State of California
AIR RESOURCES BOARD

# EXECUTIVE ORDER D-89
Relating to Exemptions under Section 27156
of the Vehicle Code

## ROTO-MASTER, INC.
## "ROTO-MASTER TURBOCHARGER KIT"

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-45-5;

IT IS ORDERED AND RESOLVED: That the installation of the "Roto-Master Turbocharger Kit" manufactured by Roto-Master, Inc., 7101 Fair Avenue, N. Hollywood, CA 91605, has been found to not reduce the effectiveness of required motor vehicle pollution control devices and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for the following applications:

1. 1975 and 1976 Mercedes-Benz 240D diesel-powered vehicles with automatic transmissions. The control orifice in the vacuum bias line of the turbocharger kit is 0.055 inch diameter and the maximum fuel adjusting screw is to be turned counterclockwise one and a half turns from the original specification.

2. 1975 and 1976 Mercedes-Benz 240D diesel-powered vehicles with manual transmissions. The control orifice in the vacuum bias line of the turbocharger kit is 0.043 inch diameter and the maximum fuel adjusting screw is to be turned counterclockwise one turn from the original specifcation.

This Executive Order is valid provided that installation instructions for this device will not recommend tuning the vehicle to specifications different from those listed by the vehicle manufacturer except those specifically approved by the Air Resources Board.

Changes made to the design or operating conditions of the device, as exempted by the Air Resources Board, that adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

This Executive Order is valid provided that Roto-Master, Inc. will assume the original vehicle manufacturer warranty obligations set forth in California Adminstrative Code, Title 13, Chapter 3, Sections 2035 et. seq., of any warranted part that needs repair or replacement if the Roto-Master Turbocharger Kit is the cause of the need for the repair or replacement of the part.

Marketing of this device using an identification other than that shown in this Executive Order or marketing of this device for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board.

This Executive Order does not constitute any opinion as to the effect that the use of this device may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE ROTO-MASTER TURBOCHARGER KIT.

No claim of any kind, such as "Approved by Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

Section 17500 of the Business and Professions Code makes untrue or misleading advertising unlawful, and Section 17534 makes violation punishable as a misdemeanor.

Section 43644 of the Health and Safety Code provides as follows:

> "43644. (a) No person shall install, sell, offer for sale, or advertise, or, except in an application to the state board for certification of a device, represent, any device as a motor vehicle pollution control device for use on any used motor vehicle unless that device has been certified by the state board. No person shall sell, offer for sale, advertise, or represent any motor vehicle pollution control device as a certified device which, in fact, is not a certified device. Any violation of this subdivision is a misdemeanor."

Any apparent violation of the conditions of this Executive Order will be submitted to the Attorney General of California for such action as he deems advisable.

Executed at El Monte, California, this 27 day of April, 1979.

G. C. Hass

G. C. Hass, Chief
Vehicle Emissions Control Division

State of California
AIR RESOURCES BOARD

April, 1979

Staff Report

# Evaluation of the Roto-Master, Inc. Turbocharger System in Accordance with Section 2222, Title 13 of the California Administrative Code

## I. Introduction

Roto-Master, Inc., of 7101 Fair Avenue, North Hollywood, CA 91605, has submitted an application requesting an exemption from the prohibitions of Section 27156 of the Vehicle Code for its turbocharger system. The applicant intends to install the turbocharger system on 1975 and 1976 Mercedes-Benz 240D vehicles equipped with OM 616 diesel engines.

## II. System Description

The Roto-Master turbocharger consists of a turbine and compressor assembly, exhaust and intake manifold extensions and other miscellaneous hardware for installation. The turbine, driven by exhaust gases, rotates at high speeds (usually at 50,000 to 100,000 RPM) and is linked to the compressor by a solid shaft. The compressor, installed between the carburetor throttle body and the intake manifold thereby rotates at the same speed, and compresses incoming air to a higher density. For the same engine speed as the naturally-aspirated engine, a greater mass of air will be be drawn into the engine. This additional air, coupled with a predetermined increase of fuel from the fuel injection system, when combusted, translates to higher combustion temperature and pressure and higher horsepower.

The original fuel system on the vehicle uses a vacuum signal from an auxiliary venturi in the throttle body to a pnuematic governor to control the amount of fuel delivery. The vacuum signal is a function of the air flow through the auxiliary venturi. The applicant modifies the OEM system by using a bias line to monitor the vacuum signal. This bias line is installed between the intake manifold and the vacuum line from the auxiliary venturi to the pneumatic governor. According to the applicant, the amount of air-bleed from the intake manifold through the bias line will monitor the vacuum signal to a level comparable to the naturally-aspirated version. A complete discussion of the vacuum signals under various engine operating conditions is presented in Exhibit A.

The applicant also recommends the maximum fuel adjusting screw be backed off 1 turn for vehicles with manual transmissions and 1 1/2 turns for automatic transmissions. According to the applicant, this adjustment is required to deliver the extra fuel needed for the excess air intake; and the adjustment will not cause adverse effects on the engine.

The turbocharger kit has two versions: one for manual and another for automatic transmissions. These two versions are identical except for the following:

1. In the vacuum bias line, there is a control orifice. This orifice is 0.043 inch in diameter for vehicles equipped with manual transmissions and 0.055 inch in diameter for automatic transmissions.
2. The maximum fuel adjusting screw will be backed off 1 turn for vehicles with manual transmissions and 1 1/2 turns for the automatic transmissions.

The operating characteristics of the compressor is illustrated in the performance map (Exhibit B). The maximum boost pressure (intake manifold pressure downstream of the compressor) can reach 10.5 psi under wide open throttle and extremely high engine speed (4500 RPM); however, under normal operating range, the boost pressure ranges from 0 to 5 psi (See Exhibit C).

## III. Applicant Test Results

The applicant submitted back-to-back CVS-75 emission data on two vehicles. The test results are presented in Table 1.

## Table 1

1976 Mercedes-Benz 240D, A/T

| Cold Start CVS-75 | Exhaust Emissions (gm/mi) | | |
|---|---|---|---|
| | HC | CO | NOx |
| Baseline | 0.05 | 0.76 | 1.64 |
| Turbocharged* | 0.06 | 0.18 | 1.68 |
| % Change | 20% | -76% | 2% |

*Tested with maximum fuel adjusting screw 1 1/2 turns out.

1975 Mercedes-Benz 240 D, M/T

| Cold Start CVS-75 | Exhaust Emissions (gm/mi) | | |
|---|---|---|---|
| | HC | CO | NOx |
| Baseline | 0.12 | 0.17 | 1.60 |
| Turbocharged** | 0.10 | 0.16 | 1.72 |
| % Change | -17% | -6% | 8% |

**Tested With maximum fuel adjusting screw 1 turn out.

The tests were conducted by Olson Engineering, Inc., Huntington Beach, California. The test results showed no significant change from the baseline emissions except a decrease in CO of 76% in the vehicle with automatic transmission. The HC emissions were measured by nondispersive infrared (NDIR) technique instead of the more accurate heated flame ionization detector (HFID) method. The low HC measurements reflect the inability of NDIR to measure the heavier hydrocarbons associated with diesel exhaust.

## IV. Test Vehicle

The applicant has provided a test vehicle to the California Air Resources Board for confirmatory testing. The vehicle description is as follows:

| | |
|---|---|
| Vehicle Make & Model: | 1975 Mercedes 240D |
| Engine Size : | 2.4 litres (146 CID) |
| Engine Code : | OM 616 |
| Transmission : | 4 speed manual |
| Fuel System : | Bosch Diesel Injection |
| Calif. License No. : | 093 NHH |

This vehicle has been turbocharged before and has accumulated approximately 4000 miles of turbocharging. The vehicle was restored to its OEM configuration for the baseline test.

The vehicle was sent to Lloyd Pearson, Inc., an authorized Mercedes-Benz dealership for a diagnostic examination and adjustment to OEM specifications if necessary. The following summarized the results and adjustments:

| | | Before | After |
|---|---|---|---|
| 1. | Idle Speed | 780 RPM | 750 RPM |
| 2. | Injection Timing | 20° BTDC | 24° BTDC |

The idle speed was erratic because of a defective governor assembly cover. The part was replaced and a consistent idle speed was obtained.

## V. Turbocharger Installation

The turbocharger installation was performed by an ARB mechanic in accordance with the installation instructions provided by the applicant and witnessed by Mr. Hugh MacInnes of Roto-Master, Inc. and an ARB staff member. The installation instructions were fairly complete; however, the installation required two days and it is not likely that the average consumer without a hoist and proper tools could install the system without encountering some difficulties.

Mr. MacInnes performed the final adjustments, road tested the vehicle and was satisfied that the vehicle and the turbocharger kit were functioning properly.

## VI. Test Program

The ARB staff conducted confirmatory testing at the ARB Laboratory at El Monte. Driveability and emissions tests were performed on the vehicle in both the OEM and modified configurations. In either configuration, a driveability test was performed prior to the emissions tests. The test sequence is summarized as follows:

(i) Driveability Test, OEM
(ii) Emissions Test, OEM
(iii) Driveability Test, Turbocharged
(iv) Emissions Test, Turbocharged

The driveability test was performed according to ARB warm driveability test procedure. Additional tests were performed allowing a minimum of two seconds during each transmission shift with the clutch completely disengaged to detect any potential surging problem.

Emission tests were performed according to the following test plan:

(i) One CVS-75 test
(ii) Two hot-start CVS-72 tests
(iii) One highway fuel economy test
(iv) Steady-state tests as follows:

|  | Road Load | 2X | 3X |
|---|---|---|---|
| Idle | - | - | - |
| 20 |  | X | X |
| 40 | X | X | X |
| 50 | X | X |  |
| 60 | X |  |  |

The turbocharged configuration was tested with the maximum fuel adjusting screw one turn out. The above emission tests were repeated for both the original and the turbocharged configurations.

## VII. ARB Test Results

This section discusses the results of the emission tests and measured physical parameters to provide some understanding of the turbocharger characteristics. The results of driveability tests are also presented.

### A. Emission Tests

Table 2 presents the emission results of the cold-start CVS-75, hot-start CVS-72 and highway fuel economy tests. The hydrocarbon emissions were measured by both the HFID and NDIR techniques (heated flame ionization detector and nondispersive infrared). The hydrocarbon increases measured by NDIR were almost indistinguishable from the baseline; therefore, only the results by the HFID method are presented since this method provides a more accurate measurement of hydrocarbon emissions.

The CVS-75 test results in the turbocharged configuration show a slight increase in HC, CO and NOx by 9%, 3% and 6% respectively with 3% decrease in fuel economy. The hot-start CVS-72 and highway fuel economy tests show increases in HC of 36% and 43% respectively. Although the percentage increase in HC appears large the increase in magnitude is relatively insignificant.

Table 3 presents the steady-state test results performed at various speeds and loading conditions. The idle test indicates an insignificant increase in HC of 0.02 to 0.05 gm/min with no change in CO and NOx. On the other steady state tests the change in HC is again insignificant because of the low emissions levels. The increase in NOx of approximately 12% at road load is marginal. It shows a trend of NOx increase with turbocharging, possibly because of increased combustion temperatures, but the NOx increase appears to be smaller at higher loads.

## Table 2

## ARB CVS Emission Results

| | Exhaust Emissions (gm/mi) | | | Fuel Economy |
|---|---|---|---|---|
| Cold-Start CVS-75 | HC | CO | NOx | (mpg) |
| Baseline (Average of 2 tests) | 0.23 | 1.24 | 1.72 | 23.4 |
| Turbocharged (Average of 2 tests) | 0.25 | 1.28 | 1.82 | 22.7 |
| % Change | 9 | 3 | 6 | -3 |

| | Exhaust Emissions (gm/mi) | | | Fuel Economy |
|---|---|---|---|---|
| Hot-Start CVS-72 | HC | CO | NOx | (mpg) |
| Baseline (Average of 4 tests) | 0.22 | 1.21 | 1.64 | 24.3 |
| Turbocharged (Average of 4 tests) | 0.30 | 1.26 | 1.80 | 23.6 |
| % Change | 36 | 4 | 10 | -3 |

| | Exhaust Emissions (gm/mi) | | | Fuel Economy |
|---|---|---|---|---|
| Highway Fuel Economy Test | HC | CO | NOx | (mpg) |
| Baseline (Average of 2 tests) | 0.23 | 0.75 | 1.21 | 29.8 |
| Turbocharged (Average of 2 tests) | 0.33 | 0.75 | 1.26 | 29.1 |
| % Change | 43 | 0 | 4 | -2 |

## Table 3 ARB Steady-State CVS Emission Results

| | | Exhaust Emissions (gm/mi) | | |
|---|---|---|---|---|
| | | HC | CO | NOx |
| Idle<br>(gm/min) | Baseline | 0.02 | .12 | .12 |
| | Turbocharged | 0.05 | .12 | .12 |
| | % | 150 | 0 | 0 |
| Road Load | | | | |
| 40 MPH | Baseline | 0.20 | 1.23 | 1.71 |
| | Turbocharged | 0.19 | 1.16 | 1.90 |
| | % Change | -5 | -6 | 11 |
| 50 MPH | Baseline | 0.15 | 0.76 | 1.62 |
| | Turbocharged | 0.12 | 0.71 | 1.82 |
| | % Change | -20 | -7 | 12 |
| 60 MPH | Baseline | 0.15 | 0.80 | 2.11 |
| | Turbocharged | 0.14 | 0.85 | 2.38 |
| | % Change | -7 | 6 | 13 |

Table 3 (continued)

| | | Exhaust Emissions (gm/mi) | | |
|---|---|---|---|---|
| | | HC | CO | NOx |
| Twice Road Load | | | | |
| 20 MPH | Baseline | 0.43 | 1.84 | 1.63 |
| | Turbocharged | 0.49 | 1.73 | 1.74 |
| | % Change | 14 | -6 | 7 |
| 40 MPH | Baseline | 0.26 | 1.20 | 2.15 |
| | Turbocharged | 0.28 | 1.15 | 2.41 |
| | % Change | 8 | -4 | 12 |
| 50 MPH | Baseline | 0.20 | 0.77 | 2.27 |
| | Turbocharged | 0.23 | 0.76 | 2.51 |
| | % Change | 15 | -1 | 11 |
| Three Times Road Load | | | | |
| 20 MPH | Baseline | 0.27 | 1.87 | 1.68 |
| | Turbocharged | 0.24 | 1.62 | 1.74 |
| | % Change | -11 | -13 | 4 |
| 40 MPH | Baseline | 0.16 | 1.12 | 2.68 |
| | Turbocharged | 0.17 | 1.14 | 2.74 |
| | % Change | 6 | 2 | 2 |

## B. Physical Parameter Analysis

Table 4 presents the comparison of physical parameters between the baseline and turbocharged configurations which may have a bearing on the change in emissions. The test was performed twice, and both sets of data are given. The fuel vacuum signals of the turbocharged configuration are almost identical to the baseline configuration and are not shown. This indicates that there is no significant change in the amount of fuel delivered to the engine between the OEM and turbocharged configurations.

The boost pressure in the steady state tests is relatively low throughout the series indicating that the turbocharger does not contribute much in the way of additional power at cruise conditions under 60 mph or at moderate loads. In order to check the conditions under which near maximum boost would occur, a few additional runs were made. The boost at three times road load at 50 mph was 4.5 psig, though this was not at WOT. A boost of 4 psig was recorded at WOT at 43 mph (2760 rpm) and 5 psig boost was recorded at WOT at 53 mph (3000 rpm).

The exhaust gas temperatures were measured and recorded on a chart recorder. The figures given in table 4 are average temperatures. The turbine inlet temperatures are lower than the baseline exhaust temperatures, probably because of excess air from the turbocharger installation.

Table 4 - Temperature and Pressure Measurements

| Mode | Trans gear | Compressor Air Temp, °F inlet | Compressor Air Temp, °F outlet | Exhaust Gas Temp, °F baseline | Exhaust Gas Temp, °F turbine inlet | Exhaust Gas Temp, °F turbine outlet | Compressor outlet pressure (psig) |
|---|---|---|---|---|---|---|---|
| idle | N | 69 | 125 | 230 | 133 | 160 | -1.0 |
| | | 81 | 140 | | 200 | 240 | * |
| 40(RL) | 3 | 89 | 170 | 590 | 520 | 537 | 0.5 |
| | | 95 | 230 | | 497 | 548 | 0.1 |
| 50 (RL) | 4 | 94 | 187 | 660 | 530 | 565 | 0.5 |
| | | 113 | 225 | | 410 | 485 | 0.1 |
| 60 (RL) | 4 | 91 | 245 | 870 | 560 | 620 | 1.5 |
| | | 112 | 232 | | 570 | 577 | 0.75 |
| 20 (2X) | 2 | 78 | 163 | 430 | 335 | 305 | -0.5 |
| | | 92 | 185 | | 330 | 365 | * |
| 40 (2X) | 3 | 84 | 185 | 675 | 507 | 405 | 0.5 |
| | | 94 | 210 | | 512 | 510 | 0.35 |
| 50 (2X) | 4 | 92 | 195 | 900 | 635 | 550 | 1.0 |
| | | 110 | 195 | | 582 | 680 | 0.45 |
| 20 (3X) | 2 | 78 | 158 | 440 | 320 | 275 | -0.5 |
| | | 93 | 180 | | 310 | 355 | * |
| 40 (3X) | 3 | 88 | 175 | 800 | 505 | 427 | 1.0 |
| | | 110 | 190 | | 535 | 542 | 0.45 |

*A compound gage was used to measure compressor outlet temperature in the first test and a pressure transducer reading positive pressure only was used in the second test.

### C. Road Test and Driveability

Road tests were performed in the OEM and turbocharged configuration. No driveability problem was detected during these two tests. The turbocharged vehicle had a better acceleration time from 0 to 55 MPH during extreme acceleration (17.5 sec. vs. 23 sec in the OEM configuration). This agrees with the result that the applicant has submitted.

## VIII. Conclusions and Recommendations

The test results of the CVS-75 and hot-start CVS-72 tests showed no significant increase of any pollutant with the turbocharged vehicle over the baseline. Results of the steady-state tests indicate that there are slight percentage decreases in HC in some modes and increases in others but the absolute magnitudes are too low to be of concern. There is generally a marginal decrease in CO and a slight increase in NOx in most of the steady-state tests, part of which may be attributed to test variability.

The ARB staff believes the installation and use of the Roto-Master turbocharger system on 1975 and 1976 Mercedes-Benz 240D vehicles in accordance with Roto-Master's instructions will not adversely affect the OEM exhaust emission control system. The staff therefore recommends that Roto-Master, Inc. be granted an exemption from the prohibitions of Vehicle Code Section 27156 for its turbocharger systems to be installed on 1975 and 1976 Mercedes-Benz 240D vehicles.

EXHIBIT A

# DESCRIPTION OF ROTO-MASTER TURBOCHARGER INSTALLATION FOR MERCEDES-BENZ 200/220/240 DIESEL POWERED PASSENGER CARS WITH MANUAL AND AUTOMATIC TRANSMISSIONS FOR MODELS YEARS 1967 THROUGH 1976

The vehicles as manufactured have four-cylinder diesel engines of the indirect injection type with either 2000, 2200 or 2400 cc. displacement, depending on the model years. The fuel pump used on these engines is unique in that the quantity of fuel delivered is controlled pnuematically and the only mechanical connection between the accelerator pedal and the fuel injector system is for idle fuel control.

After the turbocharger is installed, the engine is adjusted, maintained, started and operated as Mercedes-Benz has specified and described in their operator's handbook and technical literature for the naturally-aspirated engine.

The operating principle of the normally-aspirated engine is as follows:

The fuel pump is controlled by a pneumatic governor which automatically limits fuel flow over the whole speed range from idle to maximum, and a vacuum signal from the auxiliary venturi which is a function of the butterfly valve position and engine air flow (Figures 1 and 2). This vacuum signal moves the diaphragm (Figures 1 & 3) against the governing spring which in turn controls the fuel delivery. The throttle body (Figure 2) is attached to the entrance of the intake manifold.

With the engine running (Figure 4), the position of the diaphragm and that of the fuel control rod, are a function of the difference in pressure across the diaphragm and the force of the governing spring. The amount of vacuum in the chamber is a function of the air velocity through the auxiliary venturi. When the butterfly valve is closed, either at idle or during deceleration, all of the engine air must pass through the auxiliary venturi, resulting in maximum vacuum in the vacuum chamber. This would shut off the fuel completely except for an override from the pedal linkage (not shown) which opens the control rod slightly at idle to prevent the engine from stalling.

When the throttle is opened at low engine speeds (Figure 5), the velocity through the auxiliary venturi is low, resulting in very little vacuum in the vacuum chamber. This allows the spring to extend and move the fuel control rod against the maximum fuel flow adjusting screw. This is the condition of maximum fuel flow.

With the throttle still wide open but at high engine speed (Figure 6), the air velocity through the auxiliary venturi will be high enough to cause some vacuum and reduce the fuel flow. This prevents the engine from overspeeding, even at full throttle.

When the turbocharger is added to the system, the compressor is located between the venturi control unit and the intake manifold (Figure 7). If the compressor were located upstream of the venturi control unit, it would not allow the pneumatic governor to operate properly since the pressurized auxiliary venturi would never send a vacuum signal to the vacuum chamber behind the diaphragm.

With the engine at idle condition and the turbocharger in place (Figure 7), the signal from the auxiliary venturi is the same as when naturally-aspirated. The intake manifold vacuum will be slightly higher than that in the vacuum pipe connecting the auxiliary venturi to the vacuum chamber, so the check valve in the bias line will be closed.

Under normal operation such as on a level road without acceleration, the condition in Figure 8 will exist. Here the throttle is partly open and if the engine were normally aspirated, the vacuum signal to the pump would allow it to deliver a certain amount of fuel. In the case of the turbocharged engine, this vacuum signal would be too high due to the higher flow and velocity through the auxiliary venturi. If the vacuum signal were not biased in some way, the turbocharged engine would deliver less power than the naturally-aspirated version. For this reason, the bias line is added to the system between the intake manifold and the vacuum pipe (Figure 8). This bias line has a check valve to prevent the intake manifold vacuum from being the dominant signal at low load conditions. At road load condition, the pressure in the intake manifold will open the check valve in the bias line and flow through the control orifice to overcome the high vacuum signal from the auxiliary venturi. The size of the orifice was established by testing, to allow the fuel flow to increase at about half the rate of the air flow increase produced by the turbocharger. This accomplishes three things:

1) It reduces combustion temperature, resulting in lower exhaust temperatures under all operating conditions.

2) It increases the air fuel ratio and promotes better combustion.

3) It increases the output of the engine to make the vehicle much more driveable.

When the throttle is opened fully at medium or low engine speed (Figure 9), the pressure in the intake manifold is much higher than the signal from the auxiliary venturi and will flow through the bias line and control orifice to overcome the vacuum from the auxiliary venturi and cause the pump to deliver maximum fuel.

As engine speed increases, the velocity through the auxiliary venturi will increase and the flow through the control orifice will become critical. When this happens, the pressure signal through the bias line will no longer overcome the vacuum signal and the pump will prevent the engine from overspeeding (Figure 10).

When the turbocharger is applied to the engine in this manner, the increase in power is slight because the maximum fuel adjusting screw prevents the pump from delivering any extra fuel. The only increase in power will come from improved combustion due to the increase in available air. The factory setting on the naturally-aspirated engine is limited by smoke, exhaust temperature, or both. Since the turbocharger supplies a large excess of air, neither of these limitations is necessary. The only limit is the mechanical integrity of the engine. Tests have shown the adjusting screw can be backed off one-and-one-half turns without harming the engine. The pump has not been pushed further than this since the power at 1½ turns out is more than adequate.

Because of the different acceleration characteristics between the manual and automatic shift models, separate kits were developed for each so that performance would not have to be compromised. The manual transmission model has a larger nozzle in the turbine housing and a smaller orifice in the bias line. The reason for this is to prevent overboosting and over fueling the manual transmission model during acceleration because it can be held in a lower gear while the automatic transmission will shift to a higher gear.

This system is not designed for racing and we have found it to improve the performance of the vehicle considerably with no detrimental effects on the engine.

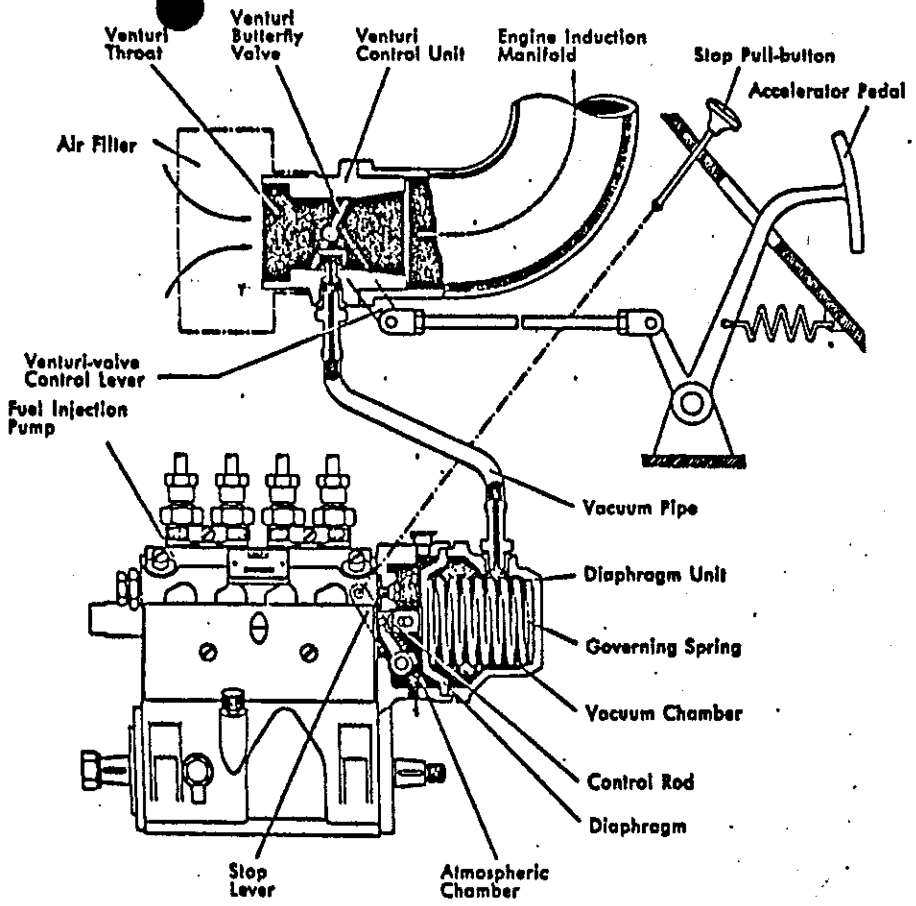


FIG 1

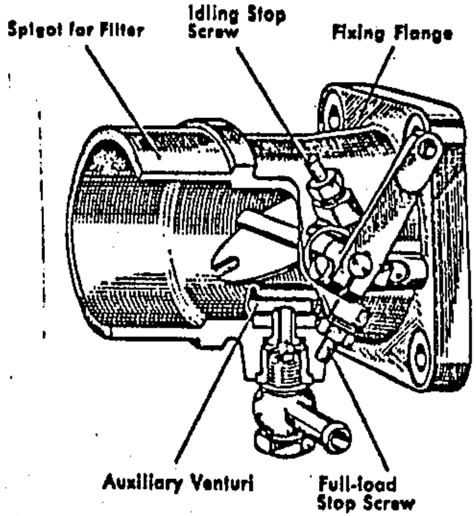


FIG 2

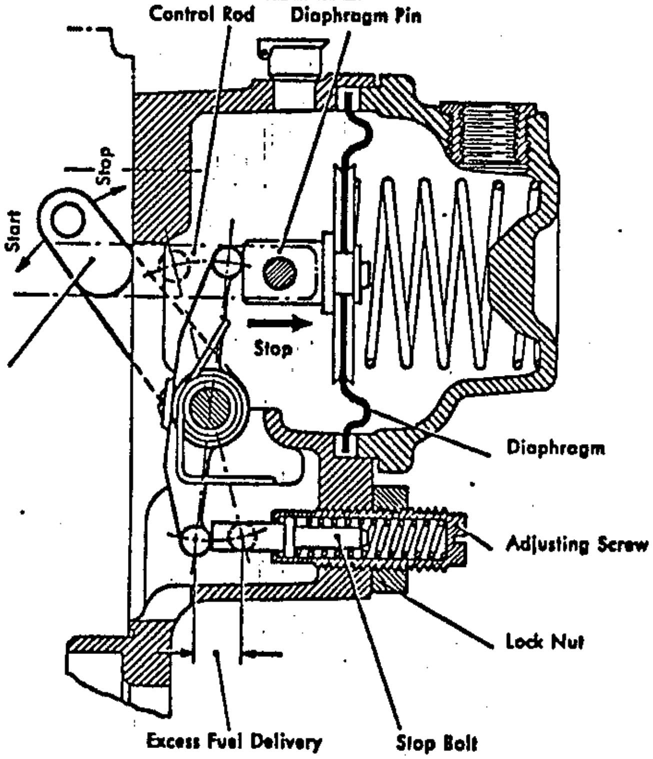


FIG 3

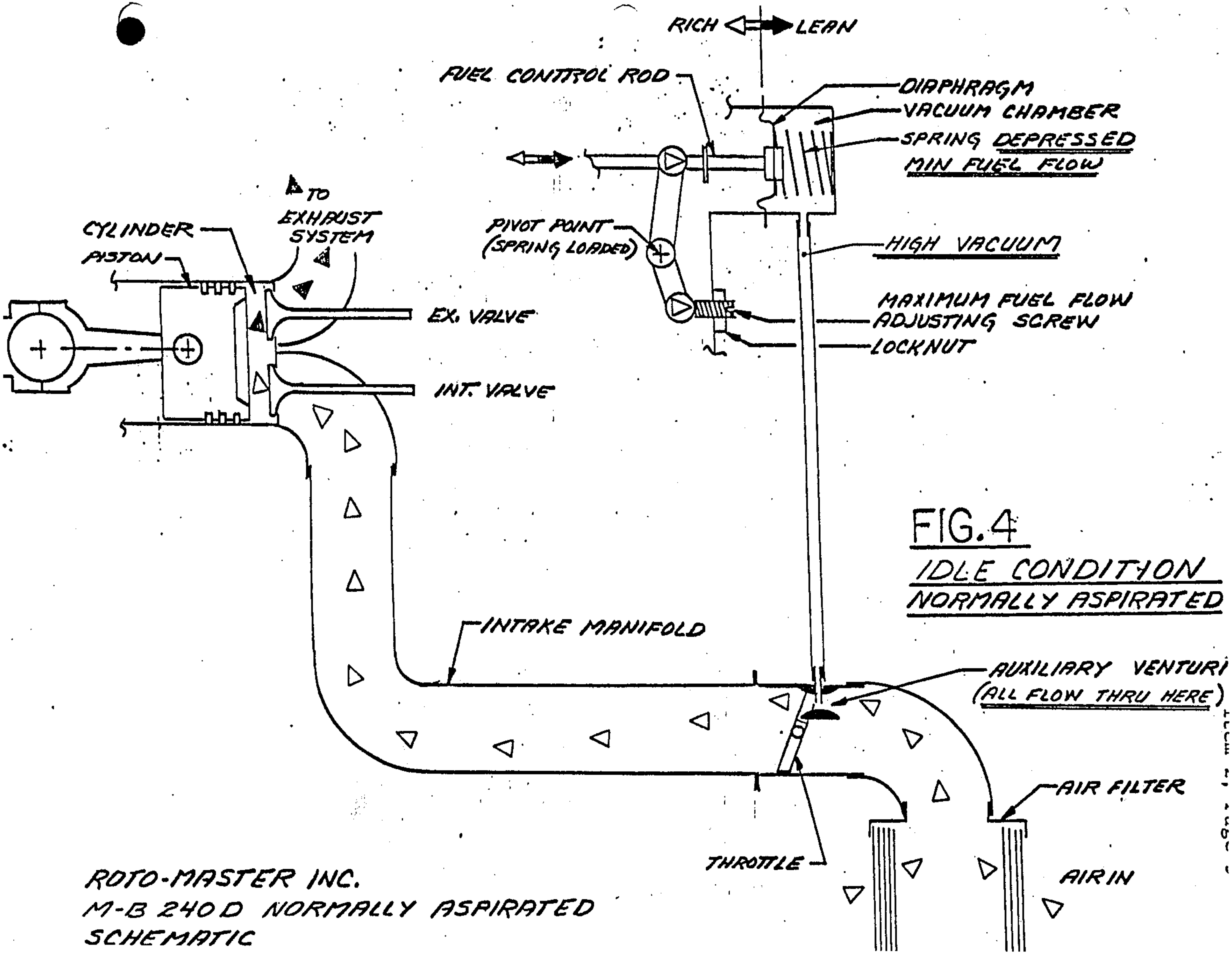


FIG. 4

IDLE CONDITION
NORMALLY ASPIRATED

ROTO-MASTER INC.
M-B 240D NORMALLY ASPIRATED
SCHEMATIC

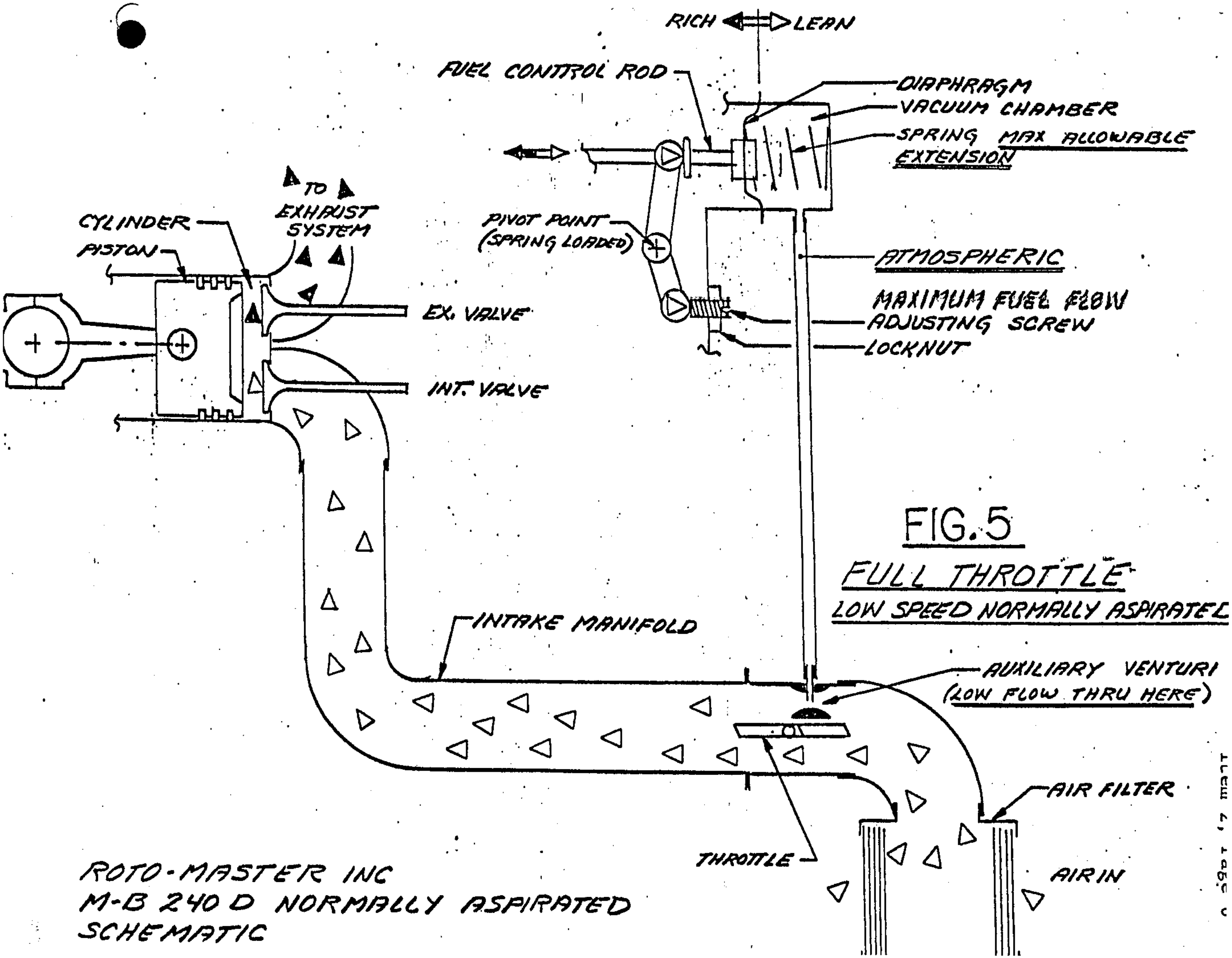


FIG. 5

FULL THROTTLE

LOW SPEED NORMALLY ASPIRATED

ROTO-MASTER INC
M-B 240 D NORMALLY ASPIRATED
SCHEMATIC

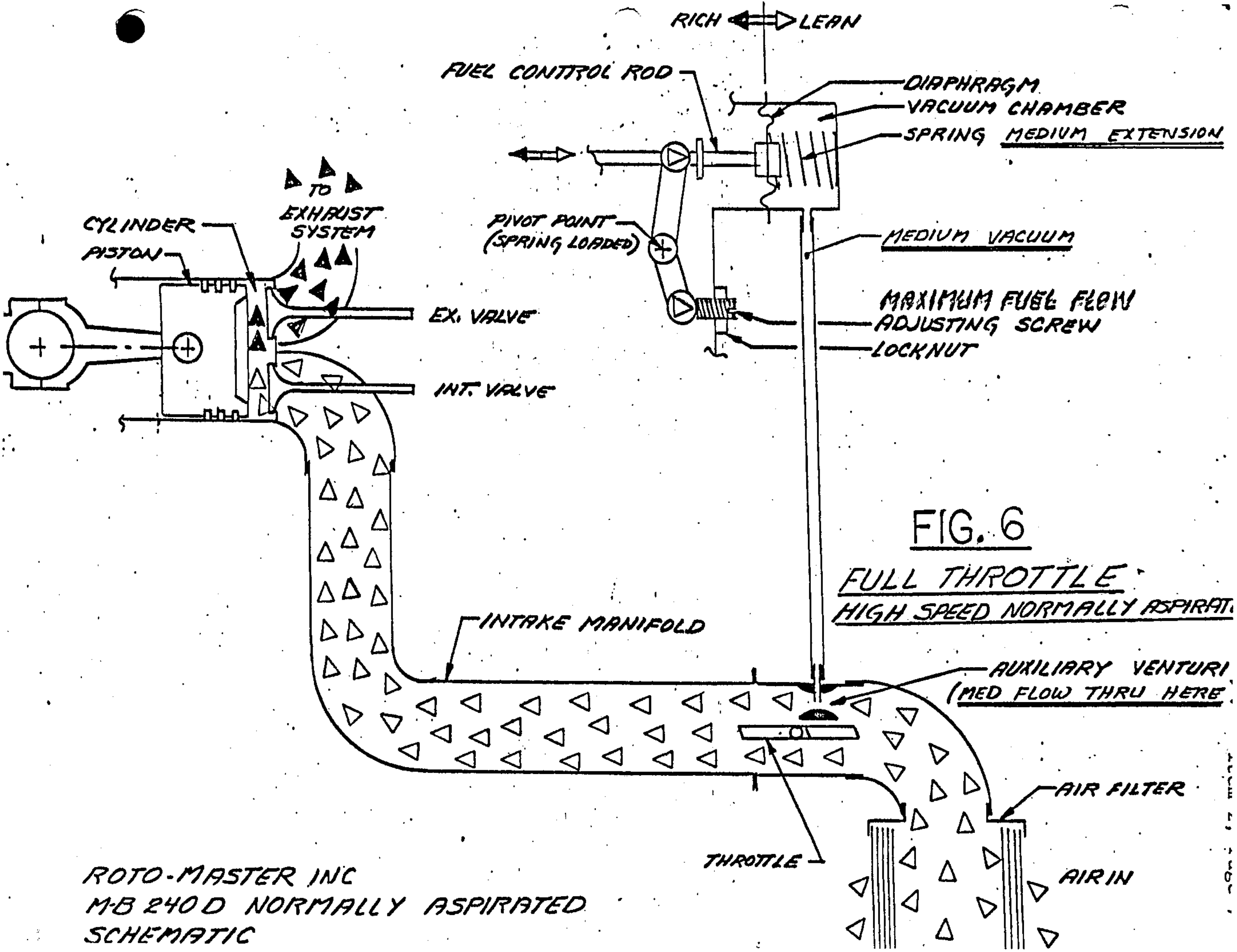


FIG. 6

FULL THROTTLE

HIGH SPEED NORMALLY ASPIRAT

ROTO-MASTER INC
M-B 240 D NORMALLY ASPIRATED
SCHEMATIC

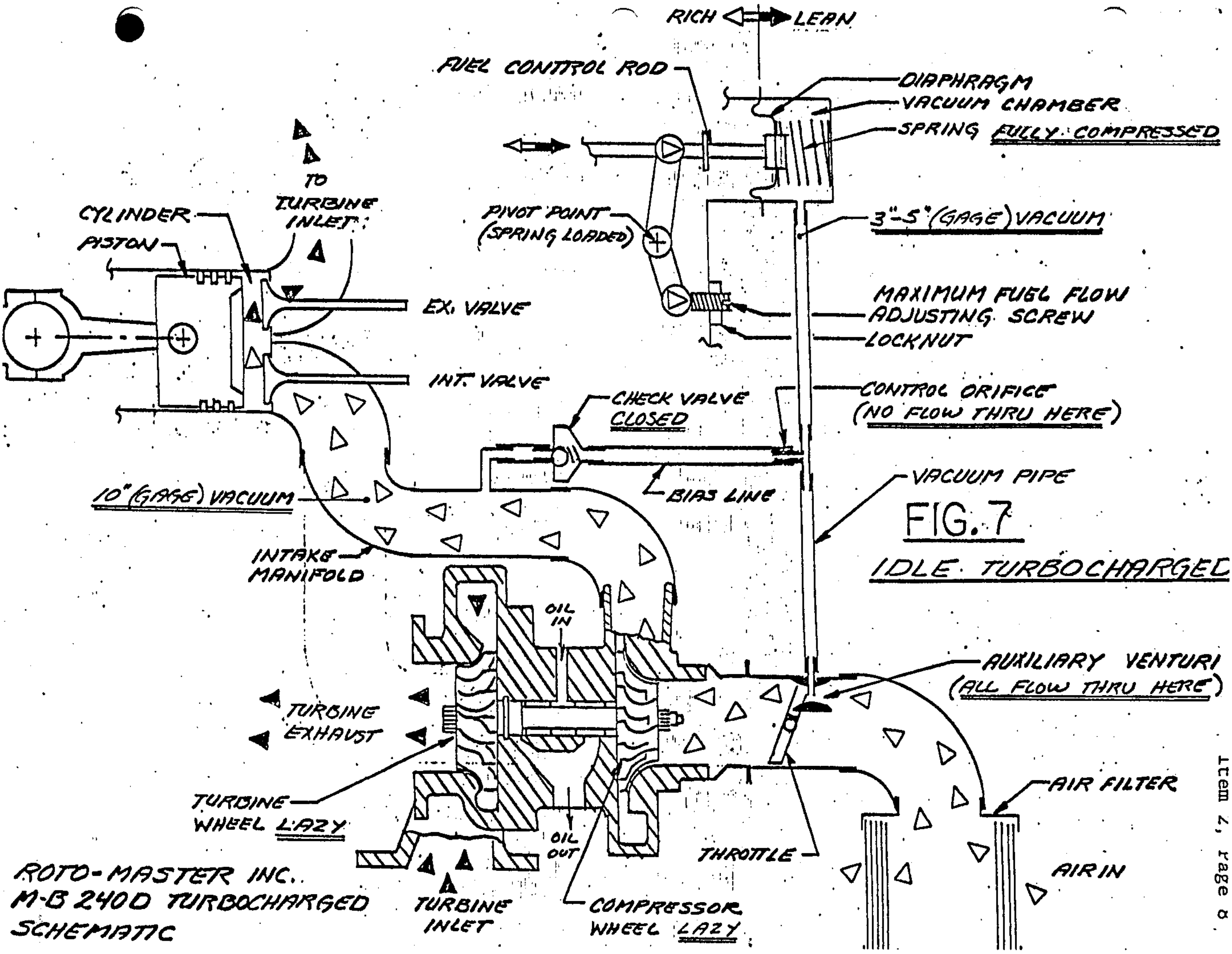


FIG. 7

IDLE TURBOCHARGED

ROTO-MASTER INC.
M-B 240D TURBOCHARGED
SCHEMATIC

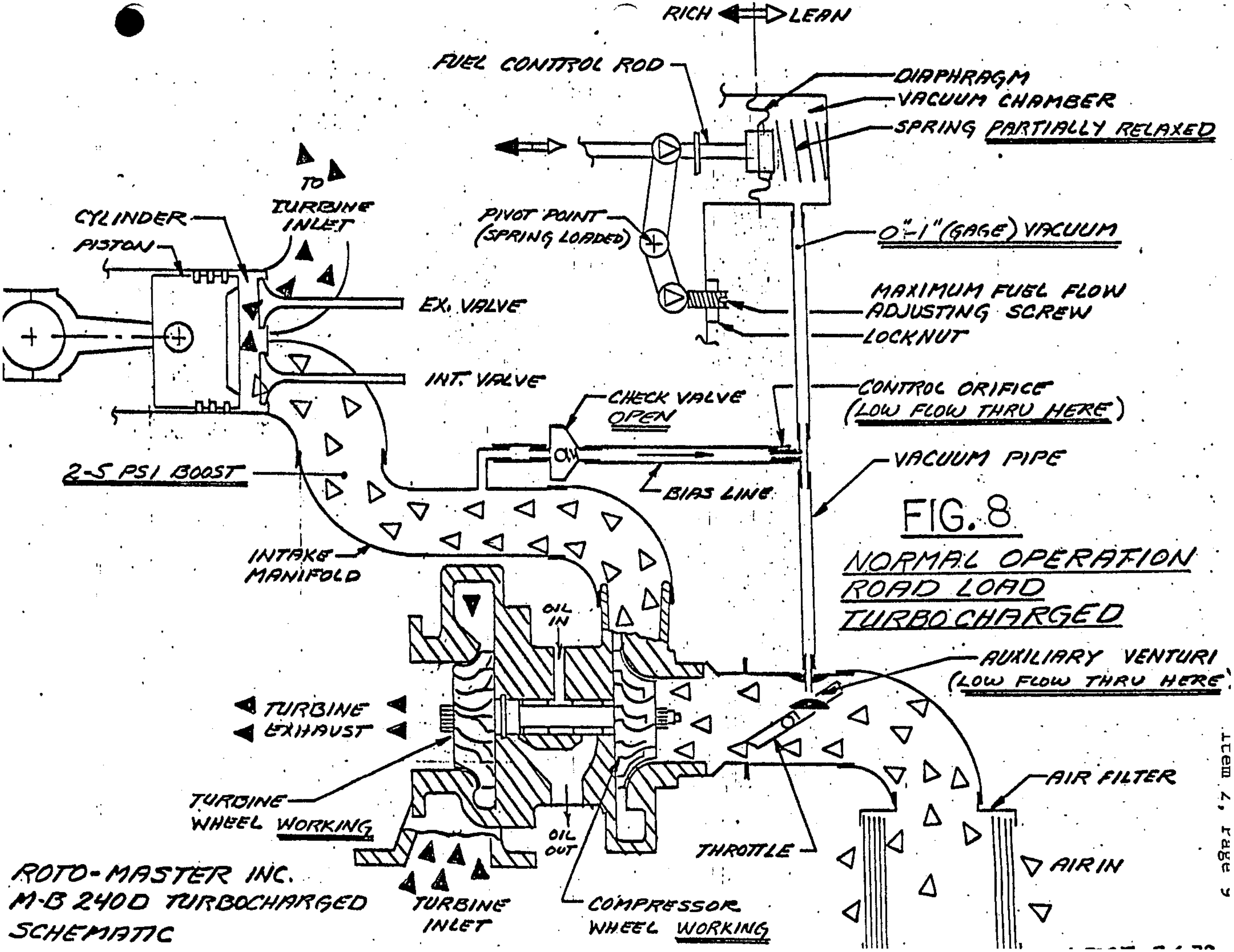


FIG. 8

NORMAL OPERATION
ROAD LOAD
TURBOCHARGED

ROTO-MASTER INC.
M-B 240D TURBOCHARGED
SCHEMATIC

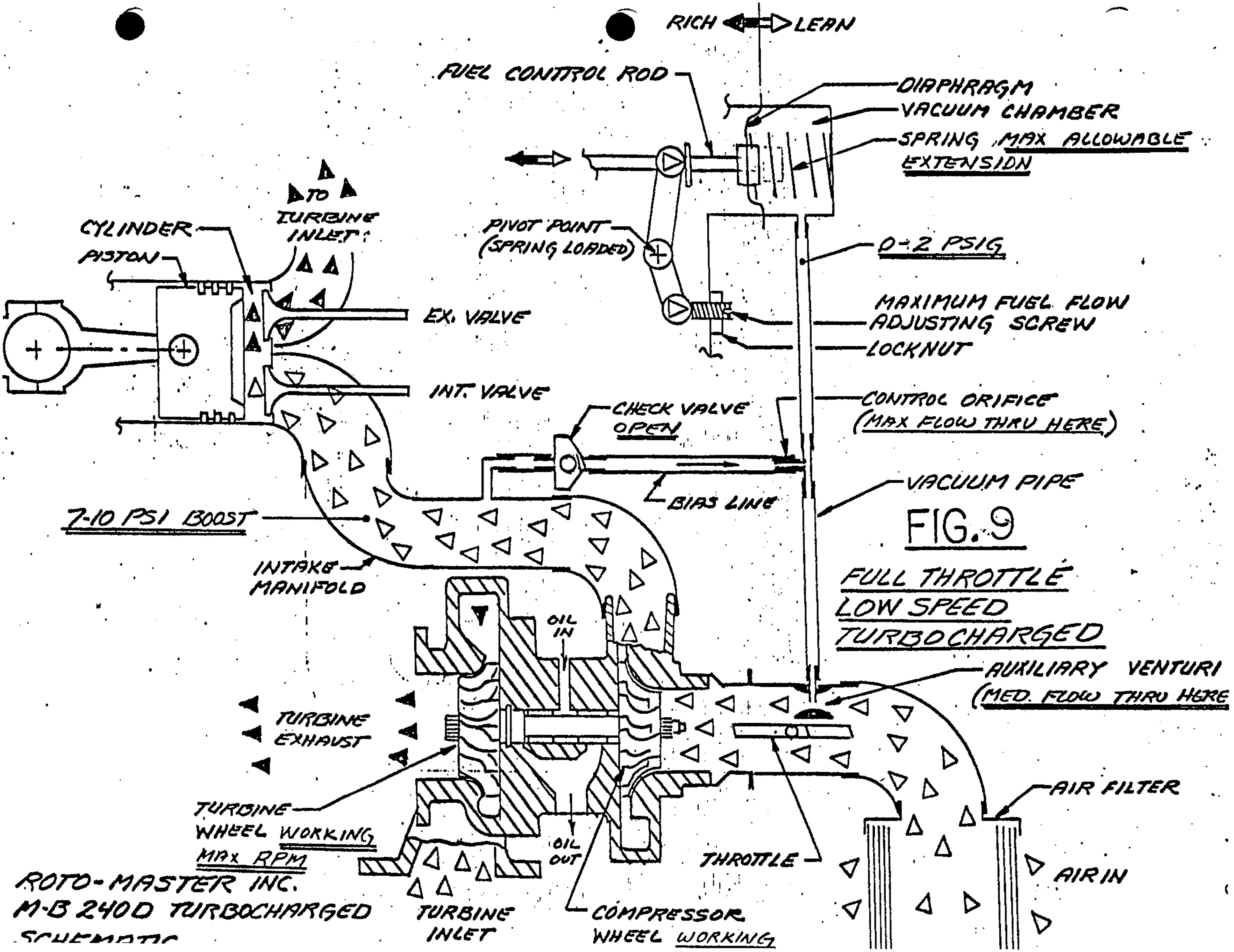


FIG. 9

FULL THROTTLE
LOW SPEED
TURBOCHARGED

ROTO-MASTER INC.
M-B 240D TURBOCHARGED
SCHEMATIC

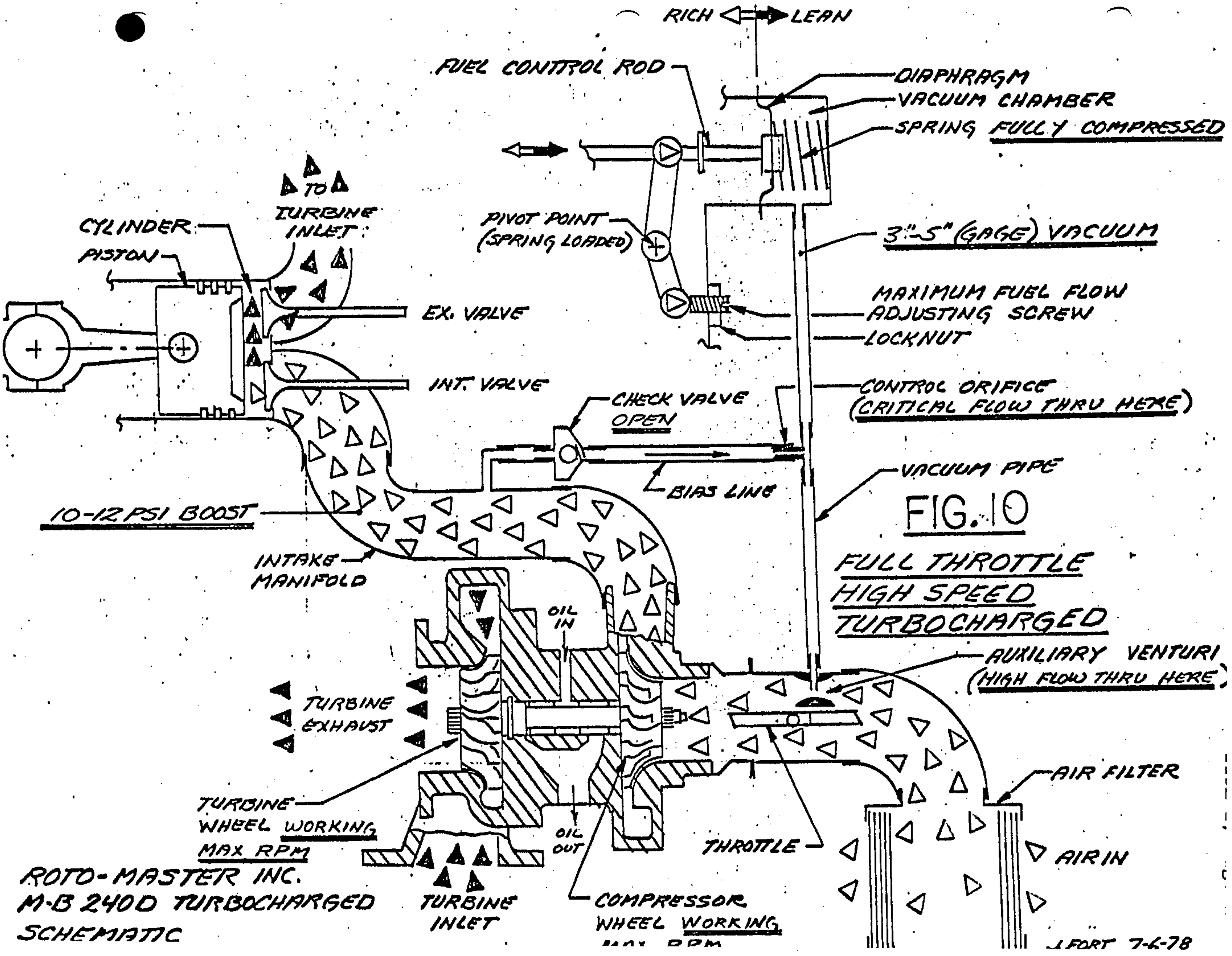
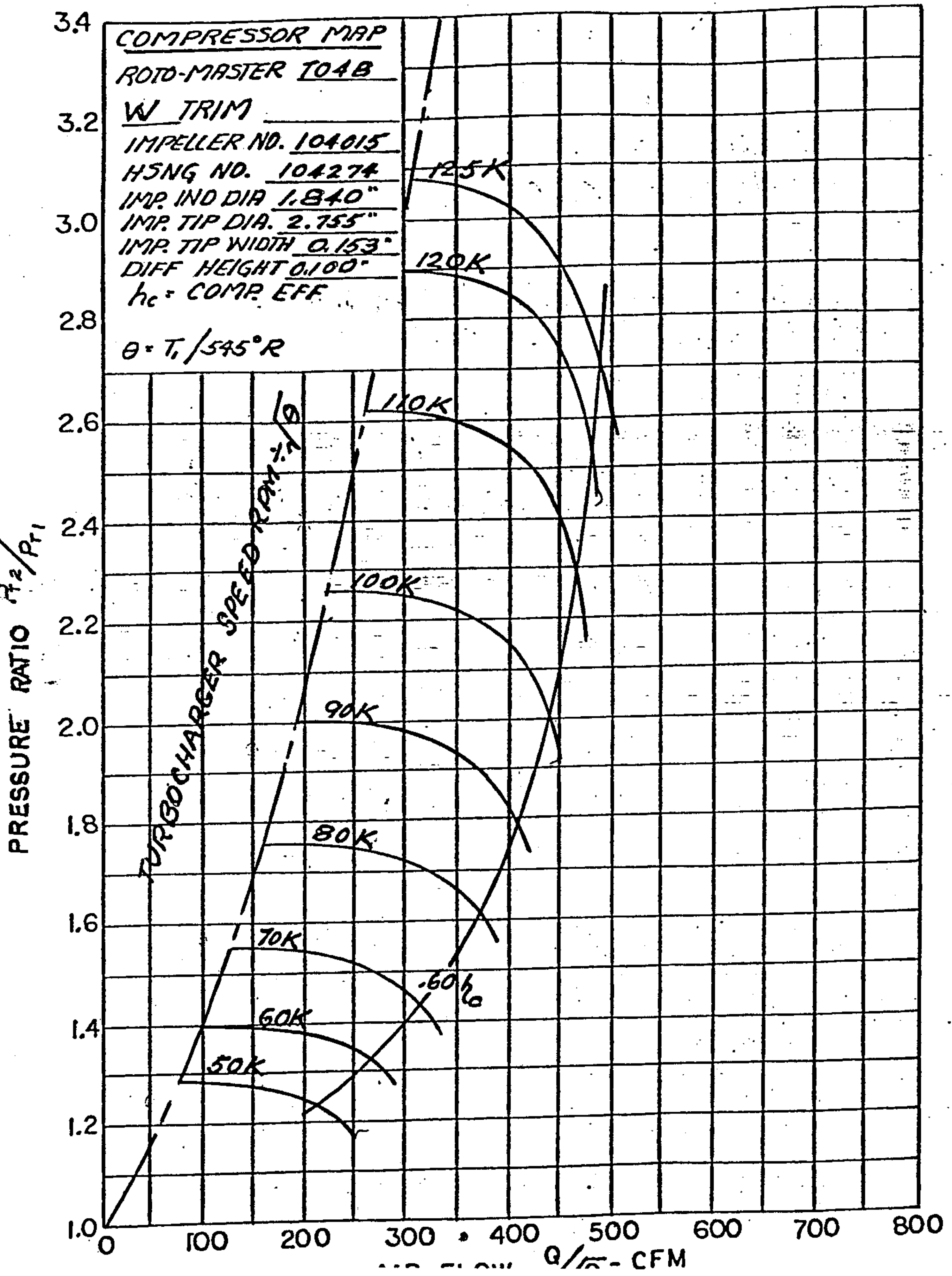


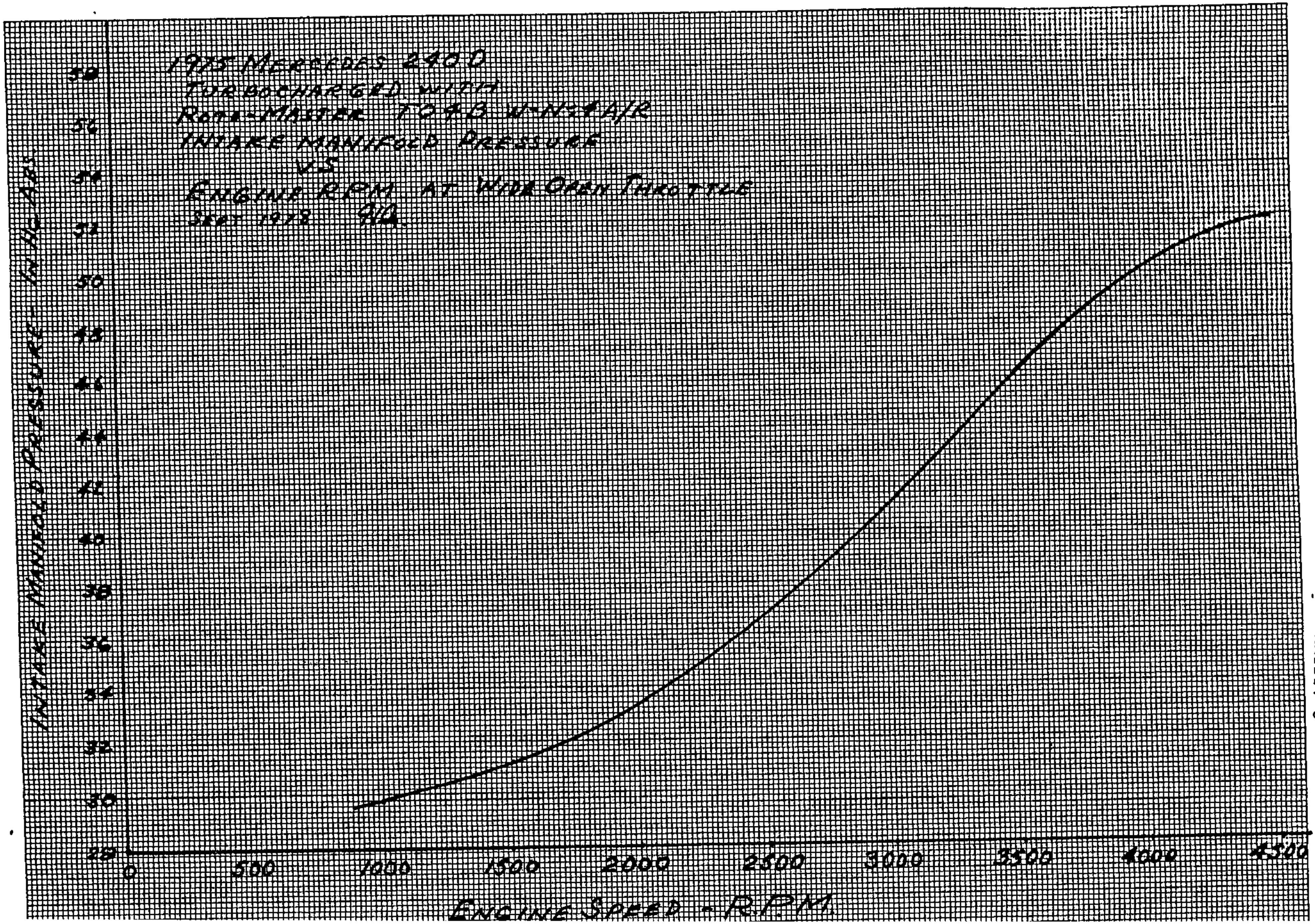
FIG. 10

FULL THROTTLE
HIGH SPEED
TURBOCHARGED

ROTO-MASTER INC.
M-B 240D TURBOCHARGED
SCHEMATIC

ITEM 2 EXHIBIT B





1975 MERCEDES 240 D
TURBOCHARGED WITH
ROTO-MASTER TO4B W-N1 A/R
INTAKE MANIFOLD PRESSURE
VS
ENGINE RPM AT WIDE OPEN THROTTLE
SEPT 1978

ITEM

EXHIBIT C