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RESEARCH MEMORANDUM

for the

Air Material Command, U. S. Air Forces

PRELIMINARY TRANSIENT PERFORMANCE DATA ON THE J73 TURBOJET ENGINE

III - ALTITUDE, 45,000 FEET

By John E. McAulay and Lewis E. Wallner

Lewis Flight Propulsion Laboratory
Cleveland, Ohio

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

JULY 6, 1953

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SUMMARY

A program was undertaken to determine the J73 turbojet engine compressor stall and surge characteristics and combustor blow-out limits encountered during transient engine operation. Data were obtained in the form of oscillograph traces showing the time history of several engine parameters with changes in engine fuel flow. The data presented in this report are for step and ramp changes in fuel flow at an altitude of 45,000 feet and flight Mach numbers of 0 and 0.8.

INTRODUCTION

One phase of the altitude-performance investigation of the J73 turbojet engine conducted at the NACA Lewis laboratory consisted in determining the compressor stall and surge characteristics and the combustor blow-out limits encountered during and immediately following rapid changes in engine fuel flow.

The data were obtained on oscillograph traces which showed the time history of several engine parameters following a change in fuel flow. The preliminary data presented herein were obtained at an altitude of 45,000 feet and flight Mach numbers of 0 and 0.8. Similar data are presented in preliminary form in references 1 and 2 for altitudes of sea level, 15,000, and 35,000 feet at several flight Mach numbers.

The preliminary data which appear in this report consist of reproductions of oscillograph traces obtained at various operating conditions. A check on the accuracy of the calibration values listed on the oscillograph traces has been made but no analysis of the data is presented.

APPARATUS

Engine and Installation

The J73 turbojet engine used in this investigation has a thrust of approximately 9000 pounds, a rated engine speed of 7950 rpm, and an exhaust-gas temperature of 1185° F (1645° R). The engine is normally equipped with an hydraulic control system which was inoperative during this phase of the investigation. For these tests, the fuel system was so modified that fuel flow was a function of fuel-valve position only. Other engine components are a 12-stage axial-flow compressor with variable inlet guide vanes, an annular-type combustor with 10 cannular-type chambers, a two-stage axial-flow turbine, and a fixed-area exhaust nozzle.

The engine was mounted in a 14-foot diameter altitude chamber. A group of automatic throttle valves was incorporated at both inlet and exhaust ends of the test chamber to provide control of simulated altitude and ram-pressure ratio.

Instrumentation

The transient responses of the engine variables were recorded on a multiple channel, direct-inking, magnetic motor oscillograph. The oscillograph chart speed was 5 units per second.

The location of the measuring stations are shown in figure 1. The sensing devices used for indicating variations in the performance parameters are given in table I. Inasmuch as the total-pressure profile at the engine inlet was flat, it was possible to select almost any total- or static-pressure sensor to record on an oscillograph trace or its corresponding calibration gage without introducing errors. In the case of compressor-outlet total pressure, the sensor selected for both the oscillograph and the calibration gage was approximately the average total pressure at that station, as indicated from earlier steady-state data. Appropriate correction factors were employed where necessary for gage error and sensor location.

PROCEDURE

The oscillograph traces were calibrated by operating the engine at several widely different engine operating points and recording the corresponding pen deflections on the oscillograph trace. Fuel changes were introduced over a range of initial engine speeds at the conditions shown in the following table:

Altitude, ft	Flight Mach number	Inlet guide vane position	Type of fuel change	Engine-inlet temperature, °F
45,000	0	Open	Step	60
	.8	Open	Step	35, 75
	.8	Open	Ramp	35, 75
	.8	Closed	Step	35

The variable inlet guide vanes, which normally move from closed to open position at an engine speed of 6800 rpm as speed was increased, were maintained in a fixed closed or open position during all transients of this phase of the investigation.

The size of the fuel step or ramp changes was increased until limited by either compressor surge or combustor blow-out or until it was felt that large steps in fuel flow would expose the engine to excessively high temperature. Only the traces which were considered pertinent in determining an operating limit are presented. Thus, in general, at any given initial engine speed two traces are shown. One gives the maximum step or ramp change in fuel flow obtained without encountering compressor surge or stall. The other gives the minimum step or ramp change in fuel flow which produced compressor surge or stall.

During the period of transient engine operation, both the engine-inlet total pressure and the exhaust pressure varied from the initial value. However, the engine operating limit usually occurred before the engine-inlet total pressure or the exhaust pressure changed appreciably. The time history of the behavior of the engine-inlet total pressure during transient engine operation is shown on the oscillograph traces, but the variation of exhaust pressure is not shown. In general, the maximum increase in exhaust pressure was 7 percent of the initial value.

DISCUSSION

The conditions for each oscillograph trace (figs. 2 to 73) presented herein are given in table II. On each set of oscillograph traces the figure legend specifies the engine conditions at the beginning of the change in fuel flow. Each trace is identified by a label below which is given the calibration factor for the trace. As indicated by the calibration factor, all traces are considered linear except the fuel-flow trace which follows the square-law relation. On each trace is shown the initial value of the engine variable. In the case of fuel flow, one or more additional values are given. The arrows on each figure indicate the direction in which the variable is increasing.

Caution should be used in applying the calibration factors to the traces. Although the horizontal or time scale is linear, the vertical

scale on all traces is a circular arc. In obtaining the rate of change of any variable or in calculating elapsed time, this curvature must be considered.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, July 1, 1953

REFERENCES

1. Sobolewski, Adam E., and Lubick, Robert J.: Preliminary Transient Performance Data on the J73 Turbojet Engine. I - Altitude, Sea Level and 15,000 Feet. NACA RM SE53F22, 1953.

2. Lubick, Robert J., and Sobolewski, Adam E.: Preliminary Transient Performance Data on the J73 Turbojet Engine. II - Altitude, 35,000 Feet. NACA RM SE53F29, 1953.

TABLE I. - INSTRUMENTATION

Measured quantity	Engine station	Steady-state instrumentation	Transient instrumentation	
			Sensor	Range over which frequency response is essentially flat, cps
Fuel flow	-	Rotameter	Aneroid-type pressure sensor, with strain-gage element, connected to measure pressure drop across variable orifice in fuel line	Undetermined
Dynamic pressure at engine inlet	1	Bourdon-type gage	Aneroid-type pressure sensor with strain-gage element	0-10 At sea-level static
Engine-inlet total pressure	1	Bourdon-type gage	Aneroid-type pressure sensor with strain-gage element	0-10 At sea-level static
Compressor-outlet total pressure	2	Bourdon-type gage	Aneroid-type pressure sensor with strain-gage element	0-10 At sea-level static
Compensated exhaust-gas temperature	3	Five paralleled thermocouples connected to self-balancing potentiometer recorder	Six paralleled 20-gage, chromel-alumel, butt-welded thermocouples and electric network to compensate for thermocouple lag	0-30 At sea-level static when used with properly adjusted compensator
Uncompensated exhaust-gas temperature	3	Five paralleled thermocouples connected to self-balancing potentiometer recorder	Six paralleled 20-gage, chromel-alumel, butt-welded thermocouples	0-1 At sea-level static
Engine speed	-	Chronometric tachometer	Direct-current generator with output proportional to engine speed	0-5

TABLE II - OSCILLOGRAPH-TRACE CONDITIONS

Figure	Altitude, ft	Flight Mach number	Inlet guide vane position	Type of fuel change	Engine inlet temperature, °F		Initial engine speed, rpm	
					Nominal	Actual	Nominal	Actual
2	45,000	0	Open	Step	60	57	6400	6420
3						57		6428
4						57		6428
5						57		6438
6						58		6420
7						58		6412
8						58		6417
9						58		6415
10						58	6700	6680
11						58		6645
12						58	7000	7050
13						56		7060
14						57		7022
15						57		7030
16						58		7022
17						57	7500	7500
18						57		7480
19						57		7515
20		0.8			35	32	5500	5471
21						32		5503
22						36		5488
23						36		5465
24						36	5700	5671
25						32	6100	6085
26						32		6040
27						31	6400	6470
28						31		6405
29						30	6500	6540
30						32		6570
31						32		6520
32						30		6525
33						30	7100	7050
34						33		7050
35						33		7075
36						30	7500	7420
37						30		7490
38						30		7480
39						30		7480
40					75	75	5800	5780
41						74	6300	6280
42						74		6280
43						74	6800	6800
44						74		6850
45						74	7200	7250
46						74		7250
47				Ramp	35	32	6600	6600
48						32		6570
49						32		6590
50						32		6575
51						32		6570
52						32		6600
53					75	71	5500	5580
54						71		5500
55						71	6100	6080
56						71		6060
57						71		6070
58						73		6170
59						72	6600	6620
60						72		6600
61						73		6680
62						72		6600
63						72		6600
64						72	7100	7120
65						72		7170
66			Closed	Step	35	31	5500	5500
67						31		5500
68						31	6000	6055
69						31		6055
70						30	6500	6505
71						30		6505
72						30	7100	7115
73						30		7115

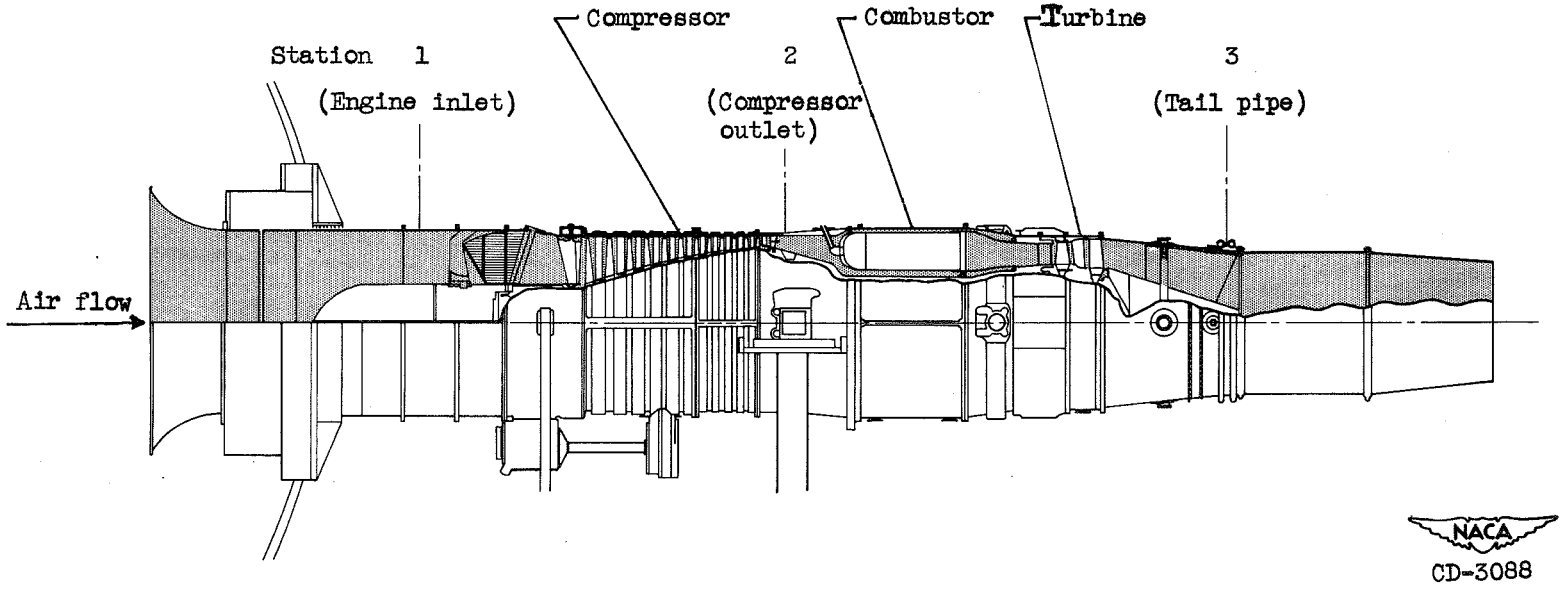

Figure 1. - Side view of turbojet engine installation showing stations at which instrumentation was installed.

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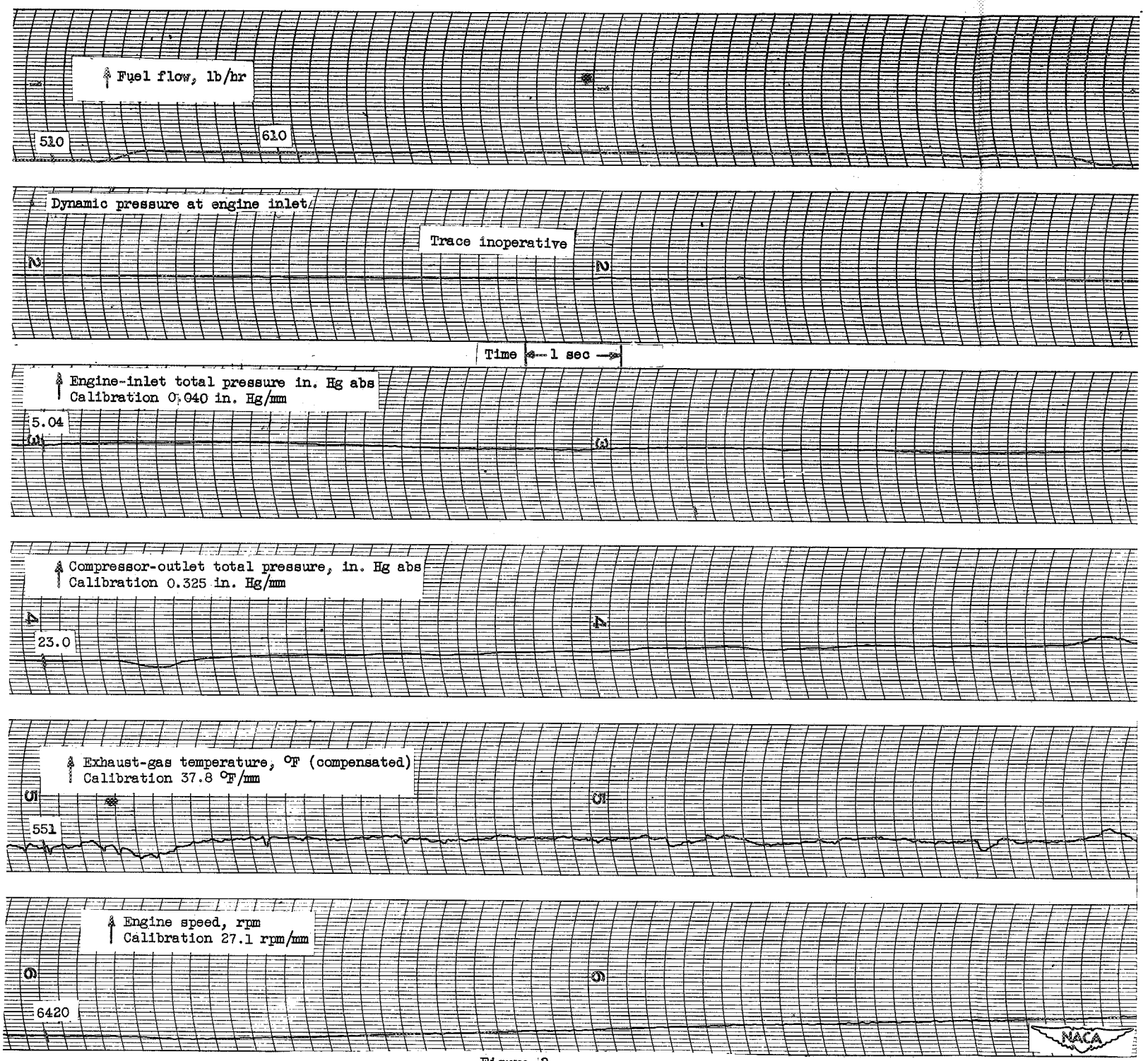

Figure 2
Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

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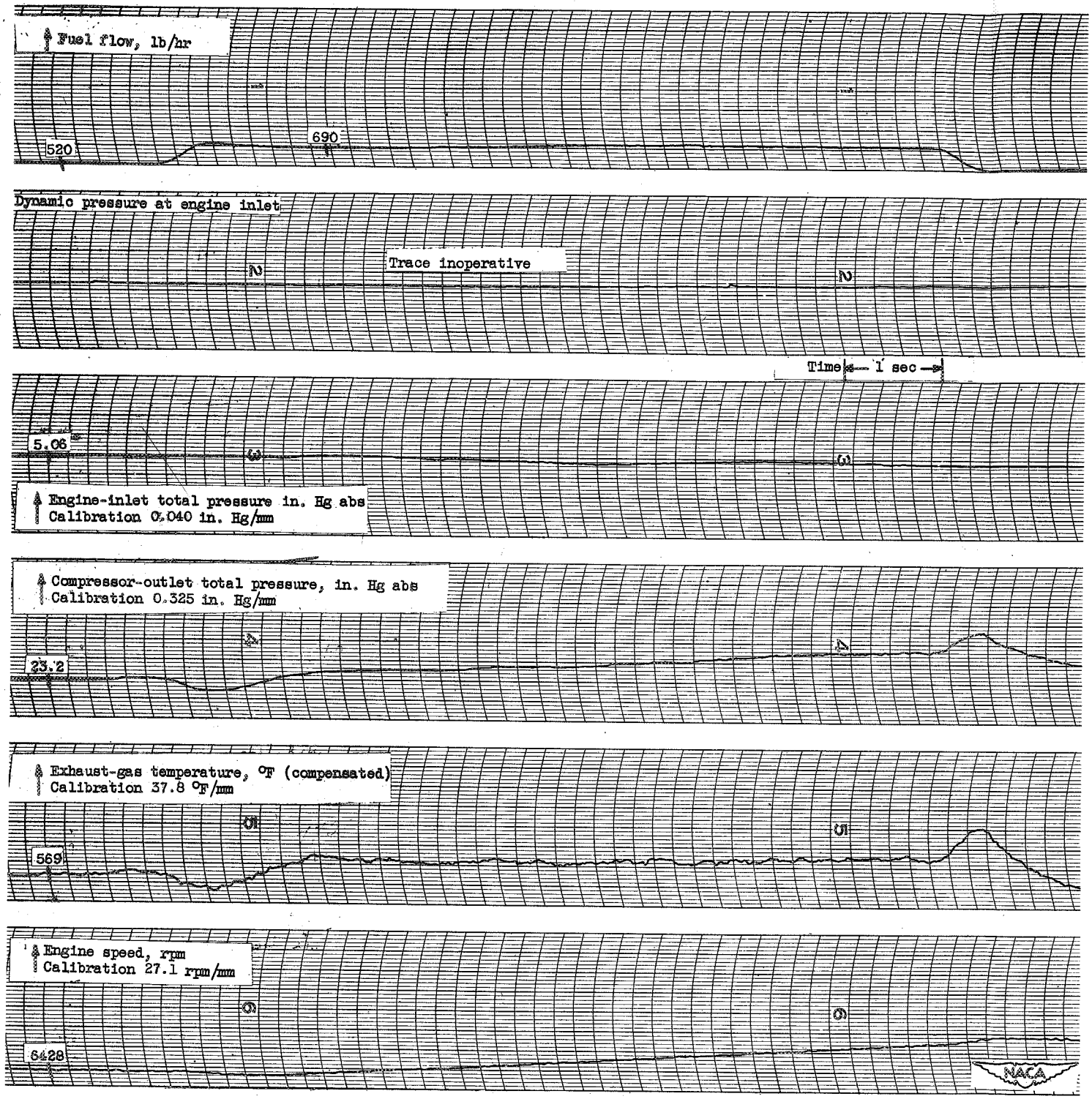

Figure 3

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open. L 907

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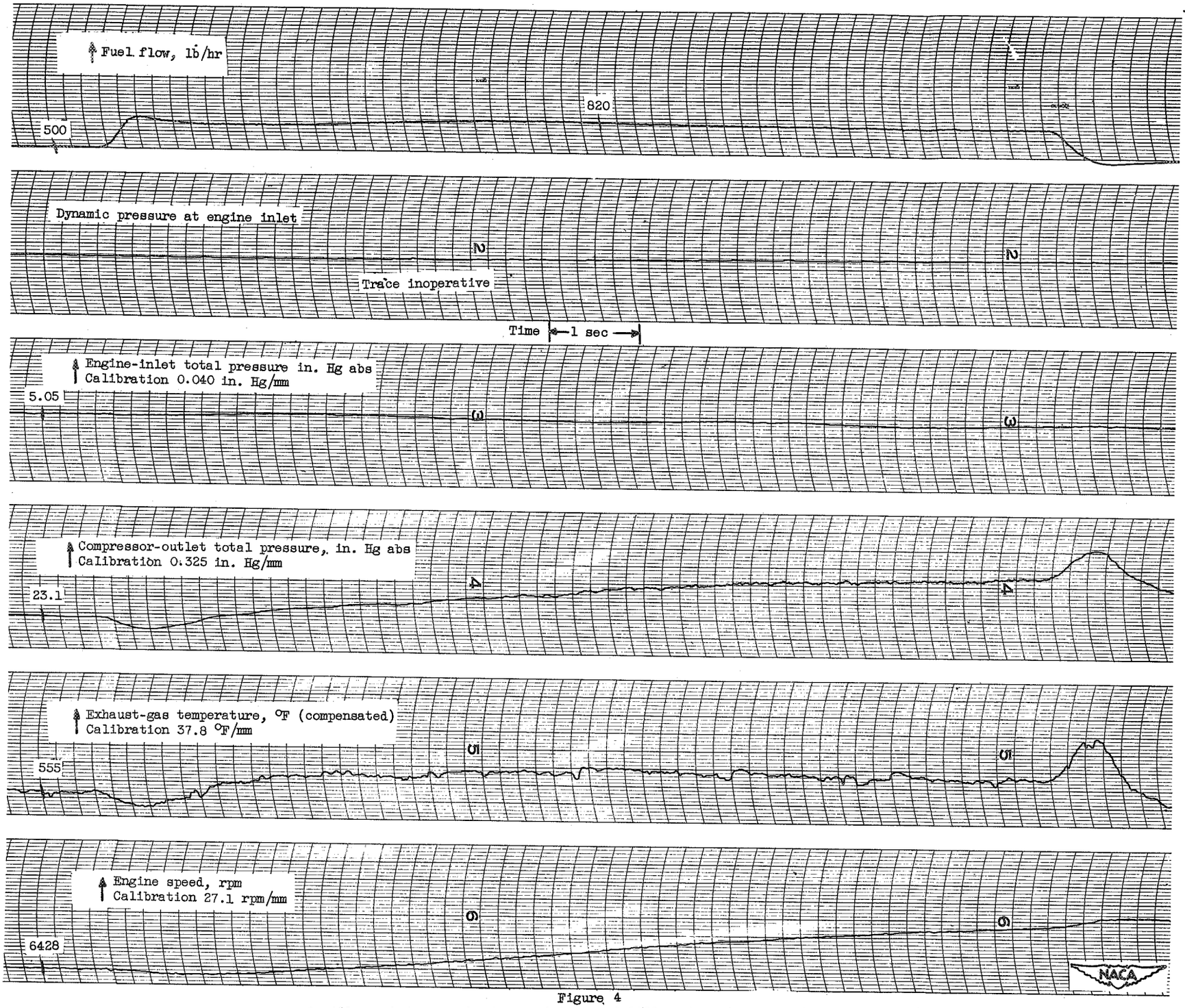

Figure 4

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

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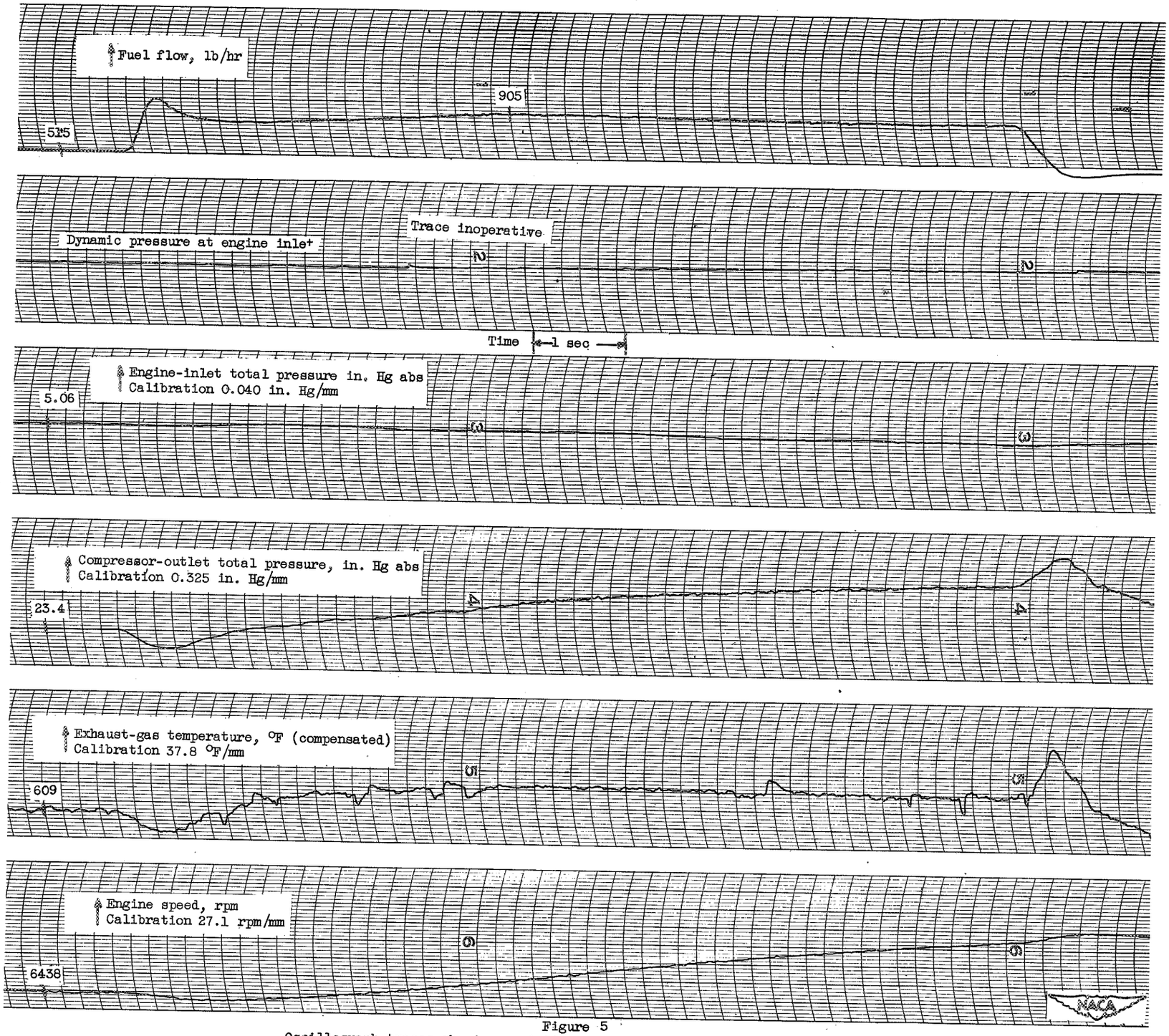

Figure 5

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

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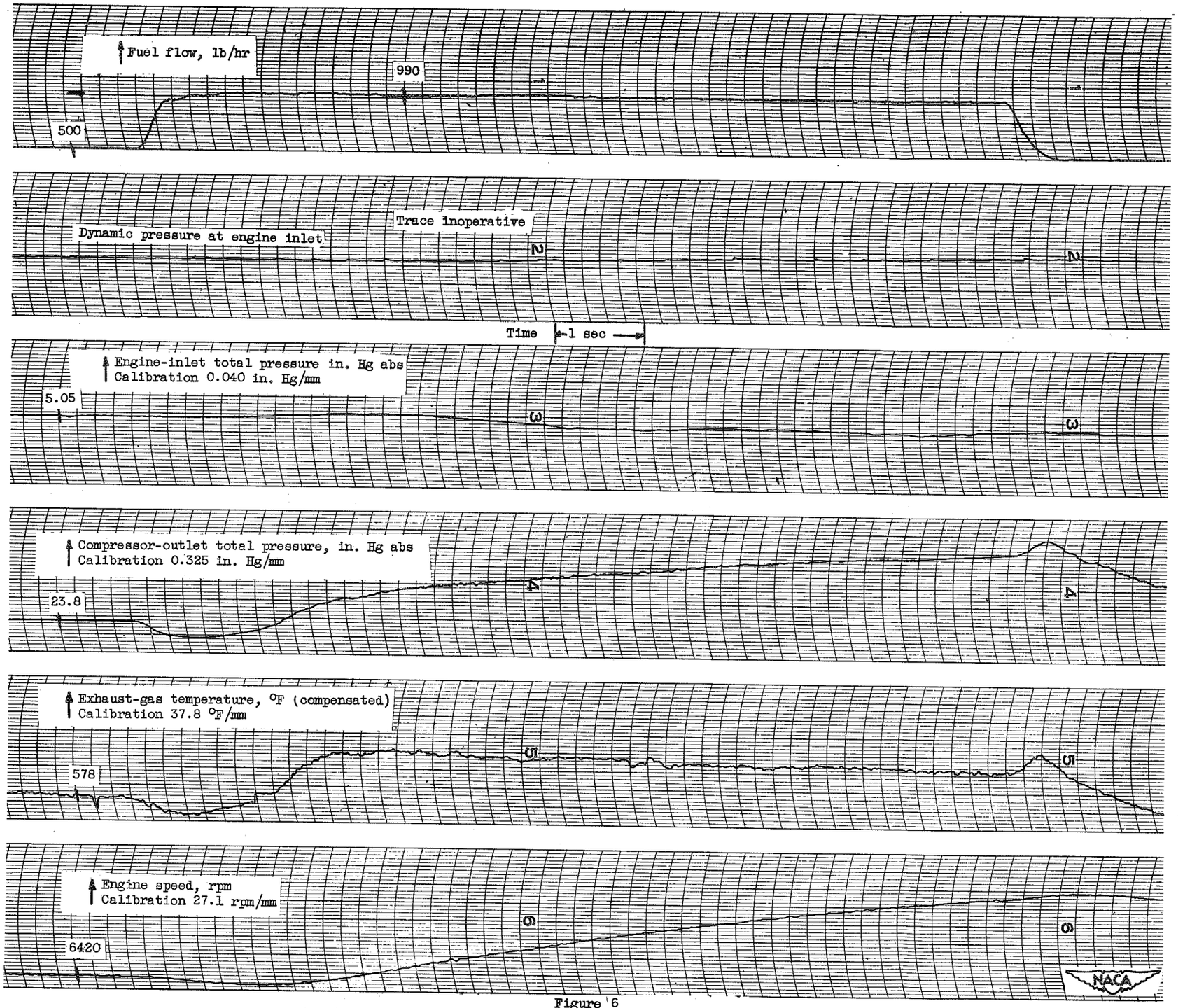

Figure 6

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

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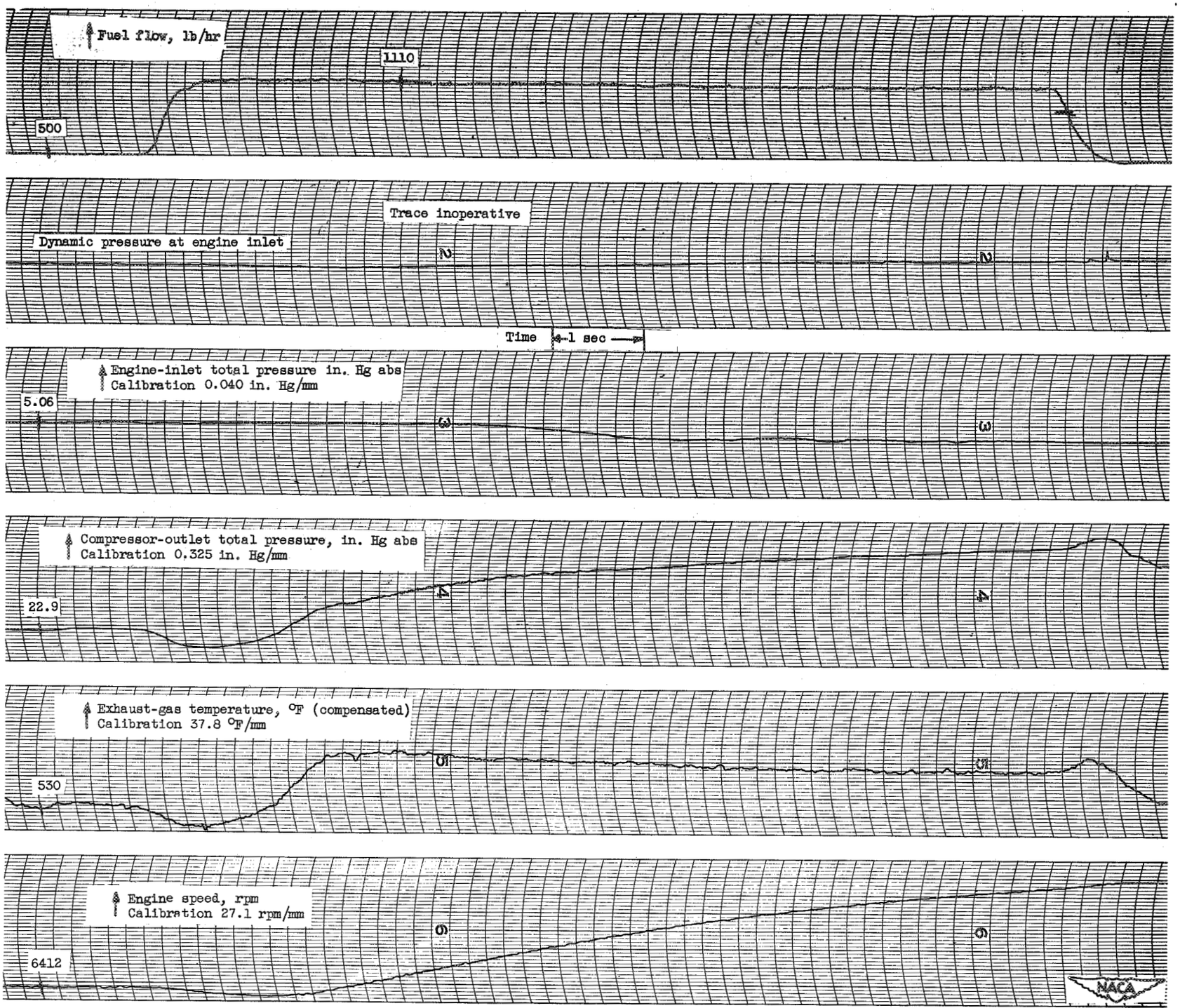

Figure 7

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

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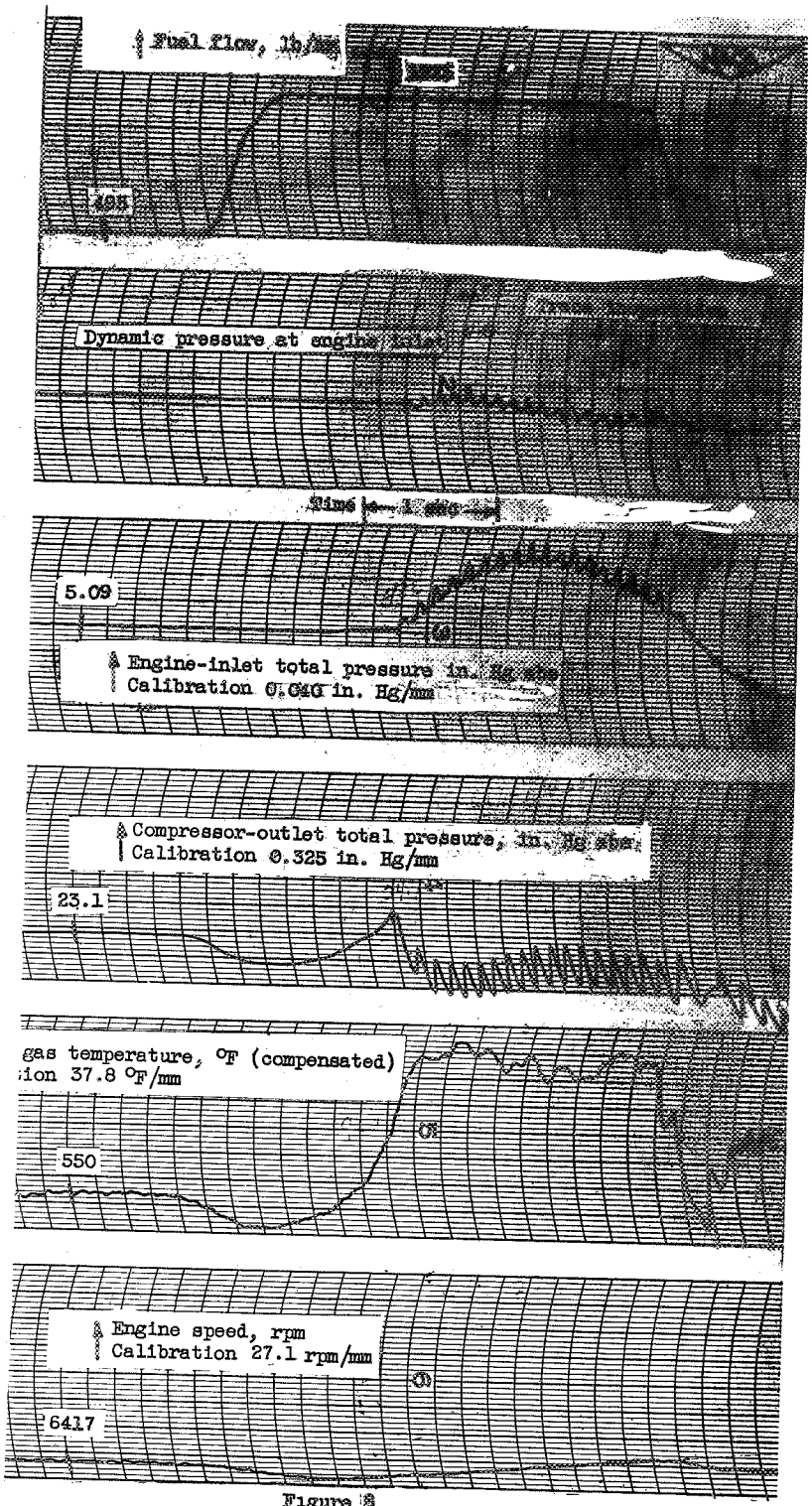

Figure 8

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.87; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

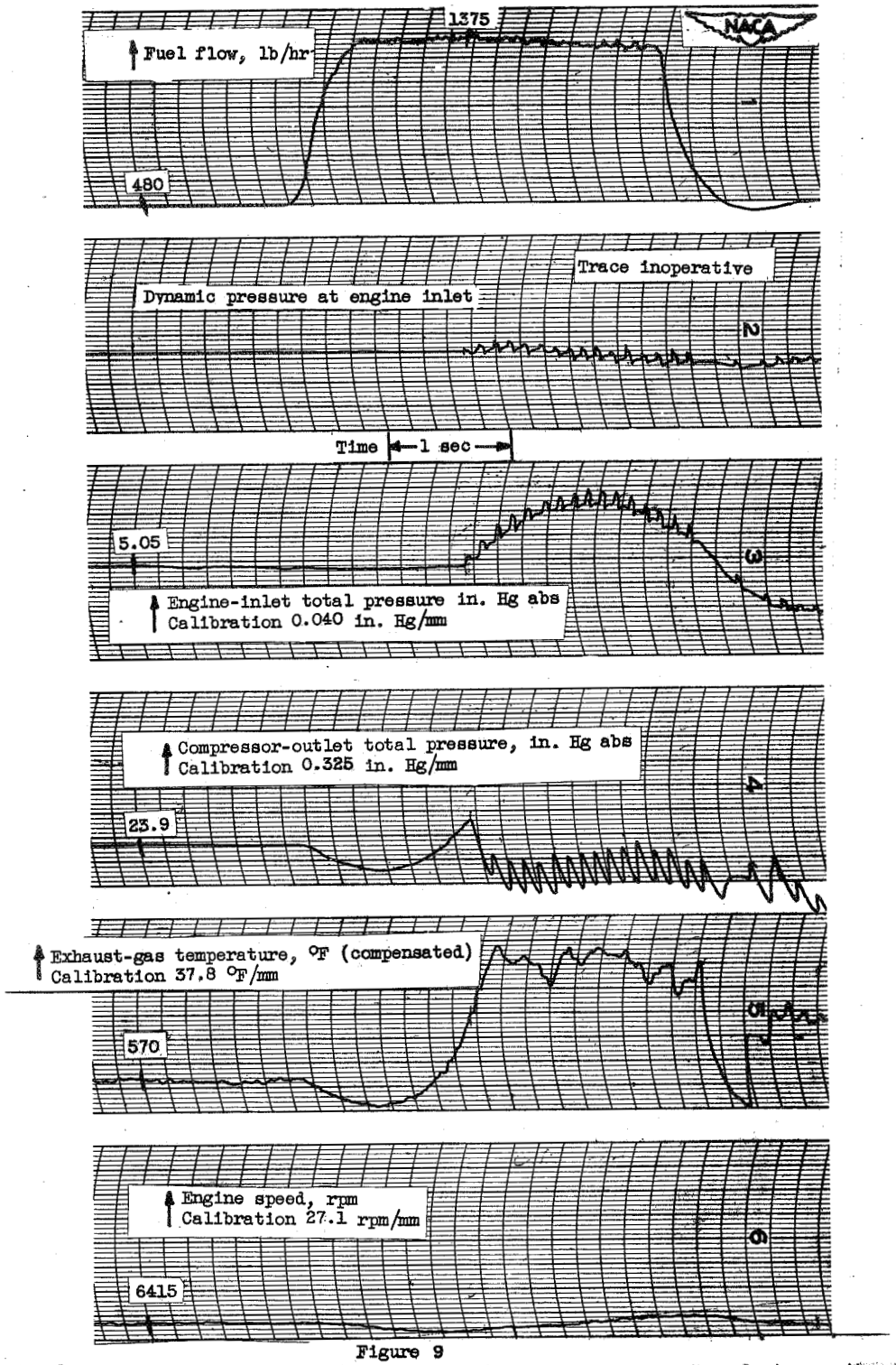

Figure 9

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

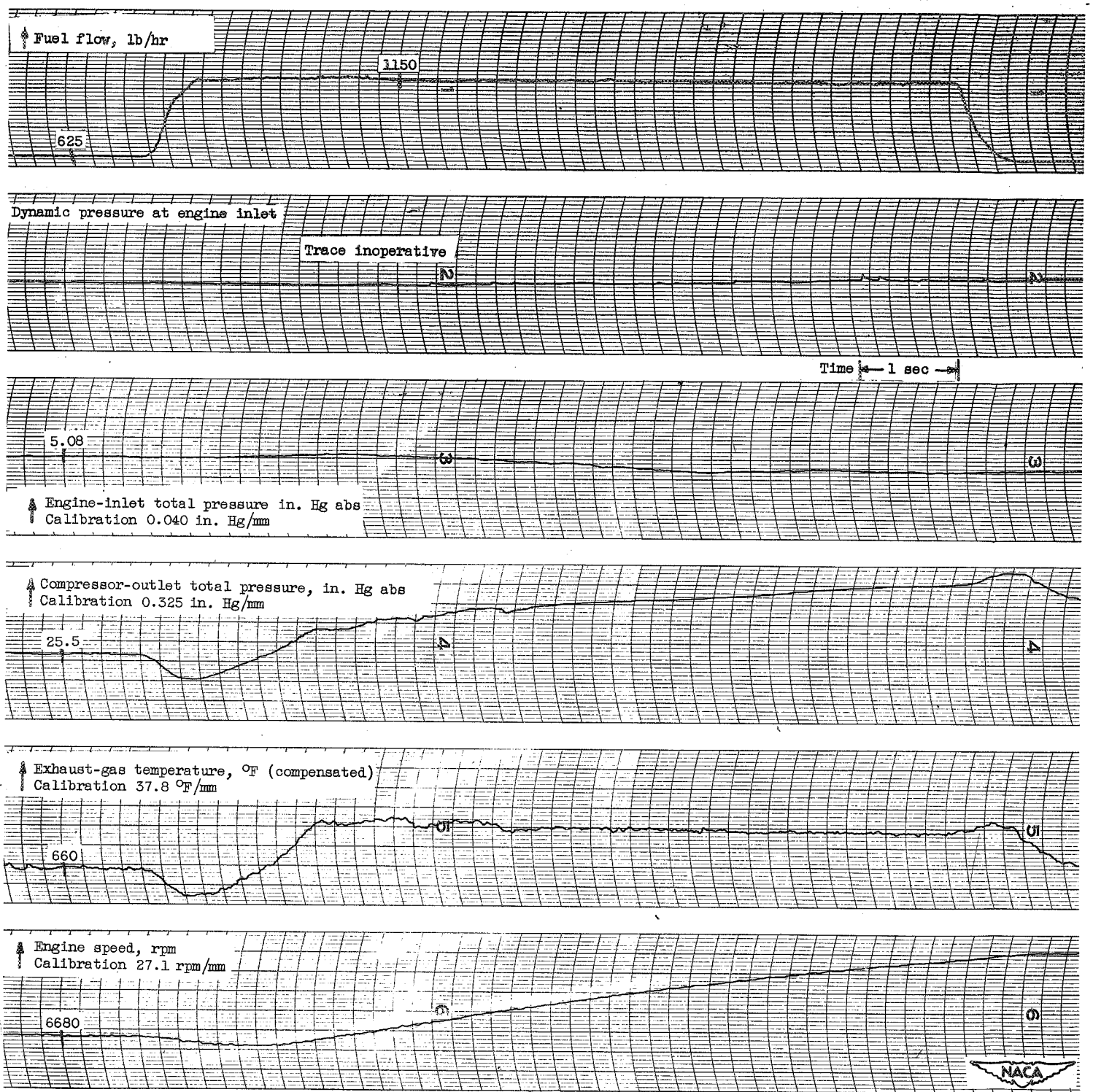

Figure 10

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

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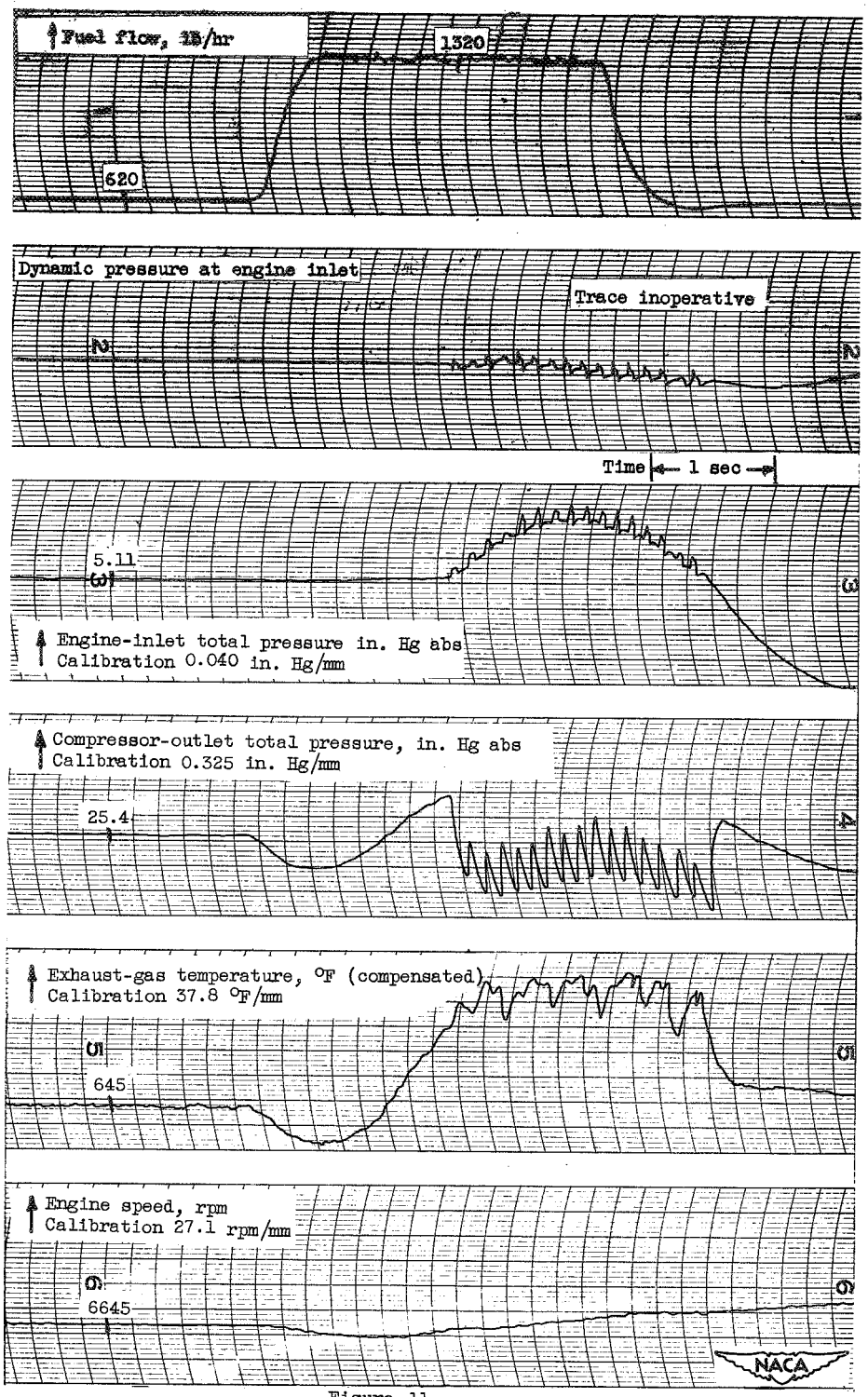

Figure 11

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

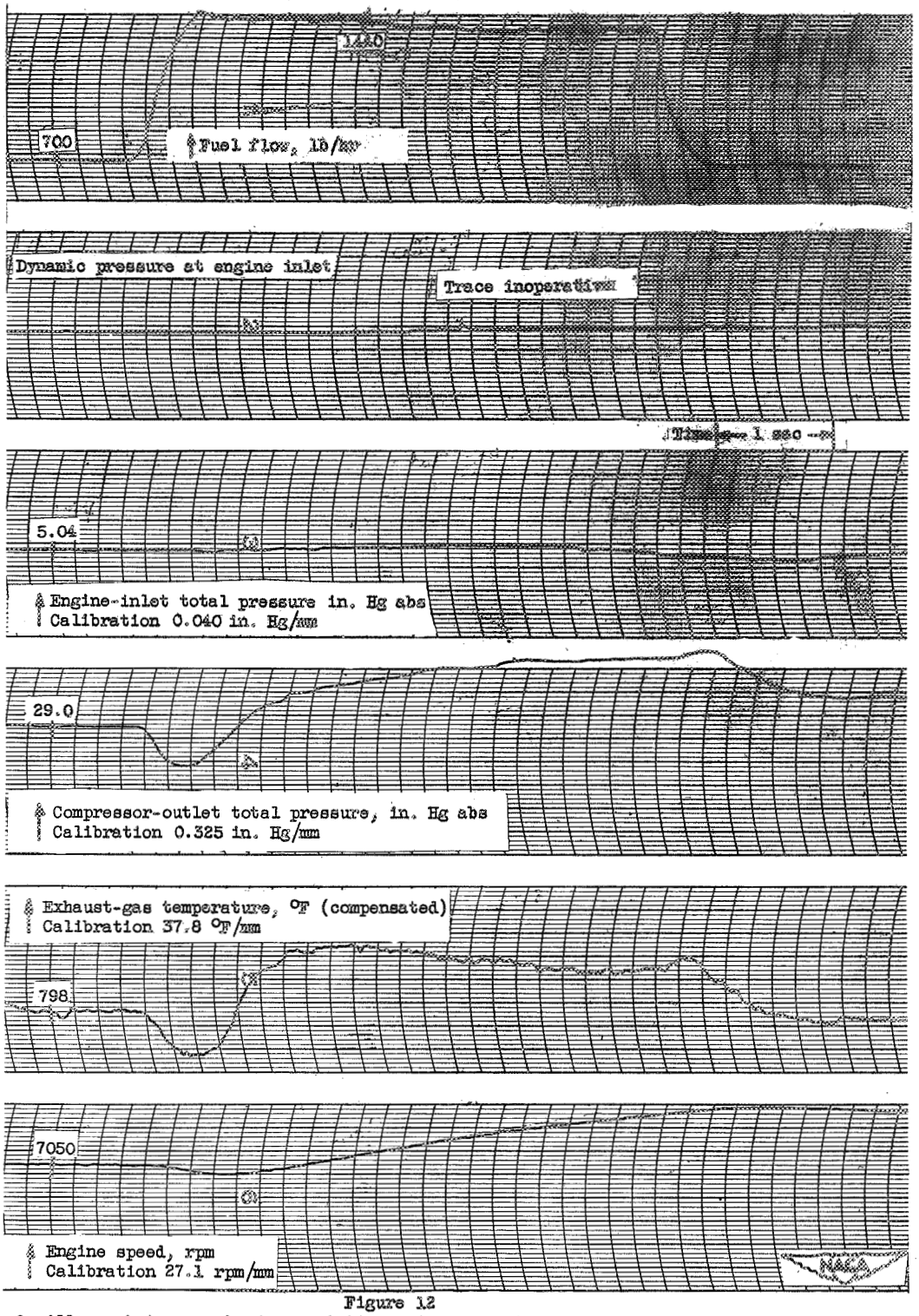

Figure 12

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

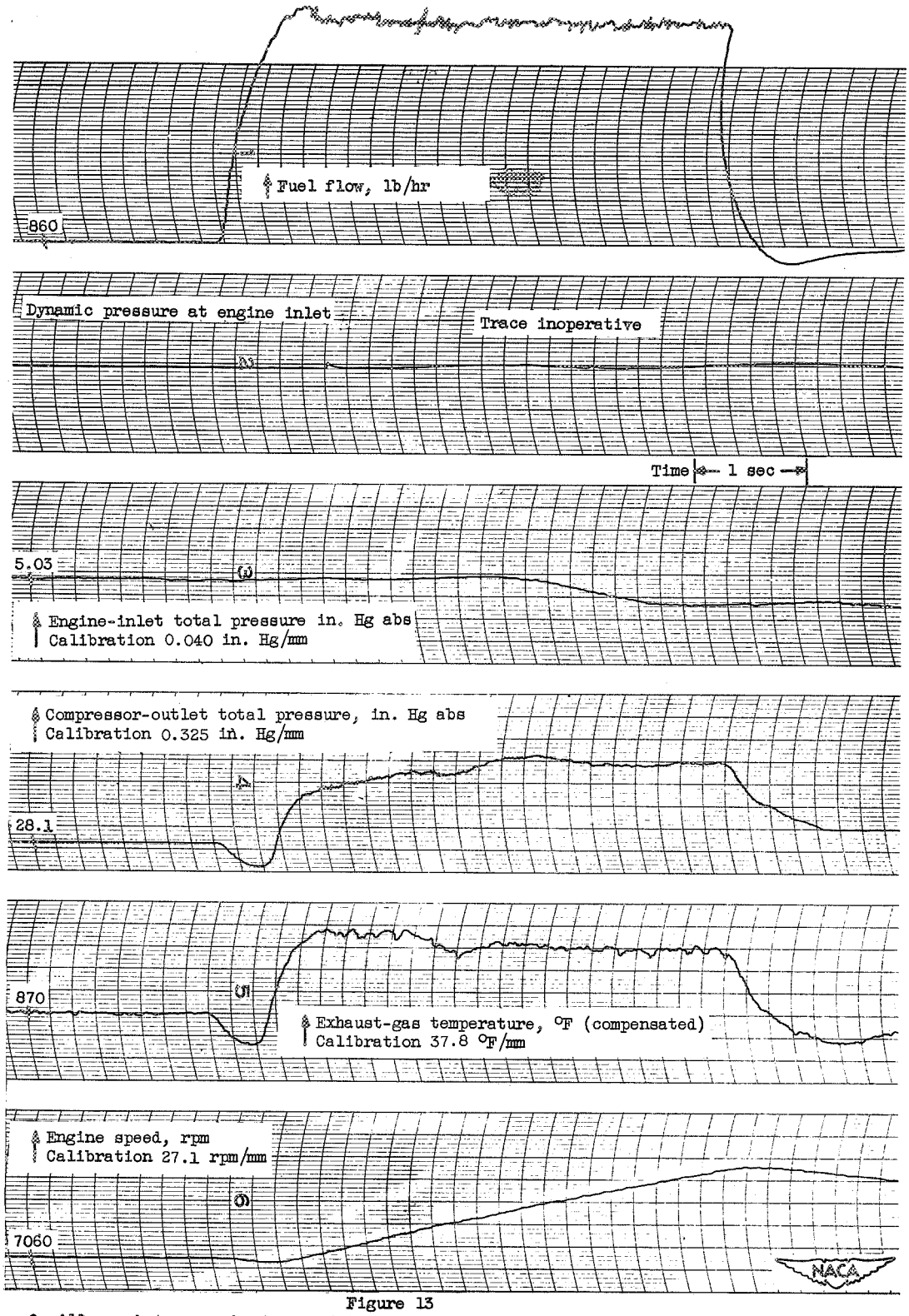

Figure 13

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 56° F; inlet guide vanes position, open.

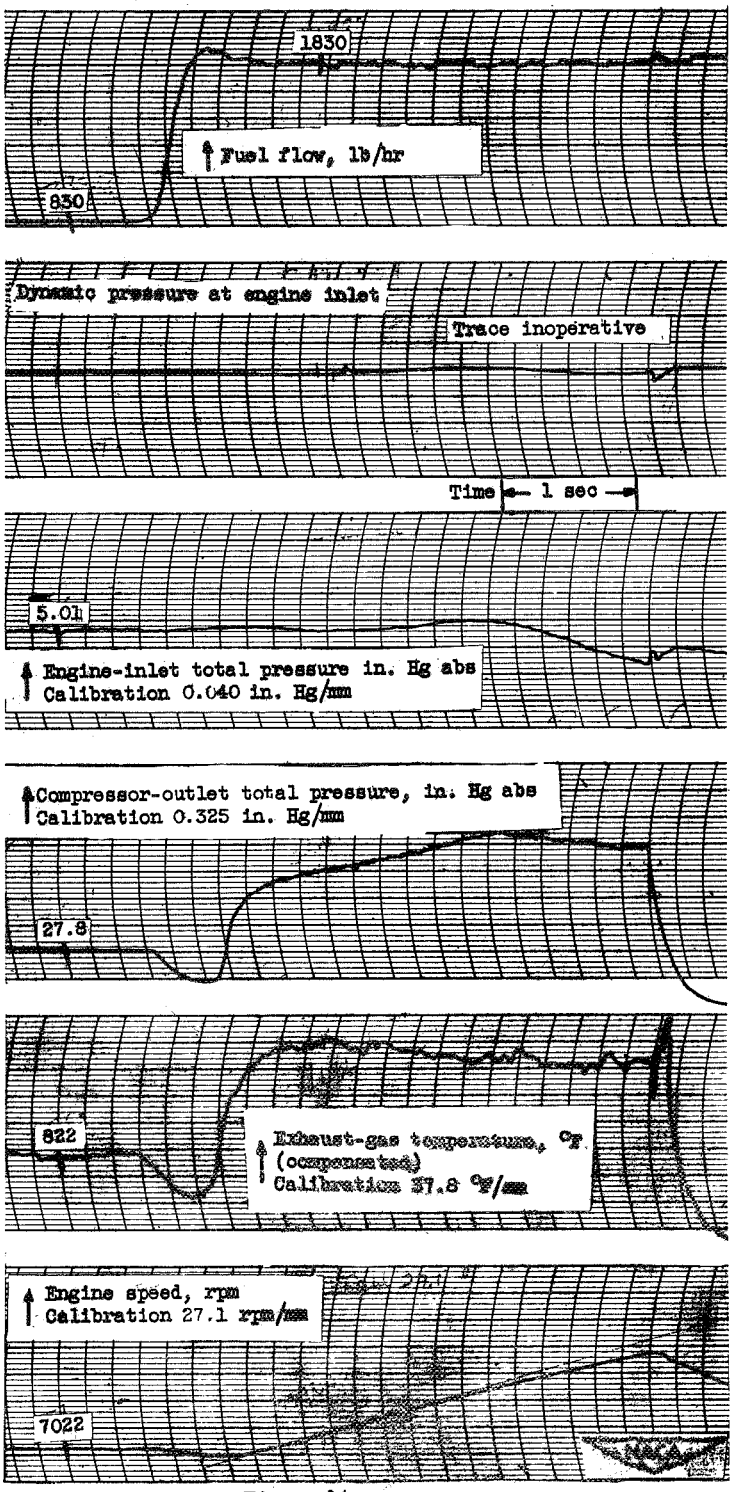

Figure 14

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.40; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

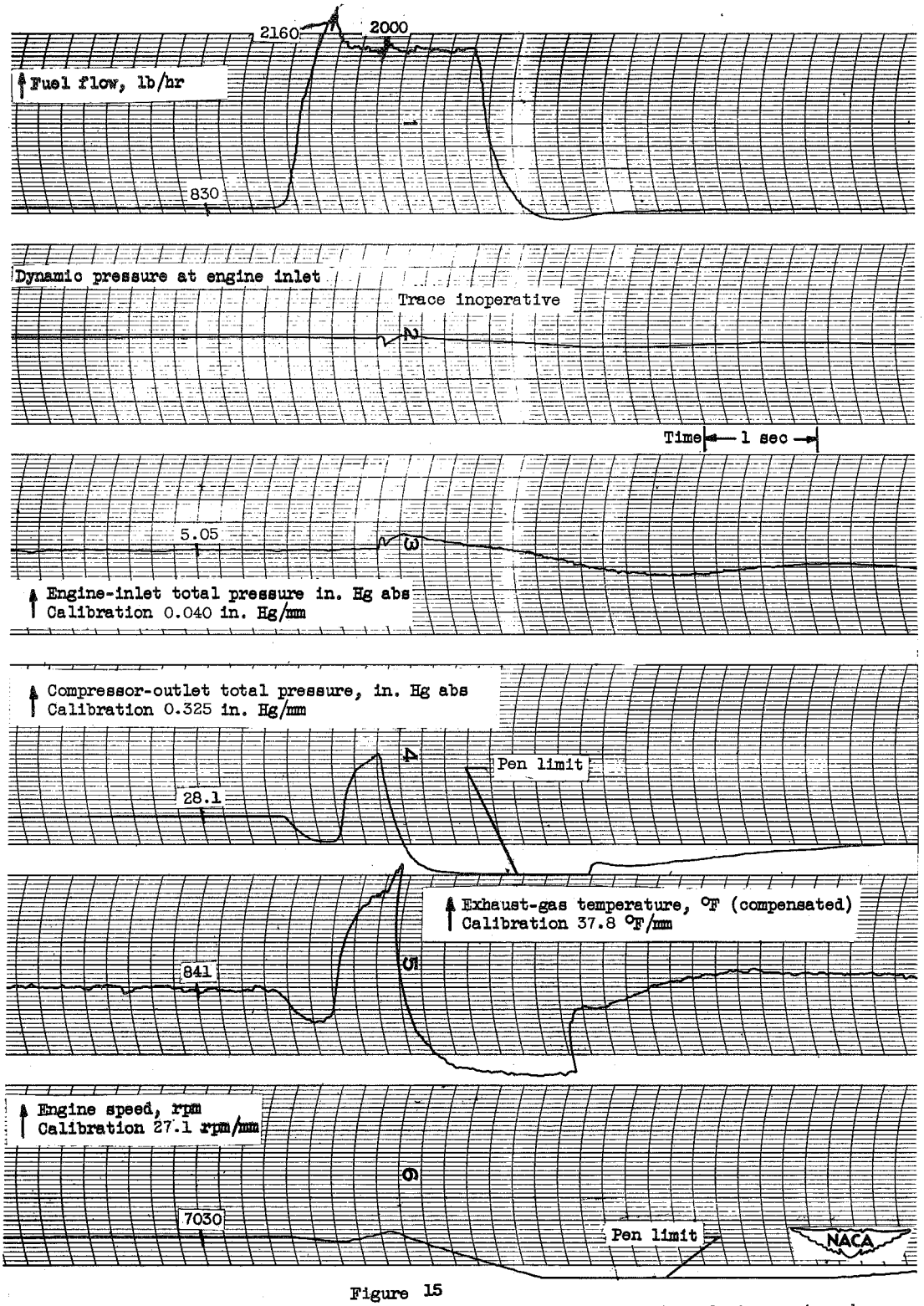

Figure 15

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

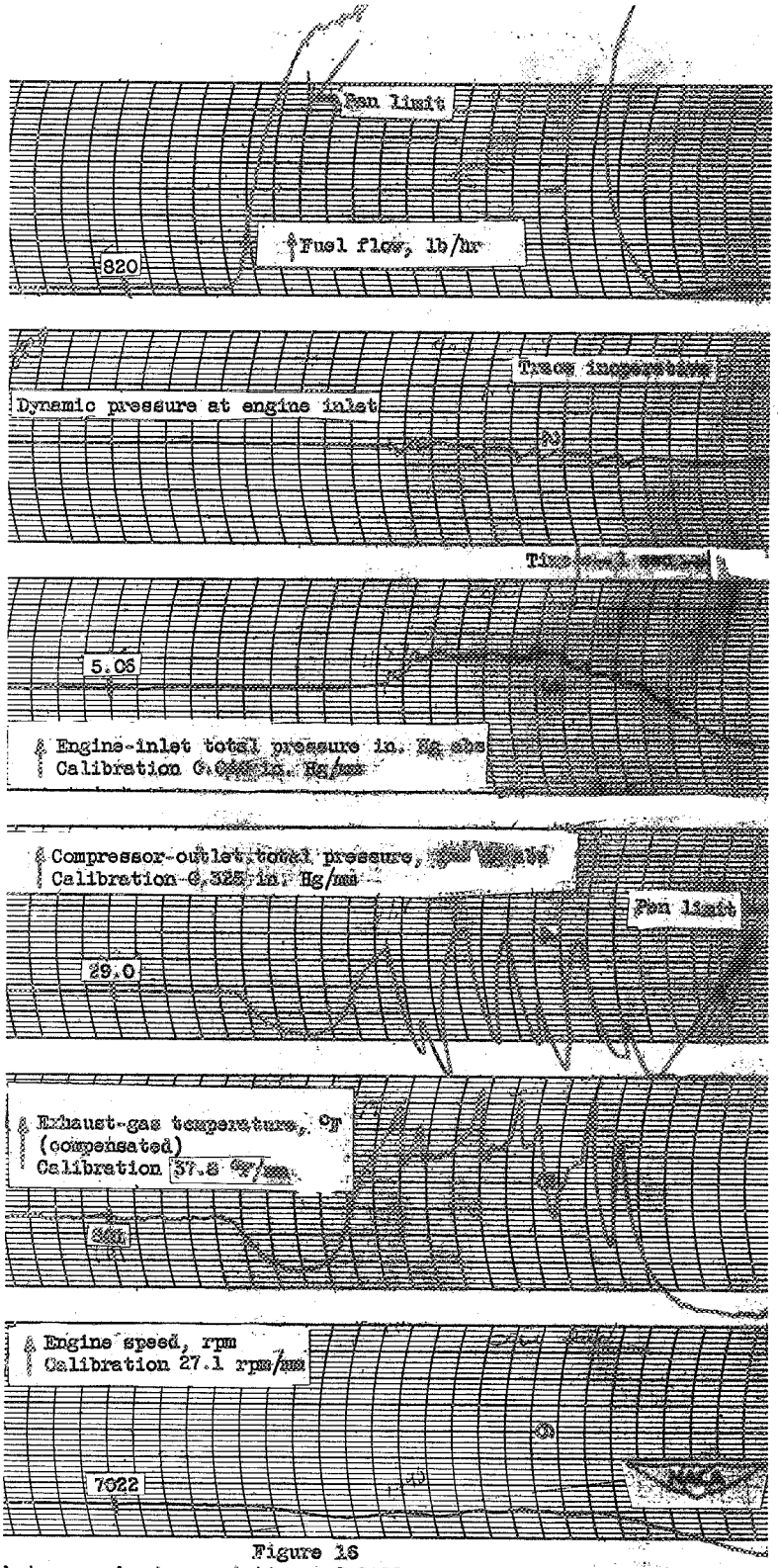

Figure 16

Oscillograph traces showing variations of different engine parameters during a step change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 58° F; inlet guide vanes position, open.

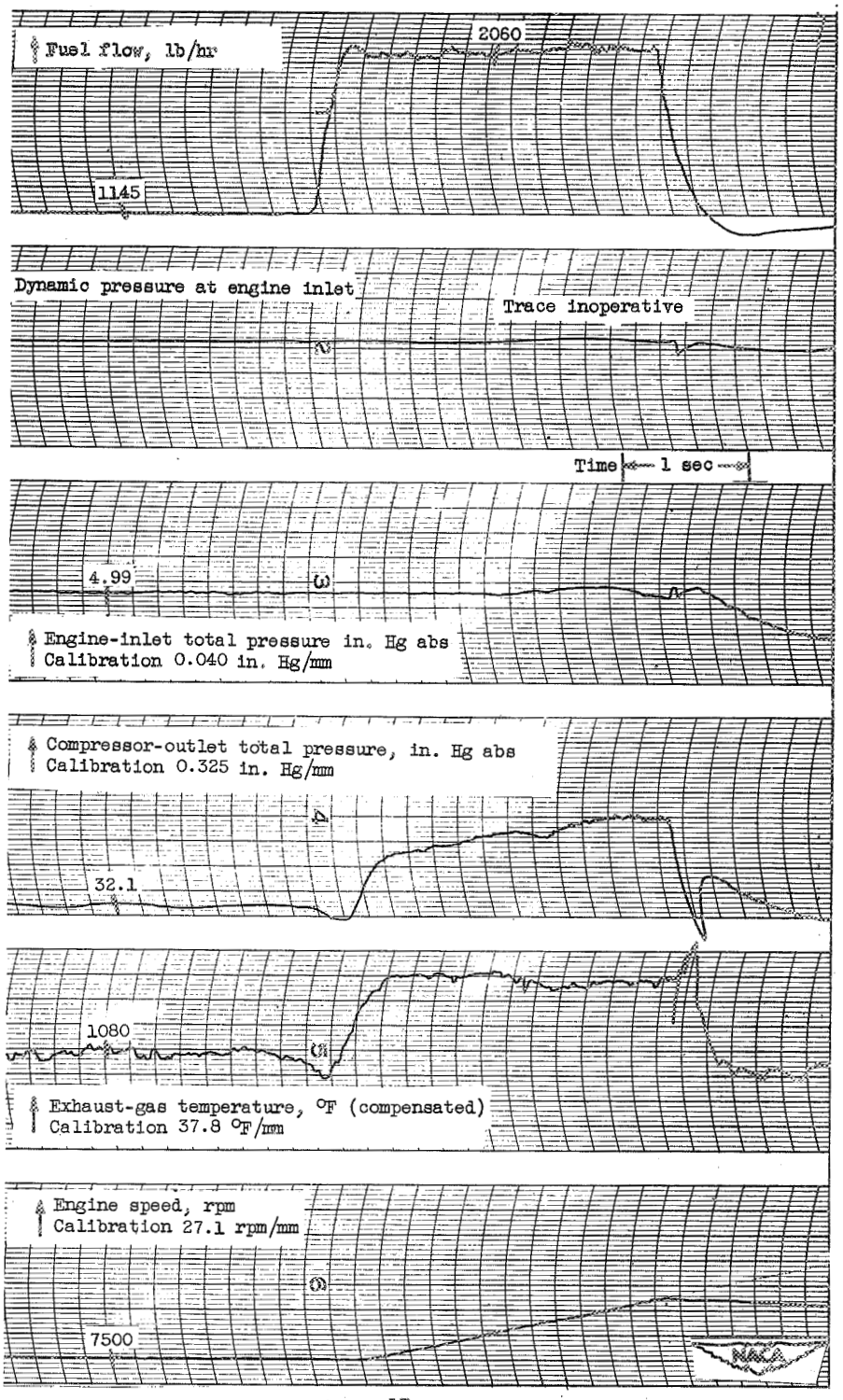

Figure 17

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

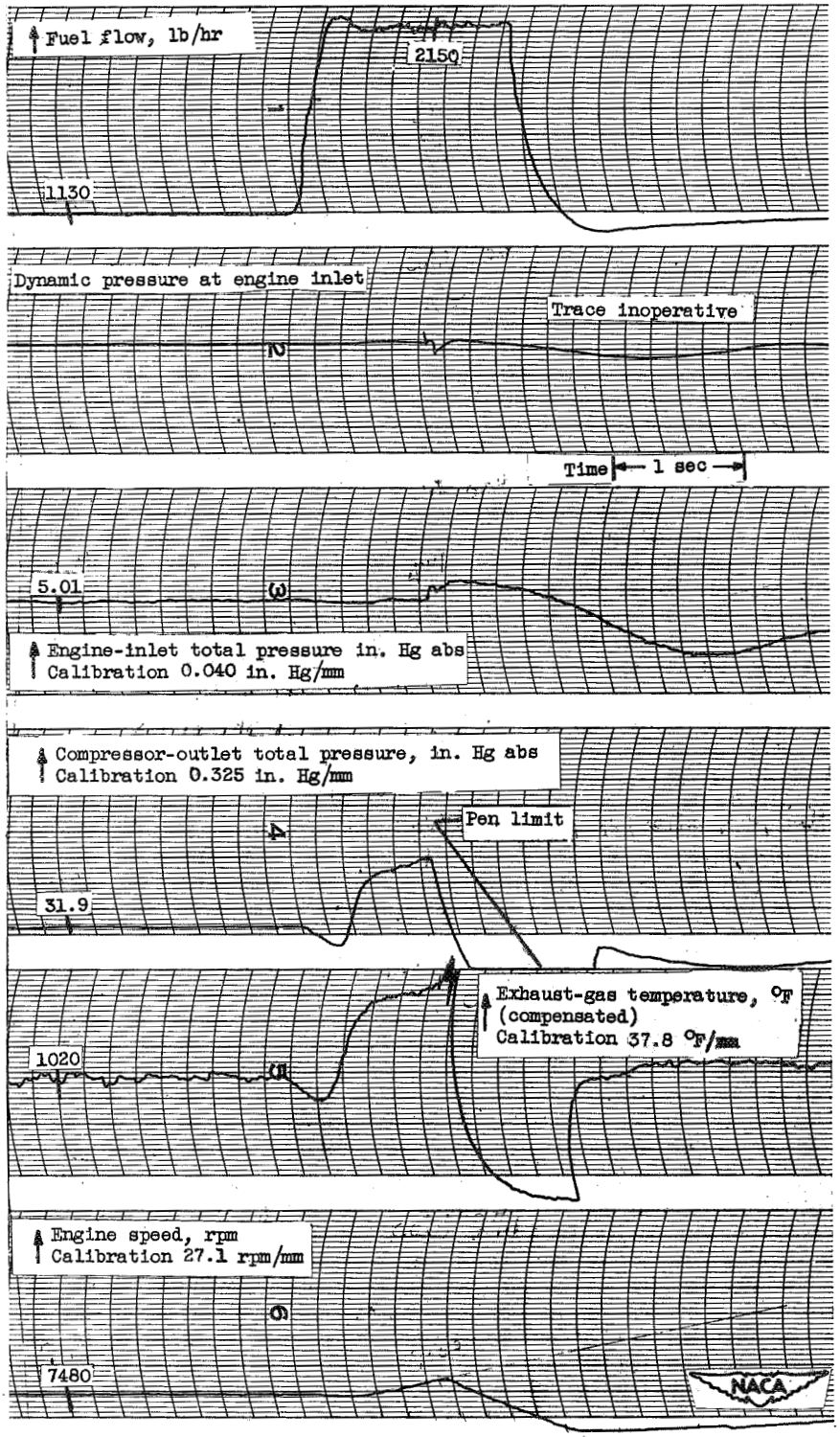

Figure 18

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.6; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

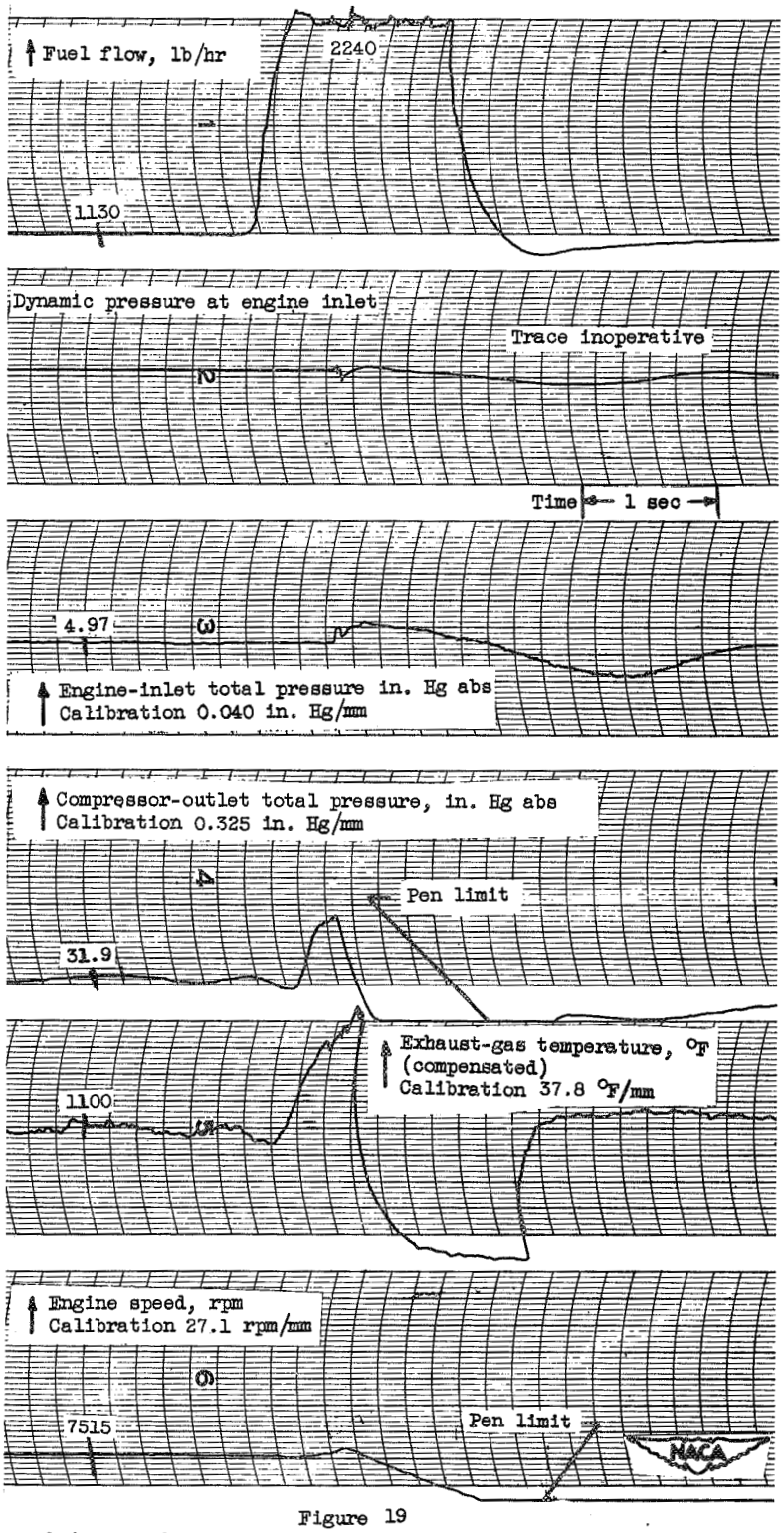

Figure 19

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0 0; engine-inlet air temperature, 57° F; inlet guide vanes position, open.

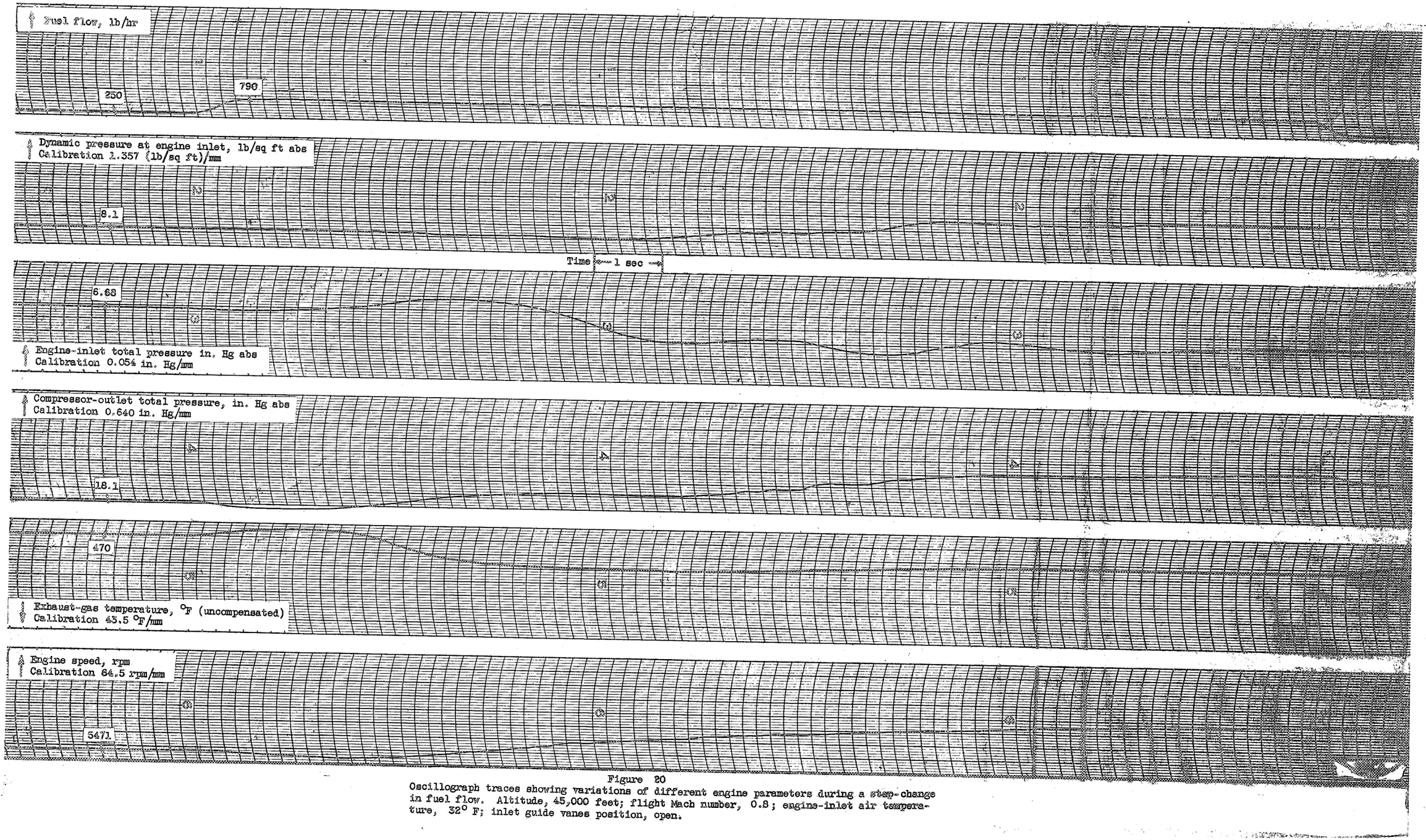

Figure 20
Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

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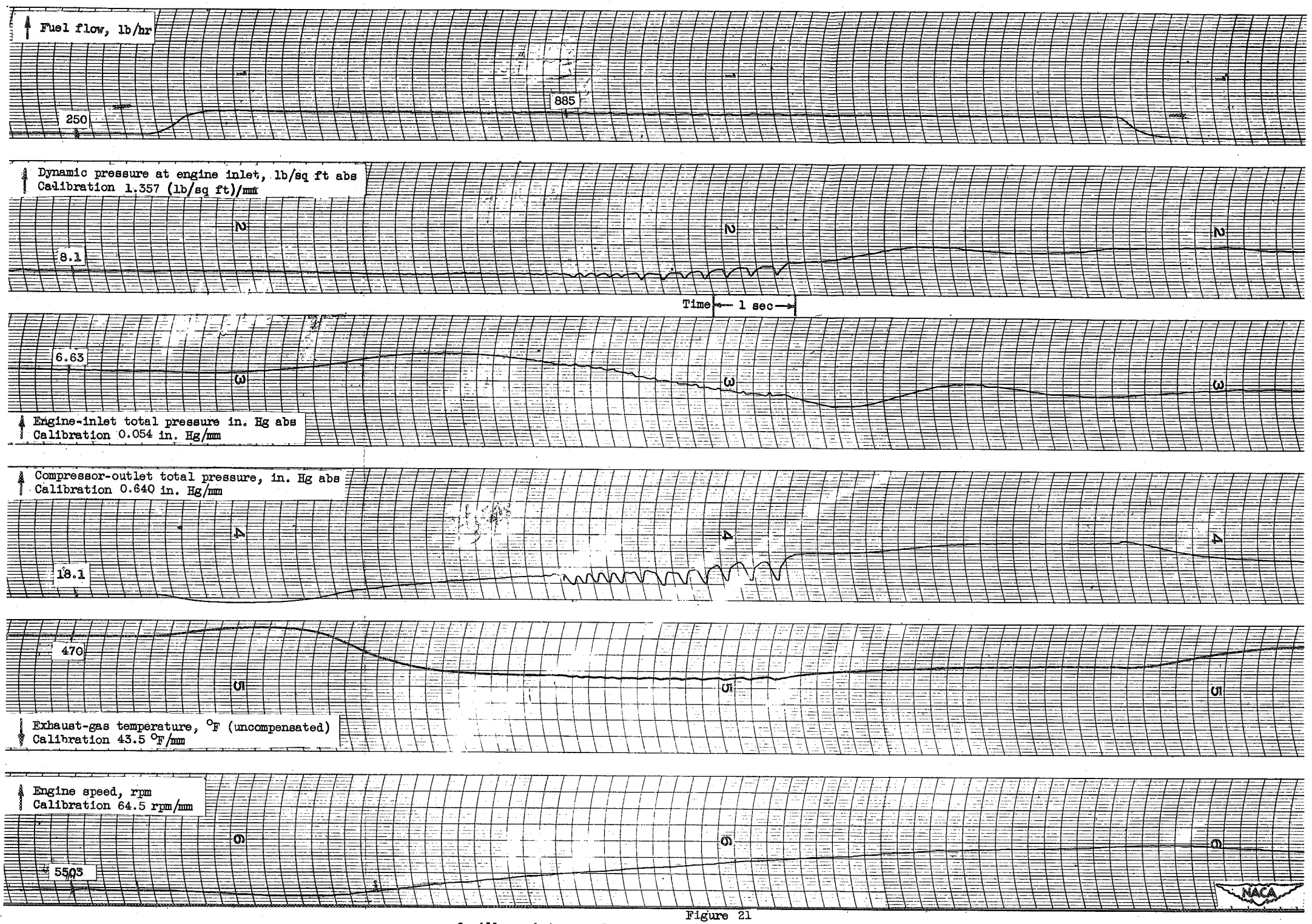

Figure 21

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

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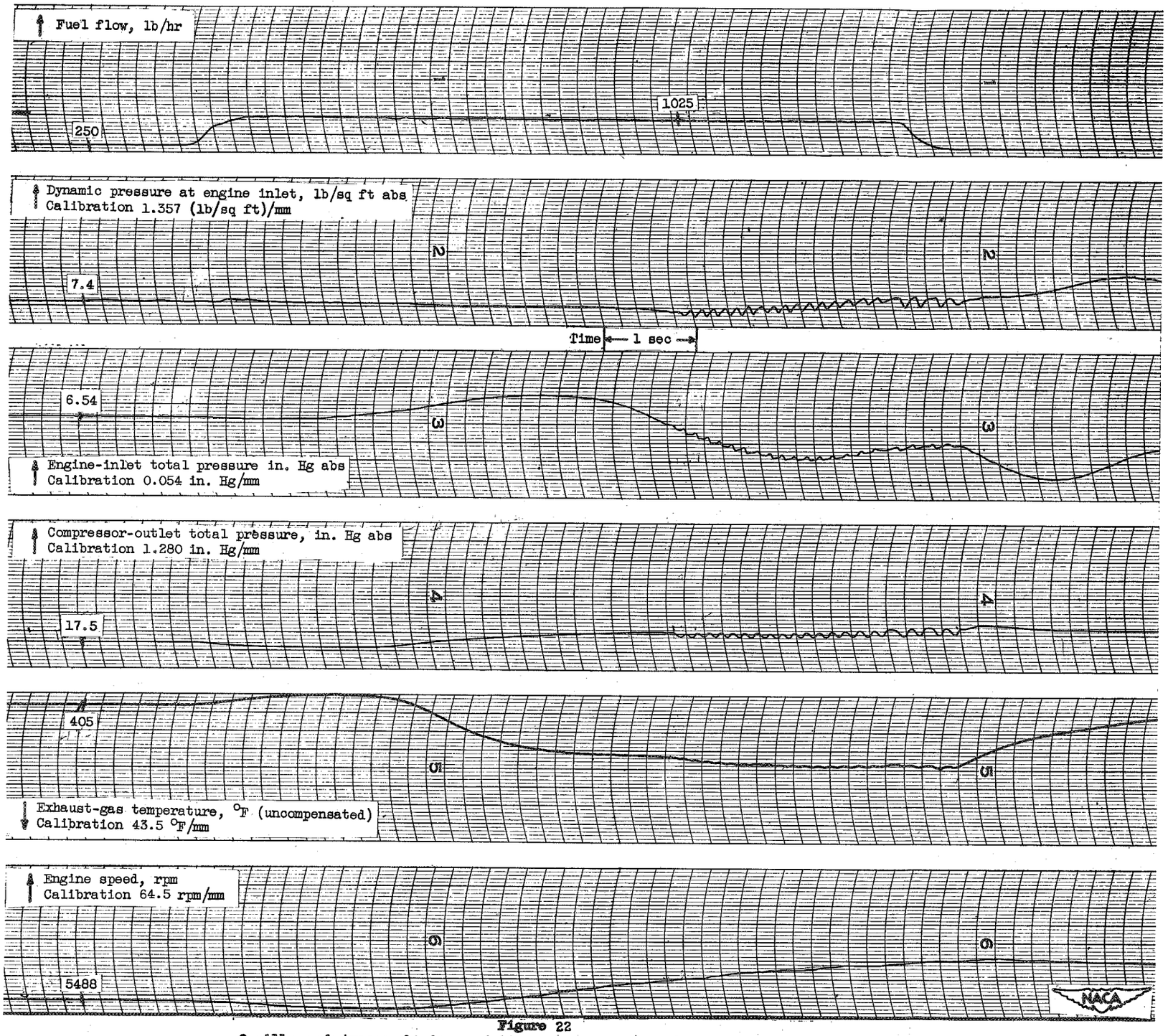

Figure 22

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 36° F; inlet guide vanes position, open.

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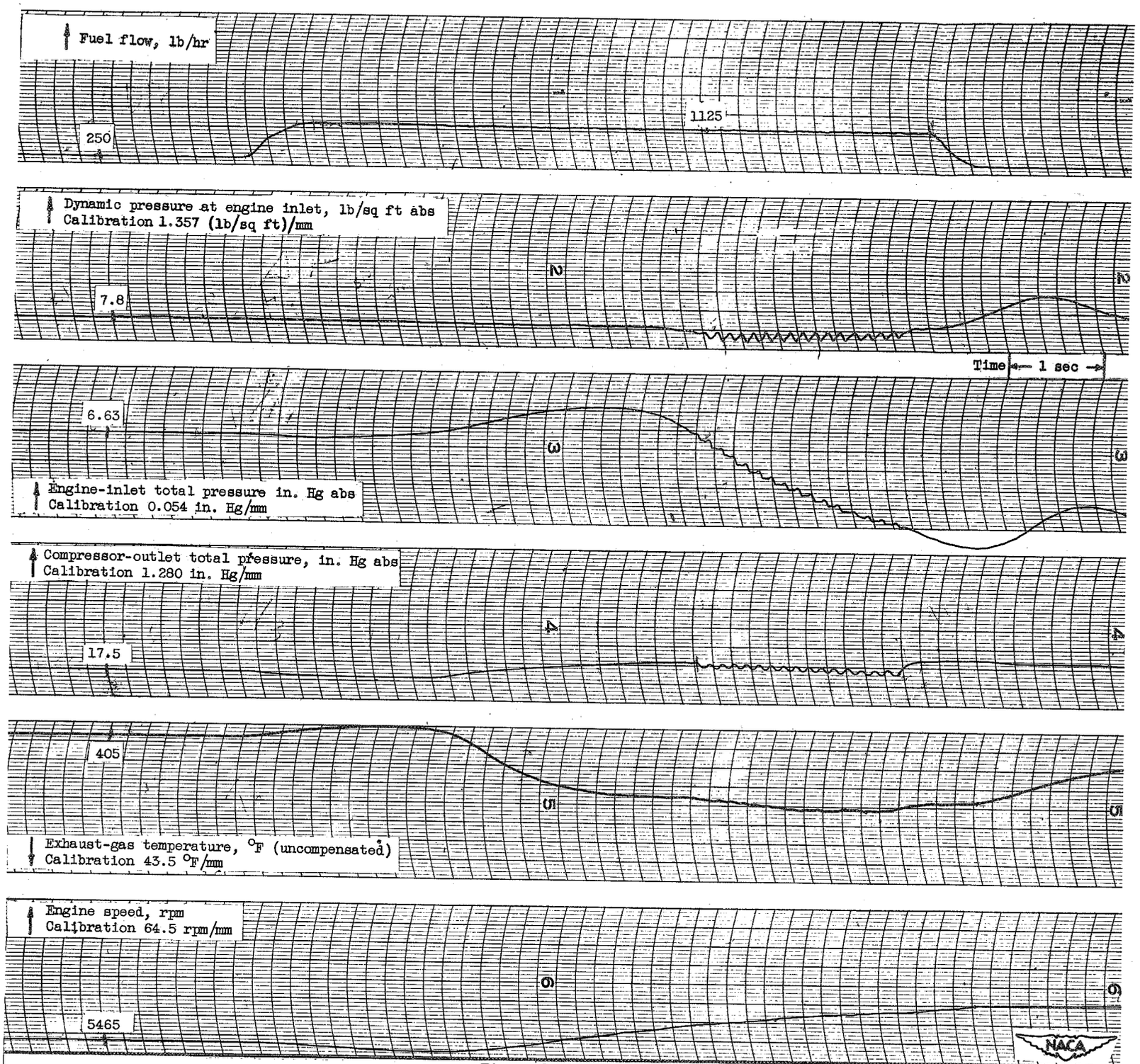

Figure 23

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 36° F; inlet guide vanes position, open.

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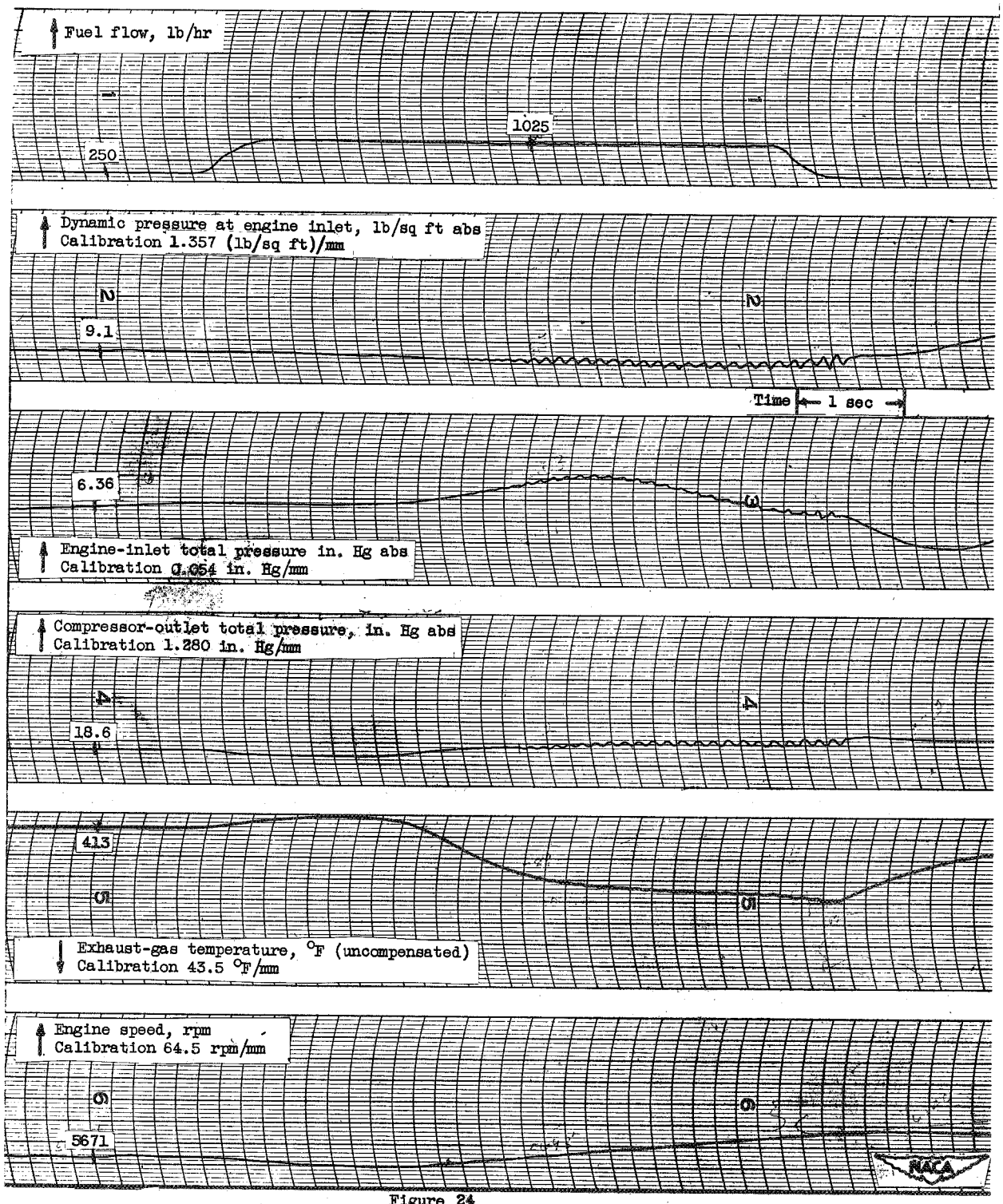

Figure 24

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 36° F; inlet guide vanes position, open.

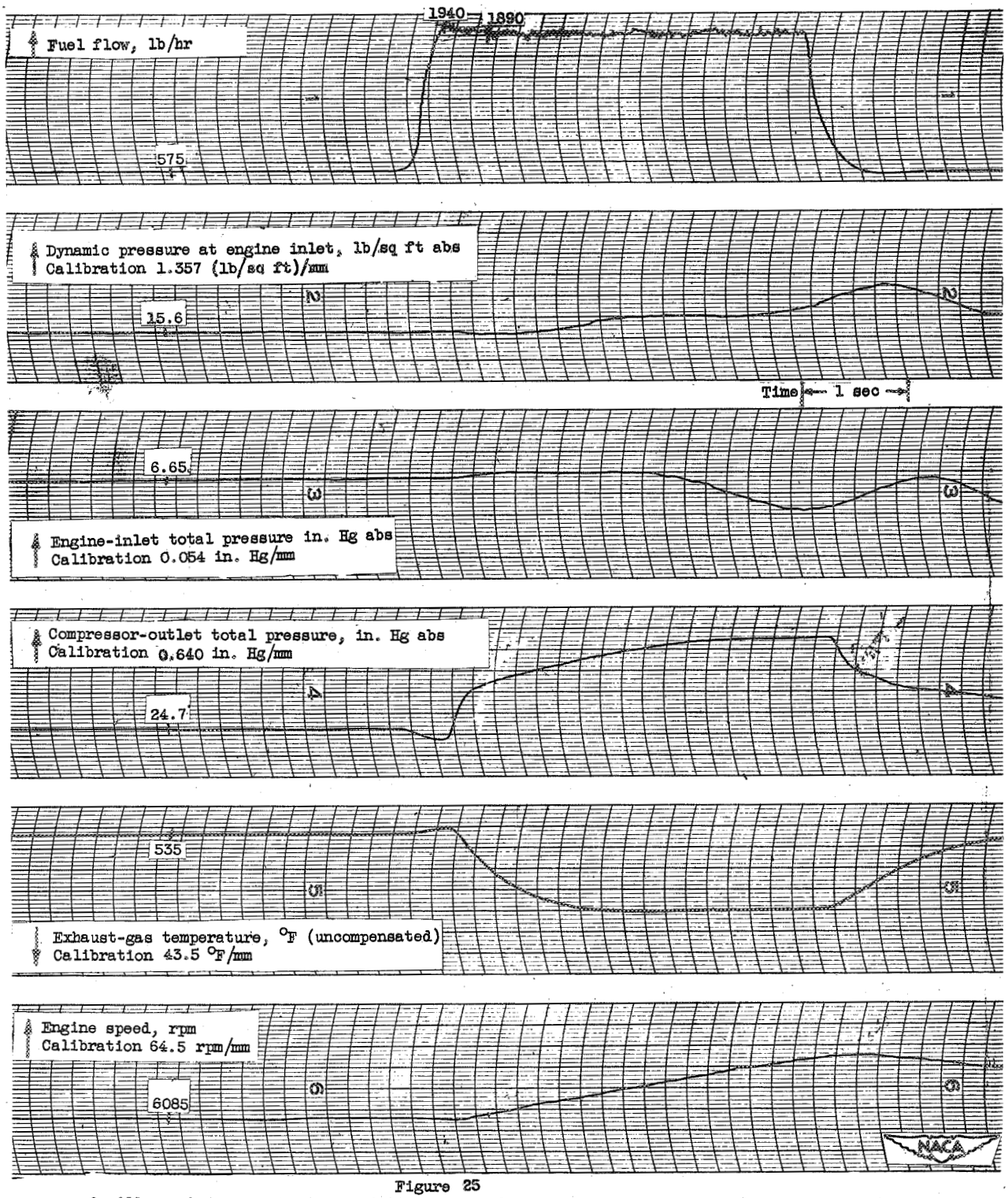

Figure 25

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

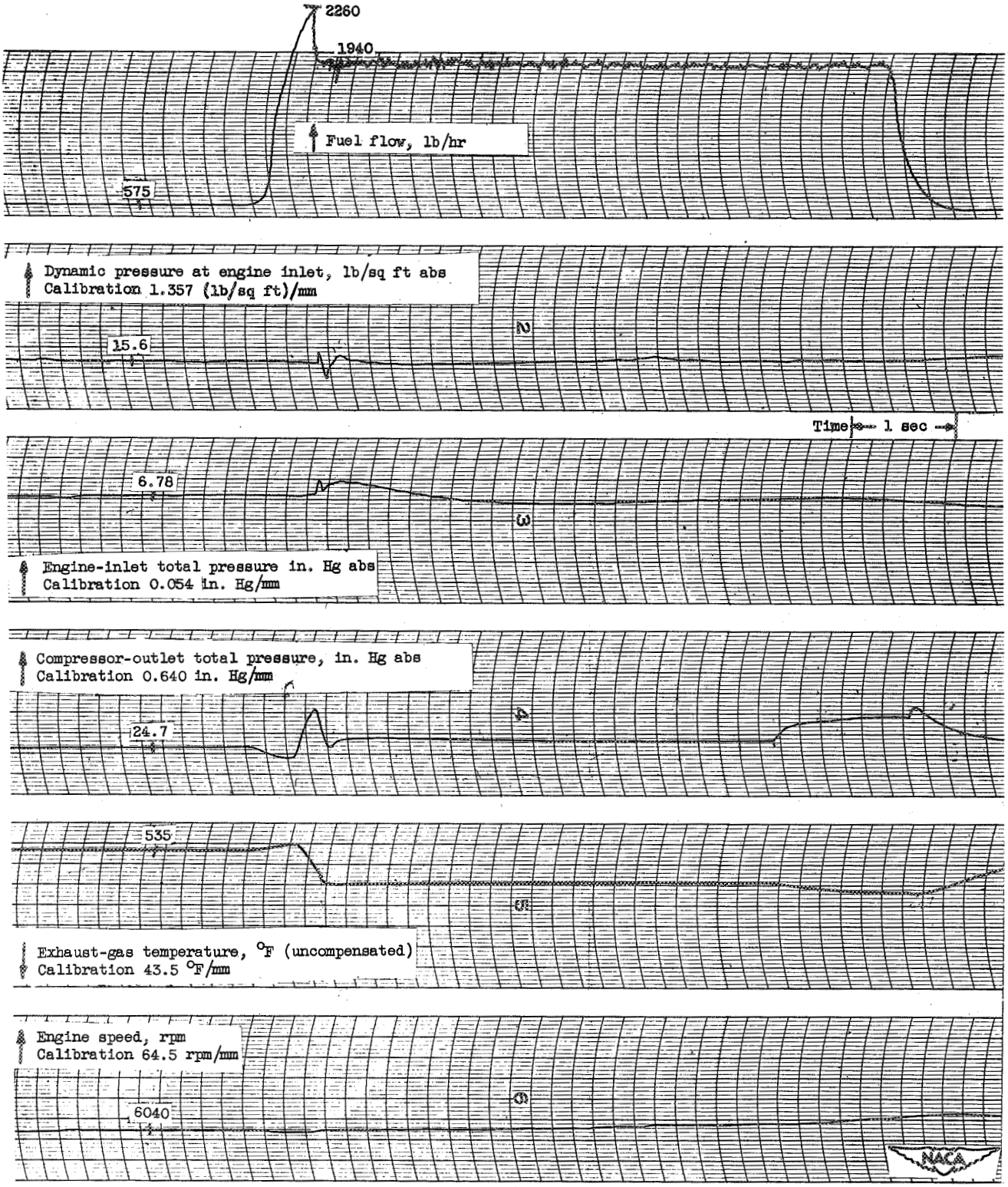

Figure 26

Oscillograph traces showing variations of different engine parameters during a step change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

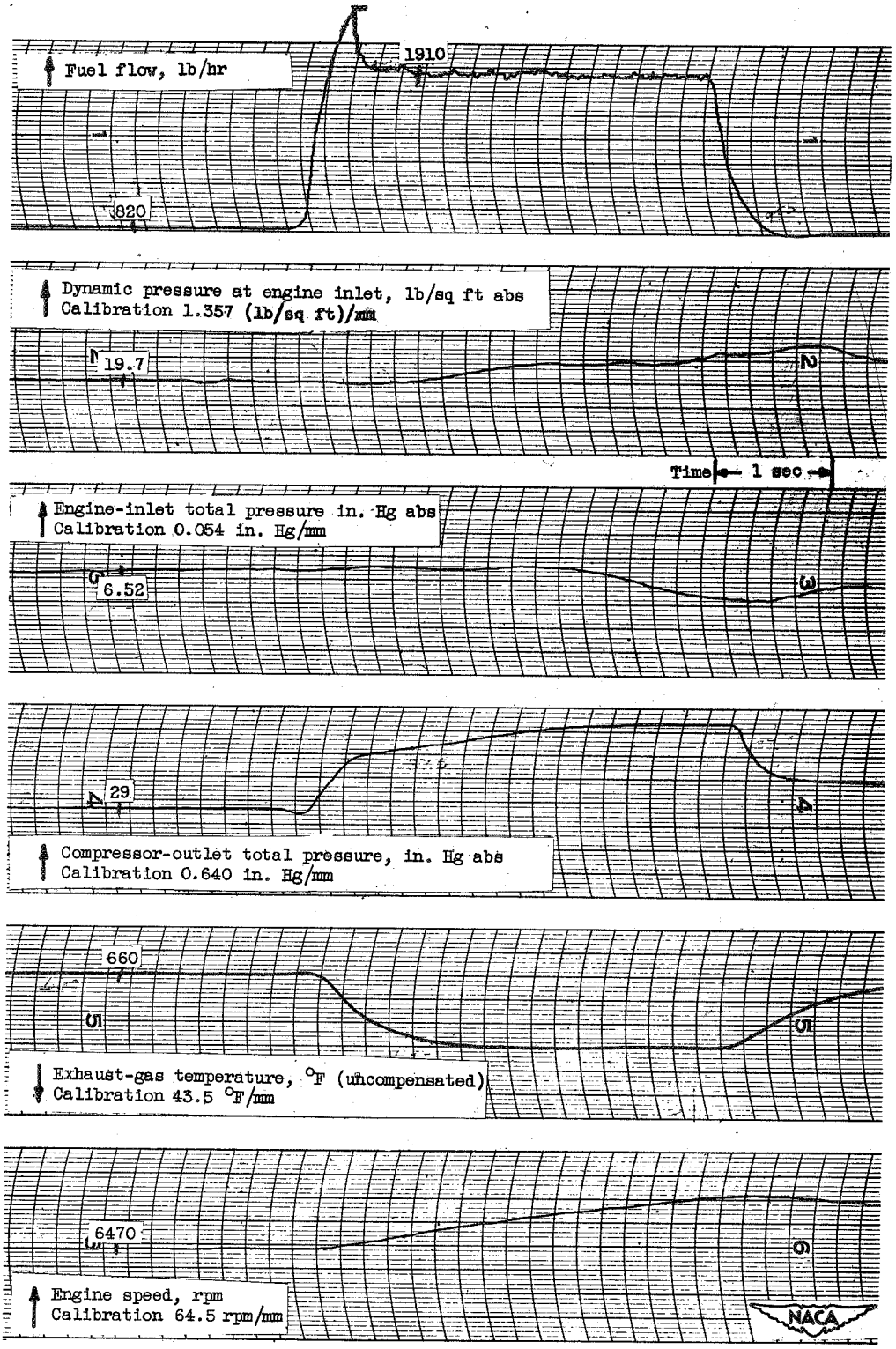

Figure 27

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, open.

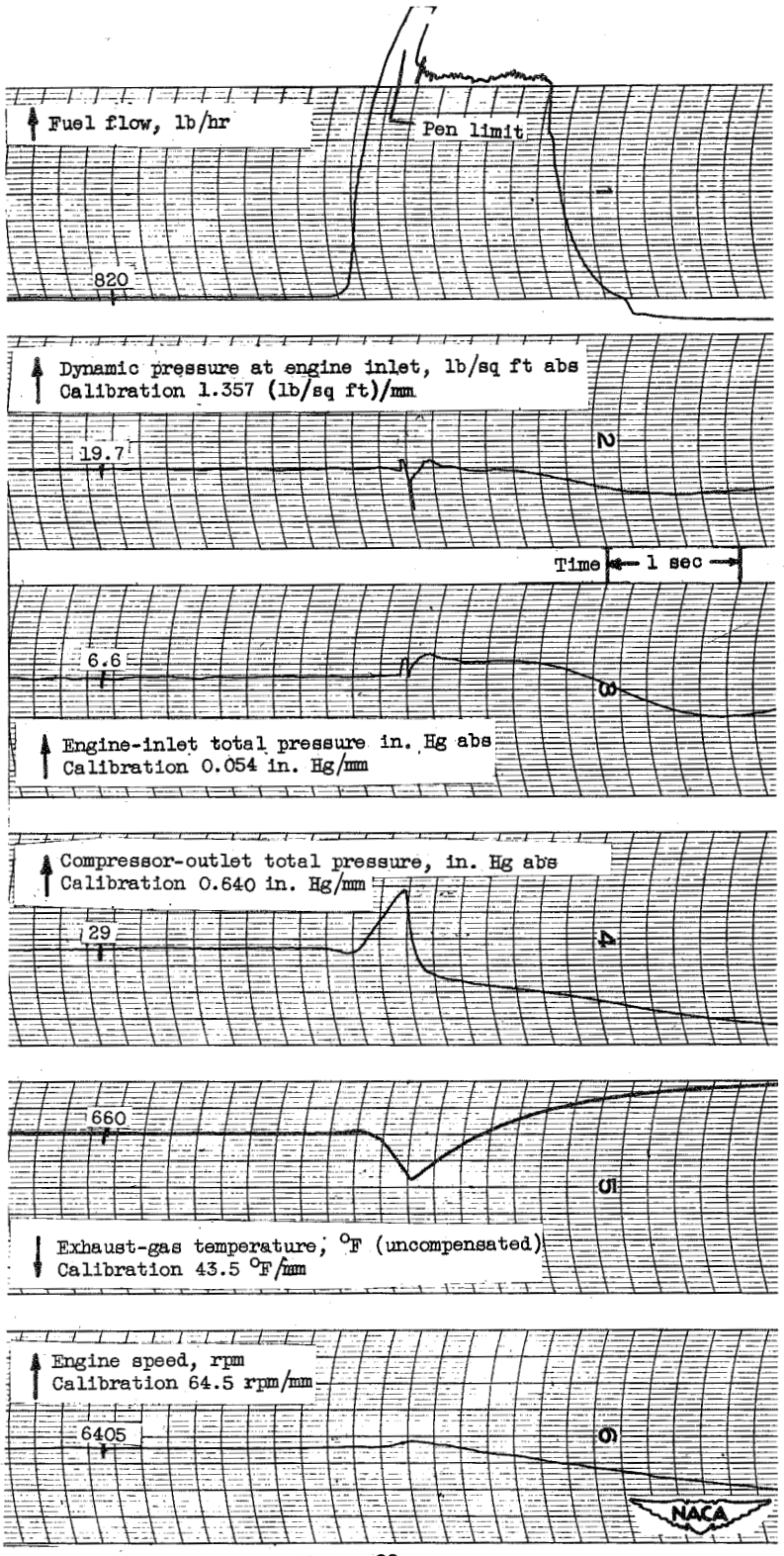

Figure 28

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, open.

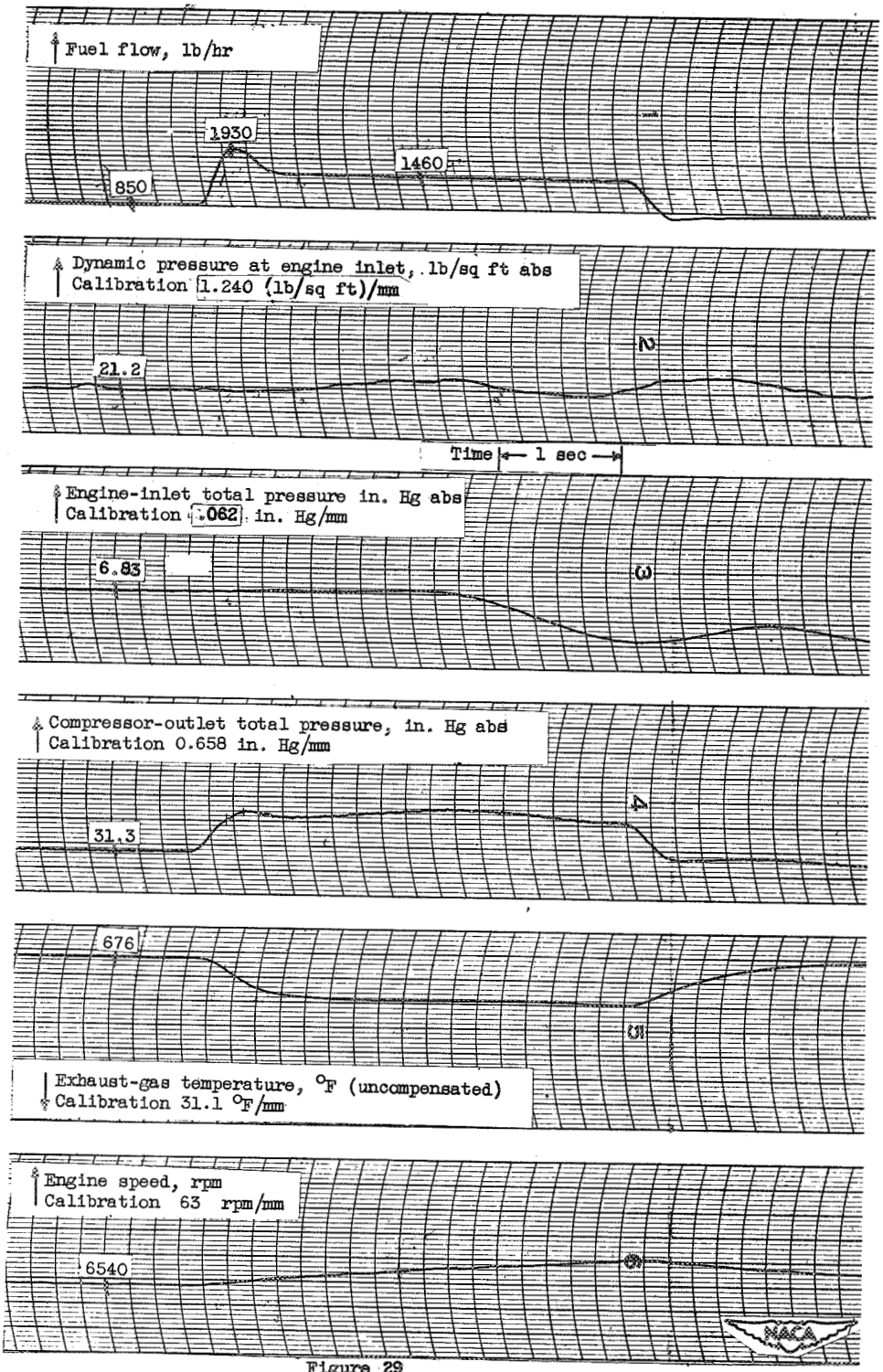

Figure 29

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30 °F; inlet guide vanes position, open.

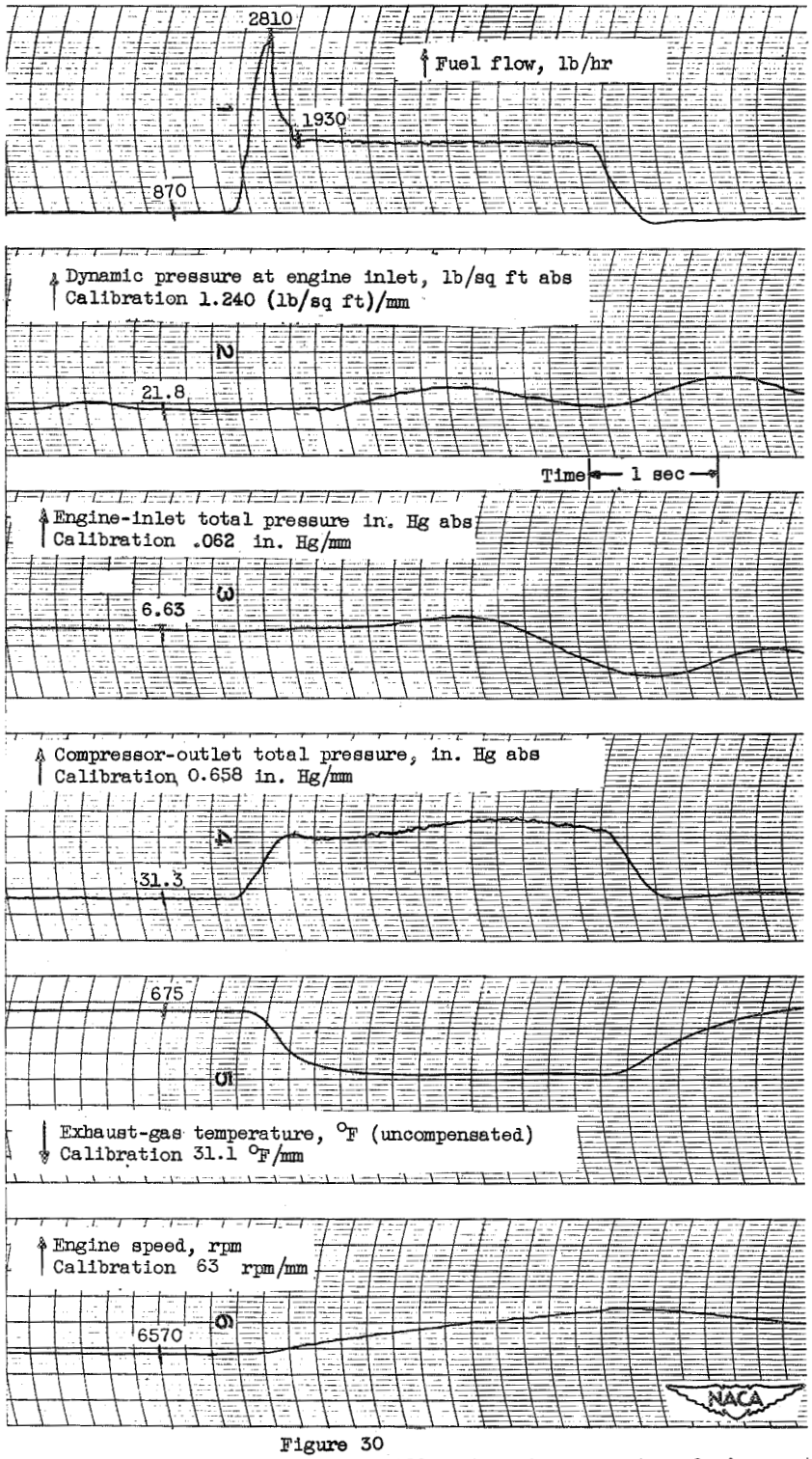

Figure 30

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

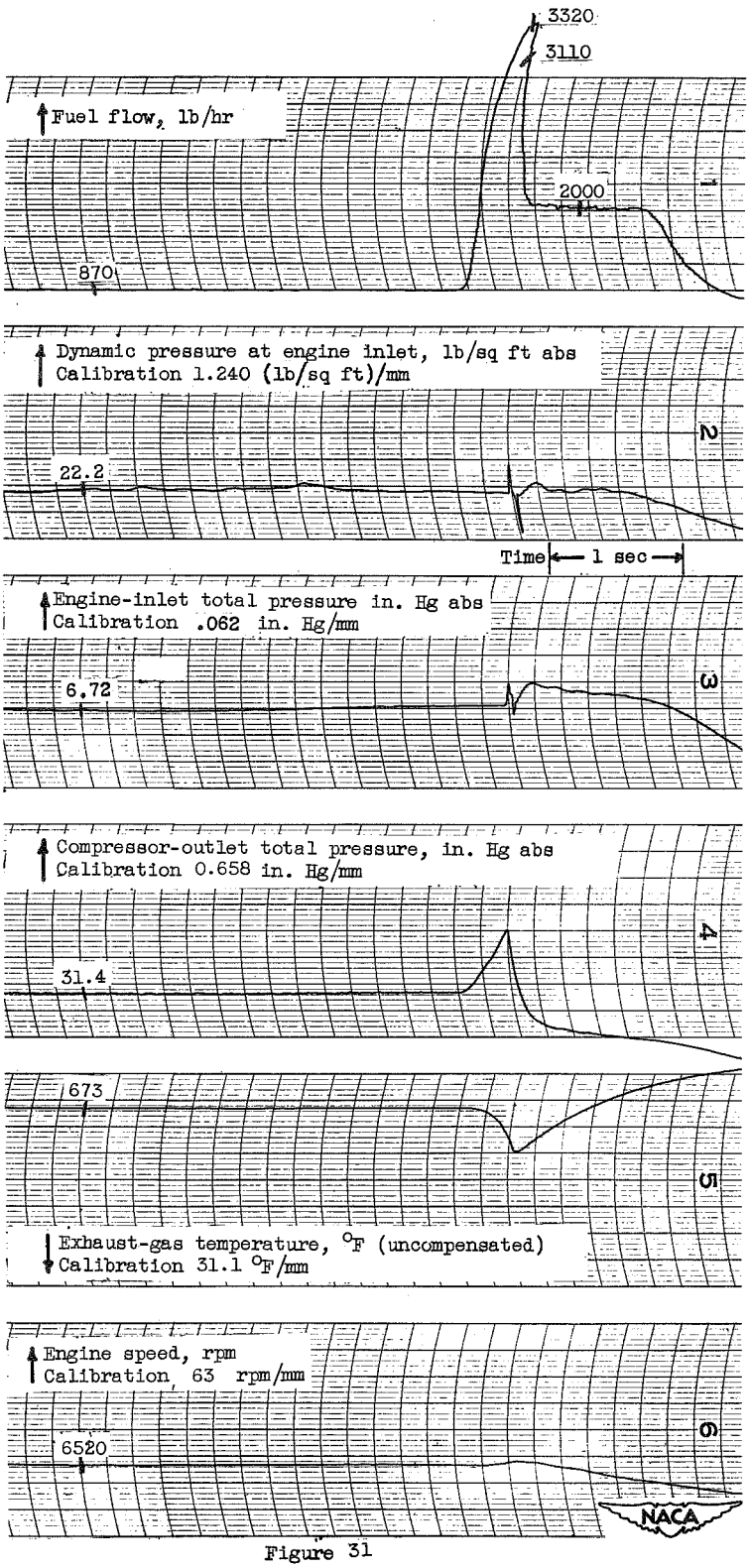

Figure 31

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

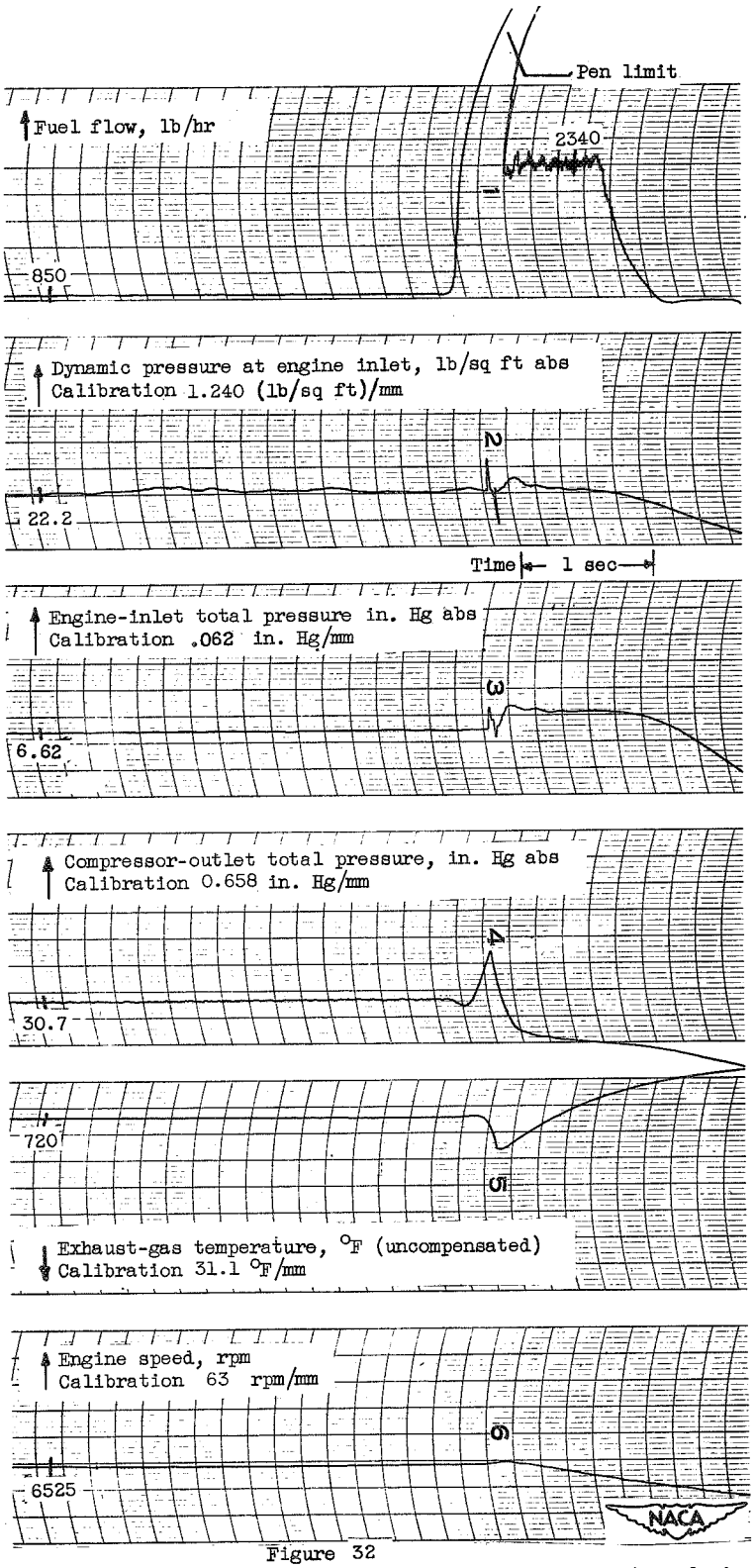

Figure 32

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

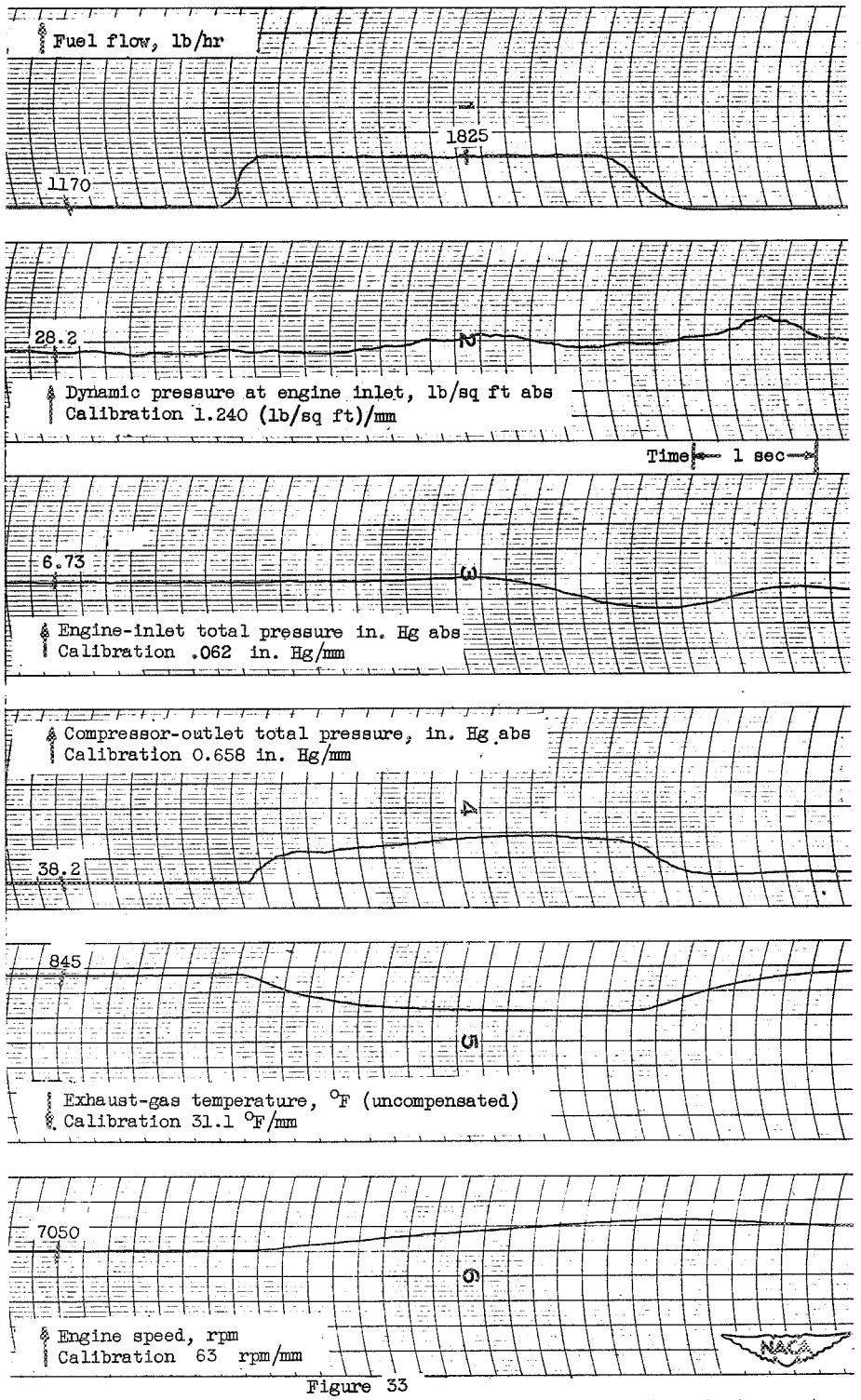

Figure 33

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

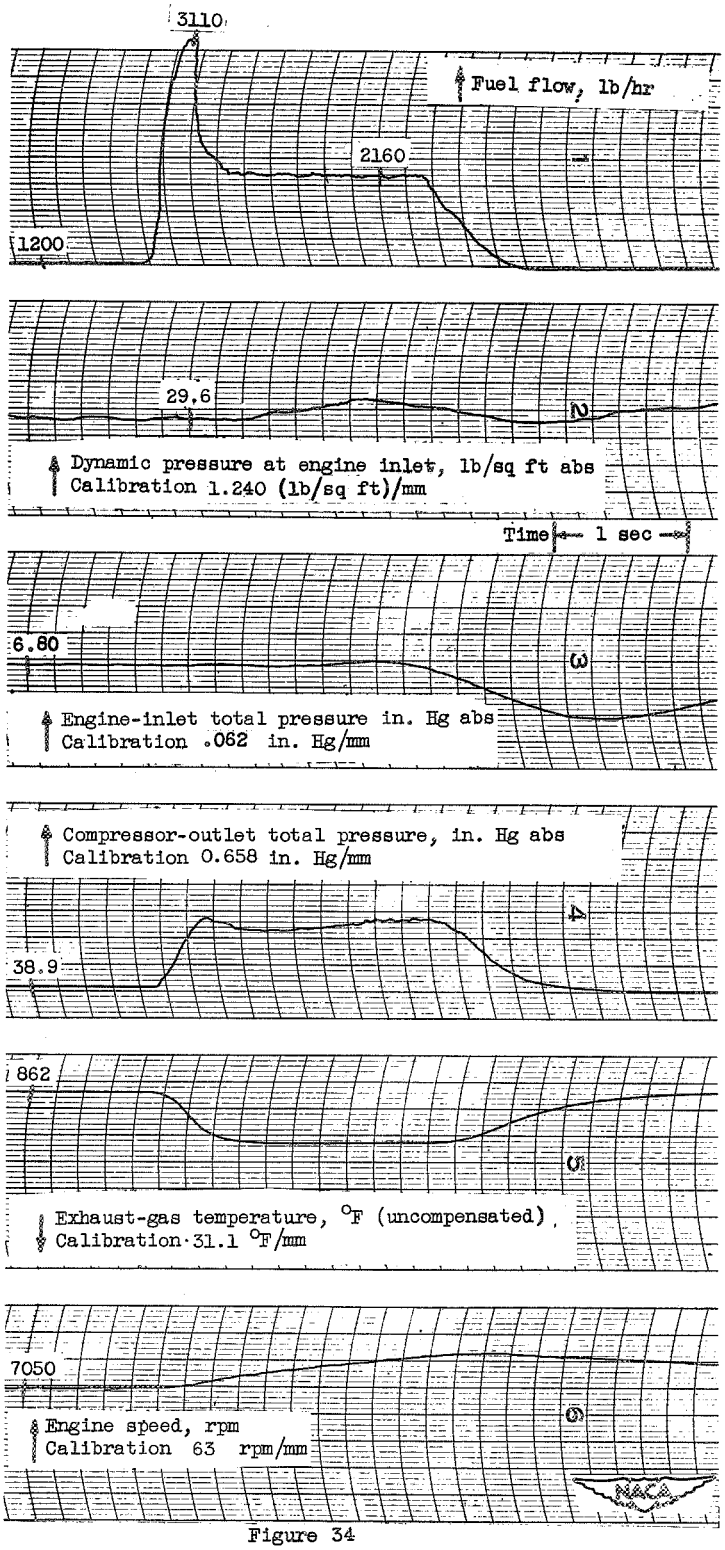

Figure 34

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 33 °F; inlet guide vanes position, open.

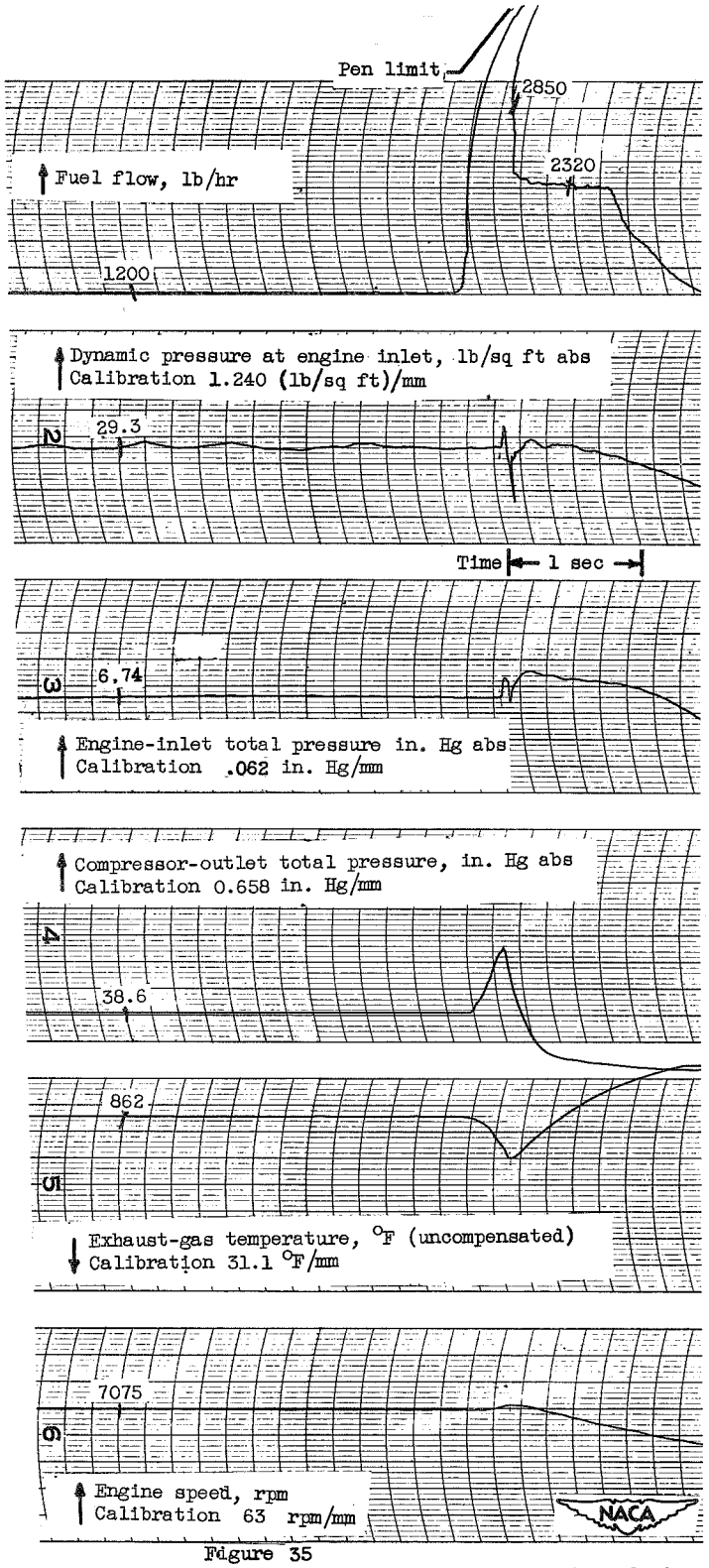

Figure 35

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 33° F; inlet guide vanes position, open.

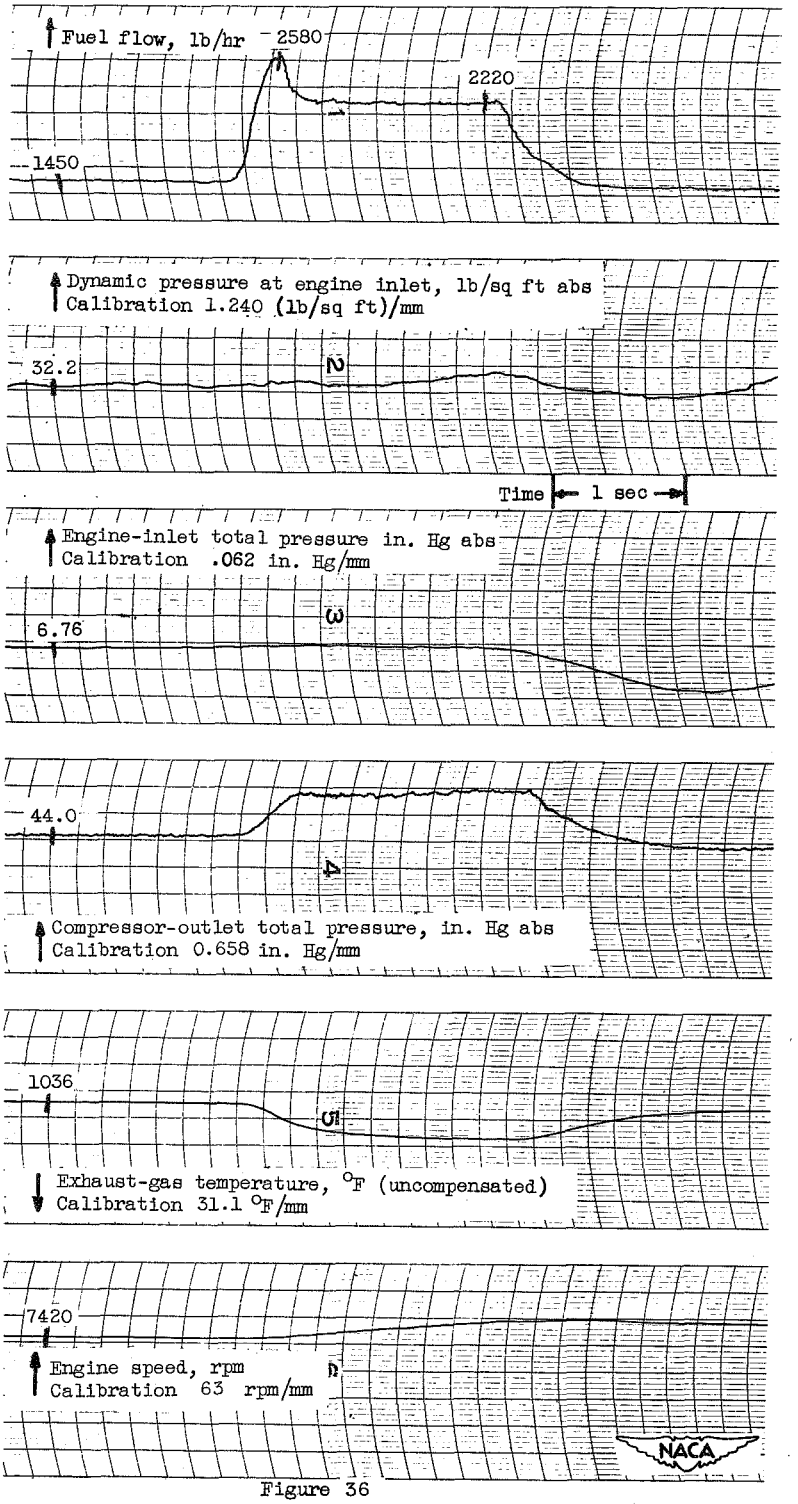

Figure 36

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

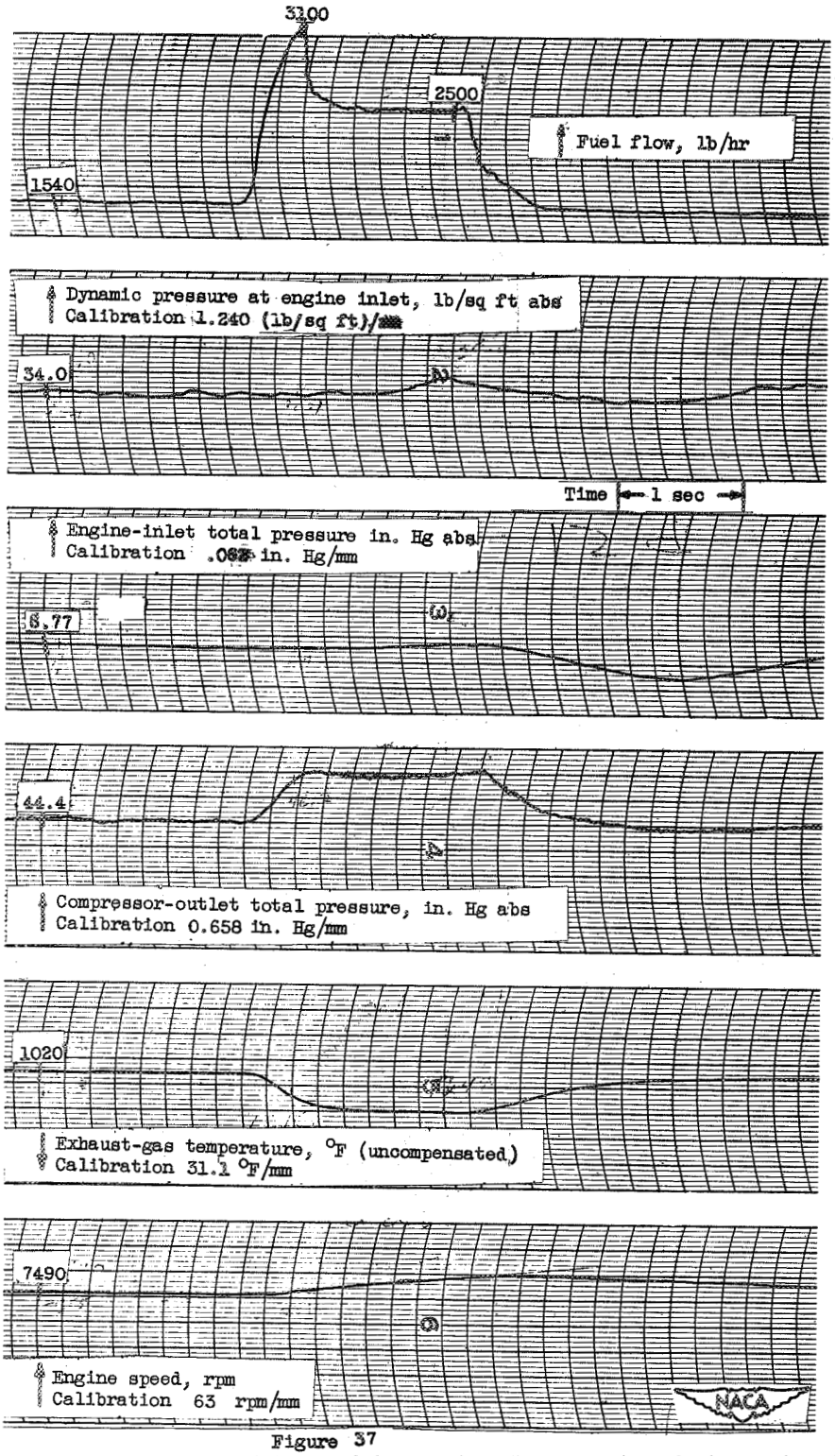

Figure 37

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

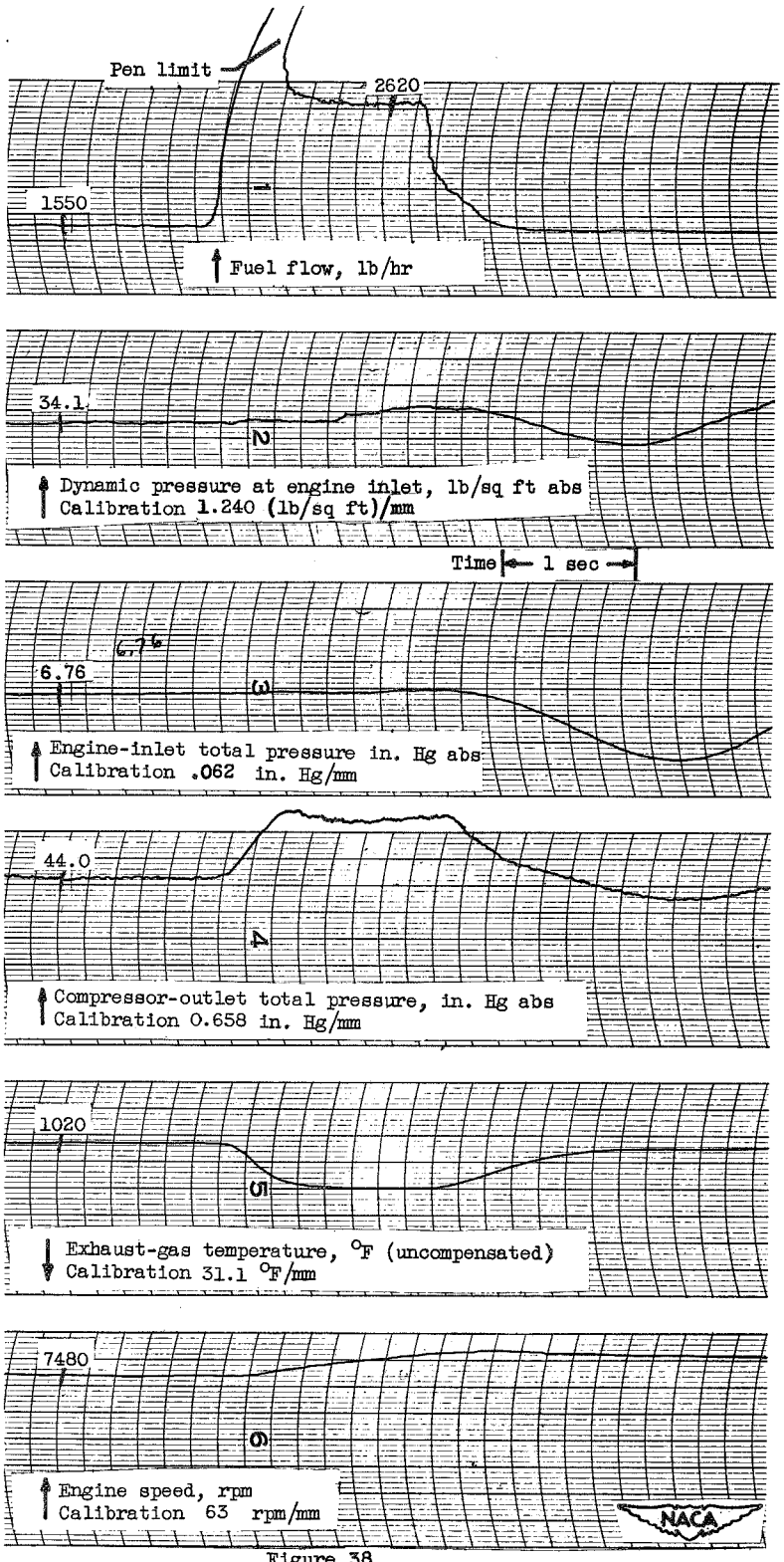

Figure 38

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

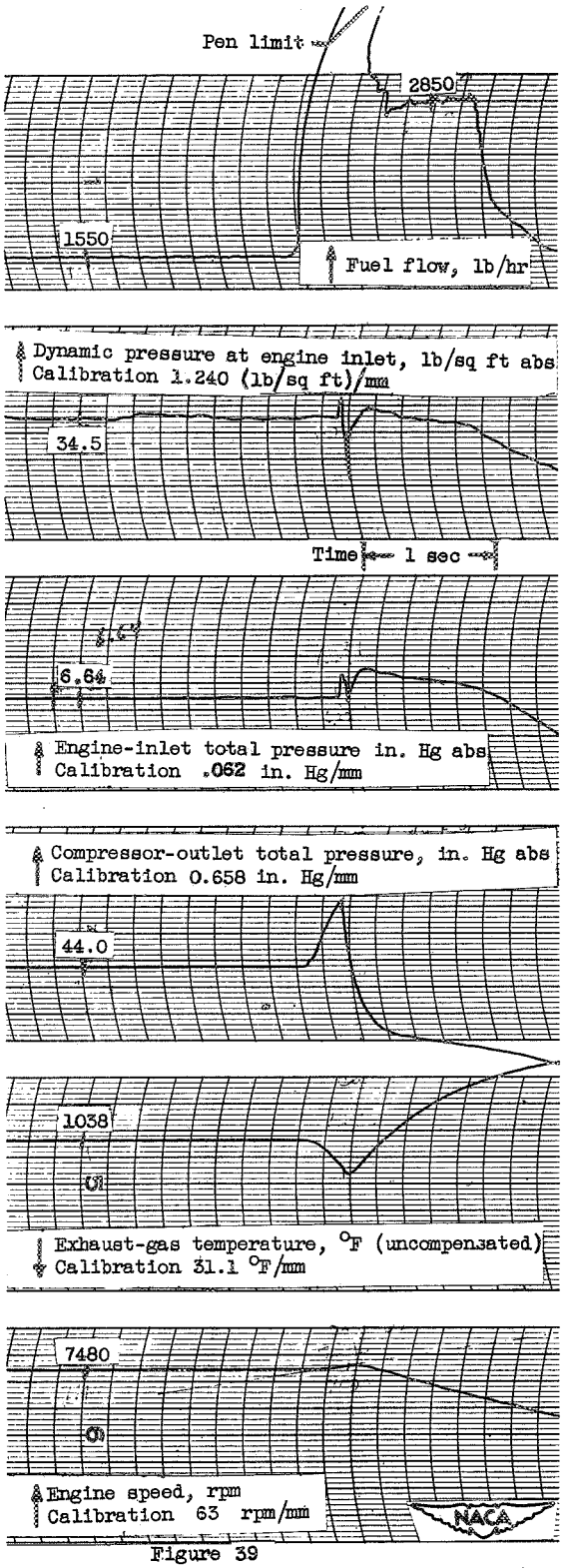

Figure 39

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, open.

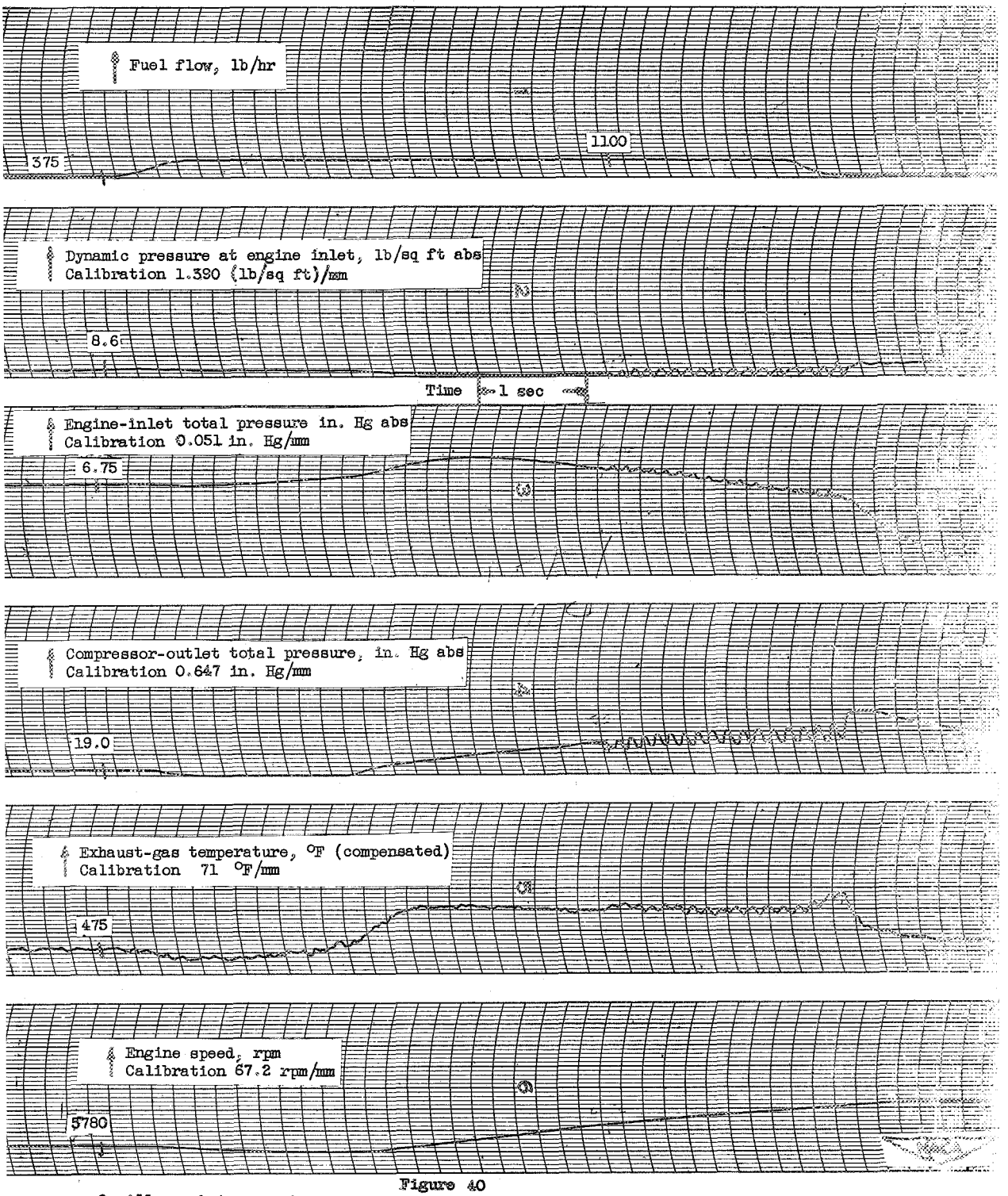

Figure 40

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 75° F; inlet guide vanes position, open.

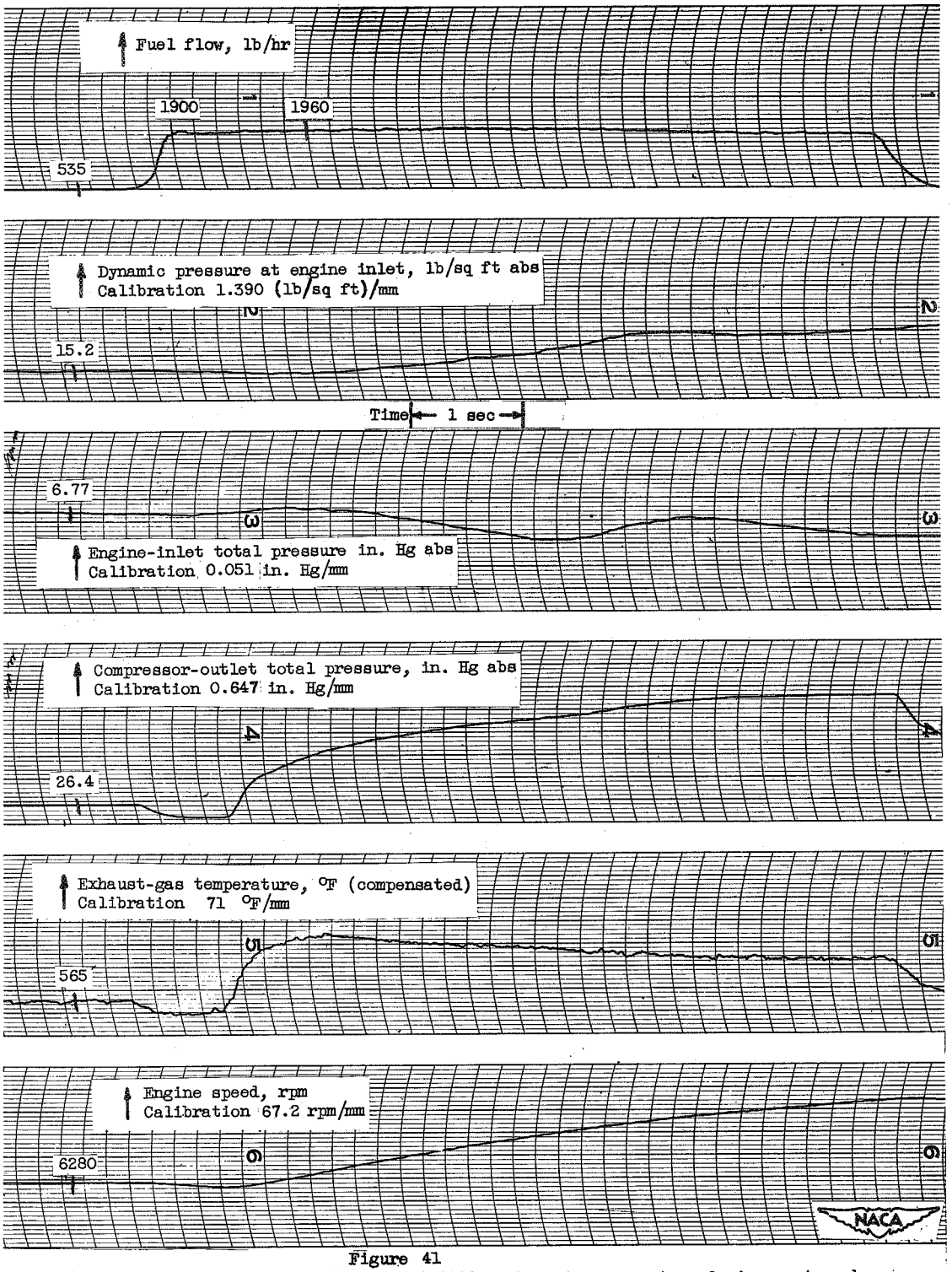

Figure 41

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

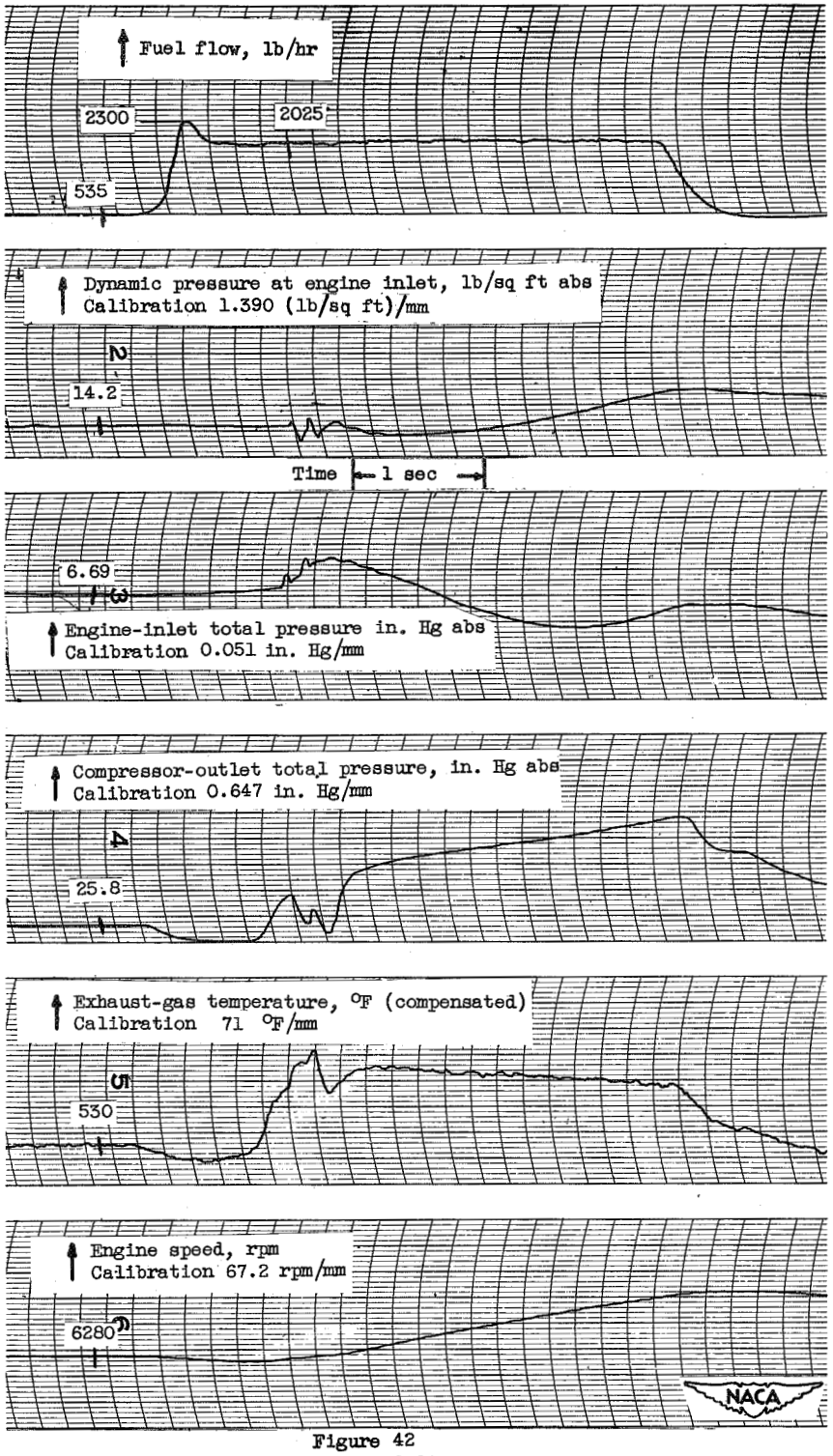

Figure 42

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

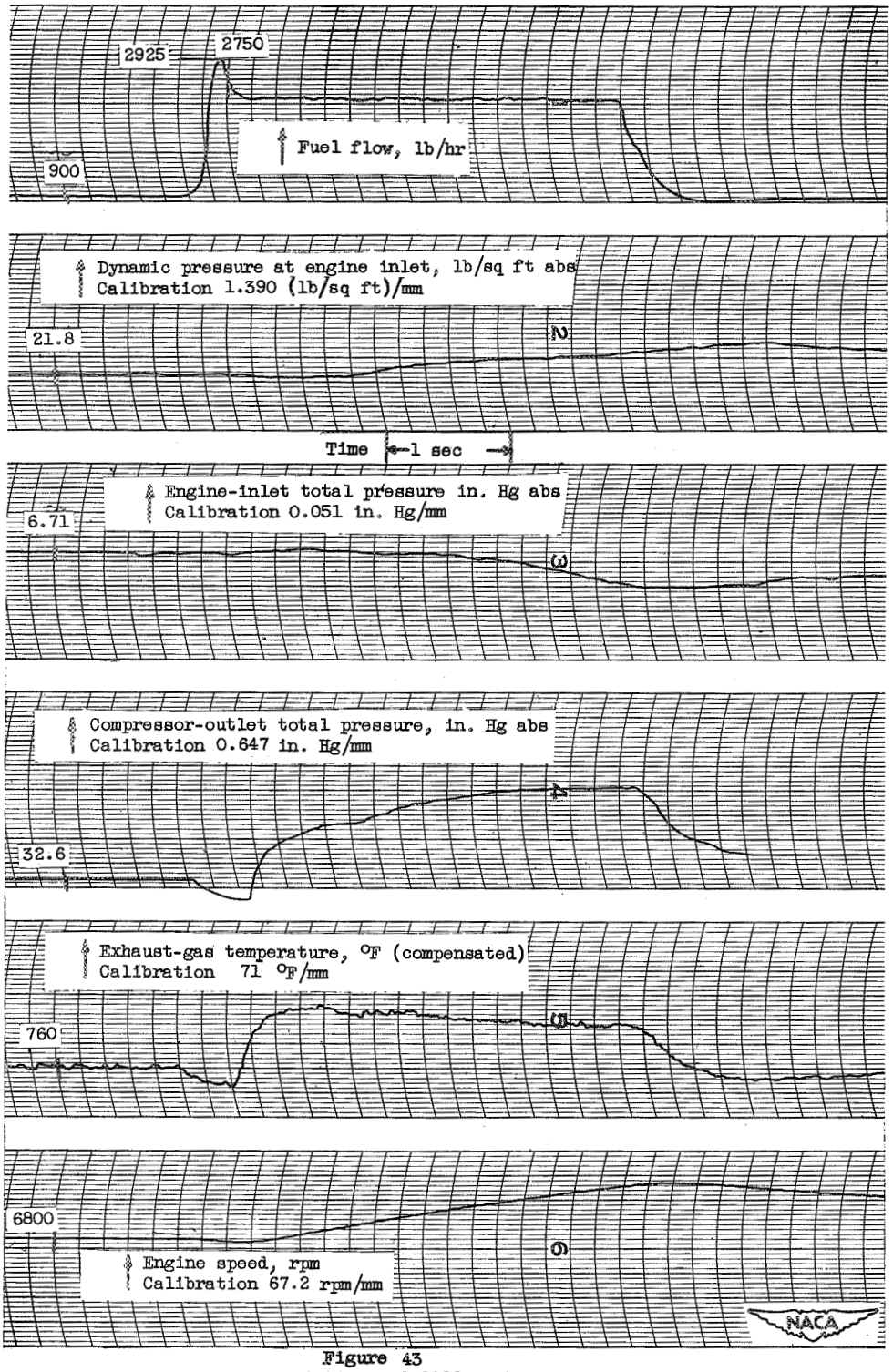

Figure 43

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

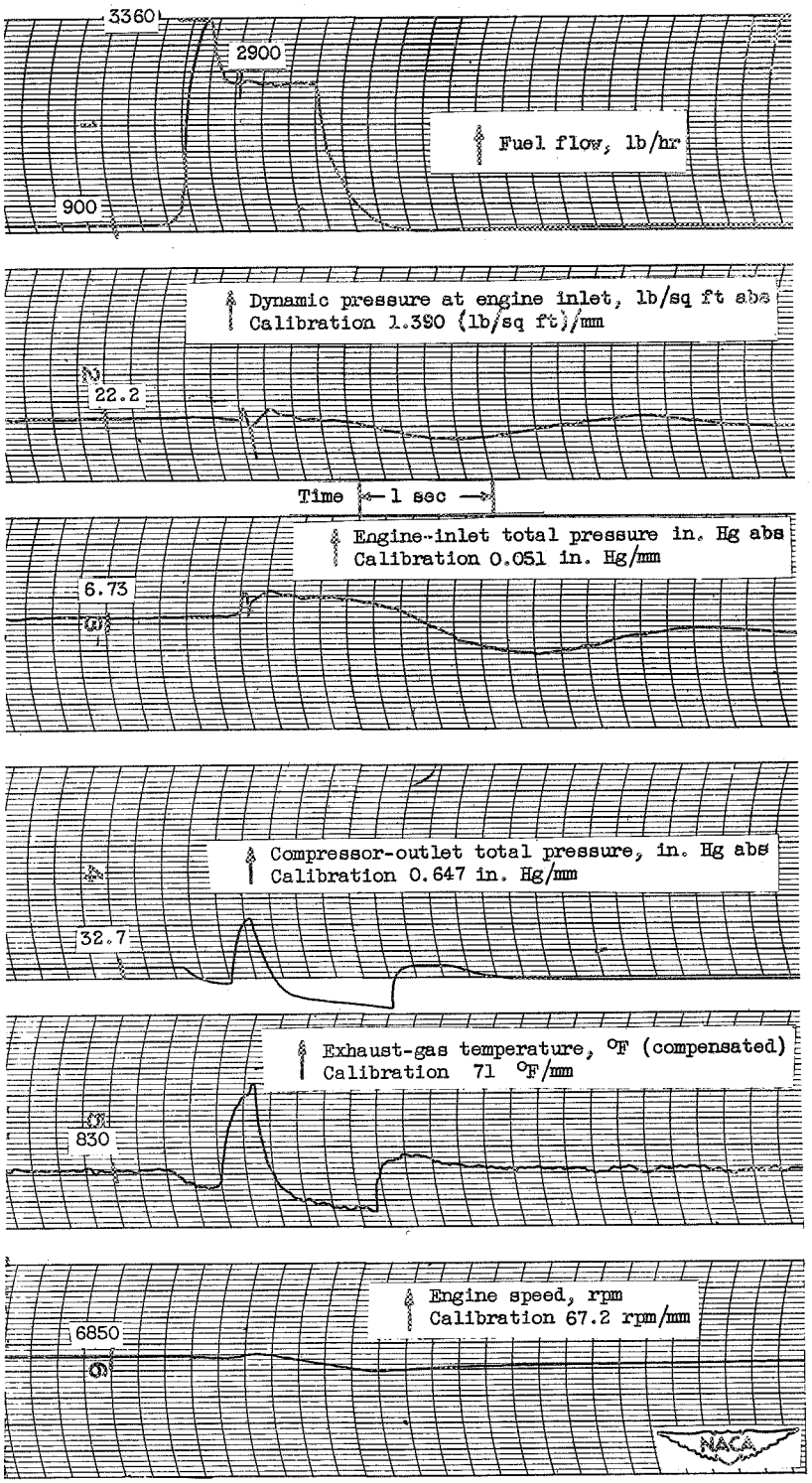

Figure 44

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

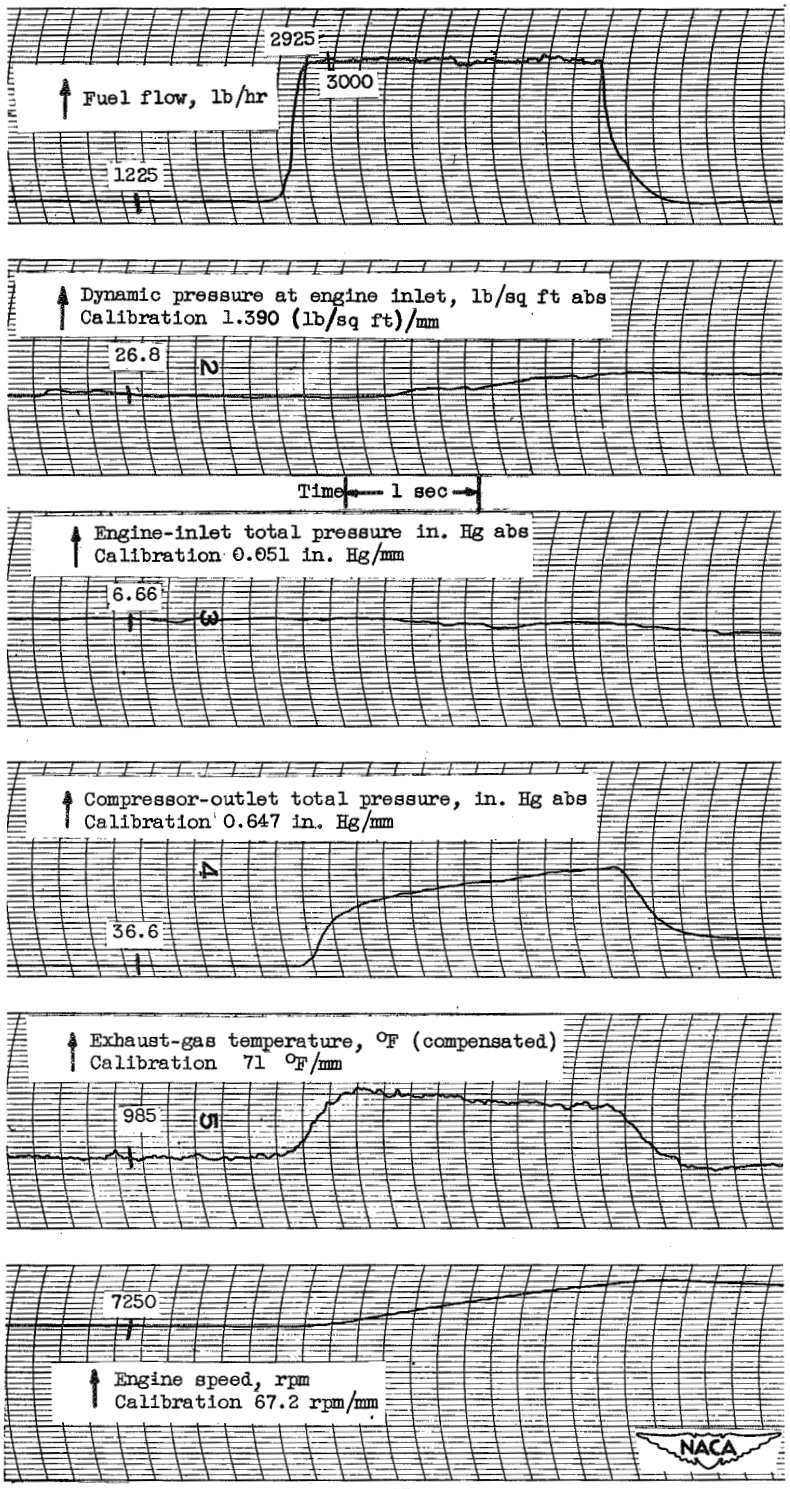

Figure 45

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

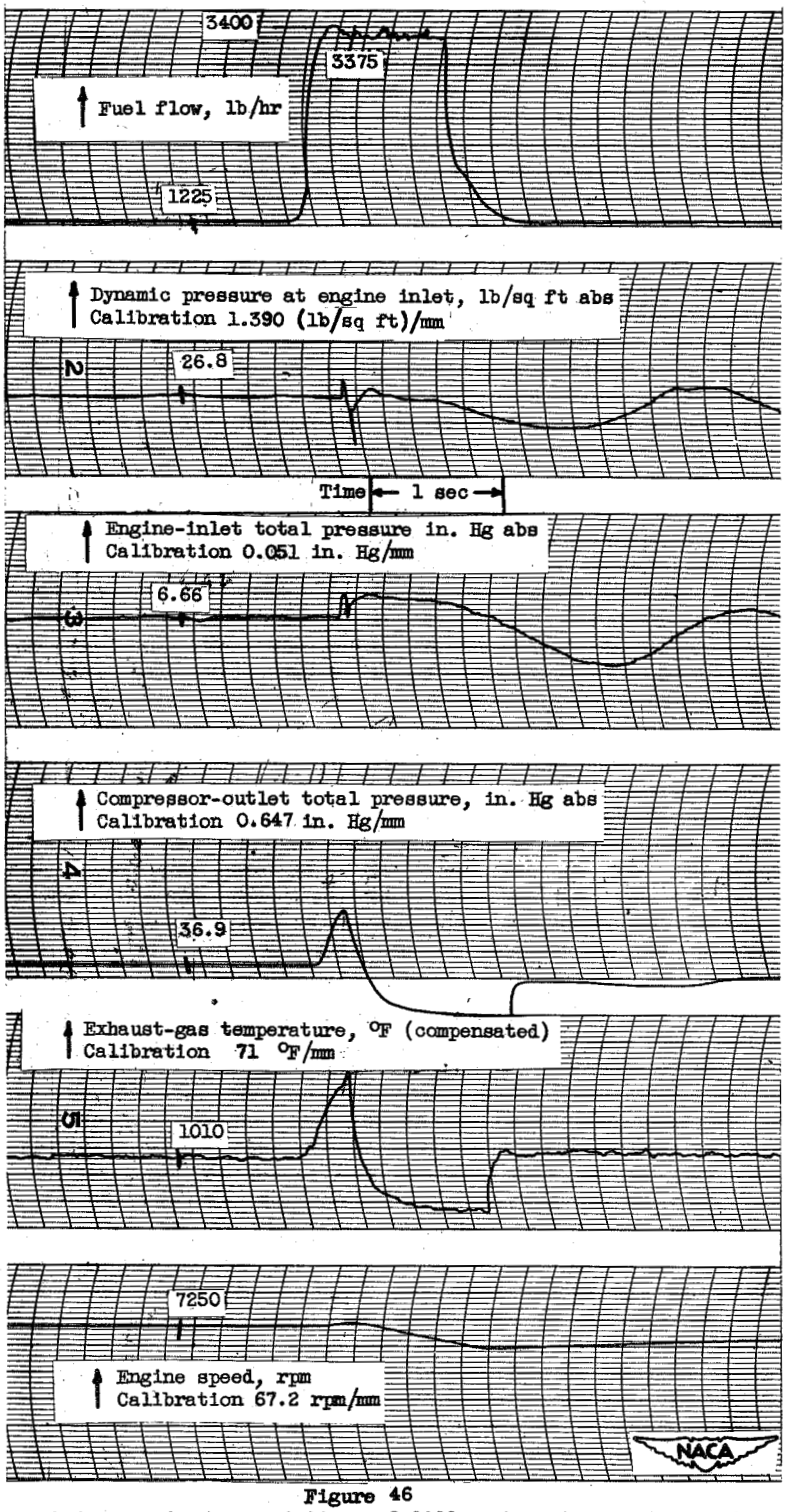

Figure 46

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 74° F; inlet guide vanes position, open.

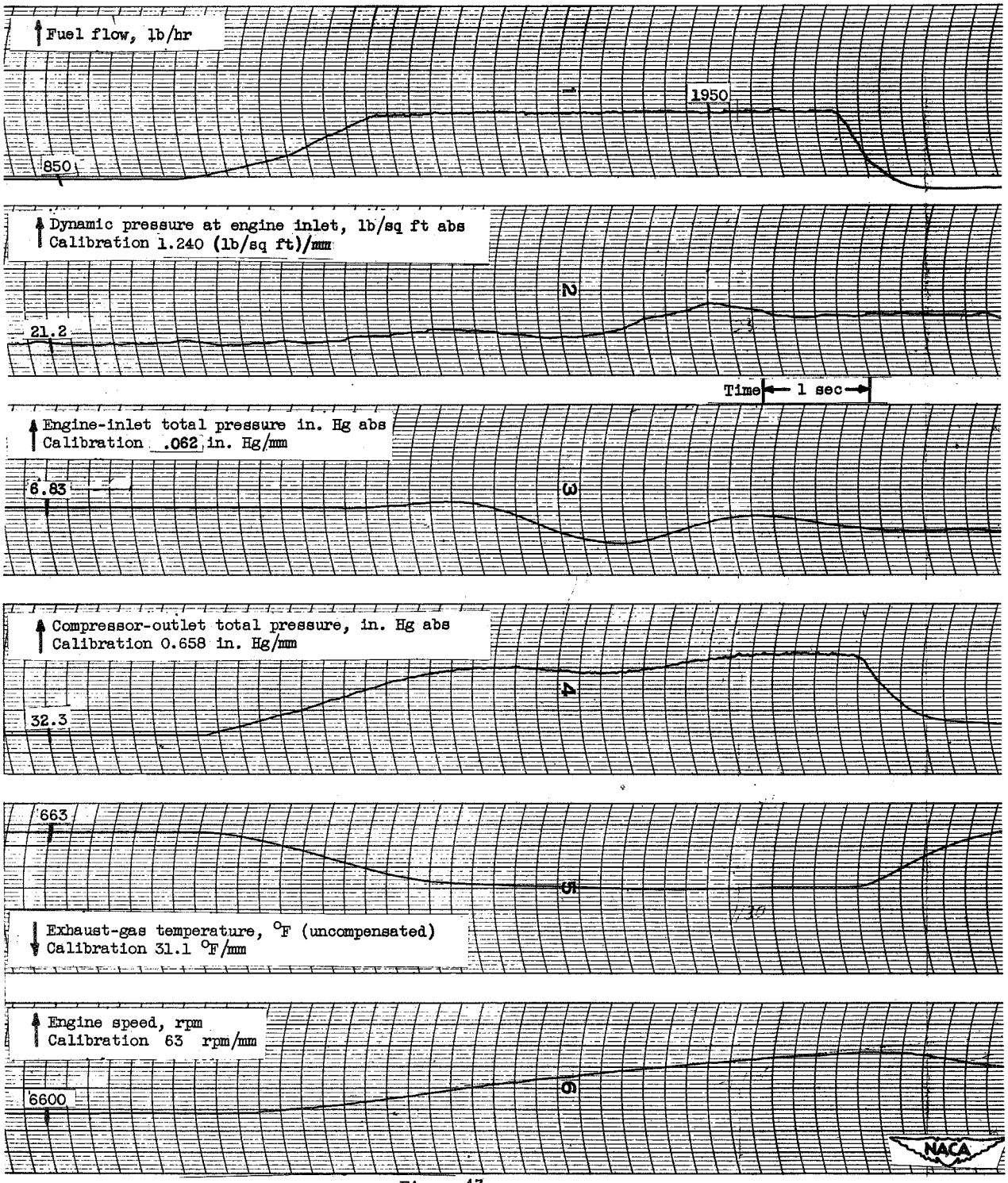

Figure 47

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

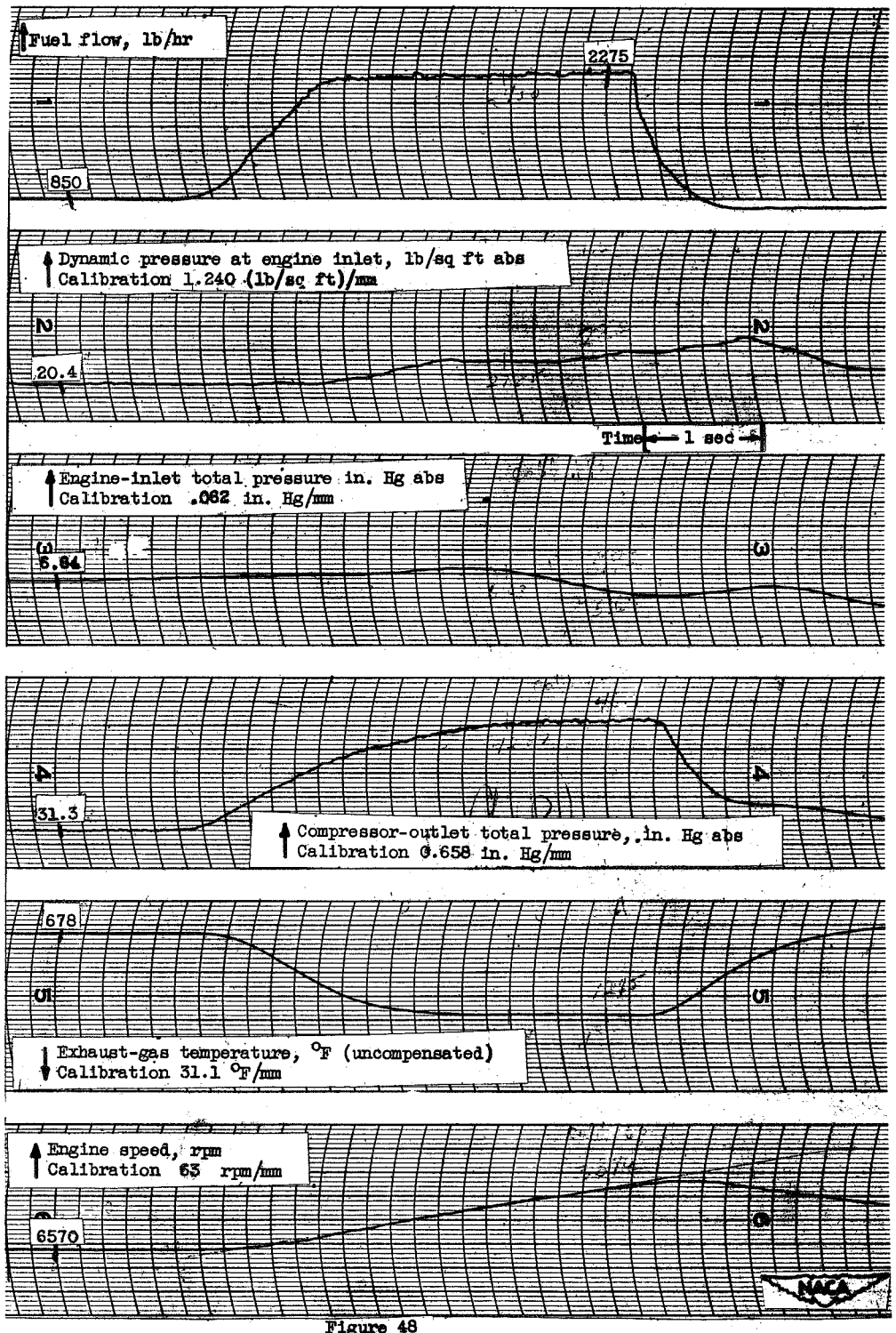

Figure 48

Oscillograph traces showing variations of different engine parameters during a ramp change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

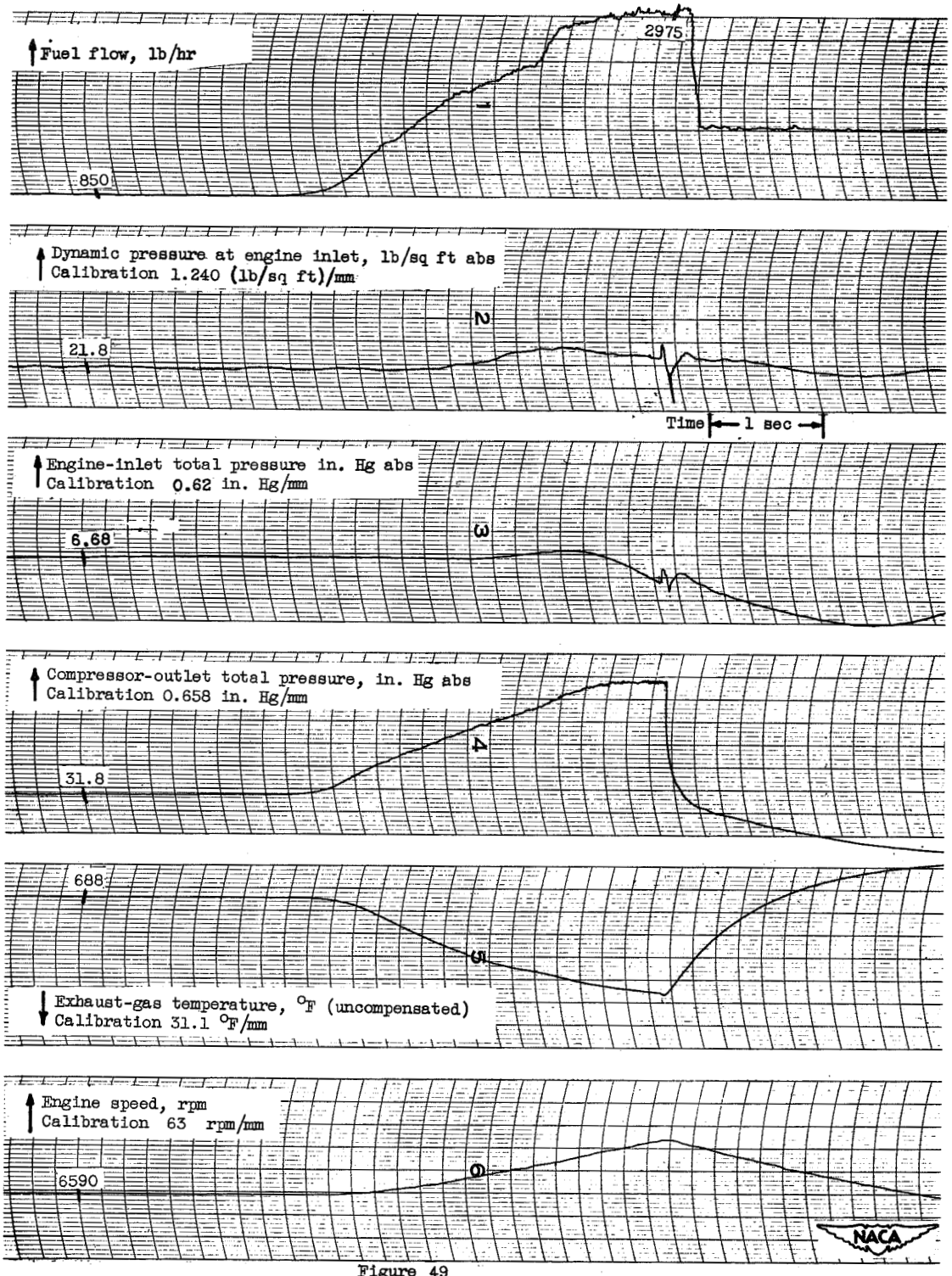

Figure 49

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

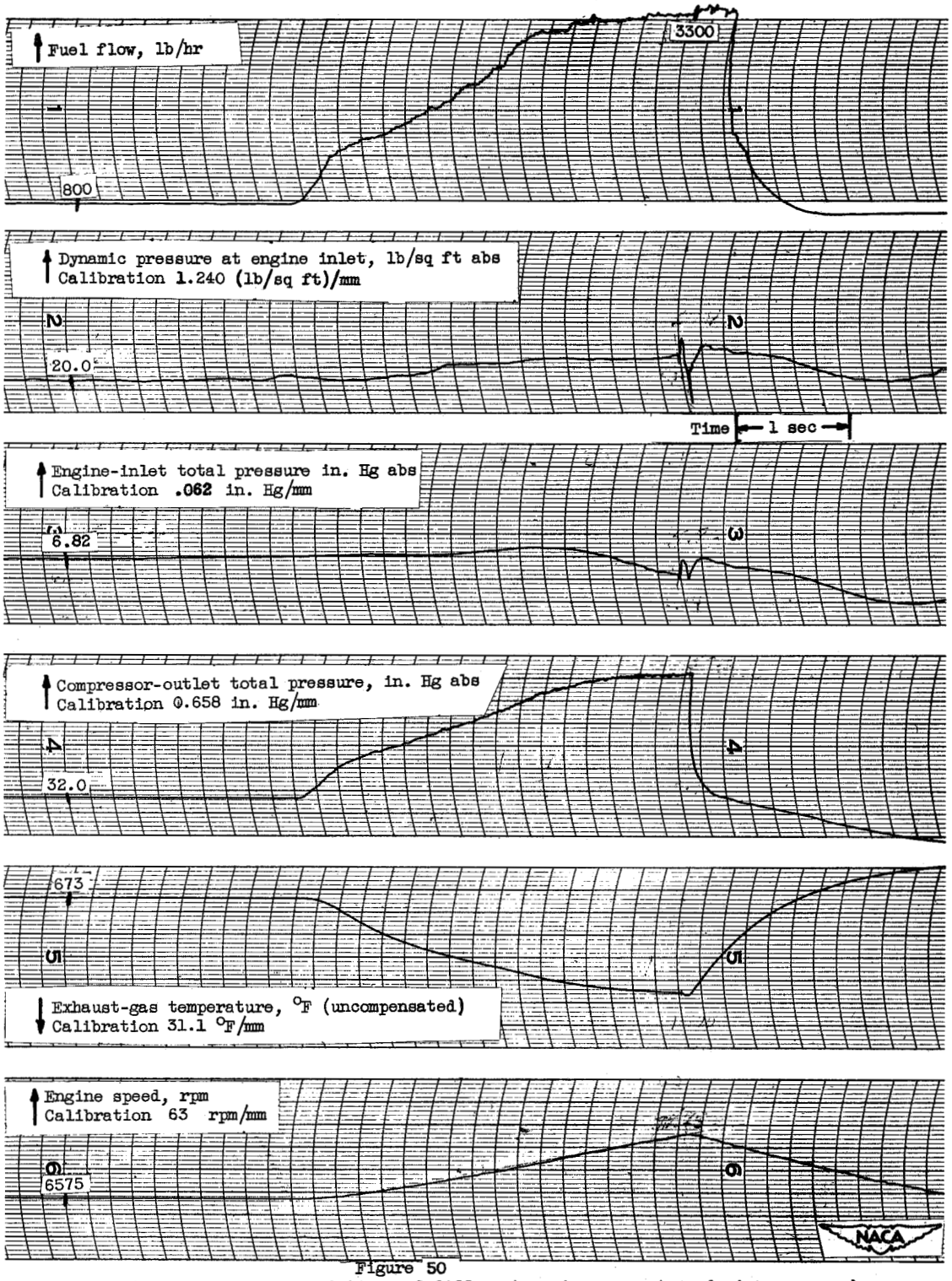

Figure 50

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

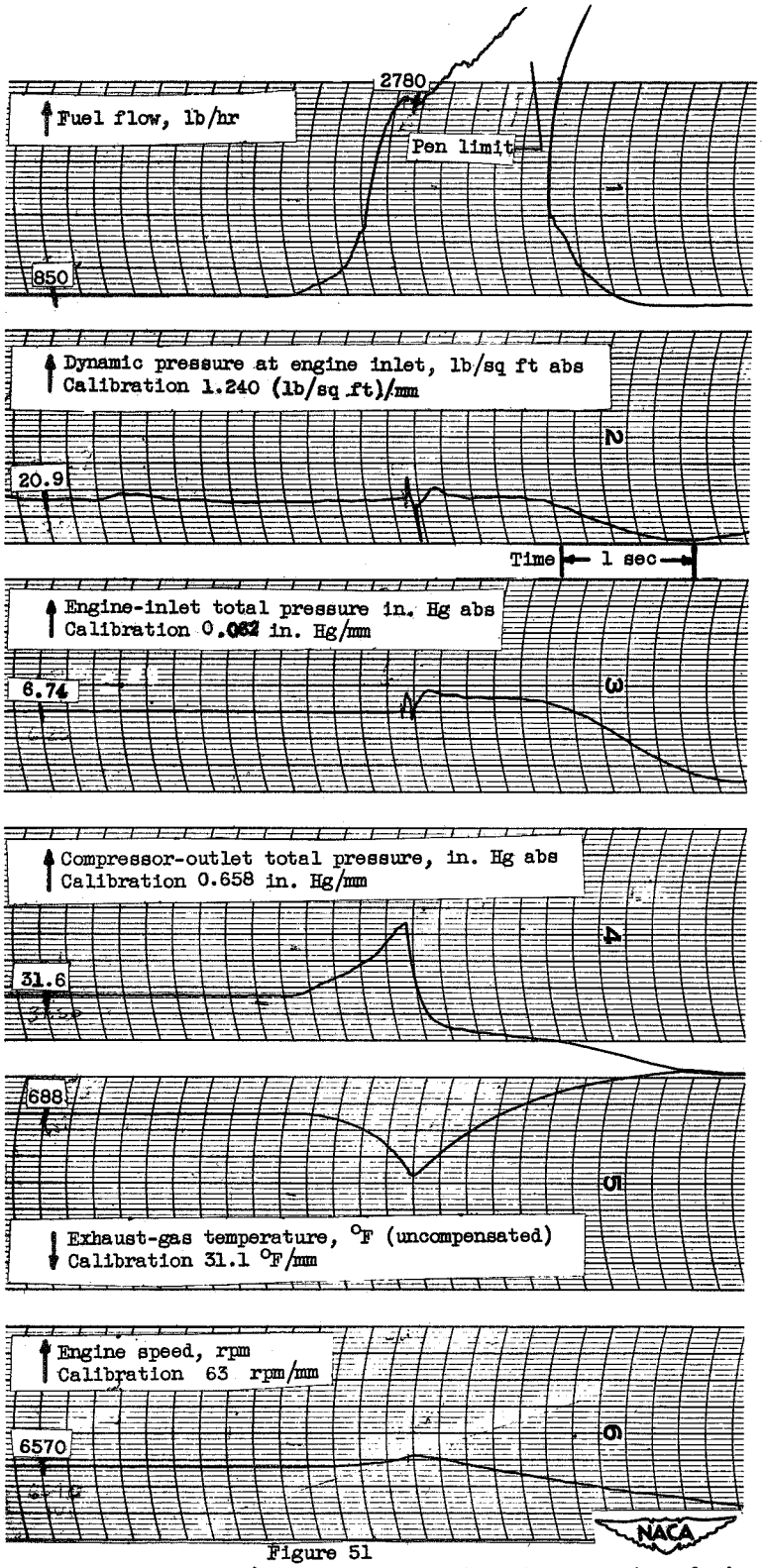

Figure 51

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

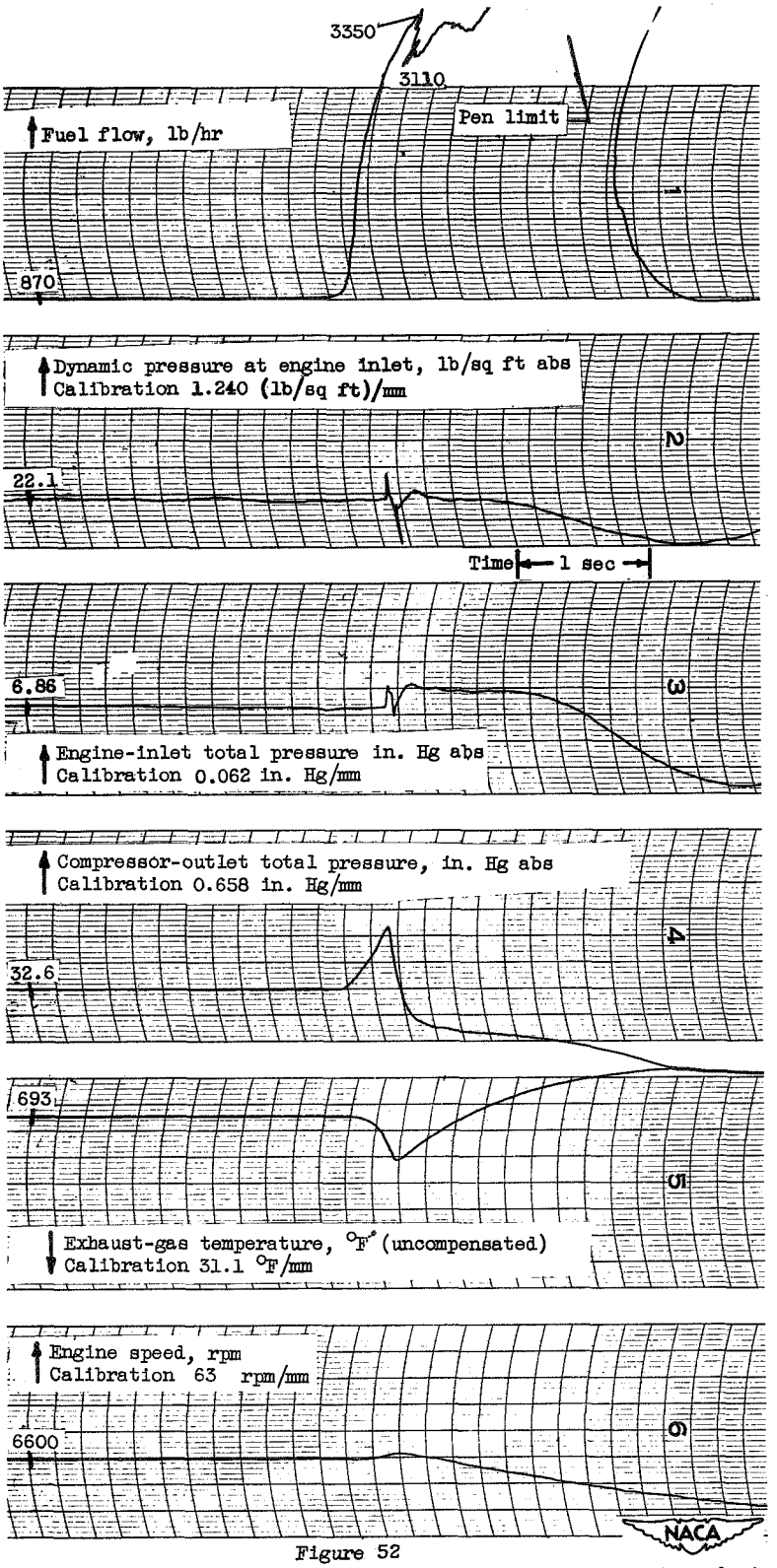

Figure 52

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 32° F; inlet guide vanes position, open.

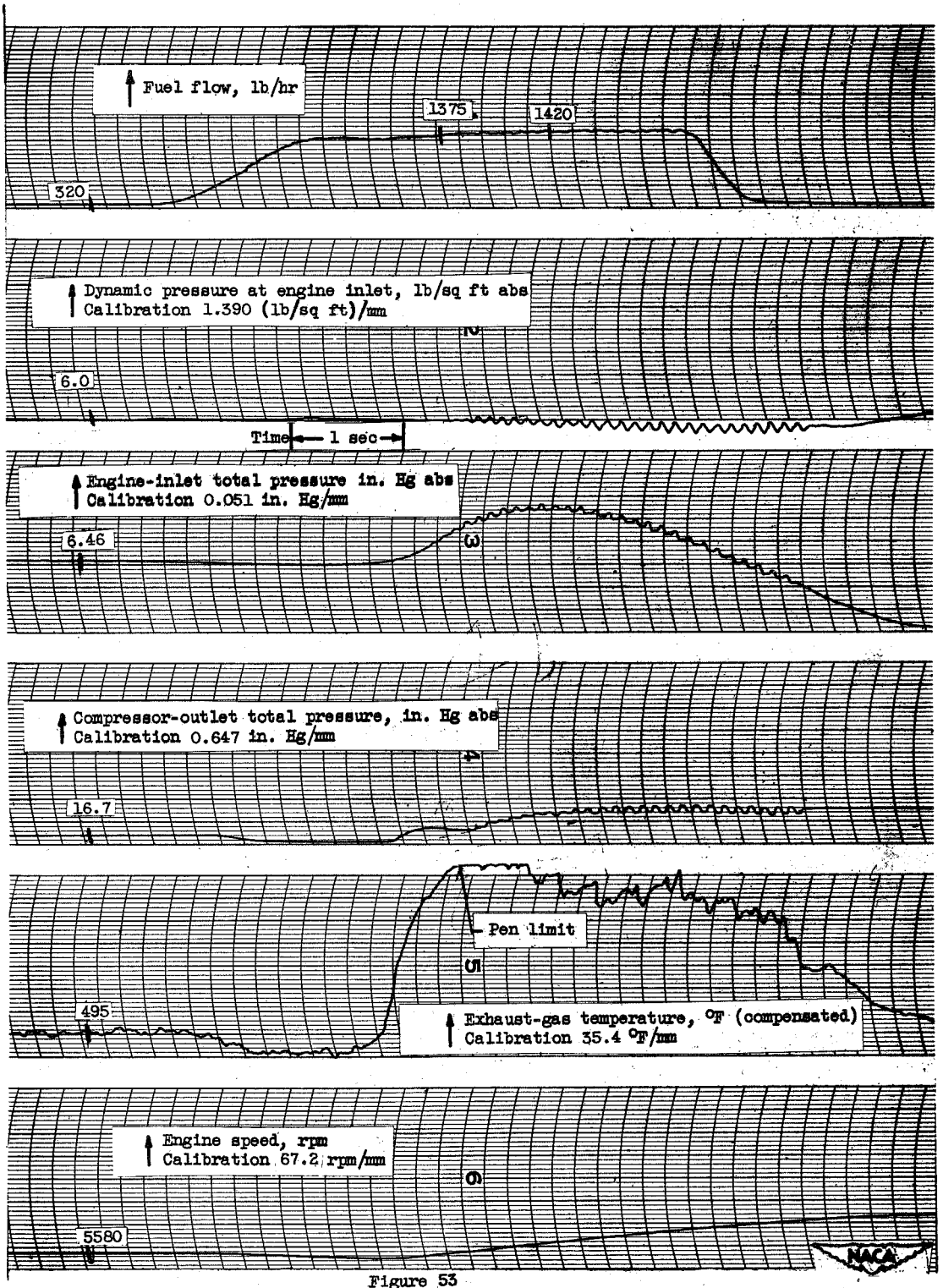

Figure 53

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 71° F; inlet guide vanes position, open.

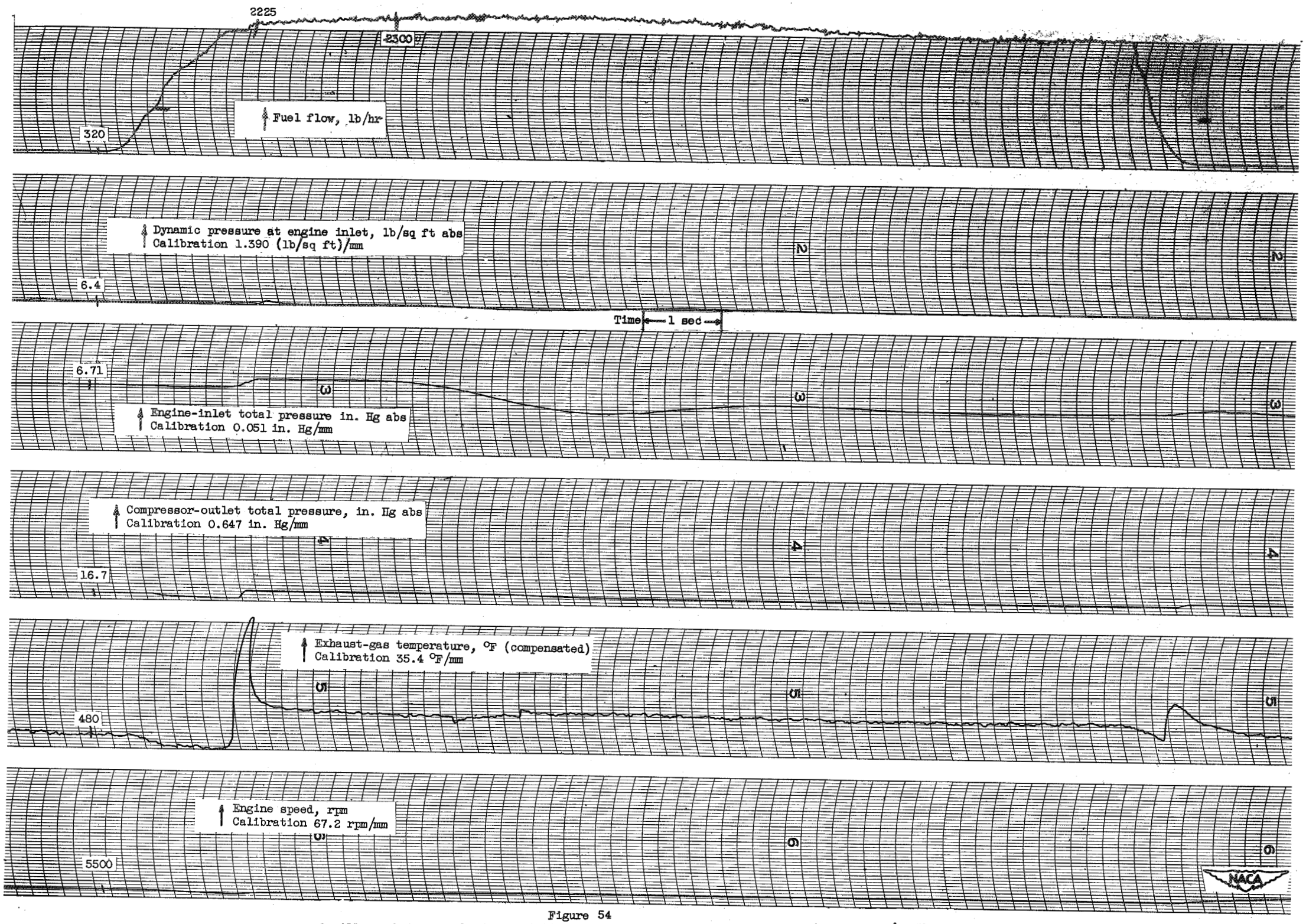

Figure 54
Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 71° F; inlet guide vanes position, open.

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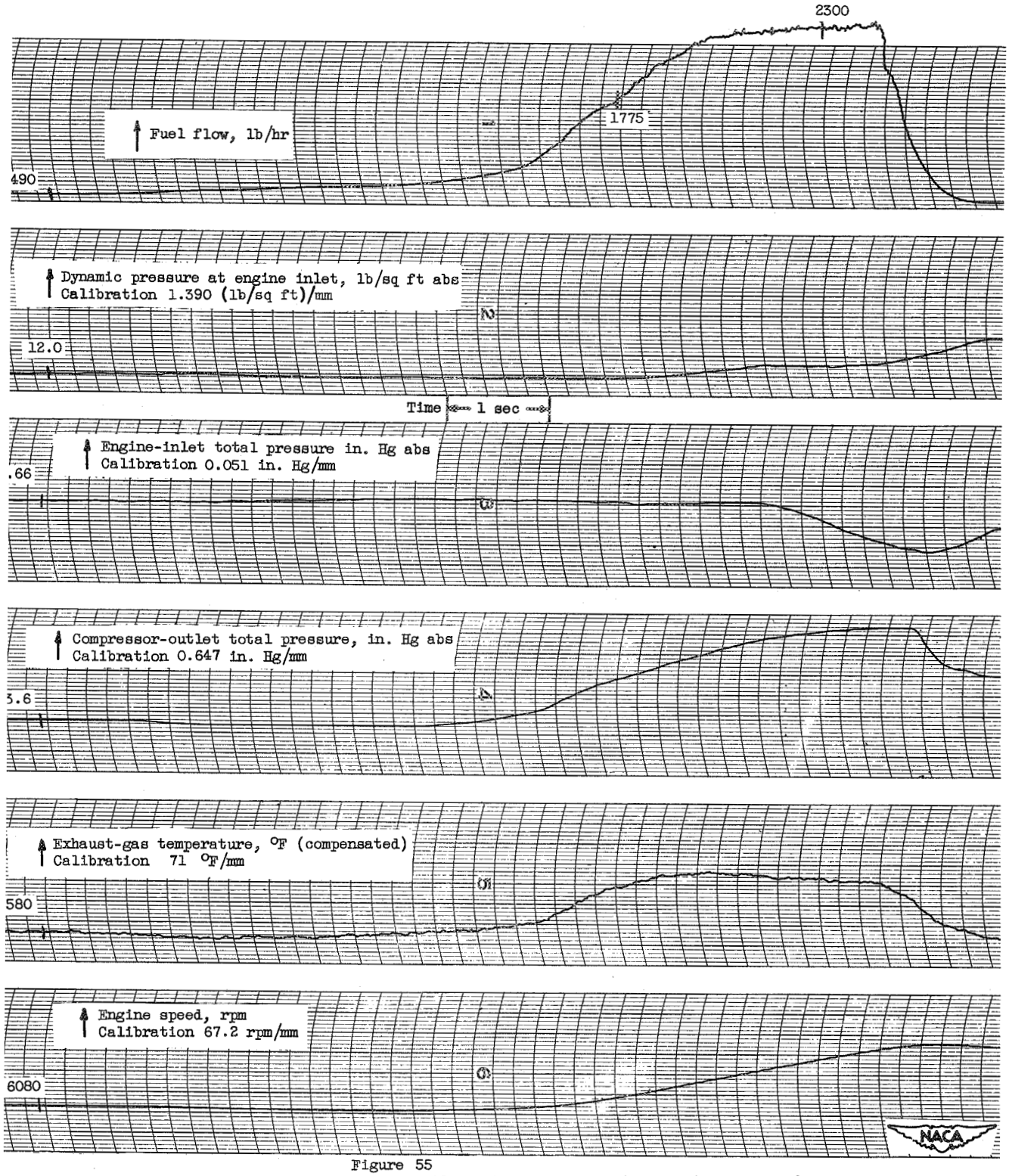

Figure 55

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 71° F; inlet guide vanes position, open.

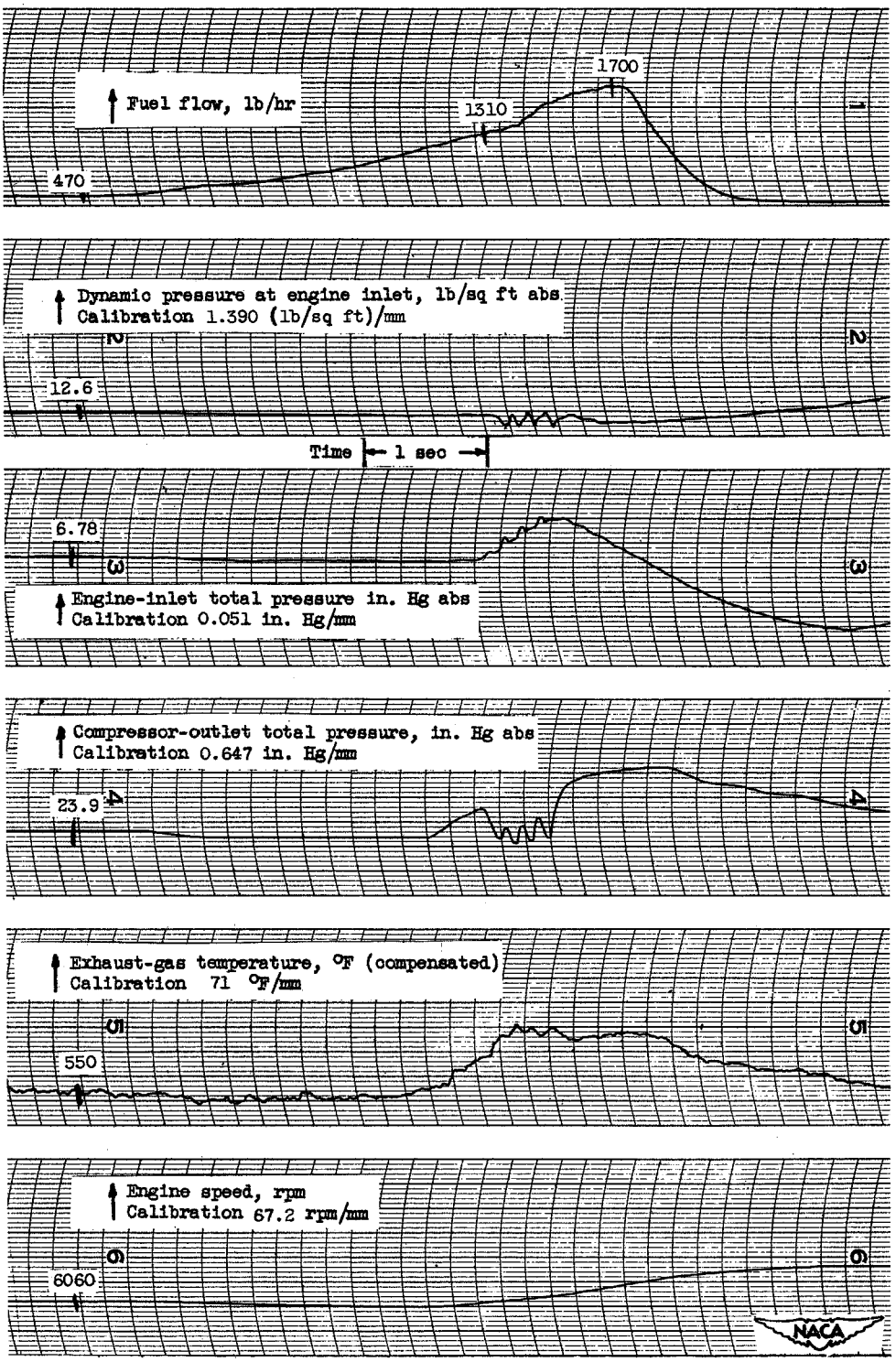

Figure 56

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 71° F; inlet guide vanes position, open.

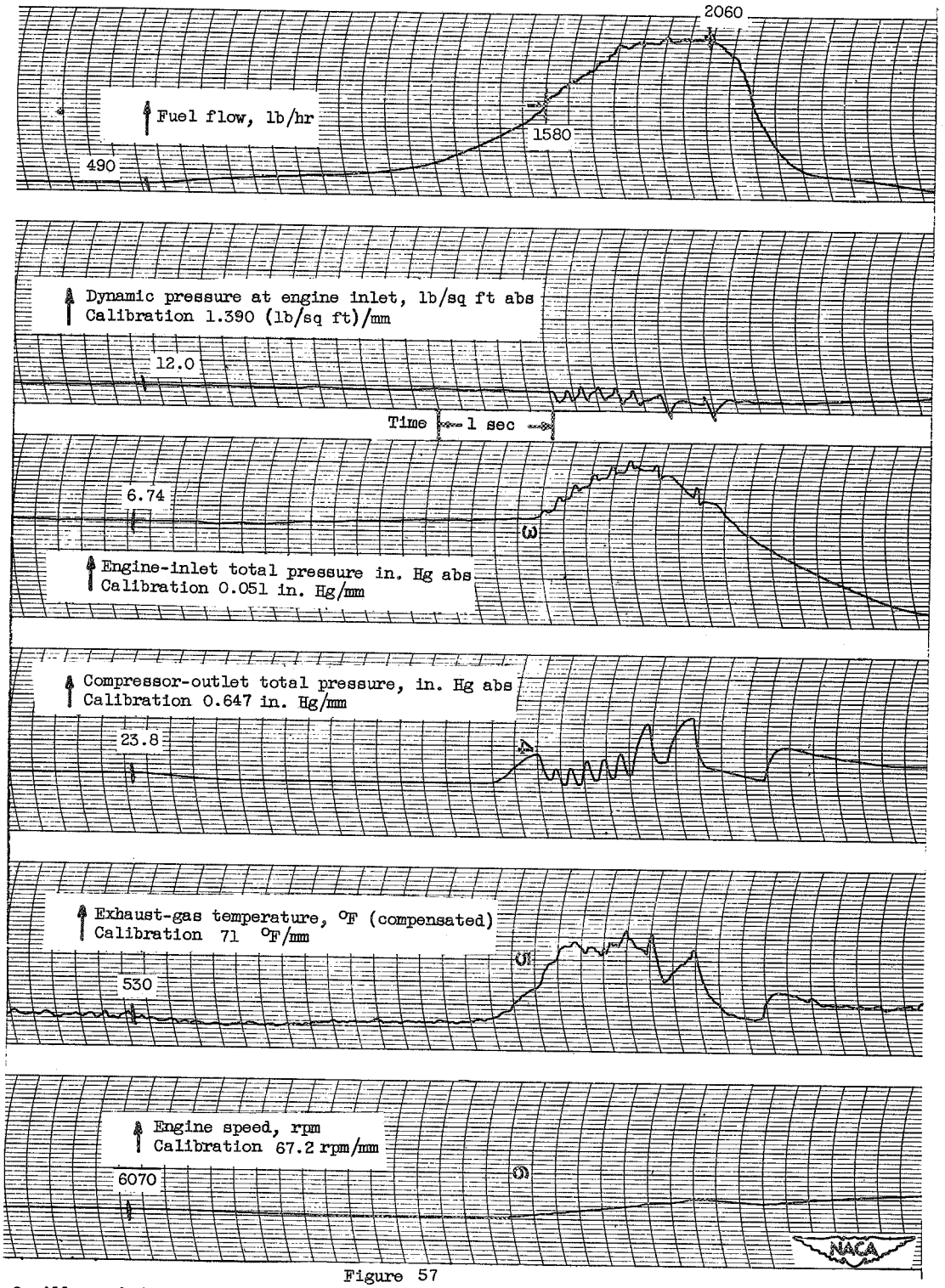

Figure 57

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 71° F; inlet guide vanes position, open.

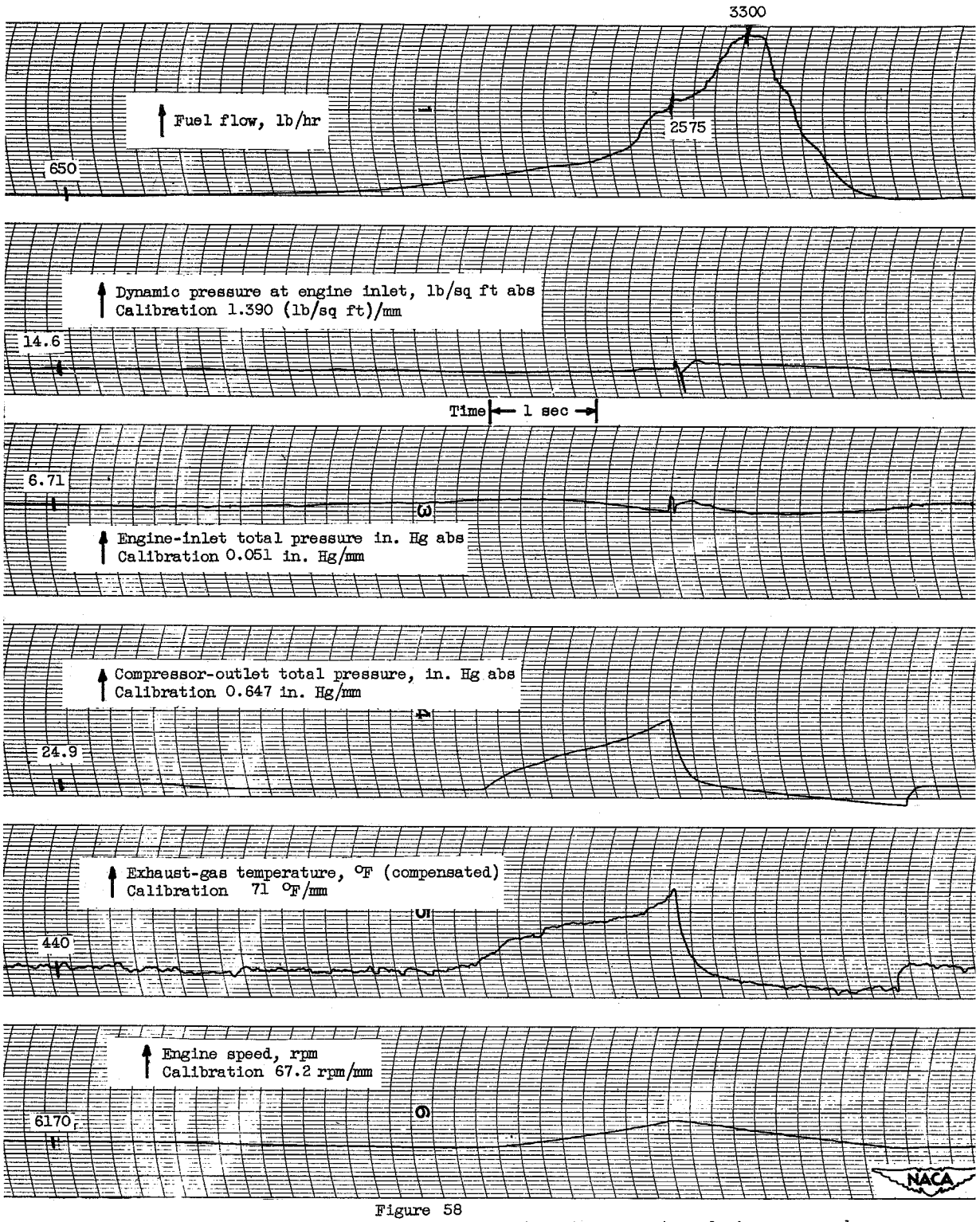

Figure 58

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 73° F; inlet guide vanes position, open.

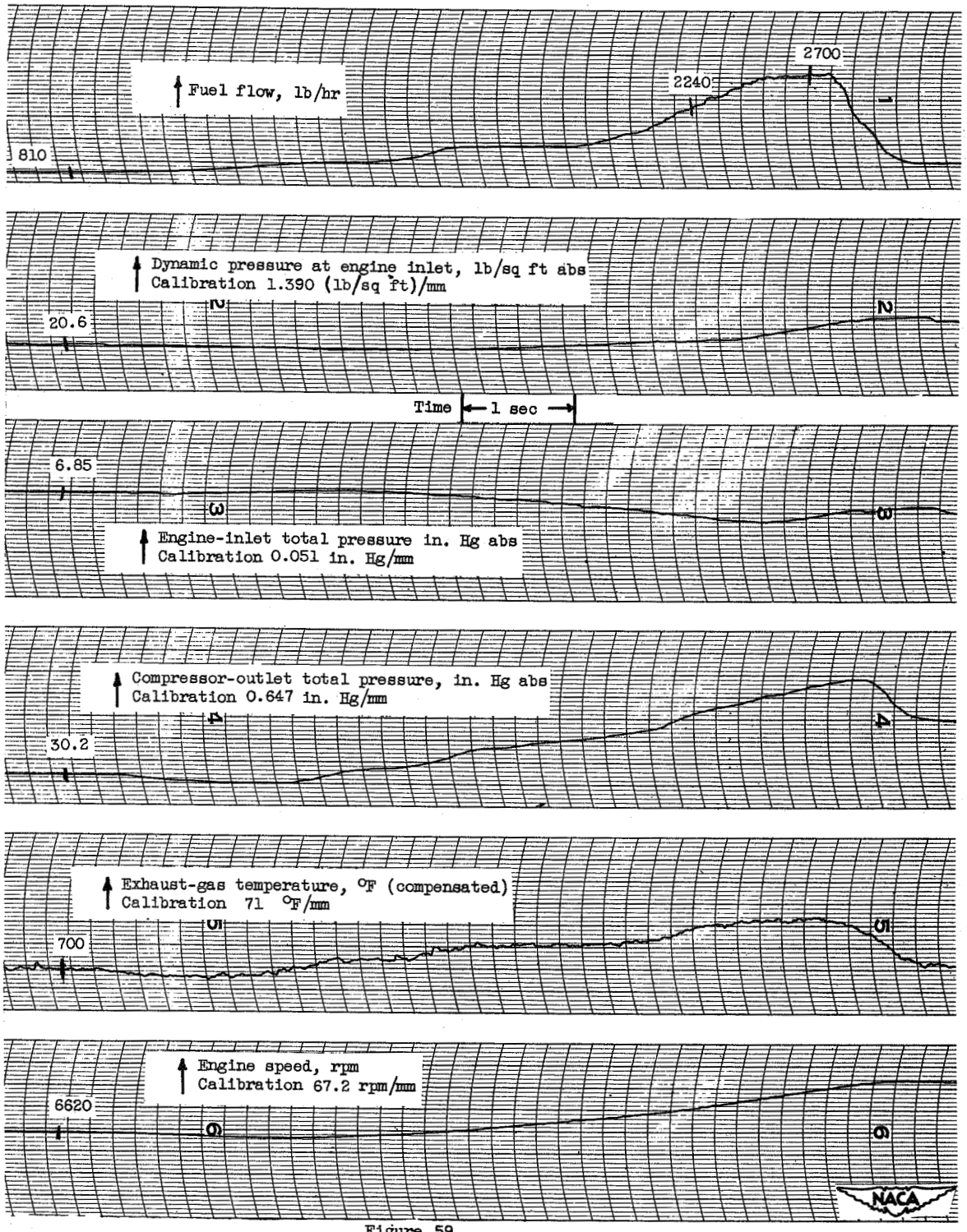

Figure 59

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 72° F; inlet guide vanes position, open.

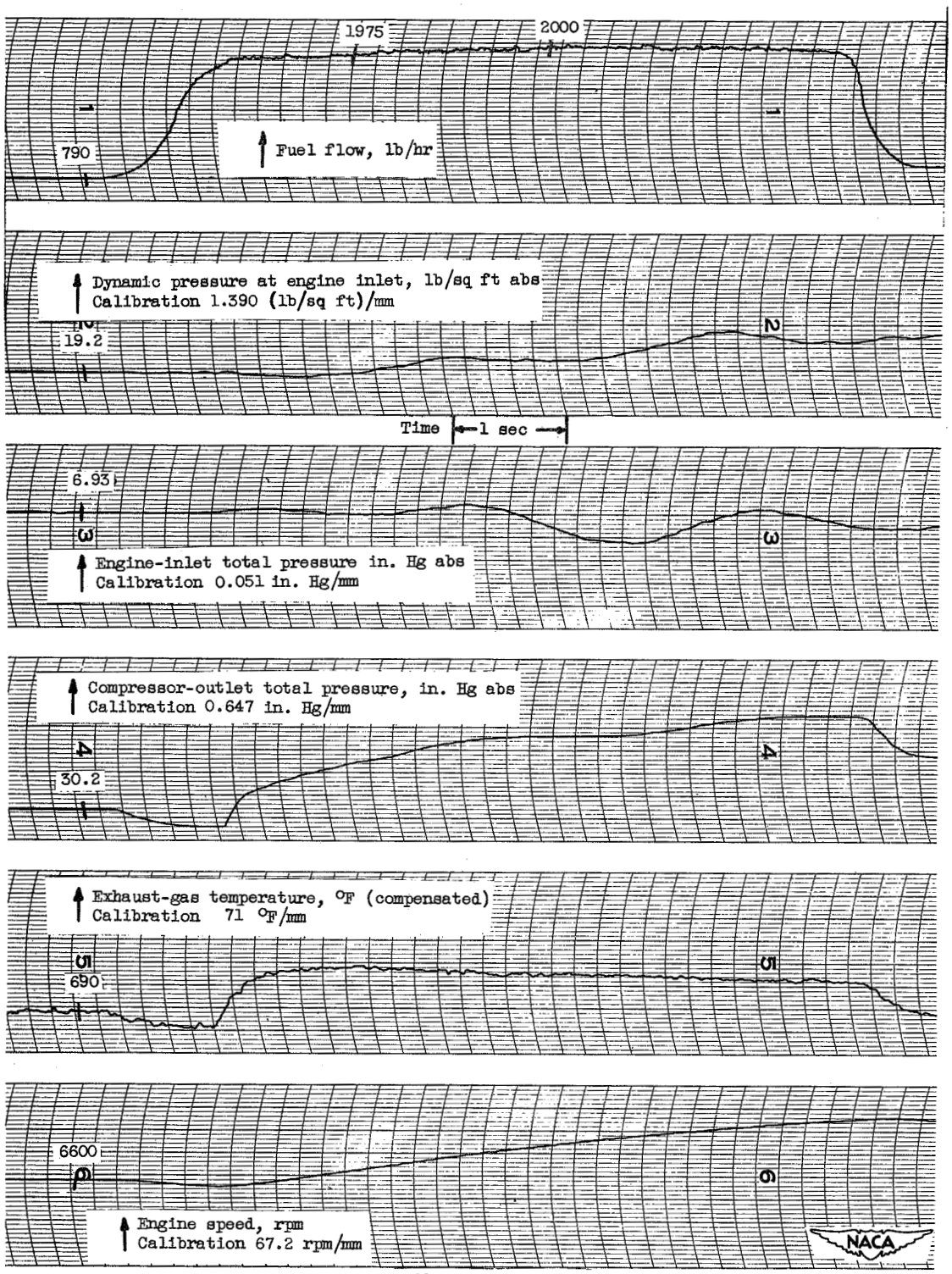

Figure 60

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 72 ° F; inlet guide vanes position, open.

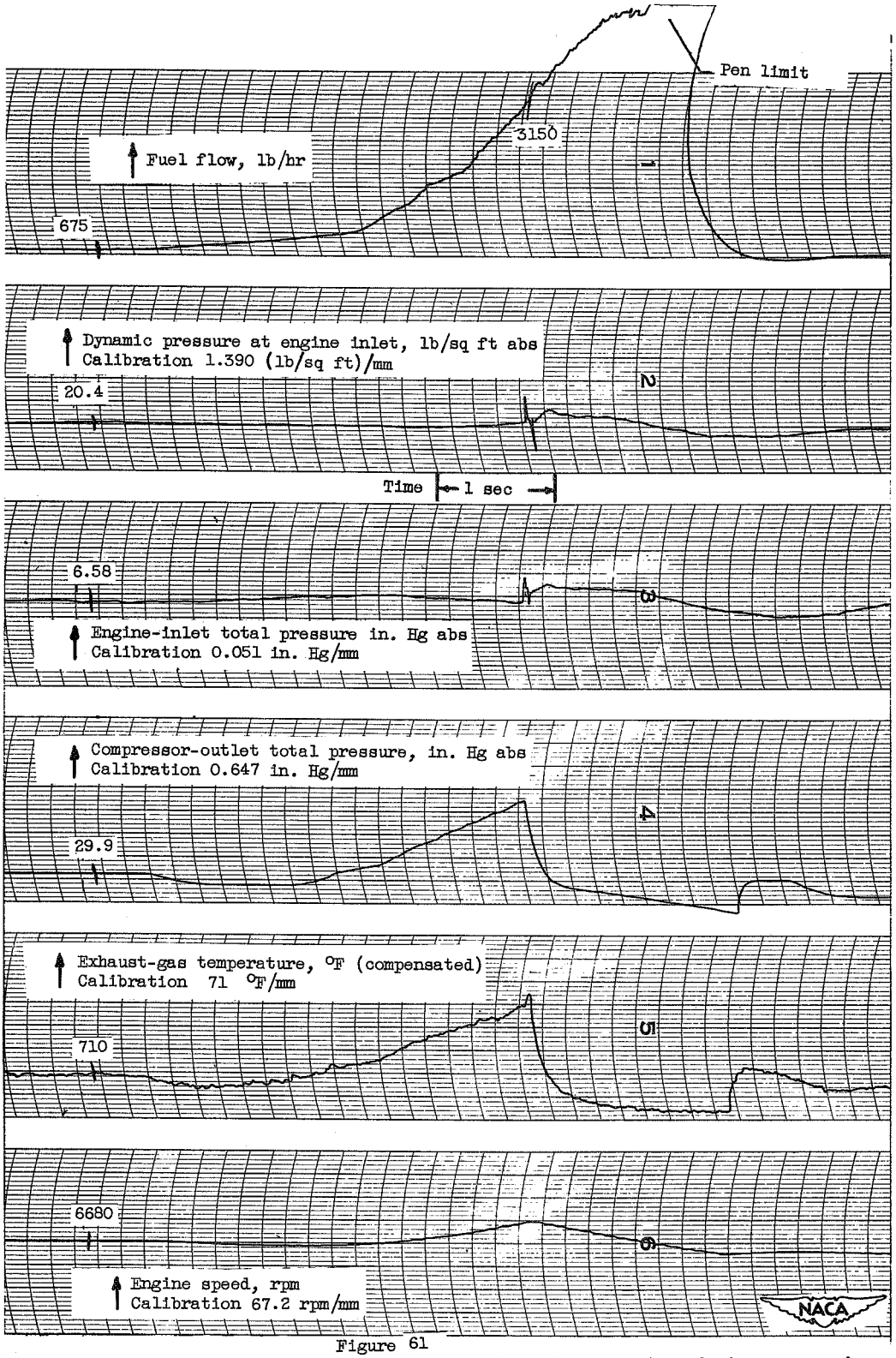

Figure 61

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 73 °F; inlet guide vanes position, open.

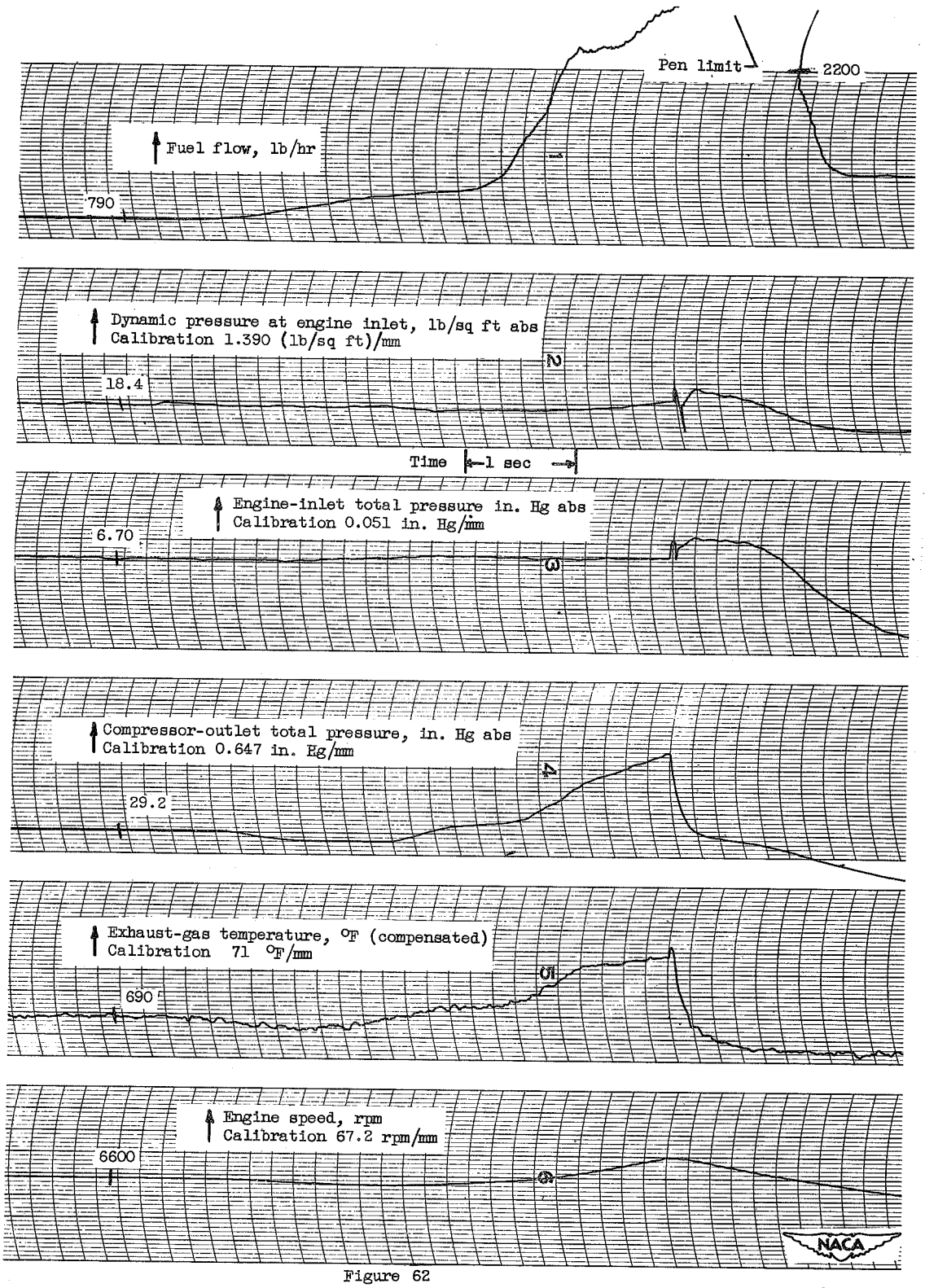

Figure 62

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8 ; engine-inlet air temperature, 72° F; inlet guide vanes position, open.

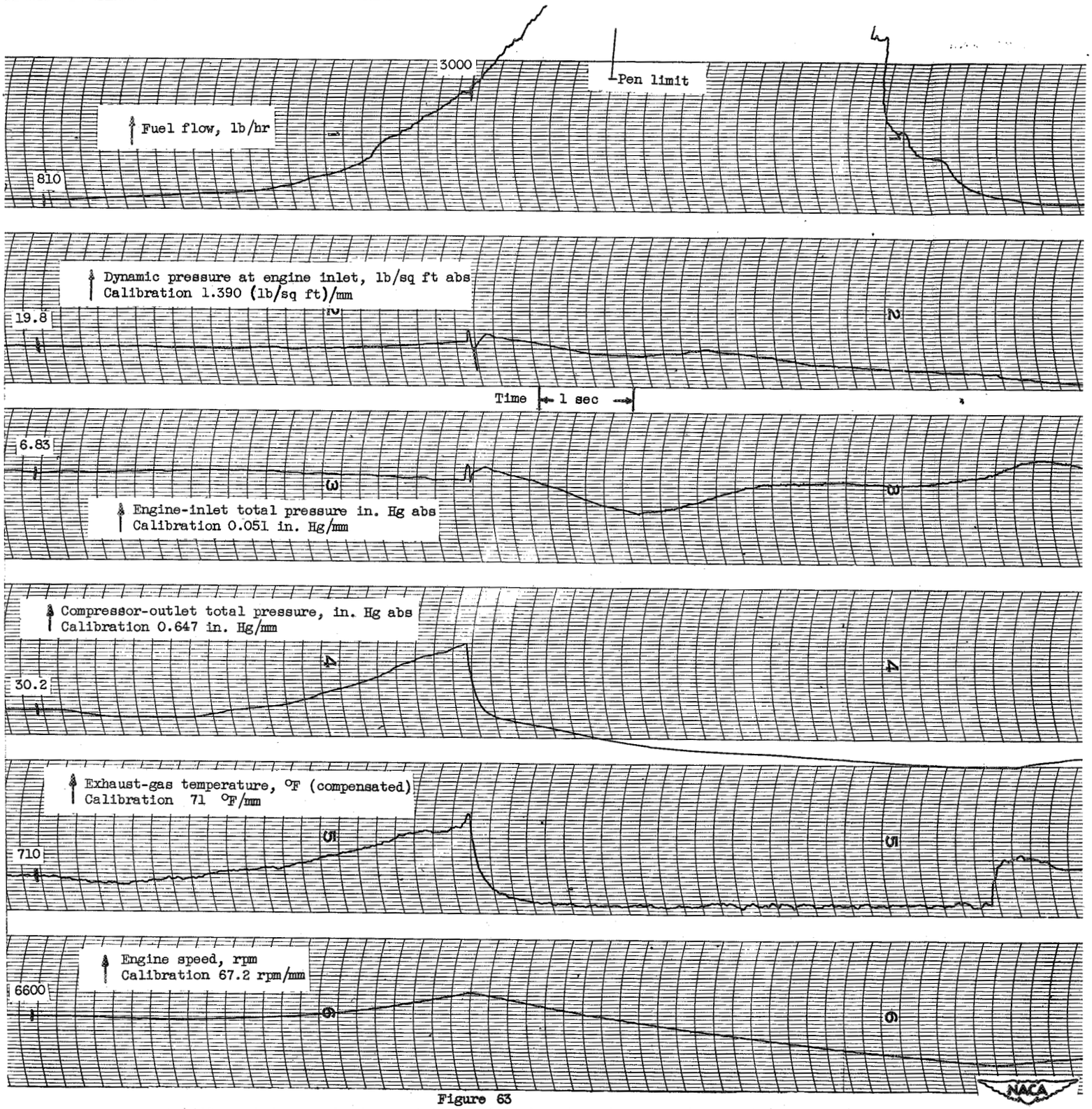

Figure 63

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 72 ° F; inlet guide vanes position, open.

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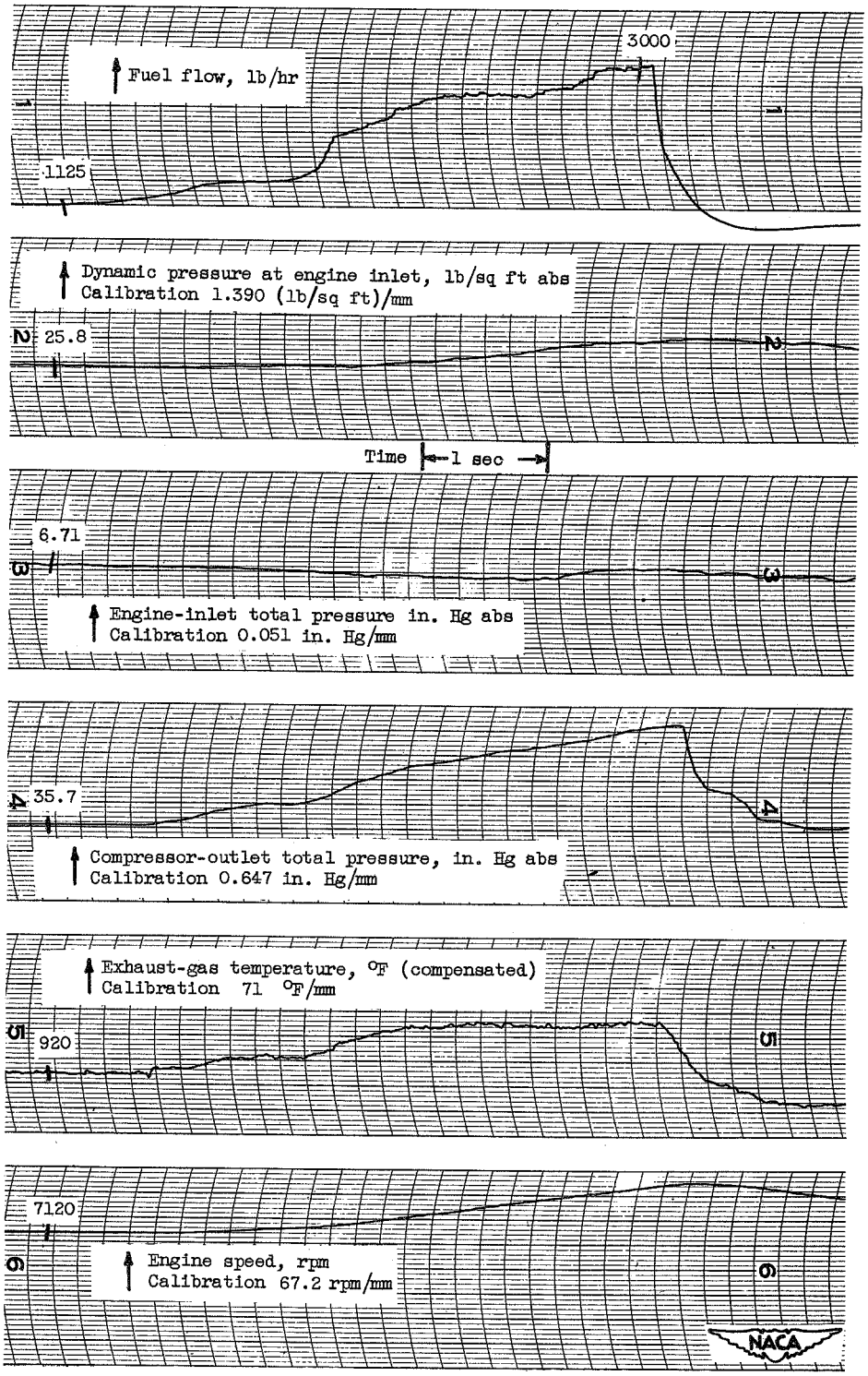

Figure 64

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 72° F; inlet guide vanes position, open.

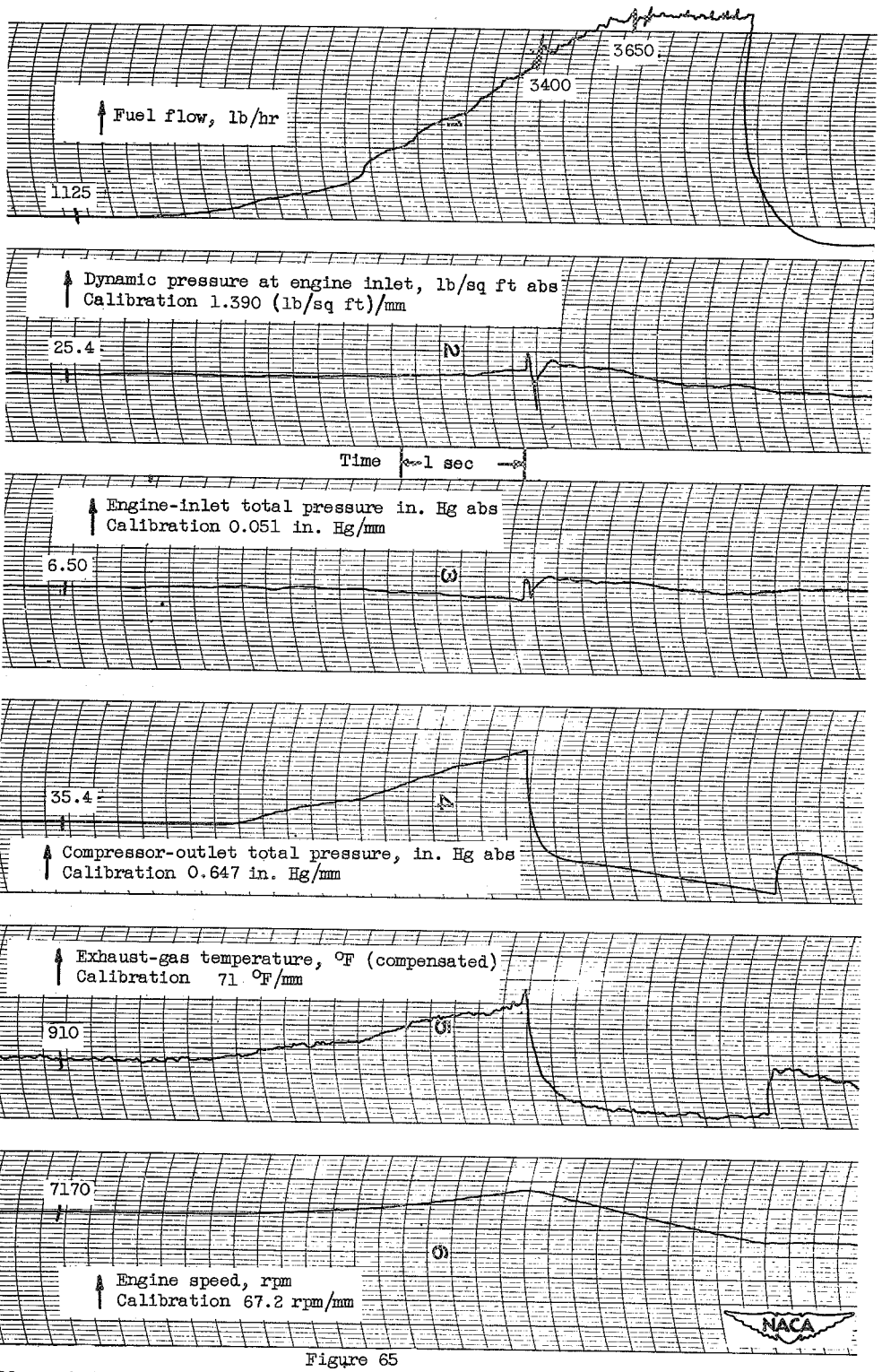

Figure 65

Oscillograph traces showing variations of different engine parameters during a ramp-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 72° F; inlet guide vanes position, open.

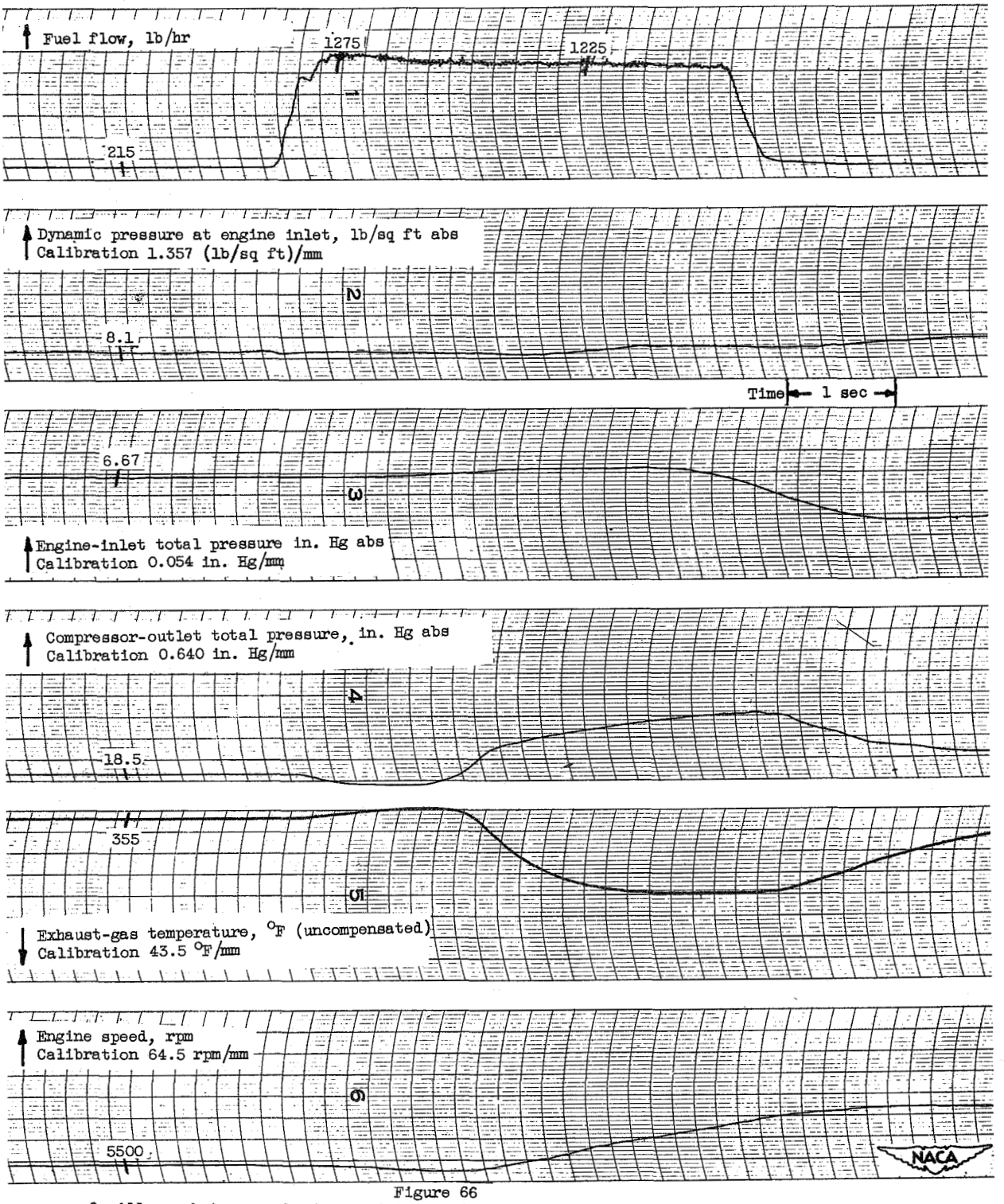

Figure 66

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, closed.

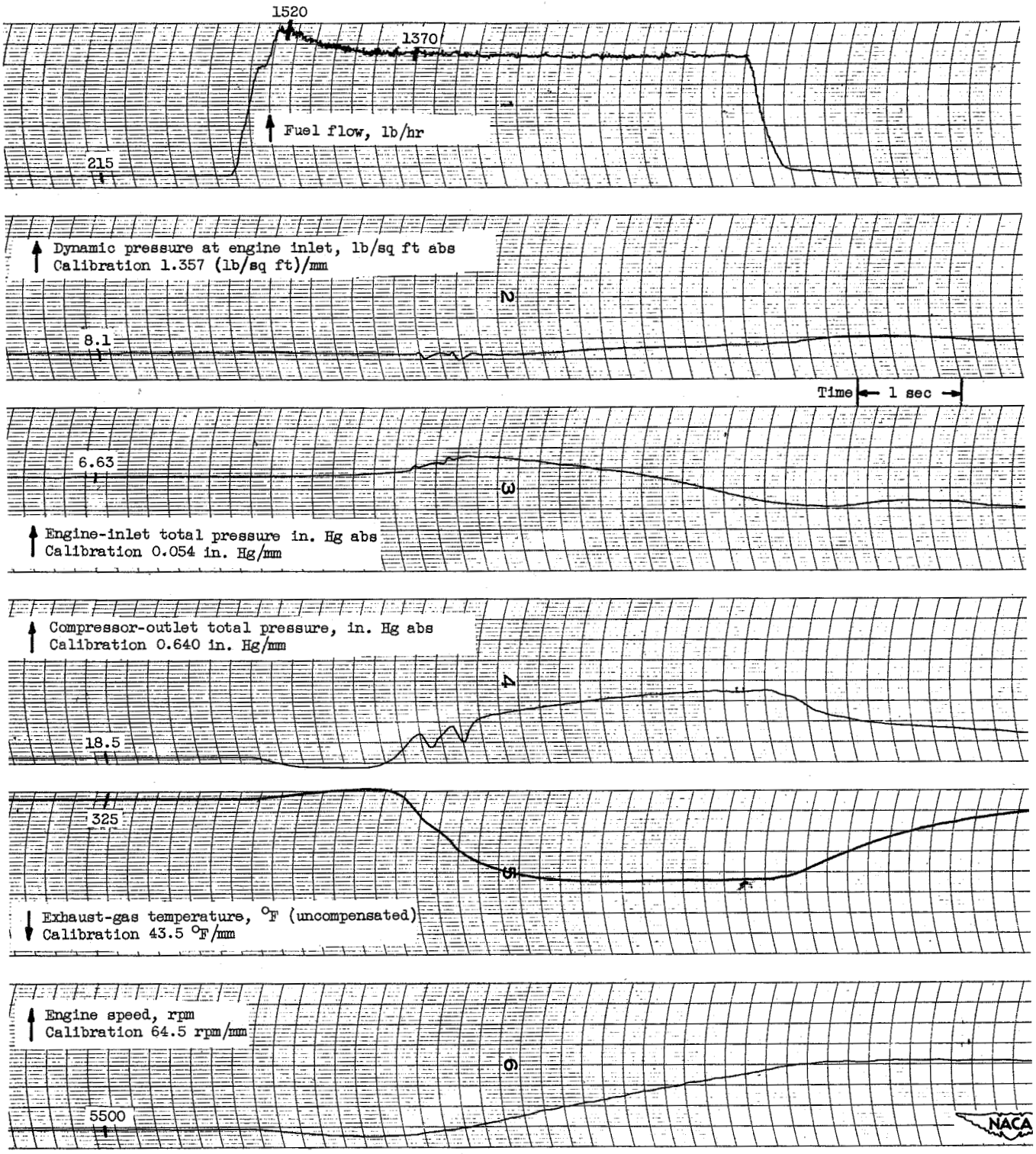

Figure 67

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, closed.

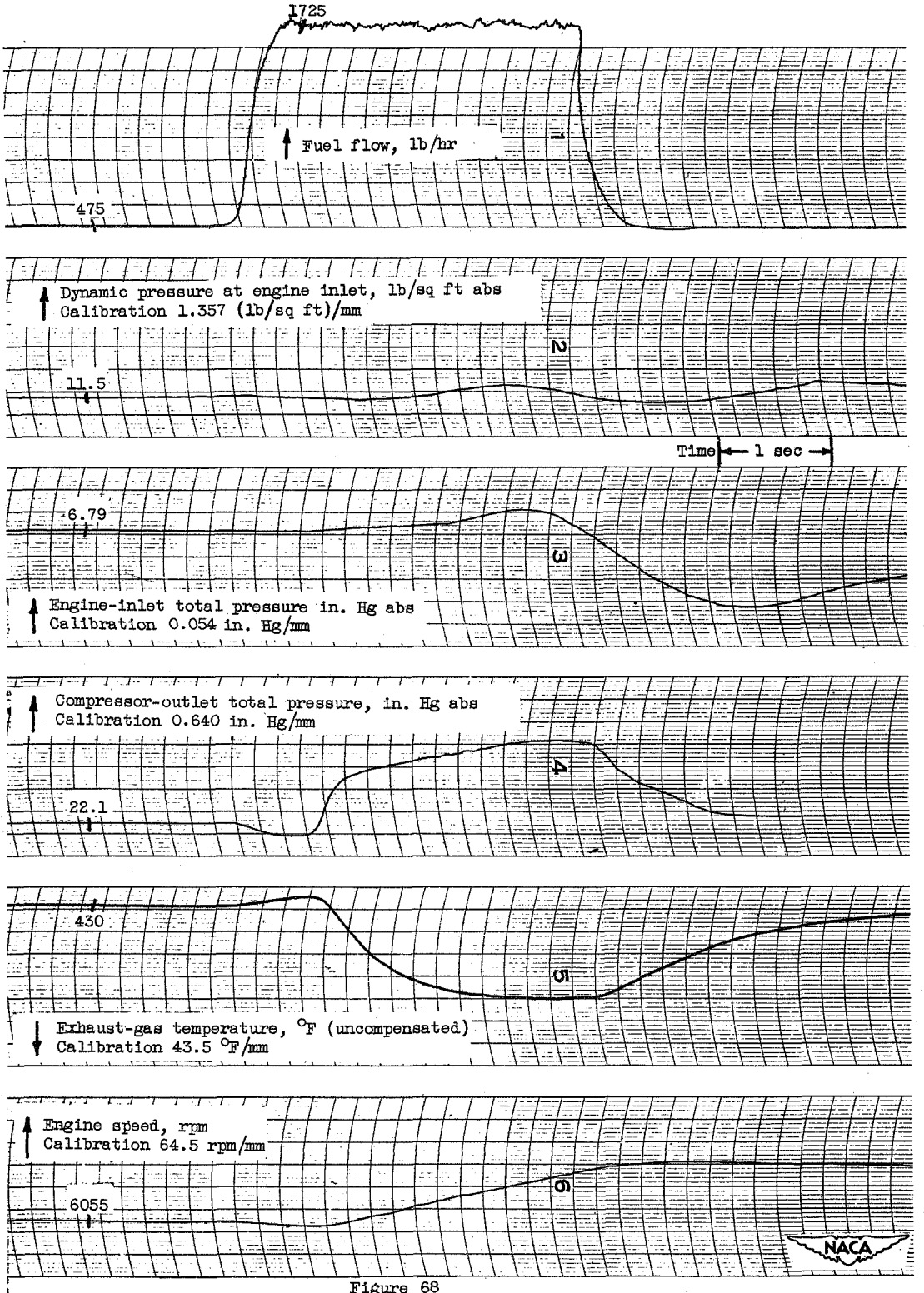

Figure 68

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, closed.

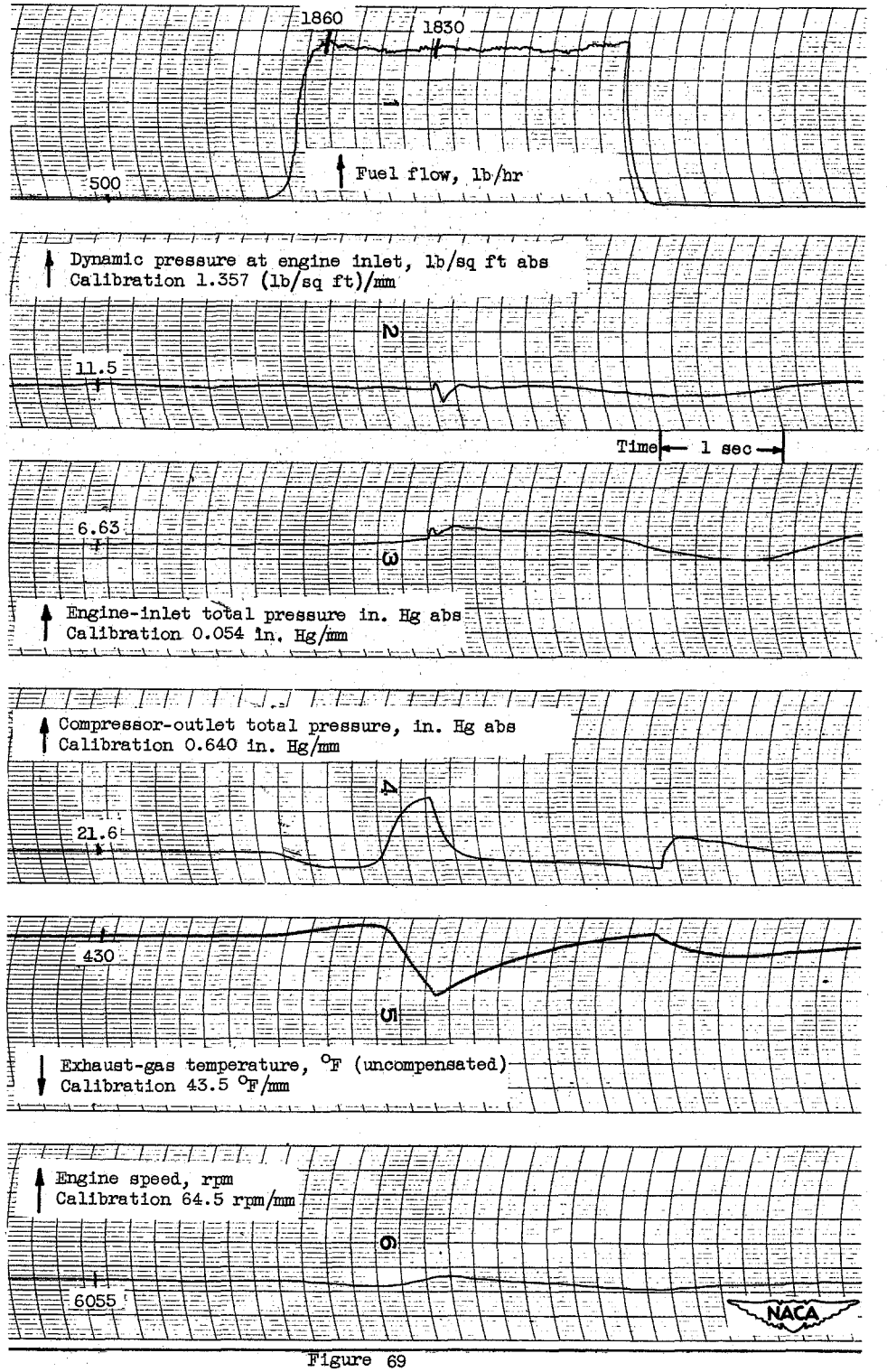

Figure 69

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 31° F; inlet guide vanes position, closed.

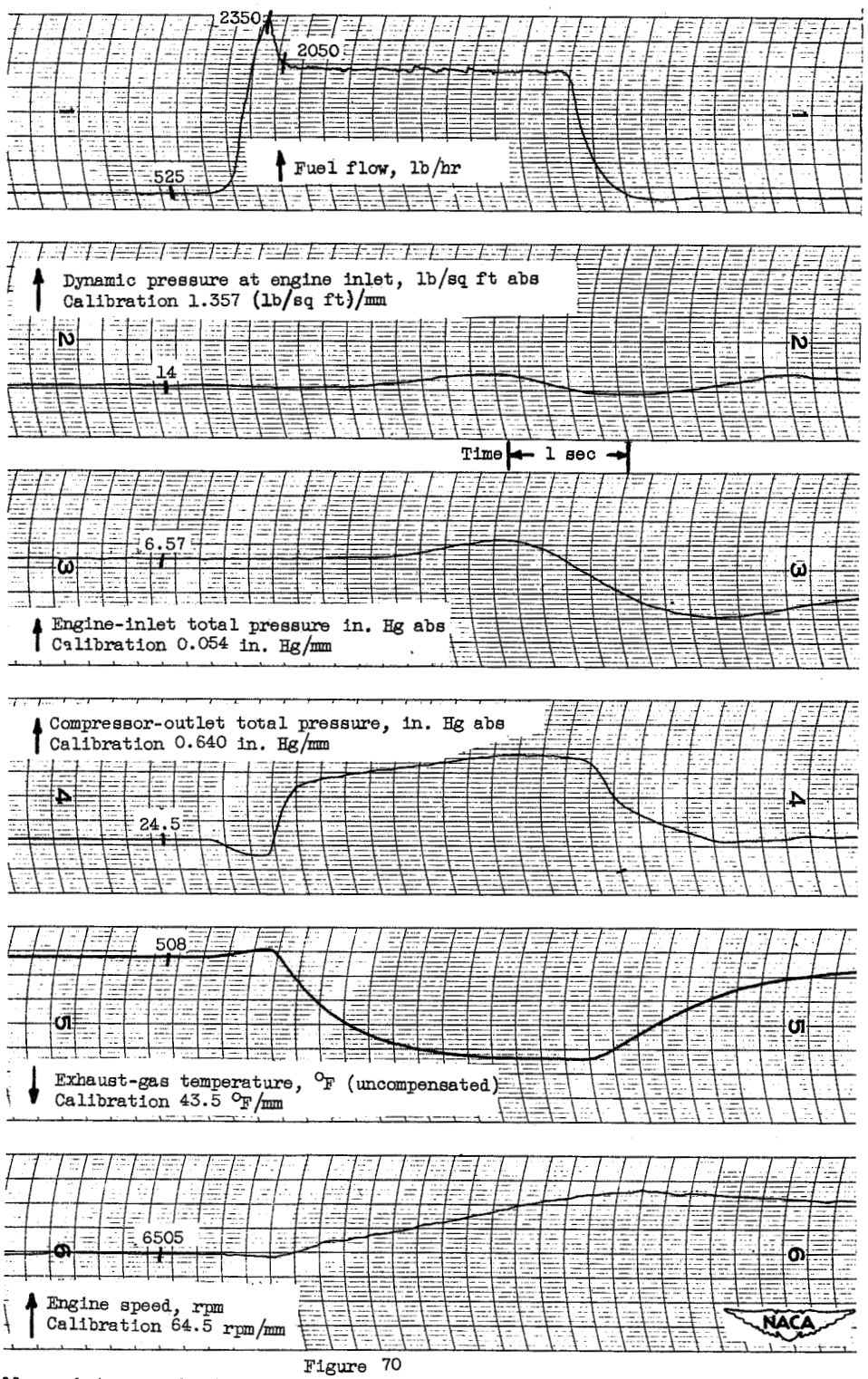

Figure 70

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, closed.

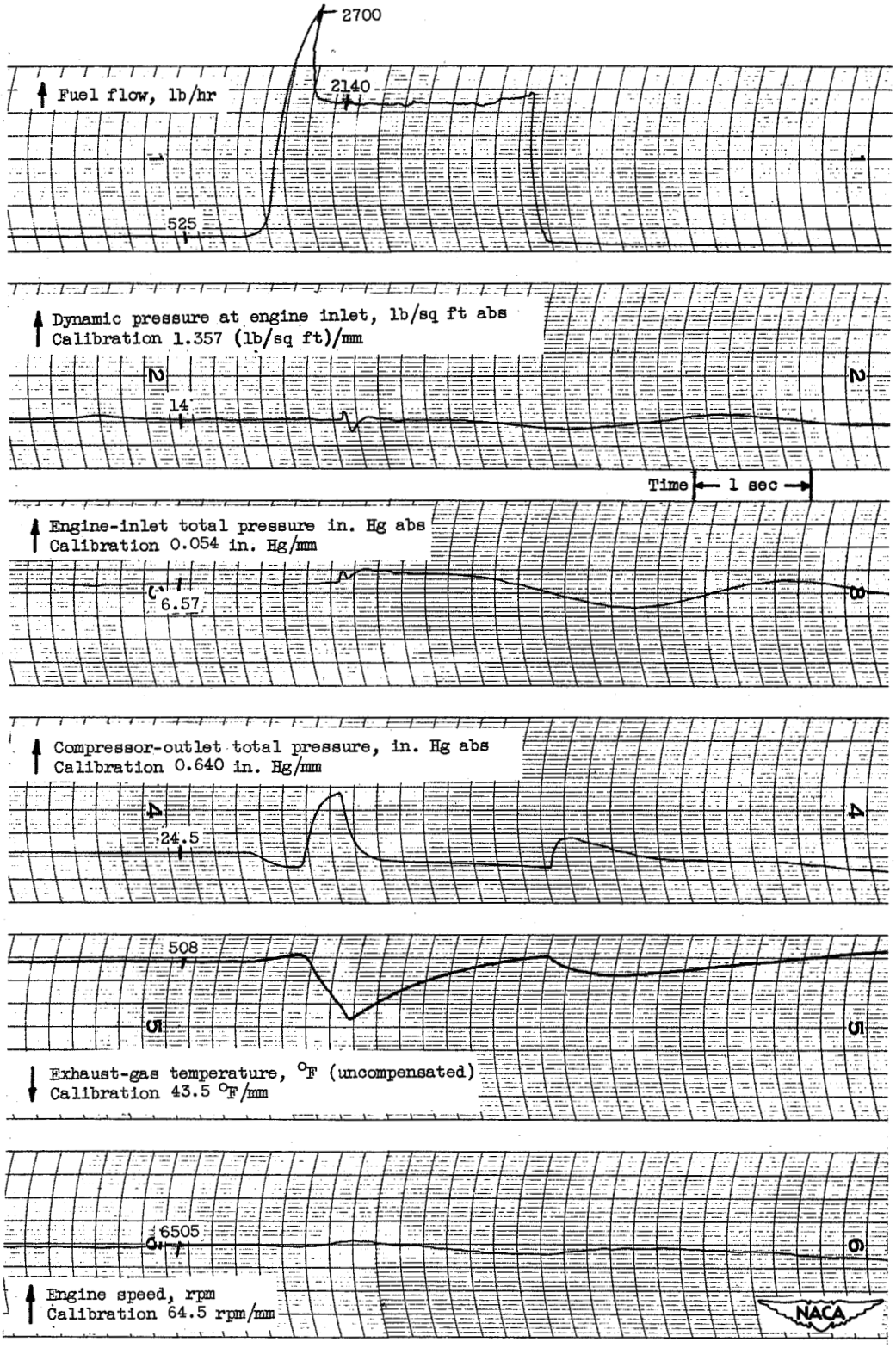

Figure 71

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, closed.

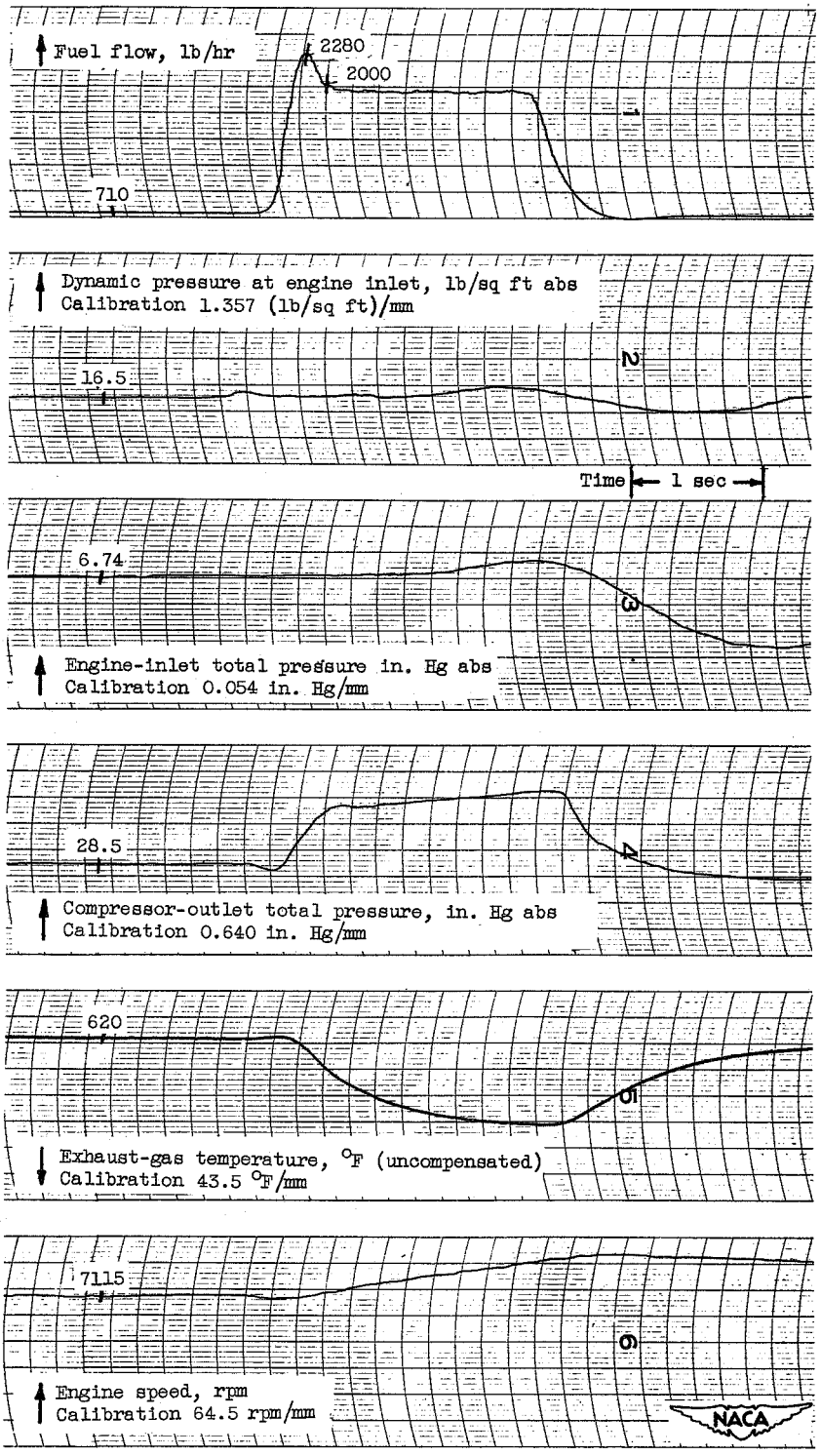

Figure 72

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, closed.

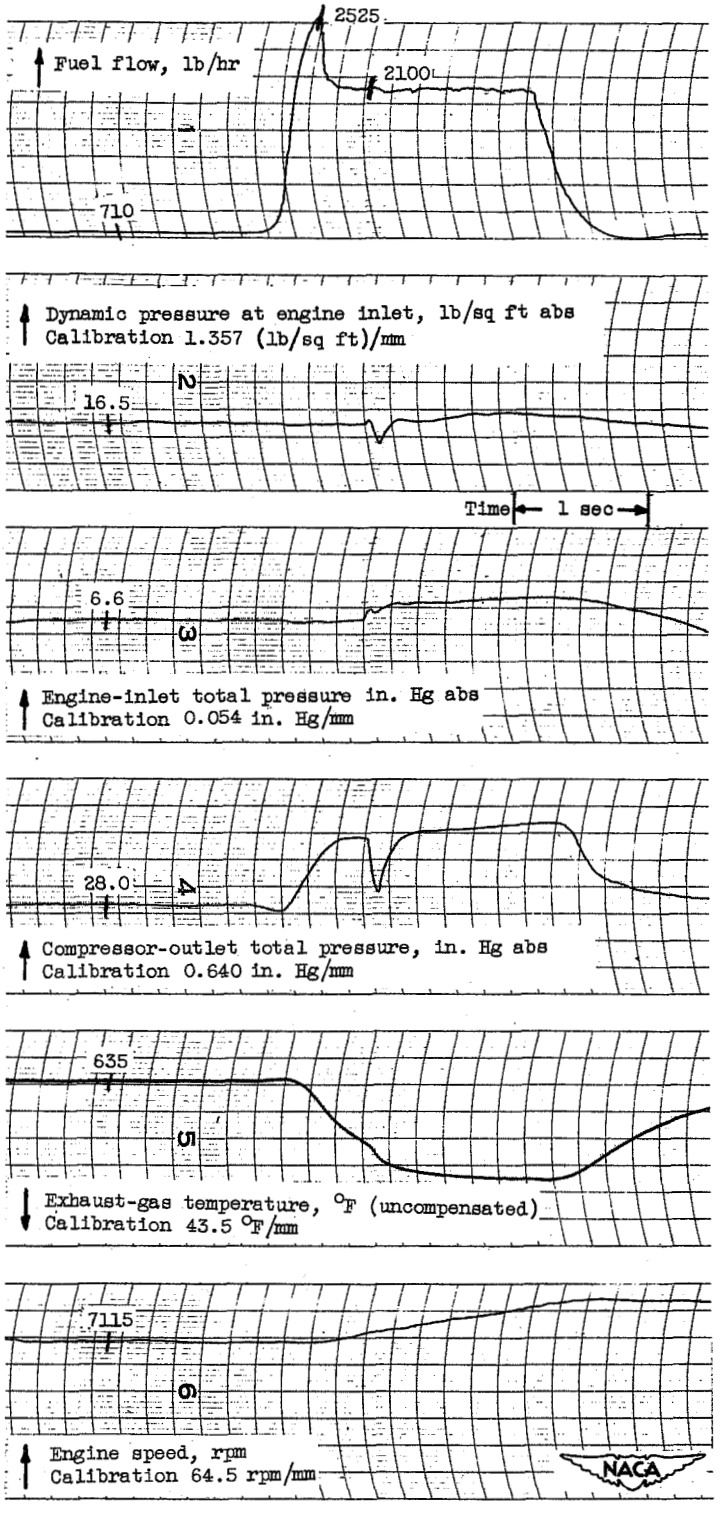

Figure 73

Oscillograph traces showing variations of different engine parameters during a step-change in fuel flow. Altitude, 45,000 feet; flight Mach number, 0.8; engine-inlet air temperature, 30° F; inlet guide vanes position, closed.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

PRELIMINARY TRANSIENT PERFORMANCE DATA ON THE J73 TURBOJET ENGINE

III - ALTITUDE, 45,000 FEET

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Restriction/Classification Cancelled