Dec. 10, 1929. F. J. PIKE ET AL 1,738,727

APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

Filed Jan. 30, 1929 6 Sheets-Sheet 1

Fig. 1.

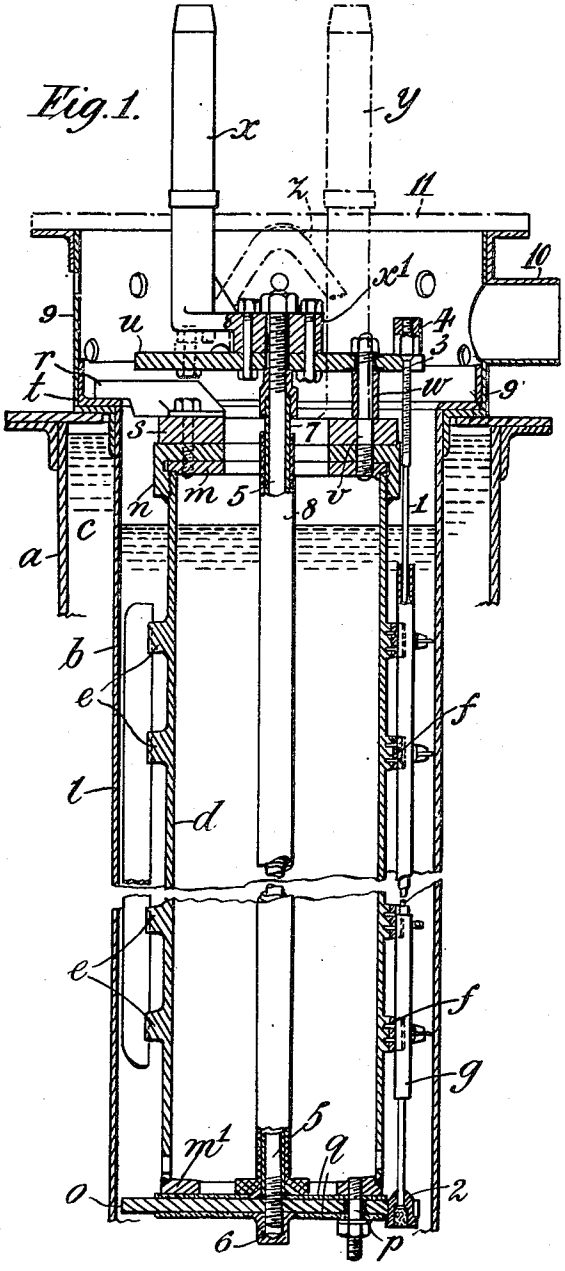
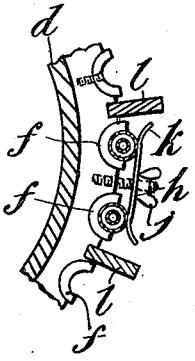


Fig. 2.



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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

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Fig. 3.

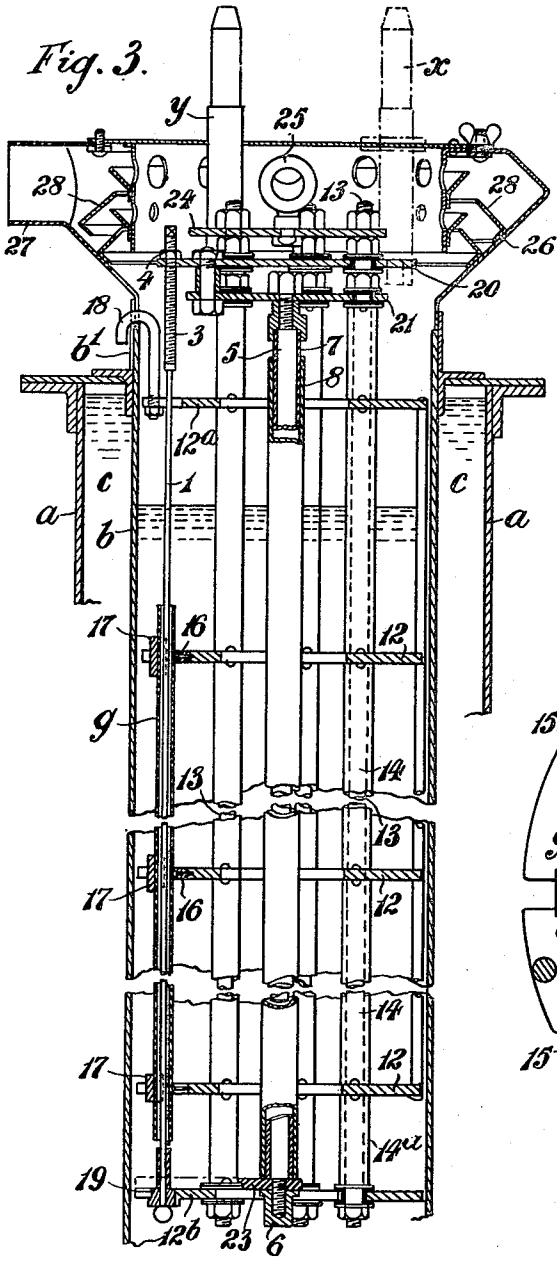
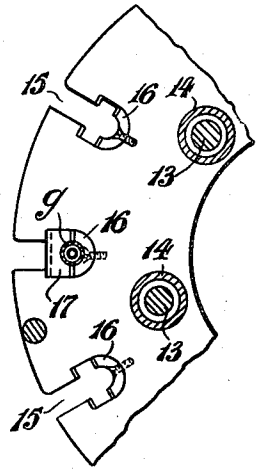


Fig. 4.



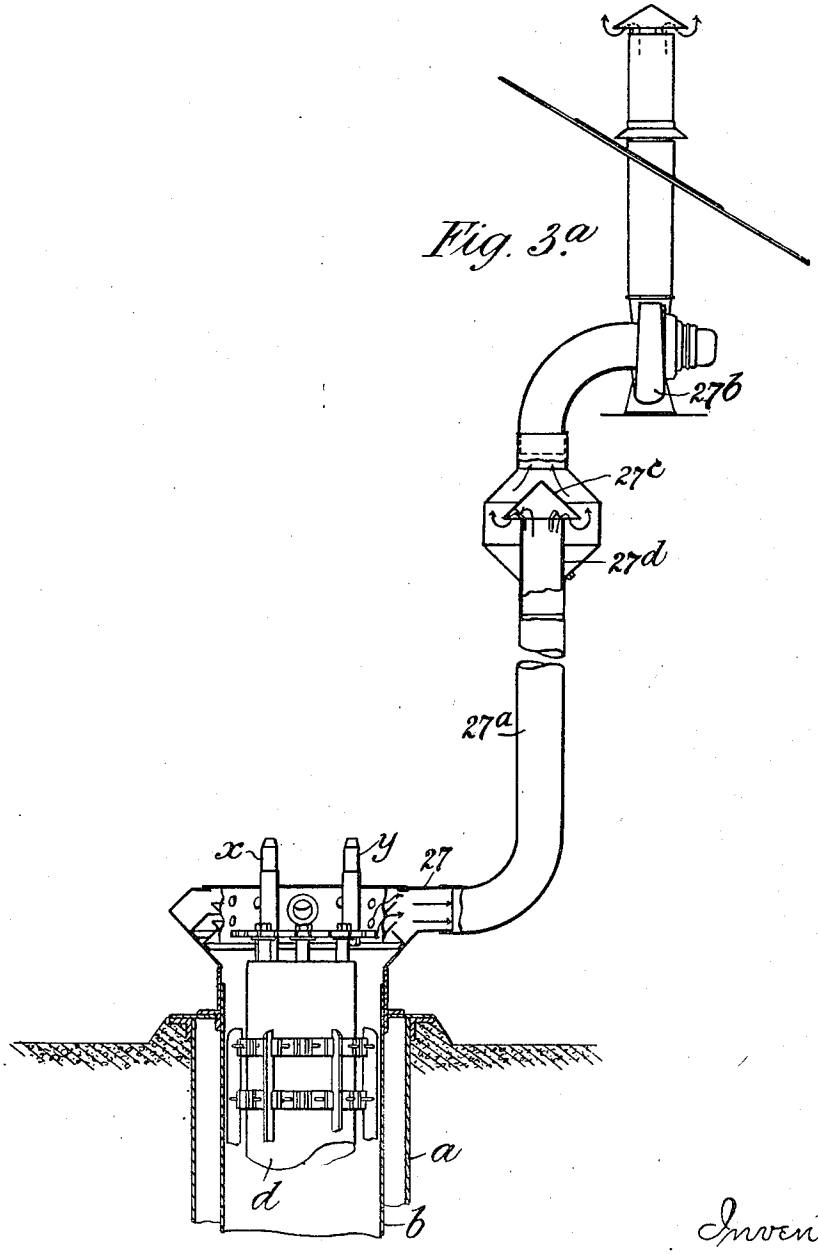
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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

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Fig. 3.a



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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

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Fig. 5.

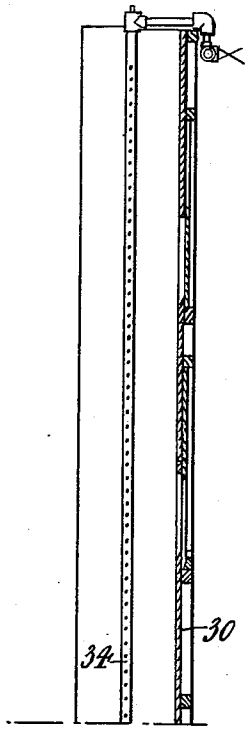
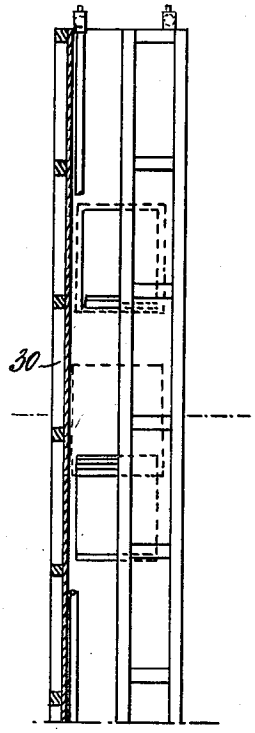


Fig. 6.



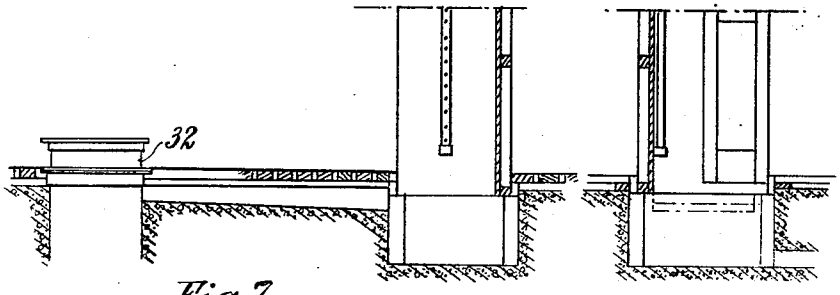
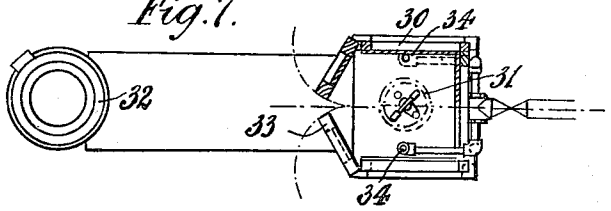


Fig. 7.



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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

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Fig. 8.

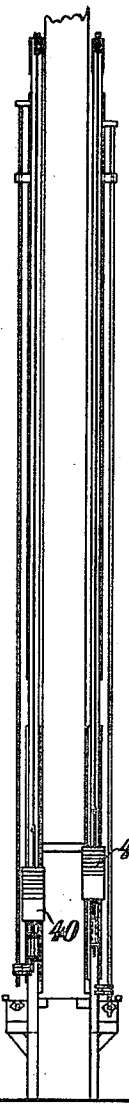


Fig. 9.

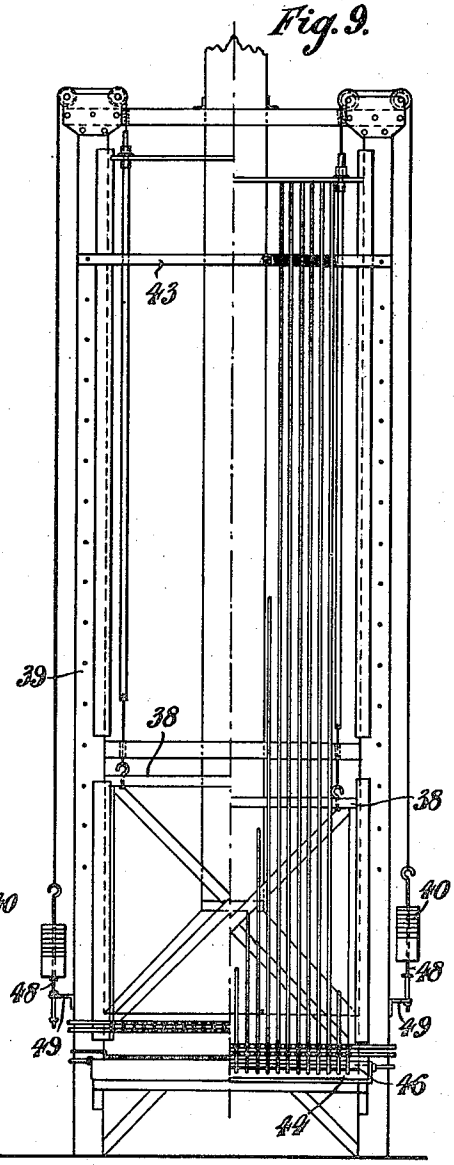


Fig. 11.

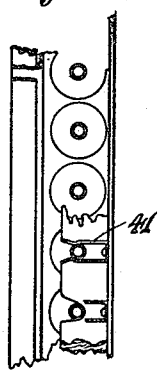
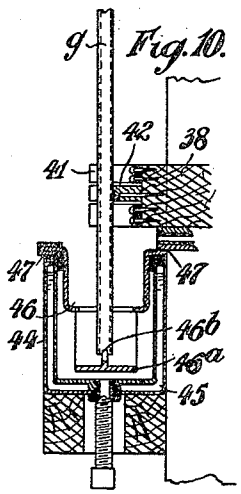


Fig. 10.



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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

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Fig. 12.

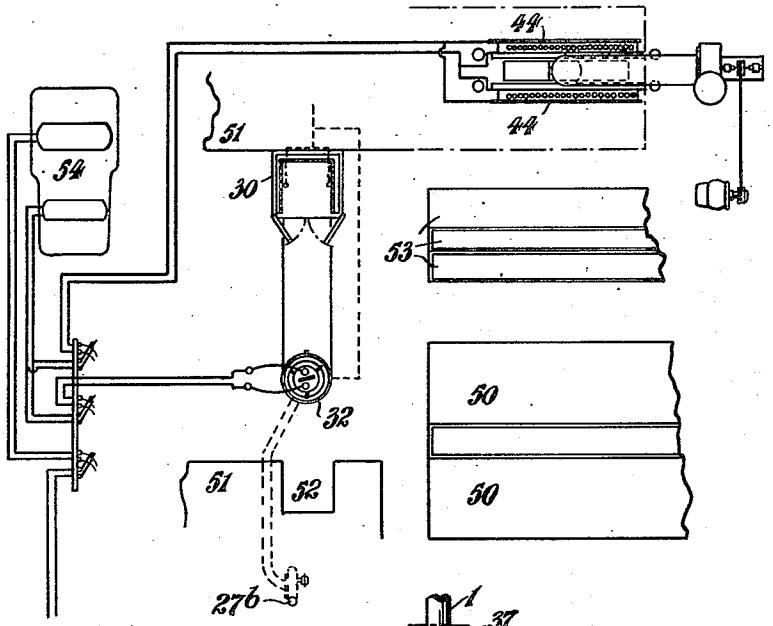


Fig. 13.

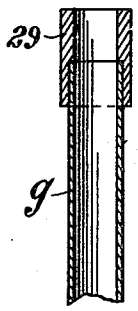
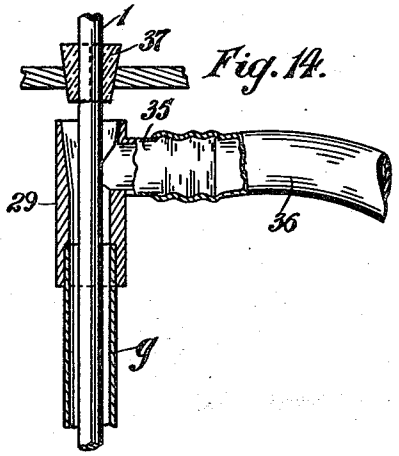


Fig. 14.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR USE IN THE ELECTROLYTIC DEPOSITION OF METAL ON METAL TUBES

Application filed January 30, 1929, Serial No. 336,154, and in Great Britain November 30, 1927.

This invention comprises improvements in apparatus for use in the electrolytic deposition of metal on metal tubes and particularly in the electrolytic deposition of chromium upon the interior of long tubes of small diameter, such as are employed in condensers.

In the specification of the patent application of Martin and Ramsay Serial No. 222,829 dated 29th September 1927, apparatus is described in which tubes of the kind referred to are supported at a number of points along their length in a cathode frame, and flexible anodes insulatedly supported in the frame are tensioned concentrically within the bores of the tubes. It is important when large numbers of tubes have to be coated, as is the case when condenser tubes are in question, to be able to load the frames quickly and with little trouble or liability to bend the tubes out of straightness. The principal object of these improvements is to provide frame constructions which facilitate to a maximum degree the insertion and removal of large numbers of slender tubes without liability of impairing their straightness but with firm support for preserving such straightness and good contact with the cathode frame. A further object is to provide advantageous fittings and arrangements for enabling the plated tubes to be washed in an efficient manner whilst still in the frames used for supporting them in the plating bath.

According to this invention, the tube-supporting members of the frame are formed with shaped slots, notches or the like into which the tubes are entered most conveniently by a bodily movement laterally, clamping devices, wedges or other suitable securing devices being applied for pressing the entered tubes against the seats provided by the walls of the slots, notches or the like, whereby the tubes are firmly held and supported in good electrical contact with the frame. A similar adaptation of frame members may be adopted for the lateral entering of the flexible anode rods.

According to a further part of the invention a washing chamber or cabinet is provided into which the loaded frames can be readily introduced immediately after being elevated from a plating well and in which the frames and external parts of the tubes can be washed by sprays or jets. Also, readily attachable hose or pipe connections are provided for the tubes, so that the bores of such tubes may be simultaneously washed by water streams.

In the case of tubes, such as condenser tubes, which are required to have their ends jointed in tube plates or metal walls, it is desirable or necessary to provide such ends with a protective coating. It would add to the expense unnecessarily, and might be otherwise quite undesirable, to coat the tubes over the whole of their external surfaces. Consequently, it is important to devise means for enabling end portions of the tubes to be coated externally as well as internally. In the specification of the patent application Serial No. 222,829 aforesaid, the external coating of the ends simultaneously with the internal coating of the bores of the tubes was proposed to be carried out by the aid of external anodes of ring form. The external appearance of a tube coated in accordance with that process, however, did not exhibit a sharp line of demarcation between the coatings of the ends and the uncoated length lying between such ends, as there was a diffusion of the deposited chromium due to the entire immersion of the tubes connected up as cathodes. These present improvements further provide for the external coating of the end portions of the tubes so that a sharp line of demarcation is obtained between the coated and uncoated portions. For this purpose, the tubes are supported in a vertically adjustable frame immediately above a shallow bath or trough containing an anode and the electrolyte and the frame is lowered to immerse the lower ends of the tubes to the correct depth so that the end portions receive a uniform deposit which ceases sharply at the surface of the electrolyte.

In order to enable this invention to be readily understood reference is made to the accompanying drawings illustrating several examples of pieces of apparatus constructed in accordance with these improvements, in which drawings:—

Figure 1 is a central vertical sectional elevation of an improved frame loaded with tubes and anodes and suspended in an electro-plating pit.

Figure 2 is a detail plan view to a larger scale of tube clips used on the frame in Figure 1.

Figure 3 is a view similar to Figure 1 but illustrating a modified construction of frame.

Figure 3ª is a view showing an arrangement of means for drawing off fume and spray during an electroplating operation in the pit aforesaid.

Figure 4 is a detail plan view to a larger scale illustrating the fixing of the tubes by wedge devices on the frame of Figure 3.

Figure 5 is a sectional side elevation, Figure 6 is an end elevation, and Figure 7 is a plan of washing apparatus to be employed in association with the electro-plating pit aforesaid.

Figure 8 is a side elevation and Figure 9 is a front elevation of apparatus comprising rising and falling frames and fixed trough-like baths for electro-plating externally the ends of a number of tubes.

Figure 10 is a sectional side elevation to a larger scale of one of the electro-plating baths and fragment of one of the frames seen in Figures 8 and 9.

Figure 11 is a plan of Figure 10.

Figure 12 is a ground plan of a plant comprising pieces of apparatus illustrated in the preceding figures.

Figures 13 and 14 are detail sectional views of tubular extensions to be fitted to the ends of tubes being plated when desired.

Referring to Figure 1, the electro-plating bath is advantageously in the form of a pit sunk in the ground and lined with a cylindrical metal lining *a*, an acid tank *b*, which is the plating bath proper being suspended concentrically within the lining *a* and the intervening annular space *c* being filled with cooling liquid such as water or supplied with steam, hot water, oil or other fluid. The tubes to be plated, one is seen at *g*, are supported upon a frame or long tubular structure, now to be described, which is lowered into the bath *b*. The said frame or structure, comprises a long tube *d* encircled at a number of points along its length by rings *e*. Each ring *e* is formed peripherally with a number of seatings which may take the form of notches in which are fixed small segments of cylinders *f*, Figure 2, of an internal diameter corresponding with the external diameter of the tubes *g* to be seated therein. If desired, however, V-shaped notches may be formed in the rings with uniform spacing around the latter and such notches may be adapted for seating tubes of different diameters, whereas the segments *f* are suitable for tubes of one diameter only. The rings *e* are mounted, of course, so that there is accurate registration or alignment of the notches of one ring with those of its neighbour or neighbours. The rings *e* may be secured to the tube *d* by welds, or by screws or rivets, or they may as shown be formed integrally with the tube.

Fastening or clamping devices may be provided in alternate spaces between the seatings *f*. For example, and as seen clearly in Figure 2, the peripheries of the rings *e* in such alternate spaces, may have holes drilled and tapped to receive screw threaded studs *h*. On these studs are screwed wing nuts *j* which are operative upon resilient clamp strips *k* of sufficient length to extend across the two adjacent seatings *f* when such strips *k* are set at right angles to the axis of the tube *d*, as seen in Figure 2. If desired, resilient clamp strips may be perforated to pass over the studs *h* and may be secured to the wing nuts *j* by rivets. With such a construction, the clamp strips *k* are turned to set them in the direction of the axis of the tube *d*, thereby freely opening the notches or seatings *f*. Each tube *g* to be plated is then applied laterally to the frame structure so as to lie longitudinally thereof in a row of aligned notches or seatings *f*. Upon two adjacent rows of such seating being occupied by tubes, the corresponding clamp strips *k* are given a quarter turn to set them at right angles to the tubes and to clamp or clip the latter in the seatings *f*, the wing nuts *j* being adjusted so that a sufficient clamping pressure is attained. If the strips *k* are fixed to the nuts *j*, the latter are given a preliminary adjustment to suit the size of the tubes and are finally adjusted to bring the strips *k* to the desired clamping position.

A frame loaded with a number of condenser tubes is of substantial weight and in order to prevent damage to the clamping devices *j k* by the swinging of the load in the plating pit or well, it is advantageous to provide guard fins or ribs *l* extending along the frame structure and projecting radially outwards beyond the clamping devices. Such fins or ribs *l* may be in the form of iron or steel bars applied edge-on to the peripheries of the rings *c* and suitably let into and may be welded in appropriate notches formed in such rings.

The ends of the tubular frame structure *d* receive rings *m m'* which are secured thereto by welding. On the upper end, there is screwed an annular cap *n* which is further secured by brazing. To the lower end a steel disc *o* is fixed to the ring *m'* by insulated bolts *p*, insulation discs *q* being interposed so that there is no electrical connection between the disc *o* and frame *d*. To the top ring *m* and cap *n* are bolted several, say three, laterally extending brackets *r*, a gun metal cathode ring *s* being interposed between the brackets *r* and the cap *n*. The brackets *r* extend out-

wards to such an extent that when the loaded frame is lowered into a plating pit or well, the said brackets come to rest upon a ring casting *t* at the top of the acid tank *b* and support the loaded frame therein, as seen in Figure 1. An anode disc *u* is connected with the ring *m* and cap *n* by insulated bolts *v* being spaced from the cathode ring *s* by sleeves *w* on the bolts *v*. An anode terminal pillar *x* extends vertically from an arm on a boss *x'* bolted centrally to the anode disc *u* and a cathode terminal pillar *y* extends vertically from the cathode ring *s*. Suspension eyes or loops *z*, shown in dotted lines in Figure 1, for raising and lowering the loaded frame, may be bolted to the anode disc *u*, or the stems or legs or suspension eyes or loops might pass through apertures in the disc *u* and be fixed, by screwing or bolting, to the annular parts *s n m*.

Flexible anodes 1, which may be of copper sheathed with lead, are tensioned between the anode disc *u* and the bottom disc *o* after being passed through the tubes *g*. A nipple device 2 is fixed to the bottom end of each anode and is engaged with the disc *o*, the upper end of each anode being joined to a screw threaded rod 3 on which is screwed a tensioning nut 4 bearing upon the anode disc *u*. As will be seen from Figure 1, the disc *o* and *u* are formed with peripheral notches so that the nipples 2 and nuts 4 may be engaged with the discs by lateral application of the anodes 1. The discs *o* and *u* are interchangeably mounted on the apparatus so that for tubes of any given diameter it is possible to select and attach discs having their notches suitably disposed for supporting the anodes at the correct radial distance for centering such anodes in their respective tubes *g*.

If it be desired to supply current to the lower ends of the anodes 1 as well as to the upper ends through the anode disc *u* and nuts 4, a conductor 5 is brought down from the anode disc *u* and is electrically connected with the disc *o* as by the nut 6 which screws on to the conductor 5 and bears against the disc *o*. The conductor 5 may be a copper rod enclosed in a steel tube 7 which may be welded at the bottom to the disc *o* and surrounded for the greater portion of its length by a tube 8 of ebonite in order to shield the anodic conductor 5 from the cathodic frame *d*.

A casing 9 surrounds the mouth of the well or pit, and is formed with a fume exhaust connection 10, a suitable cover 11 being applied after the loaded frame has been lowered into the well.

According to the modified construction illustrated in Figures 3 and 4, the frame comprises a number of annular steel plates 12, spaced apart along a number of circularly disposed longitudinal bolts or rods 13, spacer sleeves 14 being conveniently employed for this purpose. These annular plates are all slotted in their periphery with a species of keyhole slot 15, as seen clearly in Figure 4. The stem portion of each slot 15 is radial and of sufficient width for a tube of given diameter to pass. The enlarged portion of each slot is rectangular with a semi-circular or other depression in the back straight wall. These depressions receive similarly shaped seating blocks 16 which are fixed by screws and are formed with semi-cylindrical seatings appropriate for the diameter of the tubes to be seated. The annular plates 12 are mounted on the rods 13 so that any given slot in one plate is in accurate alignment or registration with the corresponding and similar slots in other plates. Each tube *g* to be plated is presented laterally to the frame and passed through the stems of a line of slots 15 into the enlargements of such slots, whereupon the tube is seated against the semi-circular seatings 16 in the back walls thereof. Steel wedges 17 are then passed endwise into the slot enlargements which they fit, the said wedges 17 being formed longitudinally with grooves which are semi-circular in section to fit against the tubes. Pressing the wedges 17 home downwardly in the slots causes the tubes *g* to be gently but firmly gripped so that the tube is supported at several points along its length in true alignment and in good electrical contact with the plate members of the cathode frame.

In this modification, a top annular plate 12^a is furnished with hooks 18 for taking over an upward extension *b'* of the acid tank *b* in order to suspend the loaded frame in such tank, the latter being surrounded by a water space *c* as in Figure 1. A bottom annular plate 12^b is spaced from the plate 12 next above by a short spacer sleeve 14^a and is peripherally notched for the reception of nipples or abutments 19 on the lower ends of the flexible anodes. At the upper end of the frame two spacer discs 20, 21 are insulatedly mounted on the rods 13 and spaced from the top frame plate 12^a and from one another by suitable distance sleeves. The disc 20 carries the anode terminal pillar *x* and has its periphery notched for the reception of screw threaded rods 3 attached to the upper ends of the flexible anodes 1, tensioning nuts 4 being screwed on the rods 3 and bearing upon the disc 20. The disc 21 is put into electrical connection with the disc 20 through short gun metal bolts 22, and this disc 21 serves for the attachment of a central conductor 5 which extends down to the bottom of the frame where it is connected by a nut 6 with a conductor 23 attached to the plate 12^b and extending inwards to the centre of the frame. The conductor 5 is enclosed by a steel tube 7 which is surrounded by ebonite 8 as in Figure 1. A third disc 24 non-insulatedly mounted on the rods 13 and spaced from the disc 20, is fitted with a cath-

ode terminal pillar *y* and with a suspension eye 25 for raising and lowering the loaded frame. A cover device 26, with fume draw-off connection 27, is fitted with baffle devices 28 adapted for intercepting acid spray and vapour. As shown in Figure 3ª, the connection 27 may be jointed to an uptake 27ª which includes a suction fan 27ᵇ a conical baffle 27ᶜ and collector chamber 27ᵈ to the delivery of the uptake being suitably disposed for instance above a roof as in Figure 3ª.

The frame structures described with reference to Figures 1 to 4 can be loaded with tubes whilst lying on their sides or whilst standing vertically. The latter is preferable, as it saves the labour and possible disturbance of the tubes involved in up-ending a horizontal loaded frame. The flexible anodes may be passed through the tubes whilst the latter lie upon a bench prior to loading them into a frame. Thus when the tubes *g* are moved bodily laterally into their slots or seatings in the frame, the respective anodes 1 are moved likewise so that the devices on their ends laterally enter and engage with the peripheral notches of the frame plates *o u*, Figure 1, or 12ª and 12ᵇ Figure 3.

As shown in Figure 13, the tubes *g* before being wedged on to the frame may have their ends fitted with short extension pieces 29 of brass or other tube having the same bore as the tubes *g* excepting that the bore is enlarged at one end for slipping friction tightly on to the tubes *g*. These extension pieces prevent eddying or swirling of the electrolyte in the extreme ends of the bores of the tubes *g* and thereby ensure internal coating of the tubes right up to the extremities of their bores.

It is of importance to provide means for expeditiously washing the frames and tubes after withdrawal from the plating well or bath. While it is advantageous to have the plating baths sunk in the form of pits as above described, it would be a very expensive proceeding to sink additional pits for washing purposes, and moreover such washing pits entail labour and loss of time in lowering the frames into them and lifting them out again. These improvements, therefore, provide a washing cabinet or chamber 30, Figures 5 to 7, in which the loaded frames, indicated diagrammatically at 31 in plan in Figure 7, can be readily introduced after being elevated from a plating pit indicated at 32. The cabinet 30 is of the necessary height to receive the said frame and may be provided with doors 33 at its front. Down the sides, or in any other convenient position, spray tubes 34 are fitted so that the frames and external parts of the tubes can be sprayed and washed by water supplied to the tubes 34. The tubular extensions 29 which may be fitted to the tube ends as described with reference to Figure 13, may be fitted with lateral spigots 35, Figure 14, for the attachment of hose connections 36. Also, split coned rubber or other plugs 37 may be applied to the anodes 1 and during the plating operation may occupy the position seen in Figure 14, in which they remain elevated above the extensions 29 owing to their grip on the anode 1, thus leaving free the orifices of extensions 29 for the exit of the gases generated by the electrolyte action. When the plating is finished, a loaded frame is elevated from the plating pit to floor level and is deposited upon the floor. Thereupon, an operator on an elevated staging lowers all the rubber plugs 37 and presses them in to the upper ends of the extensions 29. He then connects the hoses 36 with the spigots 35. The loaded frame is then introduced into the cabinet 30 Figures 5 to 7 and the water is turned on to the spray pipes 34 and also to the hose connections 36, so that active streams are introduced into the bores of the plated tubes for the efficient washing thereof, at the same time that all external parts are washed by the sprays from the spray pipes 34. If desired the spigots may extend upwardly at an angle of about 60° to the extensions 29 and the latter may have an annular end wall at the top to fit more or less closely around the anodes 1. With such an arrangement the plugs 37 can be dispensed with.

Two or more plating pits 32 may be disposed in the track of a traveller and also one or more washing chambers 30, so that the washing of a loaded frame or frames may proceed whilst the plating of tubes in other frames is in progress.

For externally coating the end portions of tubes, such as condenser tubes which may require to be jointed in tube plates or metal walls as already explained, the apparatus illustrated in Figures 8 to 11 is provided. Frames 38 vertically slidable on a supporting frame 39 are counterbalanced by weights 40 attached to cables passing over idle pulleys. Cross bars of these frames 38 are fitted with metal clips 41 and with seating blocks 42, Figures 10 and 11, the tubes being pressed between the clips 41 and seated against the blocks 42. The clips 41 are electrically connected together and with a suitable conductor to form a cathode connection. Near the top of the fixed frame there are cross bars 43 formed with guide holes for the upper end portions of the tubes, as seen in Figure 9, the upper ends of the tubes being inserted into holes in the top bar of the movable frames 38. A trough-like bath 44 is supported on the fixed framing beneath each of the movable frames and these baths are preferably water-jacketed as shown at 45, Figure 10. The bath may be heated by steam or other means instead of being cooled. In each bath, a lead anode plate 46 is immersed, this plate being conveniently troughed and

flanged so as to be supportable on insulation 47 along the side edges of the trough and perforated for the passage of the lower ends of the tubes *g* carried by the movable frames.

An additional anode plate 46[a] may be carried underneath the lower ends of the tubes *g* and may be provided with upwardly projecting cylindrical bosses 46[b] one opposite the lower end of each tube *g*. These additional anode plates and their bosses have for their purpose to cause the chromium to be thrown effectively on to the end surface of the tubes.

The movements up and down of the movable frames 38 may be limited by adjustable stops. Thus, each counterweight 40 may have a depending screw threaded rod 48 which passes through the eye of a bracket 49 on the main frame, nuts adjustable on such rod constituting stops which come into engagement with the bracket 49 for limiting the ascent or descent of the movable frame.

A frame 38 is loaded with tubes whilst in the elevated position seen in the left hand half of Figure 9. The top bars of the movable frames may serve as gauge bars, or other means may be employed for ensuring that the lower ends of all tubes inserted in to the frame 38 are at the appropriate level. The loaded frame is then lowered until arrested by the stops on the rods 48, whereupon the lower ends of the tubes *g* are found to be immersed to the correct depth in the trough-like bath as seen in the right hand half of Figure 9. The current, being switched on, passes from the anode plate 46, to the tube ends and through the cathodic clips and the immersed ends are thus electroplated. If it be desired to plate the extreme edges or end faces of the tubes *g* an anode strip may be suspended from the anode plate beneath the level to which the lower ends of the tubes descend.

Figure 12 shows a ground plan of plant comprising apparatus of the kind hereinbefore described. 50 indicates benches upon which the tubes are laid when the flexible anodes are passed through them. 51 indicates an elevated staging for operators attending to the upper ends of the tubes and frames, the latter being loaded with tubes in the bay 52 adjacent to the plating pit 32. A traveller lifts the loaded frame and deposits it in the pit 32, afterwards raising it again and delivering it into the washing cabinet 30. After washing and removal from the cabinet 30, the tubes are unloaded from the frame. Any further treatment such as washing, pickling and marking of the tubes is performed in the tanks and on the bench indicated diagrammatically at the position 53 and the ends of the tubes are plated externally in the baths 44 by the aid of the apparatus described with reference to Figures 8 to 11. A motor generator set for the supply of plating current is indicated at 54 with the switchboard at 55. A fan 27[b] for exhausting the fumes from the plating pit has been described with reference to Figure 3[a].

We claim:—

1. Apparatus for electroplating the bores of tubes comprising an elongated framing having spaced open seatings into which tubes are insertable by lateral bodily approach, tube securing means adapted for holding the tubes tightly to their seatings, and anode mountings adapted for supporting elongated anodes within the tubes.

2. Apparatus for electroplating the bores of long metal tubes, comprising an electrolyte container, an elongated tubular frame having spaced members, tube-supporting means provided on the periphery of said members, suspension means for said frame within the container, and longitudinal guard ribs on the exterior of said frame.

3. Apparatus for electroplating the bores of metal tubes comprising an electrolyte container, an elongated frame having spaced rings formed with peripheral tube-seating slots, closure devices operative for retaining tubes in said seating slots, end anode plates formed with peripheral slots, tensioning means adapted for engaging the slots in said anode plates and operative for supporting and tensioning elongated anodes within seated tubes and a longitudinal sheathed conductor connected between said anode plates.

4. Apparatus for electroplating the bores of long metal tubes comprising an electrolyte container, an elongated tubular frame composed of spaced rings formed with seating slots around their periphery, swivel clips adapted for securing two adjacent tubes in their seatings, and tensioning means adapted for holding anode rods concentrically within the tubes.

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