	404	391	395	395	399	411
12		376	380	383	389	398	391	395	395	400	406
13		383	387	390	396	405	396	399	402	405	415
14		378	383	384	391	402	398	400	402	404	411
1 - rear ℄ flange at base of cylinder											
2											
3		288	288	288	291	295	297	297	297	299	301
4		284	282	286	286	291	292	292	292	294	297
5		273	273	275	275	277	279	281	281	281	283
6		288	288	288	291	295	292	294	294	297	299
7											
8		280	284	288	288	293	290	292	290	294	294
9		295	293	295	297	299	299	299	299	301	305
10		302	302	304	304	308	305	308	308	310	312
11		282	282	282	286	291	283	288	286	290	292
12		299	299	302	304	308	303	308	308	310	312
13		286	286	288	293	297	290	294	294	297	299
14		297	297	299	302	306	303	305	305	308	310
10 intake port		213	213	213	213	215	216	219	214	219	219
Mixture at blower rim		155	151	153	150	150	160	156	155	156	156
Fuel on suction side of pump		74	75	78	78	84	78	81	81	84	91
" " pressure " " "		77	78	81	84	87	84	84	84	84	94
" in carburetor float chamber											
11 - front spark plug elbow		46	42	42	36	36	41	41	38	37	31
11 rear " " "		93	91	90	90	90	94	94	91	91	91
Recorded free air		38	35	32	29	26	34	31	28	27	24
Air in carburetor scoop		39	38	36	32	29	37	34	31	31	27
" at top annular rake											
" in front of cylinder #1		43	42	39	36	36	41	41	35	34	31
" behind cyl #1		158	160	163	163	172	163	165	168	172	178
" at exit of oil cooler		68	65	61	58	58	64	b4	61	61	61
Oil-in line		133	135	135	132	135	137	133	133	137	133
Oil out		203	201	203	203	203	208	207	206	207	207
Accessory compartment		105	107	106	103	106	108	107	107	107	107
Left magneto		96	97	97	97	97	101	104	100	101	98
Pilot's cockpit		68	75	78	75	71	71	74	74	74	78
Recording instrument compartment		68	71	71	68	68	68	71	71	71	71

Table II (concluded)

	16B-1				16B-2				16-1				16-2				16-3			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Indicated Airspeed, mph	157	155	155	155	141	138	138	138	158	157	155	156	144	144	140	144	140	138	138	156
q_c	12.1	12.0	11.8	11.8	9.8	9.4	9.4	9.4	12.2	12.1	11.8	12.0	10.0	10.0	9.6	10.2	9.6	9.4	9.4	12.0
Pressure Altitude	4300-	9450-	15600-	19050-	4550-	10350-	14950-	18700-	5500-	10600-	15000-	18700-	6200-	10850-	15800-	19650-	4750-	10600-	16650-	20250-
Range, ft	5800	11000	16700	19950	6550	11900	16300	19650	7350	12500	16250	19600	7550	12400	17150	20300	6500	12150	17950	20300
Average free air temperature, °F	50	35	16	4	48	33	19	6					50	30	16	3	57	32	15	5
Average bhp	820	860	760	680	910	840	710	615	860	890	800	720	860	870	770	670	890	830	670	580
Average Manifold pressure	39.9	39.9	34.3	30.2	43.0	40.2	34.0	30.0	39.9	39.9	35.2	30.7	39.5	39.8	34.0	29.5	43.0	40.0	32.2	29.5
R.P.M	2530								2520				2525				2500			
	Auto Rich Climb				Full Rich Climb				Auto Rich Climb								Full Rich Climb			
	Without Cuffs								With Cuffs											
Cyl. No.-Point of Measurement	Temperature, °F																			
1 - Rear sp. plug gasket	371	376	371	369	373	358	321	297					389	393	389	384	373	359	311	291
2	373	378	369	365	371	353	323	303					393	393	391	382	366	351	309	291
3	378	382	380	376	378	360	338	323					400	405	400	393	382	359	329	311
4	382	373											400	402	391	382	375	355	325	307
5	395	400	395	393	400	389	384	367					411	418	418	409	397	379	373	355
6	362	369	371	367	362	349	341	323					387	389	389	382	362	344	334	336
7	387	393	398	391	395	391	389	378					407	413	420	418	390	377	375	359
8	371	378	384	380	376	371	371	358					387	391	391	387	364	355	353	340
9	378	382	395	391	382	380	382	371					405	407	416	411	386	373	377	362
10	387	395	408	402	389	382	382	369					409	411	422	413	377	371	375	359
11	380	386	400	393	385	378	373	358					407	409	416	413	384	368	368	355
12	376	382	389	384	378	371	358	336					398	400	402	400	375	358	344	329
13	385	391	391	388	386	369	332	311					398	410	413	407	381	367	329	314
14	384	393	391	389	387	365	332	308					409	407	407	402	384	354	320	303
1 - Rear & barrel flange																				
2																				
3	281	288	288	286	281	279	272	261					290	294	294	292	280	276	265	258
4	279	290	290	286	279	279	272	263					290	294	292	288	278	274	263	253
5	266	272	272	268	266	266	263	259					270	276	276	274	265	263	256	249
6	279	290	292	288	279	281	279	272					288	294	297	294	276	276	269	263
7													270	276	276	274	256	256	251	242
8	277	286	288	286	279	279	277	270					285	290	294	290	274	274	271	265
9	288	294	299	294	288	290	290	281					294	301	306	303	285	285	283	276
10	290	299	305	303	292	297	292	283					303	310	315	312	292	292	289	280
11	275	283	290	286	277	277	277	268					285	292	297	294	276	276	274	265
12	283	294	299	297	286	288	283	272					297	301	306	301	287	285	276	267
13	281	286	288	286	281	277	268	259					290	297	297	294	285	278	263	256
14	286	294	294	294	288	283	270	261					294	299	299	297	285	280	265	258
10 - intake port	219	212	207	200	214	200	193	184					228	214	208	205	215	200	190	183
Mix. at blower rim	165	168	156	153	162	159	151	142					177	155	158	152	169	163	145	136
Fuel - suction side of pump	77	74	74	71	74	74	71	71					93	82	82	82	77	77	77	74
" - pressure " " "	80	77	71	71	74	71	[redacted]						[redacted]	82	82	79	77	77	77	71
" - carb. float chamber																				
11 - front sp. plug elbow	71	53	37	24	68	53	35	25					76	53	40	26	77	58	39	23
11 - rear " " "	105	92	83	71	105	93	81	68					111	95	85	75	108	89	77	64
Recorded free air	57	40	22	15	50	36	23	11					54	34	23	10	56	38	30	12
Air in carb. scoop	58	43	24	15	55	37	[redacted]						[redacted]	40	23	10	61	39	23	13
" at top annular rake																				
" in front of cyl. no. 1	65	49	34	21	62	46	31	21					66	46	29	16	68	49	29	19
" behind cyl. no. 1	182	182	168	176	183	177	160	154					201	195	195	192	190	178	157	145
" at exit from oil cooler	83	71	62	49	83	74	61	48					85	69	59	46	86	68	49	19
Oil-in line	138	132	129	126	138	129	126	126					139	133	130	127	142	136	136	133
Oil out	194	197	194	194	195	194	192	189					198	198	198	195	193	196	190	187
Accessory compartment	99	89	80	71	96	87	81	71					104	92	82	72	99	86	14	64
Left magneto	89	86	80	77	93	90	81	78					101	95	88	82	99	93	83	77
Pilot's cockpit	77	71	65	58	77	71	64	58					92	79	72	63	93	77	68	61
Instrument compartment	80	71	65	58	77	71	64	58					92	79	72	59	86	77	64	55

Temperatures Unreliable

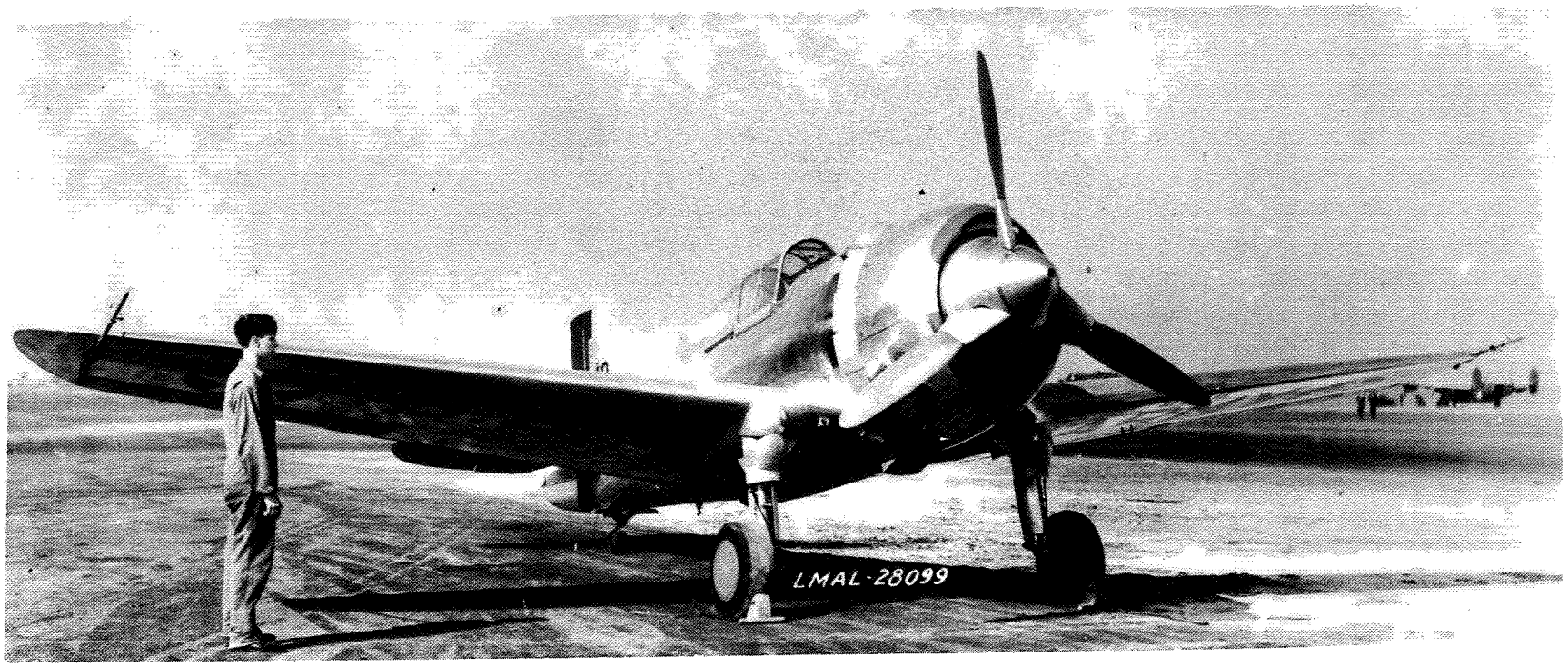


Figure 1.- XP-42 airplane with short-nose high-inlet-velocity cowling.

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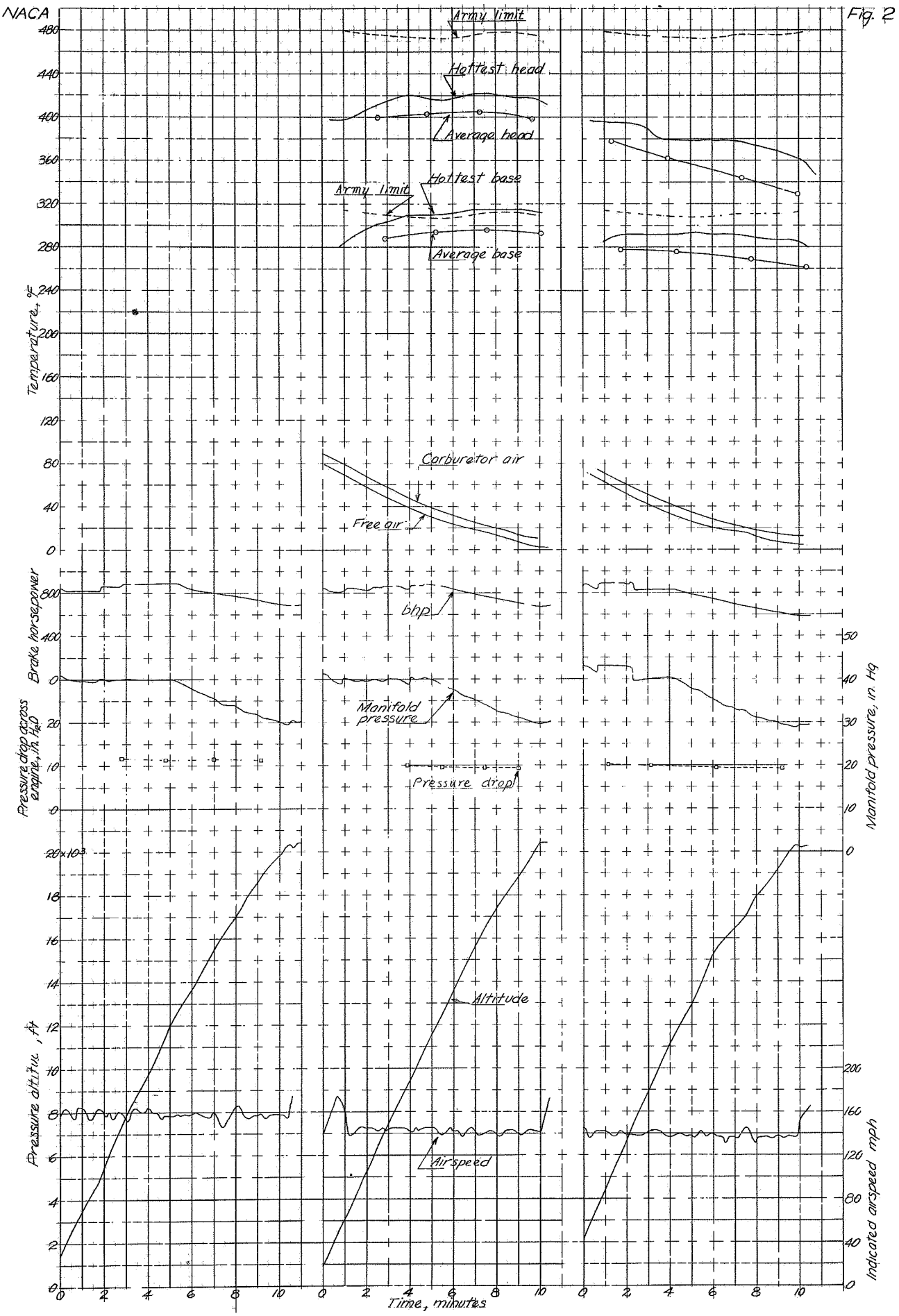
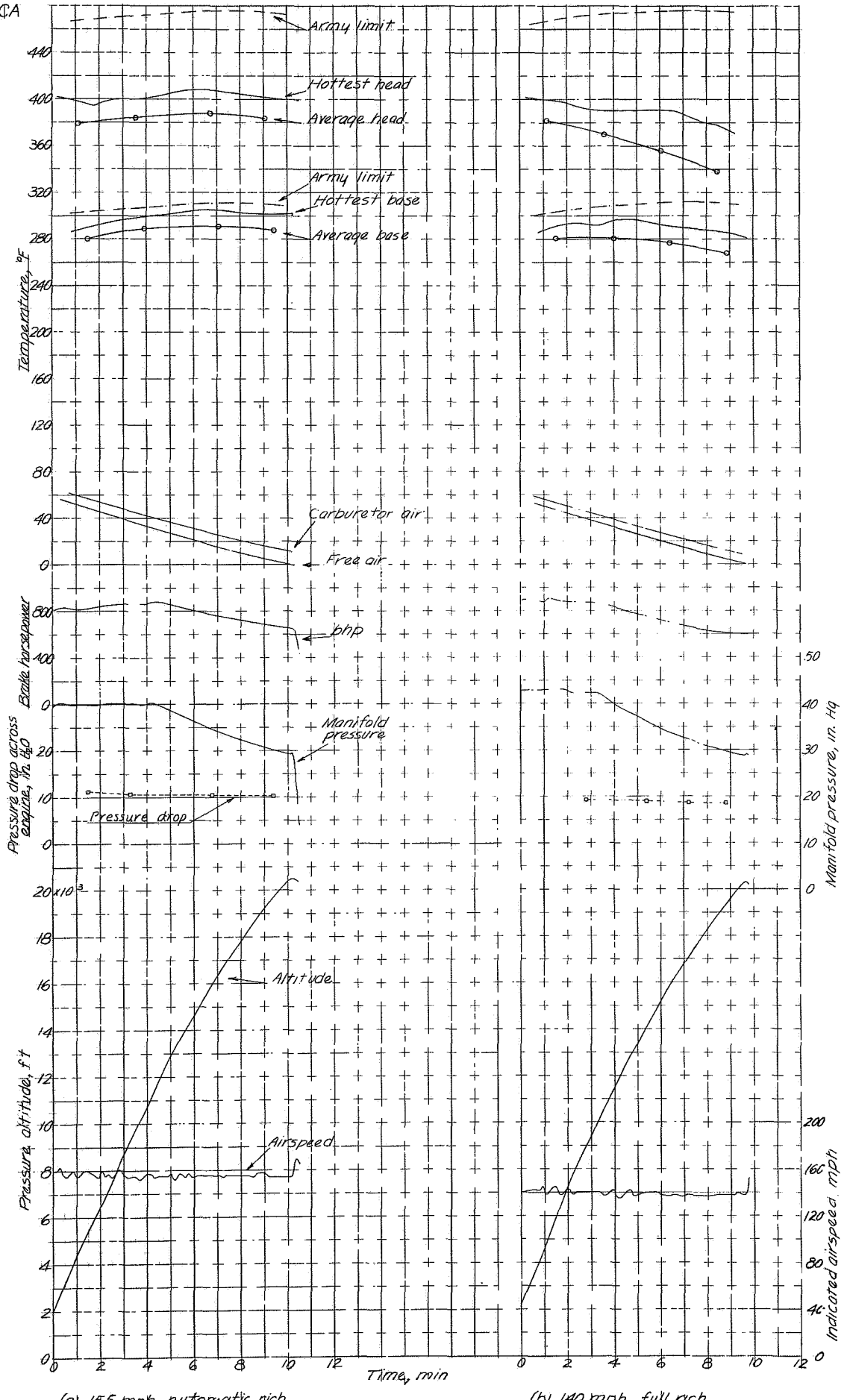


(a) 135 mph automatic rich. (b) 140 mph, automatic rich. (c) 140 mph, full rich

Figure 2 Time histories of climbs. Test 16 (with cuffs)

(Measure with 5/16



(a) 155 mph, automatic rich

(b) 140 mph, full rich

Figure 3.- Time histories of climbs. Test 16B (without cuffs).

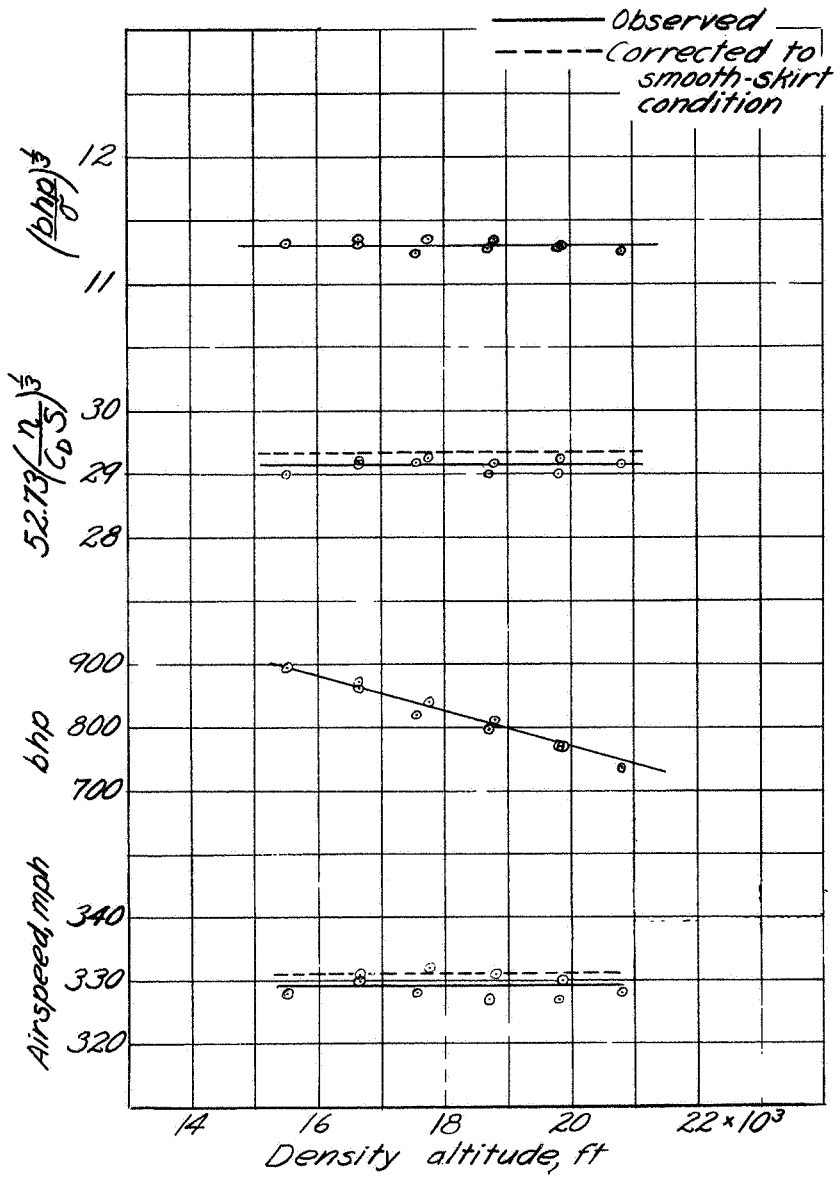


Figure 4. - High-speed performance without cuffs.

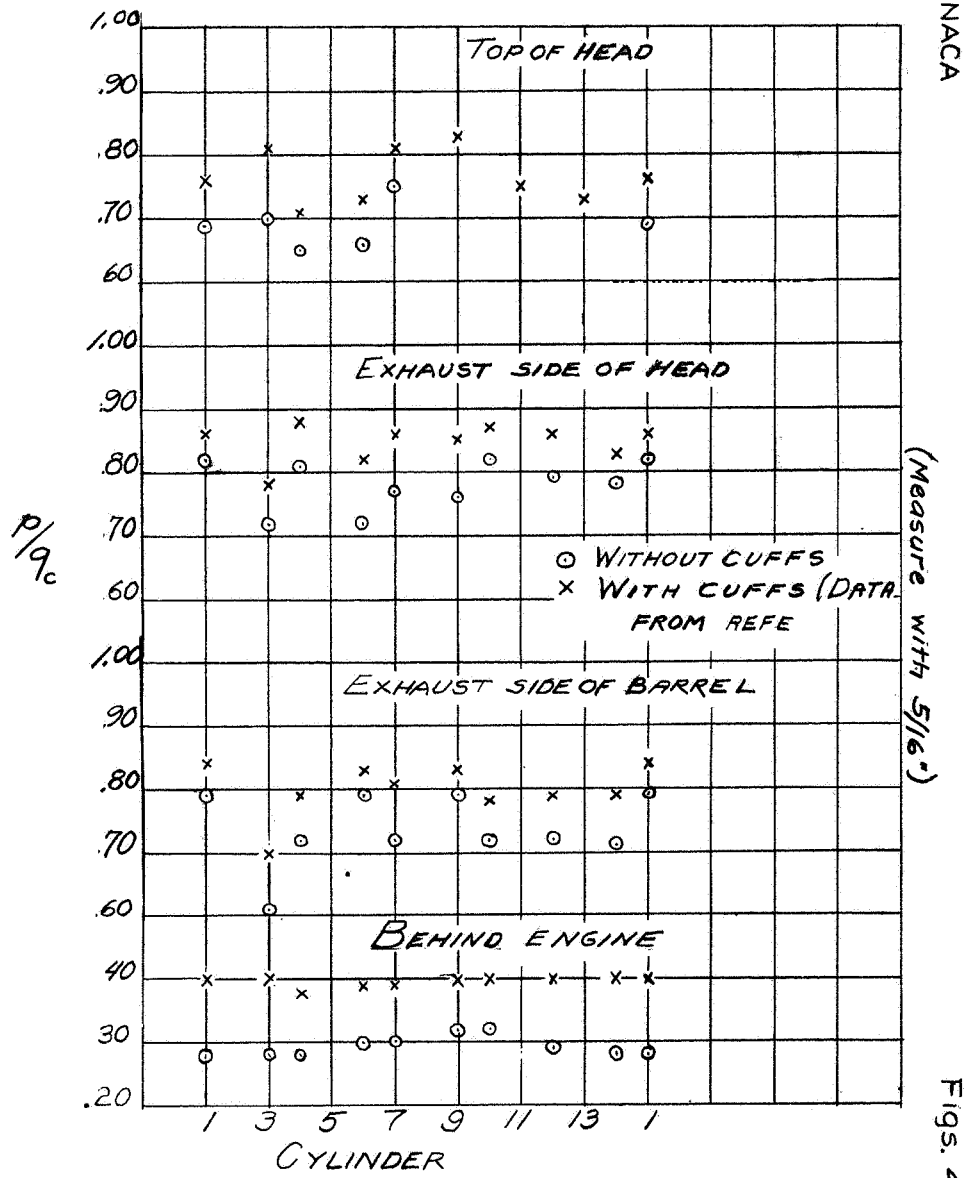


Figure 5. - Engine cooling-air pressure distributions at high speed.

(Measure with 5/16")

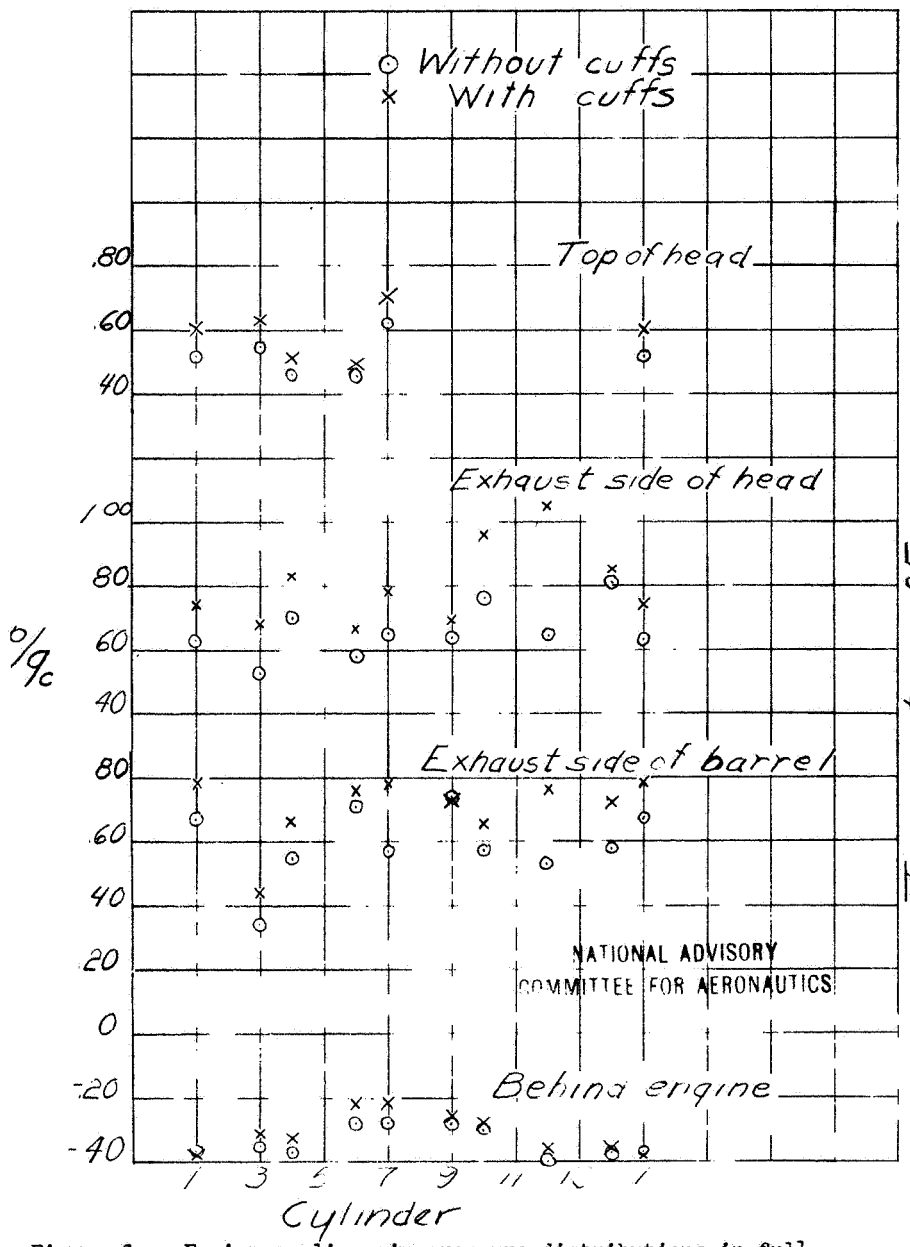


Figure 6. - Engine cooling-air pressure distributions in full-power climb at 140 miles per hour.

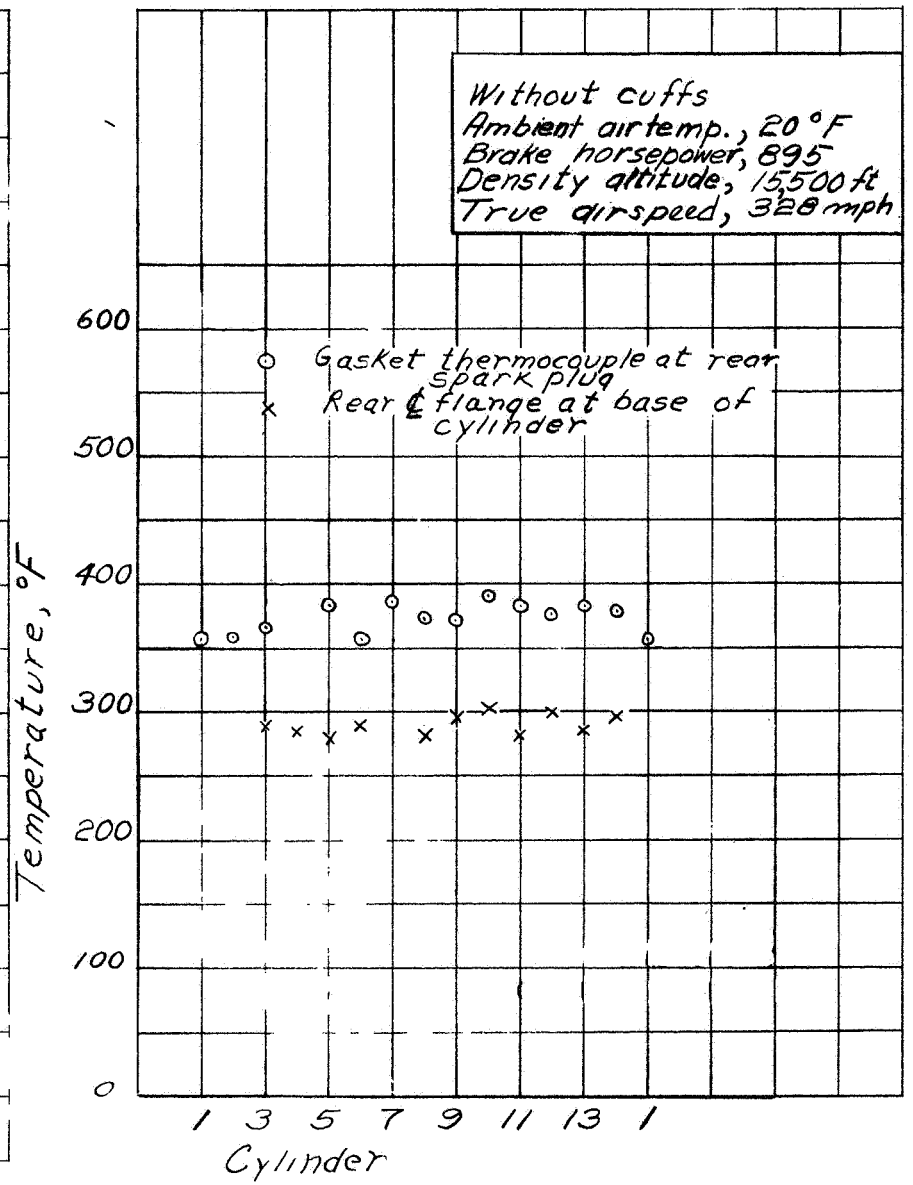


Figure 7. - Observed cylinder-temperature distribution at high speed without cuffs.

(Measure with 5/16")

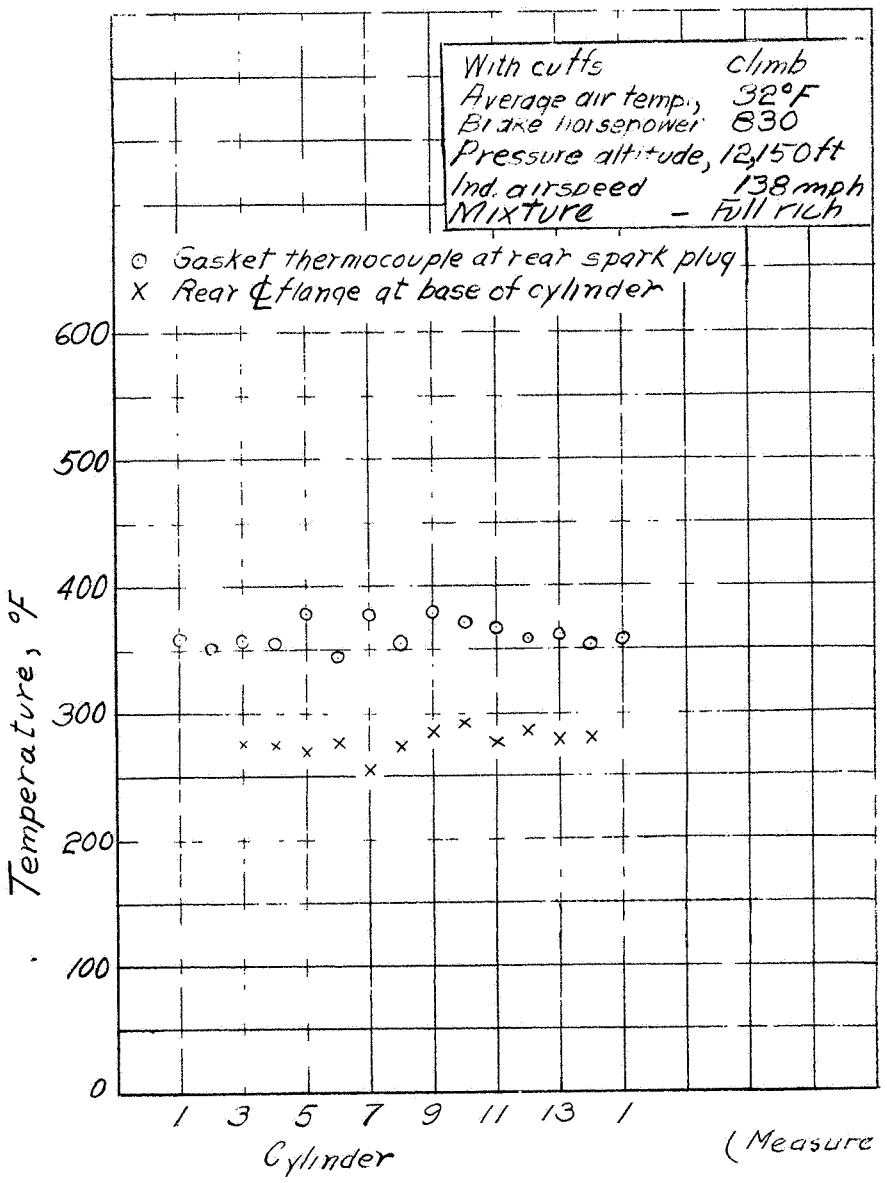
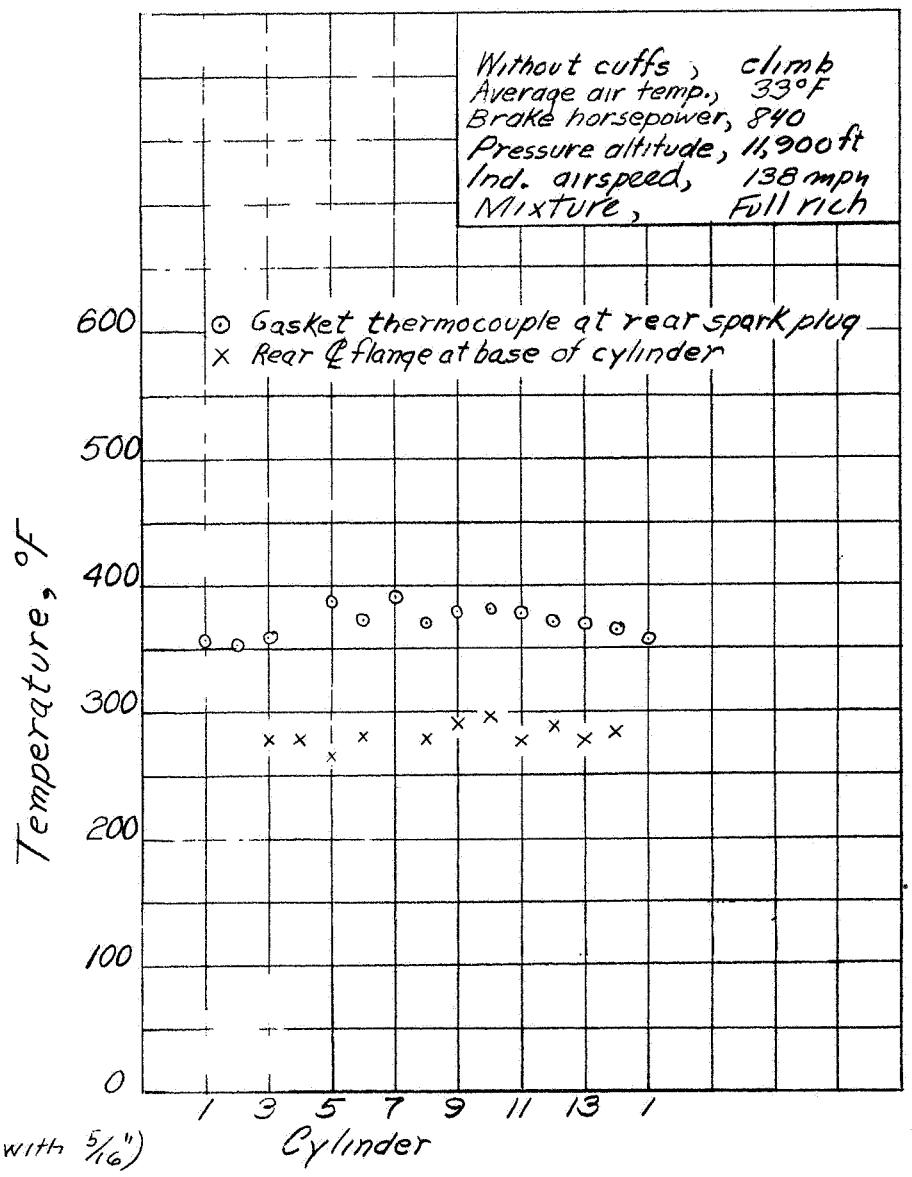


Figure 8. - Cylinder temperature distribution in climb with cuffs.



(Measure with 5/16")

Figure 9.- Cylinder temperature distribution in climb without cuffs.

(Measure with 1/30")

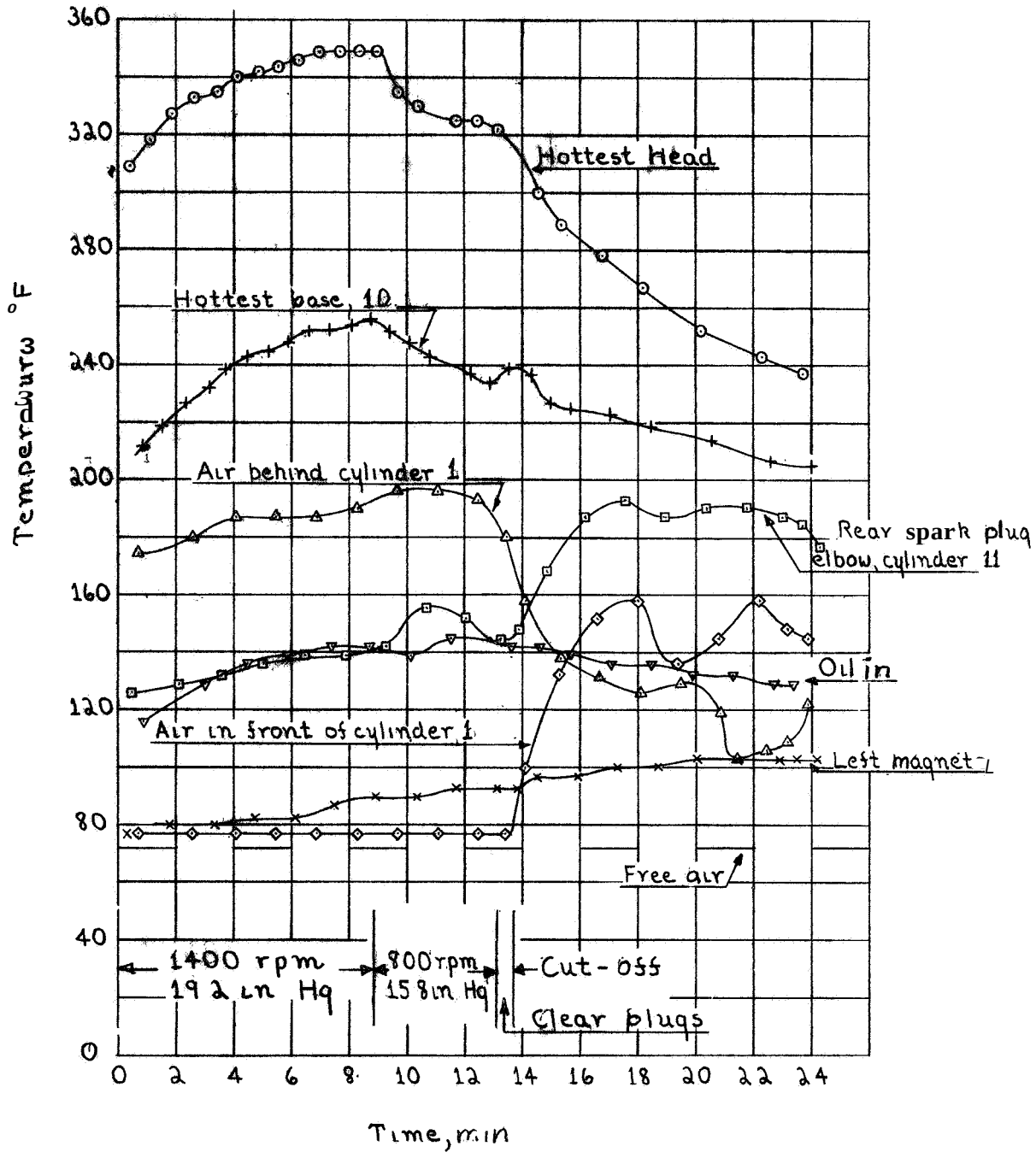


Figure 10.- Temperatures in ground run with cuffs.

(Measure with 1/30")

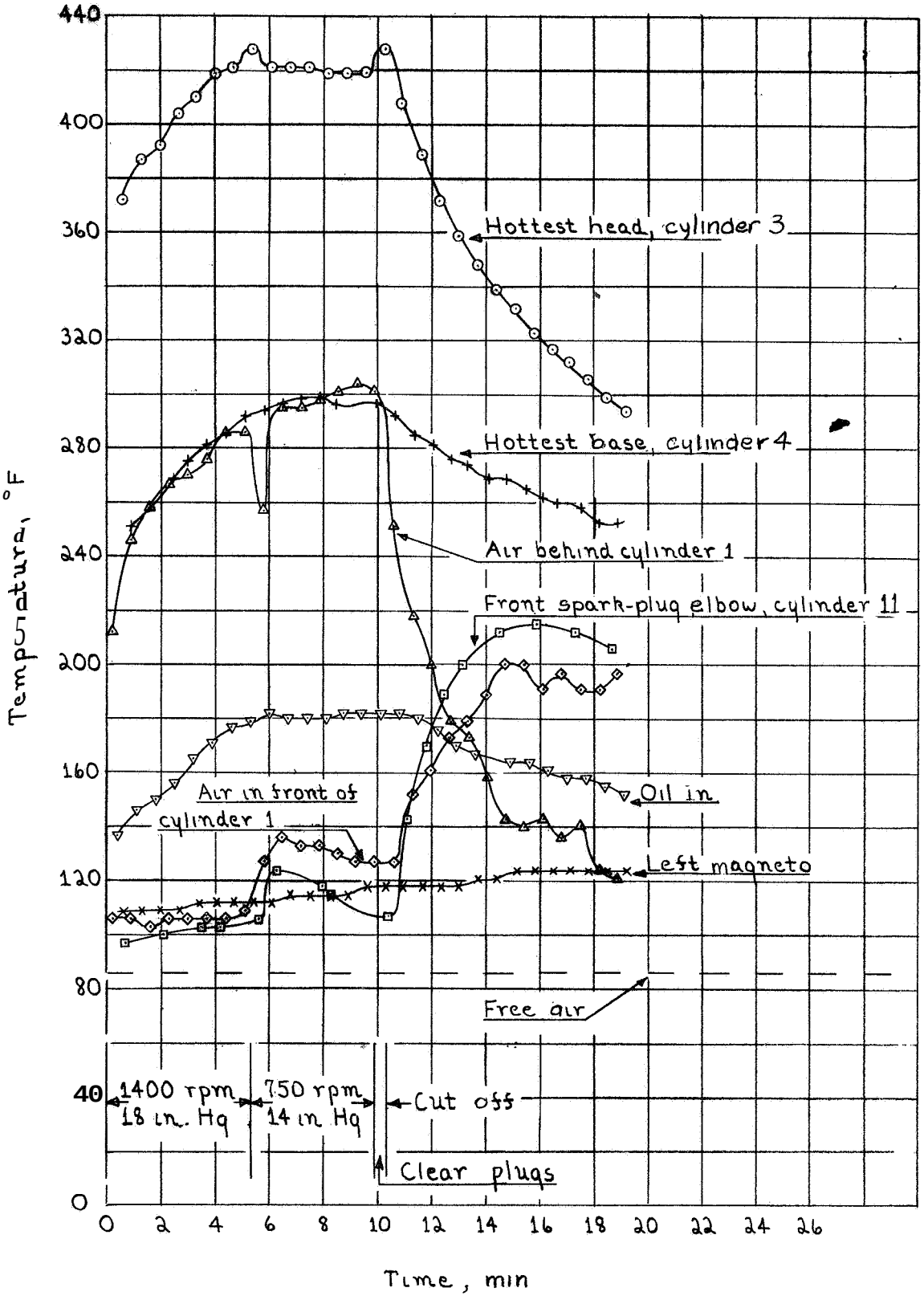


Figure 11.-Temperatures in ground run without cuffs.