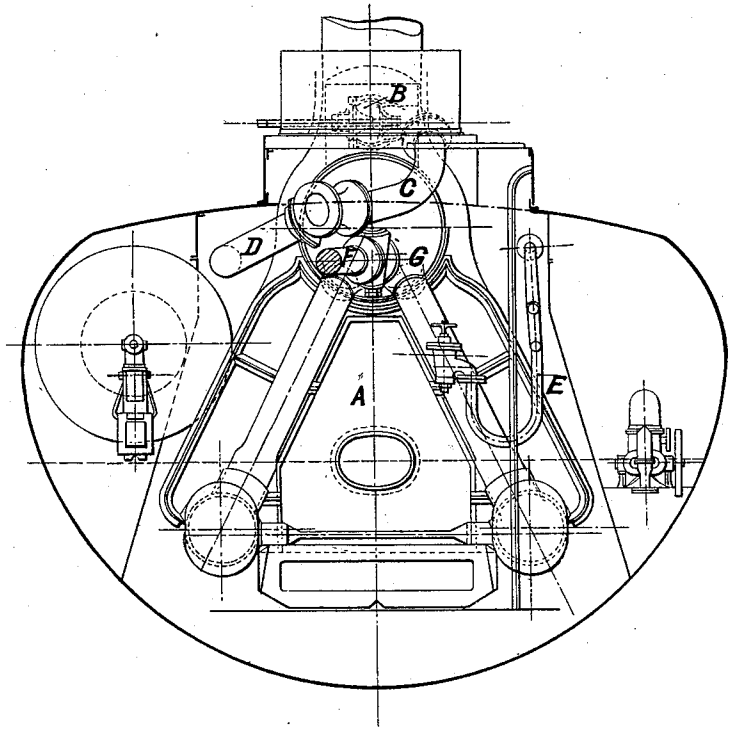
(No Model.) 3 Sheets—Sheet 1.

J. A., F. E. & M. E. NORMAND.

STEAM GENERATOR.

No. 588,464. Patented Aug. 17, 1897.

FIG. I.



Witnesses

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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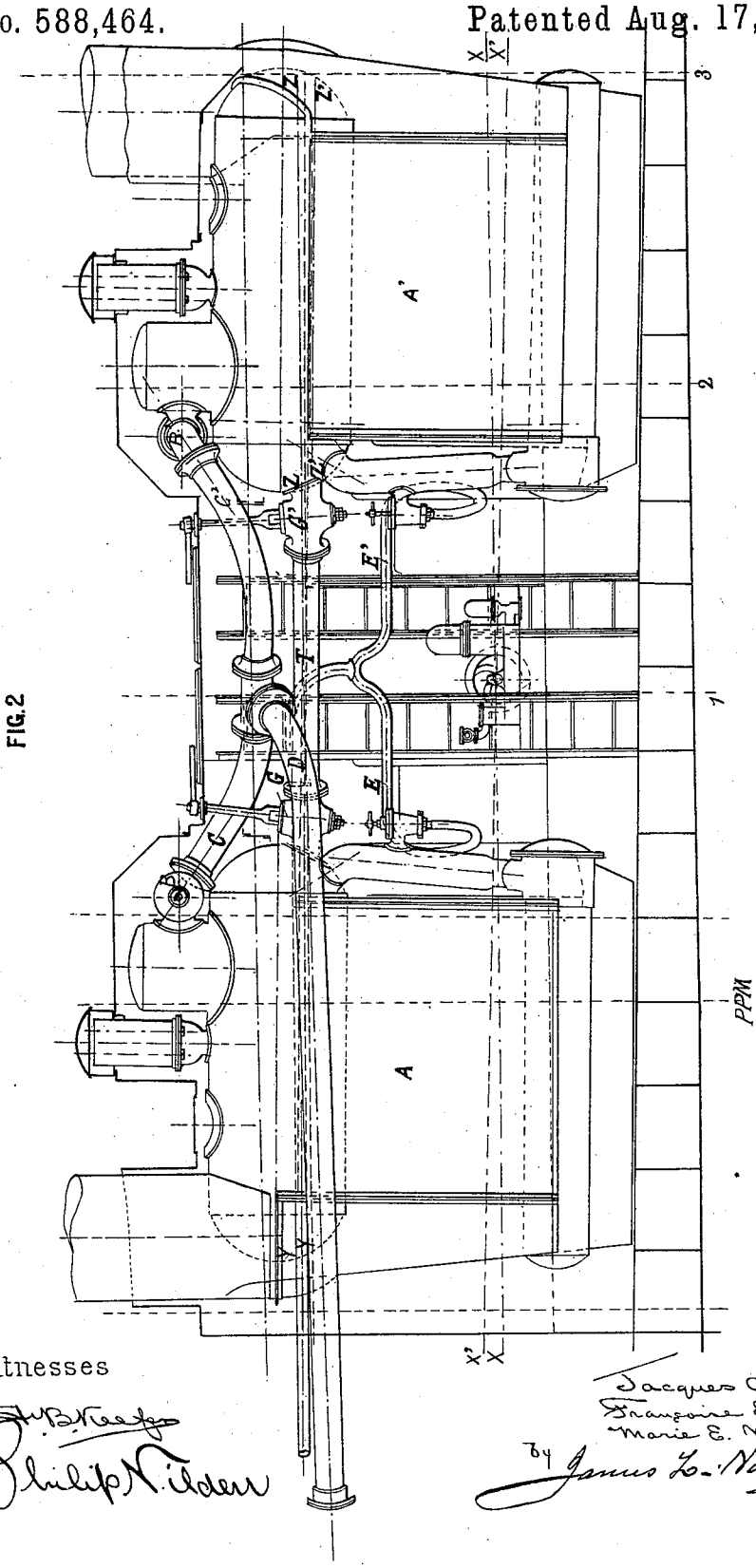


FIG. 2

Witnesses

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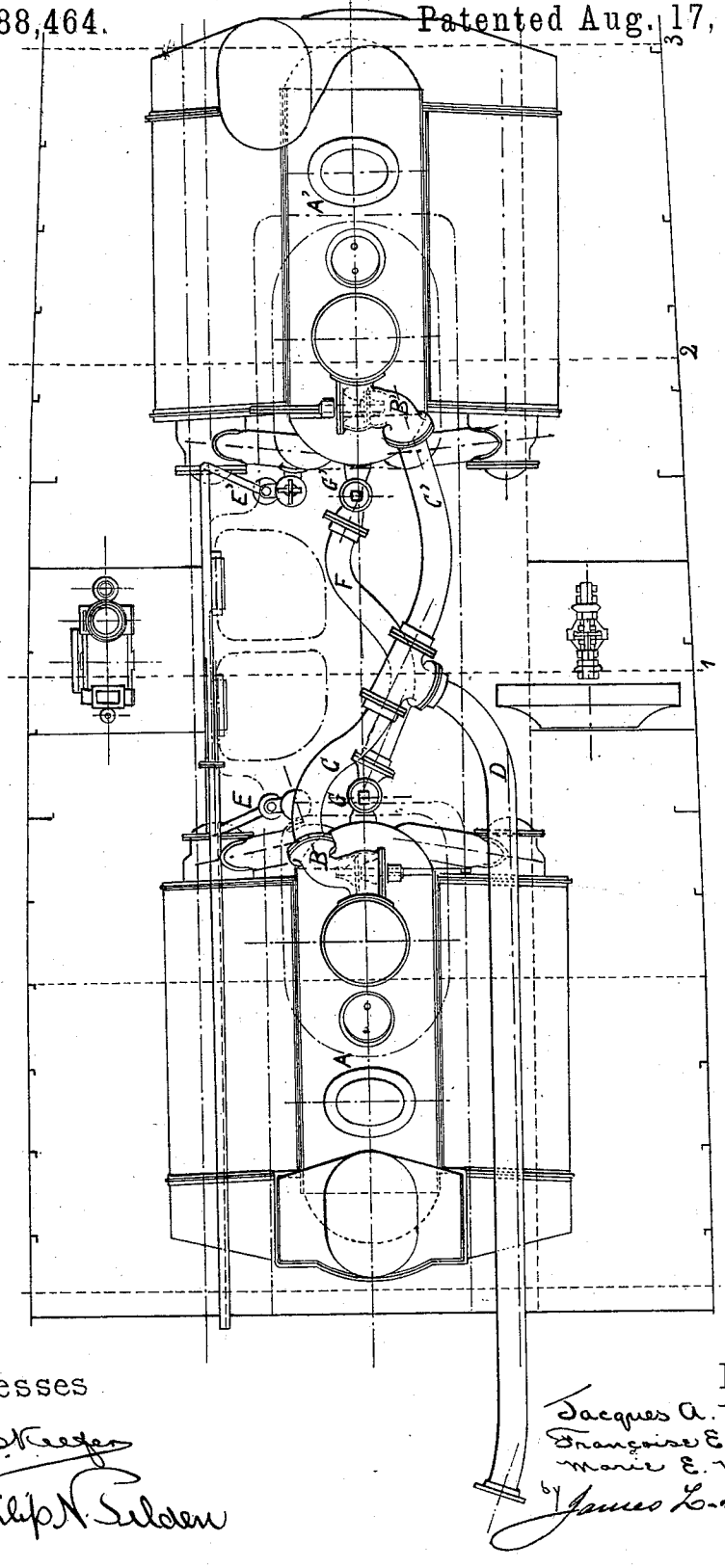


FIG. 3

Witnesses

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UNITED STATES PATENT OFFICE.

JACQUES AUGUSTIN NORMAND, FRANÇOISE ELISABETH NORMAND, AND MARIE EMILIE NORMAND, OF HAVRE, FRANCE.

STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 588,464, dated August 17, 1897.

Application filed April 3, 1897. Serial No. 630,650. (No model.) Patented in France September 16, 1895, No. 250,320.

To all whom it may concern:

Be it known that we, JACQUES AUGUSTIN NORMAND, FRANÇOISE ELISABETH NORMAND, and MARIE EMILIE NORMAND, citizens of France, residing at Havre, in the Department of the Seine-Inférieure, France, have invented certain new and useful Improvements in or Connected with Steam-Generators, (for which we have received Letters Patent in France, No. 250,320, dated September 16, 1895,) of which the following is a specification.

The subdivision into two or more parts of the total boiler-power employed in feeding an engine with steam offers the advantage that any damage that may be sustained by either of the component boilers does not entail a stoppage of the machine, while, on the other hand, such subdivision is attended with the inconvenience that it makes it difficult for the feed to be equally divided whenever combustion becomes very active. This drawback is particularly serious in the case of boilers constructed to hold but a small volume of water and subjected to intense heating, the use of which boilers is becoming more general, principally for marine purposes. But little reliance can be placed upon the readings of the water-gages in those cases, because of the violent ebullition of the water, or of the currents of water, due to the rapidity of circulation.

In ships where one engine is supplied with steam by a number of boilers of the class referred to the heating invariably proves to be less active than where one such boiler is employed and the weight is of course considerably greater. Where, however, a single boiler is used, with surface condensation, little notice is taken of the water-gage readings, and, provided the engineer has means for ascertaining that no water is lost through the accidental discharge-pipe of the hot well or otherwise, this fact is sufficient to satisfy him that the supply of water in the boiler is as required.

The object of this invention is to combine the safety which is incidental to the use of two or more component boilers with the uniformity in the feed-water supply which is incidental to single boilers.

As against the various types of feed-water regulators at present in use the improved arrangement, according to this invention, presents the double advantage of comprising no moving mechanism and of enabling the feeding to be kept up to a normal level by means of simpler appliances than are required where donkey-engines are adopted, in addition to which the apparatus, according to this invention, are not so expensive as and are more economical of steam than donkey-engines, and, farthermore, the arrangement which forms the subject of this invention is more consistent with the use of feed-water heaters, which are of course desirable on account of the saving they effect in the consumption of fuel.

This invention mainly consists in connecting the component boilers by two pipes or systems of tubing provided with valves, one of which pipes or systems of tubing puts the steam-reservoirs of the boilers in communication with each other, the sectional area being sufficient to reduce the difference of pressure between the apparatus to but a few centimeters of water, even while the firing is at its highest, while the other pipe or system of tubing makes connection between the water contained in both boilers, the lower part of this tubing being situated at the lowest water-level compatible with the satisfactory working of the boiler.

The diameter of this second pipe or tubular system should be sufficient for fully feeding one of the apparatus when the whole supply of feed-water has been introduced into the other, and that, too, without there being any difference of pressure between the two apparatus. For land boilers there is no limit to the diameter beyond that which is the outcome of the size of the cut-off valves, but for marine boilers it is desirable that such diameter should not be large enough to cause the lowering of the water-level in the boilers to a dangerously-great extent, owing to the movements of the vessel.

The accompanying drawings illustrate the manner in which our invention may be carried out on board a torpedo-boat having two boilers, from which its other applications will also be understood, but the example chosen is one of those that present the greatest difficulties, as in vessels of this class the disturb-

ances of the level occasioned by the speed of the vessel are considerable, while the boilers are erected at a considerable distance apart.

Figure 1 is a transverse section between two boilers. Fig. 2 is a longitudinal elevation. Fig. 3 is a plan.

A is the rear boiler, and A′ the forward boiler, both of which are supposed to be of the Normand type, having one common stoke-hole.

X X is a horizontal line when the vessel is not in motion.

X′ X′ is a horizontal line when the vessel has attained her maximum speed.

Y Y indicate the water-level in the rear boiler A when the vessel is at rest.

Y′ Y′ indicate the water-level in the said boiler when the vessel is at maximum speed.

Z Z and Z′ Z′ are the corresponding water-levels in the front boiler A′.

B and B′ are the steam-valves of the two boilers, respectively, and C and C′ are the steam-supply pipes of the respective boilers.

D is the collecting-pipe, which conducts the steam obtained from the two boilers to the single engine.

E E′ are feed-pipes, and F is the pipe connecting the water contained in the two boilers in the vicinity of the water-levels, the said pipe being provided with cocks or valves G G′.

The diameter of the pipes C C′ is the same as that of the collecting-pipe D, although each of the pipes C C′ is intended to deliver only one-half of the steam passing through the said pipe D. The pipes C C′ fulfill a double function, as they cause the steam to pass from the boiler where the pressure may be higher to the boiler in which a lower pressure may prevail, while at the same time they each deliver about one-half of the total amount of steam used by the engine. By slightly increasing the diameter of the pipes C C′ and their valves B B′ the employment of a special connection for restoring uniformity of pressure between the two boilers is rendered unnecessary, pipe-joints and intermediate valves are done away with, and the rapid disconnection of one boiler from the other in case of emergency is facilitated.

It is important where the main steam-pipes serve to establish equality of pressure in the two boilers that such pipes at all times when the engine is running should be kept open, and necessary arrangements are to be made in order that the valves of the said main steam-pipes should not close automatically under the pressure due to the flow of steam. The throttling of the steam, where it is deemed necessary with a view to saving fuel, should be effected at such a part of the piping as will enable it to be performed without any reduction of the sectional area of the steam connection between the boilers.

Were it necessary for the communication between the boilers to have a greater cross-sectional area than that of the collector D in order to restore equality of pressure between the two boilers it would be preferable to do this rather than to make a separate connection between the two steam-spaces.

The feed-water may be admitted either into the steam-space or at about the lowest level consistent with satisfactory working, or even at any level within the water contained in the boiler.

The first-mentioned arrangement is calculated to render the water circulation more active, and consequently the consumption of fuel more economical; but owing to possible irregularities in the feed-water supply, which at one time may be excessive and at another may fail or be insufficient, corresponding irregularities in the pressure of boiler may also arise and attain a considerable magnitude, and as feeding at the lowest level is apt accidentally to lead to the same inconveniences as feeding into the steam-space and as delivery of the feed-water into the water in the boilers is free from this drawback and as regularity of pressure is one of the main desiderata for obtaining constant levels in coupled boilers, the admission of the feed-water under the water-level of the boilers is to be preferred.

In ordinary boilers the operation of sending the feed-water into the water contained in the boilers through tubing common to more than one boiler is attended with the great danger that if the valves of the governors should remain in the raised position and if there happen to be an appreciable difference of pressure between the boilers, owing to the steam-inlet valves not being sufficiently opened or from any other cause, the boiler wherein the pressure is higher might discharge its water into the boiler wherein the lower pressure prevails up to the level of the feed. This danger is obviated by the addition of the pipe F remaining constantly open while the boilers are in normal operation and situated on a level, or approximately so, with the surface of the water in the boilers. The duty which this pipe discharges the feed-collector could not perform, even though it were placed on a level otherwise conducive to such purpose for two reasons—viz., first, because of the cut-off valves in the feed-pipes of each boiler, which destroy the free connection between the boilers, and, secondly, by reason of the considerable variations of pressure existing between the several points of the feed-collector. At all events it is important that emergency feeding from the reserved tank should always be directed into the water instead of into the steam.

We will now show that the laws which govern the delivery of steam and water enable in our arrangement the three necessary conditions to be complied with in practice, as follows: First, the diameters of the pipes connecting the steam-spaces should be sufficient to reduce the difference of pressure between the two boilers to but a few centimeters of water—say from five to ten centimeters; second, where this difference of pressure is *nil*

the diameter of the pipe situated in the vicinity of the water-levels should be sufficient to furnish the required supply of feed-water to one boiler, while the other boiler may have the benefit of a full supply; third, the diameter of the said pipe should not be large enough to allow of the water-level being lowered to a dangerous extent in one boiler and unduly raised in the other at the same time, so as to create priming while the vessel is pitching and tossing or rolling.

It is hardly necessary to repeat that there is no occasion for the fulfilment of the third condition in the case of land boilers, to which our invention may be equally applied.

Let us suppose the dimensions and other data of the apparatus represented in the drawings to be as follows: Surface of grate, two square meters; heating-surface, one hundred square meters; pressure above the vacuum, fifteen atmospheres; vaporization of water per hour while working at maximum power, four thousand five hundred kilograms; diameter of opening through valves B and B′ and internal diameter of pipes C and C′ for steam-supply to the engine, 0.16 meters; diameter of passage through the connecting-valve G and internal diameter of the pipe F, the lower part of which is situated on the lowest water-level in boilers consistent with satisfactory working, 0.10 meters.

In calculating the speed of the steam-discharge we will take the formula embodying the old theory, which is more accurate in its results than the thermo-dynamic theory. The old formula, as given by Pochet (*Nouvelle Mécanique Industrielle*, page 277) is as follows:

$$(1)\quad \frac{W^2}{2g}=16{,}600\left(1-\frac{p}{p_0}\right),$$

W representing the rate of speed per second in meters and $\frac{p}{p_0}$ being the ratio of absolute pressures between the two steam-reservoirs. From formula (1) we deduce:

$$(2)\quad p_0-p=0.00000307\,p_0\,W^2.$$

For the purpose of testing this formula take p_0 to equal eight atmospheres and p to equal seven atmospheres. The following will be the speed of delivery of steam:

$$W=\sqrt[2]{\frac{8-7}{8\times 0.00000307}}=\sqrt[2]{40{,}750}=202 \text{ meters.}$$

Zeuner's table (Pochet, page 404) gives two hundred and twenty-three meters; but the velocities contained in that table are well known to be too high.

The most unfavorable condition of things for the equalization of pressures is when the total quantity of steam generated in one boiler (this total in the present example being

$$\frac{4{,}500 \text{ kilograms}}{3{,}600 \text{ seconds}}=1.25 \text{ kilograms}$$

per second) is compelled to pass through the other boiler, instead of being conveyed almost in its entirety directly to the engine. This would happen if the steam-spaces were connected by a special pipe sixteen centimeters in diameter quite apart from the steam-inlet pipes and if while the engine was in full operation the attendant omitted to open the main steam-valve of one of the boilers.

Let the weight of a cubic meter of steam at fifteen atmospheres' pressure be 7.68 kilograms, if we suppose that in consequence of the resistances occurring the real speed W′ is only two-thirds of the theoretical speed W, then we shall find W′ to be expressed thus:

$$\frac{\Pi}{4}\times\overline{0.16}^{2}\times W'\times 7.68 \text{ kilograms}=$$

1.25 kilograms.

Whence W′ equals 8.1 meters, which corresponds to the theoretical speed W

$$\frac{3}{2}\times 8.1=12.1 \text{ meters.}$$

The difference of pressure according to formula (2) therefore is

$$p_0-p=0.00000307\times p_0\times\overline{12.1}^{2}=0.00045\,p_0.$$

Now p_0, expressed in meters of water, is

10.33 meters × 15 atmospheres = 155 meters.

Therefore the difference of pressure, in meters of water, is

$$p-p_0=0.00045\times 155 \text{ meters}=0.070 \text{ meters.}$$

Thus the maximum difference of pressure between the two boilers will be seven centimeters of water. The sixteen centimeter diameter of the connecting steam-pipes will be amply sufficient, as the pipe F will to a certain degree assist in equalizing the pressures. Let us now see to what level it will be necessary for the water to rise to cause one of the boilers to be supplied with its share of feed-water through the pipe F on the assumption that the total supply has been introduced into the other boiler. We will suppose that delivery takes place through one-half of the sectional area of the pipe only—that is to say,

$$\tfrac{1}{2}\,\frac{\Pi}{4}\times\overline{0.10}^{2}=0.0040 \text{ meters square.}$$

The rate of speed per second requisite for allowing the maximum amount of feed-water per hour—viz., cubic meters 0.00125—to pass is

$$\frac{0.00125 \text{ cubic meters}}{0.0040 \text{ square meters}}=0.31 \text{ meters.}$$

Taking, as before, the coefficient of contraction to be two-thirds, the theoretical speed will be

$$\frac{3}{2}\times 0.31 \text{ meters}=0.46 \text{ meters,}$$

corresponding to a depth of fall of 11 millimeters.

Let us now calculate how much water may pass from one boiler to the other while the vessel is pitching.

Assuming the time occupied by each simple oscillation to be 1.5 seconds, the maximum angle of motion ten degrees, the distance between the centers of the water-surfaces of the two boilers 4.50 meters, the evaporating-surface of each boiler

$$0.74 \text{ meters} \times 2.30 \text{ meters} = 1.70 \text{ meters square.}$$

The difference of level corresponding to the maximum amplitude of the angle of oscillation is

$$4.50 \text{ meters} \times \sin. 10^\circ = 0.78 \text{ meters.}$$

We will assume that the discharge during the space of 1.5 seconds of one single oscillation is the same as that which would in the same period of time be caused by a constant fall of 0.50 meters. The corresponding theoretical speed is 3.12 meters. The real speed is

$$\frac{2}{3} \times 3.12 = 2.01 \text{ meters.}$$

The quantity of water passing from one boiler to the other (it being observed that the flow of water would occupy the full sectional area of the pipe) will be

$$\frac{\Pi}{4} \times \overline{0.10}^2 \text{ meters} \times 2.08 \text{ meters} \times 1.5 \text{ seconds} =$$

$$0.025 \text{ cubic meters,}$$

and the corresponding change of level

$$\frac{0.025 \text{ cubic meters}}{1.70 \text{ square meters}} = 0.015 \text{ meters.}$$

A momentary fall or rise of level of fifteen millimeters is of no consequence.

In a large ship the time occupied by each oscillation may attain four seconds, so that the variation of level would in that case amount to—

$$\frac{4 \text{ seconds}}{1.5 \text{ seconds}} \times 0.015 = 0.040 \text{ meters.}$$

This figure, again, is of no importance, inasmuch as the firing is in that case far less active than it is in torpedo-boats, and therefore the sectional area of the pipe might be considerably reduced in relation to the steam-evaporative surface.

Within the separating-bank sea-breakers, made nearly water-tight, may be so disposed as to reduce the longitudinal movements of the water, and also consequently the difference of level between the two boilers occurring during one longitudinal inclination of the vessel.

As the heating-surfaces in pitching are uncovered or exposed but for a short time these surfaces can in no case rise to a high temperature. It is well known, moreover, that there exist boilers, such as Thornycroft's boilers, wherein the upper parts of the heating-tubes normally rise above the water-level.

A movable device adapted to partially close the pipe F during the rocking movements of the ship may be provided so as to reduce the quantity of water passing at the time from one boiler to the other. This arrangement, however, does not appear to be free from danger. It is important that the curve formed in the said pipe F as a provision for the effects of expansion should lie in a horizontal plane, so that the said pipe may serve for the passage of both steam and water. The curved steam-pipes C C′ and water-pipe F may be replaced by straight pipes with expansion-joints. Thus it will be seen that in the example we have selected the three conditions which we have assumed to be essential are fulfilled in such a manner as to render the working of a pair of coupled boilers quite reliable. In this instance the torpedo-boat steaming at full speed lifts forward, so as to take a longitudinal inclination of about three centimeters, and the distance between the centers of the evaporative surfaces of both boilers is—

$$0.03 \text{ meters} \times 4.50 \text{ meters} = 0.135 \text{ meters.}$$

It follows that the rear boiler is erected about 0.10 meters higher than the front boiler, a situation which is most unfavorable to the coupling together of such boilers. The arrangement would, however, be far less inconvenient if the two boilers were inverted and the single stoke-hole was replaced by two stoke-holes, in which case the distance between the centers of the steam-evaporative surfaces would be far less. The various practical difficulties existing in the example here adduced are such that as the invention can be applied to this the coupling of two or more boilers feeding one single engine will be possible in most cases by the same means.

Our invention is still more readily applicable to torpedo destroyers, in which steam is generally supplied to each engine by two boilers, because in vessels of that class the changes of level occasioned by the speed of motion is less than in torpedo-boats proper. It might form an advantageous substitute for the very delicate automatic governors hitherto employed, many of which are inaccessible by reason of their being situated within the boilers. The excessive activity with which firing is carried on in ships of this description renders the employment of perfectly reliable self-operating governors absolutely necessary.

Our invention may, besides, be applied to any number of boilers greater than two—say to a battery of boilers such as is met with in works on land or on board ships of high power—as it will enable the feed-water to be equally divided or distributed between boilers displaying very great aggregate power. Thus in a large ship one of Normand Sigandy's boilers of medium size may supply steam sufficient for developing two thousand horse-power with moderate firing, owing to the pecu-

liar construction of the boiler, wherein every square meter of the grate is made to burn from 160 to 180 kilograms per hour, provided the engine be of a sufficiently economical construction. Three such boilers, therefore, would develop six thousand horse-power, and a twin-screw vessel, each engine of which is driven by the three boilers, would thus be capable of indicating twelve thousand horse-power without requiring any feed-regulator other than that according to our invention. The erection will present no difficulty if the boilers be arranged athwartship with a longitudinal heating-chamber extending on both sides of the vessel, such an arrangement being particularly convenient for the supply of coals to the stokers, as well as for coupling the boilers.

Each of the Normand Sigandy double-ended boilers could be replaced by two Normand's single boilers coupled according to our present invention. It may be seen by this example how our invention may be used for dividing equally between six boilers giving steam to a single engine the feed-water furnished by a common feed-water pipe. In this case, as well as in the case of a battery of land boilers, the pipe connecting the several boilers at the level of the water should consist of a collector provided with branch pipes leading to each boiler, so that either of the boilers can at any time be isolated from the rest of the battery without interruption in the connection between the remaining boilers. The same arrangement should be used for the steam-collector, which serves, moreover, to insure equality of pressure in the several boilers. The movements in the direction of the ship's length are the only ones that are not permanent. Transversely ships are apt to assume and retain, either permanently or, at all events, for lengthy periods of time, an inclined position under the pressure of the wind or the thrust of the waves, or in consequence of a want of symmetry in the distribution of loads, or, again, during a gyratory movement of somewhat long duration, in which certain vessels are apt to heel considerably on one side. Besides the duration and amplitude of the transverse oscillations are always greater than those of the longitudinal movements. The boilers should therefore preferably be connected into a battery longitudinally.

Where transverse coupling must needs be resorted to, it will be necessary to increase the steam-spaces of the boilers lest variations in the level should produce dangerous priming; but in the case of longitudinal coupling also a slight increase in the dimensions of the steam-spaces will be found to be of advantage. At all events, whatever inconveniences may arise therefrom they will be less serious than those involved in separate and distinct feeding, which would be felt whenever the firing began to be conducted with increased activity.

From the foregoing description it will readily be seen why the lower portions of the valves in the pipe F have to be arranged in the vicinity of the lowest water-level. Were they placed higher the said pipe would not feed the boiler which is wanting in water unless the water in the overfed boiler rose to such a height as to bring about a dangerous fall of the water-level in the other boiler. If the said pipe were placed lower, whenever one of the main steam-boiler valves happened to be insufficiently opened, or in the event of all the said valves not being simultaneously closed when the engines are stopped, a difference of pressure between the two boilers might occasion a descent of the water-level in one boiler so as to endanger the heating-surfaces, while in the other boiler there would occur an undue rise of the water-level apt to produce priming in restarting. Too low a position of the pipe would also be attended with the inconvenience that should a leak of some magnitude occur in one of the boilers requiring the immediate severance of the same, the remaining boiler or boilers would lose an appreciable quantity of water before the damaged boiler could be isolated.

Under normal conditions the cocks G G′ of the pipe F should constantly remain open and only be closed in case of any accident rendering one of the boilers unserviceable. They should be operated at frequent intervals in order to ascertain whether they are in proper working order.

Our invention may be applied to boilers of all types and systems, and the proportions and dimensions of the main parts thereof, as well as its accessory arrangements, may be varied to suit various requirements without departure from the leading principle of the invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is—

The combination with two or more boilers for furnishing steam to a single engine, of the connected feed-water pipes E E′, a pipe F connecting the boilers at or near the lowest water-level consistent with a satisfactory working of the boilers, cocks G G′ at the ends of said connecting-pipe, the pipe connections C C′ between the steam-spaces of the boilers, and a collecting-pipe D from said pipes C C′, to the engine, substantially as described.

In testimony whereof we have hereunto set our hands in presence of two subscribing witnesses.

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FRANÇOISE ELISABETH NORMAND.
MARIE EMILIE NORMAND.

Witnesses:
V. L. MAIQUENT,
G. CERTAIZ.