CARBURETOR JETTING TO COMPENSATE FOR CHANGES IN ATMOSPHERIC CONDITIONS

The carburetors used on internal combustion engines are used to mix fuel with air in the proper proportion (air-fuel ratio) for combustion. For maximum horsepower and optimum performance, this air-fuel ratio must be maintained as originally established by the engine builder or tuner. The air-fuel ratio is the ratio of the weight of dry air to the weight of fuel and is directly related to true air density (pounds of dry air per cubic foot). The carburetor is a gas-velocity-actuated device, and the gas velocity of the air through the carburetor is basically a function of engine displacement and RPM. The carburetor does not compensate for changes in air density. For example, at a given RPM and throttle setting, the engine will displace the same volume of gas (cubic feet per minute) at sea level or at 5000 feet elevation. Also, the gas velocity through the carburetor and the fuel flow rate will be the same. However, the air density will le less at the higher elevation due to reduced barometric pressure. This results in a lower air-fuel ratio at 5000 feet than at sea level. If the engine were originally tuned at sea level and then run at 5000 feet, the air-fuel ratio would be too low (too rich a mixture) for optimum performance. In this case, to obtain the proper air-fuel ratio, the fuel jet size must be reduced. The procedure presented is for determining the proper fuel jet size to be used to compensate for changes in air density. It is presented in graphical form for simplicity and is derived from fundamental thermodynamics.

<u>Determination of True Air Density</u>

True air density is a function of air temperature, barometric pressure (elevation) and relative humidity. True air density decreases with: increased air temperature, increased relative humidity, decreased barometric pressure (increased elevation). These three parameters are required to determine the true air density. They may be obtained as follows:

<u>Air Temperature (Dry Bulb Temperature)</u> - Rely on an inexpensive mercury thermometer and take the temperature in the shade.

<u>Relative Humidity</u> - A sling psychrometer is a relatively inexpensive device which is sufficiently accurate for these purposes. It has two thermometers and is used to determine dry bulb temperature and wet bulb temperature. These two temperatures are then used to determine the relative humidity from a psychometric chart. The one we have available has a sliding scale on the instrument which can be read directly to determine the relative humidity.

Barometric Pressure (Elevation) - In general, the elevation of the race track or a nearby town is sufficient for this purpose. If more accuracy is desired, local weather stations or airports provide the current barometric pressure. Airports give the barometric pressure corrected to sea level, and it is necessary to correct this to the track elevation. Local weather stations may also do this, and it is important to find out whether it is corrected or actual pressure. To determine the actual barometric pressure from sea-level-corrected pressure, subtract the difference between standard sea level pressure (29.92 in. Hg) and reported corrected sea level pressure from the standard elevation pressure (see Figure 1).

Example 1.

Track elevation = 4000 ft.

Reported corrected sea level pressure = 30.10 in. Hg

29.92 - 30.10 =-0.18 in. Hg.

From Figure 1, standard 4000 ft. pressure is 25.90 in. Hg.

25.90 - (-0.18) = 25.90 + 0.18 = 26.08 in. Hg actual pressure

Example 2.

Track elevation = 2500 ft.

Reported corrected sea level pressure = 29.31 in. Hg

29.92 - 29.31 = 0.59 in. Hg

From Figure 1, standard 2500 ft. pressure is 27.30 in. Hg.

27.30 - 0.59 = 26.71 in. Hg actual pressure

When the atmospheric pressure or track elevation, temperature, and relative humidity have been established, the true air density is determined as follows:

1. Plot the air temperature and pressure or elevation on the nomograph, Figure 1. Draw a line through these points to intersect the dry air density line on the left and read the dry air density.

Example 3.

Air temperature = 80°

Elevation = 3000 ft.(pressure = 26.8 in. Hg)

Then:

Dry air density = 86.5%

2. On Figure 2a or 2b, for the appropriate elevation range read up from the air temperature to the relative humidity and then read to the right to get the air density correction factor for relative humidity.

Example 3 (cont'd).

Elevation = 3000 ft. (use Figure 2b)

Air temperature = 80°F

Relative humidity = 60%

Then:

Humidity correction factor = .976

3. Multiply the dry air density by the humidity correction factor.

Example 3 (cont'd).

86.5% x .976 = 84.2% true air density

Example 4.

Atmospheric pressure = 28.8 in. Hg (1000 ft.)

Air temperature = 60°

Relative Humidity = 40%

Then:

Dry air density = 96.4%

Humidity correction factor = .994

True air density = 96.4% x .994 = 96%

Selection of Correct Fuel Jet Size

Initially, the engine tune must be established under known test conditions, i.e., true air density. Air temperature, relative humidity, and barometric pressure are recorded during dyno testing by engine builders, and this information is used to determine true air density. Usually the engine is shipped tuned to the engine builders' test conditions. If the engine is tuned by the builder-owner during track testing, the required atmospheric data may be recorded and the true air density determined as described above. Once the tune is established, jet corrections for changes in air density are accomplished by changing the fuel jet size. The procedure described below does not apply to air correction jet sizes. Using Figure 3, the following method is used to select the correct jet size for a change in air density:

Example 5.

Original tune test conditions -

Fuel jet size = 1.4 mm

True air density = 93%

Track conditions -

True air density = 83%

Example 5(cont'd).

Then:

Change in air density = 83% - 93% = -10%

On Figure 3, read from the right along 1.4 mm original fuel jet size to -10% change in air density line, then read down to the corrected fuel jet size = 1.33 mm. Since jets are usually supplied in .05 mm size steps, use 1.35 mm fuel jet.

Example 6.

Original test conditions -

Fuel Jet = 1.5 mm

True air density = 90%

Track conditions -

True air density = 97%

Then:

Change in air density = +7%

And:

Corrected jet size = 1.55mm

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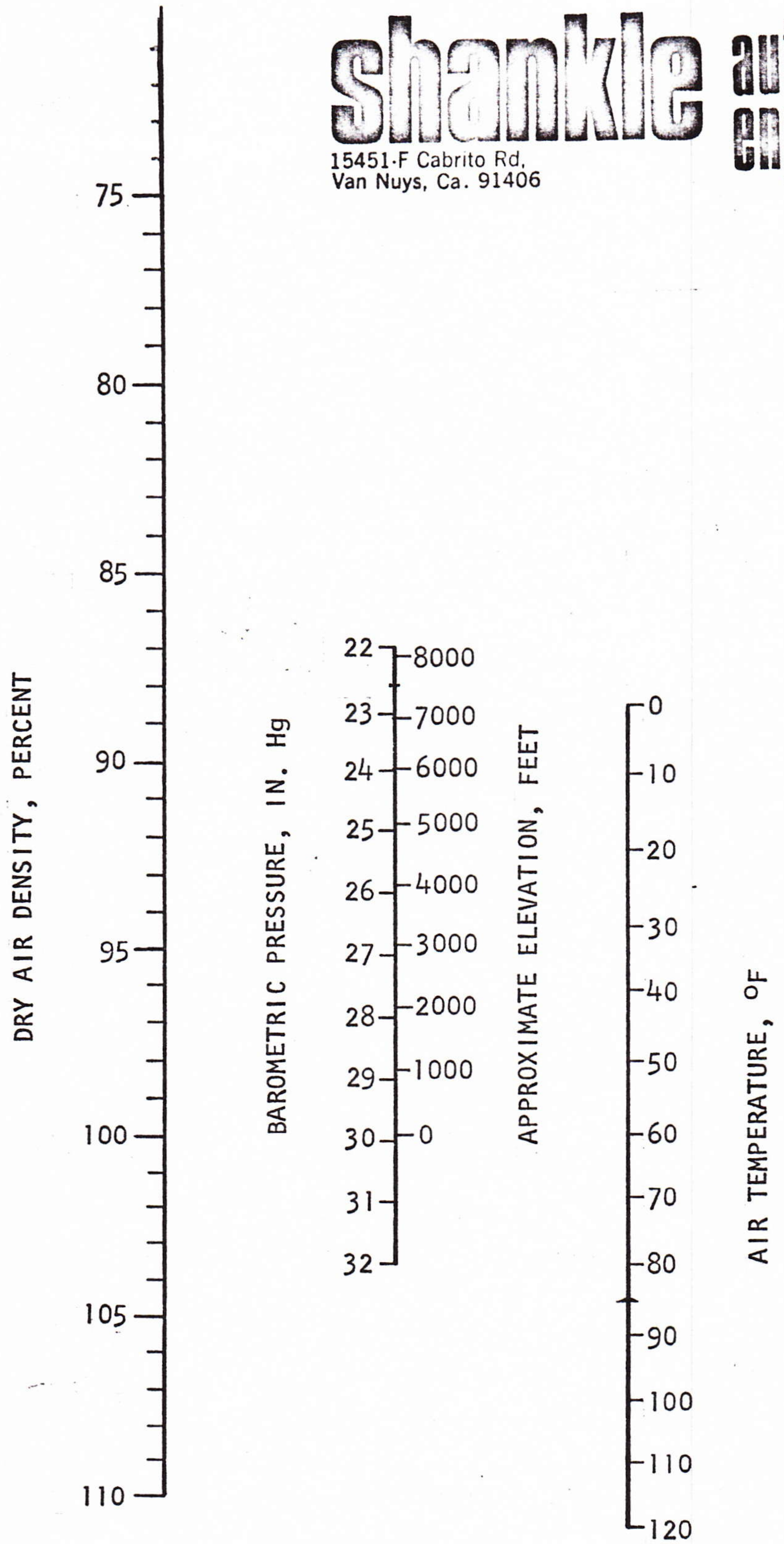

Fig. 1

Nomograph for Determining Dry Air Density

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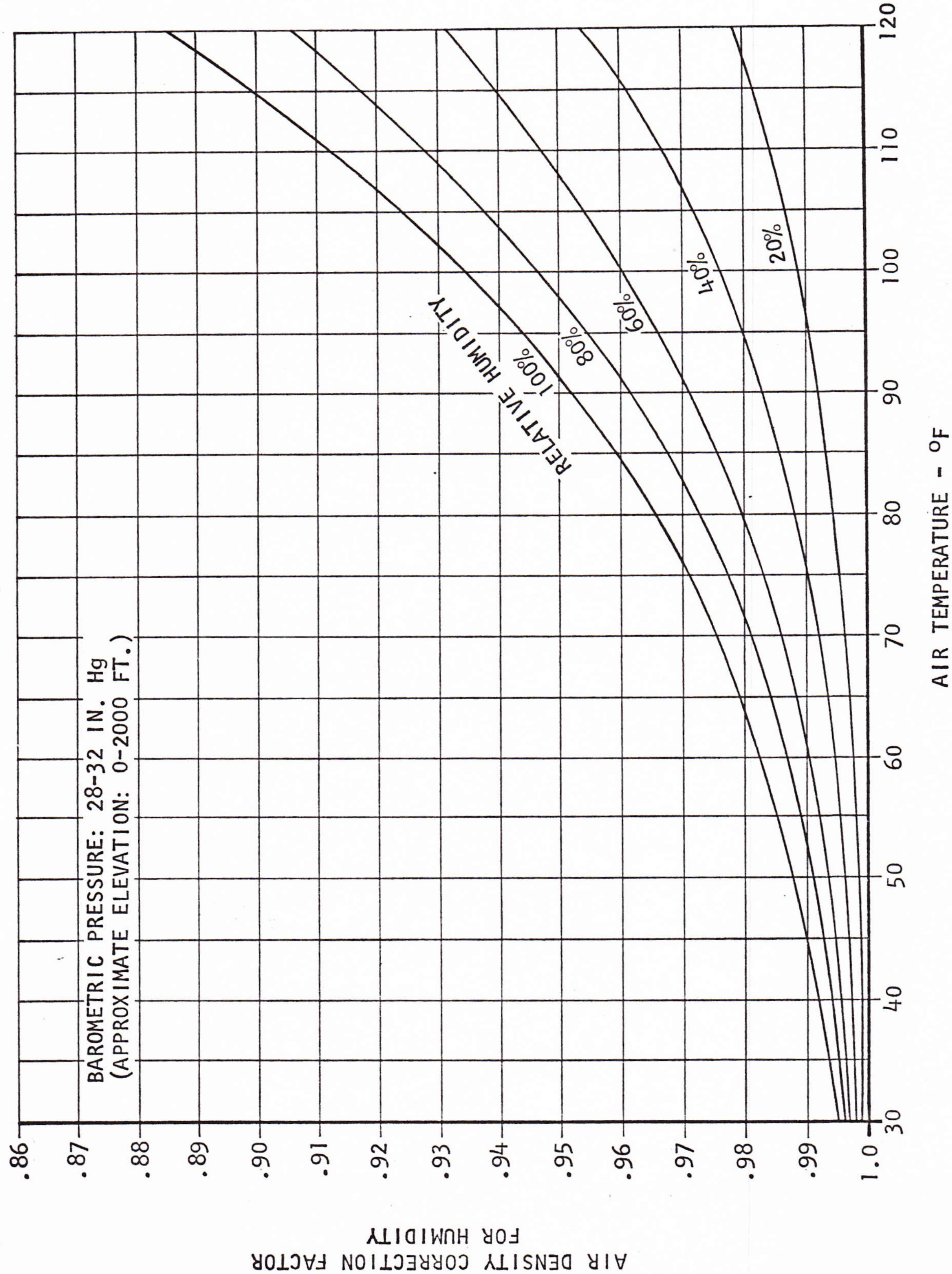

Fig. 2a

Graph for Determining Humidity Correction Factor for Barometric Pressure 28-32 In. Hg, Elevation 0-2000 Ft.

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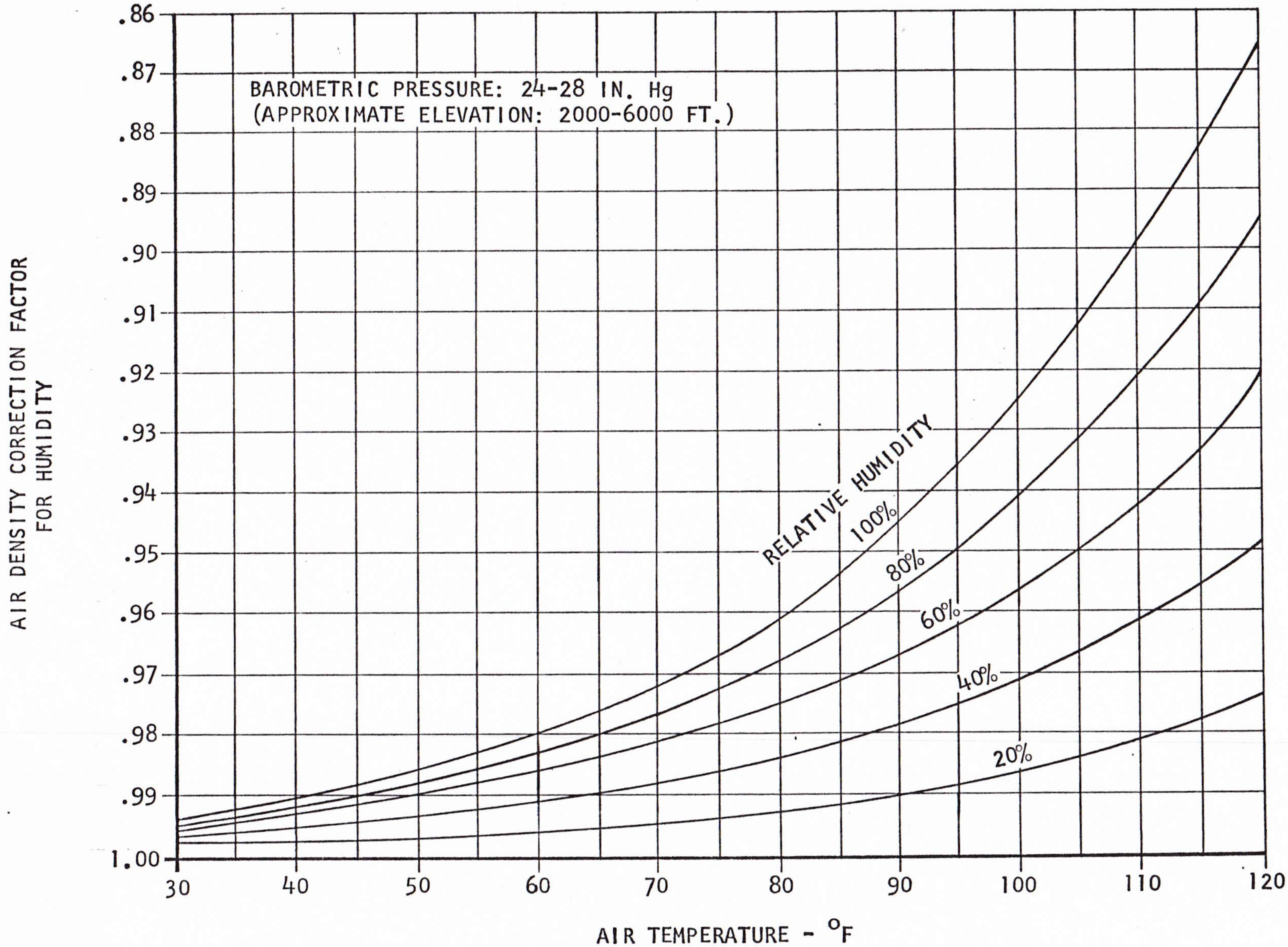

Fig. 2b
Graph for Determining Humidity Correction Factor for Barometric Pressure 24-28 In. Hg, Elevation 2000-6000 Ft.

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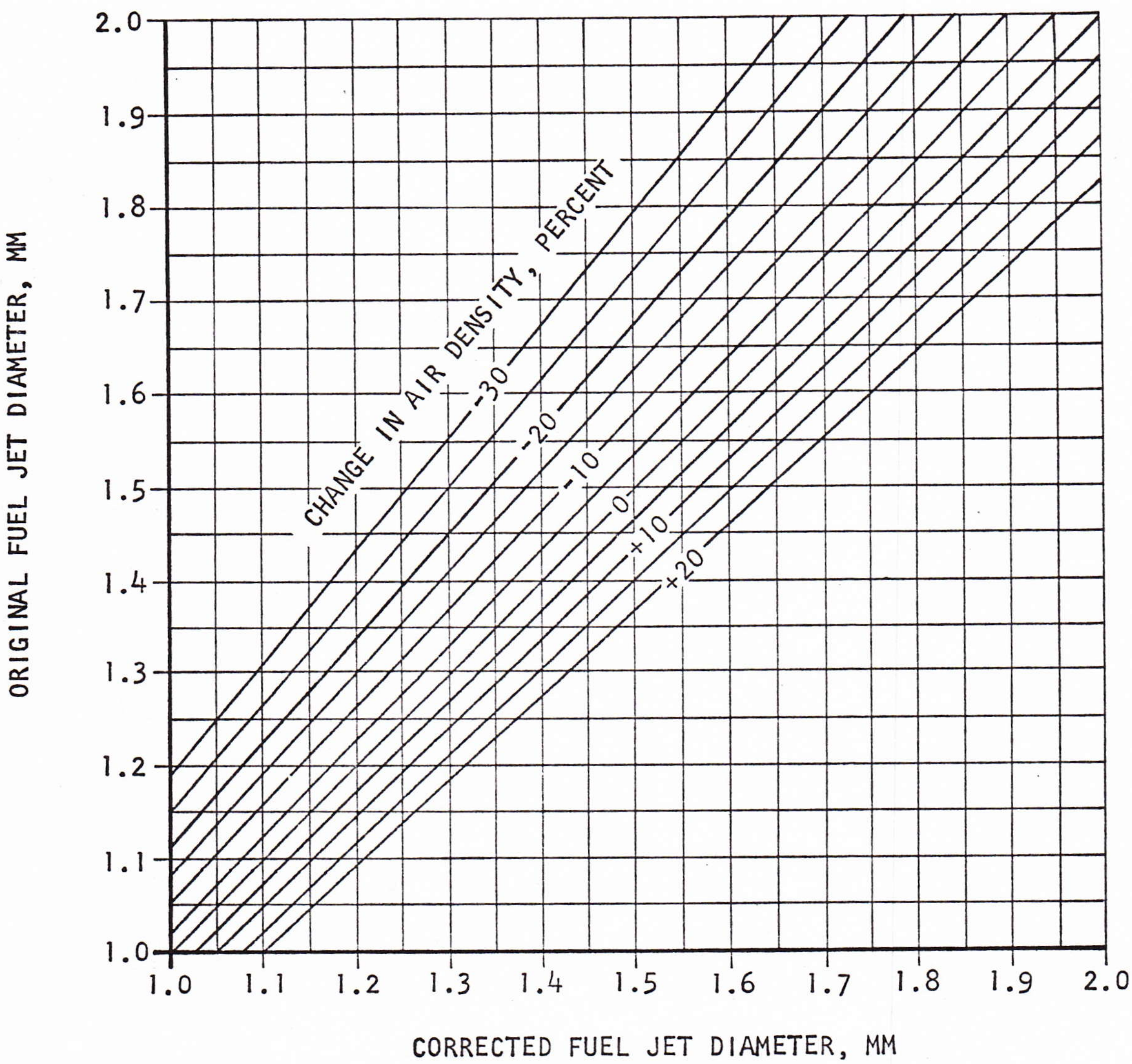

Fig. 3

Graph for Determining Fuel Jet Size Required
to Compensate for Change in Air Density