

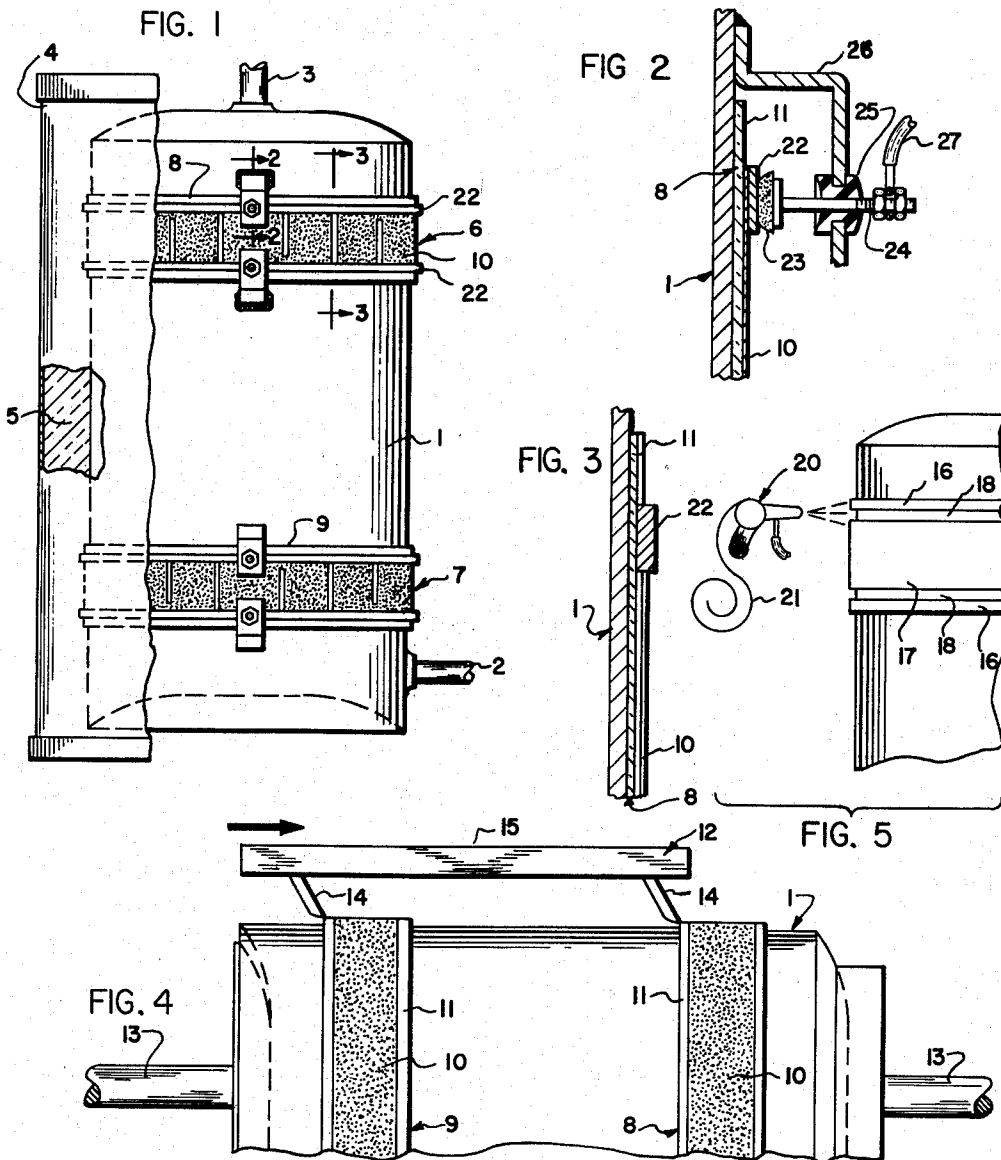
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E. F. DILLON

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ELECTRIC WATER HEATING APPARATUS

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INVENTOR.
EUGENE F. DILLON
BY
Andrew F. Hubbard

ATTORNEY

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ELECTRIC WATER HEATING APPARATUS
Eugene Francis Dillon, Chicago, Ill., assignor to General
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This invention relates to water heaters of the resistance heater storage tank type.

Water heaters of this type usually utilize one of two types of heating unit. The most common heating unit is a metal sheathed immersion unit which is introduced into the tank through a side wall opening. This arrangement is advantageous as respects direct heat transfer to the liquid but has the practical operating disadvantages of "liming up" in some of the harder waters and of galvanic erosion in installations in which magnesium rods or powered anodes are used to protect the tank against corrosion. Such installations require special electrical protection such as disclosed in Dicome et al., 2,810,815. The second general form of heating unit comprises the "clamp on" type as disclosed in Vogel et al., 2,452,214, issued October 26, 1948, and assigned to my present assignee. Obviously, the clamp on type, not being in direct contact with the water is not subject to erosion or to the other weaknesses of the immersion units, but clamp on units are expensive to apply because of the harness necessary to maintain the heating element tightly against the tank wall to insure good heat transfer. Both of the forms of resistance heaters have a common disadvantage: a rather cumbersome inventory of heating units of various wattages, or complete water heaters of various wattages, is required to satisfy the different wattage rating preferences which are prevalent in various sections of the country. An electric utility, for example, may insist upon a specific wattage rating in order that a large number of water heater installations may be made within the capabilities of its electric distribution system.

It has been previously proposed to coat the exterior of the storage tank or appropriate portions thereof, with electrical resistance films having the necessary wattage per square inch density, in lieu of the older forms of heater units. These films are inexpensive as such, although they require that the tank wall be coated with a satisfactory insulating substrate and thus introduce a somewhat more costly and demanding manufacturing procedure. There are, however, two real advantages: a direct heat path exists between the film and the tank wall thus insuring good heat transfer with the external wall of the heater tank without clamping harnesses or the like, and it is possible by applying terminal bands at locations which will produce a range of wattages according to the group of terminals utilized by the installation electrician, to produce at very nominal extra cost a standard water heater which is of itself adaptable to the preference or the specifications of a specific customer.

I have found, however, that as a result of practical mass production techniques, the resistance film may have minute deficiencies which are subject to breakdown when the heater is in service. Such breakdowns may completely interrupt the electrical resistance circuits of which the film is the primary part, thus rendering useless that heating element of the water heater. It may happen at any time after installation and because there is no practical means of rectifying the failure in the field, service can be restored only by a complete replacement of the water heater. In the mass manufacture of water heaters embodying resistance films it is a practical impossibility to insure absolutely perfect films or insulating substrates. Voltage irregularities which may be experienced after the heater is in actual service, may result in current concentrations

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producing hot spots which actually break down a small area of the resistance film. More importantly, I have found that the failures do not remain localized, but instead, spread laterally along a line which is substantially parallel to the line of the terminal strips and about midway between them. A breakdown of the film at a minute area, therefore, appears inevitably to lead to the failure of the entire resistance element. It is my experience that it is most unusual for there to be more than one or two of such danger points in any one resistance film; whereupon I conceived that if means compatible with mass production practices were found to insure that any film failure would be strictly localized, the matter of film failure could not so disadvantageously affect the water heater performance as to require a complete replacement of the water heater itself.

In a presently preferred form of carrying out the objective of localizing resistance film failures, I apply the necessary substrate to the exterior wall of the tank and apply thereon a resistance film having the desired electrical resistance characteristics. The substrate and film will be applied to the tank wall in the form of relatively wide bands which encircle the tank which as is well known, is usually of cylindrical shape. After the film is deposited on the tank but before the terminal bands are applied thereto, I subdivide the film by means of scribe lines which penetrate the film and usually penetrate at least the outer surface of the insulating substrate without exposing any of the bare metal of the tank wall. The scribe lines may be of the order of $\frac{1}{32}$ of an inch wide and will be axial in direction. The electric terminal bands are then applied along the appropriate marginal edges of the resistance film and terminal members applied thereto, whereupon when the terminal members are connected into an electric power circuit the film actually becomes a series of individual resistances in a parallel electrical circuit.

The scribe lines may be applied to the film by a simple tool of the milling machine type with respect to which the tank is rotated in indexing fashion to accomplish the required subdivision of the film. In a fifty gallon capacity water heater manufactured pursuant to common commercial standards, the tank diameter is of the order of 20". I have found that fifteen subdivisions will produce the desired insurance against the failure of the heating element. It will be obvious that in the event a hot spot failure develops in any of the subdivisions, the fault can migrate only to the marginal limits of the particular resistance area. Since the wattage of each of the resistance areas is only a small portion of the total wattage an individual failure or the failure of two such resistance areas will not effect such a large reduction of the wattage capacity as would be noticeable in the performance of the water heater.

Other features and advantages of the invention will be obvious from the following detailed description of a typical form thereof read in connection with the accompanying drawings in which:

FIG. 1 is a vertical elevation of an electric water heater embodying the present invention with the exterior casing of the heater shown fragmentarily and the number of heating units being reduced to two for simplicity of representation. In this figure some of the scribed lines delineating the electric resistance areas illustratively extend entirely across the areas and some extend from one terminal strip toward the other. These are optional arrangements and not intended in a limiting sense;

FIG. 2 is an enlarged section taken on lines 2—2 of FIG. 1;

FIG. 3 is an enlarged section taken through a scribed area of a heating unit on lines 3—3 of FIG. 1;

FIG. 4 is a schematic representation of a method of scribing the heating units; and

FIG. 5 is a schematic representation of a method of applying the terminal bands.

FIG. 1 shows a typical water heater tank 1 having the usual cold water inlet 2 and hot water outlet 3. Tank may be of any suitable material including cold rolled steel having any suitable lining (not shown) on the interior thereof for protection against water corrosion. For example, the steel in which the tank is made may have a lining of non-corrosive metal such as stainless steel, or of vitreous material. The lining material is unimportant as respects the present invention. The exterior wall of the tank is uncoated except for a thermally conducting and electrically insulating substrate as presently described. Pursuant to conventional practice the tank may have an exterior shell 4 enclosing the thermal insulation layer 5 which is usually of glass fiber or mineral wool. Such materials are thermally efficient and of course, are electrically insulating as well.

The exterior of the tank is provided with heating elements embodying the present invention. Illustratively there are only two such elements, respectively 6 and 7, located in the upper and in the lower areas of the tank. The resistance elements are selected to provide a total wattage which is consistent with the requirements of a quick recovery water heater. For example, the total wattage provided by the heating elements may be 4500. As previously indicated there may be any number of individual heating elements, or the entire surface of the tank may be coated with the resistance heating material and appropriate terminal arrangements provided so that only selected portions of the resistance material are active.

In the illustrated form, resistance material is of the film type applied to an insulating substrate for the prevention of short circuits between the film and the tank.

The exterior of the tank is grit-blasted in preparation for the application of the substrate. The exterior surface must have a bright finish and those portions to which the substrate is to be applied should not be handled after blasting. The tank is then conveyed to a spray booth within which the tank is rotated slowly on a vertical axis while being manually sprayed with substrate material. Any conventional spray guns of the type commonly used for spraying porcelain frits may be used. The tank may be masked by conventional heat resistance mask strips (not shown) to delineate the substrate application.

The preferred substrate is one which will provide a hard, smooth, base, with minimum of voids, for the conductive film. Where the tank itself is of such construction or composition to withstand temperatures of the order of 1540 to 1580° F. without deterioration of its corrosion-resistant lining, a water-resistant porcelain enamel glass is an excellent substrate material. A typical formulation, based on one hundred parts (pounds) of glass frit, includes five parts of clay, one-half part borax, from one-eighth to one-quarter part magnesium carbonate, from five to ten parts of silica and from thirty-eight to forty-two parts of water. This material is fired in a conventional oven, at from 1540° to 1580° F. The thickness of the layer may be from five to ten mils.

When it is not possible to expose the tank to such temperatures, a phosphate bonded ceramic may be used.

A presently preferred phosphate bonded ceramic formula is as follows:

150 cc. of deionized water at room temperature
56 cc. of commercial grade phosphoric acid
30 grams of 400 mesh hydrated alumina
450 grams of 400 mesh silica.

The ingredients are mixed in a ball mill for one-half hour. The mixture is sprayed onto the surface of the tank at a rate of 72 grams per square foot. This amounts to 21 cc. per square foot, or a substrate thickness of from ten to fifteen mils.

The tank is held at 600° F. until the phosphate material is hard and dry.

This material forms an excellent mechanical bond with the tank wall. It may be desirable to provide a light vitreous enamel "dust coat," as is well known in the art, on the tank wall before applying the phosphate bonded ceramic, to limit the attack of the phosphoric acid. There are also available, well known inhibitors which may be mixed with the phosphate bonded slip, to reduce the etching action of the acid. In its dried or pseudo-vitreous state, the phosphate bonded ceramic is rather porous, and does not have a hard, glassy surface to the desired degree. These deficiencies can be ameliorated in substantial measure by spraying the substrate with a filler material such as hydrolyzed ethyl silicate and burnishing the surface with a burnishing wheel or cylinder (not shown).

In any event, when the masks are removed, the tank has an upper substrate layer 8 and a lower substrate layer 9.

The deposit of the electrically conductive film 10 is done in an oven held at approximately 1050° F. The marginal edges of the substrate may be masked by metal strips or the like before spraying with the film material.

The film material is prepared by mixing two preparations as follows:

Part 1 consists of a 55 cc. of 190 proof ethyl alcohol containing 5% of methyl alcohol. This is mixed with 10 grams stannic chloride.

Part 2 consists of 20 grams of concentrated hydrochloric acid, mixed with 5 grams of antimony trichloride. This mixture should be kept covered at all times.

The spray mixture consists of 11 drops, or about .55 cc. of Part 2, added to the above quantity of Part 1. About one hour supply of solution is the maximum that should be stored, and the container should be polyethylene lined or equivalent. The spray guns should have carbide tips.

The mixture is applied by means of a spray gun for each of the two heater elements 6 and 7. During the spraying, the tank is rotated on a vertical axis at about 30 r.p.m. and means (not shown) are provided for uniformly moving the spray guns back and forth over the area to be sprayed. The film material is deposited at the rate of about 5 cc. per square foot, producing a finished film having a thickness on the order of 5 microns. The technique of spraying is essentially conventional. In view of the nature of the spray material spraying is accomplished directing the spray through suitable apertures in the wall of the oven (not shown).

The tank is allowed to cool at a normal rate and is then removed from the oven. The masking bands (not shown) are removed, whereupon the area of the resistance film is defined by the upper and lower marginal bands 11 of uncoated substrate material.

The tank with its substrate and resistance film is then transferred to apparatus schematically shown in FIG. 4 on which the scribing operation is performed. The scribing tool 12 may be of a milling machine type.

The scribes or milling cutters 14, affixed to a reciprocating head 15, scribe the film and a portion of the substrate so that in none of the scribe areas is the bare metal of the tank exposed. FIG. 3 schematically illustrates the substrate condition at the termination of the scribing operation. During the scribing operation the tank is indexed by appropriate rotation of the mounting shafts 13 to provide for the desired number and spacing of the scribed lines. For simplicity of this process, it is contemplated that the substrate bands will be scribed across their full depth, although it will be obvious that it is necessary only for the portion of the resistance layer between the terminal bands to be electrically interrupted. Preferably, the scribed line is of the order of 1/32" in width.

After the scribing operation, the heating element areas are again masked to cover the marginal areas 11 of the substrate and sufficient area of the resistance film to pro-

vide for the application of terminal bands in electrical connection with the resistance film throughout the entire circumference of the tank. Obviously, the total of the area of the resistance film 10 between the terminal bands constitutes the effective heating unit area. As schematically shown in FIG. 5 the upper and lower masking bands 16 cover the marginal areas 11 of the substrate, and the masking band 17 covers the resistance film to the extent providing the necessary areas 18 of the resistance film. The terminal bands may be formed of aluminum sprayed on with a conventional gun 209 which atomizes an aluminum wire 21 and projects it under gas pressure against the exposed areas of the resistance film, as well understood in the art. The resulting terminal bands 22 are about 1/2" in axial dimension and from .003" to .005" thick. The current carrying capacity of a terminal strip having such dimension is adequate for the load to be applied thereto, which in each of the heating elements may be of the order of 2250 watts.

It will be noted in FIG. 1 that some of the scribed lines extend entirely across the film, whereas others extend from one or the other of the terminal bands but do not intersect both. Either or both of these arrangements may be employed, although the full scribe is preferred. It is considered essential that the scribe lines intersect each terminal band, whether or not the intersections are serial or alternate, and that each of the scribe lines extend substantially beyond the central areas of the resistance films.

After the completion of the terminal strips the tank is provided with electrical terminals. As schematically shown in FIG. 2 the terminals may comprise carbon contacts 23 mounted on a steel stem 24 which is bonded to a rubber grommet 25. The grommet is mounted in a Z bracket 26 welded or otherwise secured to the exterior of the tank and inherently spring biased to urge the shaft 24 in the direction of the terminal band 22. As indicated schematically in FIG. 2, the distortion of the rubber grommet 25 maintains the carbon contact 23 always in conductive relation with the terminal strip 22.

As a final manufacturing step, the heating elements may be coated with a suitable electrically insulating water repellent film (not shown) to insure against resistance changes which might otherwise result from moisture or dampness. A satisfactory coating material comprises a clear alkylid resin varnish, such as manufactured and sold by applicant's present assignee under the trademark "Glyptal."

The terminals provide for the connection of appropriate electrical power leads 27 which may be arranged in any electrical circuit including thermostats (not shown) as well known in the art. The entire heater tank assembly is thereupon covered with the electrical and thermal insulation material 5 and enclosed in the protective and decorative outer cover 4.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim:

A water heater of the storage tank resistance heated type, comprising a cylindrical metallic pressure vessel; a layer of vitreous electrically insulating and thermally conducting material fused to the exterior surface of said vessel to provide a continuous band extending about the periphery thereof; a plurality of strips of electrically conductive resistance material disposed on said band in good heat transfer relation therewith, said strips comprising a film essentially of tin oxide and of about 5 microns thickness, each strip terminating short of the respective marginal edges of said insulating band and there being an electrically insulating gap insulating each said strip from its adjacent strip; first and second terminal bands of electrically conductive material extending continuously about said vessel inwardly of the respective marginal edges of said insulating band in electrical contact with each of said strips; first and second terminal supporting brackets fixed relative to said vessel adjacent the respective first and second terminal bands; an electric terminal including a rod-like conductor mounted in each of said brackets; annular resilient electric insulation means affixed to each said rod-like conductor and associated bracket and biased to urge said terminal resiliently into contact with the associated terminal band; means for connecting each said terminal to a source of electric energy; and a mass of thermally and electrically insulating material enclosing said pressure vessel and the above-named electrically conductive components thereof.

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