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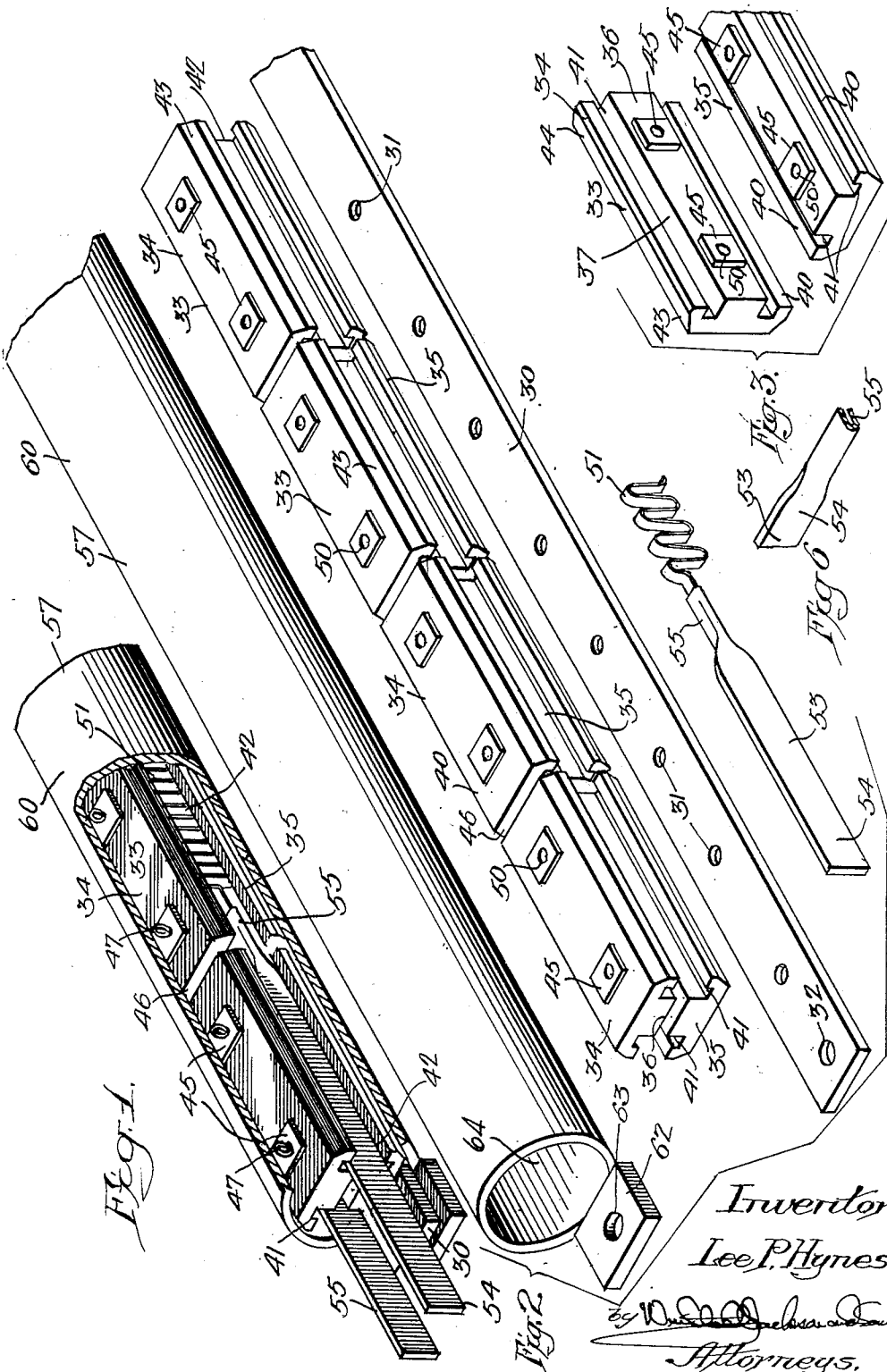
L. P. HYNES

2,536,747

ELECTRIC RESISTANCE HEATER AND HEATED VESSEL

Filed March 31, 1948

6 Sheets-Sheet 1



Inventor
Lee P. Hynes,
by *W. C. Hynes*
Attorneys.

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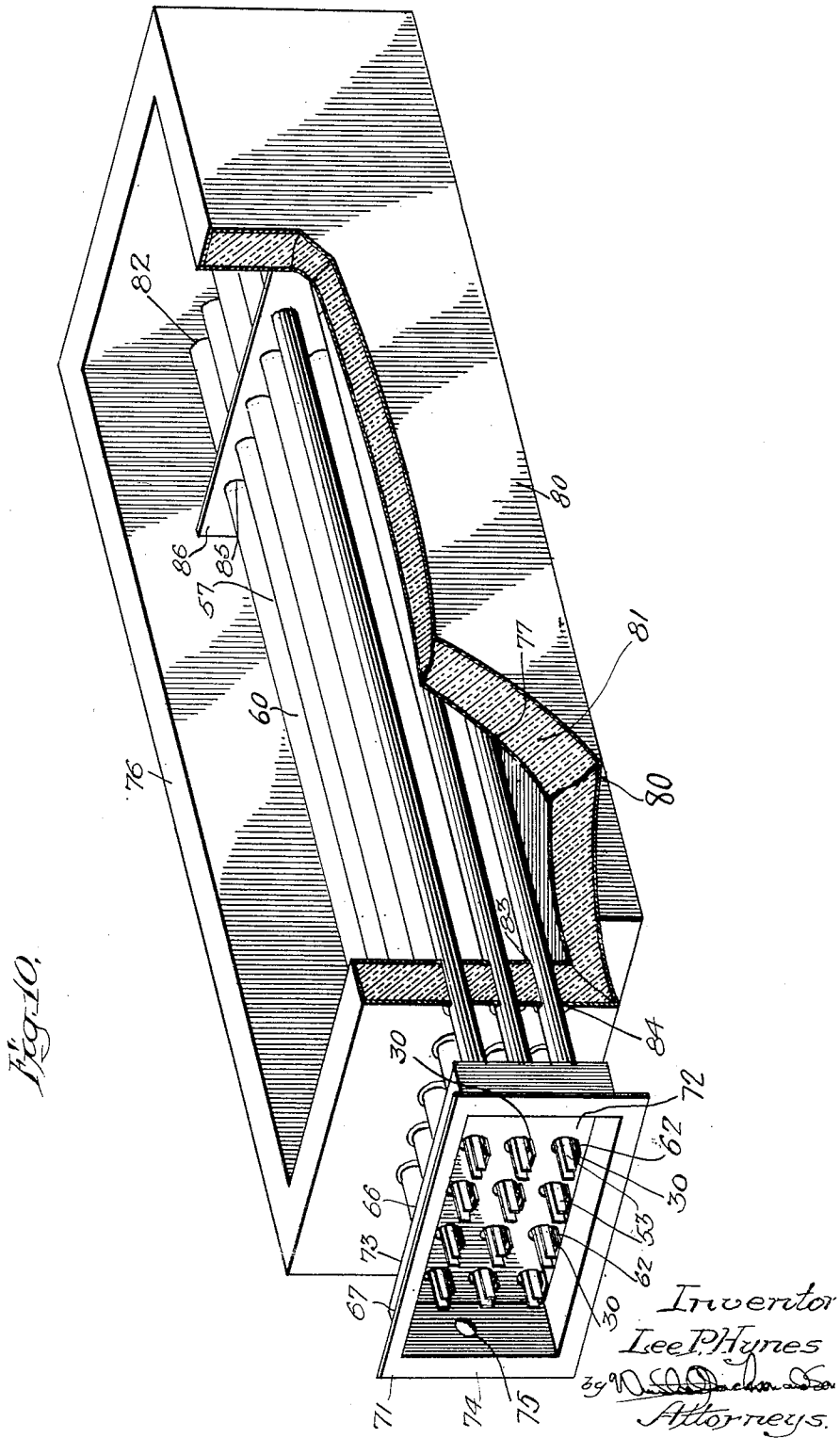
L. P. HYNES

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ELECTRIC RESISTANCE HEATER AND HEATED VESSEL

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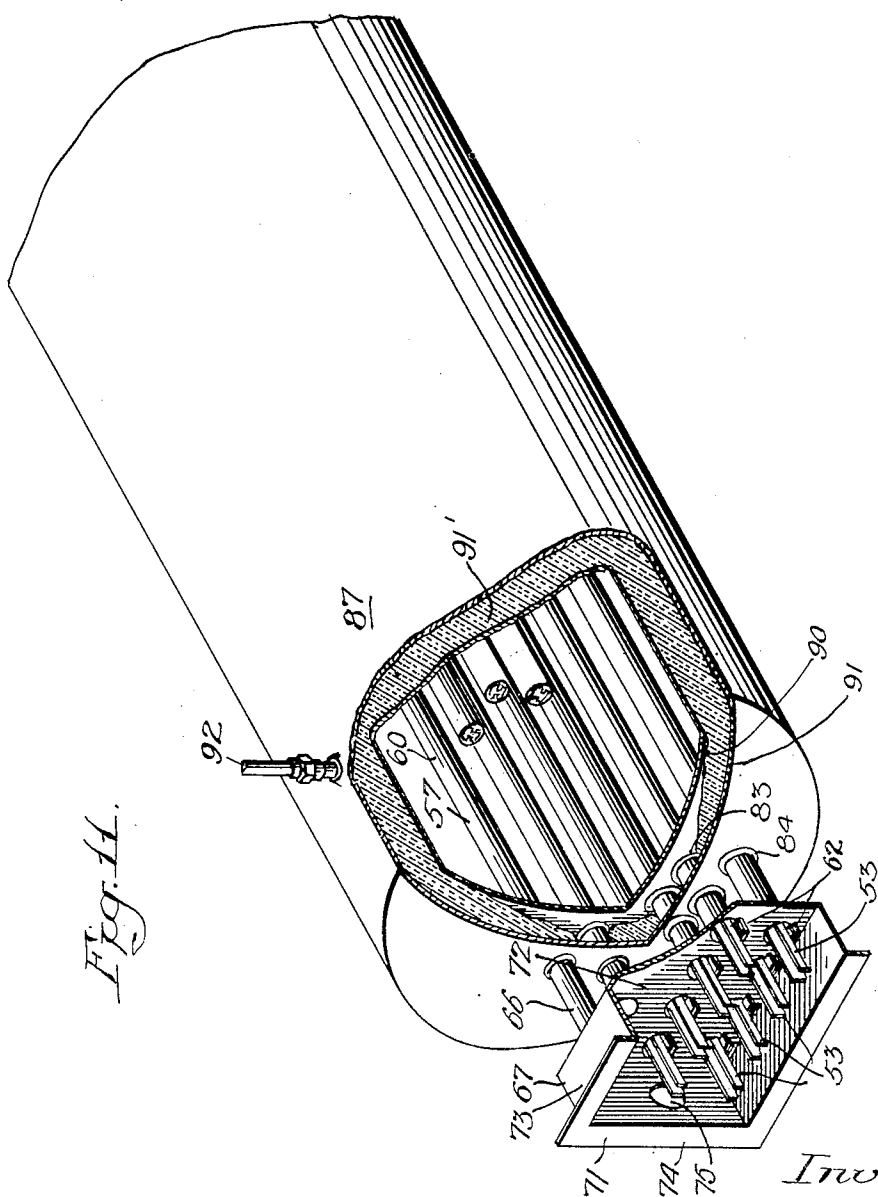
L. P. HYNES

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ELECTRIC RESISTANCE HEATER AND HEATED VESSEL

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6 Sheets-Sheet 4



Inventor
Lee P. Hynes
by *D. S. Jackson & Co.*
Attorneys.

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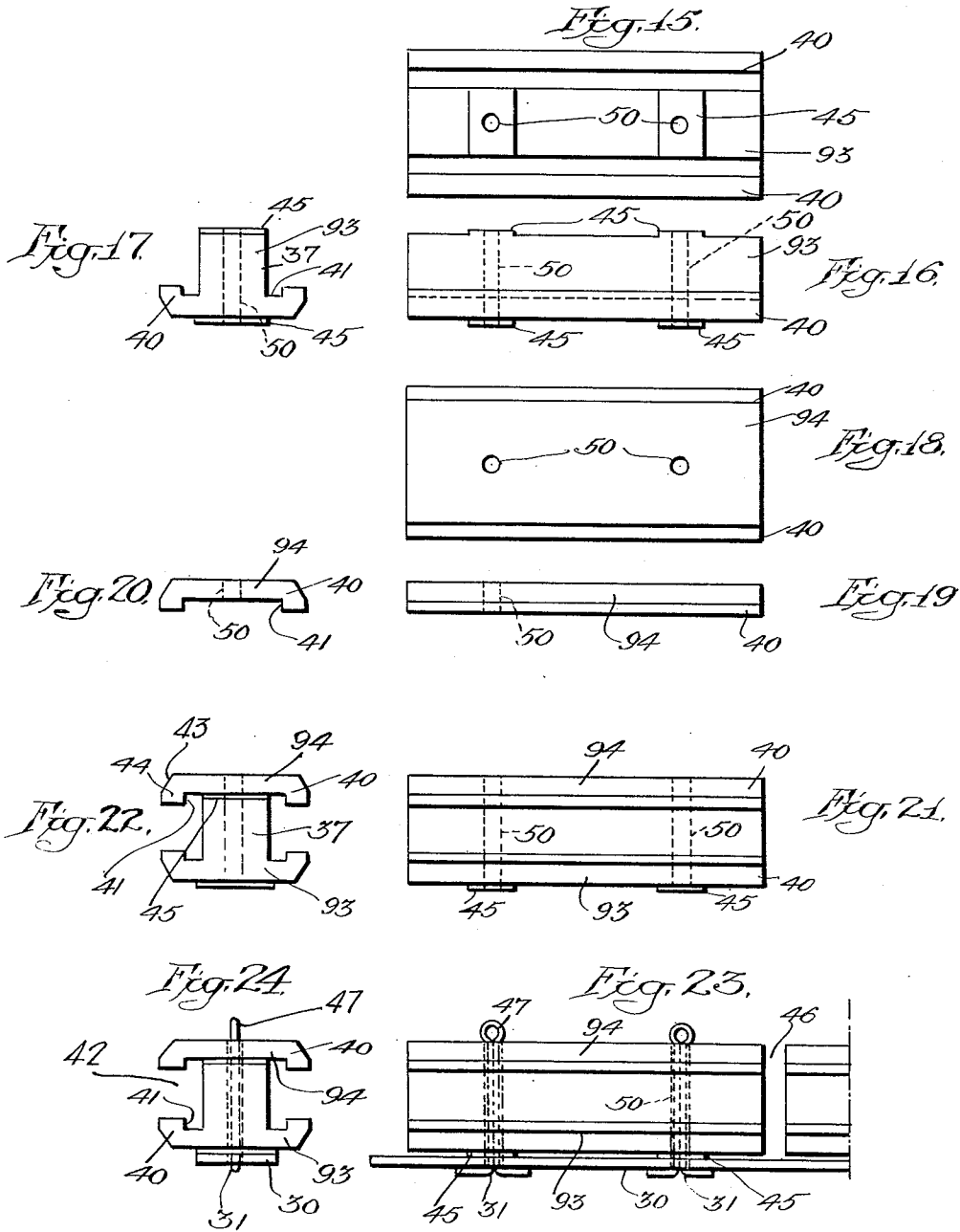
L. P. HYNES

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ELECTRIC RESISTANCE HEATER AND HEATED VESSEL

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6 Sheets-Sheet 5



Inventor
Lee P. Hynes
By W. S. D. [Signature]
Attorneys

Jan. 2, 1951

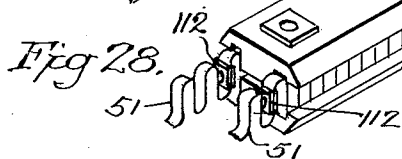
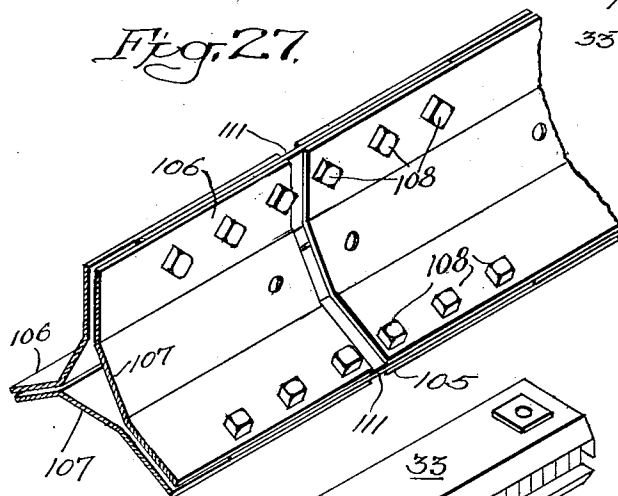
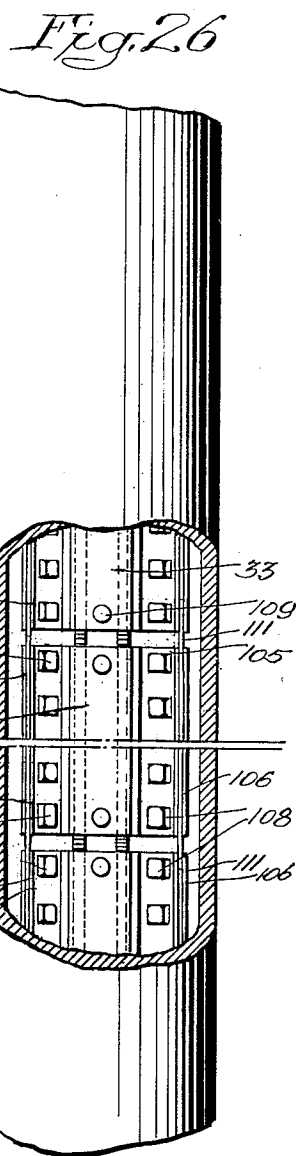
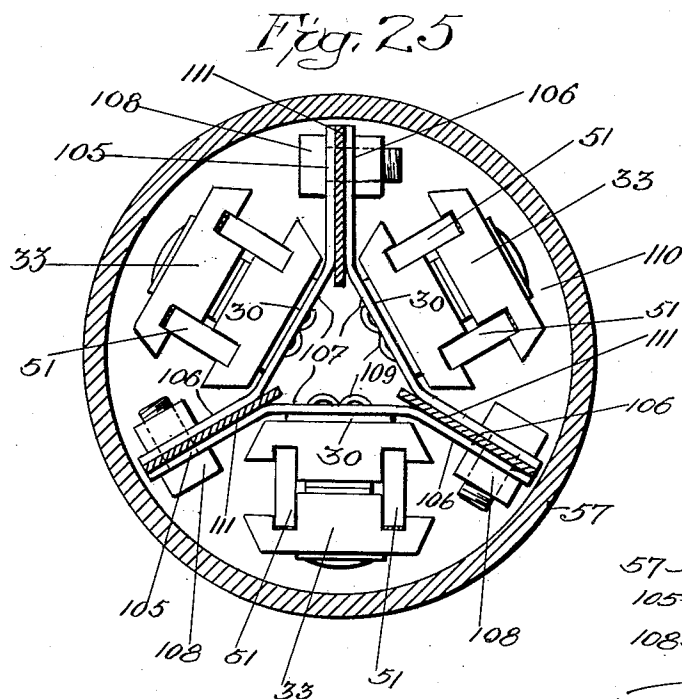
L. P. HYNES

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ELECTRIC RESISTANCE HEATER AND HEATED VESSEL

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6 Sheets-Sheet 6



INVENTOR
Lee P. Hynes
BY
W. S. [Signature]
ATTORNEYS

UNITED STATES PATENT OFFICE

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ELECTRIC RESISTANCE HEATER AND
HEATED VESSEL

Lee P. Hynes, Haddonfield, N. J.

Application March 31, 1948, Serial No. 18,163

13 Claims. (Cl. 201—69)

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The present invention relates to electric resistance heaters of the character which are especially suited to heating fluids, and to fluid heating vessels.

A purpose of the present invention is to mount a generally rectangular resistor such as a zigzag resistor from a heater bar and preferably within a metallic envelope such as a tube so that the resistor is adequately supported, is exposed to radiate to the envelope, is protected from electrical contact with the envelope and with the heater bar and is preferably flexible to permit flexing of the heater bar.

A further purpose is to mount a generally rectangular resistor such as a zigzag resistor in retaining recesses extending from slots on one or preferably both sides of a group of insulators longitudinally aligned in spaced relation along and preferably flexibly secured to a heater bar.

A further purpose is to provide an insulator with a central web, oppositely extending flanges at the top and bottom of the web, retaining recesses in the flanges adjoining the web and fastener openings extending transversely of the flanges through the web.

A further purpose is to separate an insulator into portions along a line transversely across the web, and suitably intermediate the ends of the web or at one end of the web.

A further purpose is to provide bosses to separate the insulator portions from one another and from the heater bar.

A further purpose is to provide an anchor at one end of the envelope and to removably secure the heater by attaching the heater bar to the anchor.

A further purpose is to attach terminals to the resistors and to extend the terminals longitudinally of the resistors through slots and retaining recesses in prolongation of those slots and retaining recesses in which the resistors are secured.

A further purpose is to extend the envelope, the heater bar, the insulators and the terminals to a point remote from the heating load and there attach a terminal box at an open end of the envelope.

A further purpose is to connect the remote ends of two heating elements together to complete a circuit so that both incoming connections to the supply circuit can be made at terminals at the same end.

A further purpose is to extend a heating envelope through the wall of a heating vessel and carry the envelope outside the vessel to a remote point for connection with a terminal box.

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A further purpose is to provide a vessel with a double wall and place heat insulation in the wall, extend heater tubes or envelopes through both walls and seal thereto, and carry the heater tubes or envelopes to a remote point outside the vessel for connection to a terminal box.

A further purpose is to secure heater bars on opposite sides of a line of insulators of the character set forth and to fasten the insulators through both heater bars.

A further purpose is to use a plurality of lines of insulators and a plurality of heater bars fastened thereto, preferably by split fasteners extending through insulators of a plurality of lines and through a plurality of heater bars.

A further purpose is to mount the resistance heaters in a cage, preferably constructed from heater bars having radially outwardly extending arms, suitably at apexes of a triangle, which engage the envelope, leaving aligned spaces between the arms through which the insulators and heaters are carried.

A further purpose is to join the cages into an extended structure by splice bars connecting the ends of the respective cages preferably at the arms.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the embodiments in which my invention may appear, choosing the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figure 1 is a broken perspective of the electric heater of the present invention.

Figure 2 is a fragmentary exploded perspective showing the components of Figure 1.

Figure 3 is a fragmentary perspective showing the portions of an insulator separated to illustrate the construction of the components.

Figure 4 is a partially sectioned fragmentary top plan view of the heater of the invention without the envelope.

Figure 5 is a side elevation of Figure 4 with a portion shown in vertical section.

Figure 6 is a fragmentary perspective of a terminal showing the resistor attaching recess.

Figure 7 is a fragmentary central vertical section of a terminal box connection.

Figure 8 is a fragmentary left end elevation of Figure 7.

Figure 9 is a fragmentary view of a single heater tube or envelope and terminal box.

Figure 10 is a sectional perspective of an open

vessel heater for liquids to which the invention has been applied.

Figure 11 is a sectional perspective of a closed vessel heater for fluids to which the invention has been applied.

Figure 12 is an end elevation partly in section of a modified heater assembly.

Figure 13 is an end elevation partly in section of a further modified heater assembly.

Figure 14 is a transverse section through an envelope showing in end elevation inside the envelope a further modified heater assembly.

Figures 15 to 24 inclusive show a modification in the insulator construction.

Figure 15 is a top plan view of the bottom portion of the modified insulator.

Figure 16 is a side elevation of Figure 15.

Figure 17 is an end elevation of Figure 15.

Figure 18 is a top plan view of the cooperating top insulator portion to be used with the bottom of Figures 15 to 17.

Figure 19 is a side elevation of Figure 18.

Figure 20 is an end elevation of Figure 18.

Figure 21 is a side elevation of the assembled components of Figures 15 to 20.

Figure 22 is an end elevation of Figure 21.

Figure 23 is a fragmentary side elevation showing the assembled insulator of Figures 21 and 22 fastened to the heater bar.

Figure 24 is an end elevation of Figure 23.

Figure 25 is a transverse section through an envelope and cage construction for supporting a plurality of heaters.

Figure 26 is a fragmentary sectional elevation showing the connecting of cages of the type shown in Figure 25.

Figure 27 is a perspective of the cages and splice bars at a joint in Figures 25 and 26.

Figure 28 is a view in perspective of an insulator showing means for connecting the heating elements.

Describing in illustration but not in limitation and referring to the drawings:

In the prior art efforts have been made to heat fluids especially liquids by enclosing electric resistance heaters in tubular envelopes and building up the heaters from resistance elements spaced by insulators supported on a heater bar. See for example my U. S. Patent No. 1,997,146. Installations of this kind are commonly used for fairly large energy input ratings. More recently the requirements for kilowatt capacity have greatly increased until it is no longer possible to meet the demands of service with constructions of the character of my patent aforesaid. The present invention represents an improvement of the construction of my patent, and a modification especially suited to heating fluid-containing vessels such as tanks and pressure vessels.

Whereas in my aforesaid patent the resistors are in the form of helical coils and are carried through holes in the insulators, in the present invention resistors of rectangular contour are used, preferably of zigzag bend, mounted in slots exposed at the sides and retained in retaining recesses, so that the bulk of one side of the resistor is continuously exposed to permit radiation to the side of the surrounding metallic envelope or tube. Each insulator is separable into two portions across its web so that the flanges which form the outer prongs of the retaining recesses can be separated for insertion and removal of the resistor. Terminals are provided which extend through the recesses and slots in prolongation of the resistors and permit carrying

the envelopes or tubes to points remote from the heating load for sealing to terminal boxes. The tubes are preferably provided with anchors which are conveniently connected to the heater bars to permit mounting, and removal of the heaters from the individual tubes.

The insulator and resistor construction of the present invention represents a distinct improvement over the construction of my patent. In the patent construction, where a single hole of an insulator is below the size tolerance, or becomes distorted in shape during firing, it was necessary to reject the entire insulator, whereas with the present device one portion is not affected. Where a heater having such a defective insulator was partially or wholly assembled before the defect was noticed or breakage of an insulator occurred after assembly, it was necessary to remove all heater coils from the insulators in order to replace the defective insulator, but in the present device individual insulators can be replaced with the zigzag bend resistors used in the present invention. There is a slight yielding of the resistors width-wise which permits wider tolerances in the insulators that were permissible in the device of the patent, while still holding the resistors tight.

The insulator may be used in a single set mounting resistors on the two sides, or in multiple sets each consisting of a line of insulators, and in some cases provided with multiple heater bars, for example one on the top and one on the bottom, or interspersed among the lines of insulators. Where desired the single or multiple line of insulators may be provided with some lateral stiffness after the manner of a truss by tying one heater bar to another through the insulators.

The metallic heater bar 30 forms the basic support of the heater and is conveniently of rectangular formation as shown, thin enough to bend plially and permit the heater to follow individual curvature of the surrounding envelope. The metallic bar 30 is in many cases made from plain carbon or constructional alloy steel, but in certain instances may be made of heat resisting alloy such as stainless steel or high chromium heat resisting alloy. The heater bar is provided with fastening openings 31 at suitable intervals and with an anchor opening 32 at one end.

Spaced at intervals along the heater bar in line are insulators 33 consisting of a suitable refractory insulation such as electrical refractory porcelain. The insulators consist of separate portions 34 (the top) and 35 (the bottom) which are divided longitudinally parallel to the bottom at 36 to permit separation for insertion and removal of resistors.

Each insulator consists of a web 37 and outwardly extending flanges 40 at the top and the bottom of the web extending in both directions. Adjoining the web on the interior face of each flange is a resistor retaining recess 41.

With the insulators in line as shown for example in Figures 1 and 2, it will be seen that the retaining recesses 41 on each side of the web are in line from end to end of the insulators.

Outwardly of the recesses on each side of the webs are slots 42 between the flanges at each side which permit exposure of the bulk of the side of each resistor to the surrounding envelope, retaining only the top and bottom edges of the resistors in the recesses. It will be seen that with the insulators in line as shown in Figures 1, 2, 4 and 5, the slots 42 are in line from one to another of the insulators at each side.

The flanges 40 of the insulators are desirably chamfered or bevelled at their outer corners 43 from end to end to conform more nearly to the circular contour which may be the shape of the envelope.

It will be evident that the flanges extend for a considerable distance laterally of the recesses at 44, so that the resistor held in the recesses is well protected against contact with the envelope and against contact with the heater bar.

At intervals on the top and bottom of each web are provided bosses 45 which at the bottom space the insulators from the heater bar, at the separation 36 space the insulators from one another, and at the top space the tops of the fastenings from the resistors. This permits air or other fluid circulation between the heater bars and the insulators, between the parts of the insulators and around the ends of the fastenings, if desired, for more adequate convection flow of heat. It will be seen that the ends of the insulators in a given run are spaced from one another at 46 so as to permit bending of the heater bars without jamming the ends of the insulators where the insulators are at the inside of the bend with respect to the heater bars. This space also allows for expansion or contraction.

The portions of each insulator are held together and to the heater bar by suitably split and preferably pliable fastenings which will allow yielding of individual insulators as the heater bar bends. Split fasteners 47 are shown extending through openings 50 in the centers of the bosses at the tops, at the centers of the webs and at the bottoms of the insulators, and through the openings 31 in the heater bars. The split fastenings are adequately smaller than the openings 50 and 31 in the preferred embodiment to permit longitudinal readjustment as the heater bars flex plially in passing into and withdrawing from envelopes of irregular contours, and to permit expansion and contraction.

Held at the base of the slots 42 by engagement of the edges in retaining recesses 41 are metallic resistors 51 of generally rectangular overall dimensions, conveniently made by sinuous, serpentine or zig-zag bending of strip or ribbon (the width is ordinarily substantially greater than the thickness) of electrical resistance alloy, suitably Nichrome. The width of such rectangular overall dimension represents the distance between a line connecting the tops of the return bends at one side of the zig-zag, and a line connecting the tops of the return bends at the other side.

Thus, as shown for example in Figure 1, the bulk of the side of the resistor (substantially more than half) is laterally exposed in the slots 42 of the insulators. A resistor suitably extends longitudinally on each side of the webs of the insulators supported in the recesses 41 and laterally exposed in slots 42. In the space between insulators a short portion of the resistor is carried across the air gap at 52 (Figure 5) supported at each end and permitting flexing to lengthen or shorten the widths of the individual bends at 52 as the heater bar is flexed back and forth when inserted in an envelope of irregular contour.

At one end of each resistor it is preferably united as by welding to a terminal of increased conductivity and therefore lower operating temperature. This is preferably accomplished by making the terminal of greater metallic cross section and suitably also of higher conductivity material, as for example, Nichrome, stainless steel, Monel, copper, beryllium copper, Phosphor

bronze or the like. The terminal will preferably have the same rectangular overall section as the zigzag bend resistor structure and will extend in prolongation of the resistor structure held by the recesses 41 and carried through the slot 42. The terminal 53 has a straight bar portion 54 (Figure 6) and a socket portion 55 which is suitably formed into a U-shaped transverse contour to receive the end of the resistor 51 and permit welding into the socket at 55.

At the opposite end from the terminal two resistors are suitably cross connected in any convenient manner at 56, suitably by employing a single resistor for both sides of the heater and making a U-bend at 56, so that the terminals of an individual circuit branch are both provided by the terminals 53 at the same end of the heater.

The heater unit thus consisting of the heater elements and their terminals, the insulators, the heater bars and the fasteners is ordinarily contained within a tube or envelope 57 which may be of circular contour as shown at 60 in Figures 1, 2, 10 and 11 or may be of other suitable cross section, for example rectangular as shown at 61 in Figure 14. The envelope is formed of a suitable metal such as plain carbon or constructional alloy steel or a heat resisting alloy such as stainless steel, high chromium heat resisting alloy or the like. It will be understood that whatever the contour of the envelope 57, its walls will be adequately insulated from the resistors by the depth of the slot 42 and the extending flange portions 44 of the insulators.

To permit removable positioning of the heaters in the envelopes, an anchor 62 having an anchor opening 63 is suitably located at an open end 64 of the envelope. The anchor openings 63 on the anchors are in line with the anchor openings 32 on the heater bars so that suitable fastenings such as bolts 65 can pass through the respective anchor openings as best seen in Figures 7 and 8. To remove an individual heater, it is merely necessary to remove the bolt, disconnect the terminals, and withdraw the heater bar.

Considerable difficulty has been encountered due to the tendency for the terminals to become excessively heated. It has been found that by the present invention the heater bars, insulators and terminals can be extended to a point remote from the heating load at which circuit connections can be made in a terminal box using conventional wiring without the necessity for liquid cooled connecting conductors. This represents a distinct improvement from the standpoint of efficiency and cost of manufacture. In accordance with the present invention the terminals 53, the heater bars and the insulators along with the tubular envelope, are extended in prolongation of the heaters over a substantial length 66 (Figures 7, 10 and 11) outside of the heating load and there sealed as by welding to a terminal box 67. The terminal box 67 may be individual to a given heater and envelope as shown at 70 in Figure 9, or it may be a group terminal box 71 as shown in Figures 10 and 11, in which case many envelopes are sealed into the bottom plate 72 of the terminal box. The box has the usual side walls 73 and is flanged at 74 to receive a suitable cover (not shown) and provided with conduit openings 75 for external circuit connection. The surfaces engaging with the cover may be ground if it is desired to make an explosion-proof construction.

Thus it will be seen that for each heater two sets of terminals enter the box, representing a

single phase in the preferred embodiment, and these can be connected in any well known manner for single phase or multiple phase circuit operation.

Experience indicates that the spacing at 66 between the heating load and the terminal box should in many instances be not less than twelve inches and preferably not less than eighteen inches to assure adequate low temperature of the terminals at the point connection is made.

The invention is believed to have wide applicability not only in heating pipes and preventing freezing of dam gates, but especially in the heating of fluid vessels, such as vats, tanks, boilers (including high pressure steam boilers, and Dowtherm boilers), and chemical process equipment (including stills, evaporators, and reaction vessels).

Figure 10 illustrates a fluid vessel 76 of open tank type having an inner wall 77, an outer wall 80 and heat insulation 81 in the space between the walls. Each heater envelope has a closed end 82 inside the tank and extends through and is welded or otherwise suitably sealed to the inner wall at 83 and to the outer wall at 84. The envelope then extends at 66 to a remote point where the terminal box is located.

Each envelope or tube 57 is slidably supported to permit free longitudinal expansion and contraction in an opening 85 of a tube support 86 extending across the interior of the vessel and secured thereto.

Thus it is seen that the liquid content of the vessel surrounds the envelopes but does not come in direct contact with the heating elements, heating being accomplished by radiation and convection from the elements to the envelopes.

In Figure 11 I illustrate a closed pressure vessel 87 which has the same character of envelope tube support and terminal box as in Figure 10. In this case the inner wall 90 is spaced from the outer wall 91 to provide a jacket space 91' which may be employed for heating or heat insulation (as shown) when the pressure vessel is intended for heating purposes, or for cooling where it is employed as a reaction vessel. Suitable connections to the interior of the pressure vessel and independent connections to the jacket are suggested by the pipe 92, the detail of the connections required when the jacket space contains a heating or cooling medium being omitted.

In the preferred form of insulator as previously described, the separation between the top and bottom insulator portions is preferably accomplished near the middle of the web. In Figures 15 to 24 an alternate form is illustrated in which the separation is accomplished at or near the top of the web. In this instance the bottom insulator portion 93 carries the flanges 40, the lower recesses 41 and the web 37 as well as the lower and upper bosses 45. The upper insulator portion 94 carries the upper flanges 40 but does not include the web except the bridging portion between the flanges, and includes the outer walls of the recesses 41 at the top. When the members are joined together as shown in Figures 21 to 24, they produce a cross section closely resembling that of the preferred form of insulator as shown in Figures 1 to 5 inclusive.

In some instances the marked resilience provided by the heater bar is not desired, and in such cases a stiffer construction may be preferred. In such instances an auxiliary heater bar 95 may be employed engaging the top of the line of insulators and fastened thereto by the

same split fasteners passing through both heater bars and the intervening heater insulator, as shown in Figure 12. Where higher heat inputs are desired, it may be preferable to employ a plurality of lines of insulators 96, 100 and 101, as shown in Figure 13, assembled one on top of another. In this case the auxiliary heater bar 95 may optionally be used with or without sufficient freedom between the split fastening and the opening in the heater bars to permit flexing of the heater bars. The employment of a plurality of lines of insulators 96, 100 and 101 may occur in a structure where great stiffness is desired, as shown in Figure 14 where with three lines of insulators, auxiliary heater bars 102, 103 and 104 are employed between each line of insulator, and on the top of the uppermost line. In this case a single fastening 47 may pass through all of the heater bars and all of the intervening insulators between the two outermost heater bars at each fastening point along the length of the heater. The form of Figure 14 is desirably employed with a rectangular cross section of the envelope 61. The auxiliary heater bars 102 and 103 also serve as internal supports for the flat walls of the envelope 61 against crushing under the pressure of a closed vessel. Thus the side walls can yield enough to contact the bars 102 and 103 without interfering with function, and thin-walled envelopes can therefore be used.

In Figures 25 to 28 a variant form of heater support is shown, employing aligned spaced metallic cages 105. Each cage is preferably triangular and is provided with radial arms 106 which contact the interior of the envelope and position the heaters in the envelope, whether the latter be horizontal or vertical. Each cage is suitably constructed of heater bars 107 reversely bent near the ends to form the arms and joined by bolts 108.

The insulators 33 are secured to the heater bars 107 at 109 adjoining spaces 110 between the arms. Each cage may be separate, and the cages will then be joined at their ends to form supports of indefinite length by splice bars 111 extending from one frame to the next, preferably between the heater bars 107 at the arms 106, joined by the bolts 108. The heaters may suitably be connected end to end from one cage to the next, as by connections 112.

Thus the arms space the heaters from the envelope. The cages are inserted one at a time, and preferably connected successively as each cage is being pushed or lowered into the envelope. The cages form a closed configuration in cross section. The triangular construction is very rigid and assures adequate strength to support many cages vertically from the top, and to support the heaters horizontally from the envelope, depending upon whether the structure is horizontal or vertical.

In operation the heaters can conveniently be assembled and shipped with the tubes or envelopes or separately therefrom. The assembly is simple, consisting merely of arranging the lower set of insulators along the lowermost heater bar, placing the heaters and their terminals in the recesses of the lower set of insulators, applying the next set of insulators (repeating the operation if additional heater bars or lines of insulators are to be included), and then applying the split fasteners through the insulators and the heater bar or bars. The heaters can be assembled in the tubes or envelopes after the tubes or envelopes are properly posi-

tioned and sealed into the walls of the vessel, if a vessel is to be employed, and after the anchors and terminal boxes have been applied to the ends of the tubes. The securing of the heaters in the tubes is conveniently accomplished by fastening the heater bars to the anchors, and then connection to the terminals can be made using any well known wiring methods. If, as in the preferred embodiment, each pair of heaters is to constitute a single phase, the heaters will be cross connected at their remote ends before they are inserted in the envelope.

In view of my invention and disclosure variations to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In an electric heater, a flexible metallic heater bar, a plurality of mating sets of longitudinally positioned spaced insulators distributed along the heater bar, the sets cooperating to form side slots extending for the length of each insulator and retaining recesses from opposite walls of the side slots, the side slots and retaining recesses of the insulators extending in prolongation of one another, fasteners uniting the insulators of each set and securing each set to the heater bar and a zigzag resistor extending through the side slots, at its edges held in the retaining recesses of the various sets of insulators.

2. In an electric heater, a flexible metallic heater bar, a plurality of longitudinally positioned spaced sets of mating insulators connected to the heater bar, each having a pair of opposite side slots extending for the length of each insulator and retaining recesses from opposite walls of the side slots, the side slots and retaining recesses of the insulators extending in prolongation of one another and the slots widening when the insulators of a set are separated, and generally rectangular resistors extending through the side slots, and at their edges held in the retaining recesses of the various insulators and cross connected to one another at one end.

3. In an electric heater, a flexible metallic heater bar, a plurality of mating pairs of longitudinally positioned spaced insulators flexibly connected to the heater bar having formed from each insulator opposite side slots extending longitudinally of each insulator and retaining recesses from opposite walls of the side slots, the side slots and retaining recesses of the pairs of insulators extending in prolongation of one another and a pair of generally rectangular resistors, each extending through one of the side slots and at its edges held in the retaining recesses of the various pairs of insulators.

4. In an electric heater, a flexible metallic heater bar, a set of longitudinally arranged insulator bottoms aligned longitudinally upon the heater bar, each having an upstanding web, and bottom flanges extending on opposite sides from the web adjoining the heater bar having retaining recesses in the bottom flanges on opposite sides of the web, a plurality of insulator tops mounted on the bottoms and having downwardly extending webs cooperating with the upwardly extending webs of the bottoms and top

flanges outwardly extending on either side of the web having retaining recesses in the flanges on either side of the web, there being fastener openings in line with one another extending through the tops and bottoms and through the heater bar, zigzag resistors extending on either side of the webs secured in the retaining recesses and fastenings extending through the fastening openings and securing the top and bottom portions of the insulators together and to the heater bar.

5. In an electric heater, a heater bar, a plurality of insulators each consisting of longitudinally separated mating top and bottom portions open continuously at one side and having near the open side cooperating retaining recesses in the top and bottom portions, the insulators extending longitudinally of the heater bar, fastenings securing the insulators to the heater bar end to end, a resistor of generally rectangular cross section extending through the slots and retained by the retaining recesses, one side of the resistor being exposed continuously to the outside through the slots of the insulators, and a terminal of rectangular cross section secured to the end of the resistor, extending through the slots and retained in the retaining recesses in prolongation of the resistor.

6. In an electric heater, a heater bar, a plurality of insulators each consisting of longitudinally separated mating portions open continuously at one side, and having near the open side cooperating retaining recesses in the mating portions, the insulators extending longitudinally of the heater bar, fastenings securing the insulators to the heater bar end to end, a resistor of generally rectangular cross section extending through the slots and retained by the retaining recesses, one side of the resistor being exposed continuously through the slots, a tube closed at one end and open at the other end surrounding the heater bar, insulators and resistor, an anchor secured to the tube adjacent one end and a fastening securing the heater bar to the anchor.

7. In an electric heater, a tube closed at one end and open at the other end, a vessel to be heated into which the tube extends at a point remote from the open end, a terminal box secured to the open end remote from the vessel, a removable heater extending into the tube and comprising a flexible heater bar, a plurality of insulators having side slots and retaining recesses spaced along the heater bar, flexible fastenings securing the insulators to the heater bar, zigzag resistors extending through the slots of the insulators, retained in the recesses, exposed to the tube over a major portion of the side of each resistor through the slot and spaced from the tube and from the heater bar, a terminal on each resistor adjacent the open end of the tube and extending from the vessel to the terminal box, an anchor secured to the tube near the open end and a removable fastening for connecting the heater bar to the anchor.

8. A vessel for liquids, tubes having sealed ends and open ends extending through and sealed into the wall of the vessel and having the closed ends of the tubes inside the vessel, tube supports slidably positioning the tubes toward the closed ends to permit expansion and contraction longitudinally, the open ends of the tubes extending to a remote point outside the vessel, a terminal box sealed to the open ends of the tubes at the remote point, removable electric heaters within the tubes each comprising a flexible heater bar and the

heaters having terminals extending into the terminal box, anchors secured to the tubes near the open ends, fastenings connecting the anchors to the heater bars, and each heater comprising refractory insulators flexibly attached along the bar and having slots and retaining recesses and resistors positioned in the slots and held by the recesses spaced away from the tube walls.

9. In an electric heater, an envelope, a pair of generally parallel spaced heater bars inside the envelope, insulators between the heater bars extending in spaced relation longitudinally and having side slots and retaining recesses, fastenings extending through the insulators securing them to both heater bars and a resistor extending through the slots and retained by the recess, in spaced relation to the heater bars and envelope.

10. An electric heater comprising a rectangular envelope, removable electric heaters within the envelope, the heaters comprising a plurality of heater bars with refractory insulators flexibly attached thereto, the insulators having slots and recesses for support, resistors on two sides spaced away from the enclosure wall in the slots and retained in the recesses and a terminal box attached to an end of the envelope.

11. A vessel for liquids, tubes having sealed ends and open ends extending through and sealed into the wall of the vessel and having the closed ends of the tubes inside the vessel, tube supports slidably positioning the tubes toward the closed ends to permit expansion and contraction longitudinally, the open ends of the tubes extending to a remote point outside the vessel, a terminal box outside the vessel sealed to the open ends of the tubes at the remote point, removable electric heaters within the tubes having terminals extending into the terminal box, each heater comprising a flexible heater bar, refractory insulators individually flexibly attached along the bar and having slots and retaining recesses and resistors po-

sitioned in the slots and held by the recesses spaced away from the tube walls, the terminals extending to the terminal box through the slots of the insulators.

12. In an electric heater, an envelope, cages positioned at intervals longitudinally of the envelope and having arms extending to the interior of the envelope and spaces between the arms, a plurality of insulators secured to the cages in line with the spaces and having aligned engaging recesses and electric resistance heaters extending through the recesses longitudinally of the insulators.

13. In an electric heater, longitudinally spaced aligned cages having arms extending radially outward and spaces among the arms longitudinally in line, splice bars joining one cage to the next, recessed insulators extending along and secured laterally removably to each cage, the insulators being individually laterally separable at the recesses, and electric resistance heaters extending through the recesses.

LEE P. HYNES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,736,451	MacInnes	Nov. 19, 1929
1,829,785	Christian	Nov. 3, 1931
1,899,933	Bennett	Mar. 7, 1933
1,997,146	Hynes	Apr. 9, 1935
2,035,306	Fannin	Mar. 24, 1936
2,255,518	Norton	Sept. 9, 1941

FOREIGN PATENTS

Number	Country	Date
175,282	Great Britain	Feb. 9, 1922