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THE I.G.TEST ENGINE

by

F.PENZIG

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Translated by M.O'Farrell.

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In engine development work it is always desirable to investigate fundamental questions on single-cylinder engines, and it is usual to build full-scale marine and aircraft engines only after satisfactory tests have been run on single-cylinder units.

In previous years when detonation became an urgent problem, it was first studied on automobile engines, but the accuracy was soon found to be unsatisfactory since the cylinders behaved differently as a result of non-uniform mixture distribution. Fundamental investigation of the detonation process in single cylinder engines was therefore undertaken, and since an evaluation of Diesel fuels was required a single-cylinder apparatus for this purpose was also necessary. Such special engines had the advantage that measuring devices could be employed, which could not be fitted to a full scale engine.

The conditions in the I.G.Test engine and the I.G. Test Diesel corresponded approximately to those under which the fuels tested in these units were used, and the conversion of the results to practice presented no difficulties. The dimensions of aero-engine cylinders are, however, of a much greater order of magnitude. The surface/volume ratio of the combustion chamber and the flame travel are so different that it is desirable to carry out the investigations on aero-engine cylinders. It is also desirable to utilise components used in the actual aero-engine, so that the conclusions from the single cylinder tests may be applicable to the main engine. It is relatively easy to do this in the case of air-cooled engines, which are constructed of individual cylinders, but for liquid-cooled engines, the development of specially manufactured single-cylinder units is necessary.

Research engines for the study of aviation fuels must therefore be able to be fitted with different types of cylinder, which leads to the construction of a crankcase with a top-plate to carry the cylinder. This type of test stand, as, for example, that developed by the DVL, is often arranged so that the top-plate can be raised or lowered for alteration of the compression ratio.

The Test Station decided to build a research engine specially adapted to fuel testing.

An essential feature was a very strong construction, on account of the unusually high boost pressures employed in fuel testing. It was also considered essential to have an arrangement for varying the compression ratio while running by raising or lowering the top-plate. Furthermore a large number of auxiliary drives was to be supplied to operate the various auxiliary mechanisms. Since the proposed investigation called for an extensive variation of the injection sequence, special consideration was given to the provision of a wide range of adjustment by means of planetary gears. The I.G.research engine developed on these lines and described below, has proved itself excellent for prolonged operation. It has been manufactured in small quantities for research purposes. One unit was supplied to the Rechlin Test Station and one to the Hermann Goering Research Department. Four units are at the Technical Test Station, Oppau.

Construction of the I.G.Research Engine.

The design of the engine is new in so far as a crankcase of cylindrical cross section is used, in which, as shown in Fig.1. is a long tubular sleeve screwed at its lower end (Fig.2) and adjustable vertically by means of a nut. The nut has teeth cut on the outside so that it can be moved by an external hand wheel. Different top-plates can be attached to the upper end of the sleeve, according to the type of cylinder used. In Fig.1. a BMW.132 top-plate is shown, on which the valve gear is also carried. Top-plates for valve gear with vertical drive shafts are shown in Figs. 8 and 9. The long sleeve provides a completely safe means of adjusting the compression ratio under the most severe operating conditions. This is particularly important for fuel testing in which series of tests at different compression ratios have to be performed. With the construction shown in Fig.1. the weight of the sleeve, top-plate and cylinder assembly is taken on four small hydraulic cylinders, so that the play is always taken up in the adjusting thread.

Crankcase and Mechanical Details.

Special attention was paid to the crankshaft bearings, so that no bearing failures should occur with excessive loading. The bearings are attached to the outer housing and supported close to the webs. For this purpose a forked support is provided in the middle of the housing, which transmits the crankshaft forces directly to the base plate. Fig.3. shows the housing and the bearing locations. It is a disadvantage in research work if the engine has to be run for a long time to warm up. To avoid this the crankcase of the I.G.Research engine is equipped with two different types of heating. An electric heating coil surrounds the housing and, in addition, the base plate is hollow and can be heated by steam. According to the supply available the engine can be kept warm overnight, so that testing can be begun without delay the following morning.

The crankshaft, which is carried in roller bearings, consists of several parts assembled by means of the Hirth-type coupling. A dismantled and an assembled shaft are shown in Fig.4. The ends of the crankshaft are screwed into the webs by bolts with the end threads of different pitch, so that an extremely tight connection is obtained by differential action. The hollow crankpin is held by an anchor bolt between the webs.

Gear Box with Auxiliary Drives.

The front bearing housing comprises also a gearbox (Fig.6.) Two accessory shafts are provided, which are driven from the crankshaft by spur gears. They are fitted with bevel gears which drive right and left hand horizontal shafts for the magneto and the injection pump, and shafts arranged vertically downwards for the fuel and oil pumps. Provision is also made for valve gear drives above these shafts. For cylinders with overhead camshafts, the necessary vertical shaft, as shown in Fig.6. is driven directly from the crankshaft. The gearbox is closed by a cover through which the crankshaft and the right and left hand shafts project. It is thus possible to attach additional apparatus, for example a cross shaft driving at the upper end a contact breaker and at the lower end a rev. counter coupling (Fig.7) Other devices can also be used, as for example an indicator for the electric tachometer (Figs. 8 and 9) The free end of the crankshaft can be used to drive the I.G.time sweep apparatus which is provided for use with the quartz indicator to give a stationary diagram on the screen of a cathode ray tube.

In many investigations it is required to adjust the injection timing over a wide range, which can be achieved by fitting a planetary gear drive on the horizontal drive shaft. Such an arrangement is shown in Fig.8, in which adjustment by a hand wheel is provided. A similar arrangement in which a lever adjustment is used for rapid setting of the injection timing is shown in Fig.9, and in Fig.5. the parts of the adjustable drive are given.

Since all engines at the Technical Test Station are situated in sound-proof rooms, remote control systems are essential. Further development is therefore concerned with adjustable drive gear operated by servo motors. This station is applying itself to electrical methods.

The lubricating oil pump, which is seen in Fig.6. is from a BMW.132. By means of one pair of gears the oil is drawn from the crankcase and delivered to the supply tank, from which the other half of the pump takes oil and delivers it to the filter carried under the gear box. From here it flows to the front bearing housing the crankshaft and the crankpin. Further oil ways lead to the bearing housing on the flywheel side and the hydraulic cylinders, and to a distribution point, from which suitable leads may be taken to the valve gear and other mechanisms.

The valve gear for air-cooled engines is built on to the top-plate and enclosed in a cover (Figs.1 and 7). This gear is built as low as possible, so as not to interfere with the cooling air flow. Engines with overhead camshafts require a vertical shaft and bevel drive, the connection between camshaft and drive being through a sleeve with 36 teeth at one end and 40 at the other, so that, as well as a flexible drive, an angular adjustment of the camshaft is provided.