No. 11

(a) EMERGENCY GOVERNORS OF TURBINE DRIVEN AUXILIARY MACHINERY

The turbine driven auxiliaries fitted in modern warships are generally fitted with two governors—

(1) a speed or pressure governor, and

(2) an emergency governor.

The emergency governor is fitted to trip the stop valve at a predetermined speed and so prevent the speed of the turbine reaching dangerous limits : it is set to operate at a speed sufficiently above the maximum running speed, as controlled by the speed or pressure governor, to avoid its operation during normal running but before a dangerous speed is reached.

It is essential that these emergency governors should be kept in an efficient condition, and that their operating speed is correctly maintained. With this object in view, instructions for the maintenance and testing of these emergency governors have been issued in an amendment to the Engineering Manual.

The governors are first set by the makers in the shop, and are again tested by them after installation on board and just prior to contractors' trials. Certain precautions are necessary in the carrying out of these tests, especially in the case of high speed rotary pumping units.

These pumps should never be run dry because a flow through the pump is essential to lubricate the running parts and to carry away heat. If the pumps are run dry, the friction between the rotating parts and the stationary parts generates heat which may give rise to sufficient differential expansion to cause seizure. The procedure must, therefore, be such as to ensure the pump having a reasonable flow of water or oil during the operation. The power generated by a centrifugal pump varies as the cube of the speed, so that it is necessary in all cases to make arrangements to reduce the resistance opposed to the pump during the operation by opening the discharge valve, and to allow air to pass into the pump. The operation also should be carried out as quickly as possible in order to avoid running the pump empty of water or oil.

Before testing the trip speed, the following instructions must be carefully followed :—

Before the master steam valve is opened on the steam range, the steam valve on the turbine should be opened fully and the trip gear tested by hand. This is to ensure that the valve closes and all link gear is in working order before steam is admitted to the turbine.

In the case of turbines governed by a speed governor, the steam throttle valve must be disconnected from the governor.

In the case of turbines governed by a pressure governor, the resistance opposing the pump must be reduced below the setting of the pressure governor.

When testing pumps, care must be taken to ensure that there is a reasonable flow of water or oil passing through the pump and that the resistance opposing the pump is reduced as much as possible in order to permit the turbine to run up to trip speed with a minimum loss of time.

In all tripping operations, all the turbine auxiliary valves should be opened so as to use the maximum number of nozzles available.

The maximum possible steam pressure should be available, the exhaust valve must be wide open and the test should be carried out quickly.

The turbine must not be operated for any appreciable length of time in the vicinity of the trip speed. If the turbine does not run up and trip immediately, it should be stopped, and more steam pressure obtained, or the resistance opposing the pump reduced before re-testing.

If it is necessary to test a pump a second time, the pump should be refilled with water or oil before re-testing.

When running the turbine up to trip speed, the tachometer should be watched carefully and if the governor fails to trip within the approved range, the turbine should be shut down instantly either by closing the steam valve or by means of the hand trip gear.

The approved range for turbo generators before September, 1935, was 15 per cent. to 20 per cent. above the normal full load speed of the turbine, but since this date the range has been altered to 12½ per cent. to 17½ per cent.

For other turbine driven auxiliaries the approved range is 12½ per cent. to 17½ per cent. above the normal full load speed of the turbine, but a greater margin has been accepted in the case of some comparatively slow running turbines.

Compliance with these figures has not been strictly enforced in the past. Should, therefore, the trip speed as set by the makers not fall within the ranges referred to above, it would be advisable, before carrying out a test, to ascertain from the Engineer Officer on the Staff of the Administrative Authority for the ship what range is permissible.

For example, in the case of some of the earlier turbo-generator sets made by Messrs. Greenwood & Batley, the governor has been set to operate at 12 per cent. over the normal full load speed and it is essential that this speed should not be greatly exceeded. It is, therefore, necessary to work to closer limits when testing these machines, and the permissible range for the test is 10 per cent. to 12 per cent.

Detailed instructions for carrying out the tests on Messrs. G. & J. Weir's standard types of pumps are given below. The same general procedure should be used for other turbine driven auxiliary machinery. For turbo generators the speed governor should be disconnected and the machine run on no load, while for forced draught fans the reduction of pressure necessary for tripping the governor should be obtained by closing the intake louvres.

Detailed Instructions for carrying out Overspeed Tests on Messrs. G. & J. Weir's Standard Types of Pumps.

Condensate Extraction Pumps.—Open suction valve and flood pump from condenser, then shut suction valve and open discharge valve wide. Ease off set pins at bridge, which hold fulcrum in position, so as to allow steam throttle valve to take full open position. Open exhaust valve wide and all auxiliary steam valves, also turbine casing and carbon packing drain valves, open steam valve and allow turbine to run up to trip speed, as quickly as possible.

Boiler Feed Pumps.—Open suction valve and flood pump from extraction pump discharge until water comes out of air cock on top of pump casing, close air cock and suction valve, open discharge valve wide. Disconnect pipe at cock on pump side of suction valve, which leads to pressure gauge, open cock full to allow air into suction. (This is to obviate pump impeller raising vacuum in suction and causing undue thrust.) Open exhaust valve and all auxiliary steam valves, also turbine casing and carbon packing drains, open steam valve and allow turbine to run up to trip speed, as quickly as possible. If pump has to be tripped a second time, open suction to flood pump, as during the first test the pump will have lost some water through balance chamber to feed tank and to discharge line.

Oil Fuel Pumps.—Open suction valve and air cock on top of pump chamber, and discharge valve. Open exhaust valve wide and all auxiliary steam valves, also turbine casing and carbon packing drains, remove fulcrum pin out of arm which operates throttle valve. Open steam valve and run turbine slowly, until pump has lifted oil and discharged it out of air cock on top of pump casing. Shut cock, open discharge valve and shut suction valve. Open steam valve and allow turbine to run up to trip speed, as quickly as possible.

Forced Lubrication Pumps.—Open suction valve, open exhaust valve and all auxiliary steam valves, also turbine casing and carbon packing drains. Ease off set pins at bridge which hold fulcrum in position, so as to allow throttle valve to remain in full open position. Open steam valve and run turbine slowly until pump has lifted oil. Open discharge and shut suction valves, open steam valve and allow turbine to run up to trip speed, as quickly as possible.

Circulating Pumps.—Open sea inlet valve to pump and outlet valve from condenser. Open air cock on top of pump casing until pump is primed. Shut air cock. Open exhaust valve and all auxiliary steam valves, also turbine casing and carbon packing drains. Open steam valve and allow turbine to rise to half speed. Shut sea inlet valve and open bilge injection valve, when air will enter suction and turbine will immediately rise to trip speed.

Fire and Bilge Pumps.—Open sea suction valve and flood pump. Shut suction valve and open discharge valve. Open exhaust valve and all auxiliary steam valves, also turbine casing and carbon packing drains. Ease off set pins at bridge which hold fulcum in position so as to allow throttle valve to remain in full open position. Open steam valve and allow turbine to run up to trip speed, as quickly as possible.

(b) THE FABRICATION OF A MOTOR BOAT ENGINE CYLINDER BLOCK

While on service recently at Alexandria, a small cruiser suffered the misfortune of a cracked motor boat engine cylinder block.

The engine was a 25-h.p. 4-cylinder Ferry compression ignition engine and the fracture took place in the foremost block just below the side bosses for the cylinder head holding down studs.

Repair by oxy-acetylene welding proved unsatisfactory on account of distortion of the block and consequent leakage under water pressure, and patching was impracticable.

As much delay and consequent inconvenience would have been entailed by waiting for a replace casting from the makers, it was decided to design and fabricate a new block from steel plates electrically welded together.

Design.—The principle underlying the design was that the major stresses should not be taken by the weld metal.

The scope of the design was somewhat limited by the fact that it was necessary to conform generally to the shape and dimensions of the original casting, *e.g.*, the positioning of the holding down studs were determined by the original parts.

The main component is a ½-in. steel plate bent to form a wrapper plate and butt-welded in the centre of the base (*see* Fig. 1).

Four ⅝-in. thick pad pieces provide rigid landings for the two cylinder liners and take the cylinder head and holding down studs. Small bosses are welded on to the pad pieces in way of the studs to avoid the possibility of the circulating water gaining access to the threads and causing corrosion.

A division plate is fitted in the centre of the block. The side-plates are provided with circulating water pipe flange connection, studs for securing the push rod cover and an inspection door.

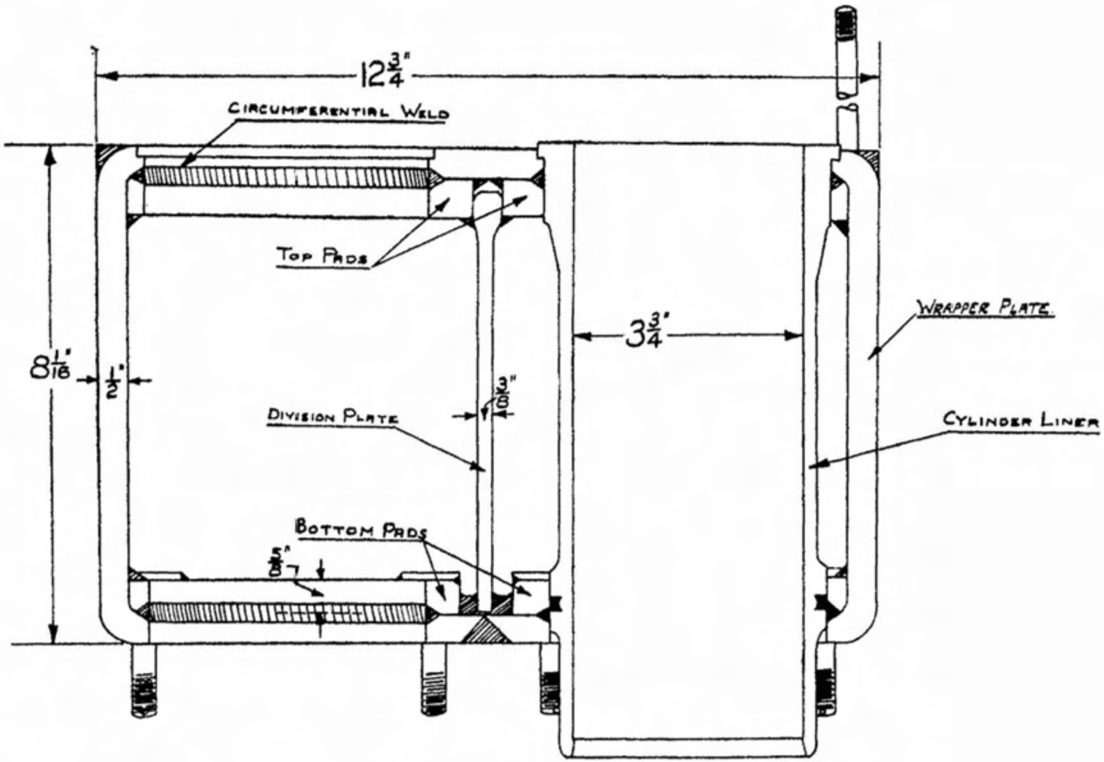


Fig. 1.
Welded Cylinder Block.
Sectional Elevation.

Construction.—The bending of the wrapper plate presented some difficulty on account of the thickness and the necessity for the vertical dimension being correct to within $\frac{1}{8}$ in. and the avoidance of buckling of the horizontal top and bottom faces. This work was undertaken in the Repair Ship. The plate was held in a press while the sections to be bent were heated by an oxy-acetylene flame.

The wrapper plate was completed by making the butt weld, after which it was found that the top and bottom surfaces were sufficiently fair to receive the pads without being machined, no appreciable buckling having taken place during bending or welding. The wrapper plate was then marked off, using a lathe face plate as a marking off table, and trammels made to check any possible distortion during subsequent welding operations.

The pads and division plate, which had been cut roughly to shape by the Repair Ship, were chipped and filled to shape and secured in position by welding, after which the edges of the pads were machined by means of the lathe milling attachment and the sideplates fitted and welded into place.

The block was then marked off for rough machining.

The top and bottom surfaces were roughly surfaced in the lathe and the holes for the cylinder liners bored to $\frac{1}{16}$ in. of finished size, 90° V grooves were cut at the junction of the pads and wrapper plate and the circumferential welds completed.

These welds were made with the block mounted in the lathe, so that by turning the spindle by hand the operation was carried out in a downhand direction over the whole circumference. After the marking off was again carefully checked, the bottom surface was finish machined and the block set up for final boring, using a plate gauge for the dimension, bottom surface to the spigots for the cylinder liner flanges.

After finish machining the top surface and inserting the liners, the cylinder head with suitable sleeves in the stud holes was used as a drilling jig for the stud holes in the block, the head being located by the liner flanges.

The eight cylinder holding down stud holes proved more difficult to mark off. No spigot is provided, so that the studs locate the cylinder block on the crankcase. As it happened, the stud holes in the crankcase were neither accurately pitched nor were they accurate in diameter. To ensure correct alignment, therefore, the block was placed on the crankcase with connecting rods and pistons in place. The athwartship alignment was checked by means of a straight edge through the centres of Nos. 3 and 4 cylinder bores. The pitch between Nos. 2 and 3 cylinders was then adjusted to drawing dimensions and checked by means of the side clearances of crankhead bearings, the gudgeon pin bearing side clearances having been previously taken up by washers.

Reference marks were made on block and crankcase and the required positions of the studs marked off from the underside of the crankcase.

The studholes were then drilled and tapped, the liners removed, and the water space given two coats of red lead and copal varnish, the studs and liners finally inserted and the head bolted down for water pressure test of 50 lbs./in.^{2}

Welding.—A total of 100 ft. of Murex " Cresta " electrodes of gauge Nos. 10 and 12 were used with a current of 90–100 amps. and an average length of weld per foot of electrode of approximately 9 ins. With the exception of the bosses and water connection flanges, all joints consisted of one run of No. 12 followed by two of No. 10 electrode. As the block was light and easily handled all runs were made in the downhand position and consisted of either fillets or 90° V's. To minimize distortion, liberal use was made of tacking and long runs were made in sections.

The distortion checked by trammels and callipers was less than was anticipated. The weld metal proved to be only slightly harder than the parent metal and no difficulty was experienced in machining.

The welding operation demonstrated the difficulty of making sound welds in confined spaces and right angled corners, and emphasized the desirability of designing all welded joints as straight as possible and in positions which are accessible and can be worked n the downhand direction.

Remarks.—The engine has given entirely satisfactory service since the new block was fitted. The work was completed in 18 days, the allocation of time being as follows :—

	Man hours.
Marking off	6
Shaping plates and pads	65
Welding	12½
Milling sides of wrapper plate	14¾
Surfacing and boring	54
Drilling and tapping	31½
Testing and erecting	12¾

This time was in excess of the original estimate on account of the time spent in the hand work involved in the shaping and fitting operations. The whole of the machining operations were carried out in an 8½ in. centre lathe, no milling machine or horizontal boring machine being available.

The weight of the finished block was 54 lbs. compared with a weight of 36 lbs. for the original casting. This is accounted for by the fact that the only material available for wrapper and side plates was unnecessarily thick : also the design was possibly unduly conservative, and from the experience gained, a lighter simpler design could be produced were another block required. Figs. 1, 2 and 3 show the general arrangement of the block.

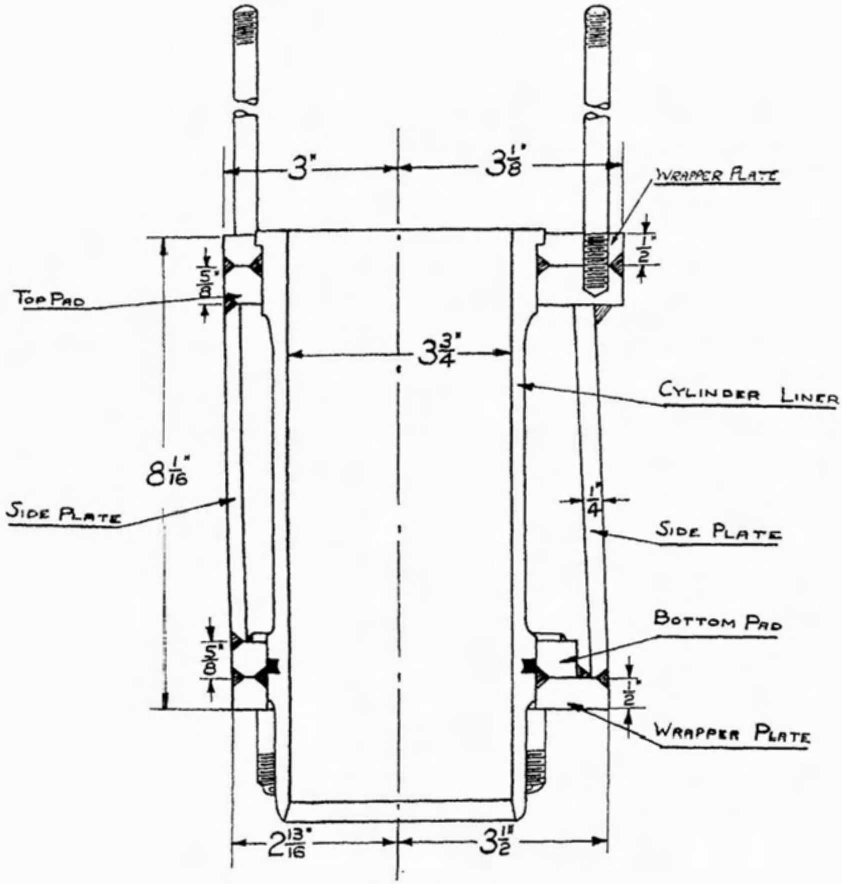


Fig. 2.
Welded Cylinder Block.
Cross-Sectional Elevation.

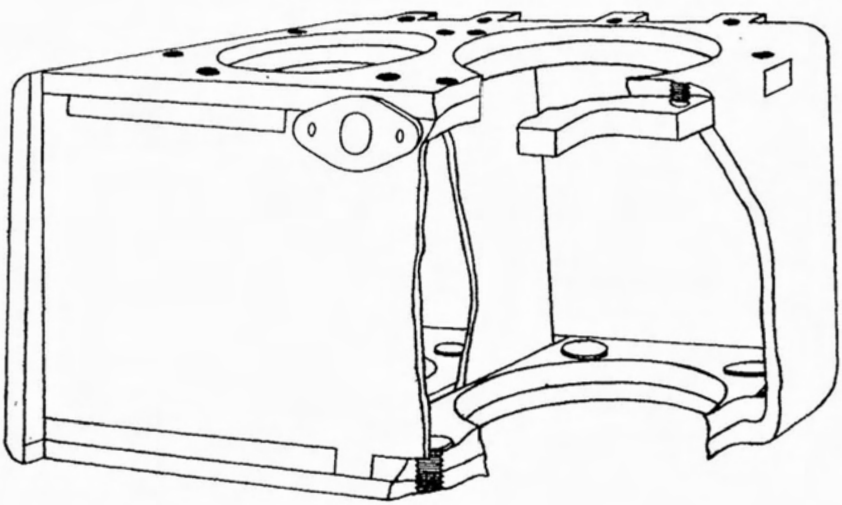
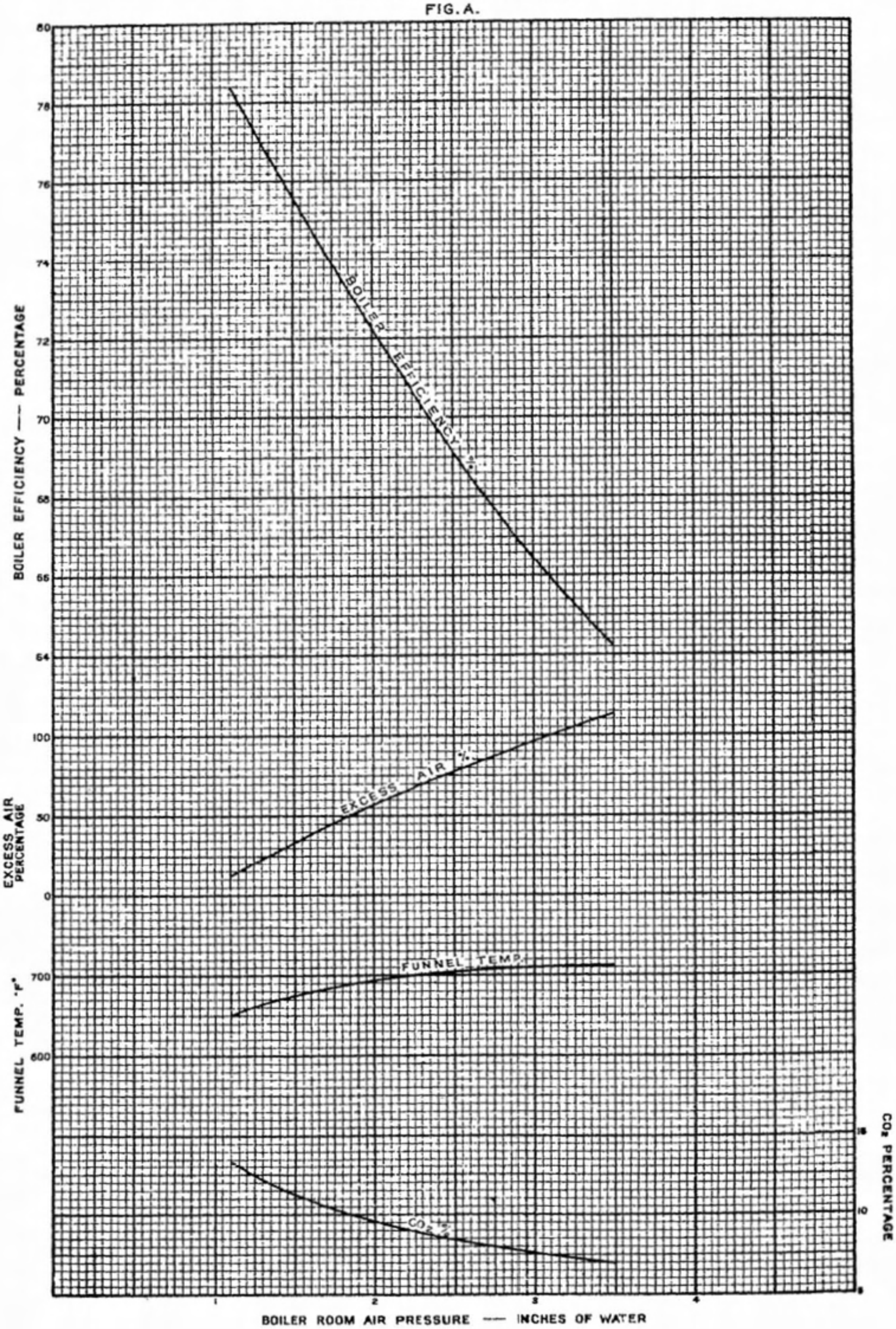


Fig. 3.
Welded Cylinder Block.

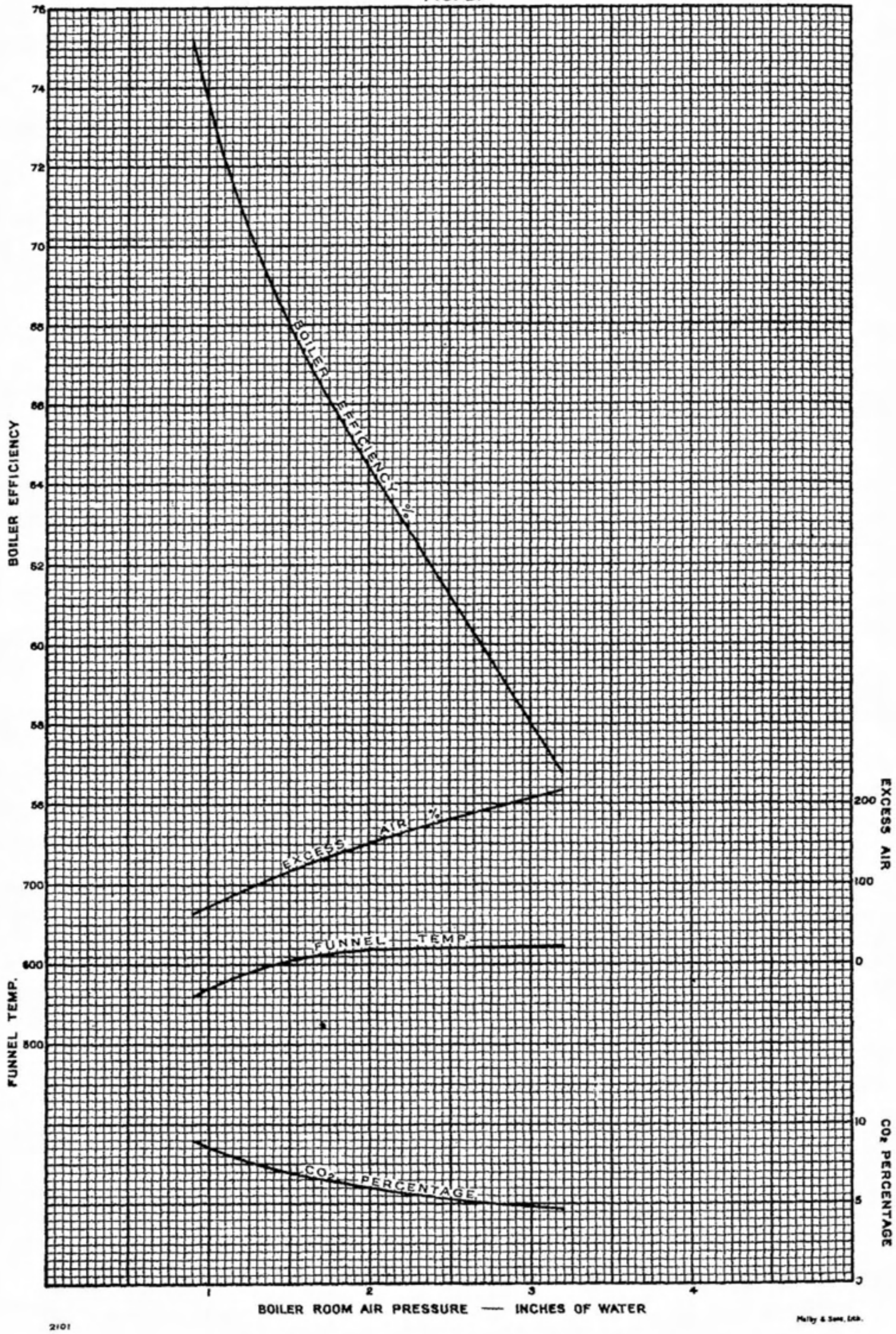
CURVES OF BOILER EFFICIENCY, EXCESS AIR, CO_2 PERCENTAGE & FUNNEL TEMPERATURE.

FIG. A.



CURVES OF BOILER EFFICIENCY, EXCESS AIR, CO_2 PERCENTAGE & FUNNEL TEMPERATURE.

FIG. B.



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(c) THE EFFECT OF EXCESS AIR ON BOILER EFFICIENCY

The following Note is an elaboration of the terms of A.F.O. 752/36.

The oil burning arrangements fitted in new construction since 1931 give maximum combustion efficiency when the exhaust gases are practically clear, only a faint brown haze being visible at the funnel. Under this condition, the air supply is only of the order of 10 per cent. in excess of that theoretically necessary for complete combustion. If the air supply is reduced, smoke will be generated with loss of efficiency and a sooting up of the heating surfaces. This will generally be accompanied by a fluttering noise of the air entering the air boxes and a vibration of the boiler front. This vibration is quite distinct from the " pulsation " experienced with old type fronts at high outputs ; it causes no damage and serves as a guide to the correct air supply, which is obtained when the vibration is just avoided.

A very slight further increase in air pressure will give a clear funnel. Beyond this point, however, lies the zone of " clear funnel " with increasing loss of efficiency. The latter becomes very serious before the white smoke condition is arrived at, caused by such over-cooling of a proportion of the fuel vapour that it passes out of the furnace as unburnt vapour.

The accompanying curves show the importance of the clear funnel zone loss of efficiency as demonstrated on an experimental Admiralty boiler.

Fig. A.—2 in No. 1,200 lb. sprayers in use at 100 lbs./in.^{2}

(i)	Funnel	Light haze.
	Efficiency	Maximum, *i.e.*, 78·4 per cent.
	Air pressure	1·1 in. Excess air, 12 per cent.
(ii)	Funnel	Just clear.
	Efficiency	77·7 per cent.
	Air pressure	1·2 in. Excess air, 18 per cent.
(iii)	Funnel	Clear.
	Efficiency	64·2 per cent.
	Air pressure	3·5 in. Excess air, 113 per cent.

The clear funnel range from 1·2 in. air pressure to 3·5 in. represents a falling off in steam output of over 17 per cent.

At this point the trial was discontinued as the fan power available was not sufficient to increase the air pressure.

Fig. B.—2 in No. 1,200 lb. sprayers in use at 50 lbs./in.^{2}. Under these conditions white smoke was not produced until an air pressure of 3 in. was obtained with an excess air supply of 200 per cent.

The boiler efficiency had then fallen to 58 per cent., which, compared with a maximum value of 75·2 per cent., represents a falling off in steam output of nearly 23 per cent.

(d) FITTING REPLACE WHEEL TO A BROWN CURTIS TURBINE

While on service in 1936, the first stage wheel of the starboard inner H.P. turbine of H.M.S " Hood " was found to be slack on the spindle and keys, and the method of fitting of a new wheel is of interest in connection with that adopted in the case of H.M.S. " Renown " and described in Issue No. 15 of these Papers.

The diagrams show the arrangements made for the operations.

The rotor was supported in wood blocks erected on the bottom half of the casing, the top half casing having been transported to a position aft over the gear case.

Two gas rings were provided, one arranged to play on the wheel just inside the rim and the other near the boss.

Water cooling was provided in the centre of the shaft.

The wheel was just entered on to the keys and was held in position by three withdrawing bolts which were locked by nuts each side of the withdrawal strongback.

The draw of the wheel was a bare $\frac{11}{16}$ in. (The estimated stress at the hub due to the combined effects of centrifugal loading and residual shrink fit grip at 15 per cent. overspeed is 25,000 lbs./in.^{2}, giving a factor of safety of 3 on the U.T.S.)

On the desired final temperature being obtained the wheel was pushed home by use of the nuts on the wheel side of the strong-back.

The wheel went home easily, and although two hydraulic jacks were brought into use on the boss, it was evident that the with-drawal screws alone would have sufficed.

The time-table of the operation and sequence of events were as follows :—

0915 Outer gas ring lit and shaft cooling water circulation started.
Difficulty was experienced in keeping the gas jets nearest to the air supply alight, and in order to overcome this, it was necessary to shut down at 0950 for a period to make adjustments.

1007 Relit outer gas ring.
Rim temperature was brought slowly up to 400° F.
The boss temperature had risen to 180° F.

1040 Inner gas ring lit.
Gas rings were now controlled to produce a minimum temperature of 400° on the boss with the temperature of the whole wheel as even as possible.
Temperatures were taken with a surface pyrometer.

1145 Temperature readings satisfactory (*see* Fig. 2).
Gas shut off.
Wheel forced home.

1148 Wheel home.

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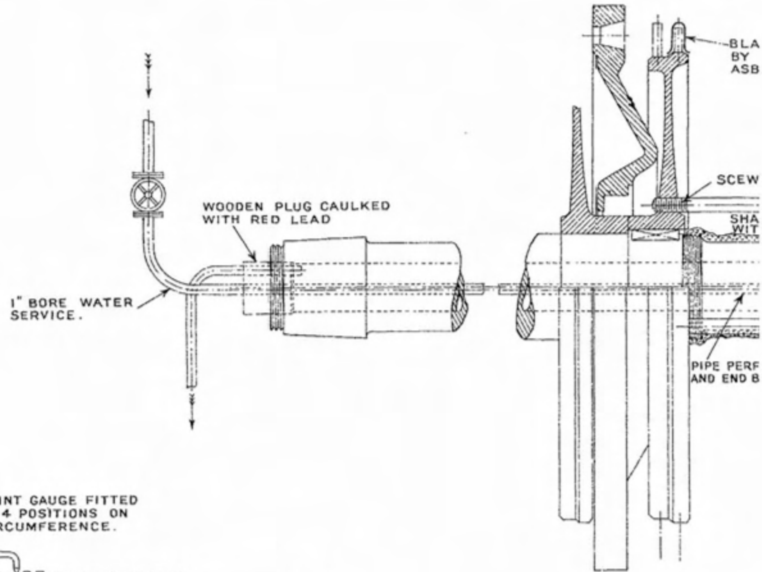
REMOVAL & REPLACEMENT OF 1ST STAGE



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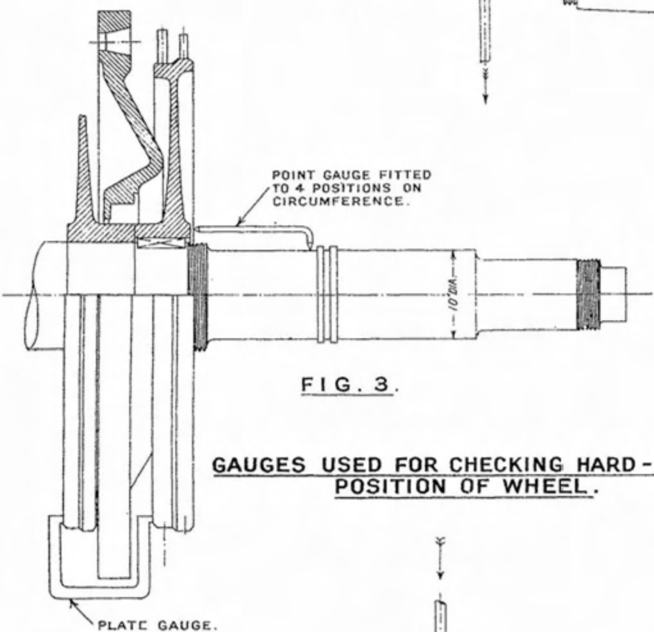
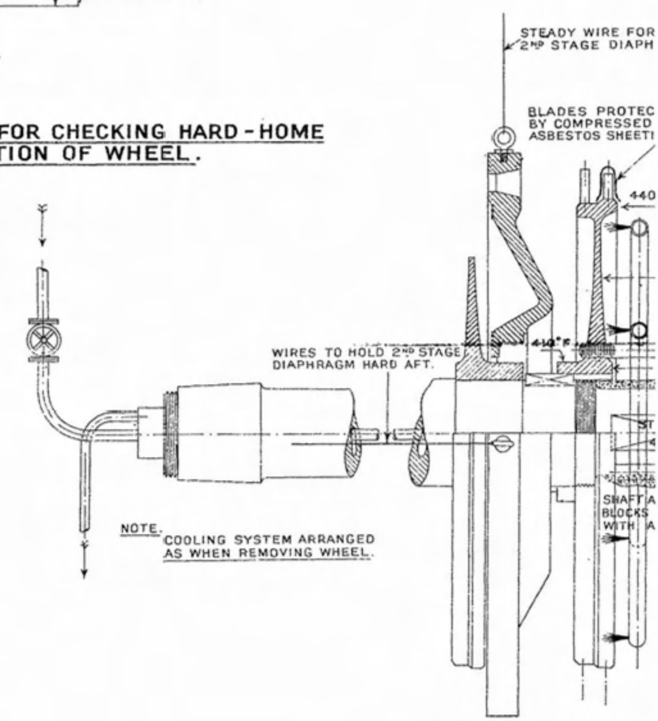


FIG. 3.

GAUGES USED FOR CHECKING HARD-HOME POSITION OF WHEEL.



REPLACE

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. "HOOD."
IMPULSE WHEELS.— S. INNER H.P. TURBINE.

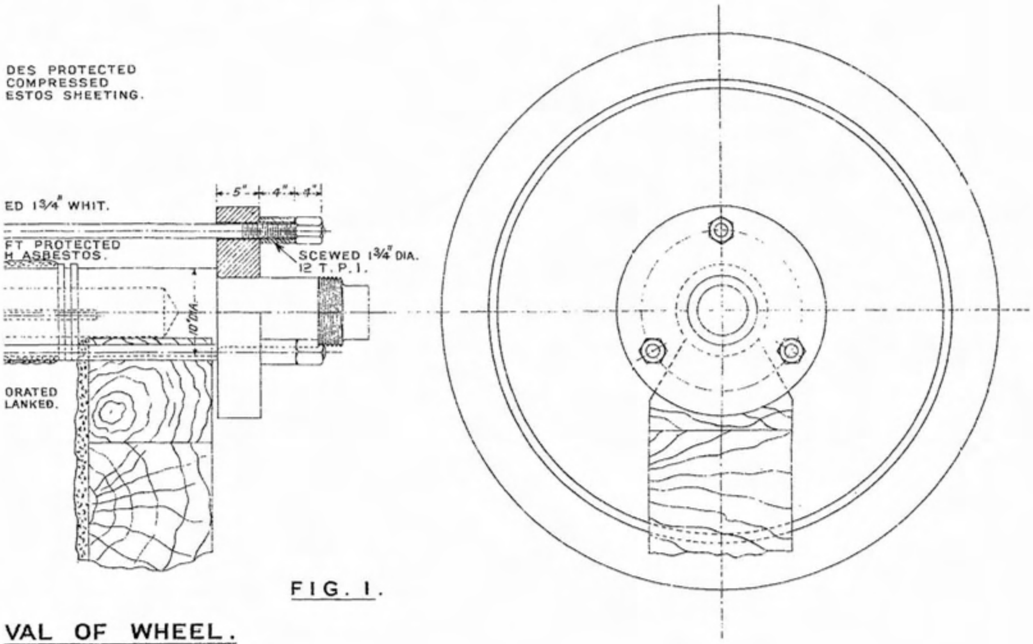

FIG. I.

VAL OF WHEEL.

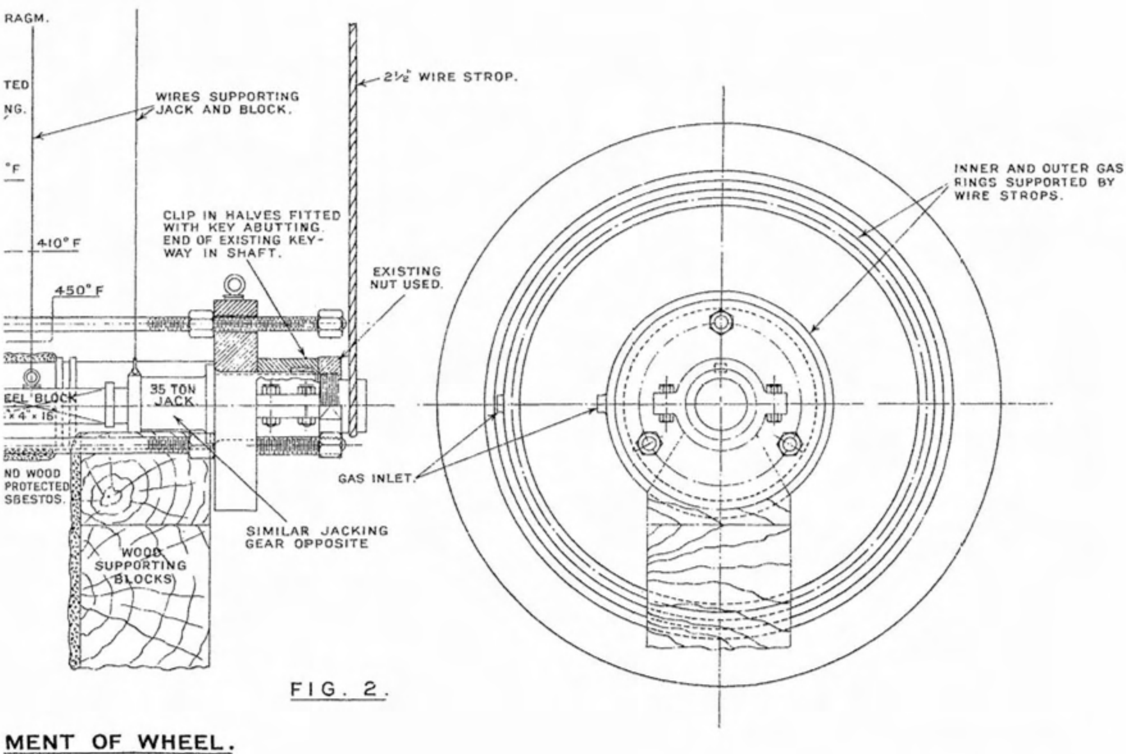

FIG. 2.

MENT OF WHEEL.

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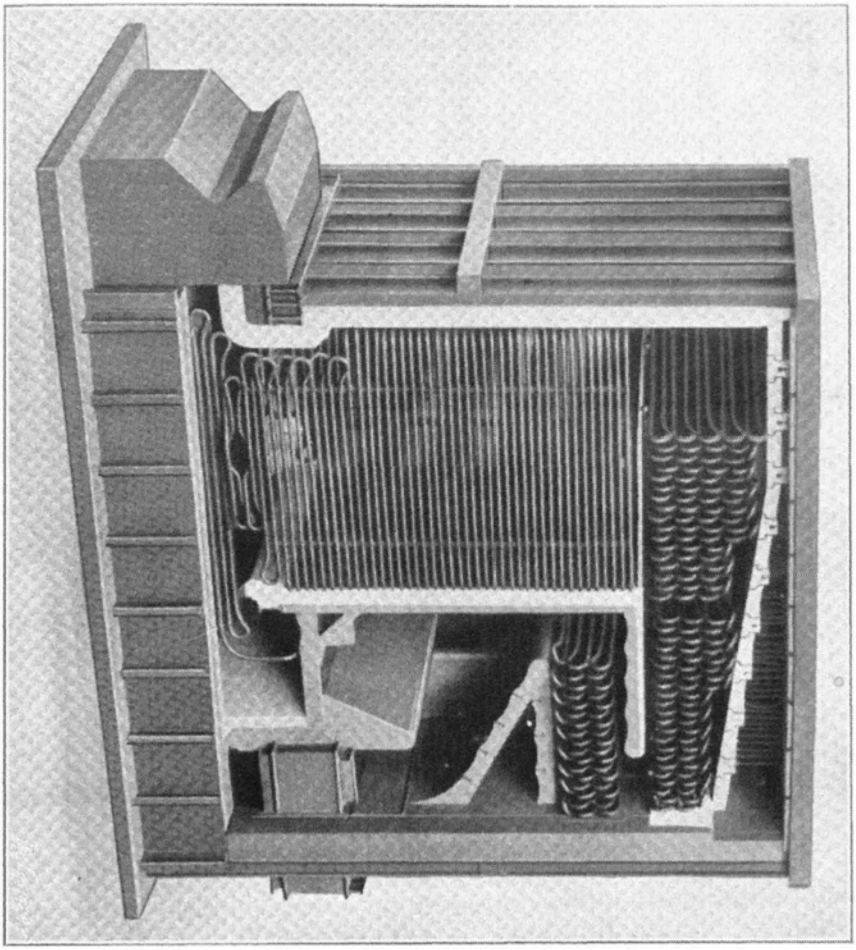

1206 Commenced playing air on boss and shut off water cooling to shaft.

1300 Temperatures :—

Rim	.. .. ..	200° F.
Boss	.. .. ..	150° F.
Spindle	.. ..	140° F.

1345 Temperatures :—

Rim	.. .. ..	160° F.
Boss	.. .. ..	140° F.
Spindle	.. ..	135° F.

1415 Temperatures :—

Rim	.. .. ..	145° F.
Boss	.. .. ..	120° F.
Spindle	.. ..	120° F.

Load on jacks and screws was then released.