Oppau Method for Octane Number Determination.

The Oppau Method as described permits the evaluation of commercial paraffinic or aromatic leaded aviation gasoline in a similar way as the DVL Supercharging Method. Unleaded fuels or those containing an extremely high percentage of benzol as well as alcohol blends cannot be tested by this method.

The Oppau Method gives the octane number of aviation gasoline in relation to the fuel-air ratio. Consequently, for each gasoline as many values are obtained as tests with different fuel-air ratios are made instead of a single octane value. The results are plotted in a diagram but they can also be expressed in easily understood numerical terms. For the latter purpose the octane number is well suited since it is a familiar term and permits the evaluation of fuels independently from the characteristics of the test engine.

The different values for a fuel are obtained by changing the fuel-air ratio. In general, maximum knocking intensity lies at a fuel-air ratio of 0.95, that is, between the carburetor setting for maximum output and minimum consumption. The lowest octane number corresponds to the highest knock intensity. At a lean or rich carburetor setting, therefore, higher octane numbers will be obtained for the same fuel as compared to the octane rating by maximum knock intensity.

Whereas the gasoline sample is tested at fuel-air ratios between 1.4 and 0.8, the reference fuel blend is set as usual for maximum knock intensity. The values found in this way are called Oppau Octane Numbers (OOZ). It is advantageous for current tests not to run each sample with two reference blends but to standardize the octane dial of the test engine according to the conditions of the new method. The knock value can then be read directly from the dial and the corresponding fuel-air ratio can be calculated from the consumption of fuel and air. Otherwise, the procedure for octane number determination is the same as usual.

Since the aviation fuels to be tested are very knock-resistant and since this knock-resistance is further increased by making the mixture leaner or richer, the range of the regular IG test engine is not suitable for the octane number determination by the Oppau Method. By raising the inlet pressure the range of the engine is brought within the region desired. As usual, the compression ratio is used as the test variable and is standardized in octane numbers. It should be mentioned here that the inlet pressure also can be used as variable and expressed as octane numbers; however, the compression ratio is more advantageous since the mixture temperature remains constant at all fuel-air ratios, the mixture ratio can be set immediately and read, in most cases, from the gas meter and, finally, the compression pressure is similar to that obtained when working with the bouncing pin indicator which is not the case when measuring by means of the inlet pressure.

Test Engine. The test engine is provided with the following additional equipment:

1. Pressure reducing valve.
2. Surge tank.
3. Gas meter for air

4. Safety valve.
5. Air manometer with connection.
6. Necessary lines and valves with thermometer.
7. Pressure carburetor.
8. Knock meter.
9. Octane number dial.

Parts 1 to 6 are mounted on a common base which is placed in front of the test engine.

As shown in Figure 3, the air enters the surge tank through the reducing valve which is manually controlled to obtain the pressure desired. From the surge tank the air passes through the gas meter and the safety valve into the carburetor air inlet. The second air line branches off ahead of the gas meter and is connected to the three fuel reservoirs of the carburetor; it serves to equalize the pressure on the carburetor and to regulate the fuel-air ratio and this quantity of air is not metered.

The pressure-resistant three float carburetor is shown in Figures 4 and 5. The fuel flows from the reservoir B past the shut-off valve A through the needle valve N into the float chamber from where it passes through the selector stopcock H and the fuel nozzle D into the suction line.

Due to the above-described pressure equalizing line, the pressure in the fuel reservoir and, at first, in the float chamber is equal to the pressure in the air inlet line.

The shut-off valve A is bypassed by a special fuel line which is provided with the measuring bulb K of 20 cc. volume. When the valve is open the fuel reservoir and measuring bulb are connected by a U-tube. When the valve is closed only the fuel in the measuring line can flow into the float chamber. Since the equalizing air can be shut off by valve C, the reservoir can be filled while the engine is run on the fuel from the measuring line.

The carburetor is designed in such a way that it provides a very rich mixture at complete pressure equalization. By means of the special set screw E, the air pressure in the float chamber can be reduced, which results in a leaner mixture. The circumference of this set screw is provided with a scale which makes it easier to find the previously used fuel-air ratio again. The air inlet of the carburetor can be connected with the atmospheric air by means of a special valve V.

<u>Test conditions.</u> The following conditions shall be maintained during fuel testing by the Oppau Method:

1. 600 revolutions per minute.

2. Cooling water at 212°F.

3. Mixture temperature 125°C. (257°F.)

4. Ignition setting 22° before upper dead center.

5. Bosch DM 175 spark plug.

6. Inlet pressure 1000 mm. Hg absolute.

7. Fuel-air ratio; between 1.4 and 0.8 stepwise for the fuel under test; maximum knock intensity for reference fuel.

8. Knock intensity: is controlled by the compression ratio and should be similar to that of the octane number determination by the motor method. It should correspond to the following relation; E = 6.40 for Oppau octane No. 100. Special attention should be given to a sufficiently long run-in time for the reference fuel with Oppau octane No. 100.

9. Bouncing pin apparatus of CFR design. The pointer indication should be at about 50.

10. Knock meter. A moving coil voltmeter with good damping is used. The wiring diagram is given in Figure 6.

11. Octane dial. The dial is standardized in accordance with figure 7.

12. Otherwise, the operating instructions for the IG test engine should be followed.

Experimental Procedure. The shut-off valve of the air inlet for the carburetor is opened and the engine is run according to the operating instructions using fuel from reservoir #2. The sample is filled into the clean reservoir #1 and the reference fuel with Oppau octane No. 100 is filled into reservoir #3. Because of the overly rich carburetor setting, the selector stopcock is not turned exactly to position 2B but is slightly shifted. In this way the diameter is decreased and less fuel flows, thereby providing a normal mixture. The approximately correct setting of the stopcock is determined by listening to the intensity of the knock. The engine should be run at a medium knock until the test temperature has been approximately reached, which requires about half an hour.

The scale of the mercury manometer is set in such a way that the two mercury columns indicate the atmospheric pressure as determined from a barometer. Now the compressed air line is opened, the bypass valve in the air inlet is closed and the motor is operated with the charging pressure. If necessary, the pressure in the surge tank is brought to the desired value by means of the pressure reducing valve. Preheating of the mixture is regulated so as to bring the temperature to the desired value. The selector stopcock is set in position 3B and the testing can begin with the standardization of the octane scale.

The reference fuel of 100 octane number consists of standard fuel-TEL and standard fuel Z1-TEL in the volume ratio 18 to 82; in both cases the tetraethyl lead content is 1 cc. per liter. The mixture ratio is taken from Figure 8. The engine is regulated with the reference fuel of Oppau

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octane number 100 in such a way that the pointer of the knock meter indicates about 50 on the octane dial; this is accomplished first by regulating the compression ratio and then by controlling the set screw of the carburetor. The compression scale should show a value of 6.40. The movable octane dial is now regulated so as to indicate the value of the reference fuel, namely, an octane number of 100, and the average of the pointer indications is noted. All subsequent octane determinations should be controlled to obtain an average pointer indication corresponding to that of the reference fuel.

After checking the octane dial the selector stopcock of the carburetor is turned to position 1B. The engine operates now on the test fuel. The test starts as usual with the determination of the minimum octane number of the sample. For this purpose the compression ratio is set for light knock by turning the hand crank; then the carburetor is set for maximum knock by turning the set screw. The knock meter should now give the same indication as during the previous standardization of the octane dial. If this should not be the case, the compression ratio is changed till the desired indication of the knock meter has been obtained. The octane dial now indicates the knock value of the fuel sample.

In order to measure the air-fuel ratio the shut-off valve of the carburetor is closed and the engine is run only with the gasoline from the measuring bulb. When the gasoline level passes the upper mark of the measuring bulb, the gas meter is started from the zero setting and is stopped as soon as the gasoline level passes the lower mark of the measuring bulb; in this way the air consumption for 20 cc. of fuel can be read immediately. After the gasoline has passed the lower mark of the measuring bulb, the shut-off valve is opened and the measuring tube filled with fuel again. Octane number and air consumption are noted.

The compression ratio is now raised by about one octane number according to the indication of the octane number dial. By turning the set screw clockwise, the air ratio is changed slowly until the pointer of the knock meter reaches the standard setting. Then, the second octane number is read off, the air consumption for 20 cc. of gasoline is determined and noted.

Now the compression ratio remains unchanged and the set screw of the carburetor is slowly turned counter-clockwise until the pointer, after first rising, returns to the desired value. The air consumption for 20 cc. of fuel is again determined and noted together with the octane number which now has not changed.

Testing is continued in this way until 5 to 8 values have been obtained which should correspond approximately to the fuel-air ratio of 1.4 to 0.8. The fuel-air ratio itself is calculated in the usual way. Plotting of the air-fuel ratio against the octane number gives curves as shown in Figure 9. Testing of the sample of fuel takes about half an hour and requires approximately half a liter of fuel. After the test has been completed the selector stopcock is again turned to position 3B and the compression ratio is set to correspond to an Oppau octane number of 100. Simultaneously, the reservoir #1 is emptied after shutting off the air, the reservoir is filled with the next sample and again placed under pressure. During this time the engine has been run with the reference fuel 100. In this way, checking of the octane scale can be done without loss of time.

The accuracy of the determination can be taken as ± 0.5 octane numbers and ± 0.02 air excess numbers in the region of an octane No. 100. These values, however, are only valid for tests on the same test engine.

Similar to the usual octane number determinations, it is necessary to determine periodically the supercharging curve of a suitable test fuel. The octane dial also has to be tested periodically. The bouncing pin indicator is subjected to higher pressures during testing by the Oppau Method and this requires a stronger membrane and also results in higher loads on the lower contact points. The safety valve is set for 0.5 atmospheres and should be tested periodically. No auto-ignition after shutting off the ignition should take place within the region of regular test conditions with the fuel-air ratio as indicated above. According to our experience, auto-ignition is without effect on the test results in the region of the rich carburetor setting.

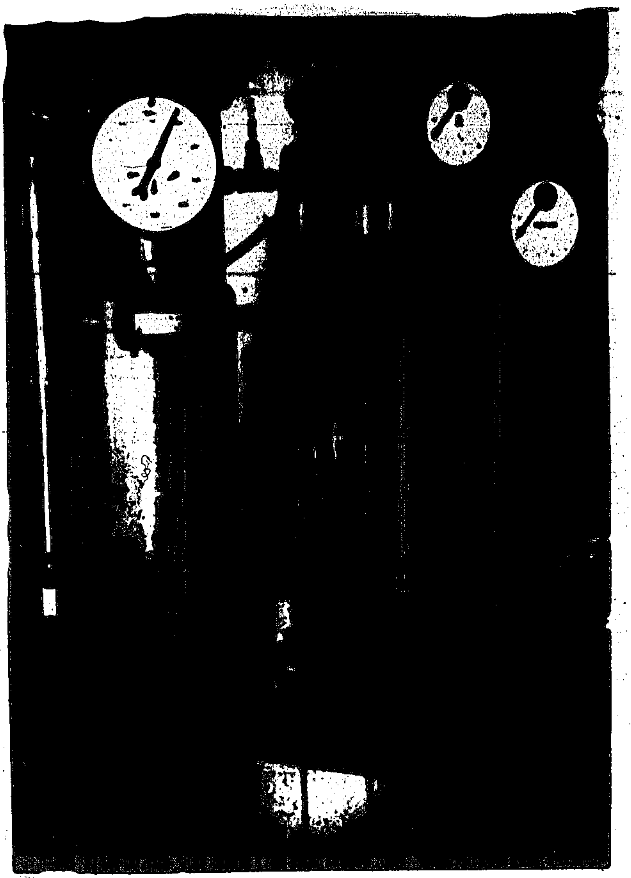

FIG. 2 IG TEST ENGINE WITH ADDITIONAL EQUIPMENT FOR OPPAU METHOD

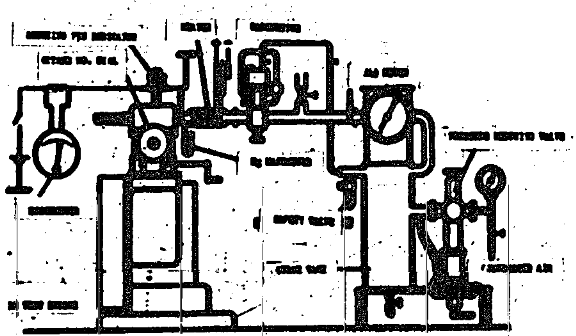

FIG. 3 DIAGRAM OF THE ASSEMBLED TEST ENGINE FOR OPPAU METHOD

ENGINE SPECIFICATIONS

BORE 3.35 IN., STROKE 3.94., DISPLACEMENT 30.25 CU. IN., COMPRESSION 4:1 TO 15:1, 600, IGNITION 22°, COOLANT TEMPERATURE 212°F., MIXTURE TEMPERATURE 257°F., INLET PRESSURE, 1000 MM Hg (CONSTANT).

a. SHUT-OFF VALVE
b. FUEL CONTAINER
c. SHUT-OFF VALVE
d. NOZZLE
e. SET SCREW
k. MEASURING BULB
n. FLOAT VALVE
s. FLOAT HOUSING
h. SELECTOR STOP COCK
v. SELECTOR VALVE

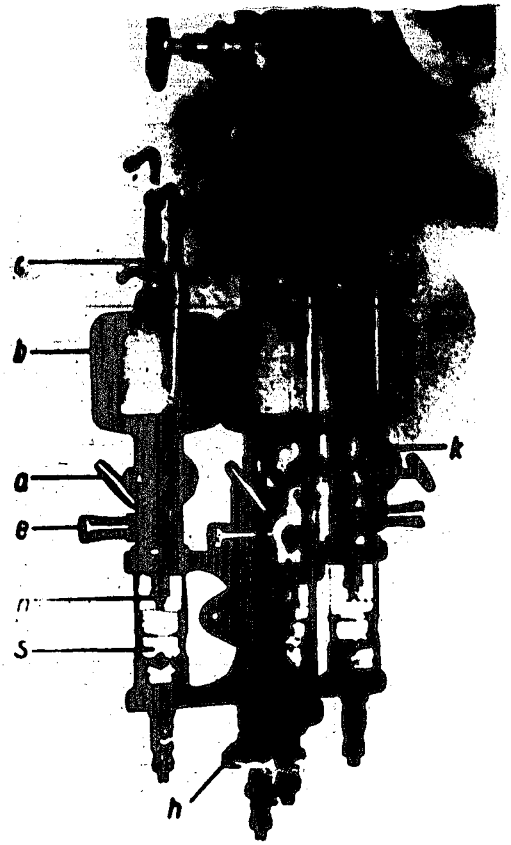

FIG. 4 PRESSURE CARBURETOR

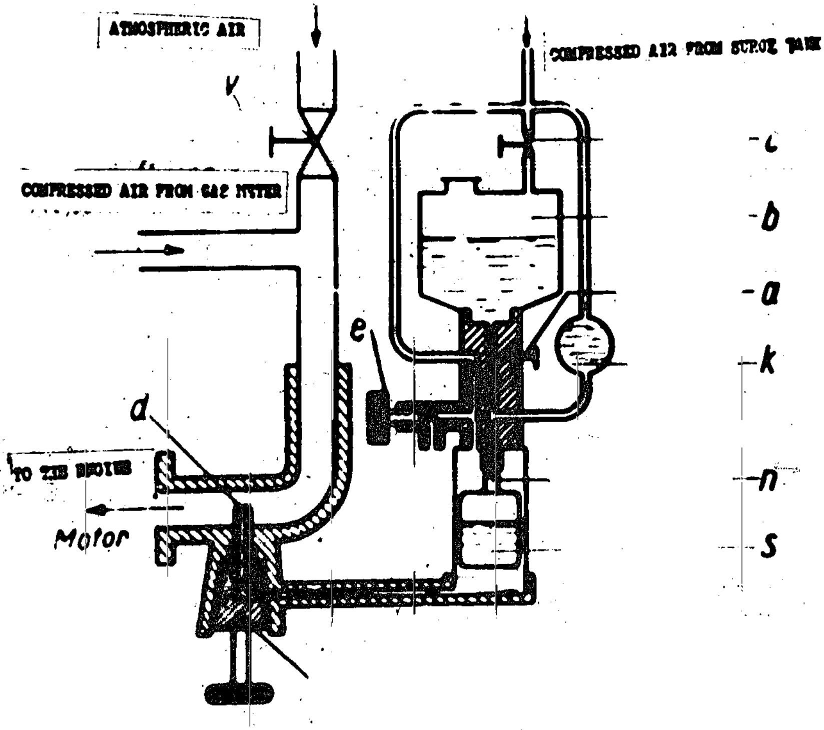

FIG. 8 DIAGRAM OF THE PRESSURE CARBURETOR

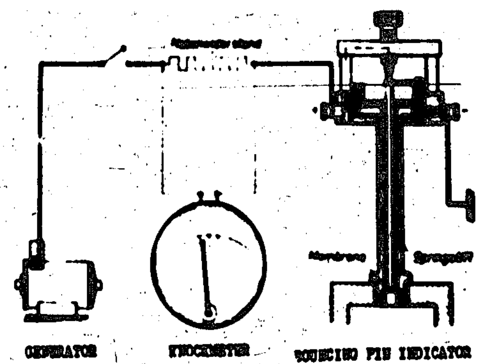

FIG. 6 KNOCKMETER ARRANGEMENT

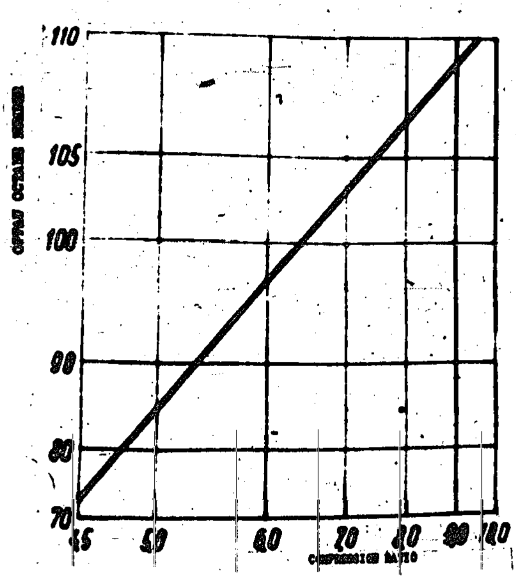

FIG. 7 COMPRESSION RATIO AND OCTANE NUMBER

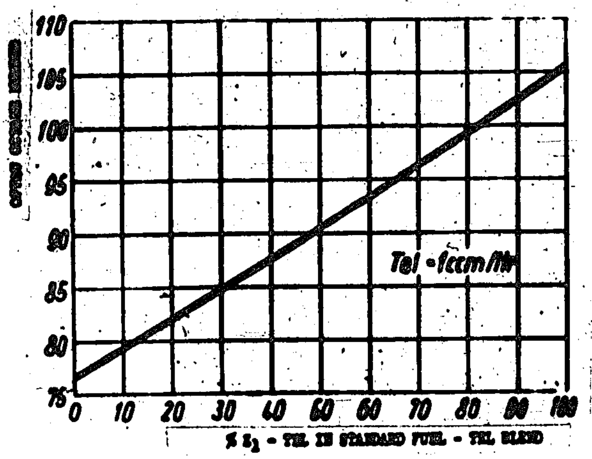

FIG. 8 REFERENCE BLEND AND OCTANE NUMBER

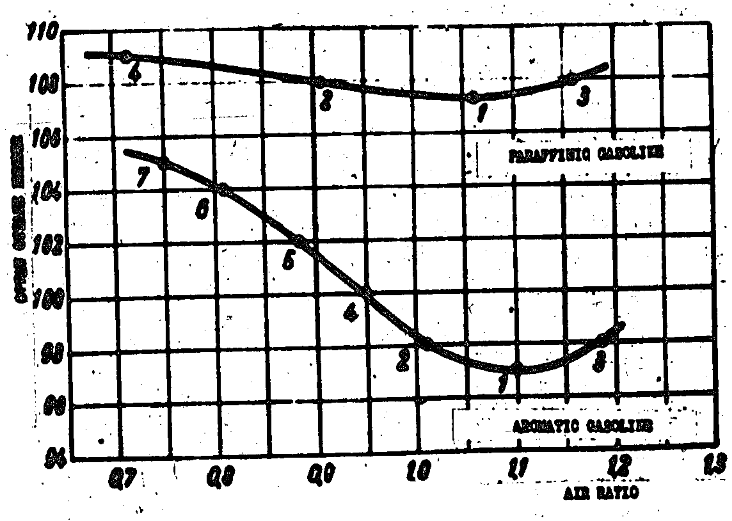

FIG. 9 SUPERCHARGE CURVES AI
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ACCORDING TO THE OPPAU METHOD