FUEL ECONOMY METHODS.

The following particulars of the methods followed in a light cruiser, in which a very marked reduction in fuel consumption was maintained in comparison with similar vessels employed on much the same service, are extracted from a current report as being likely to be of service for general reference. It is appreciated that most of these methods are already in force, but others are not so generally well known and are worthy of careful consideration. In cases where the design and conditions of service will permit of their being employed, their adoption can hardly fail to lead to an improvement in economy.

It is to be particularly observed that, while due economy was observed and wastage checked, the saving effected was not realised by withholding the provision of reasonable amenities, such as heat, water, light, and so on, from the ship's personnel. Such a line of attack is rarely attended by an adequate measure of success and leads in any case to difficulties of one sort or another. On the other hand, whole-hearted team work is called for from the engine room personnel, if a saving is to be effected and maintained day by day, and, the fostering of this spirit, if possible by competitive means, is of no less importance than the actual methods adopted for attaining it. Once the ratings have been convinced that the best and most economical way of doing a thing is in the long run the easiest way, and that any saving in fuel leads to reduced wear and tear and so to lighter duties, an important advance towards the solution of the problem has been made. This point is particularly important in the case of oil-fuel burning, in which, when improper or careless methods are permitted, important losses may occur.

Methods Adopted.—The principal source of economy rests in the careful burning of the fuel oil.

In order to ensure that the excess air supplied to the furnaces is reduced to a minimum when the sprayers, oil conditions, etc., are properly set, it is essential that the air supply is reduced to such an extent that some smoke issues from the funnels.

It has been found by experiment that, with the present oil burning appliances, in order to work with a clear funnel, *i.e.*, emitting no smoke, the air supply has to be increased, and the boiler efficiency is considerably reduced by the cold air passing into the furnace and so cooling the boiler.

A very great excess of air is often supplied under these conditions producing a very considerable loss in economy.

When under war conditions and when carrying out exercises it is necessary for military reasons to work with a clear funnel, but otherwise, under ordinary conditions in peace time, this source of economy seems worthy of consideration. At ordinary speeds the smoke can be at once eliminated, on an order being received from the bridge to work with a clear funnel, by increasing the air pressure.

The remaining methods by which the fuel consumption has been reduced are as follows, viz. :—

(1) Using the smallest number of turbine nozzles for the speed required.

(2) Keeping the steam pressure steady and as near the designed working pressure as practicable, thus keeping the boiler and turbine conditions steady. (This requires careful training of the stokehold staff.)

(3) Keeping the feed temperature high. The temperature has been kept at 150° F. to 160° F.

(NOTE.—This course can only be followed in cases where there is assurance that no oil is gaining admittance into the system or alternatively where grease extractors are fitted in addition to sponge filters on the feed tanks.)

(4) Keeping the speed of the auxiliaries as low as practicable for the work required of them, and using the minimum number of auxiliaries that will suffice for the duties in view.

(5) Keeping the vacuum as high as practicable.

(6) Using the cruising turbines up to a speed of about 23 knots by leaving the steam full open to the cruising turbines and their bye-passes, and admitting steam, in addition, to the H.P. turbine to give the required speed.

This is done instead of disconnecting the cruising turbines, or running them in a vacuum and using steam direct to the H.P. turbines as soon as the maximum power of the cruising turbines is reached, *i.e.*, 17 knots.

The economy due to the more expansive working of the steam which passes through the cruising turbine is thus gained.

(NOTE.—This is only applicable to cases, where, as in "D" Class cruisers, the cruising turbines are directly coupled to the H.P. turbines.)

By adopting this method of working, the cruising turbines are not disconnected for speeds up to 23 knots and the necessity for stopping the ship for coupling up cruising turbines after exercises is therefore avoided. (*See* Appendix (*a*).)

(7) Using closed exhaust for evaporators when making fresh water.

(8) Avoiding distilling at sea as far as possible.

(9) Working with low oil pressures at the fuel sprayers 50 to 75 lbs. (*See* Appendix (*b*).)

(10) Controlling the steam pressure for small variations in revolutions by small variations in oil pressure, and *not* by increasing or decreasing the number of sprayers. (*See* Appendix (*b*).)

(11) Regulating the oil pressure by regulating the steam to the oil-fuel pump instead of by using the adjustable spring-loaded valve on the pump discharge. The use of the spring-loaded valve for controlling the pressure introduces a waste of power as all the power used to discharge the excess oil through the spring-loaded valve and back to the suction is lost. (*See* Appendix (*b*).)

(12) Paying very careful attention to the regulation of the boiler-room fans.

(13) Putting the closed exhaust into the H.P. turbines as soon as the turbines are going ahead and not putting it into the L.P. turbines until the back pressure reaches a pressure of 20 lbs. (*See* Appendix (*g*).)

(14) Frequently sweeping the fire sides of the boiler tubes.

When in harbour the following additional methods are used :—

(*a*) Using closed exhaust whenever practicable for steam heating purposes, and for baths, and for warming turbines.

(*b*) When evaporating in harbour and using all the closed exhaust in the evaporators, to shut down the condensing plant whenever practicable, taking care to start up the condensing plant whenever it is desired to admit steam to the condenser.

(*c*) Keeping sprayer on boiler throttled down to $\frac{3}{8}$ to $\frac{1}{2}$ turn and keeping air pressure low.

It is also the practice to work without the boiler room fans, *i.e.*, under natural draught, in harbour, except in hot weather. This is done by using special sprayers, but good results can be obtained by using a 400 lb. sprayer or sprayers throttled and working with fan. (*See* Appendix (*c*).)

(*d*) Using only one dynamo engine when practicable, and keeping the dynamo load low by cutting down waste current.

(*e*) When condenser is in use, using the fire and bilge pump instead of the main circulator for circulating water through the condenser. The fire and bilge pump is used to draw the warm water away from the top of the condenser. This water can be discharged into the fire main when water is required for fire purposes or for washing decks, thus obviating the necessity for starting an additional pump for this purpose, with its attendant expenditure of fuel.

(*f*) Using a steam ejector instead of the condenser fresh water pump for extracting the condensed water from the condenser. The ejector fitted for use with Sand's lime tanks has been found suitable for this purpose. By this method the heat of the steam used is recovered in heating the feed-water.

(*g*) Keeping the feed-water temperature as high as practicable. 190° F. to 200° F. is often reached. (*See* earlier note.)

(*h*) Keeping the steam pressure low in harbour and only sufficiently high for the efficient working of the dynamo engine. A pressure of 180 lbs. has been found to be all that is necessary.

(*j*) Regulating the fuel oil supply by regulating the steam to the oil-fuel pump, as in para. (10) above. (*See* Appendix (*e*).)

(*k*) More frequently changing the boiler is use for auxiliary purposes in order that the fire side of the tubes may be thoroughly swept and blown through. It is found that there is a marked falling off in boiler efficiency and consequent increase in fuel consumption if a boiler is kept in use for more than five days without sweeping the fire sides of the tubes.

Further particulars of the reasons influencing the choice of certain of these methods, and of the ways and means of carrying them out, are given in the following appendices :—

Appendix (a).—*Operation of Cruising Turbines.*

As steam is admitted to the H.P. turbine when the steam to the cruising turbine is fully open, the back pressure on the cruising turbine is increased so that the steam flow through the cruising turbine, and the pressure difference between the forward and after ends of the cruising turbines, is reduced.

The pressure on the cruising turbine thrust is therefore reduced as more steam is admitted to the H.P. turbine. There is, therefore, no tendency to overload the thrust bearings of the cruising turbines as the power is increased.

A pressure gauge has been fitted to the last stage of the cruising turbine and it is found that at 25 knots the pressure recorded by this gauge is 55 lbs. per sq. inch. As the receiver pipe between the cruising turbines and the H.P. turbines is tested to 110 lbs. per sq. inch, 25 knots (*i.e.*, a propeller speed of 225 revs. per minute) is the limiting speed at which the cruising turbines can be run under these conditions.

In order to give à further margin a limiting speed of 23 knots is suggested in the foregoing notes.

Appendix (b).—*Burning of Oil Fuel.*

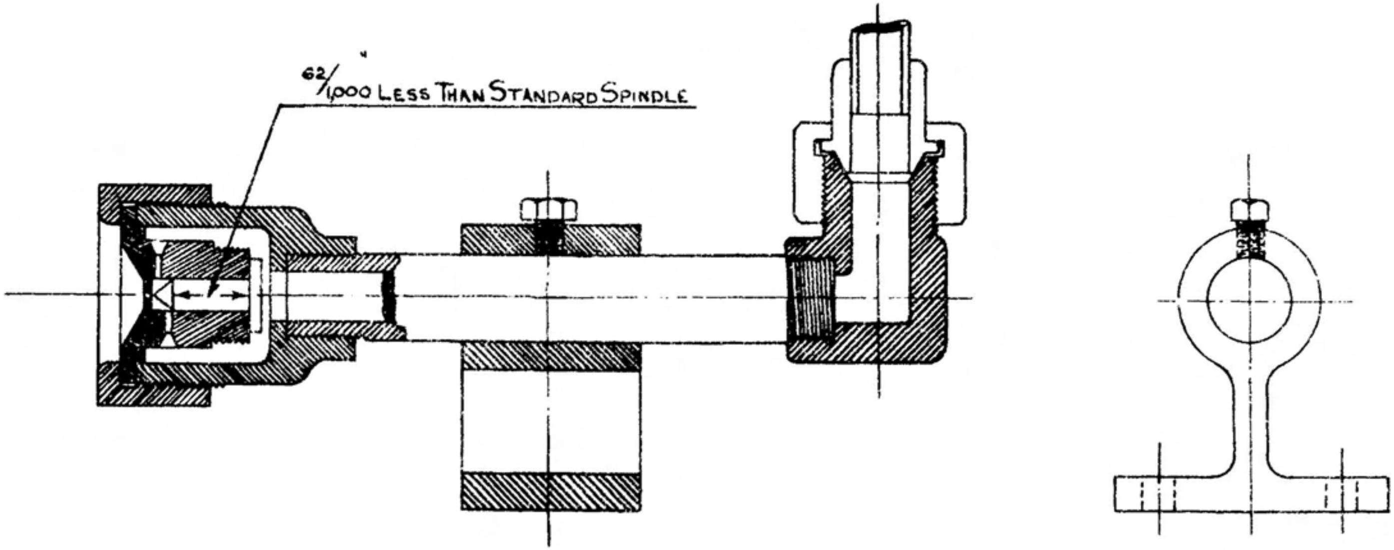
By using a low-fuel oil pressure the fuel pumps have less work to do as they have to pump the oil to a lower pressure. The use of a low-fuel oil pressure necessitates the use of more oil-fuel sprayers with the attendant increase in the number of air openings for the supply of air to the sprayers. The air pressure required for the supply of air to the boiler is thus reduced, as there is a larger area for the air to pass through.

The work of the fans and their engines is thus reduced with the consequent saving in steam and in fuel consumption.

With the lower air pressures the leakage of air is also reduced, which gives a further decrease in the work of the fans and their engines.

The usual practice is to control the steam pressure by increasing or reducing the number of sprayers in use. While this is necessary for large changes in revolutions, it is found to be much more economical for small changes in revolutions and for steady steaming to control the steam pressure by slightly increasing or decreasing the oil pressure.

When additional sprayers are put on, the first result is a rush of cold air into the furnace and a quantity of partially burned oil discharged into the furnace causing a loss of efficiency until the sprayers are burning properly.



– FIGURE 1 –

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The change in the number of sprayers also produces changes in furnace conditions and temperature which cause losses in efficiency.

Tables have been prepared and are kept in the engine room showing the number of sprayers and oil pressures required for the different speeds of revolution of the engines. Separate tables are prepared for the number of boilers in use, *i.e.*, 2, 3, 4, 5, or 6. The orders for the sprayers and pressures are transmitted to the boiler rooms by the telegraph fitted for the purpose.

The instructions provide in ordinary circumstances for the number of sprayers signalled from the engine room being definitely used. The oil pressures signalled are regarded only as a guide and may be varied as required to keep the steam at the required steady pressure. In cases of emergency, however, or when for any reason it is found impracticable to keep steam with the number of sprayers ordered, the boiler-room watch-keepers are authorised to act on their own initiative as regards numbers of sprayers in order to maintain the steam pressure.

In such cases the engine room is immediately informed.

Appendix (c).

While fairly satisfactory results can be obtained by using 400-lb. sprayers when working without fans, it is found that there is a tendency for the cones to become overheated and distorted under these conditions.

By the use of special sprayers much better results have been obtained, and the overheating of cones eliminated. The design is illustrated in Fig. 1.

Appendix (d).—*Analysis of Fuel Consumptions of Auxiliaries in Harbour.*

Careful tests have been carried out to measure the steam and fuel used by the various auxiliaries employed under harbour conditions in order to obtain definite data bearing on the economical running of the machinery.

The results obtained show that the fuel consumption of the various auxiliaries in harbour when working under the conditions already described are :—

		Tons per Day.
(1)	One dynamo engine with mean load of 400 amps. -	2·20
	Two dynamo engines with total load of 400 amps. -	3·30
(2)	Main circulator when running as slowly as practicable -	·75
(3)	Fire and bilge pump when in use on main condenser -	·15
(4)	Distiller pumps when evaporators are in use, each -	·28
(5)	Auxiliary feed pump - - - - - - - -	·48
(6)	Fan engine when working as slowly as practicable - -	·20
(7)	Oil fuel pump - - - - - - - - -	·05

From the above data it will be seen that the saving by using the fire and bilge pump instead of the main circulator is ·6 ton of fuel per day, apart from the additional saving due to the fact that no additional pump is required for the fire main for ordinary purposes.

The saving due to working without the fan engine is ·2 ton per day for the fan engine itself; but this is considerably increased in practice, as when using the fan there is always a tendency to run the fan too fast and so increase its fuel consumption and, in addition, to cool the boiler and reduce its efficiency by the supply of too much air.

Appendix (e).—*Working of Oil Fuel Pumps in Harbour.*

When under harbour conditions the output of the oil fuel pumps is is very low, and there is a tendency for the pumps to stop when the fuel supply is controlled by controlling the speed of the pump.

This can be remedied by drilling a hole 1/16 in. in diameter through one of the discharge valves, which allows the pump to work slowly with the discharge shut, as in the case of a boiler feed pump.

Appendix (g).—*Auxiliary Exhaust Valve to Condenser.*

The auxiliary exhaust valves to the condenser are spring loaded and require some time to open and close when the auxiliary exhaust is put into or taken off the turbines.

One result of this is that, when manœuvring, the time required to change over the exhaust steam from the condenser to the turbines, or *vice versa*, makes it in many cases hardly worth while to use the auxiliary exhaust steam on the turbines.

An alternative course is to keep a back pressure in the auxiliary exhaust system and operate the auxiliary exhaust valve on the turbine, but this is open to the same objection and necessitates keeping an unnecessary back pressure in the auxiliary exhaust system when the exhaust steam is not being used in the turbines.

By removing, however, the spring from the auxiliary exhaust valve to the forward condenser and fitting a tubular distance piece in its place, the valve can be operated as a screw-down valve. The auxiliary exhaust valve on the other condenser remaining, as designed, a spring-loaded relief valve will provide the necessary relief in the event of the pressure rising unduly.

This has been done and it is found that the screw-down valve can be readily operated to relieve the pressure in the auxiliary exhaust system, and greatly facilitates the control and use of the auxiliary exhaust to the turbines.

Appendix (h).—*Boiler Brickwork.*

It is found that, with the design of cone bricks Pattern Number 31, there is a tendency for a carbon deposit to form on the bricks when burning the Mexican oil fuel supplied. The cleaning of the deposit from the cone bricks often results after some time in the bricks being displaced and pushed into the furnace.

The bricks have accordingly been cut away to form a bell mouth, n order to lessen the deposition of carbon formed by the spray striking the brick and to reduce the tendency to displace the bricks with the cleaning rods. As modified, the internal diameter of the Pattern No. 31 bricks is made about 23 inches on the furnace side, tapering to 19 inches at the front side, and the corners of the Pattern No. 1 bricks are removed to continue the taper.

After six months' experience, it has been found that the carbon deposit are much less with the new form of cone bricks, and the displacing of the cone bricks, which before modification was of frequent occurrence, is now a comparatively rare occurrence.

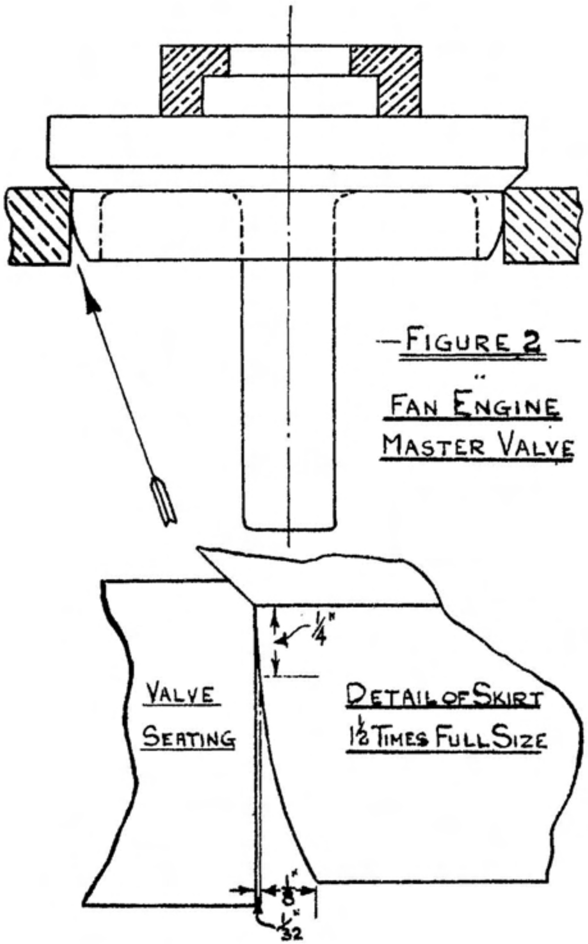
It is found that the larger bell mouth to the cone is entirely filled with flame when the sprayers are in use, and it is considered that there is a slight increase in boiler efficiency due to the use of the modified form of cone brick, apart from the saving in labour and expense of renewals.

Appendix (k).—*Control Valves to Fans.*

The master valves fitted to control the boiler-room fans are designed to control the fans when working at their full output.

Under cruising conditions, when the air supply to the boiler room is only one-tenth, or even less than that supplied at full power, it is found that the regulation of the fans becomes difficult, a very slight movement of the master valve causing a big increase or decrease in the speed of the fan.

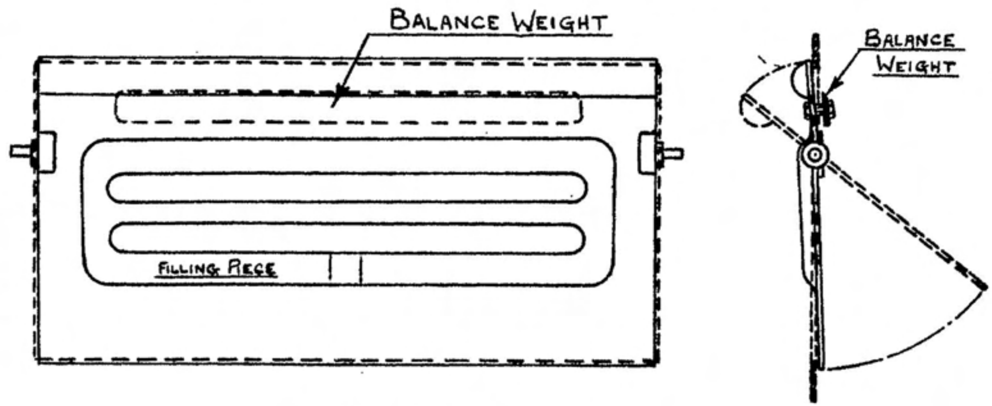
To provide increased flexibility, new master valves have been designed and fitted in the ship as shown in Fig. 2. These valves have skirts attached and are so designed that when the valve is opened the space between the tapered skirt and the valve chest opens up very gradually as the valve is first opened so that there is only a small increase in the steam opening for a considerable movement of the valve wheel. As the valve is further



— Figure 2 —

Fan Engine Master Valve

Modifications to Boiler Air Doors



— Figure 3 —

opened, the increasing taper of the skirt allows the full area for the passage of steam required for the running of fans at full output.

These modified master valves have been in use for six months and have greatly facilitated the accurate regulation of air which is essential for economical burning of oil fuel. It has been noticed incidentally that the modified valves remain steamtight longer than the ordinary valves, the scoring action of the steam being taken by the skirt instead of the valve seat.

These modified valves may with advantage be adopted for other auxiliaries.

Appendix (1).—*Boiler Air Doors.*

It is found that although the self-closing air doors fitted to the air boxes on the boiler fronts are partially balanced, there is always a tendency for the lower doors to close when working with low-air pressures, and so seriously restrict the air supply to the sprayers, unless special means are adopted such as hanging small weights to the upper sides of doors to keep them open. This method is considered to be undesirable, as under some conditions it might possibly prevent the door closing in the event of a back flash.

These doors can be more perfectly balanced by fitting a strip of suitable weight as shown in Fig. 3, and when so balanced, the opening of the doors can be properly regulated by the adjusting gear already provided for the purpose.

Many of the air-box doors have been more precisely balanced in this way and a considerable improvement in working has resulted. The balanced doors have been specially tested by arranging for a back flash, and found to close satisfactorily and as intended.

From the figure it will be seen that the doors as designed have their centre of gravity somewhat to one side of the line of supports. By fitting the balancing strip as shown, the centre of gravity is brought into the line of supports, thus improving the balance of the door.