NOTES.

ALTERNATIVE FUELS FOR DIESEL ENGINES.

In continuation of the series of trials with alternative oils in Diesel engines, referred to in Papers No. 5, a series of trials has been completed, using Special Mineral Vacuum No. 2 Lubricating Oil. The physical properties as tested at the laboratory were as follows :—

S.G. at 60° F. - - - - - - ·884.
Flash point - - - - - - 378° F.
Viscosity at 60° F. - - - - 876 secs.
Calorific value - - - - - 19,948 B.T.Us.

Preliminary ignition tests were carried out in the special apparatus used for such purposes and the results showed that no difficulty would be encountered in burning the oil under the conditions obtaining in the engine. The arrangements for the trials were the same as those in the earlier experiments, which permitted running on either of two oils as required; pre-heating was unnecessary.

The engine was first run on shale oil at three quarter load for half an hour and then changed over to lubricating oil; no change was noted in the running of the engine. The diagrams showed little difference except that the ignition was slightly delayed. The exhaust became bluish grey in colour but was not very marked.

After running for one hour, the engine was stopped for 1½ hours. It then re-started readily on lubricating oil. Short fuel consumption trials were run at one half and at one quarter load. A little difficulty was experienced in obtaining steady running at the lowest power although at loads above one quarter the engine was as steady as with shale oil. A short run was made at full power satisfactorily.

On the following day the engine started readily from cold and carried out a six hours' test. During the course of this test, the exhaust became appreciably clearer and towards the end of the run the colour was hardly visible. A variation in the blast pressure from 900 to 960 lbs. had no noticeable effect.

In all the engine ran for 10 hours on this fuel.

A summary of the results follows, in comparison with shale and Texas. It will be noted that the results approach closely to those obtained from Texas, which had a calorific value of 19,200 B.T.Us.

Oil.	R.P.M.	B.H.P.	Fuel in lbs. per B.H.P. hr.	Blast Air Pressure lbs. per sq. inch.
Shale - - -	376	30·1	·407	950
	341	22·4	·406	800
	297	14·9	·421	700
	237	7·5	·466	600
Texas - - -	375	30	·426	950
	341	22·5	·422	850
	299	15·1	·446	750
	236	7·5	·494	550
Vacuum No. 2 Lubricating.	373	29·8	·446	950
	343	22·6	·427	950
	300	15·1	·439	750
	235	7·5	·517	650

The consumptions given do not take into account the power required for the injection air compressor, which is separately driven. On this account about 10 per cent. would require to be added to the fuel rates per B.H.P. at full power and rather more at the lower powers.

Subsequent examination of internal parts showed them to be clean except a soft carbon deposit on the piston crown and inlet and exhaust valve heads, etc. No hard deposits were noted.

The action of palm oil on metals which was noted during the earlier series of trials has been investigated. Weighed rods of five materials, viz., zinc, solder, copper, Naval brass and steel were half submerged in the oil for a total period of 800 hours, during 200 of which the oil was maintained molten at a temperature of about 100° F.; otherwise the oil was kept at atmospheric temperature. After the test the specimens were examined, measured and weighed. Each specimen had a dull lead coloured stain at and just below the "water line." There was no sign of pitting or roughening or other local action. Micrometer measurements, however, showed that the diameter of the submerged parts were from 1 to 2 thousandths less than the original. Each rod also had lost weight noticeably, the percentage losses being :—

Zinc	1·3	per cent.
Solder	3·5	,,
Copper	4·1	,,
Naval brass	6·1	,,
Steel	3	,,

These figures are not strictly comparative, since the areas of the specimens in contact with the oil were not precisely determined. The experiments showed, however, that warm palm oil had a small uniform solvent action on all the samples tested.

In another test a small piece of thin sheet copper (hard rolled) was suspended by a glass hook and completely immersed in molten palm oil kept at an approximately constant temperature at 50° C. At the end of five days the specimen was found to have lost weight at the rate of 2 mgms. per sq. dcm. per day, or ·29 grains per sq. ft. per day.

The oil was allowed to solidify over the week end and during that period the rate of loss of weight was found to be 1 mgm. per sq. dcm., or ·15 grains per sq. ft. per day. The oil was then kept molten for a further five days during which the copper lost weight at the rate of 2·2 mgms. per sq. dcm., or ·33 grain per sq. ft. per day. It thus appears that copper is dissolved approximately twice as fast in warm palm oil as in solidified oil at the ordinary temperature, and that there is an appreciable attack in both cases.

The possible choking effect on oil ways, referred to in earlier notes, has also been investigated. One part of the semi-solid matter removed from the engine after using palm oil was mixed with 10 parts of vacuum No. 2 lubricating oil.

On heating to 75° F., this palm oil appeared to dissolve or be held in suspension, the mixture resembling dirty lubricating oil. This mixture was then heated to 120° F. and thoroughly stirred, afterwards being allowed to cool to 60° F. The palm oil was still held by the lubricating oil and no unusual deposit settled out. The test was repeated with one part of palm to three parts of lubricating oil with generally similar results. It is therefore concluded that the leakage of palm oil into the crank-case would have no special deleterious effects as regards choking of the oil ducts, at least no more than obtains with some other classes of fuels, although the nature of the oil in the system would in time be changed as regards its viscosity and flash-point, this also being common with other fuels in general use.

MICHELL ENGINE DEVELOPMENTS.

The advent of the Michell bearing lifted accepted ideas of lubrication and bearings out of the rut which they had occupied, and better acquaintance with the applied principles was sufficient to show that the Michell bearing did not begin and end in marine thrust blocks. Many promising mechancial applications have failed owing to friction and the overloading of lubricating films, and the Michell principle is reviving hopes in the ultimate success of many such projects.

The swash plate or slanting disc on a rotating shaft has become familiar through its extensive use in hydraulic variable gears, and by its use Mr. Michell has been able to dispense with a crankshaft and connecting rods in a prime mover. The pistons drive directly on the sloping surface of the swash plate (or " slant," as it is preferably called), and the bearings between the plate and the pistons are in the form of the familiar rocking pads faced with white metal. A Michell bearing is also used for the thrust of the engine shaft. The Air Ministry recently commissioned Rolls-Royce, Ltd., to build an experimental aero-engine on these lines, and the results have been very successful, while crankless 400 h.p. 18-cylinder aero-engines are being developed in America.

A Michell crankless 35 b.h.p. 8-cylinder motor-car engine is fully described in the current technical press. The nominal power is developed at 1,250 revolutions per minute, but owing to the ease with which such an engine can be balanced, 3,000 revolutions per minute can be easily attained without noticeable vibration, 60 b.h.p. being developed at this speed. The makers expect that 5,000 revolutions per minute will be possible when certain alterations in the valve gear and carburettor—details which at present limit the range—have been effected. The eight aluminium cylinders are arranged at equal distances around the engine shaft with their bores parallel to the latter. Four cylinders are arranged on each side of the " slant," and opposite cylinders are connected by a steel U-shaped yoke that bridges the rim of the " slant " and forms a base for the hemispherically backed Michell bearing pads. The cylinders are each of 3·312 inches in diameter and the stroke is 3·51 inches so that the total capacity is about 4 litres. The compression ratio is five to one and the " slant," which is 10 inches in diameter, is $2\frac{1}{16}$ inches thick and inclined at an angle of $22\frac{1}{2}$ degrees with the engine shaft axis.

Some comparative tests have been made with this crankless engine, and a well-known orthodox six-cylinder motor-car engine with a total capacity about 18 per cent. greater. The most striking fact brought out by these tests is that while between 1,600 and 2,000 r.p.m. there is very little difference in the brake horse-powers of the two engines, at higher speeds the crankless engine maintained its power much better than the other engine.

Although the crankless engine described above was designed without much regard to the saving of weight, it is lighter by 25 per cent. than orthodox engines of similar power.

The principle is also applied to steam engines in Australia, these being of the uniflow type, to which the design particularly lends itself. Units of this type, designed for 750 H.P. at 1,600 revolutions per minute, are projected for driving centrifugal pumps, and it has been estimated that the consumption of steam in units of this size may not exceed 8½ lbs. per B.H.P. per hour.

HEAVY OIL ENGINE CONFERENCE IN GERMANY.

A conference was held recently in Berlin under the auspices of the Verein Deutscher Ingenieure at which a number of papers dealing with the development of and recent investigations and research in connection with the Diesel engine were read and discussed. The papers were presented in great detail, and they provide an interesting contribution to the available technical data on this class of prime mover.

Some of the particularly interesting items are given briefly in the following notes :—

Professor Nagel in a very long paper reviewed the present position of the Diesel engine, and outlined its development in the last 10 years, his present paper being a supplement to a generally similar paper read by him in 1911. He grouped the development under four main headings in which it was considered progress was most conspicuously shown.

He first referred to the constructional details of the Diesel engine, and an important feature in his opinion (which he agreed was, however, a logical accompaniment of the increase in power and particularly the application to marine work on a large scale), was the appreciation of the necessity for a construction which gave great longitudinal rigidity. Such is necesary to prevent the severe racking strains called into play by the heavy engine forces, these strains being a fruitful source of mechanical troubles due to defects in alignment that may be set up. The chief method of securing this stiffness was the departure from a construction which tended to consider each cylinder line as a separate item and the adoption of a continuous bedplate and engine framing; or, where such was not adopted, an elaboration of stays, tie-rods, etc., which maintained an intimate connection of all parts of the engine and secured a rigid whole. In particular in the high-speed designs, such as in the submarine practice, the bedplate was made very deep, the top facing being carried well above the centre line of the main bearings. As a consequence of these developments, the importance of which is still, however, liable to be overlooked, mechancial difficulties arising from the severe racking strains have been almost eliminated. Such development has, of course, gone hand-in-hand with the use of improved materials and design of individual details. The extensive use of cast steel, which is a feature of German high-speed practice, is especially to be noted.

The design and construction of cylinder covers for high speed and power engines was also particularly referred to, this constructional detail of a Diesel engine being still looked upon as most difficult to design satisfactorily, in view of its generally complicated nature and its exposure to heavy loading and heat stresses. The latter stresses can generally be considered the more important, and it can be appreciated that if the construction be stiffened to provide greater resistance to the loading stresses, the change will in general be accompanied by an increase in the heat stresses. As a consequence, in modern practice, the cover is either protected by a water-cooled combustion plate which relieves the structural portion of the heat stresses and reduces it to a pure strength member, or its construction provides for subdivision horizontally. In the latter case the cooling water is given a definitely directional flow at high velocity through the lower space and thus to reduce the heat stresses in the lower wall forming the boundary of the combustion space. The cover in some cases is also in two parts, the inner being free to expand relatively to the outer portion. The latter is the member carrying the stud or bolt holes, and in the ordinary way is not subjected to the heat which is transmitted to the central portion by virtue of its contact with the combustion space.

Various other engine details of lesser importance were referred to briefly, but these do not call for particular mention.

The second point was the increasing use of the two-stroke cycle employing port-scavenging; the larger capacity per cylinder, the absence of certain valve gear, and a possible reduction in the cost of manufacture and upkeep, being points of practical and commercial value. It was, therefore, not unreasonable to suggest that the double-acting two-stroke engine—in which one may include the opposed piston construction—was the obvious practical line of development.

A detailed description of the large 6-cylinder two-stroke double-acting engine employing valve-scavenging was given, this being the first public notification of these particulars. It was constructed at the Nürnberg works of the M.A.N. Co., and was originally intended to be fitted as a high-powered cruising engine in a German capital ship. The cylinder diameters were 840 m.m. (33½ inches), and the stroke 1050 m.m. (41½ inches), the engine being designed to develop 12,000 B.H.P. at 160 r.p.m. It was stated that after certain preliminary trials a continuous series of tests were made between the 4th January and the 5th April, 1917, during which tests the engine ran over two million revolutions at powers ranging between 10,800 and 12,000 B.H.P. with very satisfactory results. Later in the year, October, 1917, one cylinder of this engine was worked up to 3,750 I.H.P. at the reduced speed of 145 r.p.m., corresponding to a mean indicated pressure of 144 lbs. per sq. inch. The mechanical efficiency of this single cylinder unit (scavenge, etc., pumps being separately driven and not included) was of the order of 90 per cent. It was not possible from general design considerations, including capacity of auxiliaries, to run the whole engine up to such a high power, but it was stated that for a short period 17,150 B.H.P. was obtained, which represented an overload of 43 per cent. based on the design figure of 12,000.

Exhaustive data was obtained from this engine, and in spite of the high power yielded, the heat stresses in such vital details as the cylinder covers, liners, pistons, piston rods, etc., as deduced by pyrometric and thermometric means, were not excessive. This was due to the elaborate cooling arrangements, and the utilisation in particular of high speed directional flow of the cooling water. The liners were enshrouded in ribbed shields which impelled the water to follow a spiral path on their outer surfaces, whilst the cylinder covers had the divided construction referred to previously.

The fuel consumption at nominal full power was given as ·44 lbs. per B.H.P. hour, which is a little high, but must be considered satisfactory for such an engine.

This engine was never fitted in a ship and was broken up after the end of the war. The data obtained, however, must certainly be of immense value in the event of any future development necessitating very large units.

The results of a great deal of experimental work were published to support the contentions that for effective scavenging in two-stroke engines, the exhaust ports—

(1) should be on the same side as the scavenging ports;
(2) should be situated above them; and
(3) should not extend quite as far round the circumference of the liner as the scavenging ports.

This is a departure from the normal and possibly constructionally simpler arrangement where these series of ports are on opposite sides of the cylinder. Whatever else is proved by these tests, it is clear that a final conclusion as to the best disposition of these ports remains to be established. It was, however, certainly demonstrated that port-scavenging is superior to valve-scavenging, and the comparatively high consumption of the large M.A.N. engine may be partly accounted for by the latter feature. In the port-scavenging arrangement it was deduced that 1·5 times the cylinder volume is a sufficient amount of scavenging air for all practical purposes, whereas with valve-scavenging, 1·5 to 1·8 times appears necessary.

The third point was the increasing use of so-called "solid" injection of fuel as contrasted with the blast-air injection method. This can be considered an universal development and is notably a feature of the Vickers and Doxford engines in this country.

The fourth point was the adaptation of the Diesel engine to satisfactorily use low-grade fuels generally classed as "boiler" oils, and including in such category, heavy tar-oils. In the use of such fuels special injection arrangements are often necessary, including in some cases, pilot injection of a lighter fuel to initiate the combustion. Heating of the oil before delivery to the engine is also essential to ensure the complete combustion of a normally slow-burning fuel in the short time available.

A novel development in connection with the utilisation of heat in the exhaust gases refers to the pre-heating of starting air to protect the cylinders from the effects of chilling due to the expansion of the air and to economise starting and manœuvring air. The air is taken through specially arranged jackets in the non-water cooled elbow connections between the cylinder heads and the exhaust manifold. In certain extended trials on a marine engine it was stated that, following a normal running period, *i.e.*, when conditions as may be expected on service were obtained, the starting air on leaving the jacket was at 500° F., if an intermediate manœuvre were carried out. Even if the engine were maintained stationary for half-an-hour, starting air could be supplied to the engine at 275° F. in this manner. It was also stated that the average consumption of starting air per cycle was about half that of a similar operation on cold air.

In the matters dealt with by other contributors, it is noted in particular that Dr. Riehm stated he had attained a mean indicated pressure of over 170 lbs. per sq. inch, using an air excess of only 29 per cent. The experiments were carried out on a nominally 70 B.H.P. unit (400 m.m. by 600 m.m. by 160 r.p.m.). The data given, however, lacks particular information as to the length of the tests, but, considered in relation to a number of other figures given, it appears that superchanging (*i.e.*, increasing the weight of cycle air by adding air during the compression or working stroke, or by pre-compressing the cycle air) is an effective means of increasing the rating, even when the additional external work required in supplying the excess air is taken into account. Incidentally, it was stated that exhaust gas turbines may be employed for driving the blowers and thus effectively utilise from 6 to 8 per cent. of the energy otherwise lost in the exhaust pipe.

The matters discussed included a discourse on heat transmission, and also one by Dr. Geiger, on measurement and analysis of vibrations and torsional oscillations in Diesel engine work. For this latter investigation, Dr. Geiger has invented a torsiograph which enables these oscillations to be continuously recorded.

Standardisation and mass-production were also discussed.