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# LIQUID FUEL.

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The term "Liquid Fuel," in a general sense, covered all liquids that were in use as fuels, but in the particular sense in which it was used in the oil trade the expression included only that product which was otherwise known as Residual Oil.

Residual Oil, as its name implied, was not Crude Petroleum. It was a product of Crude Petroleum, from which other lighter and heavier products had been removed in the process of refining.

The Petroleum fields of greatest importance in the vicinity of Australia were those of the East Indies. Generally speaking, all Petroleums, by careful refining, could be made to yield practically a full range of products from light spirits to heavy oils and wax, all probably of fair average quality. But Petroleum Oils from various districts had each some outstanding characteristic, some quality or qualities in which they were peculiarly valuable. The outstanding quality of the East Indian Petroleums was their value as fuels, and this quality applied to all the Eastern oils used as fuels—from motor spirits down to residual oils.

The residual oil imported into Australia was of Eastern origin. It was freely flowing oil, dark mahogany in colour, with a high flash point and low cold test. Its specific gravity at 60 deg. F. was .950. The average composition of liquid fuel is 86 per cent. carbon, 13 per cent. hydrogen, and 1 per cent. oxygen. One pound of oil required about 22 lbs. of air as a minimum for combustion. Oil was in use for a great variety of fuel purposes, the most important being for boiler firing, oil engine fuel, rivet heating, glass making, and distilling for gas-making purposes.

Naturally, all fuels, whether solid or liquid, must be handled with care. If a few simple precautions were observed, residual oil was a perfectly safe fuel. Given these precautions, it was, on the average, a safer fuel than coal.

Oil was the most valuable of all commercial fuels. Its theoretical value, as compared with coal, works out as follows:—

| Fuel. | S. G. at 32° F. | B.T.U. | Pounds Water Evaporated. | |
|---|---|---|---|---|
| | | | From and at 212° F. | At 8½ atmospheres effective pressure |
| Petroleum ... (4 Samples) | ·909 | 20,683 | 21·41 | 17·8 |
| Good English Coal 98 Samples) | 1·380 | 14,112 | 14·61 | 12·16 |

Oil, therefore, weight for weight, had a very much greater theoretical fuel value than the best coal. In practice this advantage was still greater, because it was possible to attain an efficiency with oil fuel that was unattainable with coal. The steamer "Murex" burned 24 tons of Cardiff coal per day, or 29 to 30 tons Japanese coal. When fitted for oil burning, she consumed only 13 tons of oil per day. The s.s. "Clam" succeeded in reducing her consumption of 31 tons of coal per day to a consumption of 15 tons 8cwt. of oil. Oil, with an average calorific value of 19,320 B.T.Us., would evaporate 16.6 lbs. of water per lb. of fuel burned, 83 per cent. of the calorific value being recovered in the actual work. Coal, with a calorific value of 14,500 B.T.Us., would evaporate 8.5 lbs. of water per pound of fuel burned, representing an efficiency of 55 per cent. On the Japanese Government railways, engines burning Borneo oil on the Holden System, evaporated up to 14.42 lbs. of water per lb. of oil, the yearly average for oil being 12.6 lbs. of water per lb., as against 6.4 lbs. of water evaporated per lb. of coal.

In 1906 the tank steamer "Goldmouth" ran from Singapore to London, via the Cape, 11,752 miles, in 52 days, at an average speed of 9.43 knots on a consumption of 30¼ tons of liquid fuel per day for her main engines. Nearly 2500 tons of coal would be required for a similar trip.

The twin-screw steam "Wien," on a 47¾ hours' run from Brindisi to Alexandria, put up the following performance, using Wallsend-Howden patent pressure oil-burning system and Howden's forced draught:—

| | |
|---|---|
| Number of burners in use . . . . . . | 27 |
| Calorific value of fuel used . . . . | 19,620 B.T.U. |
| Sp. G. of oil at 60 deg. . . . . . . | .9294 |
| Steam pressure average . . . . . . | 213 lbs. |
| Weight of oil burned per hour . . | 10,003 lbs. |
| Oil consumption per I.H.P. per hour for propelling machinery | 0.907 lbs. |
| Oil consumption per I.H.P. per hour for main engines only . . | .845 lb. |

The advantages of liquid fuel as compared with coal do not lie only in such performances as these. In no place are its advantages so conspicuous as when used for marine purposes, and particularly when used for naval vessels. The Royal Commission appointed by the British Government, through its Chairman, the late Lord Fisher, reported that "the advantages of oil fuel had been conclusively established," and the Admiralty had now asked for half a million pounds to increase its oil reserves.

Liquid fuel saves labour. It had been calculated that if the "Lusitania" were converted to oil burning, her 312 firemen could be replaced by 27 oil attendants, and her boilers would steam more regularly and with less wear and tear. On the steamers "Murex" and "Clam," fourteen firemen and trimmers were replaced by three firemen, one on each watch.

Liquid fuel was a clean fuel. It could be burned without smoke. It could be put on board without either the dust or noise occasioned by bunkering with coal.

Liquid fuel saved time, not only by its regular service, but also by the rapidity with which bunkering could be accomplished. R.M.S. "Niagara," on her first visit to Vancouver, took 4200 tons fuel oil in 30 hours, more than enough for a complete round trip. A similar steamer taking coal bunkers at the same time at an adjoining wharf, for half a similar round trip only, took a week; so that the bunkering for her round trip would occupy about a fortnight. Assuming that such steamers had a daily expense of £120 for labour, upkeep, etc., the extra delay caused by bunkering with coal would run over £1400. The speed of bunkering depended almost entirely on the rate at which the steamer was able to take the oil. Bunkering a passenger steamer with oil had been carried out in Sydney at the rate of 180 tons per hour.

Liquid fuel enabled saving of space to be made. If the "Lusitania," for instance, were on oil fuel, the quarters occupied by 285 firemen could have been used for other purposes. Apart from such savings as these, liquid fuel, weight for weight, occupied only five-eighths of the space required for coal, and further it could be stored in ships' bottoms and in other parts of vessels in which space was wasted. When used for naval purposes, liquid fuel could be taken on board at sea even in rough weather; high speeds could be more readily attained and held; and the range of action of war vessels vastly increased.

Patented oil burners were almost without number, and some highly-efficient systems had been devised for securing economical results. Between the best half-dozen systems there was little to choose. The Wallsend-Howden system appeared to be the most commonly used of the better systems. In the older methods of fuel-burning, it was found necessary to use a great deal of brickwork, for two main reasons, viz., to prevent the gases impinging on the water-cooled plates before combustion was complete, and to ignite any imperfectly atomised oil that might fall on the incandescent brickwork. The Wallsend-Howden system dispensed almost entirely with brickwork. The illustration (Fig. I.) showed only a single ring of brick at the firebox end. This was provided chiefly to protect the front plates of the furnace from the great heat developed by the combustion of the oil. In the Wallsend-Howden system the oil was injected into the furnaces under pressure by means of

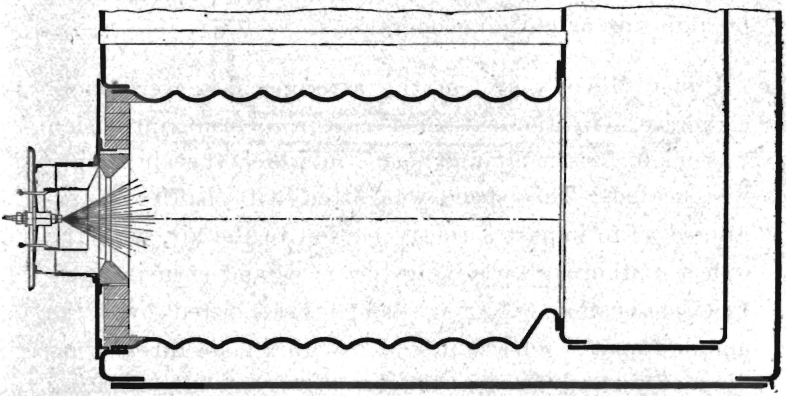


Fig 1.

special pumps, passing through strainers and heaters en route. The oil was given a whirling motion just before it left the burner, from which it was forced through a very small orifice, opening out into a conical spray, well atomised, and burning at a distance of about 6-8 inches from the nose of the burner. The fire-bars being dispensed with, the whole furnace was available for combustion space and heating surface, and consequently uniform heating of all parts of the furnace took place. The admission of the air was so controlled that a whirling motion was given to it having a direction of rotation opposite to that of the particles of oil. As a consequence a very thorough mixing of air and gas took place. In principle this system was broadly illustrative of the best of the modern systems in use. It was the practice in some plants to duplicate the pumps, heaters, etc., so that there would be no stoppages on account of breakdowns or cleaning operations.

Under Meyer's system the arrangements were more elaborate. In the extended cast-iron front, provision was made for an annular space in which the air supply was heated. This space was fitted with baffles so arranged as to impart a rotary motion to the air, with the object of thoroughly mixing the gases and ensuring perfect combustion. A ring damper was fitted over the annular space, and was provided with a male thread running over studs fixed in the furnace front. By rotating this damper the supply of air could be controlled with absolute precision. With this system it was usual to leave the firebars and brick arches in position so that the furnace could be converted for use with coal in very short time. In other respects, this system was practically identical with the former one, the oil being heated and filtered and sprayed under pressure without the aid of either steam or compressed air. The s.s. "Romany," 3592 tons gross, fitted with the Meyer system, recently completed a voyage of three months, during which she steamed at an average speed of 11 knots, with a daily consumption of 20 tons of oil for all purposes. This worked out at .95 lbs. of oil per I.H.P. per hour. It would be noted that each of the systems described dispensed with the use of either steam or compressed air as a spraying medium. High efficiency, however, was obtained with many burners designed to use these mediums; quite a large number of them yielded first-class results. An elementary burner or sprayer could readily be made with two lengths of ordinary gas pipe placed concentrically one within the other, the oil being introduced through the outer one and atomised by steam issuing from the other. Fig. II. showed a modified form of such a burner, in which the internal steam pipe is contracted to form a jet, and the oil allowed ingress to this through holes provided in the end portion. The combustion would be very intense about the nose of the burner, and firebrick construction would be necessary in order to evenly distribute the heat. The burners used in the railways of Southern Russia were modified forms of this pattern.

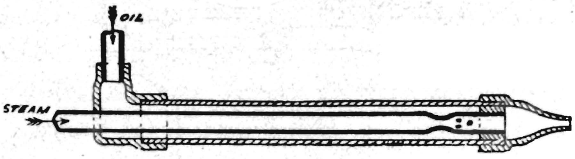


Fig. 2.

On the British railways, Mr. James Holden, Locomotive Superintendent of the Great Eastern Railways, had used liquid fuel for steam raising for many years.

His burner was made in several patterns to suit various purposes. One of these was shown in Fig. III. The oil

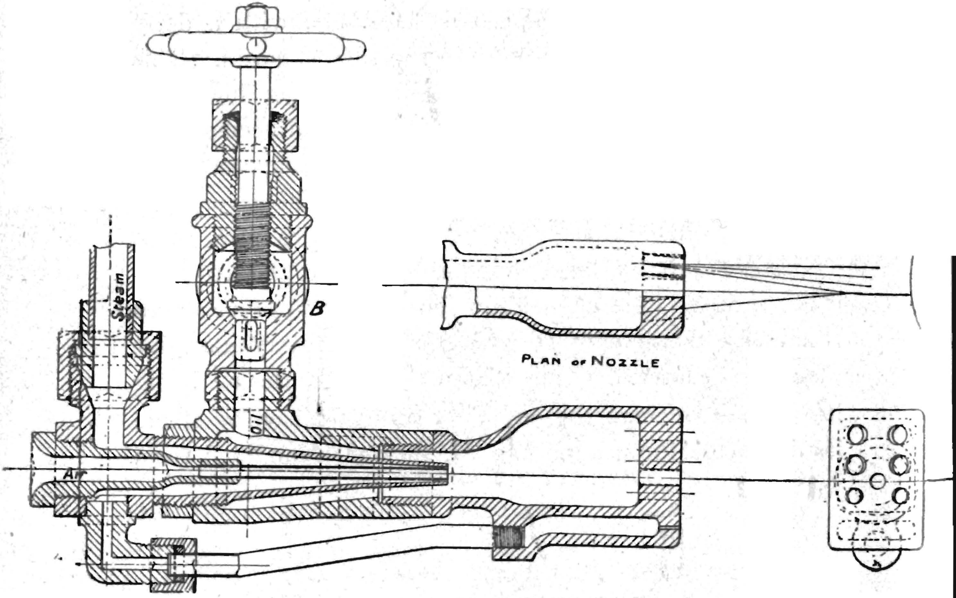


Fig. 3.

was admitted through the top of the burner through a special control valve. The steam was admitted in the rear of the burner, and passed through an annular passage to the chamber at the fore end, where it came in contact with the oil, and also with the induced air which was drawn through the central orifice from the rear. The mixture was sprayed through angular jets at the nose of the burner, and the atomising was completed with the assistance of the supplementary steam jet in the lower part of the burner.

Another very effective steam spraying burner that made use of a central air supply was the Osborn burner shown in Fig. IV. Three of these burners were in use

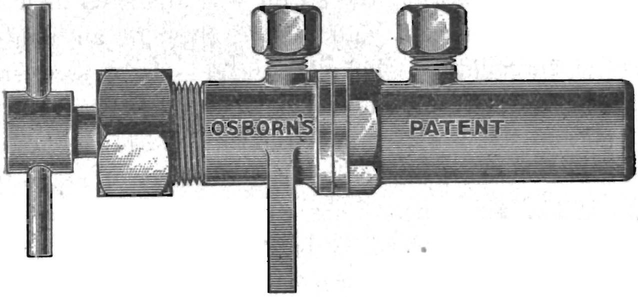


Fig. 4.

in Sydney on a Babcock and Wilcox boiler. This burner could also be used with compressed air for spraying instead of steam.

The Rusdon and Eeles burner (Fig. V.), using steam, had a special feature of its own, in the shape of a steam jacket around the oil space. As the steam for atomising purposes passed through the centre of the burner, the annular oil space was always surrounded by live steam, which was a decided advantage in cold weather, especially where no preliminary heating devices were in use.

Messrs. Kermode and Co. made three types of burners in which the spraying was accomplished by means of hot compressed air, steam and oil pressure respectively.

In the first-named type the oil was partially vaporised and sprayed by means of hot air at from ½ lb. to 4 lb. pressure. The oil and air both entered near the rear of the burner, and travelled through it together, being well mixed by the influence of the twisted spindle. A further supply of air was encountered by the oil at the nozzle, and other air was supplied just where combustion commenced beyond the burner.

In the steam burner the steam was admitted near the centre of the burner, and passed through an annular passage surrounding the oil passage. In consequence, the oil was heated as it travelled along the spiral spindle. The oil and steam united near the fore end of the burner, and were mixed with an induced draught of air before leaving the air cone. This air was given a whirling motion by means of spiral baffles. The makers stated that the hot air system was more economical than the steam system.

In the pressure jet burner, the air, after preliminary heating and filtering, was sprayed through a very small orifice at the end of the burner by means of a force pump. Provision was made for giving the oil a whirling motion just as it left the burner. This burner was very efficient, and was largely used for naval purposes.

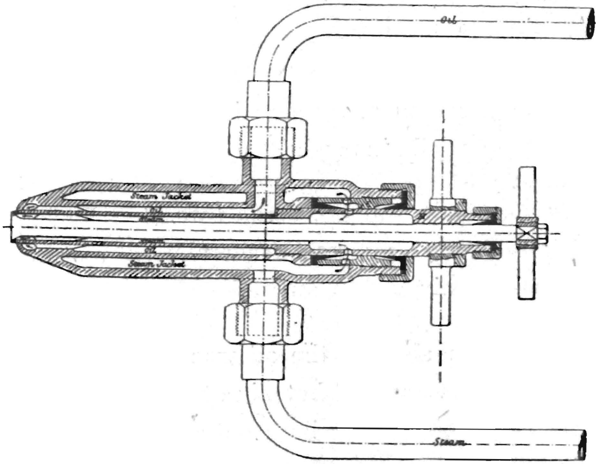
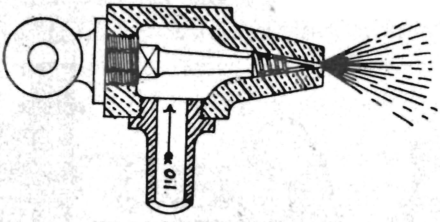


Fig. 5.

The Korting burner (Fig. VI.) was a very simple one, and was designed for use in connection with a pressure system. As it passed down the cone at the nose of the



Körling's Burner.

Fig. 6.

burner, the oil traversed a tapered screw thread, which gave it a whirling motion. The oil left the burner through a very fine orifice, and was very finely atomised.

The Rockwell burner, shown in Fig. VII., was designed to work on a pressure of from 8 to 16 ounces of air and was used chiefly for furnace work.

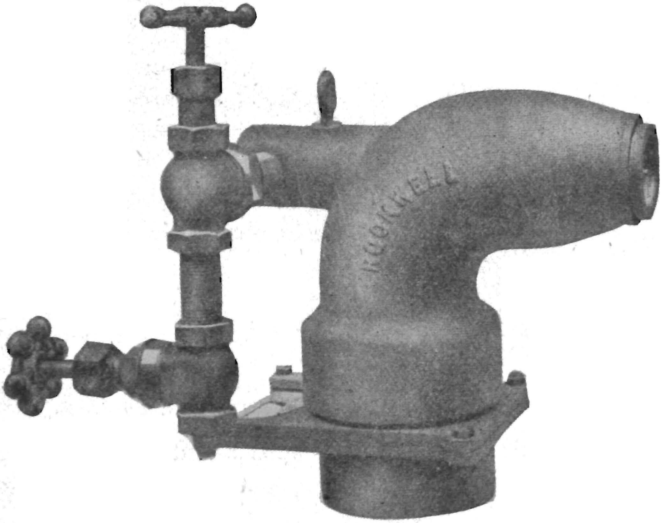


Fig 7.

In Fig. VIII. was shown a view of the Amet-Ensign oil gas producer. There were broadly three types of oil gas producers in use. In the first the bulk of the fuel

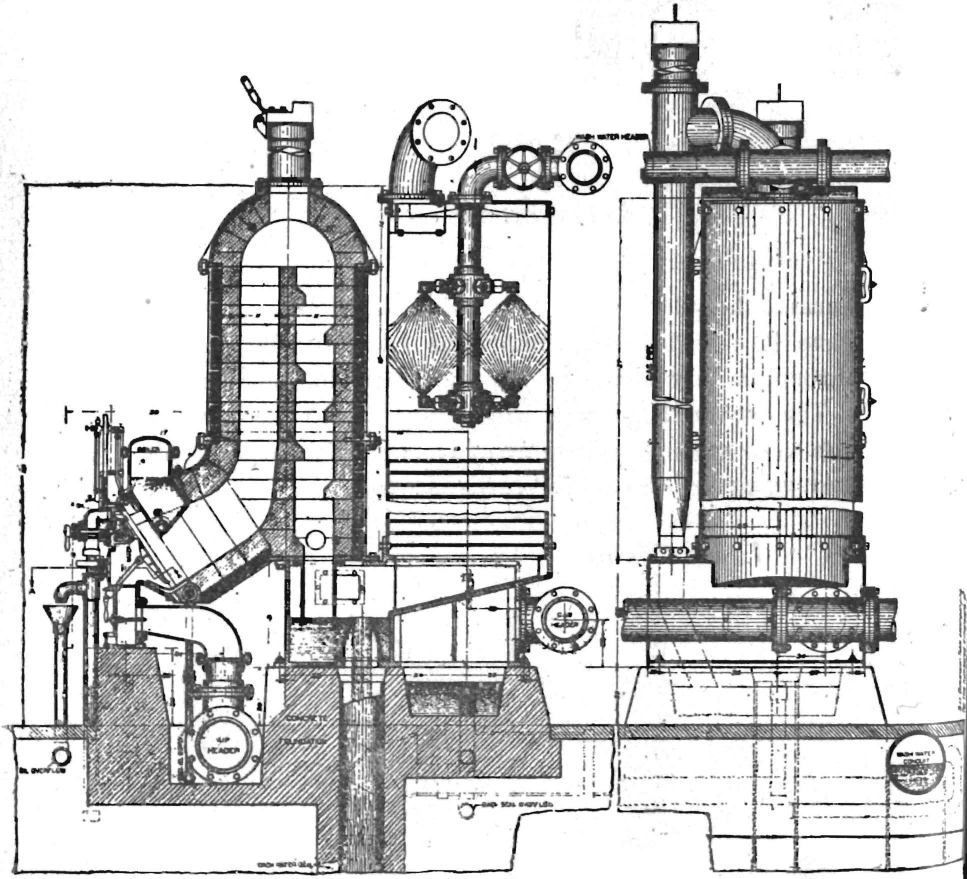


Fig. 8.

was converted into $CO_2$, and subsequently reduced to CO.; in the second type the fuel was burned with a deficiency of air, and the resultant gases were carburetted while passing through the vapours of distillation; while the third type shown in Fig. VIII. used the heavier products of the oil as a fuel for supplying the heat required for the vaporisation of the more volatile constituents. Such a plant as this would make an ideal standby for a works in a location subject to labour troubles, and where it was imperative that important gas-driven machinery should be kept going continually.

The real future of oil fuel does not lie in the directions set forth above, but in its use in the internal combustion engine. This was now generally recognised, and astonishing developments have taken place in the improvement of the oil engine for both land and marine use. A lecturer before the Manchester University Engineering Society made some interesting comparisons between the three chief prime movers. On the assumption that the calorific values of coal and oil were respectively 14,000 B.T.U. and 18,000 B.T.U., he deduced that the consumptions for steam, gas, and oil were respectively 1.8, 0.95, and 0.40 lbs. The late Dr. Diesel, in comparing various kinds of prime movers, gave the following particulars of the heat utilisation of each for the development of 1 B.H.P. hour:—

| | | |
|---|---|---|
| Steam engine with exhaust | 7000-10000 | heat units |
| Superheated steam engine and condensing steam turbine | 4000- 7000 | „ |
| Gas engine with producers | 3000- 3600 | „ |
| Gas engine without producers | 2300- 2600 | „ |
| Diesel Motor | 1800- 2000 | „ |

At the Turin Exhibition a manufacturer exhibited a steam turbine with oil-fired boiler and condensers complete, and a large Diesel engine. Each plant used the same fuel, and the comparative results obtained showed that the steam plant used over 2½ times the fuel consumed by the oil motor per horse-power delivered.

A further interesting comparison was made by Professor Menz in an article on Marine Engines:

"In a steamship, of the 100 per cent. energy stored in coal, only about 73 per cent. ever reached the engine, the remainder being lost in the process of raising steam; further, 60 per cent. of the remainder was lost in the condenser, 6 per cent. as mechanical friction in the engine itself; only 10 per cent remaining as shaft horse-power.

"The efficiency of a good slow-speed propeller could be estimated at approximately 70 per cent. Therefore, finally, it was found that only 7 per cent. to 8 per cent. as horse-power was available to drive the boat.

"These figures were much the same for a steam turbine; the friction losses in the engine were lower, but, owing to the higher speed, the propeller's efficiency was only about 65 per cent., and this additional loss compensated the higher efficiency of the turbine itself. In the Diesel engine the losses were similar. About 34 per cent. of the heat stored in the fuel was lost in the cooling water, 24 per cent. in the exhaust gases, and 10 per cent. to 15 per cent. as engine friction (air pump and compressor included). As the speed of the Diesel engine could be chosen as low as that of the steam engine, the propeller efficiency would be about the same, i.e., 70 per cent.; and after deduction of all losses, about 17 per cent. to 22 per cent. was still available to drive the boat.

"Expressed in heat units, under the assumption that the Diesel consumes 2100 calories per shaft horsepower, this meant that it would require about 3000 calories per propeller horse-power, whereas this figure was about 6200 for the steam engine, including auxiliaries."

The advantage of oil fuel as compared with coal for marine purposes has already been stated. These advantages were doubly emphasised when the oil fuel was intended for use in an internal combustion engine of the Diesel or semi-Diesel type. Carels, in "Internal Com-