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RESEARCH MEMORANDUM

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PRELIMINARY TRANSIENT PERFORMANCE DATA FOR AFTERBURNER

OPERATION OF WESTINGHOUSE ELECTRONIC POWER REGULATOR

ON XJ34-WE-32 TURBOJET ENGINE IN ALTITUDE WIND TUNNEL

By George Vasu, Glennon V. Schwent, and James R. Ketchum

Lewis Flight Propulsion Laboratory Cleveland, Ohio

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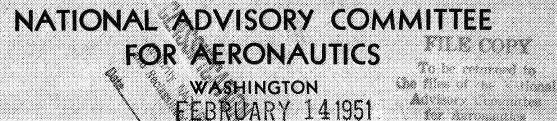
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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, an investigation of the Westinghouse XJ34-WE-32 turbojet engine is being conducted in the NACA Lewis altitude wind tunnel to determine the steady-state and transient operating characteristics of the controlled and uncontrolled engine at various altitudes and ram pressure ratios. As part of this program, transient performance data that illustrate the operation of the engine is obtained in the form of oscillographic traces. Representative data of the controlled engine for operation in the nonafterburning range is presented in reference 1. Similar data for engine operation in the afterburning range, covering a range of throttle settings from the minimum value giving rated speed (throttle position, 72°) to full afterburning (throttle position, 110°), is presented herein. These data thus serve to indicate the transient characteristics of the engine when the throttle is advance into, withdrawn from, and moved within the afterburning range in a stepwise manner, as well as the steady-state stability of the engine during afterburning.

The oscillographic traces presented herein show the responses of the following parameters to step changes in throttle position: thrust, ram pressure ratio, exhaust-nozzle area, engine speed, turbine-discharge temperature, primary fuel valve position, compressor-discharge pressure, afterburner fuel flow, primary engine fuel flow, turbine-discharge pressure, throttle position, afterburner igniter pressure, and pressures in the three afterburner fuel manifolds. These data are presented for

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a range of altitudes from 10,000 to 45,000 feet and at several ram pressure ratios. In addition, data are presented to show operation with different schedules of afterburner fuel flow against compressordischarge pressure.

APPARATUS

Engine. - XJ34-WE-32 turbojet engine with variable-area exhaust nozzle and afterburner

Minimum primary fuel flow set to 420 pounds per hour at a windmilling speed of 1500 rpm and an altitude of 2000 feet

Control. - Westinghouse electronic power regulator (part no. 61-F-758-4; serial no. S-CZA-78, modified to correspond to part no. 61-F-758-6 insofar as temperature schedule is concerned)

The original thermocouple harness of nine paralleled short thermocouples at the turbine discharge was removed and replaced by another group of nine paralleled elements which were emersed 6 inches. The thermocouples were also of equal resistance to insure more nearly average temperature indication.

Test facilities. - Lewis altitude wind tunnel with 20-foot diameter test section

Air supplied through a ram pipe connected directly to the engine

Instrumentation. - Engine parameters were recorded during transients on three multichannel direct-inking magnetic-pen-motor oscillographs. The pen motor in combination with its amplifier has an essentially flat frequency response to approximately 100 cycles per second. The oscillograph chart speed was 2.5 units per second. Timing marks are shown on the lower edge of the oscillograph reproductions. These marks serve as a reference for determining a starting point for the time bases of the three recorders. The following table lists the engine parameters that were recorded, the instrumentation used to measure the values of the parameters in the steady state, the sensing devices used to measure the variations in the parameters during transients, and the frequency-response range of the transient instrumentation.

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	[Transient instruments	ation
Measured quantity	Steady-state instrumentation	Sensor	Range over which frequency response is essentially flat (cycles/sec)
Thrust		Strain gage mounted on strain link attached to forward engine suspension	0~100
Ram pressure ratio	Airspeed indicator	Aneroid-type pressure sensor with strain gage element	0-10 at sea- level pressure
Exhaust-nozzle area	Microammeter connected to exhaust-nozzle area feedback potentiometer	Exhaust nozzle area feedback potentiometer connected to give position indication	0-100
Engine speed	Chronometric tachometer	Direct current tachometer generator	0-5
Turbine discharge temperature	Nine thermocouples in parallel connected to Brown recorder (Westinghouse control thermocouple harness)	Unshielded loop thermocouples (five in series)	O-l at sea- level mass flow
Primary fuel valve position	Microammeter connected to fuel value feedback potenticmeter	Fuel value feedback potentiometer connected to give position indication	0-100
Compressor discharge pressure	Mercury filled manometer	Aneroid-type pressure sensor with strain gage element	0-10 at sea- level pressure
Afterburner fuel flow	Rotameter	Aneroid-type pressure sensor, with strain gage element, connected to measure pressure drop across a fixed orifice in the fuel line	Undetermined
Primary fuel flow	Rotameter	Aneroid-type pressure sensor, with strain gage element, connected to measure pressure drop across a variable orifice in the fuel line	Undetermined
Turbine discharge pressure	Alkazene filled manometer	Aneroid-type pressure sensor with strain gage element	0-10 at sea- level pressure
Throttle position	Selsyn indicator	Wire-wound potentiometer connected to give position indication	0-100
Afterburner igniter pressure		Aneroid-type pressure sensor with strain gage element	Undetermined
Afterburner manifold pressure (inner ring)	Bourdon-type gage	Aneroid-type pressure sensor with strain gage element	Undetermined
Afterburner manifold- pressure (middle ring)	Bourdon-type gage	Aneroid-type pressure sensor with strain gage element	Undetermined
Afterburner manifold pressure (outer ring)	Bourdon-type gage	Aneroid-type pressure sensor with strain gage element	Undetermined

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PROCEDURE

The throttle was manually advanced or cut back in a stepwise manner within the range of throttle positions from 72° to full afterburning to determine the transient operation of the engine and control. Engine parameters were measured continuously on oscillograph recorders. Before and after each transient, photographs of panel meters and manometers were taken to calibrate the transient traces.

In the original afterburner control system, fuel flow is scheduled as a function of compressor-discharge pressure. This scheduling was selected so that fuel flow would be proportional to air flow through the engine for any condition of flight speed, altitude, or ambient temperature.

Inasmuch as one of the objectives of this study was to determine effects of variations in the schedule, it became necessary to modify the original control so as to permit such changes to be made conveniently. An analysis of the original system shows that compressor-discharge pressure is referenced to a constant pressure, which is essentially the fuel boost pump outlet pressure, and that this function then controls fuel flow. It is evident that changes in the reference pressure will cause a change in fuel flow at any one value of compressor-discharge pressure. In order to change the schedule, the fuel flow return line from the afterburner control that had been connected to the boost pump outlet pressure as a reference point was moved to the boost pump inlet pressure as a new reference point. A schematic diagram of the fixed system, as modified, is presented in figure 1.

Pump inlet pressure was then set to each of several values and in each case held constant for a series of transient runs. The engine was operated in the afterburner region in accordance with the new schedules thus established. Transient data were taken with several boost pump inlet pressures.

Simulated altitude (ft)	Nominal inlet temperature (°F)	Nominal ram pressure ratio
10,000 25,000	- 60	1.2
35,000	-11	1.2
40,000	-10	1.05
000,40	-11	1.2
45,000	-14	1.4

Throttle position steps of various sizes were made within the range of 72° to full afterburning at the following flight conditions:

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PRESENTATION OF DATA

Preliminary data are presented in the form of reproductions of oscillographic traces which have been reduced to 71 percent of their original size (except fig. 41 which is reduced to 54 percent of its original size). These data are representative of the operation of the controlled engine with afterburner in the range of throttle positions from 72° to full afterburning.

For all runs, the following parameters are shown:

Thrust

Ram pressure ratio

Exhaust-nozzle area

Engine speed

Turbine-discharge temperature

Primary fuel valve position

Compressor-discharge pressure

Afterburner fuel flow

Primary fuel flow

Turbine-discharge pressure

Throttle position

Afterburner igniter pressure

Afterburner manifold pressure (inner ring)

Afterburner manifold pressure (middle ring)

Afterburner manifold pressure (outer ring)

The average steady-state value for the preceding parameters are indicated on the individual oscillographic traces, except for the jet thrust and afterburner igniter records. These traces are shown only to indicate the variation during a transient. Because of the techniques employed in measuring jet thrust, variations in ram pressure influence the thrust trace. This effect of ram variation on thrust can be observed by noting the thrust trace when ram varies.

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As an aid in the understanding and interpretation of the transient runs, a nominal power control lever schedule for static sea-level operation is presented in figure 2. This figure shows the temperature, speed, and approximate thrust scheduled for each throttle position. Linearity of thrust is not guaranteed; instead, speed and temperature are controlled and thrust will be whatever is obtained at a given set speed and set temperature. A calibration of exhaust-nozzle area to its panel meter reading is presented in figure 3. Afterburner fuel flow schedules for several boost pump inlet pressures are shown in figure 4.

The oscillographic traces of the transient data are presented in figures 5 to 48 and are indexed in table I according to throttle position, altitude, ram pressure ratio, and boost pump inlet pressure. The figures chosen are representative of the normal operation of the controlled engine with afterburning within the range of throttle positions from 72° to full afterburning with the exception of figures 23 to 27 inclusive where boost pump inlet pressure was 30 pounds per square It was found that the afterburner manifold inner ring had been inch. partially coked when the data for figures 23 to 27 had been taken. This coking is indicated by the high pressure in the inner ring relative to that in the other rings. As a result of this coking, the afterburner fuel flow is less than normal and therefore less than that scheduled. The fuel flow and responses obtained in this particular case with partial coking are similar to those obtained with a boost pump inlet pressure of 26 pounds per square inch without coking. One point on figure 4 for a boost pump inlet pressure of 18 pounds per square inch is somewhat low, which is also due to partial coking of the fuel manifold. The only effect of partial coking appears to be a reduction in afterburner fuel flow. More severe coking than that discussed above, however, results in oscillatory engine response.

Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics, Cleveland, Ohio, January 16, 1951.

REFERENCE

 Ketchum, James R., Blivas, Darnold, and Pack, George J.: Preliminary Performance Data on Westinghouse Electronic Power Regulator Operating on J34-WE-32 Turbojet Engine in Altitude Wind Tunnel. NACA RM SE50J11, Bur. Aero., 1950.

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UJames R. Ketchum, Aeronautical Research Scientist.

Approved:

John C. Sanders, Aeronautical Research Scientist.

✓ Eugene W. Wasielewski, Aeronaptical Research Scientist.

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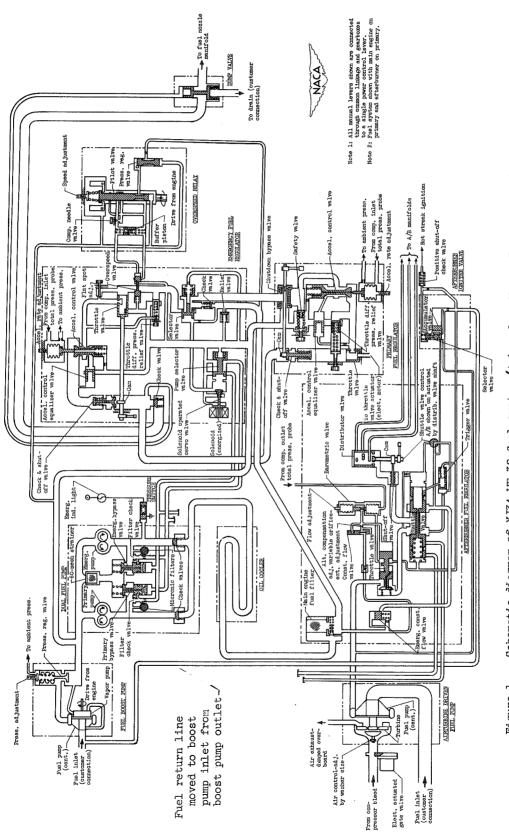
Figure	Throt posit (de Initial	ion	Altitude (ft)	Nominal ram pressure ratio	Boost pump inlet pressure (lb/sq in.)
5 6 7 8 9	82 110 82 106 110	110 82 104 110 90	10,000	1.2 1.2 1.2 1.2 1.2	18 18 18 18 18 18
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27	72 110 83 110 110-9 110-10 105 110 72 108 82 108	111 72 111 83 11-96 110 72 110 83 7-110 01-110 110 93 and cut off 108 72 108 82 90-82	25,000	1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2	$ 18 18 18 18 18 26 26 26 26 26 26 26 26 26 26 26 26 a_{30} a_{30}$
28 29 30 31 32 33 34		109 72 108 85 109 01-109 109-93-75	35,000	1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2	18 18 18 18 18 18 18
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42 43 44 45 46 47 48	110-10	110 72 110 83 04-110 00-110 94-109	45,000	1.4 1.4 1.4 1.4 1.4 1.4 1.4 1.4	18 18 18 18 18 18 18 18

TABLE I - INDEX TO TRANSIENT RUNS

^aAfterburner inner ring coked (see text).

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- Schematic diagram of XJ34-WE-32 fuel system (taken from Westinghouse manual). Figure 1.

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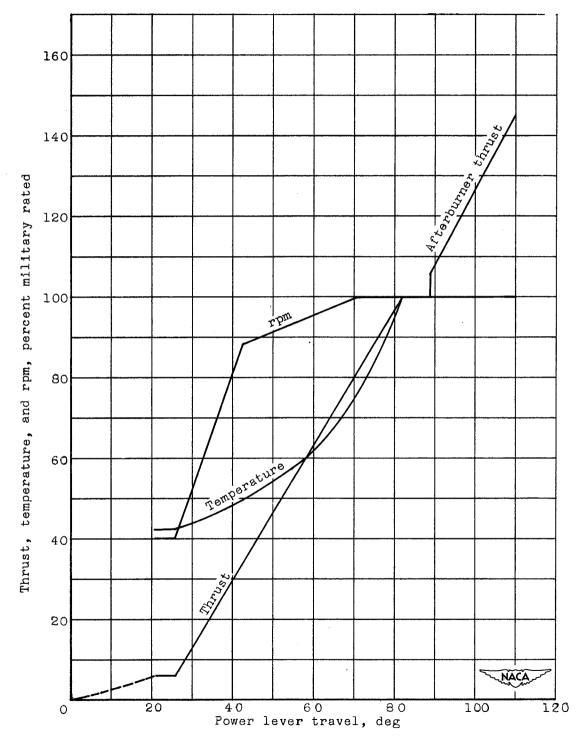


Figure 2. - Nominal power control lever schedule for static sea-level operation of typical engine.

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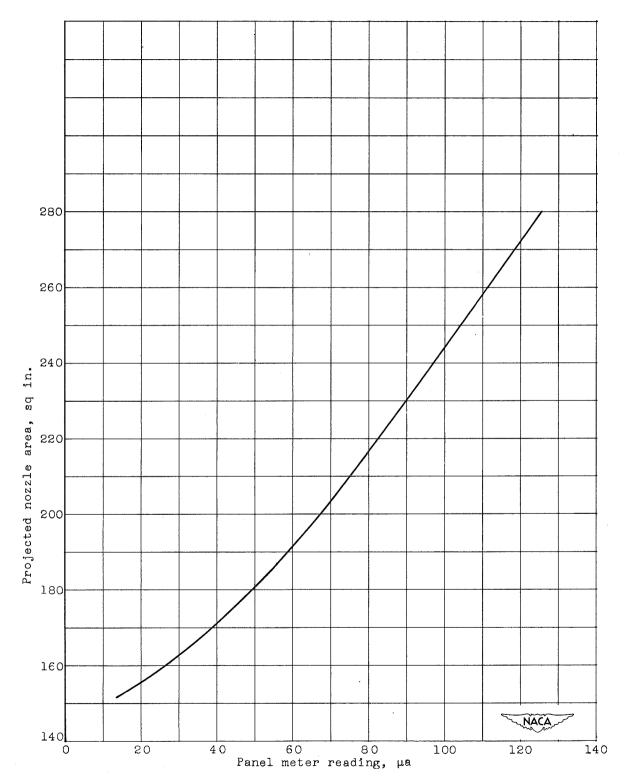
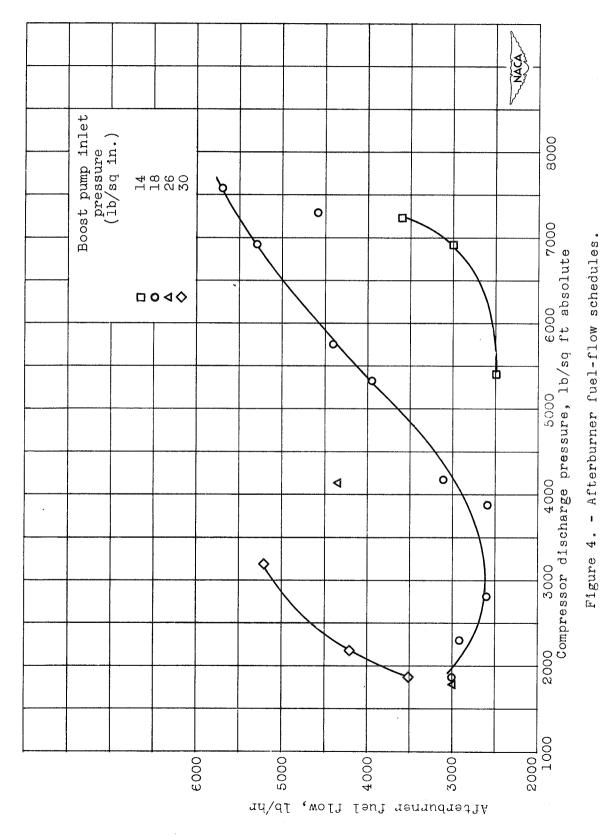


Figure 3. - Calibration of exhaust-nozzle area.

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Figure 5. - Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 110°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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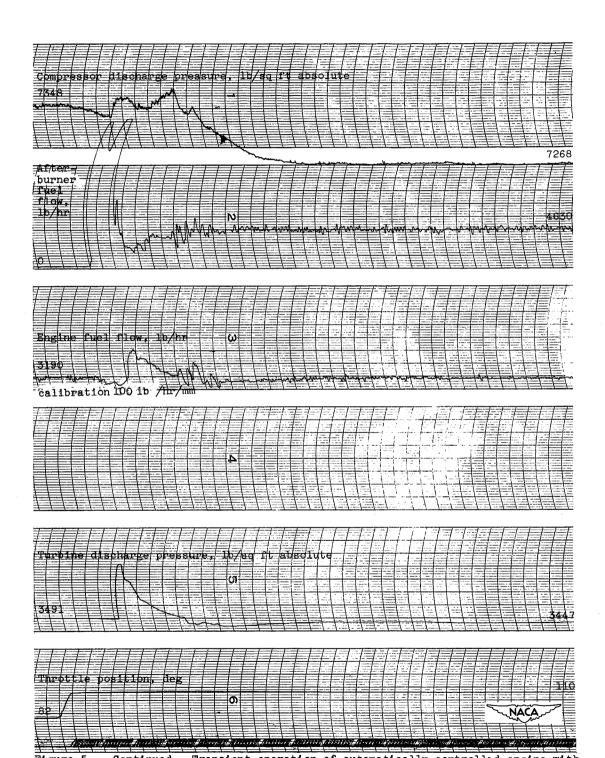


Figure 5. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 110°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 6. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 82°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 6. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 82°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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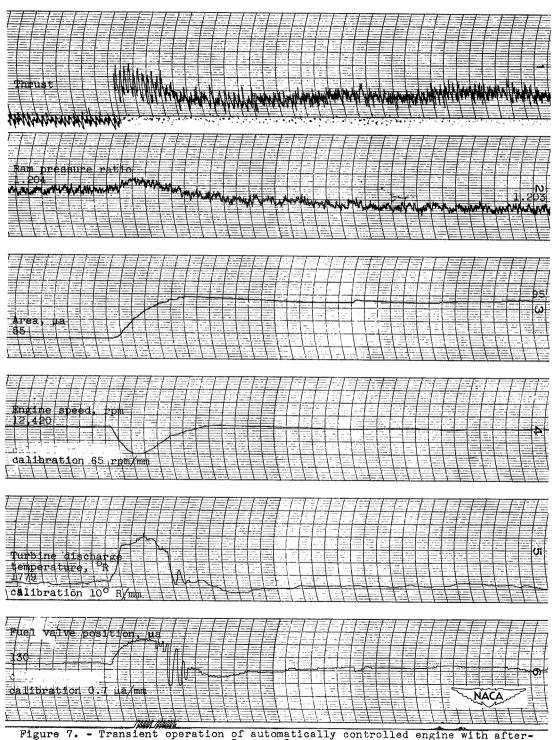


Figure 7. - Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 104°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 8. - Transient operation of automatically controlled engine with after-burner. Throttle position, 106° to 110°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Compressor discharge pressure, lp/sq ft absolute
calibration 3 Hs/sq ft absolute/mm
Afterburner fuel flow, 10/hr N 4630
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calibration 100 lbs/hr/mm
Turbine discharge pressure, h/sg ft apsplute
calibration 40 lbs/s rt absolute/un
Indutie position, deg
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Figure 8 Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 106° to 110°; altitude, 10,000 feet; nominal ram

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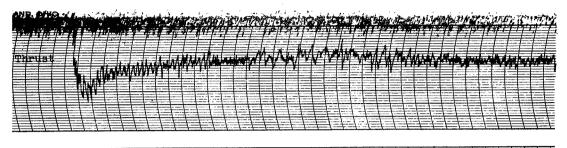
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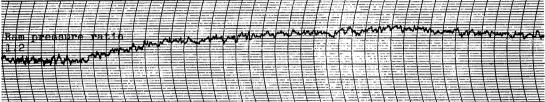
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Afferburger manifold middle-ring pressure, 10/sq ft absclute

Figure 8. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 106° to 110°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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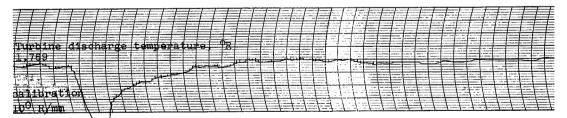
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Figure 9. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 90°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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7258 Compressor disonarge pressure,
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310/bg/ft
Afterburner file: flow, 10/hr
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Bigine fuel Clow, 19/hr 3085 - calibration 100 1b/br/mm
5065 calibration 100 lb/m/mm
Turbine discharge pressure, 16/sq ff absolute
Turnine discharge pressure, 10/sq ff absolute
cal Poration /
Throttle position, deg
Figure 9 Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 90°; altitude, 10,000 feet; nominal ram
pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Afterplumer Igniter predsure
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Figure 9 Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 90°; altitude, 10,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

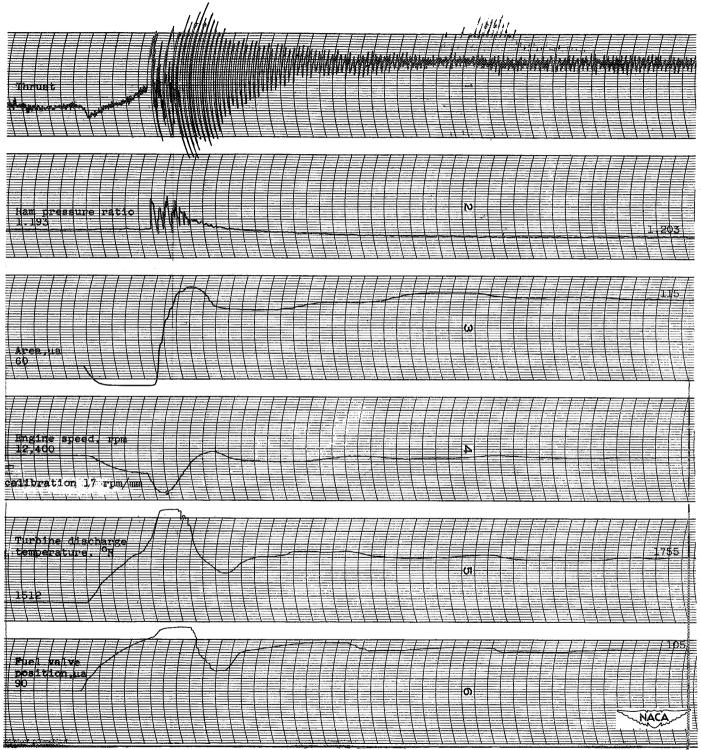


Figure 10. - Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 111°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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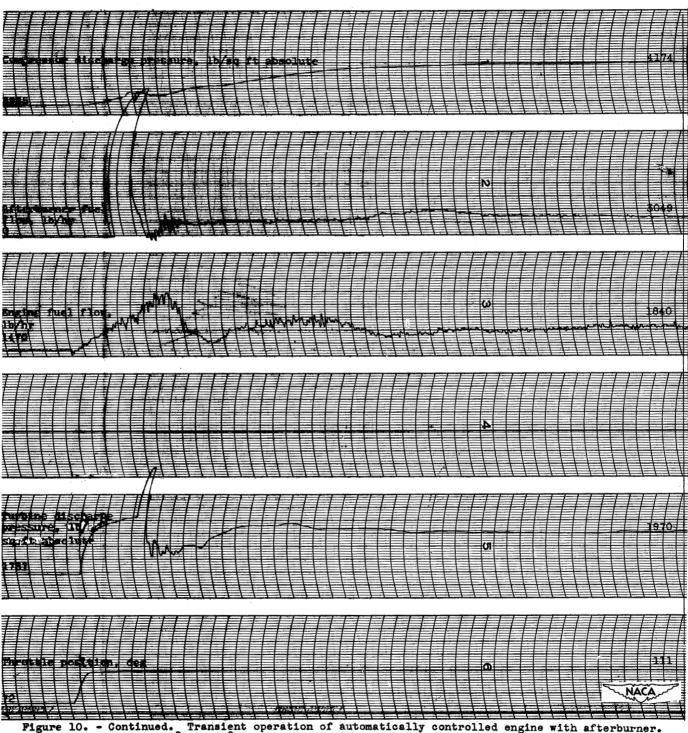
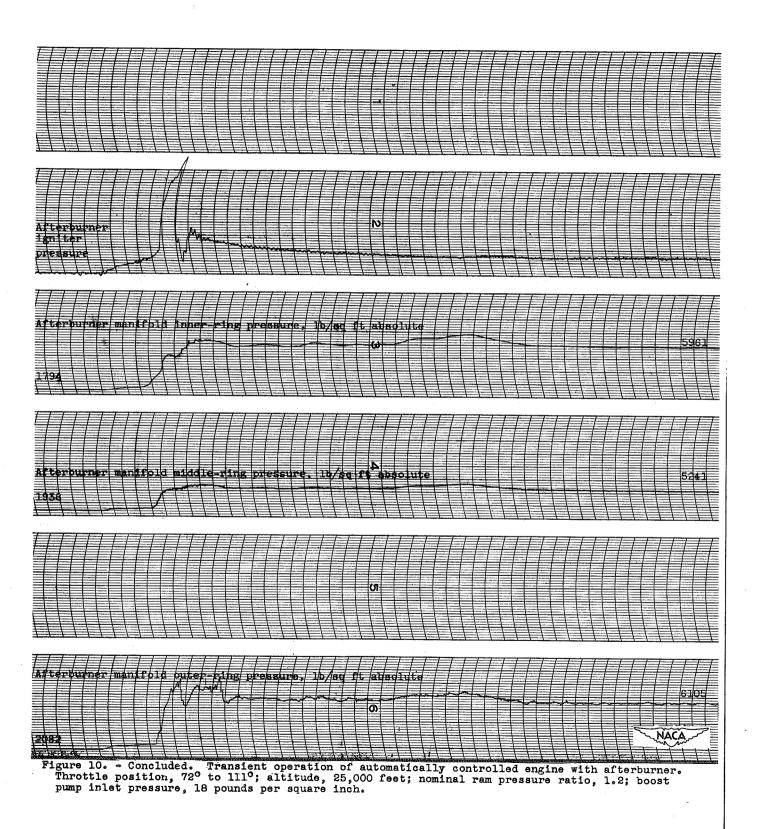


Figure 10. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 111°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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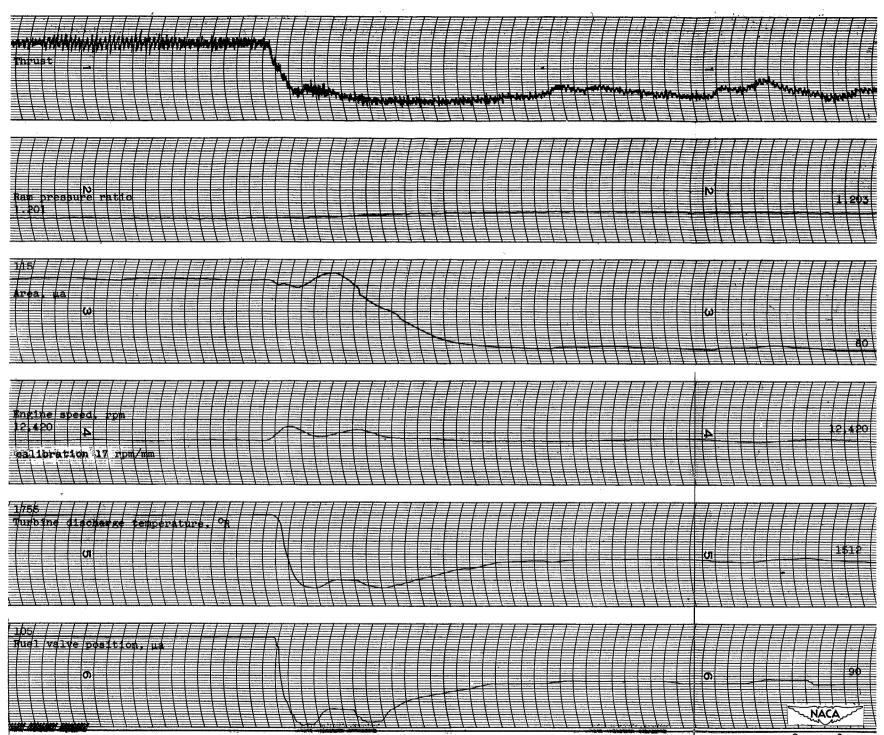


Figure 11. - Transient operation of automatically controlled engine with afterburner. Throttle position, 111° to 72°, altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

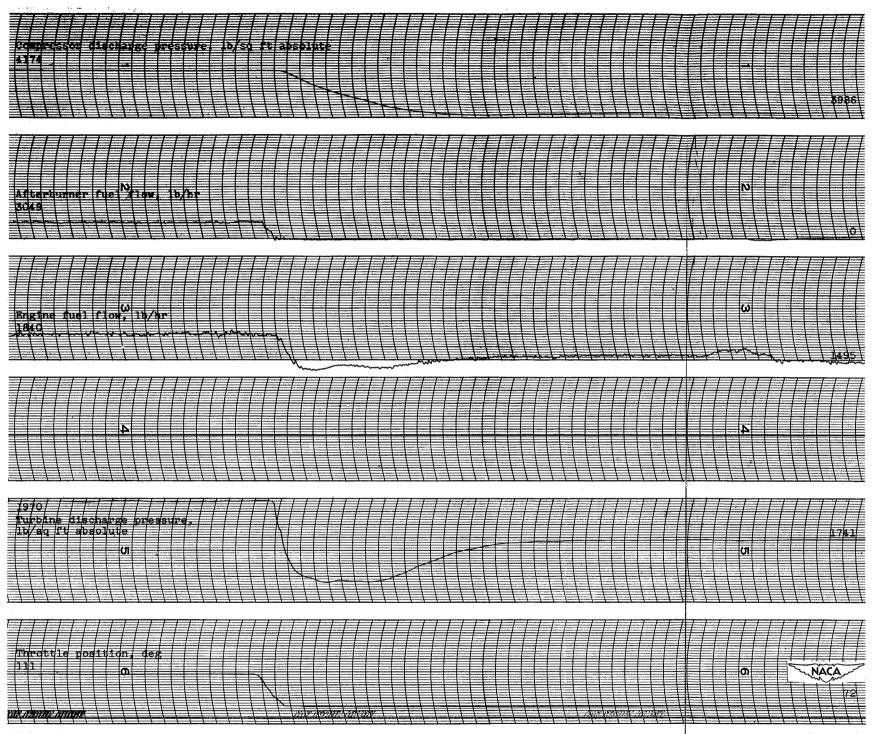


Figure 11. - Continued. Transient operation of automatically controlled engine with afterburner. Thrittle position, 111° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per squire inch.

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Afterburner manifold inner-ring pre	ssure, lo/sq ft absolute	
Aftierburrier manifold middle-ring pi S241	essure, 15/sqfft sosolute	
Afterburner manifold outer-ring pre	ssure b/sc ft absolute	NACA

Figure 11. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 111° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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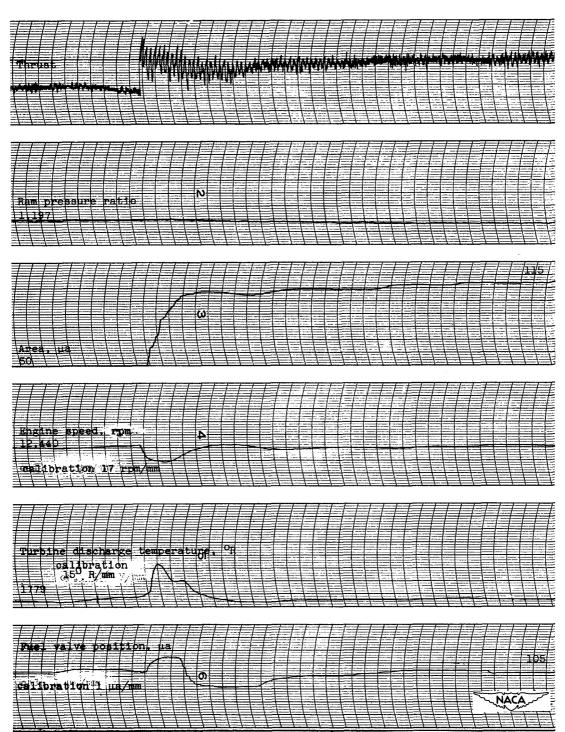


Figure 12. - Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 111°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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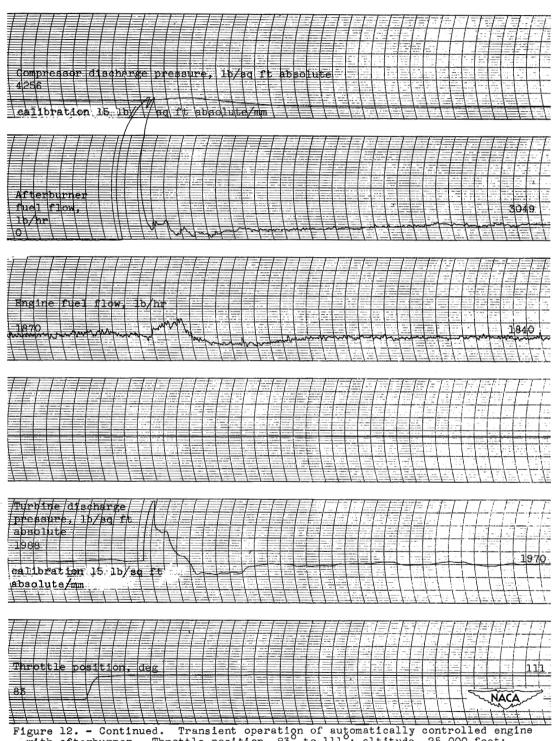
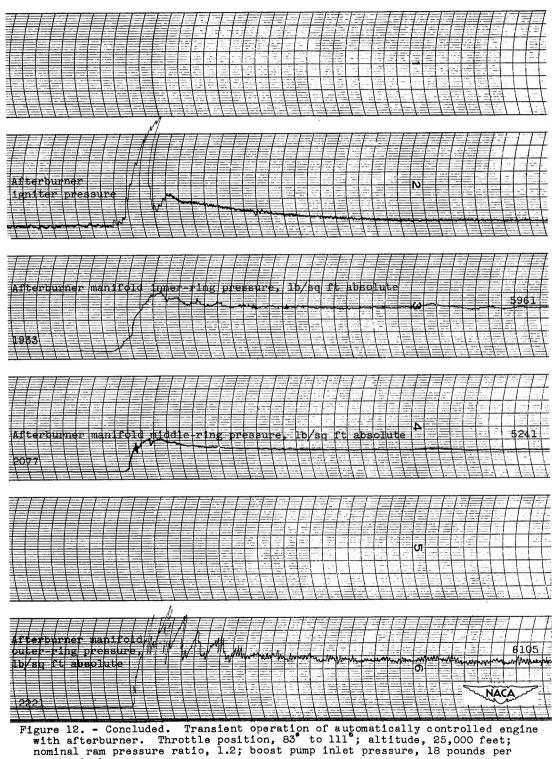


Figure 12. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 110; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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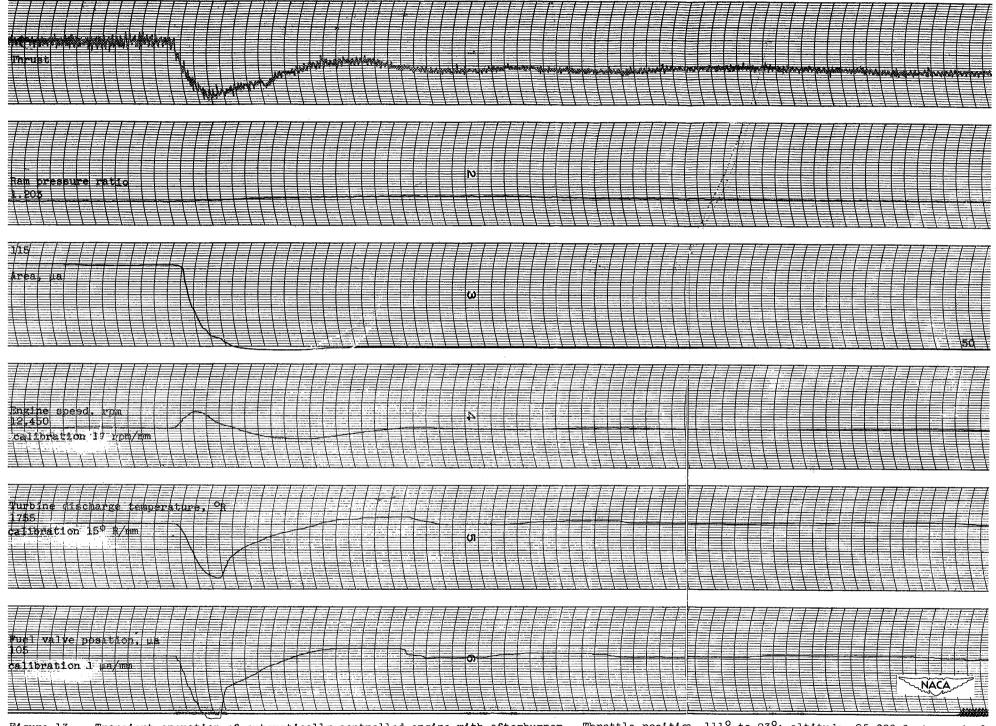


Figure 13. - Transient operation of automatically controlled engine with afterburner. Throttle position, 111° to 83°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

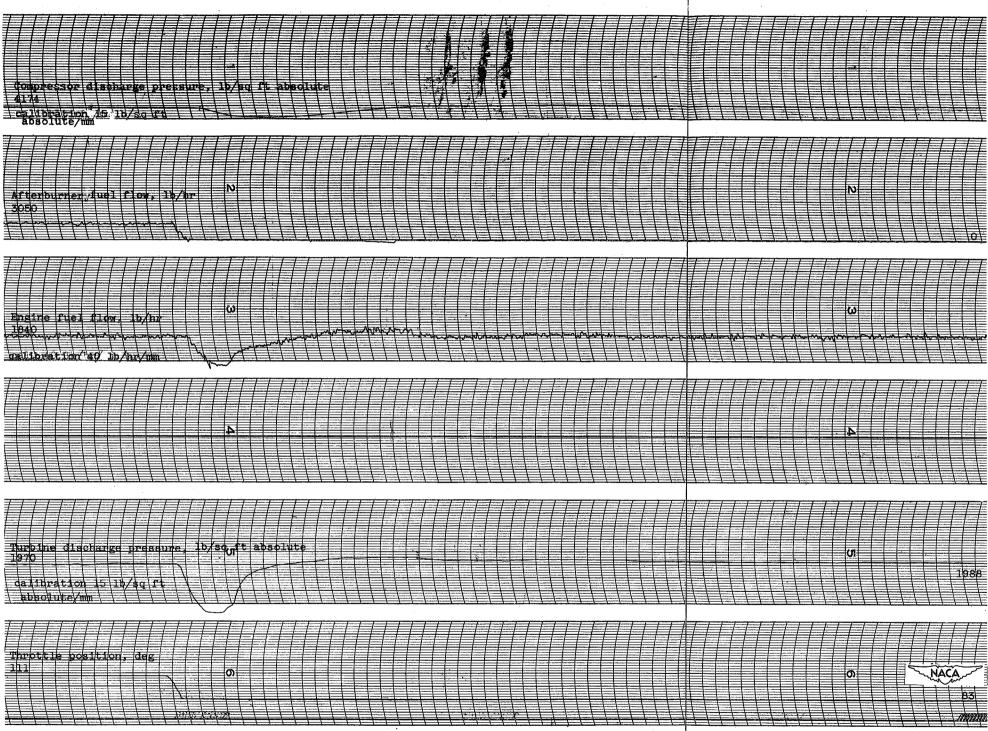


Figure 13. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, lll⁰ to 83⁰; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 punds per square inch.

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Afterburner Jenitter pressure	
Aftenburnen manifold inner-ring pressure, 15/sp ft absolute	
Afterburner manifold middle-ring pressure, 1b/sq ft absolute	7705
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Afterburner man'i fold outer ring grasure. 10/sg ft absolute	O.
mental and the second	
	00 NACA
Afterburner manifold outer ring pressure 10/ag et absolute	

Figure 13. ~ Concluded. Transient operation of automatically controlled engine with afterburger. Throttle position, lll⁰ to 83⁰; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

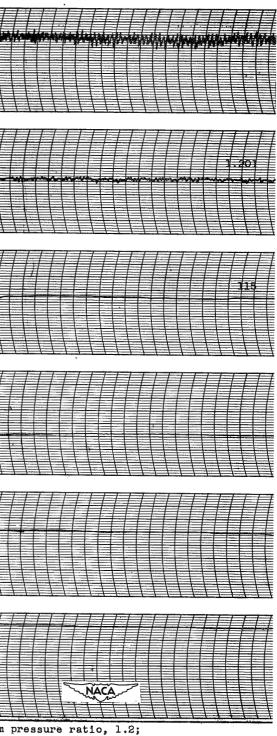
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Figure 14 Transient operation of automatically controlled en	gine with afterburner. Throttle position 069 to 1	19

Figure 14. - Transient operation of automatically controlled engine with afterburner. Throttle position, 96° to 111° and 111° to 96°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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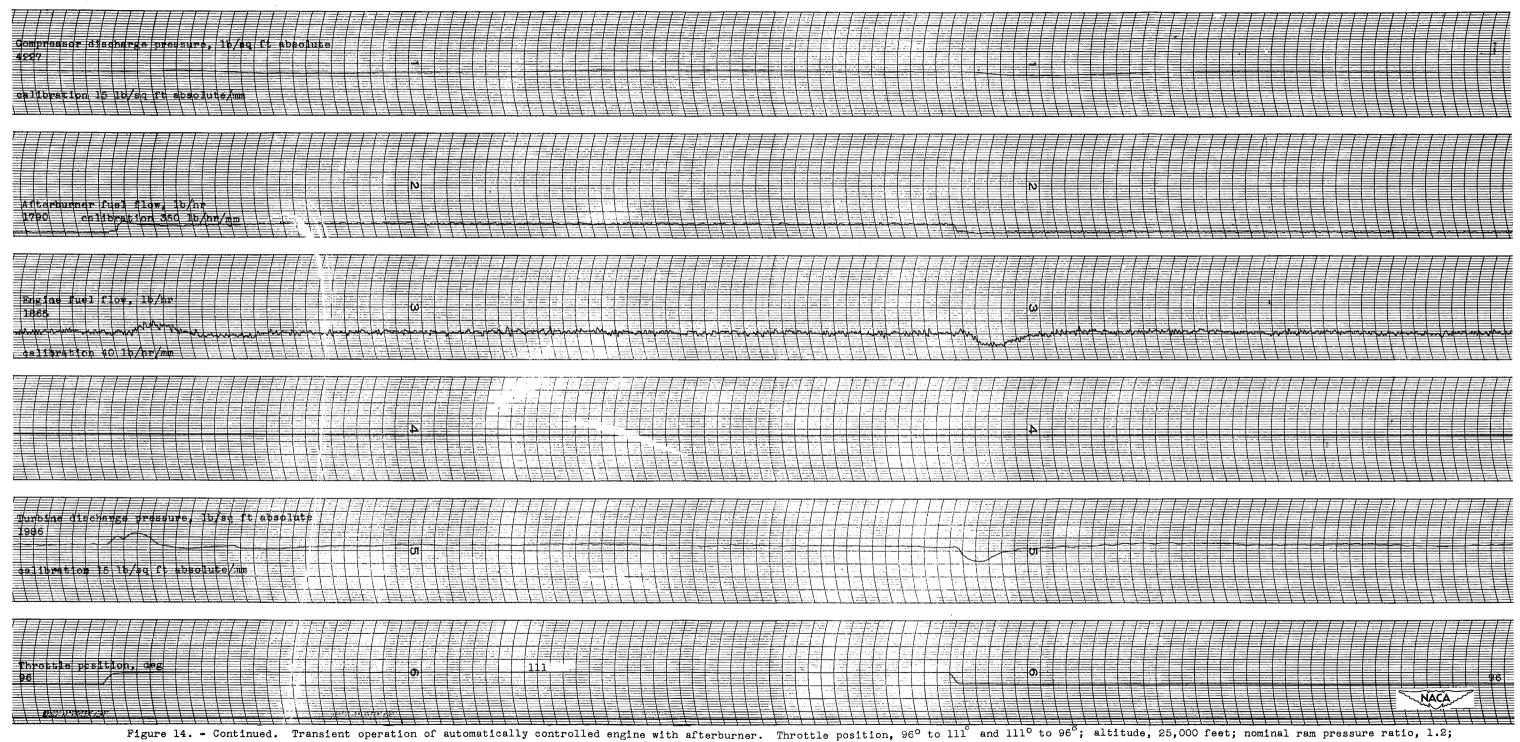
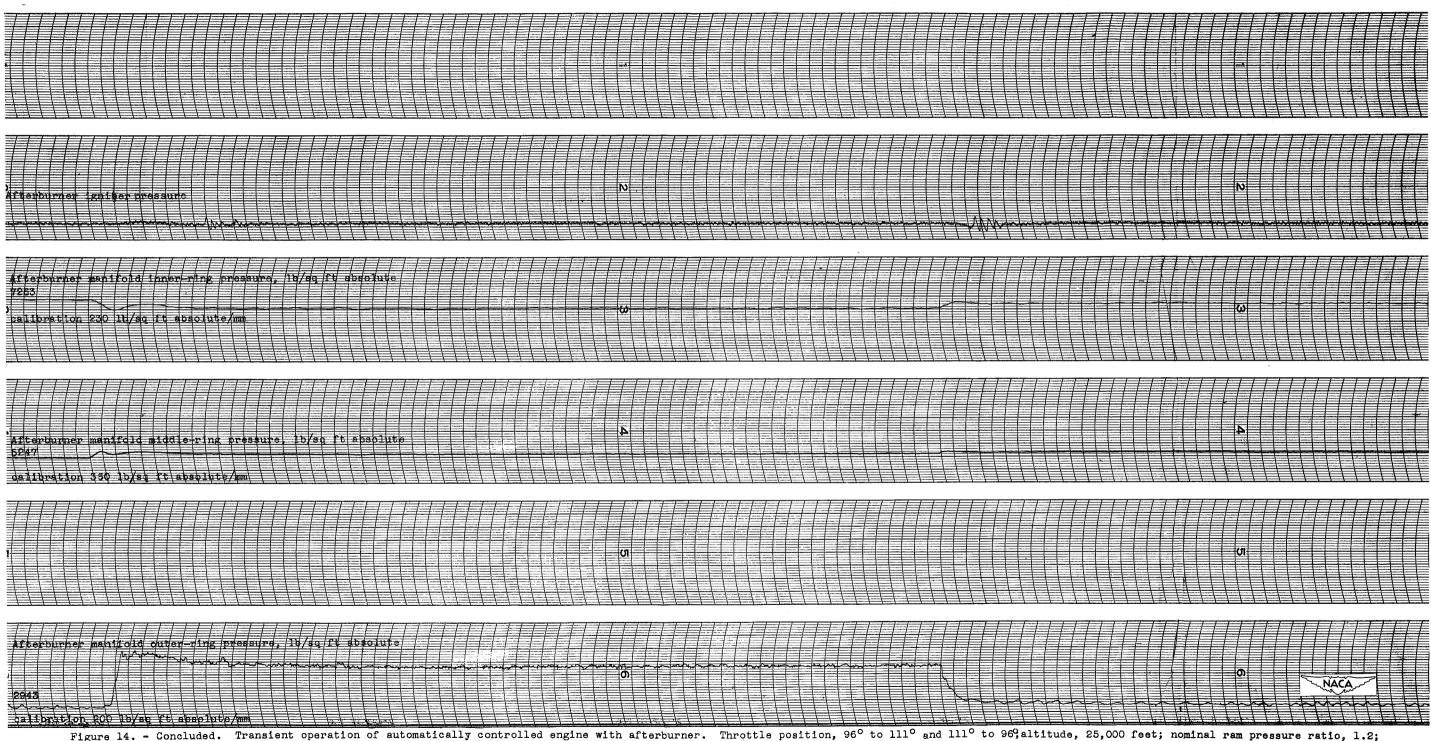


Figure 14. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 96° to 111° and 111° to 96°; altitude, 25 boost pump inlet pressure, 18 pounds per square inch.

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boost pump inlet pressure, 18 pounds per square inch.

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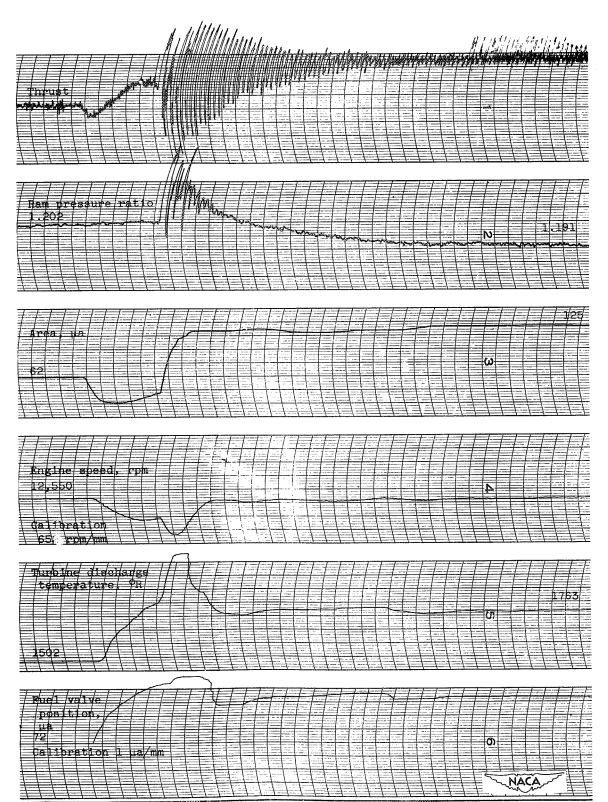


Figure 15. - Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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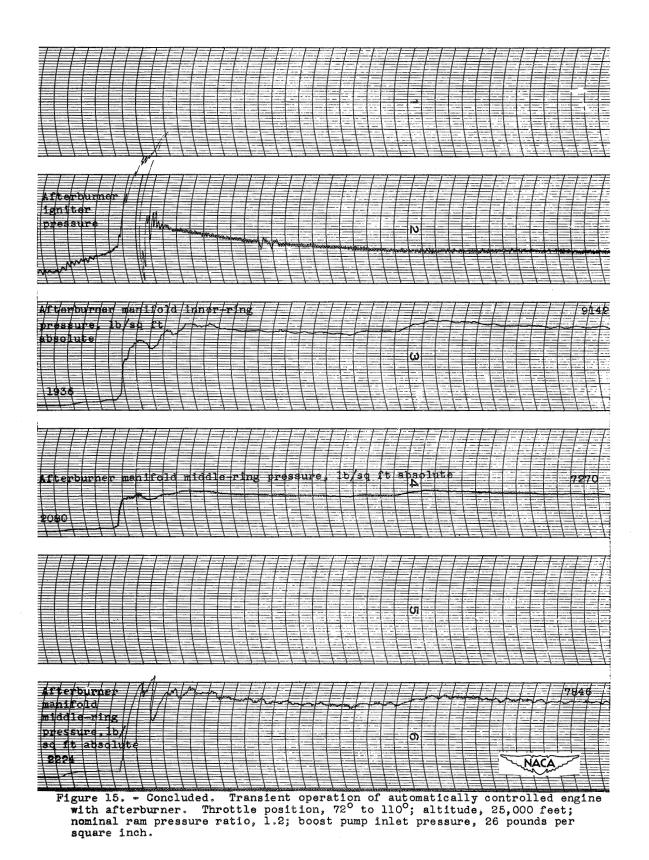
4245 Compression discharge absolute 3975 48 Afterpurner fuel flow, 4810 ---lb/hr N Ņ **m**1 ٥ Whenk mm 1845 Trace limit Engine fuel flow 1 ω 12 Ν Turbine aischarge pressure. 987 1b/sq ft (UI 5M absolute 1740 1-1 = mrdttle dosition deg 110 6 72 THE P NACA

Figure 15. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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105 Pu¢l Valve position, µa		<b>90</b>

Figure 16. - Transient operation of automatically controlled engine with afterburner. Throttle positin, 110° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per spare inch.

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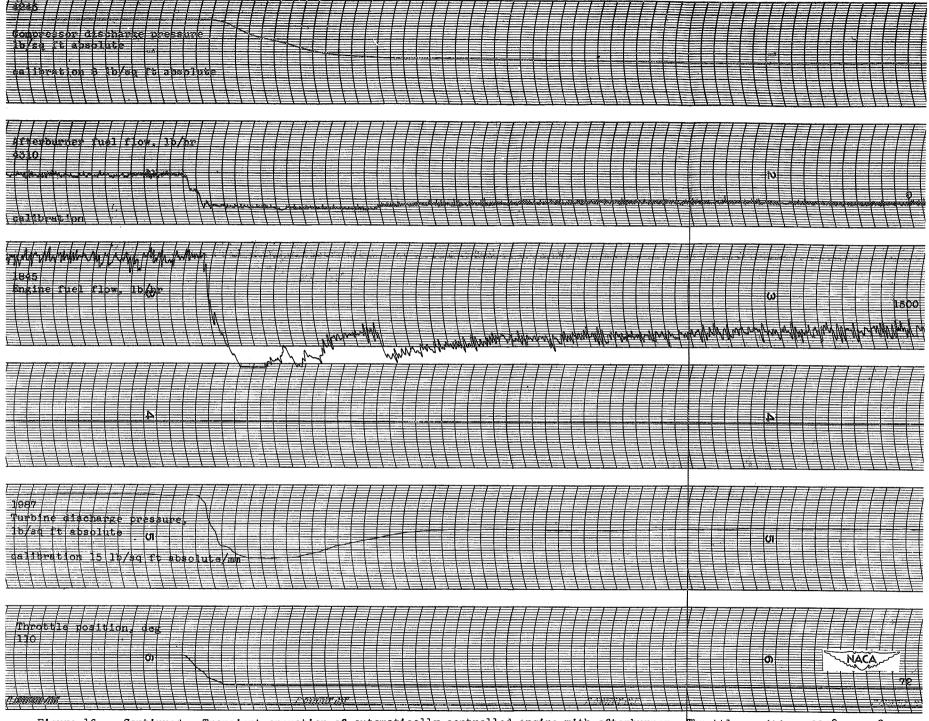


Figure 16. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 poinds per square inch.

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ring pressure, b/sg fit absolute		

Figure 16. - Concluded. Transient operation of automatically controlled engine with afterburner. Arottle position, 110° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 17. - Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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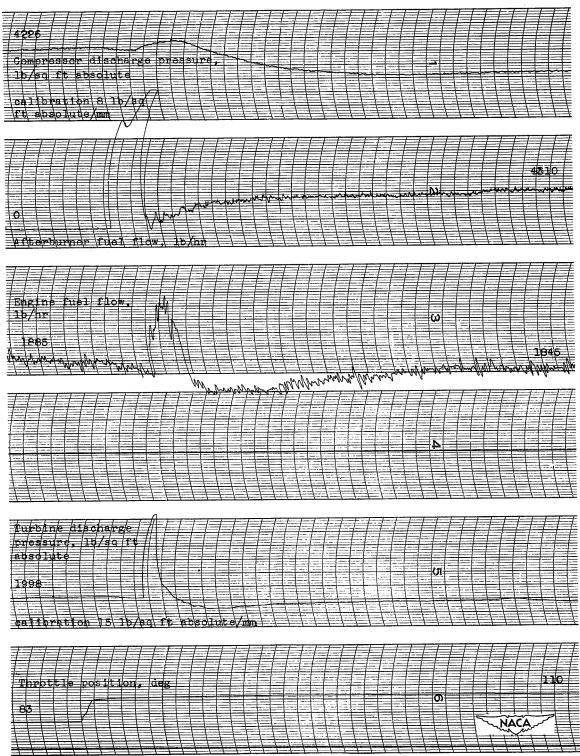


Figure 17. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 18. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 83°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 18. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 83°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 18. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 83°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

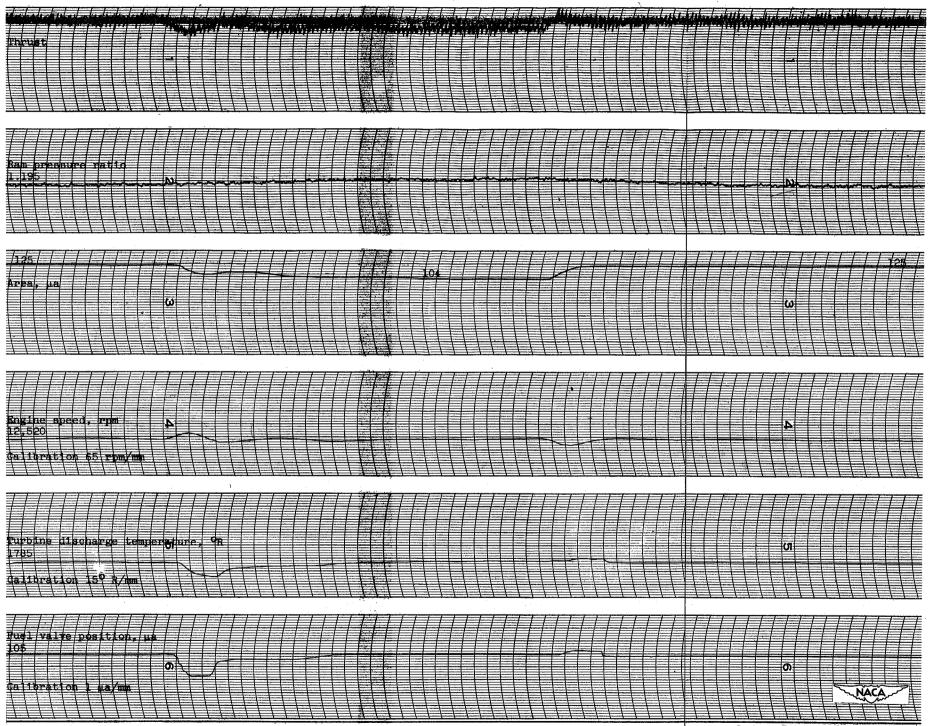


Figure 19. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 97° and 97° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 19. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 97° and 97° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 20. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 101° and 101° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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Figure 20. - Continued. Transient operation of automatically controlled engine with afterburger. Throttle position, 110° to 101° and 101° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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7270 califonation 360 14/49 ft absolutorma Afteeroumer manifold dutor 414g ptessure, 16/83 ft		
7270 calibration 360 18/49 ft absolute/mp // / / / / / / / / / / / / / / / / /		
7270 califonation 360 lb/aq ft absolute/mm Afteerburner manufficic outer-sing pressure, 19/sq ft Afteerburner manufficic outer-sing pressure, 19/sq ft Afteerburner manufficic outer-sing pressure, 19/sq ft and a ft absolute/mm		
7270 califonation 360 la/ag ft absoluto/man hfteerourner manifold dutor-divg pressure, 10/ag ft very: very: ver		
7270 califoration 360 lb/aq ft absoluto/min After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft After burner manif cld dutor - Aing pressure, lb/aq ft Afte		

Figure 20. - Concluded. Transient operation of automatically controlled engine with atterburner. Throttle position, 110° to 101° and 101° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

# ACA RM SE50L29

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Popust				
Ram pressure ret				
1.21				
Area, µa				<b>125</b>
		ω		
Engine speed, ppn 12,520		4		
Calibration 65 rp				
Turbine discharge	temperatu			
1775		() ()		
Calibration 159 R				
			7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-	
Fuel valve positi	on, µa			
Callbration 1 $\mu_{2}$	· · · · · · · · · · · · · · · · · · ·	0		NACA
				NACA

Figure 21. - Transient operation of automatically controlled engine with afterburner. Throttle position, 105° to 110°; altitude 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

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### CA RM SE50L29

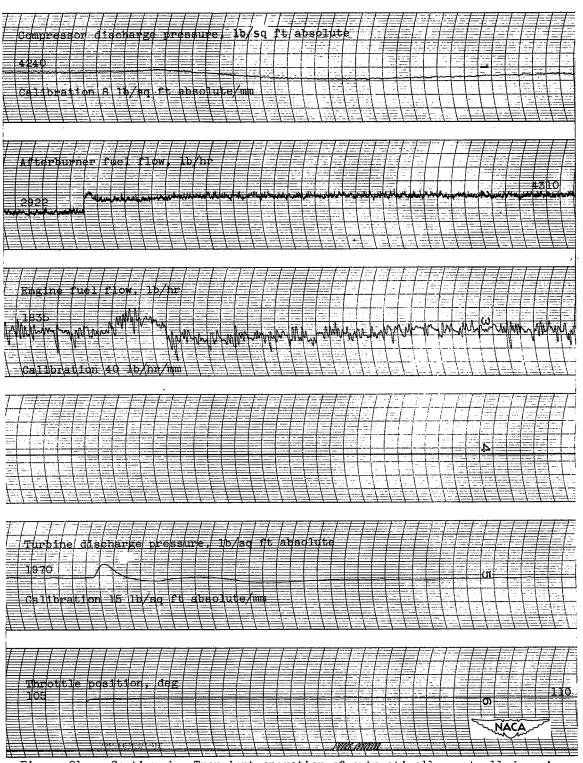


Figure 21. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 105° to 110°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

NACA RM SE50L29

N orbinier Lanter pressure
Atterburner manifold inner ring pressure. 10/sa ft absolute
Withration 230 lb/sg ft absolute/mm
Afterpurper manifold middle ring pressure, 10/sq fit ansolute
Afterburner manifold middle ring pressure, lb/sc 11 ensolute
ellibretion 360 lb/se it absolute/mm
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1 1 1 1 1 Marchal Indian Later La
3203 Atterburger mantfold buter ring pressure, 16/se at absolute
Figure 21 Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 105° to 110°; altitude, 25,000 feet;
nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

# 62

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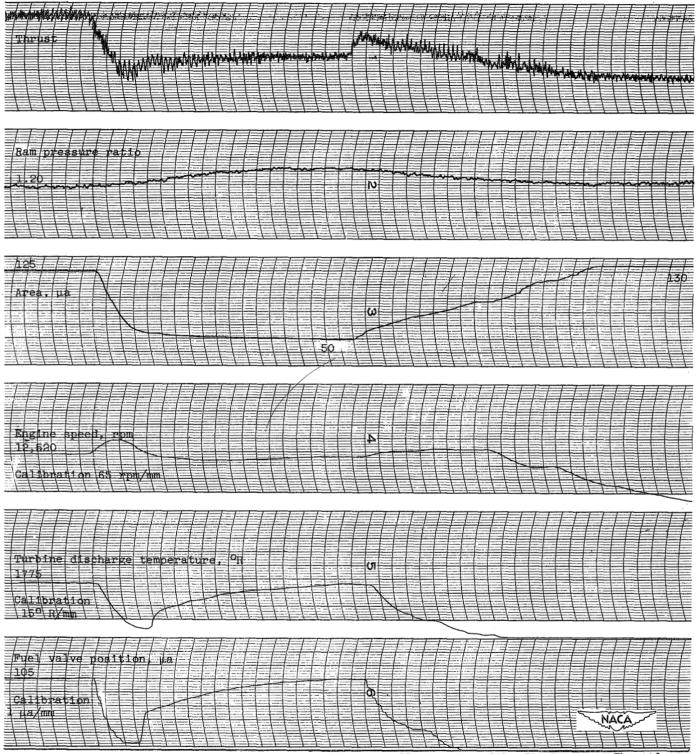


Figure 22. - Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 93° and cut off; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

### NACA RM SE50L29

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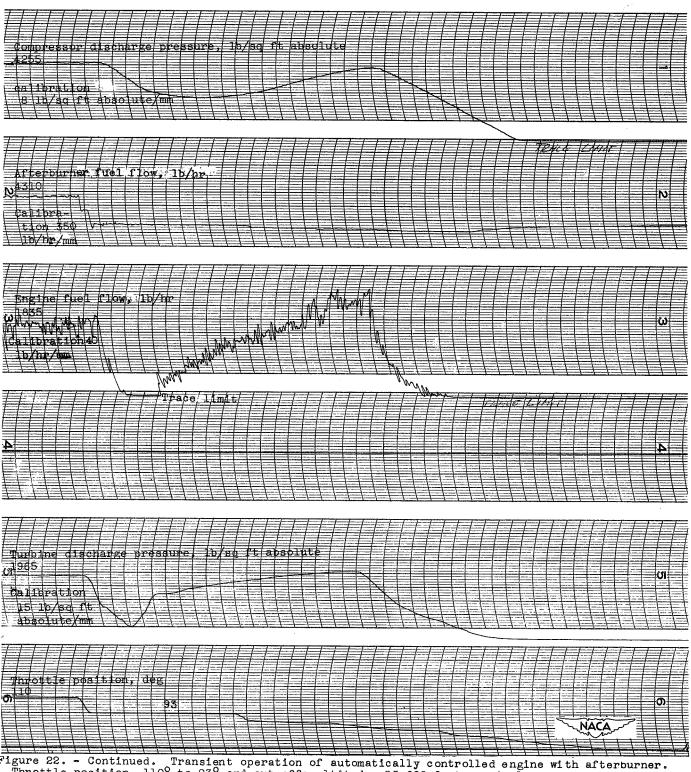


Figure 22. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 93° and cut off; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 26 pounds per square inch.

# NACA RM SE50L29

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Afterburner Igniter pressure	
9200 Afterburner menifold inner-ring pressure, 11/sq ft absolut@	
ealibration 230 lt/sq ft sbeolute/mp	
Afterburner manifold middle ring pressure, 16/sq ft absolute	
dalibration 360 lb/sb ft absplute/mm	
Afferburner munifolid outer-ring pressure, 10/sqfft ebdenute ////////////////////////////////////	
cellibration 200 lb/eq ft absolute/mm	with afterburner.
Figure 22 Concluded. Transient operation of automatically controlled engine Throttle position, 110° to 93° and cut off; altitude, 25,000 feet; nominal ram boost pump inlet pressure, 26 pounds per square inch.	pressure ratio, 1.2;

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### NACA RM SE50L29

minusu ///////////////////////////////////
Engine speed, rpm Calibration 65 rpm/mm
Trace limit
Turbine discharge
1536
Pue, valve // 101 positien, us

Figure 23. - Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 108°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

# 66

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NACA RM SE50L29

		4204
11111		
ompressor o	targe pressure, 10/sq ft absolute	
11111		
chlippatipr.	16/189/1/t absolute/mm	
1		
N		
Aftenburner	L flow, lb/hr	
	Trace limit	
		1850
10w, g/hr		
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1500		
hot have had		
1-1-1-1		
1		
4		
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		1970
1726		
1,201		
Turbine dis	ge pressure, 15/sq ft absolute	
Throttle po	oleg deg	108
0		
72		NACA_
		TITI
Figure 23.	ontinued. Transient operation of automatically cont rner. Throttle position, 72° to 108°; altitude, 25, pressure ratio, 1.2; boost pump inlet pressure, 30 p	trolled engine
with oft	mer. Throttle position, 72° to 108°; altitude, 25	.000 feet:

# 67

# NACA RM SE50L29

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Afterburner igniter	
pressure	
	see see aaree ee
	osolute
	11,299
$\omega$	
	Disclute 7843
Afterburner manifold middle-ring pressure, 10/sq ft a	
Afterburner man foto //	
Afterburner man fold	
Afterpurner man fold	
Afterburner man fois outer ring pressure, ib/ag fc absolute	
Afterburner man fold / / / / / / / / / / / / / / / / / / /	

Figure 23. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 108°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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# NACA RM SE50L29

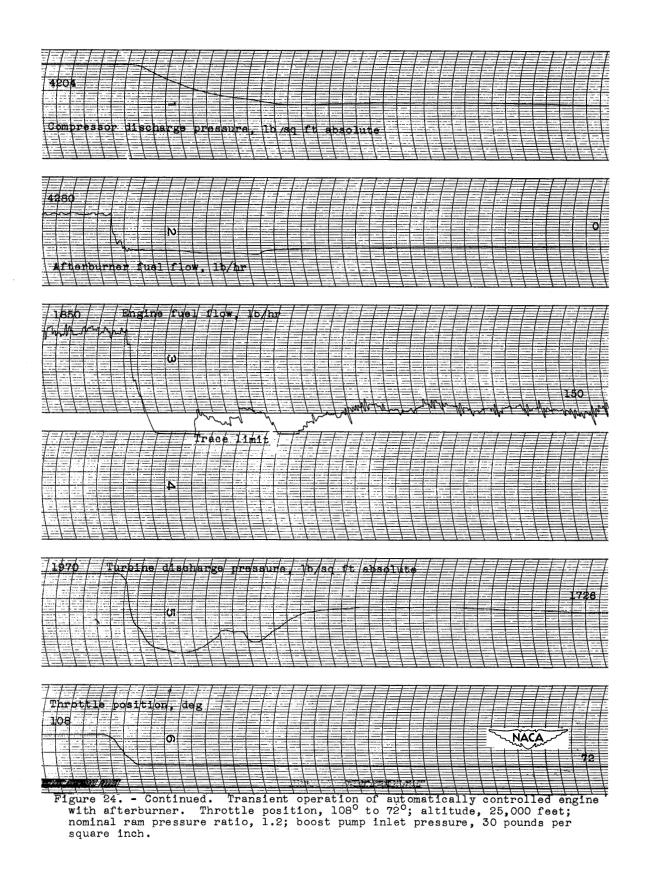
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Thrust ratic Ram pressure 1.202 1,199 1 7122 66 Area, Ha w Engine speed, 1 pm 12,450 dalibration 65 rpm/mm 4765 **⊙**∦ Turbine discharge temperature, 1\$36 **U1** / Fuel/valve/position,/ we 101 NACA **n** 90 Ξ

Figure 24. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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NACA RM SE50L29

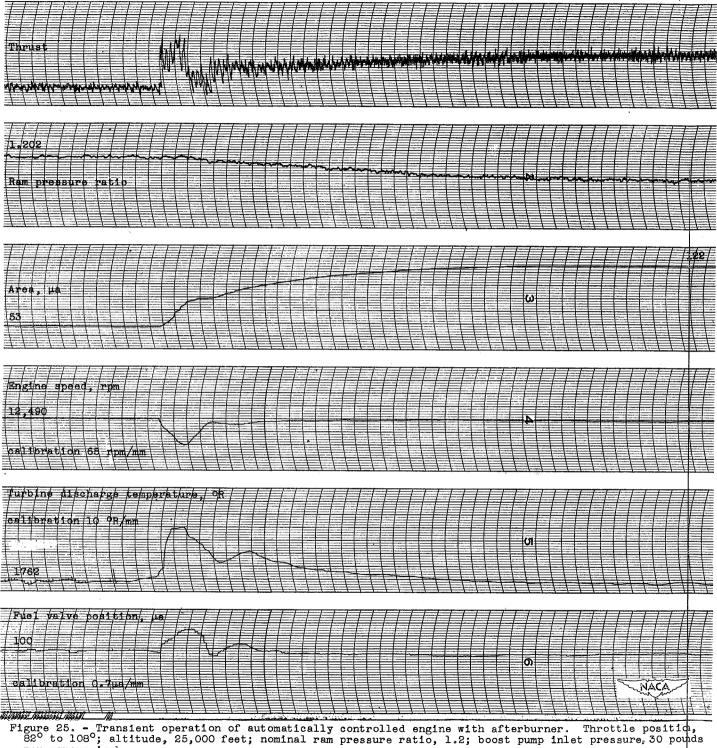


## NACA RM SE50L29

	terburner manifold inner-ring pressure, 10/50 ft absolute
Afterbumer m 7840	Cold middle-ring pre-sure, 15/sq ft absolute 1936
	rburner manifold auter-ring pressure, 10/sq ft absolute

Figure 24. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 72°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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per square inch.

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72

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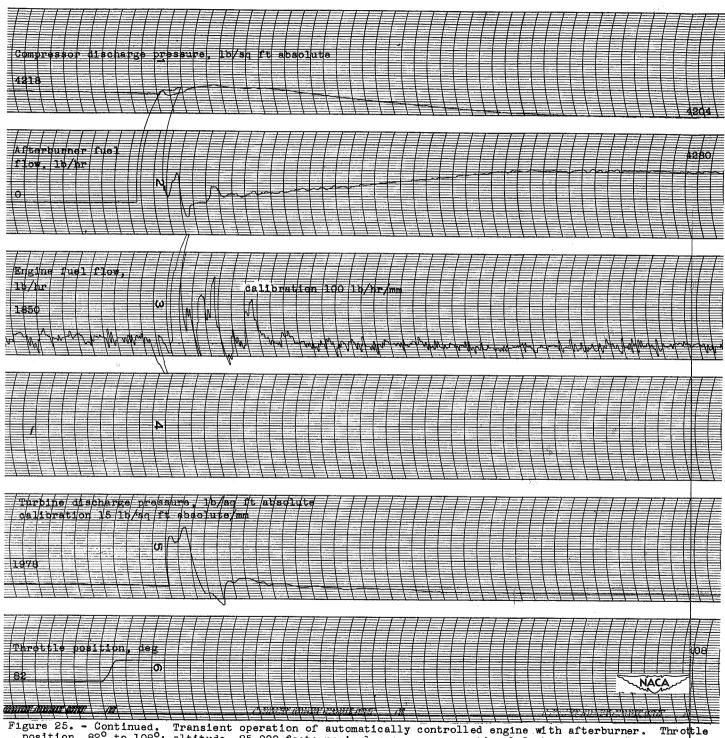


Figure 25. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure. 30 pounds per square inch.

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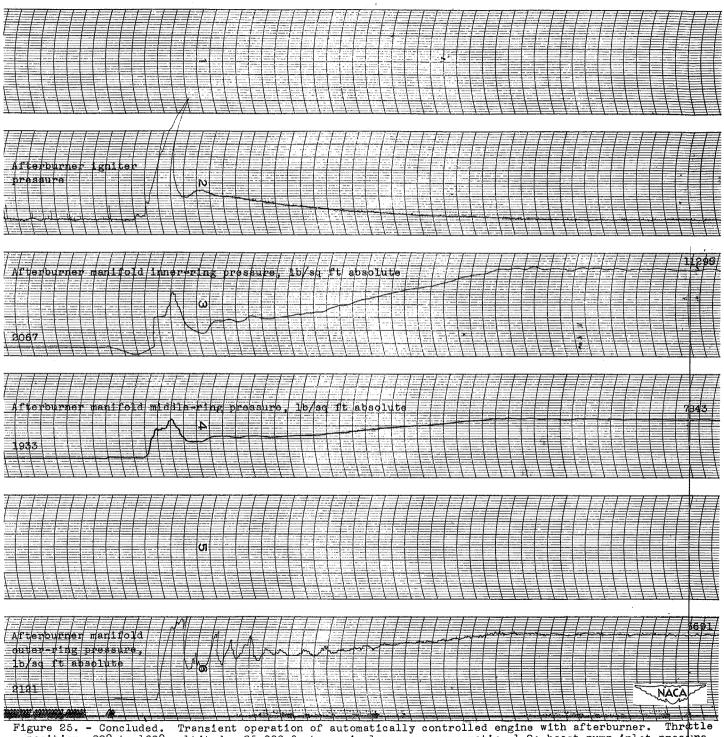


Figure 25. - Concluded. Transient operation of automatically controlled engine with afterburner. Threttle position, 82° to 108°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

### NACA RM SE50L29

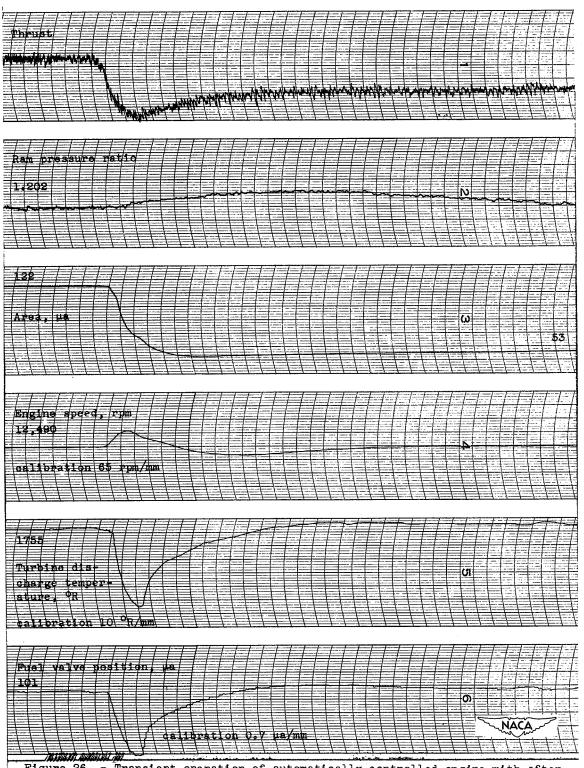


Figure 26. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

## NACA RM SE50L29

Compressor discharge pressure, ld/sg ft absolute
Compressor discharge pressure, 10/sq ft ebsolute 4204
calibration 1.5 lb/so fit absolute/mm
Afterburner fuel flow, ld/hr
Afterburner fuel flow, le/nr
Bngine fuel flow, 10/nn
ᅙᆕᆕᄚᆖᆕᇃᇍᅸᆮᆕᆕᆕᅋᅋᄺᅖᄦᄮᅸᄣᅜᅸᅸᄰᄹᇊᇍᄩᄧᄡᇊᆕᇃᇐᇐᇐᇐᇐᇐᆖ all firetion@coab/a//# 별별ᄧᄯᄡᆹᄡᄡᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣᅣ ᅖᆆᇊᆵᆋᆂᆕᄔᇆᇃᇃᇃᆕᇐᄬᅖᇆᆛᆻᆘᅖᄡᆋᅆᅌᅶᇏᆕᄮᇃᇃᆔᇤᇎᆋᇔᇐᆂᆂᇎᆋᆂ
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1970 Turbine discharge pressure ib/sq it eosolute
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Imit       Imit         Imit
Imit       Imit         Imit
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Figure 26. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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### NACA RM SE50L29

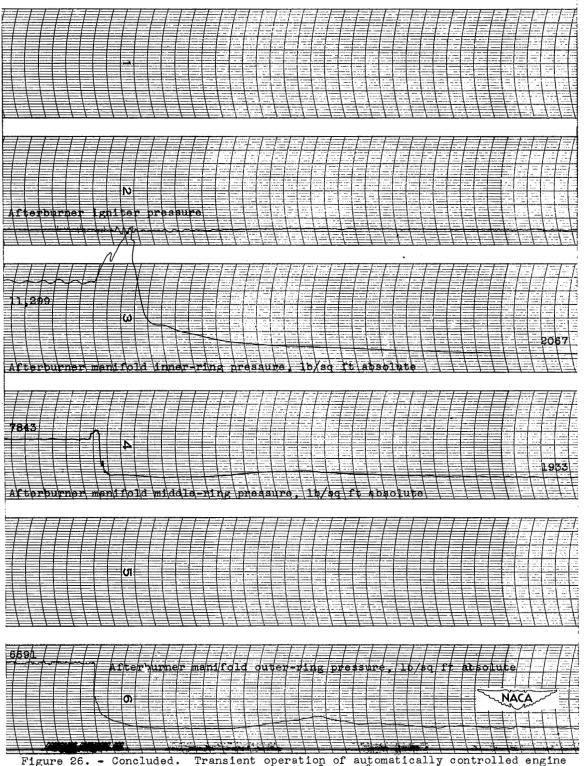


Figure 26. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 108 to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

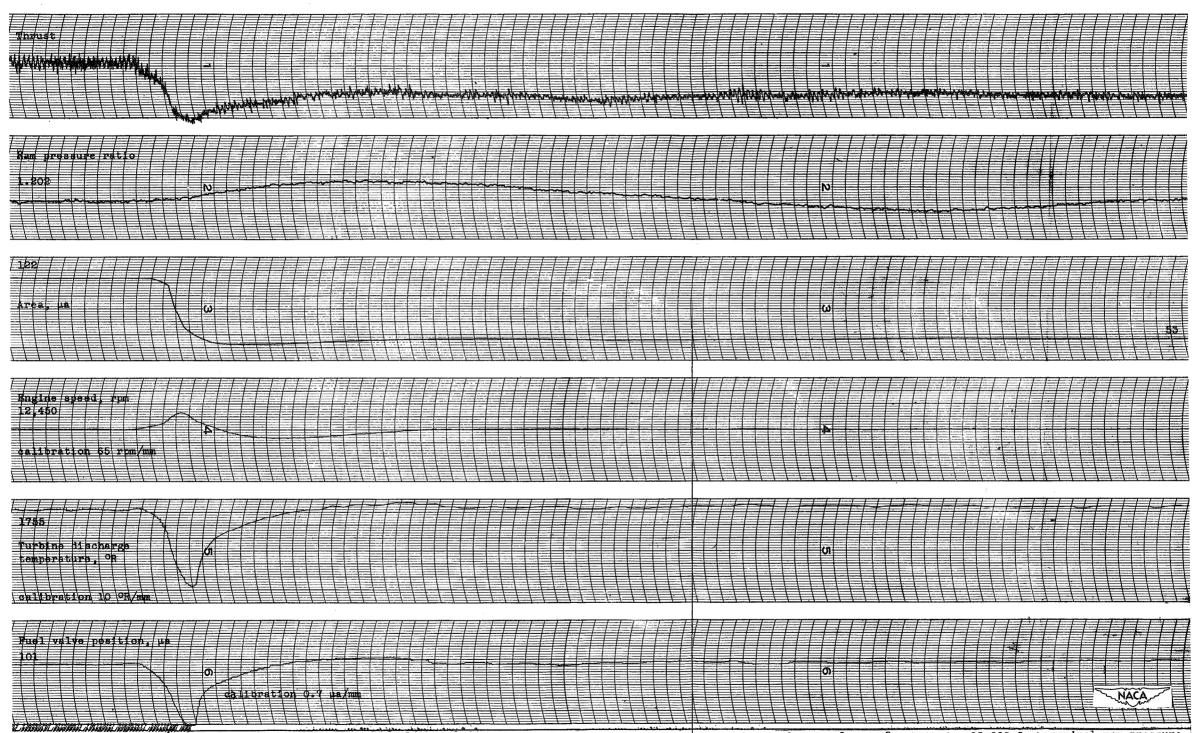


Figure 27. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 90° and 90° to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 punds per square inch.

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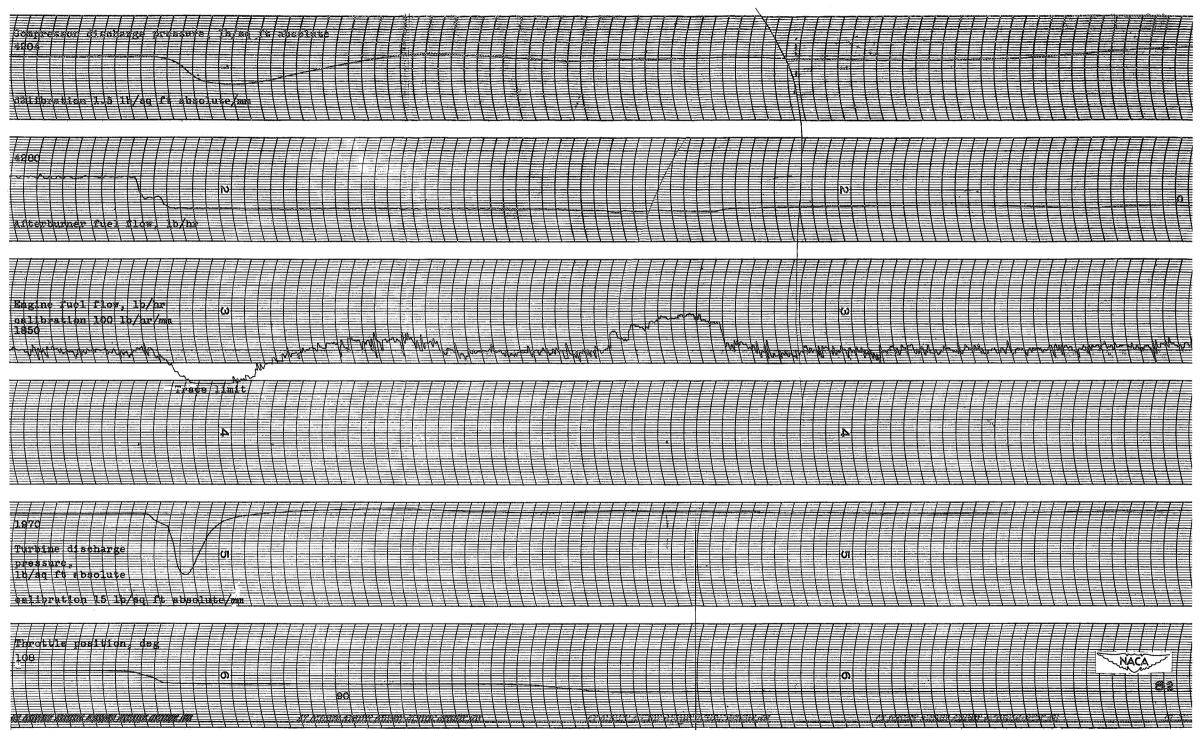


Figure 27. - Continued. Transient operation of automatically controlled engine with afterburner. Throtile position, 108° to 90° and 90° to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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Afterburher manifold inner-ning pressure, 10/sq ft absolute	
Afterburner manifold middle-ring pressure, 10/sq ft missive	
	1633

669/1 / Afterburner manifold outer ring pressure, 10/sq ft absolute o, NACA 0 _____ 2121 11+ and a 御幕

Figure 27. - Concluded. Transient operation of automatically controlled engine with afterburner. Throtle position, 108° to 90° and 90° to 82°; altitude, 25,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 30 pounds per square inch.

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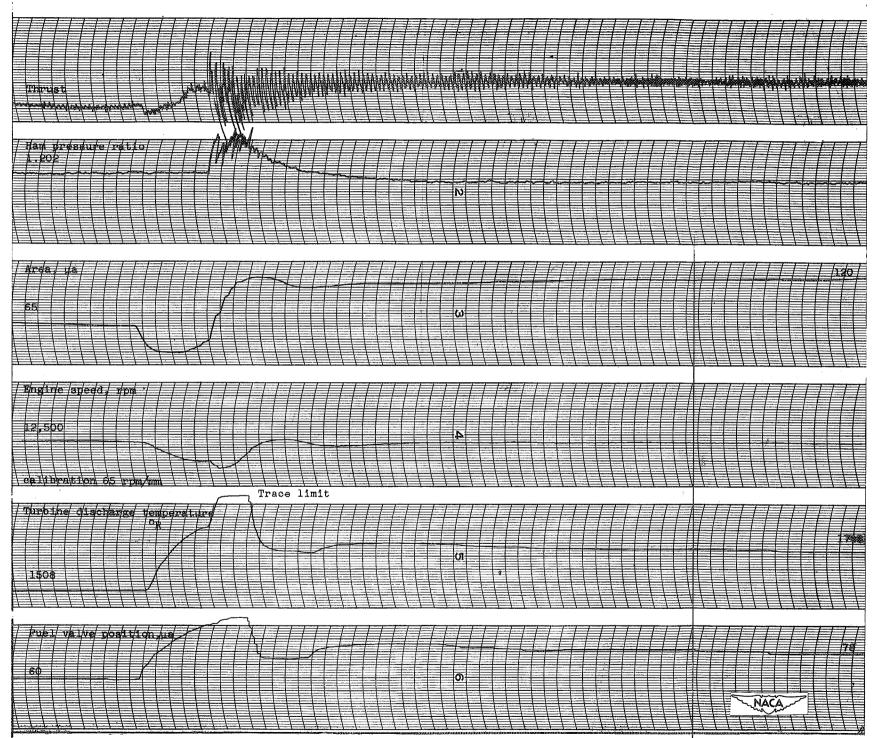


Figure 28. - Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

### 81

Gisonarye pressure,			
2560			
		an da an Anna an Anna Anna Anna Anna Ann	
/ Arterburner fuel rlow, / /			
	5		
Engline /fuel flow   10/n+   ///	/ *   		
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	Man har and a second	ω	
a martin from a martin of the			
Thirds the discrete direction of the			
	su rt absolute		
Purbline discharge gressure   b/	B¢ ft absolute		
	sg ft absbiute		
	sg ft absbiute		
	sg ft absbiute		
1105 Throttie position, asg			
Throttle pds1t1on, deg			
Throttle position. Cog			
Throttle position, deg			

Figure 28. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds pr square inch.

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Afterburner/ign/ter			
	Martin Contraction		
	W manufacture and a second sec	and a second	
eperture of appropriate particular			
Afterburner/man/1fold	Inner rind gressure   10/sq. ft av	bsolute	
	John War		5399
1850			
Afterburner/man/1fo1/d	middid-ring pressure, 10/sq/ft a	ibsolute	
	4		
1508			4535
Afterburner/mantfold	outer fring gressure / 10/sq ft at	bsbiute	
	outer ring creasure 16/sq it at		
	outer ring cressure lb/sq it at		
Afterburner/menifolg	outer ring creasure 16/sq it at		5258
	outer ring creasure 16/sq it at		5258

Figure 28. - Concluded. Transient operation of automatically controlled engine with afterburner. Throtle position, 72° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds pr square inch.

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# NACA RM SE50L29

Ram/pressure ratio	
Veren Veren Veren States Stat	
	<b>6</b> 5
Ergine speed, rpm	
12,500	
Turbine discharge temperature, PR	
Fuel valve position, la	
	60 F
Figure 29 Transient operation of automatically controlled engine with burner. Throttle position, 109° to 72°; altitude, 35,000 feet; nomina pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square i	after- l ram

# NACA RM SE50L29

Compressor/discha		
2730 2730	'ge/prebsure,, lb/sq/ t/ agsolute	
		2560
Afterburner fuel	Now, 15/hr	
2711		
and a second second		
/ Engline/fuel flow,		
1170		
		sahada ang ang ang ang ang ang ang ang ang an
<u> </u>		
/ Turbine discharge	pressure, hb/su ft/absolute / / / / / / / / /	
11-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1		
Throttle posttion,		
109		
		NACA
Figure 29 Con	tinued. Transient operation of automatically content. Throttle position, 109° to 72°; altitude, 35,	
	rinued ""monsient operation of autometically cont	anterna hallon

with afterburner. Throttle position, 109° to 72°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

# NACA RM SE50L29

Arverburner 1gr11ver pressure
Aftenburnen marifiold inner-ring pressure, lb/sh ft/absolute ////////////////////////////////////
Afterburner manifold middle-ring pressure, 15/sq ft absolute
Afterburner manifold outer-ring pressure, 10/sq ft absolute
Afterpurner manifold outer-ring pressure, 10/sq ft absolute

with afterburner. Throttle position, 109° to 72°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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# NACA RM SE50L29

Torust Multimania management of the second
Ram pressure ratio
1 Area, 4a
Engine speed, rom / / / / / / / / / / / / / / / / / / /
Engine speed, rpm
Engine speed, rom
12,500 dellibration d5 rpm/mm Turbline discharge temperature; Or
12,500 dellibration d5 rpm/mm Turbine diselarge comparature, Or (7)
12,500 dellibration d5 rpm/mh Turbling discharge tempersture (9) 1764
12,500       delibration d5 rpm/mi         Turb ind disenarge temperature; @         (j)         1764         calibration 159 R/mm         Fuel /valve /pdsition, /ud
12,500       ealibration d5 rpm/ma         Turbine disenarge temperature; ?*         1784         calibration 159 R/mm         Fuel valve position, ua
12,500       ealibration d5 rpm/ma         Turbine disenarge temperature; ?*         1784         calibration 159 R/mm         Fuel valve position, ua
12,500       dealibration d5 irpm/mm       Turbline discharge température, Ot       1764       calibration il59 R/mm

Figure 30. - Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

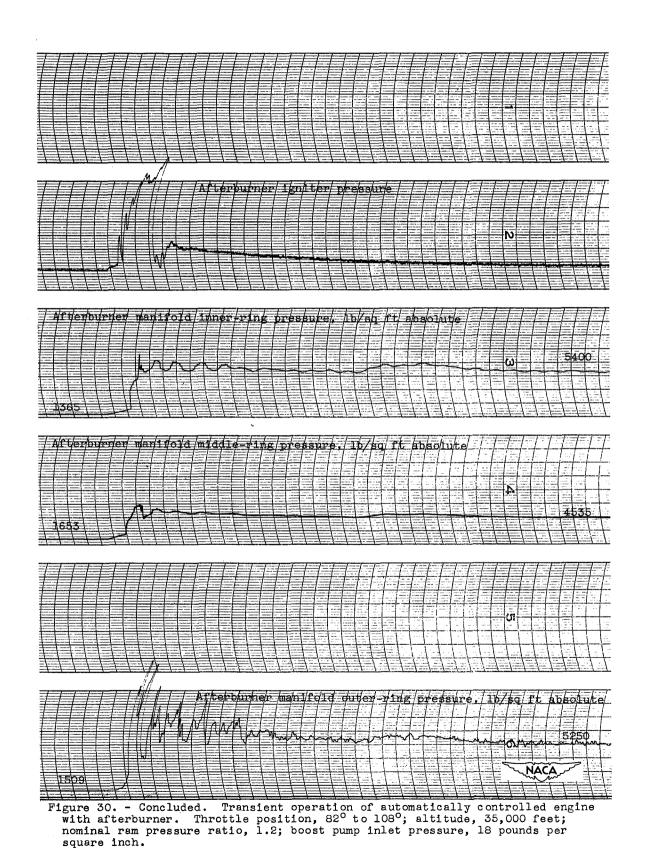
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# NACA RM SE50L29

Compression discharge pressure, 10/s0 ft/ absolute / / / / / / / / / / / /
2690 2671
I I I Afterburner the Flow, AD/De [ ] ] ] ] ] ] ] ] ] ] ] ] ]
Bigine fuel/flow, 10/hr
1275 Production of the second se
Turvine discharge pressure, 10/80/11 absolute ////////////////////////////////////
1242
callbration 18 Lb/sg ft absolute/mm
Throttle position, deg
Figure 30 Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 35,000 feet;

with afterburner. Throttle position, 82° to 108°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

### NACA RM SE50L29



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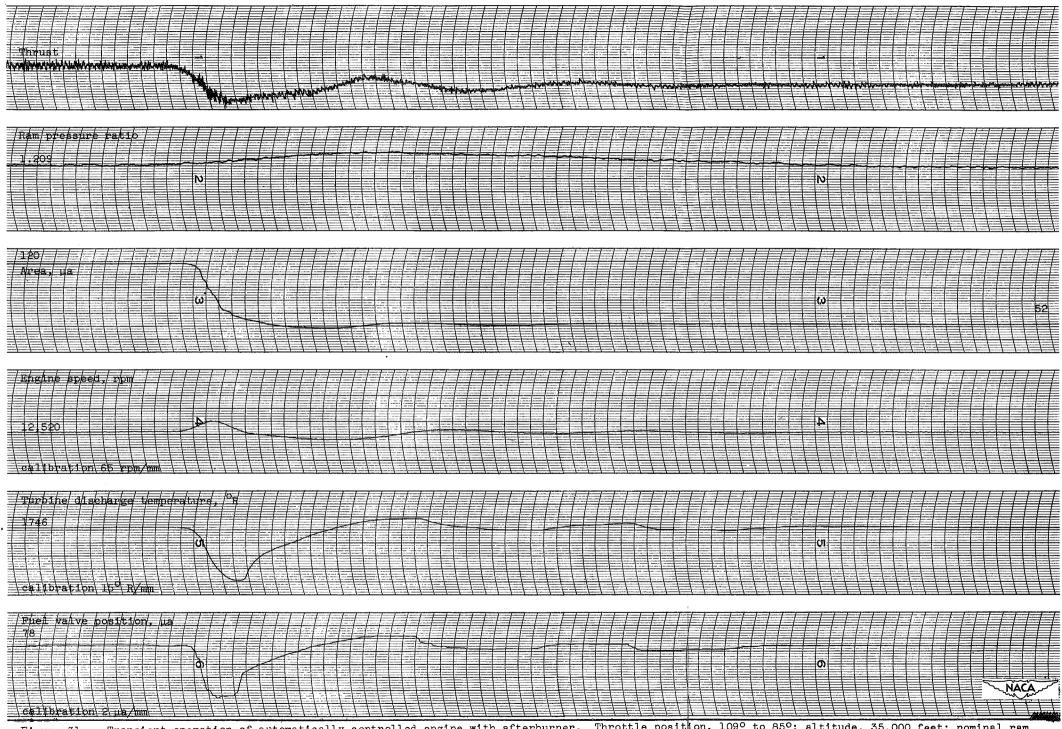


Figure 31. - Transient operation of automatically controlled engine with afterburner. Throttle position, 109° to 85°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

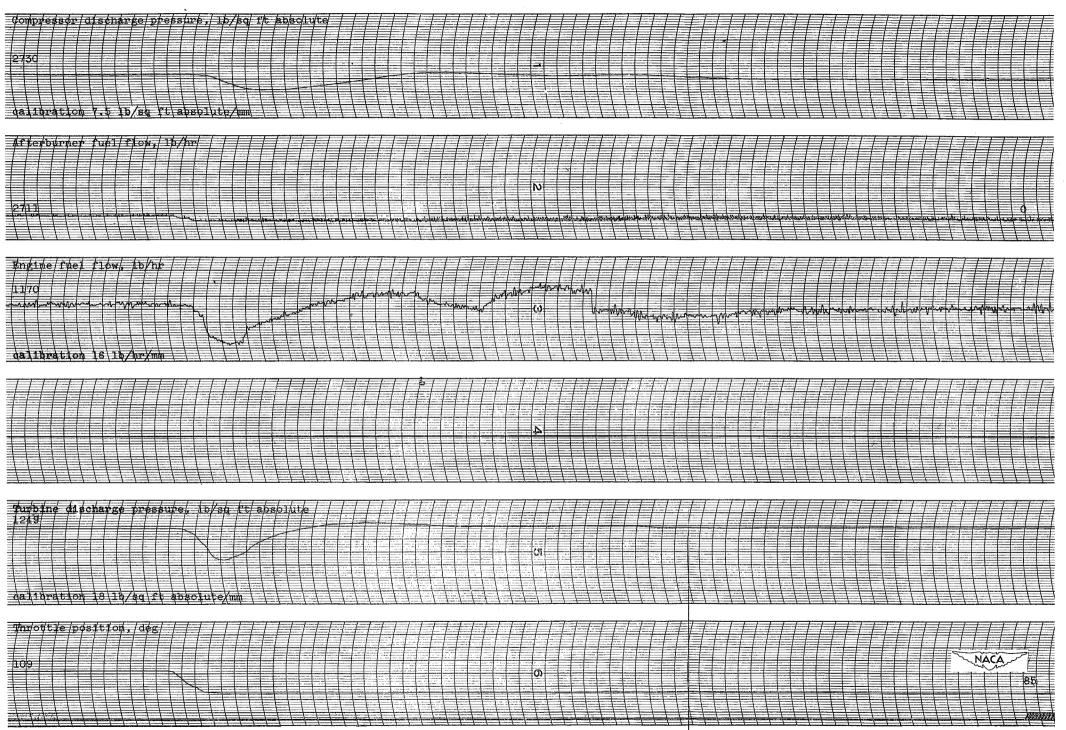


Figure 31. - Continued. Transient operation of automatically controlled engine with afterburner. Theottle position, 109° to 85°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pound per square inch.

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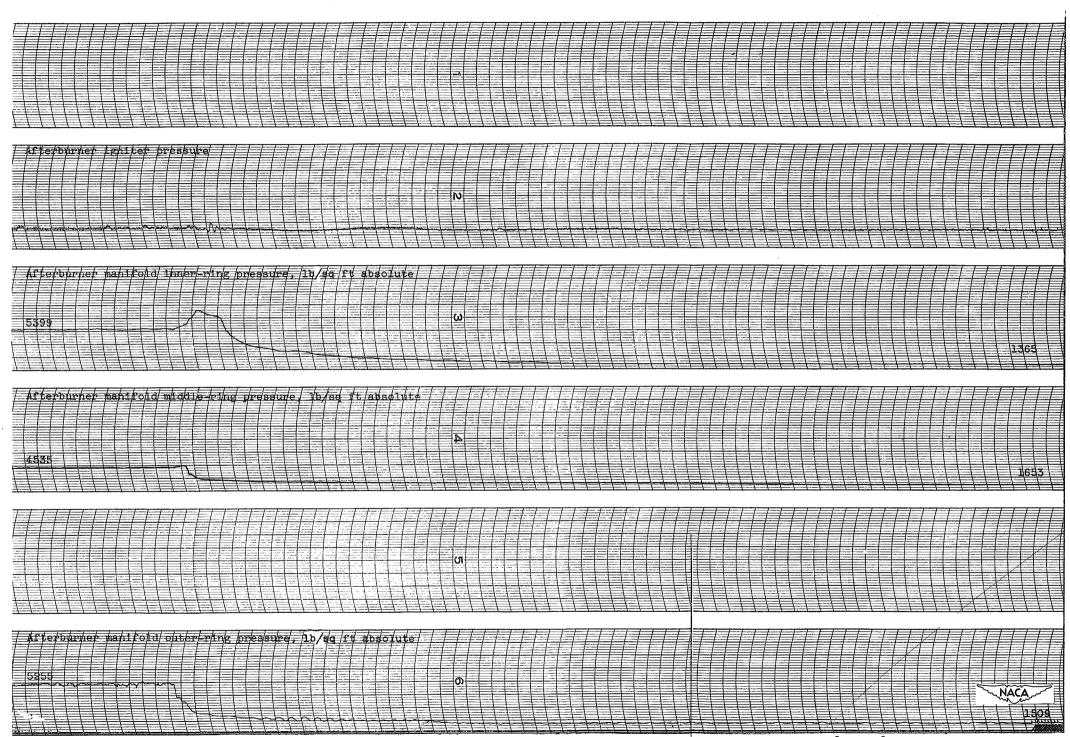


Figure 31. - Concluded. Transient operation of automatically controlled engine with afterburner. Fhrottle position, 109° to 85°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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NACA RM SE50L29

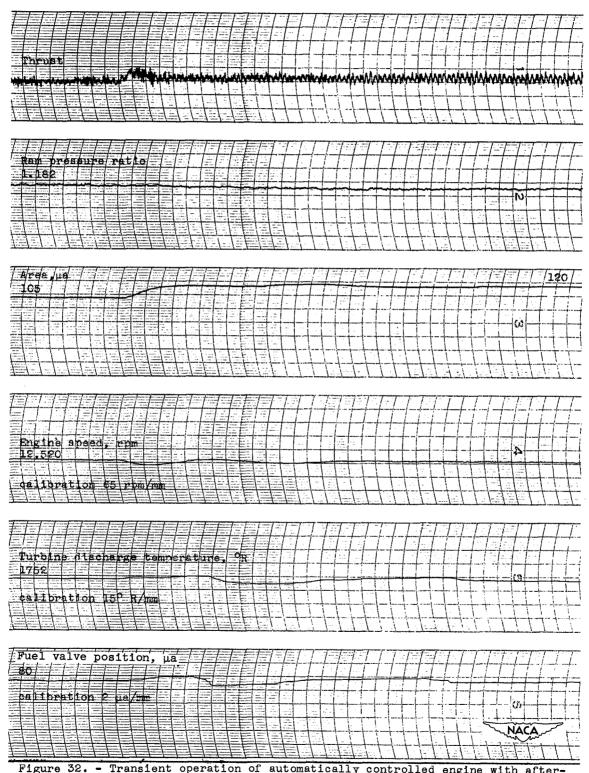


Figure 32. - Transient operation of automatically controlled engine with afterburner. Throttle position, 106° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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# NACA RM SE50L29

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Compressor discharge pressure, 10/sq ft absolute
celtbration 7,5-1p/sq ft absolute/mm
Afterpurner fuel flow, 10/4P
a sharper to a sharper a manufacture of the sharper to be a sh
caltoration 16 lb/hr/mm
Turbine discharge pressure ut b/si it ebsolute
1226
calibration 18 1b/sh ft absolute/mm
Throttle pdsition, deg
Figure 32 Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 106° to 109°; altitude, 35,000 feet;
nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per
square inch.

### NACA RM SE50L29

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믗: 알려고 본 달글 감결 글 걸 곧 본 백 명 분 걸 빛 물 경 말 을 걸 별 걸 걸 받 은 문 객실 그 일을 받 수 있는 것 같이 있 것 같이 있다. 
Afterburner tgniter pressure
Afterburner manifold inner-ping pressure, 1b/sq ft absolute
5838 ω
calibration 280 lb/so ft absolute/ma
Afterpurper manifold middle ring pressure, 10/sq ft absolute
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Figure 32. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 106° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

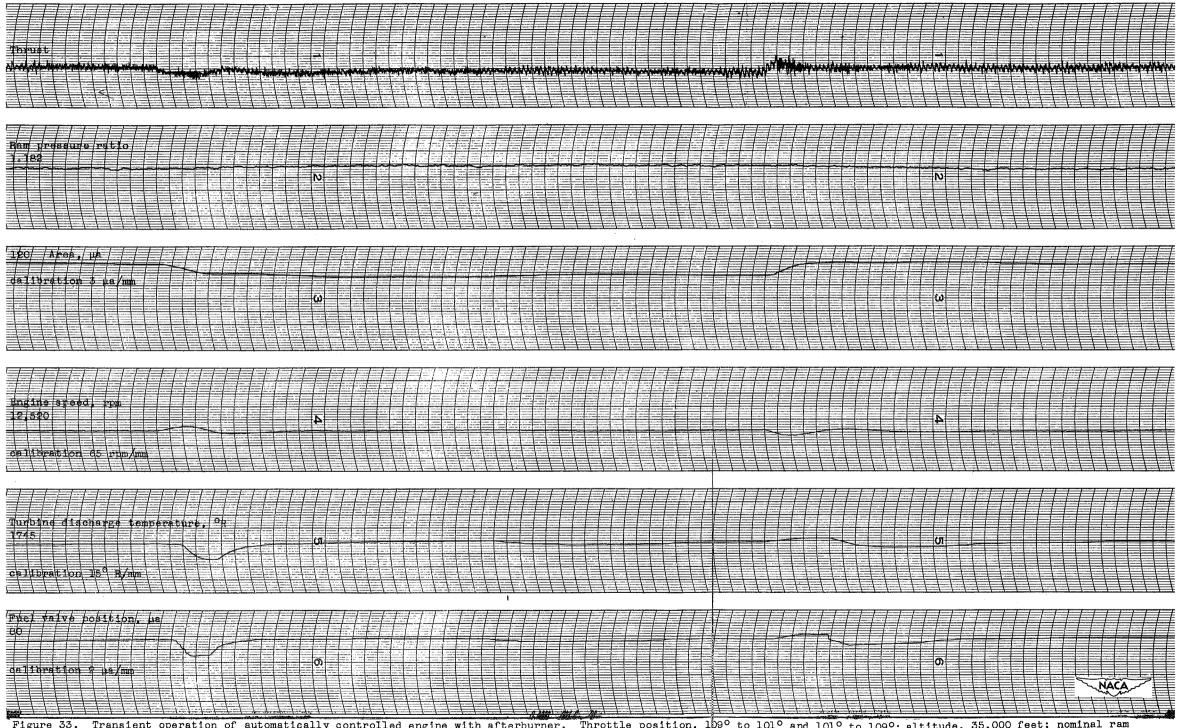


Figure 33. Transient operation of automatically controlled engine with afterburner. Throttle position, 199° to 101° and 101° to 109°: altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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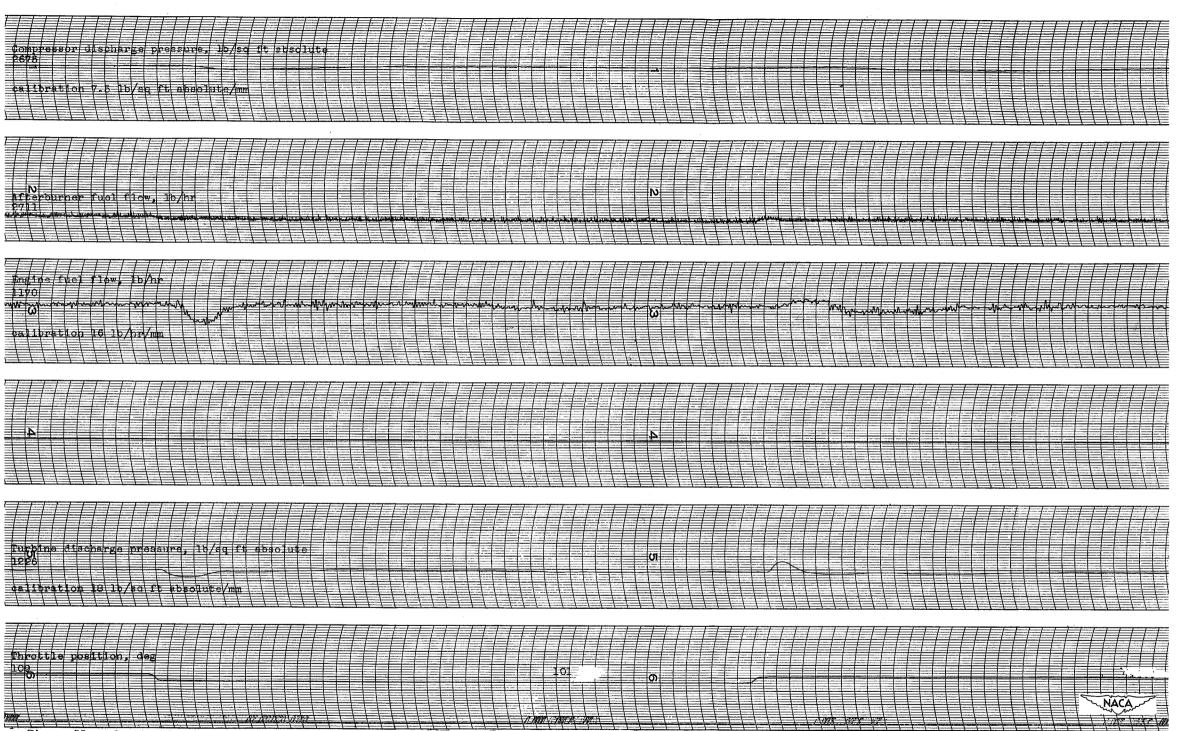
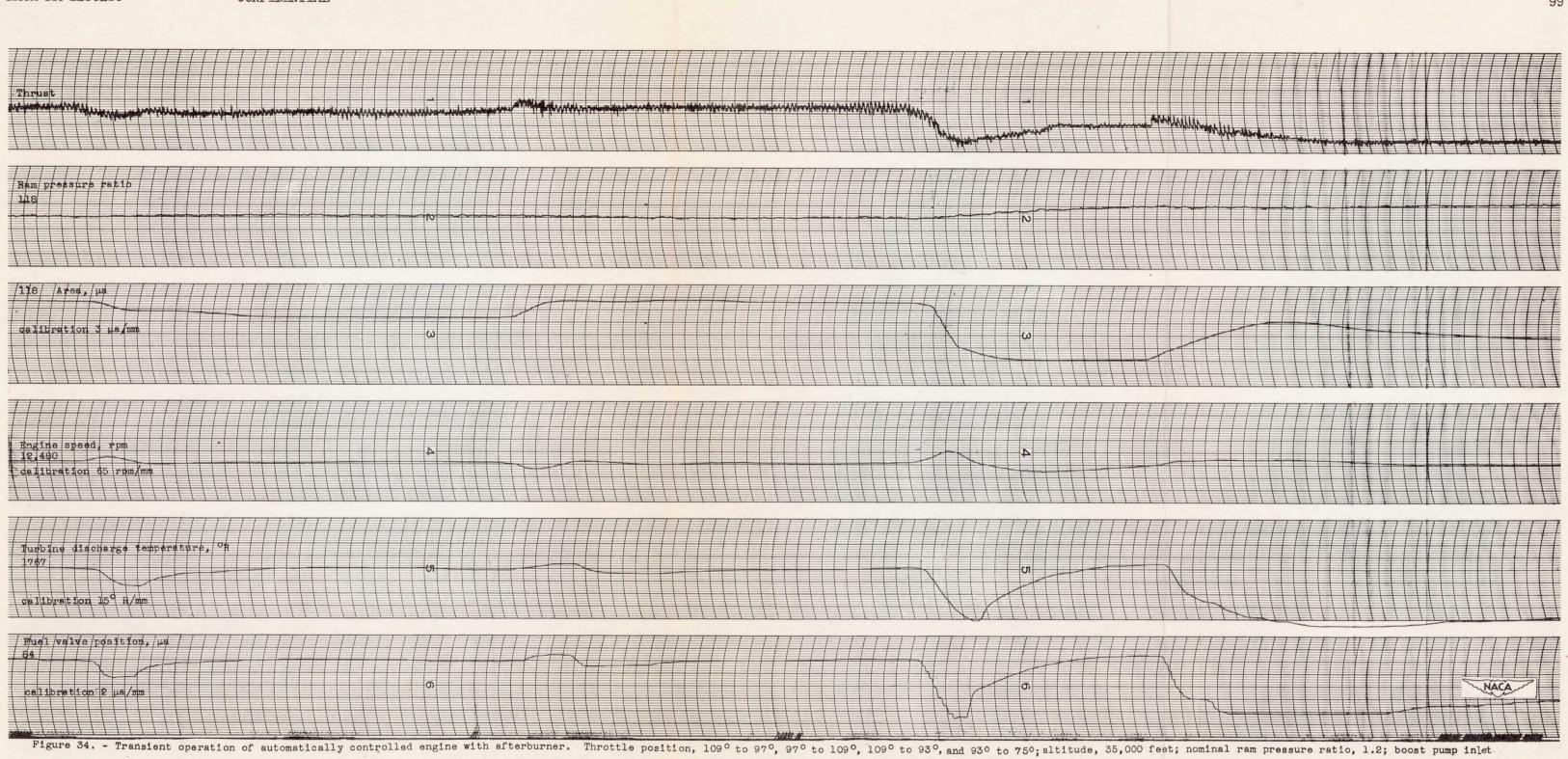


Figure 33. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 109° to 101° and 101° to 109°; altitude, 35,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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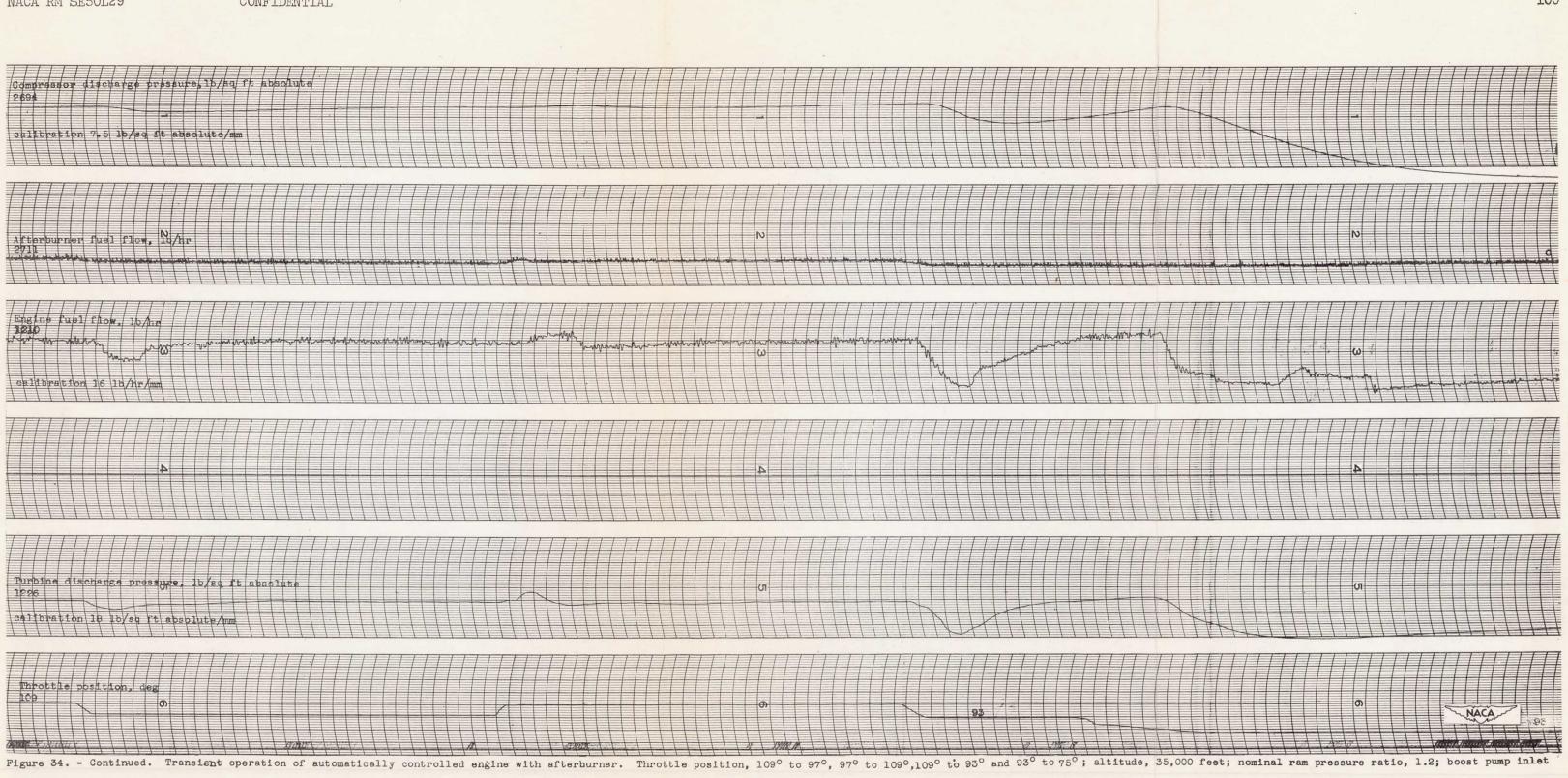
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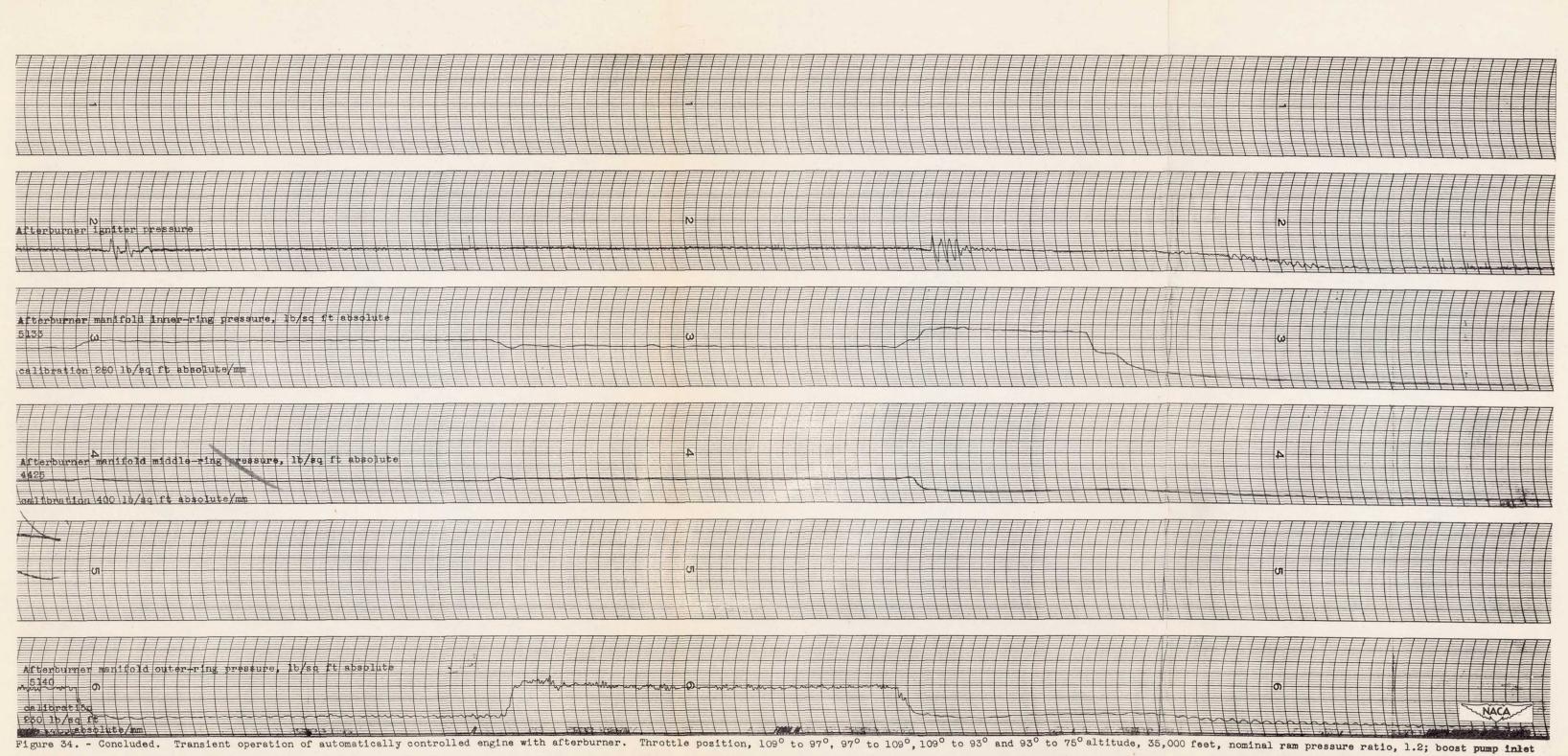
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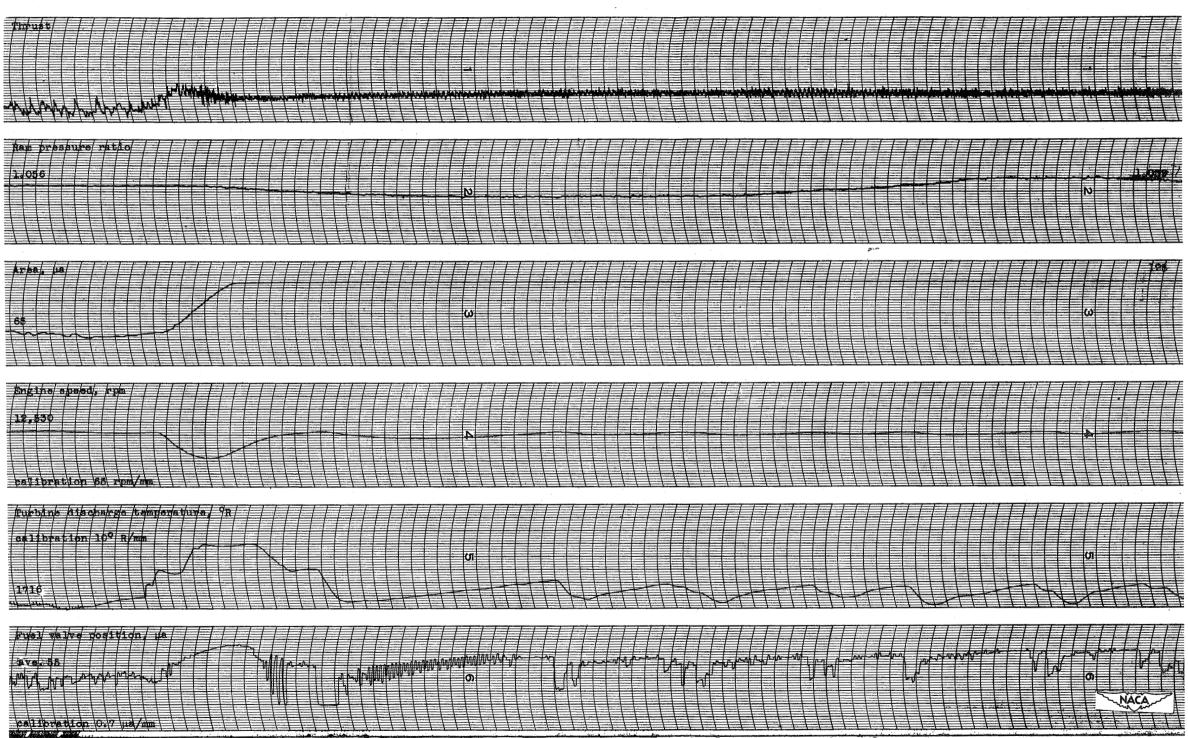


Figure 35. - Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 40,000 feet; nominal ram pressure ratio, 1.05; boost pump inlet pressure, 26 pounds per square inch.

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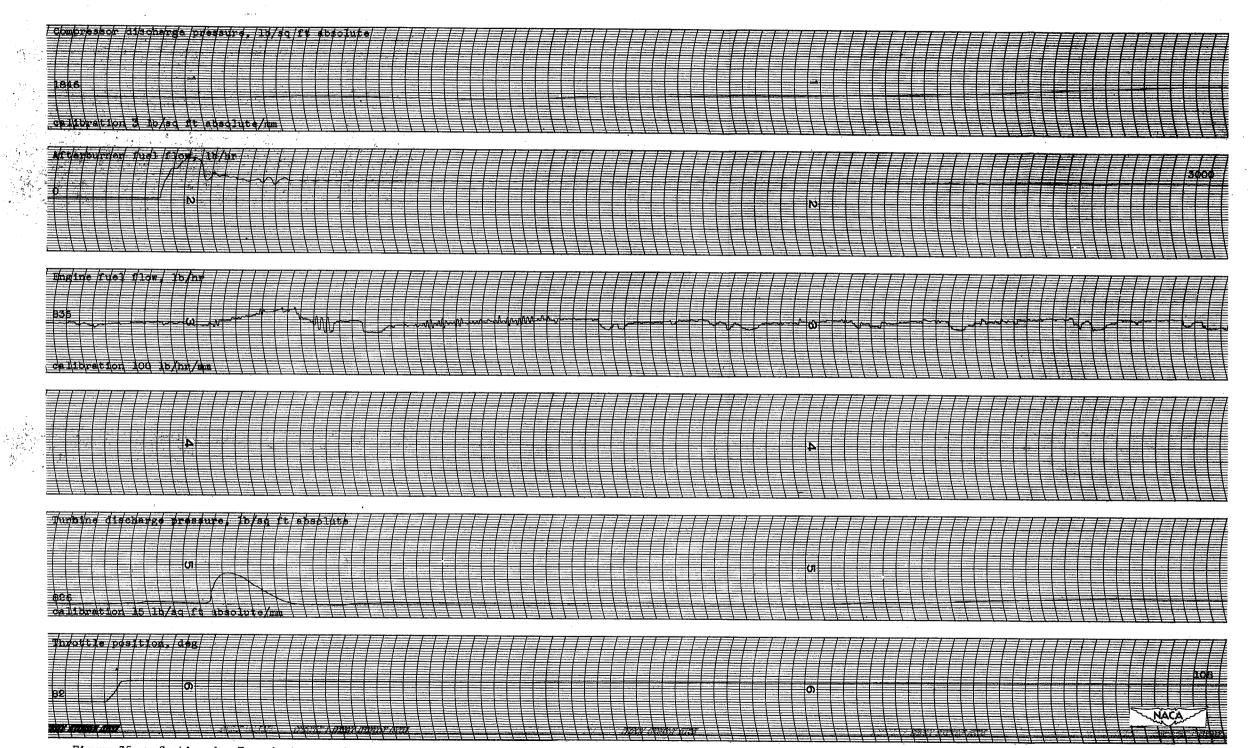


Figure 35. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 40,000 feet; nominal ram pressure ratio, 1.05; boost pump inlet pressure, 26 pounds per square inch.

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Figure 35. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 40,000 feet:nominal ram pressure ratio, 1.05; boost pump inlet pressure, 26 pounds per square inch.

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Figure 36. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 84°; altitude, 40,000 feet; nominal ram pressure ratio, 1.05;

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boost pump inlet pressure, 26 pounds per square inch.

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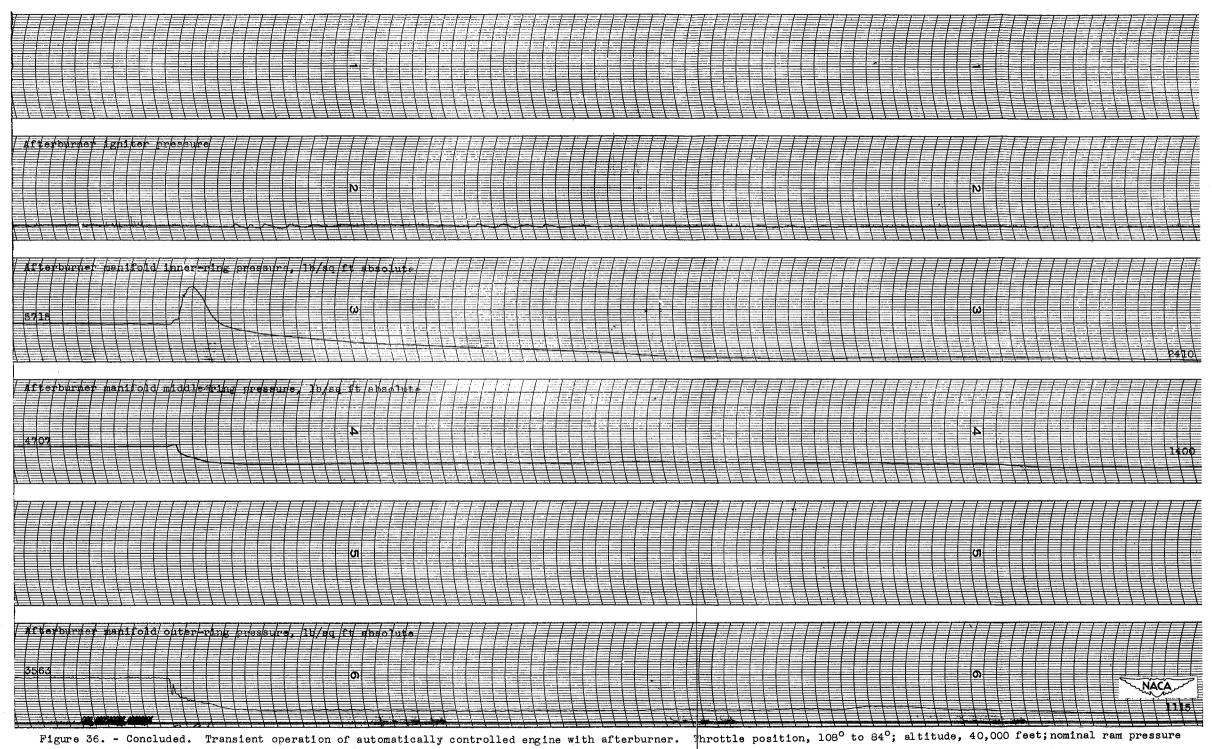
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Figure 37. - Transient operation of automatically controlled engine with afterburner. Throttle positin, 73° to 108°; altitude 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per quare inch.

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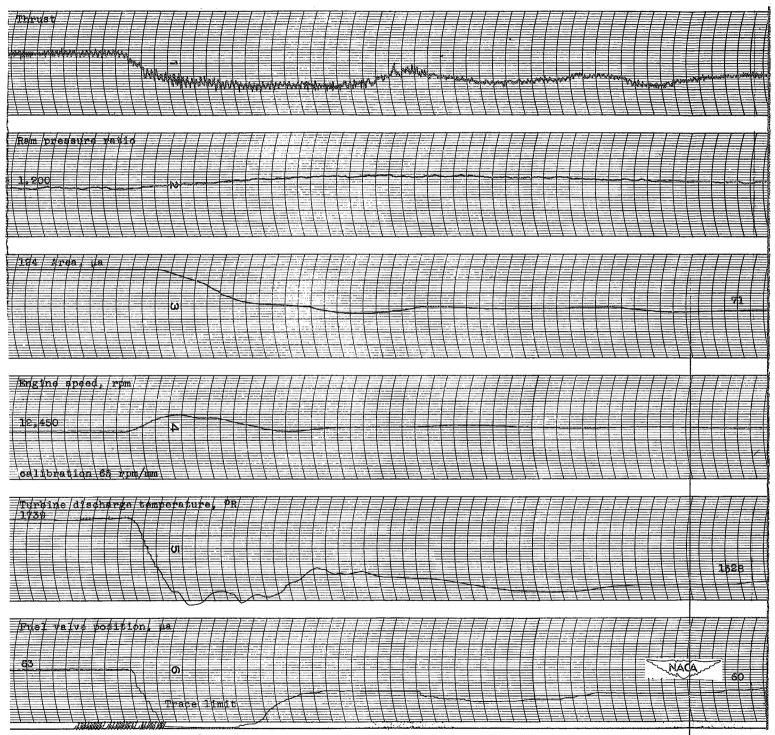
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Figure 37. - Continued. Transient operation of automatically controlled engine with afterburner Throttle position, 73° to 108°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 ounds per square inch.

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Figure 37. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 73[°] to 108[°]; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 38. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 73°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 38. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 73°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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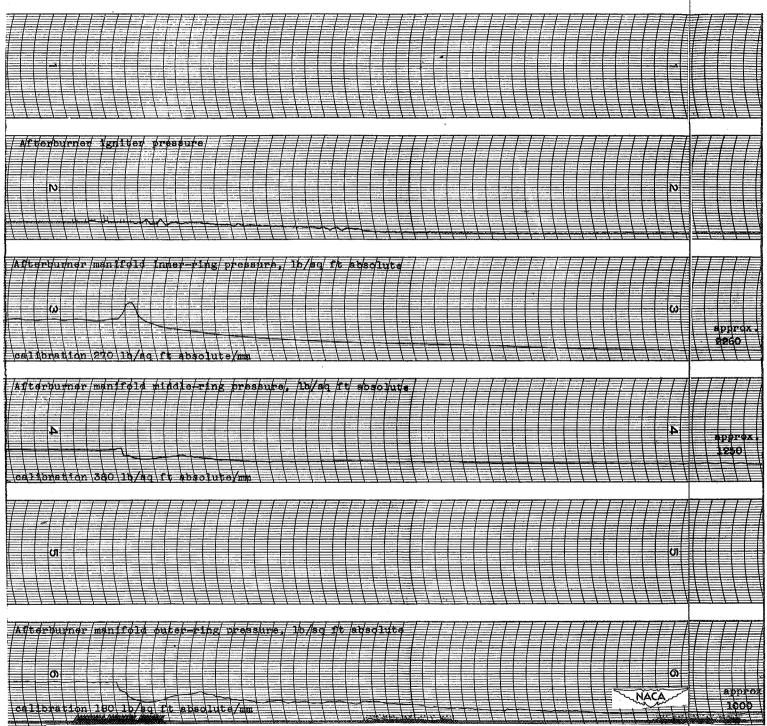


Figure 38. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 73°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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Figure 39. - Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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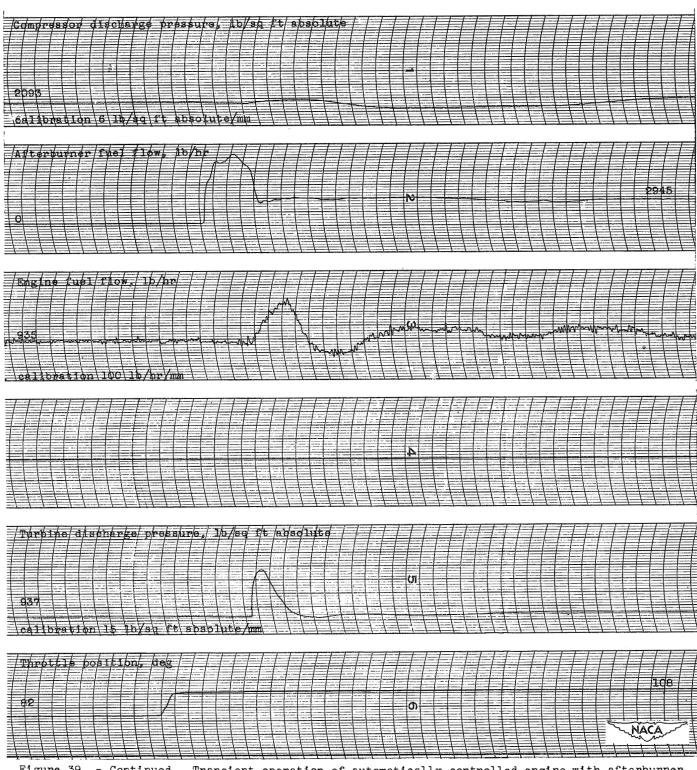


Figure 39. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 82° to 108°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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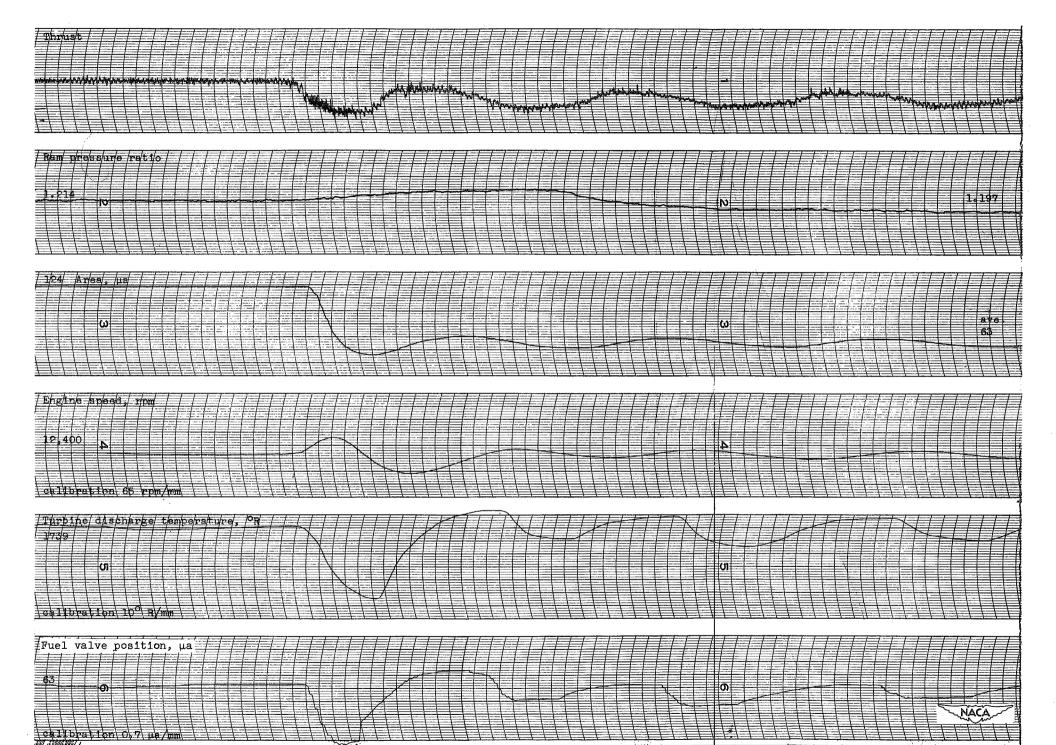


Figure 40. - Transient operation of automatically controlled engine with afterburner. Throttle position, 108° to 82°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure, 18 pounds per square inch.

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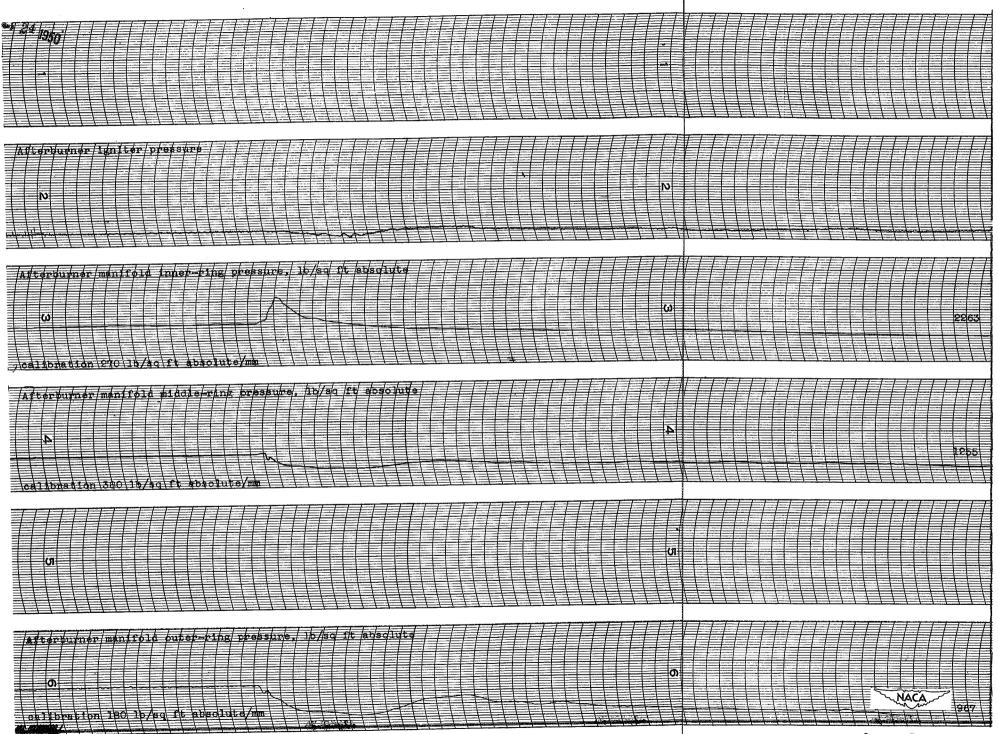
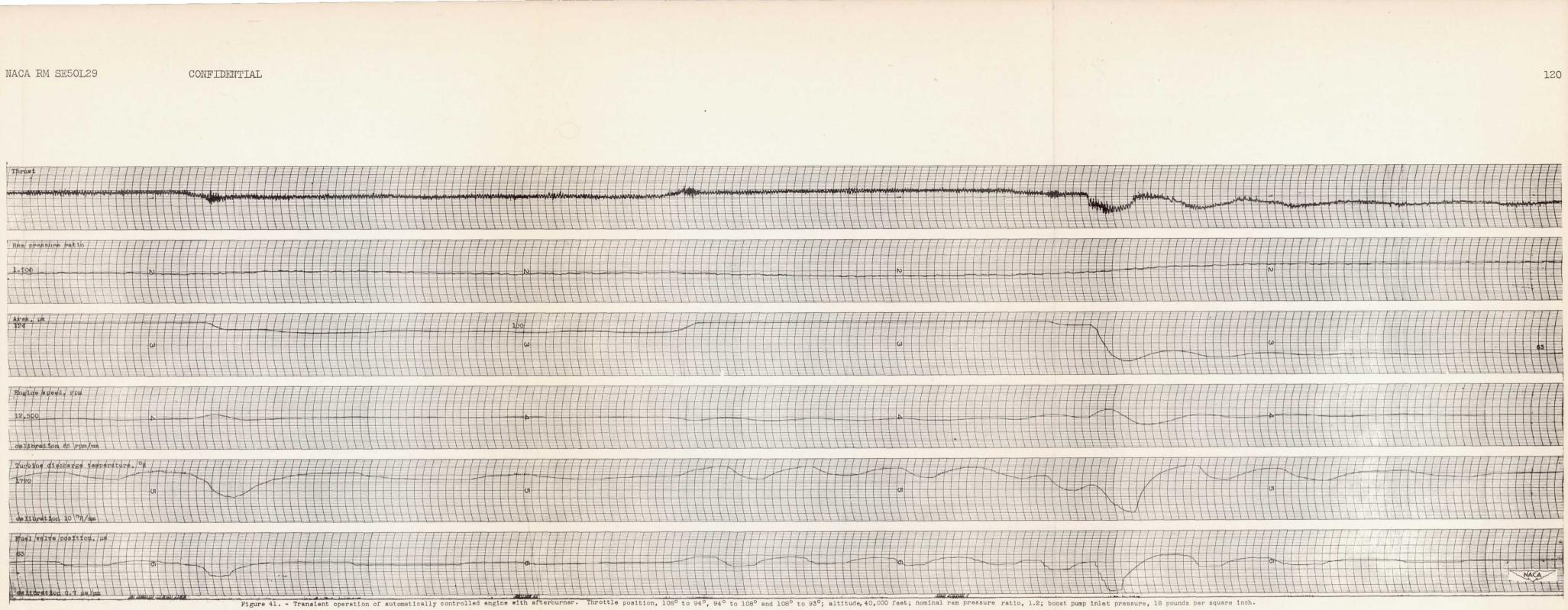
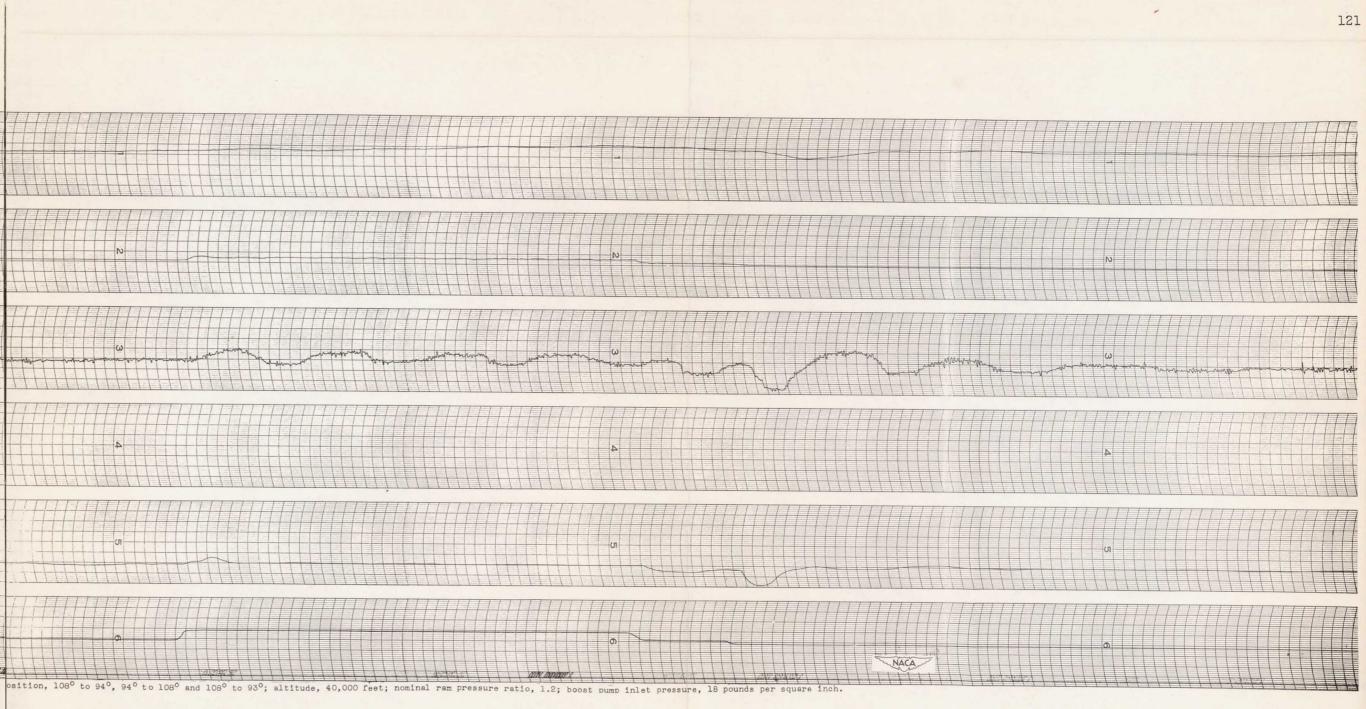


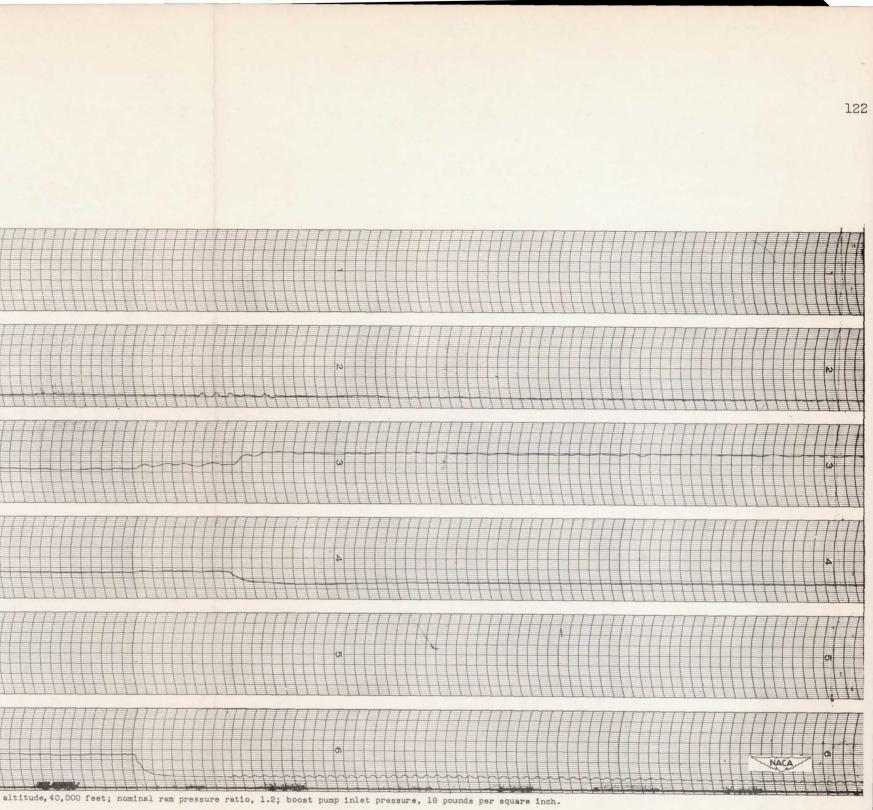
Figure 40. - Concluded. Transient operation of automatically controlled engine with afterbuer. Throttle position, 108° to 82°; altitude, 40,000 feet; nominal ram pressure ratio, 1.2; boost pump inlet pressure 18 pounds per square inch.



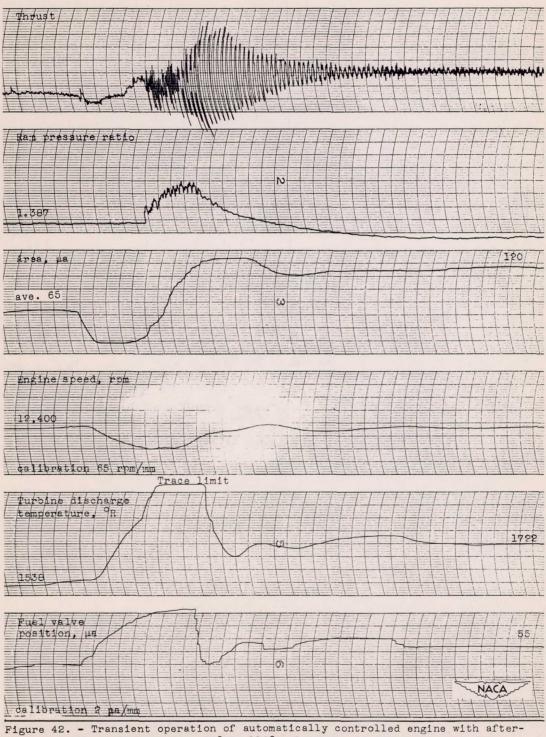
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Afterburner/such fibm, 14/11-		
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caltbration (approx) & 00 1b/hr/mm		
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cellbration 100 10/2 ir/mm		
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calibration 15 Ib/sg #t absolute/mp		
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and the second se		
	the second of automatically controllad anging with after monotila	osition, 108° to 94°, 94° to 108° and 108° to 93°, altitude 40,000 feet: nominal ram press



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ce ilinestion 160 10/ed it assolute/mm	rded engine with afterburner. Throttle position, 108° to 94°, 94° to 108° and 108° to 93°; alti



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burner. Throttle position, 72° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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Compressor discharge [:/edsure; ]t//sq/ft absolute]
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Turbine discharge pressure, 1b/s6 ft absolute / / / / / / / / / / / / / / / / / / /
894
MACAUMIN MACAUMIN
Figure 42 Continued. Transient operation of automatically controlled engine
Figure 42 Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per
nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.
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Figure 42. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 72° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

Ram pressure ratio

Engline speed, ppm

| ob 1/10 rat 10n d5 rdm / mm

callbration 10 R/mm

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Thrust /

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[ ] management 115 N) 40b ave. 65 Turbine discharge temperature, ^oR ave. 1538

‡ Fuel valve position, μa 56 S S NACA +++ a and the man and the second second

Figure 43. - Transient operation of automatically controlled engine with afterburner. Throttle positio, 110° to 72°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per squar inch.

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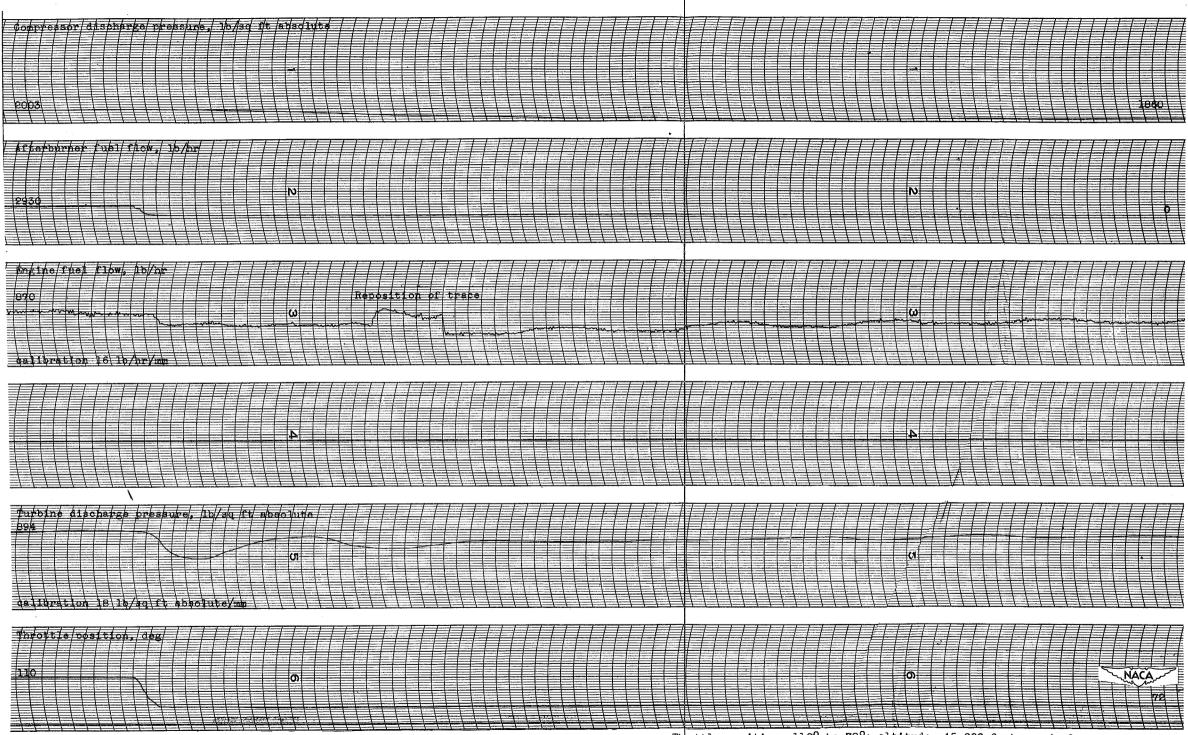


Figure 43. - Continued. Transient operation of automatically controlled engine with afterburner. Thottle position, 110° to 72°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlt pressure, 18 pounds per square inch.

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Afterburner manifold inner ring pressur	e, Nd/ag/ft absolute	
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Afterourber manifold/ middle-ring pressu	ve, Yo/sq ft/absølute / / / / / / / / / / /	
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Afterburner manifolia outer-ring presaur		
hiterburner manifold outer-ring preseur	<pre> a. lt//sq ft sbsolute b. lt//sq ft sbs</pre>	

Figure 43. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 72°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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Turbine discharge temperature, Or	
2785 Californito P _{R/mm}	
Buel velve position, us	
D5 0 calibration 2 latimatic promotion of outpaction by Figure 44 - Transfert operation of outpaction by	

Figure 44. - Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

130

Compressor Alexhange pressure, 10/30 Tt absolute	
calibration 40 lb/sg ft absolutio/mm	
Afterburger/fued flow, Ab//or	
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	E.S.C.
	2930
Cheine fuel flow, 16/br	
Ling Ine Tueil TLOM, 16/207 SBO Callbration 16 Jb/nh/mm	
Turvine dispherze pressure, 16/sg 1/t eosciute	
callonanion 18 10/36 ft abrolute/mm	
Throttle position, deg	
	110
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Figure 44. - Continued. Transient operation of automatically controlled engine with afterburner. Trottle position, 83° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 poulds per square inch.

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Arterburner igniter pressure / / / / / / / / / / / / / / / / / / /	
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Afterburner manifold midule-ring pressure, injag filebsolute	
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	4640
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Figure 44. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 83° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 punds per square inch.

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on a construction of the second secon			UI IIII
dalibration 10° R/mm			
Undl/vslve/position./us			
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			NACA
Figure 45 Transient opera	ation of automatically controlled engine v itude, 45,000 feet; nominal ram pressure	with afterburner. Throttle	

position, 110° to 83°; altitude, 45,000 feet; nominal ram pressure ration, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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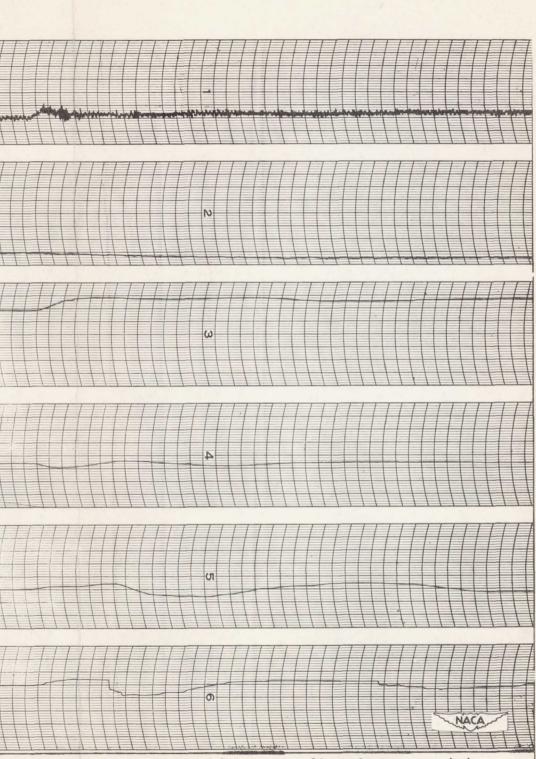
/ Compressor/discharge/pressure, 16/sq ft absglute / / / / / / / / / / / / / / /	
dalibration 40/10/82/12 absolute/una	
Acterourner cuel chow, 15/hr	
Tingine fivel flow, ib/nr	
alluration 16 1 1 Dynzami III III III III IIII IIII IIIIIIIIII	
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dellbretion 15 lb/ag fi absolute/mm	
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Figure 45. - Continued. Transient operation of automatically controlled engine with afterburner. hrottle position, 110° to 83°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pessure, 18 pounds per square inch.

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Afterburder man 1101d	imer-rine preserve, b/au tt	
	middle-fing presame, 15/99 ff	2455
Aftionourrien manifold 5072	outer-ring preseure: 15/s6 ft	NACA 3/52/2

Figure 45. - Concluded. Transient operation of automatically controlled engine with afterburner. hrottle position, 110° to 83°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pessure, 18 pounds per square inch.

Thrast	
Engine speed, rpm	
ealibration 65 rpm/mm	
Turbine discharge temperature, bR Oliver discharge temperature, bR calibration 10° R/mm	
Fuel valve position, us	
Image: Controlled engine with afterburner.         Figure 46 Transient operation of automatically controlled engine with afterburner.	sition, 110° to 104° and 104° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.



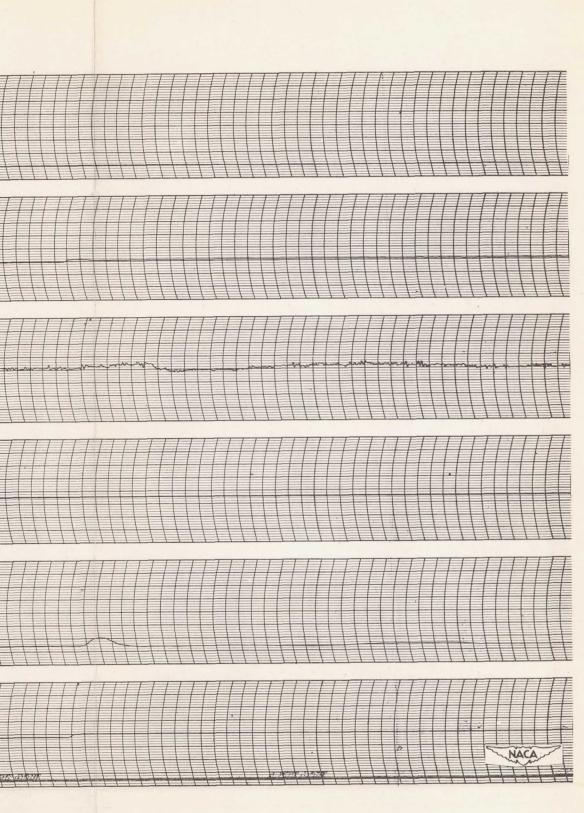
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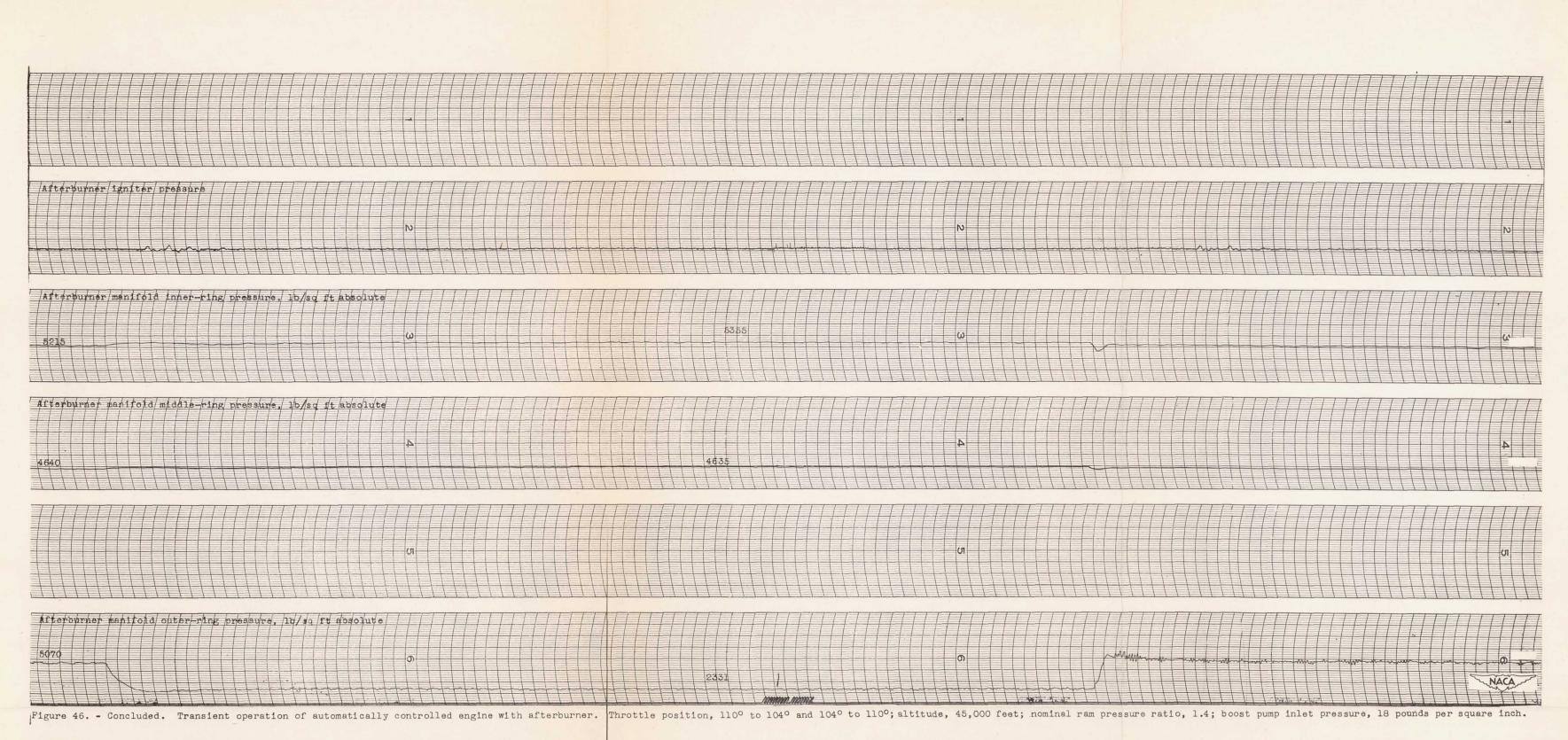
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Turbine discharge pressure. Ib/sq ft absolute		
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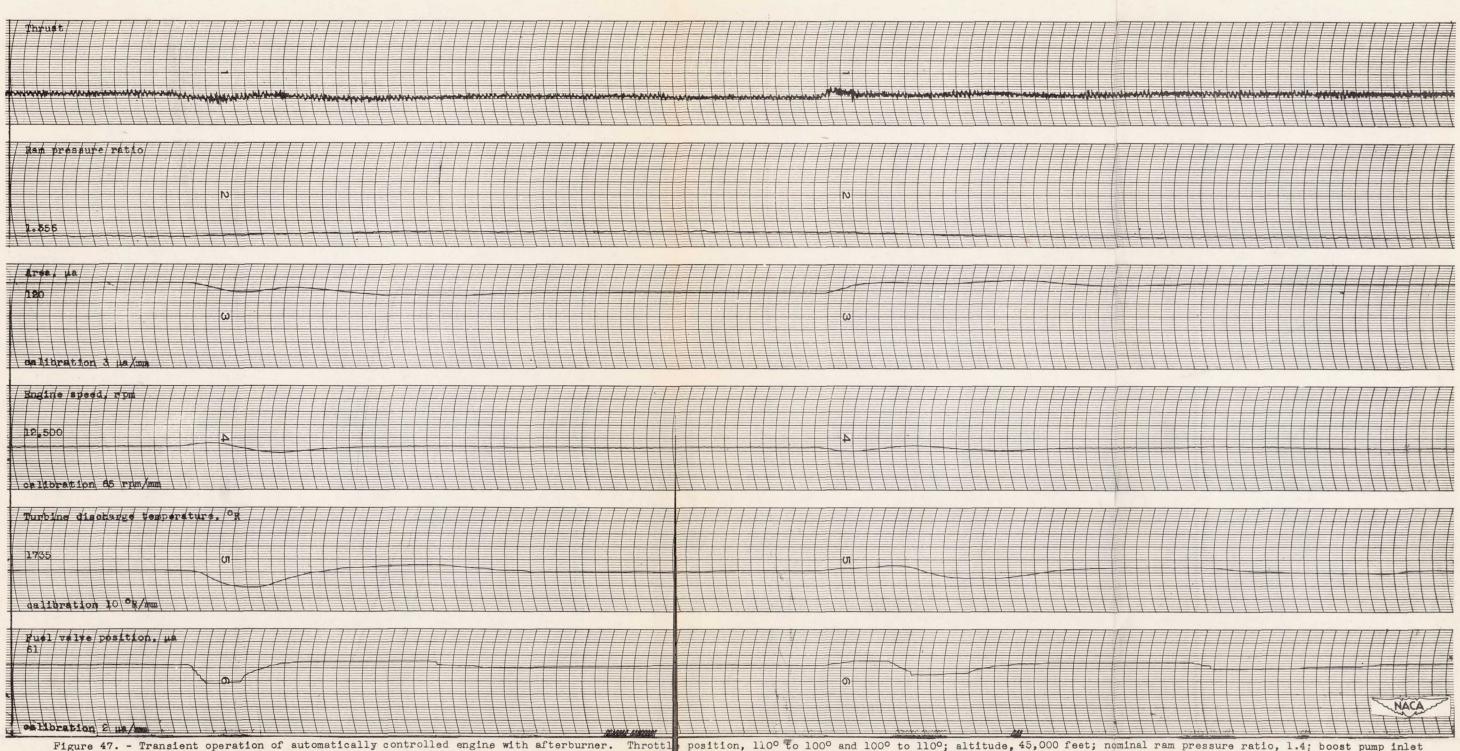
Figure 46. - Continued. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 104° and 104° to 110°; altitude. 45.000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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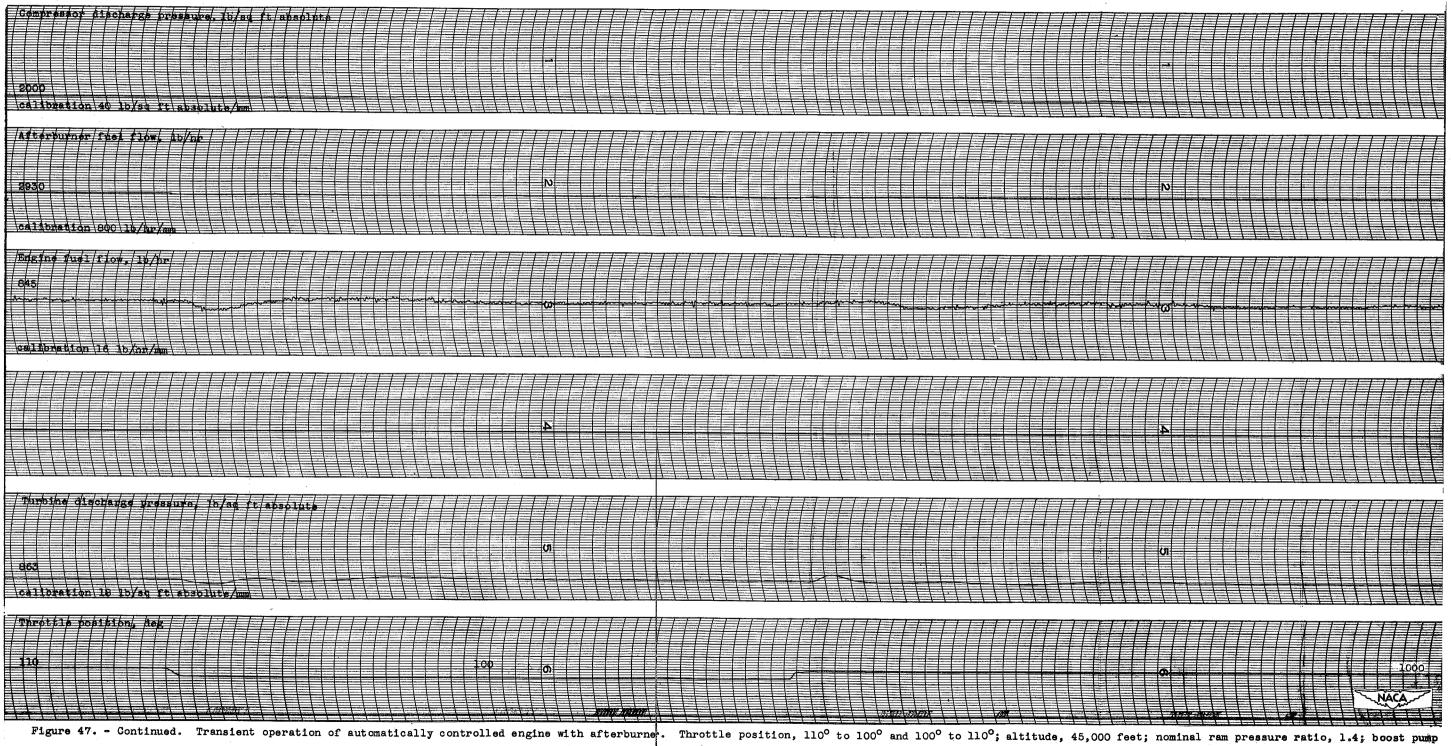




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are 47. - Transient operation of automatically controlled engine with afterburner. Throttl: position, 110° to 100° and 100° to 110°; altitude, 45,000 feet; nominal pressure, 18 pounds per square inch.



inlet pressure, 18 pounds per square inch.

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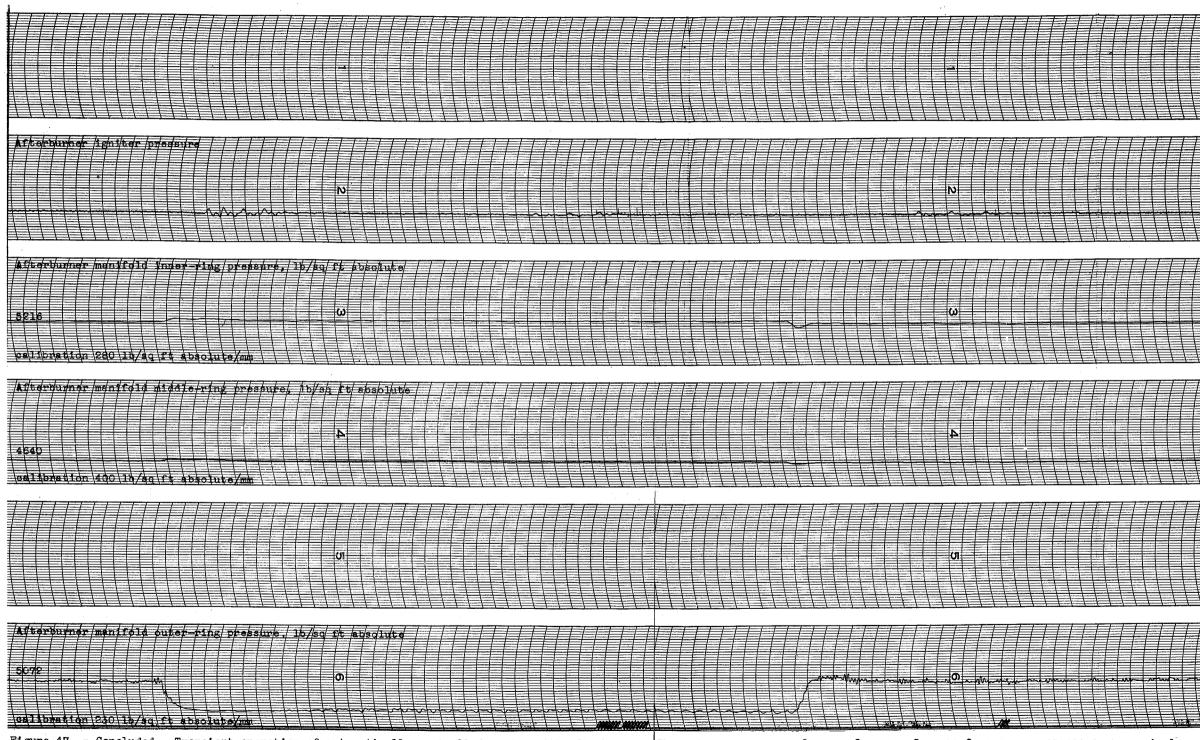
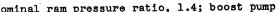


Figure 47. - Concluded. Transient operation of automatically controlled engine with afterburner. Throttle position, 110° to 100° and 100° to 110°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet presure, 18 pounds per square inch.

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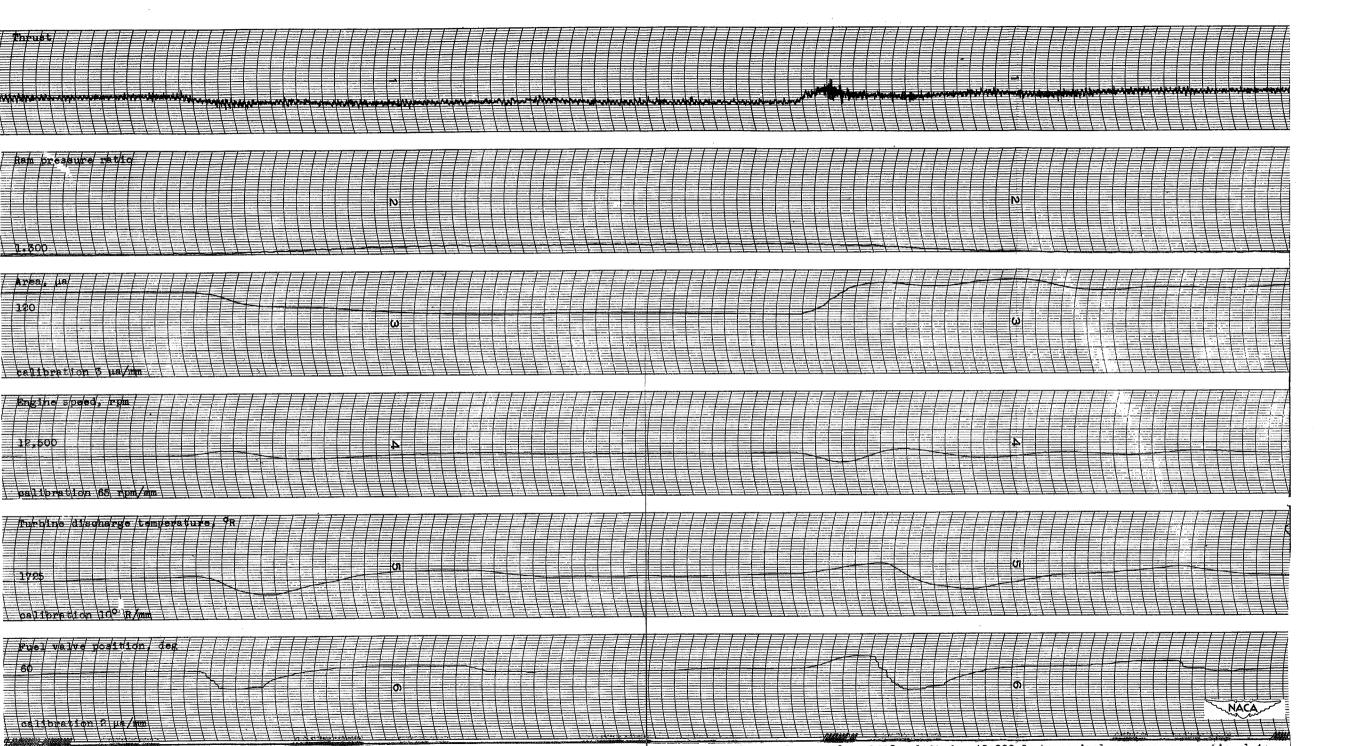


Figure 48. - Transient operation of automatically controlled engine with afterburner. Throttle position, 109° to 94° and 94° to 109°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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calibration 2 µa/mm

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Gompressor discharge pressure, 16/mg ft absolute

dallibration 40 10/20 18 absolute/mm

N

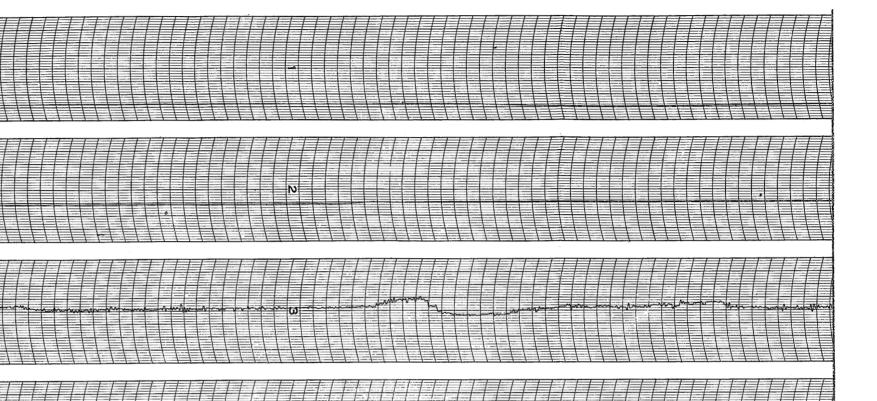
Afterburner fuel flow, 16/hr

calibretion and to in/mm

Engine fuel flow, 10/nr

callbration 16 16/nr (mm

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Turbine discharge messure. Wist fit absolute 533 543 641 bration 18 lb/sg ft absolute/mm

Throttle position, deg / 109 -Ø 94 NACA -texter lender 111 FT T I 102000 21 1-1 CARRAN - 67 Pres 1 11 202 A COMPACT MARKAR

Figure 48. - Continued. Transient operation of automatically controlled engine with afterburne. Throttle position, 109° to 94° and 94° to 109°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost pump inlet pressure, 18 pounds per square inch.

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Afterburner igniter pressure, 1			
	N		
Afterburner/mantrold inher-cing. pressure, in	b/sqtttabsolute		
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5818			
	ω		
calibration 280 lb/ag rt pbsolute/mm			
(COLLOANDIQUICON ID/ BUILTE HOBOUGLEY MALL ( )			
Afterburner manifold middle ring pressure,	lø/aq/ft absolute		
4640			
calleretion 400 lb/bg rt ubboluter um			
			OI COI
Afterburner mentfold outer-ring preserre, 16, 5072 ep 14 brat fon 626 lb/se ft	/#g/ft #bhofute/ / / / / / / / / / / / /		
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eall brettion 330 lb/sq fit 1 + + + + + + + + + + + + + + + + + +			NACA

Figure 48. - Concluded. Transient operation of automatically controlled engine with afterburne. Throttle position, 109° to 94° and 94° to 109°; altitude, 45,000 feet; nominal ram pressure ratio, 1.4; boost ump inlet pressure, 18 pounds per square inch.

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Restriction/ COLCIassification Cancelled