May 13, 1930. J. AUSTIN ET AL 1,758,810

METHOD OF AND IN APPARATUS FOR TREATING THE TUBES OF SURFACE CONDENSERS AND THE LIKE TO PREVENT CORROSIVE ACTION

Filed Dec. 16, 1925 2 Sheets-Sheet 1

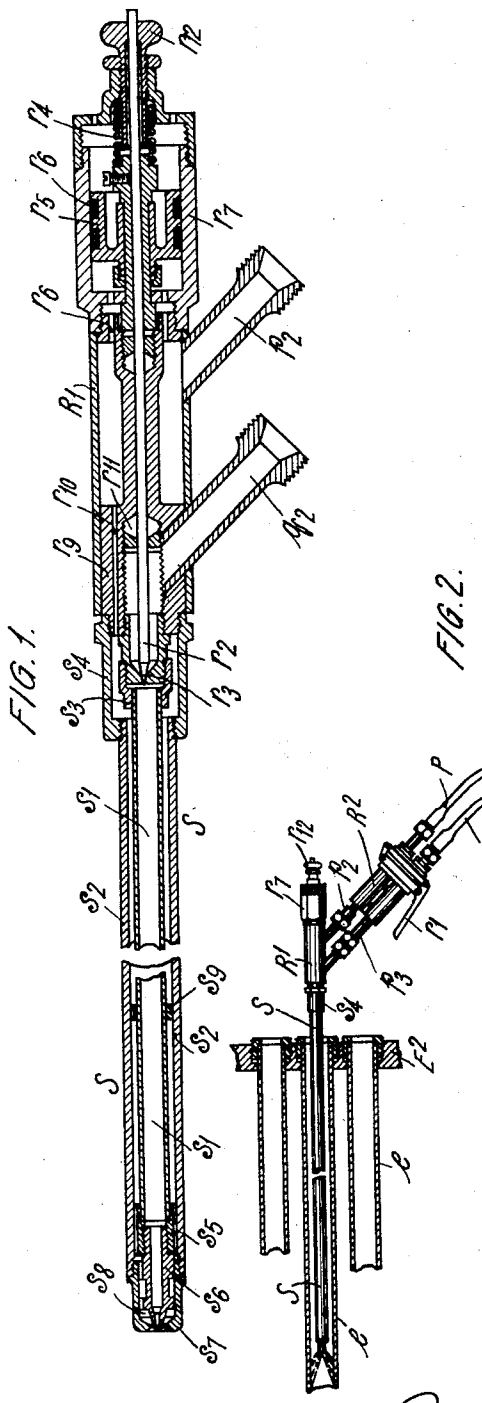


FIG. 1.

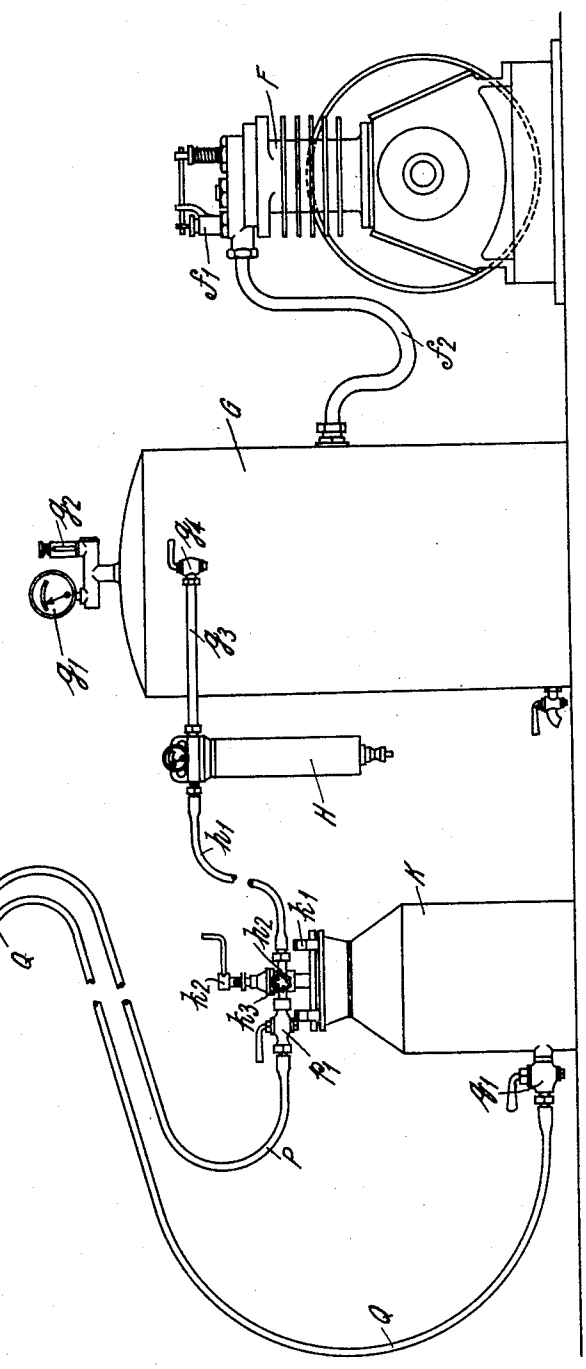


FIG. 2.

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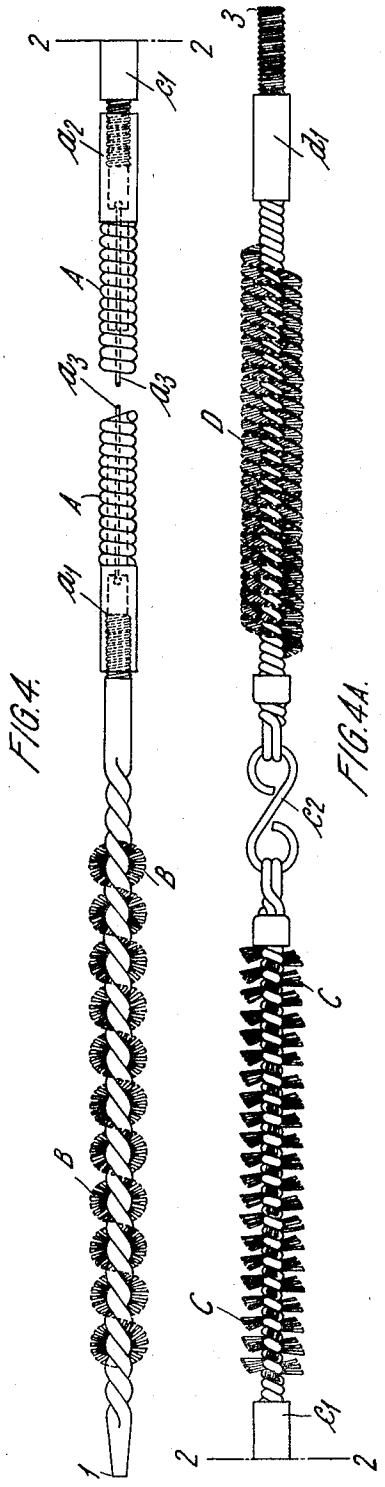


FIG. 4.

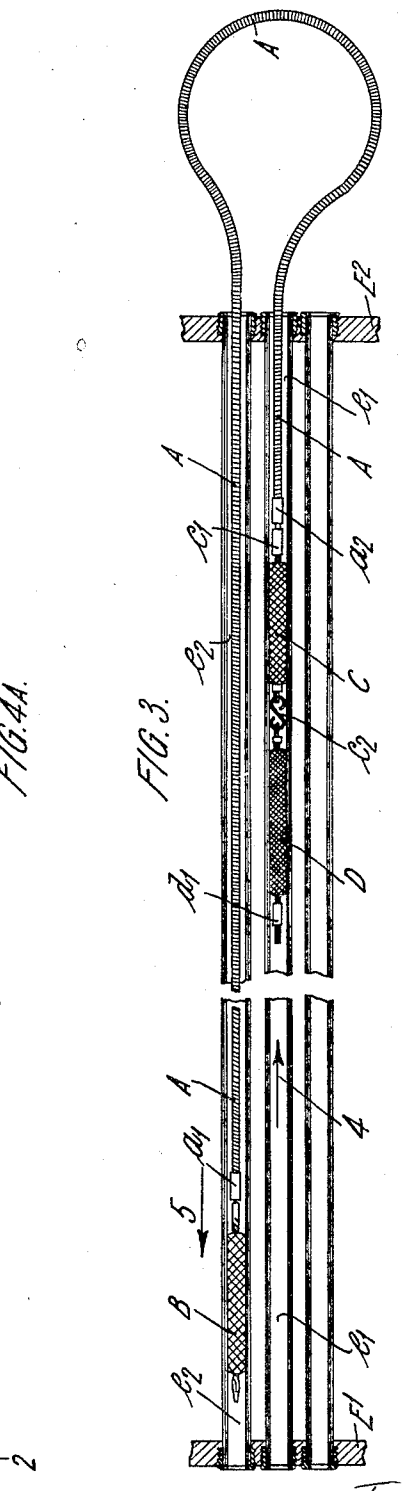


FIG. 4A.



FIG. 3.

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# UNITED STATES PATENT OFFICE

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## METHOD OF AND IN APPARATUS FOR TREATING THE TUBES OF SURFACE CONDENSERS AND THE LIKE TO PREVENT CORROSIVE ACTION

Application filed December 16, 1925, Serial No. 75,797, and in Great Britain December 30, 1924.

This invention relates to improvements in the method of, and in apparatus for treating the tubes of surface condensers and the like to prevent corrosive action.

Recent developments in steam engine and turbine design necessitating a comparatively high vacuum, and in condensers necessitating a comparatively high rate of flow of condensing water to compensate for the reduction of area of the heat transferring surfaces, now adopted per unit of power developed, have resulted in a very marked increase in the corrosive action of the condensing water upon the inner surfaces of the condenser tubes, particularly when the circulating water is, as in the case of marine engines, sea-water; in recent years the difficulty has assumed very serious proportions, active corrosion taking place in new condensers within twelve months of service, and in some cases necessitating entire re-tubing, at considerable expense, after a comparatively short period of service. The secondary results of leakage of sea-water to the steam flow, due to the corrosion, are also very serious in respect to the boiler and propelling machinery, especially when the latter is of the turbine type; in the boiler, production of scale, priming and damage to furnaces, and in the turbine plant, corrosion and incrustation.

Various attempts have been made to overcome these difficulties; various metals and alloys have been used for the condenser tubes; the interiors of the tubes have been coated with tin or the like non-corrosive metal; and counter-electrolytic methods have been employed to avoid electrolytic corrosion of the tubes; but we have found, as the result of a very wide experience, that by none of these known methods has a substantial improvement been effected. From a very careful examination of a large number of corroded tubes taken from the condensers of different types of ships we found that the corrosion was different in character from that which took place in the older types of condensers fitted to reciprocating engines working under a moderate vacuum, in which case the corrosion was in the nature of "pitting" or "dezincification", whereas in the more modern type of plant the condenser tubes were corroded or eroded from end to end.

Upon repeated failure to prevent this action by use of tubes of various kinds of alloys, or by the use of a lining of non-corrosive metal we decided to try the effect of coating the interiors of the tubes with a non-corrosive solution of the nature of a fairly quick-drying paint or varnish. Such substances are, of course, comparatively bad conductors of heat, and for this reason appeared at first to be objectionable and unsuitable. When, however the inefficiency due to the leakage of salt-water into the boilers resulting in scaling and priming and leading to deterioration of turbine plant consequent upon the deposition of sediment, together with the heavy charges for consequent overhauls and renewals, were considered, it was believed that the saving effected by the elimination of these losses would more than compensate for the decrease of efficiency, in respect to heat transfer, of the coated tubes.

We found in carrying out our invention that the coating solution must be such as would withstand the action of salt-water driven through the tubes at a comparatively high velocity, and be such as would provide from end to end of the interior tube an insulating coating adequate to prevent corrosive, erosive or electrolytic action; that the solution must be such as could be applied, in the manner herein described to the interiors of tubes of say 5/8 inch bore and 10 feet long so as to provide an even tenacious and protective coating of minimum thickness consistent with continuity from end to end; and that for practical reasons the coating must be capable of being applied to tubes in situ in the condenser, and without having to disturb the ferrules; we also found that to obtain successful results in the case of condensers which had been in service a preparatory treatment of the interiors of the tubes was necessary; that preferably more than one coating had to be applied with an intervening treatment of the applied coating; and that suitable drying means had to be employed for such coating. We also found that the coating could best be

applied by spraying the interiors of the tubes, from both ends, by means of an inserted nozzle of a spraying device, using compressed air to atomize the solution and applying it as a coating to the interiors of the tubes; and the object of our present invention is to provide a mode of, and apparatus for, carrying out the coating of the interiors of the tubes of surface condensers and the like with a preservative solution in accordance with the above requirements.

According to the invention the method of protecting the surfaces of condenser tubes and the like against the corrosve action of a circulating fluid consists in coating the said surfaces after they have been cleaned and dried, by spraying thereon by means of an air-jet a medium containing a protective substance which when dried forms a tough adherent protective layer on the said surfaces.

The medium is preferably in the form of paint containing bitumen or the like tough, plastic adherent substance adapted to resist the said corrosive action, mixed with a suitable drier liquid, the coating so applied being dried by passing over it currents of air.

In carrying out the invention the method of cleaning the tubes and applying the coating is preferably carried out in the manner and by means of apparatus as hereinafter described and claimed.

We have illustrated the apparatus employed in carrying out our invention to coat the interior of condenser tubes, in the accompanying drawings, in which:—

Fig. 1 is an elevation in longitudinal medial section showing improvements in spraying devices for coating the interior of tubes.

Fig. 2 shows the general arrangement of the apparatus employed in combination with a spraying device.

Figs. 3 and 4 and 4A show the improved brush cleaning device.

Fig. 3 shows the device in situ in the tubes of a condenser.

In Figs. 4 and 4A which are views to a larger scale it has been necessary for convenience of illustration to show the length from the end 1 to the point 2 in Fig. 4, and the length from the point 2 to the end 3 in Fig. 4A; the actual device when connected is, of course, in one length, the part 2 of Fig. 4 coinciding with the part 2 of Fig. 4A.

Our invention as applied to the coating of condenser tubes is carried out as follows:—

Preparation of the tubes;—The interiors of the tubes should be effectively dried; this may be accomplished by admitting steam to the condenser so as to dry the tubes by heat applied to the outsides.

This may be effected by allowing a slight leak of steam into the steam side of the tubes just before cleaning. Each tube is then preferably treated as follows:—

If the tubes are very dirty or choked a scraper is first used; this is followed by the application of a very severe steel wire brush, with a strong thick core, the wire bristles being in the form of a slow spiral; preferably the brushes are screwed at the end to fit the end of a strong rod by means of which the brushes are pushed in from each end of tube. By means of this severe brush an attempt is made to open up any weak places in a tube, the slow spiral form being useful as a first cleaning brush, as the dirt does not clog this form of brush as easily as is the case with a close wire bristled brush. This operation loosens the dirt which still remains in the tube.

To remove the dirt and clean the tubes the brushing device illustrated in Figs. 3, 4 and 4A is employed.

The device consists of a closely wound spiral spring or snake A, the ends of which are fitted with adapters $a^1$ and $a^2$, the adapters being connected by a flexible but non-extensible member $a^3$. The portion A for condenser tubes of the usual size would be about twelve feet long, and the spiral is closely wound so that whilst it can transmit a considerable pull without distortion, it is flexible enough to permit of its being passed through two comparatively adjacent tubes in the manner shown in Fig. 3.

To the adapter $a^1$ on the leading end is fitted a slow-spiral, steel wire brush B which is first pushed through the tube to be cleaned, the connection between the brush and the adapter being conveniently made by means of a screwed union. The adapter $a^2$ at the trailing end of the snake is fitted with a very tightly wound, closely bristled, steel wire brush C, the adapter $c^1$ of which screws into the adapter $a^2$ of the snake; attached to the brush C by a shackle $c^2$ is a hair brush D adapted to be a tight fit in the tube, which brush is fitted with an adapter $d^1$ to which further brushes may be attached if necessary.

The apparatus would be employed to clean the tubes of a condenser as follows:—Assuming E′ and E² to be the inboard and outboard tube plates of the condenser, of which three tubes $e$ only are shown, an operator would be located at each end of the condenser, the brush B would then be inserted in, say, the tube $e^1$ by the operator in front of the tube plate E′, and would be pushed through this tube in the direction of the arrow 4, emerging from the end E² of the tube before the brush V enters the end E′; the operator at the end E² would then reverse the brush B and push it through the tube $e^2$ in the direction of the arrow 5, and by exerting a pull on the snake A would then pull the brushes C and D through the tube $e^1$ in the direction indicated, simultaneously feeding the brush B through the tube $e^2$; when the brush B emerges from the end

E′ of the tube $e^2$ it is, by the operator at the end E′, inserted in an adjacent tube, this operator pulling the brushes C and D through the tube $e^2$; this operation is repeated until all the tubes of a section are treated in this way.

By this method the tubes are thoroughly cleaned. In case, however, any dust should be left behind, each tube is blown through with air at 45 lbs. pressure by means of a pipe leading from the air compressor, to be described, and a quick opening air cock tapered to fit in the end of the tube.

The spraying plant employed is shown in the general arrangement Fig. 2, and comprises;—A suitably driven portable air-compressor F, preferably air-cooled with automatic suction release $f^1$; a suitable size for two spraying devices is one providing from 7 to 12 cubic feet at from 300 to 500 revolutions, respectively, per minute, at a pressure at 40 to 45 pounds per square inch. An air reservoir G fitted with gauge $g^1$ and safety valve $g^2$ to which the compressor delivers the compressed air through the pipe $f^2$. An air purifier H fitted with any suitable filtering arrangement, say a wire mesh and cloth bag filtering medium (not shown) to which air is delivered by the pipe $g^3$ controlled by the cock $g^4$. A solution container K fitted with a quick action cover locking device $k^1$ and an externally operated stirrer $k^2$; the air supply pipe $h^1$ has a connection $h^2$ to the upper part of the container through a reducing valve $k^3$, by which the pressure on the surface of the solution is regulated to that necessary, (about 5 to 8 lbs. per square inch), to deliver the solution to the spraying device. And a spraying device, which is a modification of the spraying device employed with compressed air to apply paint in the usual manner.

The air compressor F may conveniently be driven by an independent electric motor, or off a workshop line-shaft, and the connecting pipe to the air reservoir is preferably a flexible metallic pipe of suitable length, so as to enable it quickly to be fitted up in various ships. The air purifier H is set up as nearly as possible to the condenser the tubes of which are to be coated, and is connected to the air reservoir and to the solution container by means of rubber air piping in suitable lengths with union couplings. The air and solution pipes P and Q from the regulating cocks $p^1$ and $q^1$ of the solution-container to the spraying device R′ are kept as short as possible so as not to have any more pipe than is necessary in the way of the men engaged in spraying.

According to the invention the actual nozzle from which the sprayed coating solution is discharged is at the end of a tubular extension S of the sprayer part R′ containing the automatic control valve; the part R′ is, in the usual manner common to sprayers of this type, connected by air and solution connections $p^2$ and $q^2$ to the hand-piece $R^2$ provided with the usual hand operated trigger $r^1$ by which the air supply to R′ is controlled.

$r^2$ is a needle-valve controlling the flow of the coating solution from the inlet $q^2$ through the seating $r^3$; the needle-valve is normally closed by a spring $r^4$, and is opened in opposition to this spring by a piston $r^5$ when air is admitted through the connection $p^2$, by the operation of a trigger $r^1$ (Fig. 2), the air passing through ports $r^6$ to the interior of the cylinder $r^7$; $r^{12}$ is an adjustable nut by which the extent of opening of the needle valve is adjusted. The arrangement in these respects is substantially that employed in apparatus of this type, except that we prefer to use a solid piston fitted with metallic rings $r^8$ instead of the cup leather type, and that an additional gland $r^{11}$ is fitted to prevent the flow of the coating solution into the air chamber; we also make the air supply ports $r^{10}$ and the release ports $r^6$ larger than is usual for apparatus of this type so as respectively to prevent a drop of pressure in the extension S, and to ensure rapid action of the control piston.

The extension S consists of inner and outer tubes $s^1$ and $s^2$ of length somewhat greater than half the length of the longest tubes to be coated.

The inner end of the tube $s^1$ is connected by the union $s^3$ to the block in which the seating $r^3$ of the needle-valve is formed, so that when the latter is opened the coating solution passes to the interior of the tube $s^1$. The inner end of the tube $s^2$ is connected by the union $s^4$ to the block $r^9$ in which are formed the supply ports $r^{10}$ through which air supplied to $p^2$ passes to the annular space between tubes $s^1$ and $s^2$. The outer end of the tube $s^1$ is connected by a union $s^5$ to the inner part $s^6$ of a spraying nozzle, the outer portion $s^7$ of which is attached to the end of the tube $s^2$, the coating solution being delivered to the bore of the inner nozzle, and the air to the annular space $s^8$.

The air pressure on the surface of the solution in the container K is usually sufficient to wholly or partially overcome the hydrostatic head between the jet and the solution container: the aspirating action of the air, delivered from the annular space between the tubes $s^1$ and $s^2$ into the annulus $s^8$ around the jet, inducing the necessary velocity of flow of solution and atomizing it and spraying it in a fine spray in such manner as to deposit a uniform coating on the interior of the condenser tube as the extension S is gradually inserted into and withdrawn from the condenser tube as shown in Fig. 2.

$s^9$ are supporting sleeves and maintain the inner and outer tubes $s^1$ and $s^2$ in proper relative position, the peripheries of the sleeves being grooved to form airways.

The regulating nut $r^{12}$ is adjusted to obtain

the required spraying effect, this adjustment is best affected by trial, by spraying on a sheet of tin or the like, the marking on the tin by the spray affording, after little experience, a reliable guide as to the suitability of the spray.

Assuming that the condenser tubes have been tested and defective tubes removed, and that the tubes to be coated have been dried and cleaned as described, the coating by spraying is carried out as follows:—

First coating, brushing and drying;—

Each tube is sprayed for half its length from opposite ends of the gradual insertion axially into and the gradual withdrawal from each condenser tube of the extension S, the ferrules and portion of the tube plates in the vicinity of the tube being treated being adequately coated by the spraying effect as the jet is inserted and withdrawn.

It is advisable to divide the condenser into sections so that the men at opposite ends of the condenser are some distance laterally from each other and therefore are not spraying into the same set of tubes; as these sections or portions are coated (half way along the tube only) the inboard and outboard men change positions and thereby the other half of the tubes in two sections are coated. The spraying of other sections is then dealt with in a similar manner, and any pooling or flooding in the tubes of first section is dealt with by applying the spiral hair brush referred to under cleaning. As soon as the first coat is completed fans are fitted at one end of the condenser to cause a circulation of air through the tubes. It is essential that the fans be started as soon as possible so as to speed up the drying ready for the second coat.

Second coating, brushing and drying;—This is carried out as described in reference to the first coat, the fans require to be started as soon as possible so as to keep the air circulating through the tubes until the doors are put on the condenser. It is advisable to arrange the work so as to stop spraying 48 hours before boxing up the condenser, the longer time allowed for drying and hardening the solution the better.

The air solution passages being small and the coating solution tends to dry very quickly in the spraying device when the spraying is stopped; for this reason it has been found beneficial to keep the device in action continuously when once spraying has commenced. If for any reason spraying has to be stopped it is essential before doing so to blow back through the spraying device into the solution container. To do this the cover of the container must be loosened to allow the air to escape, then, by placing a finger over the nozzle of the spraying device and pulling the trigger, the air is blown back through the solution passages in the spraying device, and through the tube to the container. If it be necessary to stop spraying for any length of time it is essential to disconnect the tube from the container and place the end in a suitable receptacle containing petrol, by pressing the trigger and thereby turning on the air, the petrol will be drawn into the tube and blown out at the spraying nozzle, and the spraying device thoroughly cleaned.

If tubes coated in the mode described be examined it will be found that the inner surface of all the tubes is coated with a very thin, smooth, glossy, coating evenly distributed except on the bottom where there is sometimes a slight tendency for a small "pool" to form.

The operation of withdrawing and replacing the sprayer, as stated, also causes all the ferrules and tube plates to be coated with the solution.

If the cast iron water ends and doors are also coated a condenser entirely protected from corrosion is obtained.

The invention may be applied to tubes other than condenser tubes, and to new tubes, provided the surfaces of the latter rendered sufficiently rough to take and retain the coating.

The mode of operation and the construction of the apparatus described may be varied in accordance with the conditions under which the invention is applied and the requirements to be fulfilled.

Having now fully described our invention, we declare that what we claim and desire to secure by Letters Patent is:—

The improved method of protecting the interior surfaces of the tubes of surface condensers so as to provide the said surface with a non-corrosive coating sufficiently thin so as not to substantially diminish the heat transmitting efficiency of the tube, but sufficiently even, continuous and tough to resist the corrosive action, characterized as follows,—cleaning the tubes in situ in the condenser by abrasive action; then blowing through the tubes jets of compressed air to remove the dust and dirt detached by the abrasive action; then applying in the form of a spray a first coating of paint containing bitumen or the like tough plastic adhering substance mixed with a suitable drier liquid; then rendering the first coating even, and dealing with the pools of paint which may be formed, by brushing; then drying the first coating by circulating air through the tubes; then applying a second coating of the paint; then rendering the surface of the second coating even by brushing and finally drying the second coating by a supply of air; each coating process being applied by spraying to coat the end surfaces of the tube, ferrule and the adjacent portions of the tube plate; substantially as described.

In witness whereof we set our hands.

J. AUSTIN.
H. SMITH.