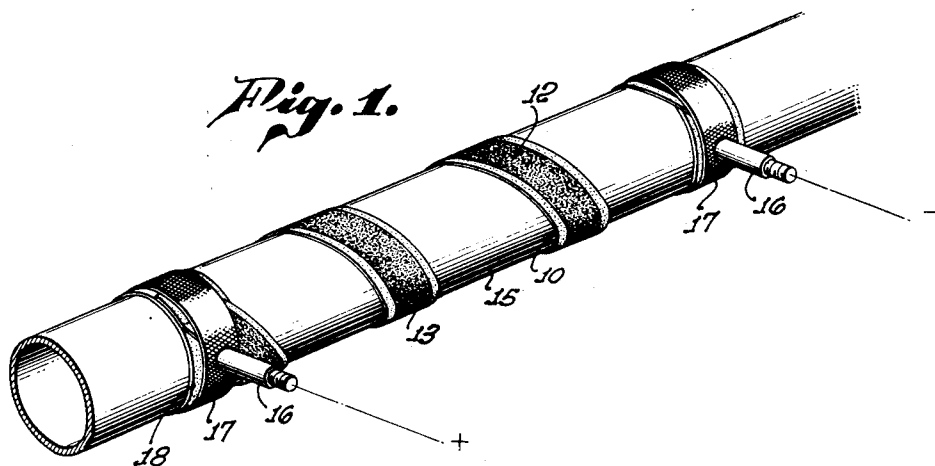
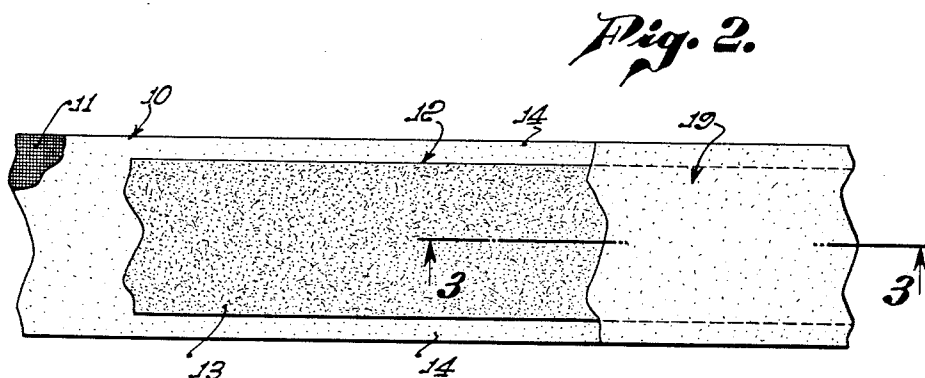
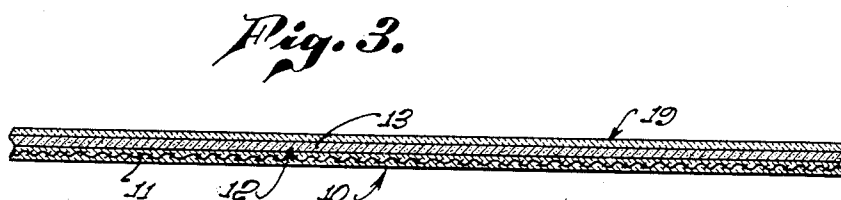


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H. I. SILVERSHER
FILM-TYPE HEATING ELEMENT

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FILM-TYPE HEATING ELEMENT

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This invention has to do with improvements in heating devices and heating elements of the type employing a uniform and intimate admixture of finely divided electrically conductive particles and relatively high resistance filler particles, held by a binder in current-passing relation. In certain of its more specific aspects the invention relates to film dimension heating elements of this general composition, and to flexible heating means in the form of a temperature resistant base layer, sheet or strip to which is bonded the heating film. Although adaptable to different specific purposes and forms, the invention has an important field of use as a flexible composite sheet or tape applicable to pipes, vessels and various other objects requiring surface or wall heating, and therefore will be described as embodied in this typical form.

One of my general objects is to provide a novel heating element having the combined properties and advantages of (1) complete flexibility for application to various surface shapes, (2) stability in its physical, thermal and electrical properties over long periods of time, and (3) capacity for heating at temperatures within the range of about 100° F. and upwards.

For better understanding of the particular objects and accomplishments of the invention, reference may be had preliminarily to the general nature and composition of the electrically conductive and resistive particles in the heating element. In its broader aspects the invention contemplates the use of any suitable finely divided particles in such proximate and current passing relation as will produce a predetermined temperature at given potential. Preferably I employ an intimate and uniform mixture of conductive metallic particles and relatively high resistance filler particles, all of which for best results are sized preferably below 10 microns in their greatest dimensions. Maintenance of contact between the particles despite flexure or thermally induced dimensional changes in the element, and stabilization therefore of the electrical and thermal properties of the element, may be assured to advantage by using metal particles in flake form, or mixtures of metal particles some at least of which have flaky form.

Typical metals include silver flake (e. g. product No. MD-585 of Metals Disintegrating Company of Elizabeth, New Jersey), nickel flake (e. g. Metal Disintegrating Company's product MD-750), zinc precipitate (e. g. "Merrillite" sold by Alloys Division of Metals Disintegrating Company, of Berkeley, California), and finely di-

vided powdered or flaky stainless steel. Copper, aluminum and various metal alloys may be used, depending upon the particular electrical and thermal properties desired for a particular heating element. As obtainable, these powdered metals may range in size as high as 40 microns, but the minus 10 micron and preferably minus 8 micron sizes have been used most successfully for the purposes of the present invention. Of the various metals silver may be regarded as preferred.

The relatively high resistance powdered filler may include any or mixtures of the following: titanium oxide, calcium carbonate, calcium silicate, talc and silica. Other materials having corresponding resistance properties may be used. For certain purposes, less resistive materials such as carbon and graphite may be used.

Generally speaking, the proportions of metal and filler particles may range within rather wide limits, depending upon the resistance and heating characteristics desired. For example in a low resistance element designed to operate at about 300° F., at 2½ watts per square inch, the mixture may contain about 60 parts of metal (e. g. silver) to 90 parts of filler. This ratio may vary typically to around 90 parts of metal to 60 parts of filler in a high resistance element designed to operate at corresponding temperature and wattage.

The invention is more particularly concerned with the manner in which the heating element or film particles are bonded together in stable condition, and with so supporting the element, particularly where the latter is in thin sheet or strip form, as to provide a composite element and support having the degree of free flexibility adapting it to various surface application uses. In this aspect the invention contemplates an improved heating element having elastomeric properties by using as a particle binder, a high temperature resistant elastomer. Also contemplated in conjunction with an elastomeric heating element, particularly in a thin or film-like form, is the use of a heat-resistant elastomer body base or carrier, bonded to and in effect integrated with the heating element.

Successful results have been achieved using as the elastomeric material, the generally-termed silicone rubbers, the commercial unpolymerized gum or resin grades of which, sold usually in a paste form, may be polymerized by heating as permanent elastomers. Although for present purposes these silicone rubbers need not be discussed in chemical detail, they may be character-

ized in accordance with their known structures as being macro-molecular alkyl di-substituted poly siloxanes copolymerized in an elastomer structure. As examples of useable commercial grades or brands of polymerizable pastes, I have used Dow-Corning "Silastic-125," believed to be a mixture of the gum or polymerizable silicones together with filler particles and an accelerator, and General Electric Company's "S. E.-76" gum, a clear polymerizable silicone material to which I add the filler particles and accelerator. These polysiloxane elastomers are to be distinguished from the non-elastomeric resins, which are unsuited for the purposes of the invention as the conductive particle binder material.

In compounding the metal and filler particle mixture with a polymerizable silicone material in which filler particles have not been incorporated, the weight ratio of the silicone material or paste to the combined metal and filler particles (which are relatively proportioned as previously indicated) may vary from 25 to 50 parts of the silicone material for 100 parts of the solid particles, the object in most instances being to use no more than enough of the silicones to give an effective elastomer binder for the particles. As will appear, formation of the element may result from heating of silicone-filler and metal particle mixture containing a suitable polymerization accelerator such as benzoyl peroxide.

Further details concerning an illustrative embodiment of the invention in an elongated strip or tape form of heating element, will be further understood from the following detailed description of the accompanying drawing, in which:

Fig. 1 is a view showing the composite heating tape applied to a pipe;

Fig. 2 is a plan view of the tape composite, with the layers progressively broken away to illustrate their relationship; and

Fig. 3 is a cross-section on line 3-3 of Fig. 2.

Referring to Figs. 2 and 3, the base or supporting layer 10 consists essentially of the silicone elastomer in which is embedded suitable reinforcement, preferably in the nature of a heat-resistant woven fabric. As illustrative, the layer 10 may comprise a sheet or tape of glass cloth 11 embedded in the elastomer and formed by initially coating both surfaces of the glass cloth at uniform thickness with the silicone paste (containing an accelerator) and then heating the base strip to polymerize and elastomerize the silicone. If for any reason desired, suitable filler may be incorporated in the rubber. Typically, the thickness of the base layer 10 may range between 0.005 to 0.015 inch.

The heating element generally indicated at 12 comprises a thin layer or coating 13 which as previously indicated, comprises in its final condition a uniform mixture of the metal and filler powders in the silicone elastomer binder which in turn is bonded to and in effect integrated with the base layer 10. It will be noted that the heating element film 12 is effectively insulated electrically from any metal surface to which the tape composite may be applied, in that the element strip is narrower than the base layer and ordinarily will be given equal spacing at 14 from the edges of the base.

In manufacture of the composite, the silicone, powdered metal and filler, together with benzoyl peroxide, may be applied to the base 10 by spraying, brushing or knife coating the paste mixture at uniform thickness and in spaced relation to the edges of the base. Following application of the heating element film, the tape may be heated

under temperature and time conditions (typically at 500° F. over a period of one hour) sufficient to polymerize the silicones to their elastomeric form. The resulting film thus has an essentially elastomeric body both in the base layer and heating element film, giving the composite complete flexibility and ready applicability to surfaces of various shapes.

As illustrative, the heating tape may be used for heating a pipe 15, as illustrated in Fig. 1, wherein the tape is shown to be wrapped spirally about the pipe and electrically connected at its ends to suitable poles or current conductors 16. The latter are shown to be attached to copper mesh conductor 17 placed about the end convolutions of the tape in direct contact with the heating film 13. At the location of the conductors, the end convolutions of the tape may be electrically insulated from the pipe by a layer of asbestos cloth or other suitable insulating material 18 placed between the tape and the pipe. In order to prevent short circuiting or electrical bleed off from the film 13, the strip composite may carry a surface insulation layer 19 suitably bonded to the surfaces beneath and composed for example of fiber glass and asbestos sheet, such as "Novabestos" manufactured by Irvington Var-nish Company of El Monte, California. For clarity in illustrating the base layer and heating film in Fig. 1, showing of any surface installation 19 has been omitted.

The following are illustrative examples of the composition and resistance characteristics of heating films which may be laid upon silicone rubber or other base supports, as discussed in the foregoing.

Example I

Lower resistance element:

Silastic 125 (Dow-Corning)	69 gms.
Silver Flake	81 gms.
Xylene	150 gms.
Resistance	approx. 0.0180 hm./sq. in.
Thickness	0.0045 inch

Example II

Moderately low resistance element:

Silastic 125 (Dow-Corning)	81 gms.
Silver Flake	69 gms.
Xylene	150 gms.
Resistance	approx. 0.240 hm./sq. in.
Thickness	0.0045 inch

Example III

SE 76 (General Elec. Silicone Elastomer)	15 gms.
Antimony Oxide	20 gms.
Silver Flake	35 gms.
Xylene	160 gms.
Benzoyl Peroxide	1.5 gms.
Resistance	approx. 0.20 hm./sq. in.
Thickness	0.045 inch

The resistance and thickness values given above are of course those of the heat-set or polymerized finished mixture.

I claim:

1. A heating element comprising a uniform mixture of finely divided metallic electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes, and a supporting member bonded to said element and composed of a heat resistant elastomer of copolymerized poly siloxanes.
2. A heating element comprising a freely flex-

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ible body composed of a uniform mixture of finely divided metallic electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes, and a flexible supporting member bonded to said element and composed of a heat resistant elastomer of copolymerized poly siloxanes.

3. The combination including a base layer having an extended flat surface and composed of a heat resistant elastomer of a copolymerized poly siloxane and a heating element layer bonded to said base layer surface and comprising a uniform mixture of finely divided metallic electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes.

4. The combination including a thin flexible base layer of heat resistant elastomer of copolymerized poly siloxanes, reenforcing woven glass fabric embedded in said elastomer, and a thin flexible heating element coating bonded to said base layer and comprising a uniform mixture of finely divided electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current passing relation by a heat resistant elastomer.

5. A heating element comprising a uniform mixture of finely divided metallic electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes, said conductive and filler particles being less than 10 microns in their maximum dimensions, and a supporting base member bonded to said element and composed of a heat resistant elastomer of copolymerized poly siloxanes.

6. A heating element comprising a uniform mixture of finely divided metallic electrically conductive particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes, said metallic particles being in flake form and both the conductive and filler particles being less than 10 microns in their maximum dimensions, and a supporting base member bonded to said element and composed of a heat resistant elastomer of copolymerized poly siloxanes.

7. A heating element comprising a uniform mixture of finely divided electrically conductive flake silver particles and relatively high electrically resistive filler particles all bonded together in proximate and current-passing relation by a heat resistant elastomer of copolymerized poly siloxanes, and a supporting base member bonded to said element.

8. The combination including a thin flexible base layer of heat resistant material and a thin flexible heating element coating bonded to said

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base layer and comprising a uniform mixture of finely divided electrically conductive flake silver particles and relatively high electrically resistive filler particles all bonded together in proximate and current passing relation by a heat resistant elastomer.

9. The combination including a thin flexible base layer of heat resistant copolymerized poly siloxane elastomer, and a flexible heating element coating of about 0.030 to 0.055 inch thickness bonded directly to said base layer and comprising a uniform mixture of finely divided electrically conductive flaky metal particles and relatively high electrically resistant filler particles all bonded together in proximate and current passing relation by copolymerized poly siloxane elastomer so that the composite base layer and coating are freely flexible, said conductive and filler particles being less than 10 microns in their maximum dimensions.

10. The combination including a thin flexible base layer of heat resistant copolymerized poly siloxane elastomer, woven glass fabric embedded in said layer, and a flexible heating element coating of about 0.030 to 0.055 inch thickness bonded directly to said base layer and comprising a uniform mixture of finely divided electrically conductive flaky metal particles and relatively high electrically resistant filler particles all bonded together in proximate and current passing relation by copolymerized poly siloxane elastomer so that the composite base layer and coating are freely flexible, said conductive and filler particles being less than 10 microns in their maximum dimensions.

11. The combination including a thin flexible base layer of heat resistant material composed of copolymerized poly siloxanes and a thin flexible heating element coating bonded to said base layer and comprising a uniform mixture of finely divided electrically conductive flake silver particles and relatively high electrically resistive graphite particles all bonded together in proximate and current passing relation by a heat resistant elastomer of copolymerized poly siloxanes, said silver and graphite particles being predominately under 10 microns in size.

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