

June 2, 1936.

J. H. TAYLOR

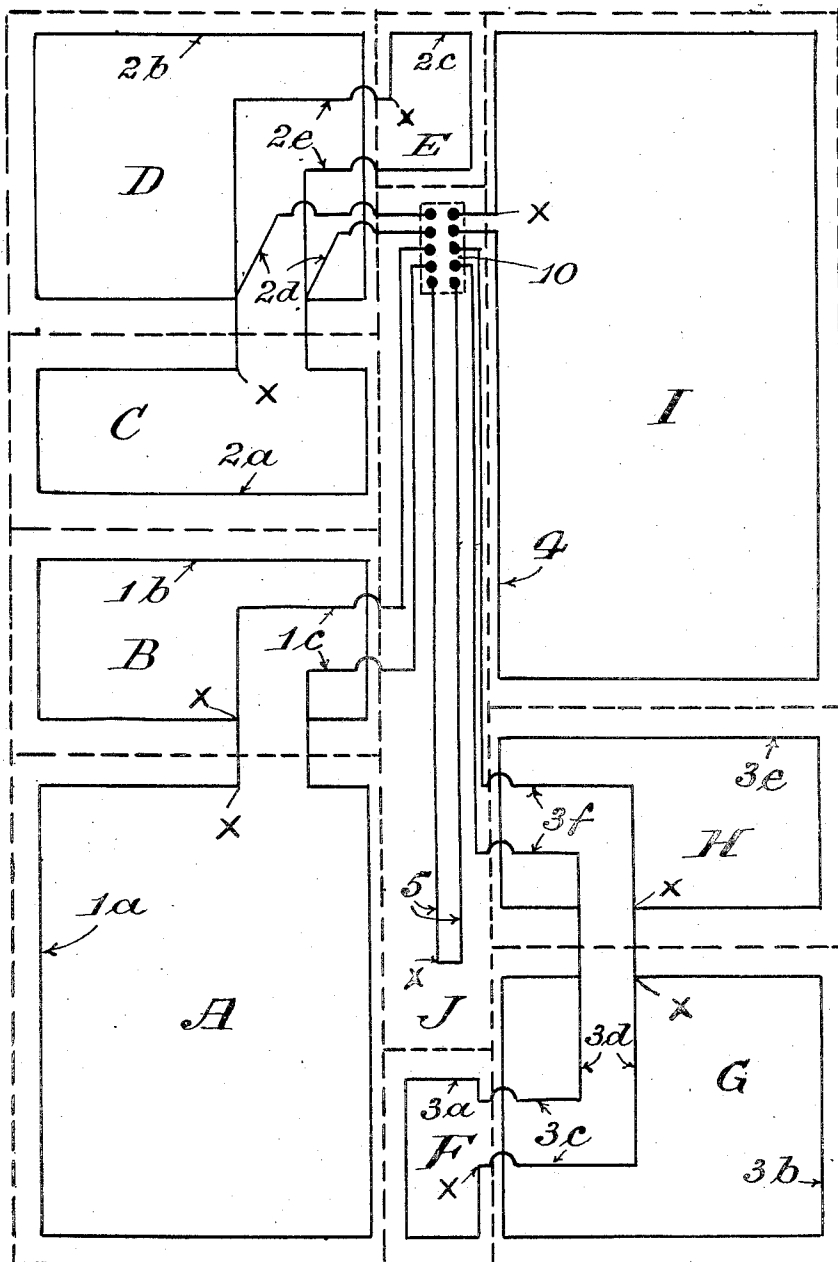
2,042,742

ELECTRICAL HEATING SYSTEM FOR BUILDINGS

Filed April 20, 1934

6 Sheets-Sheet 1

Fig. 1.



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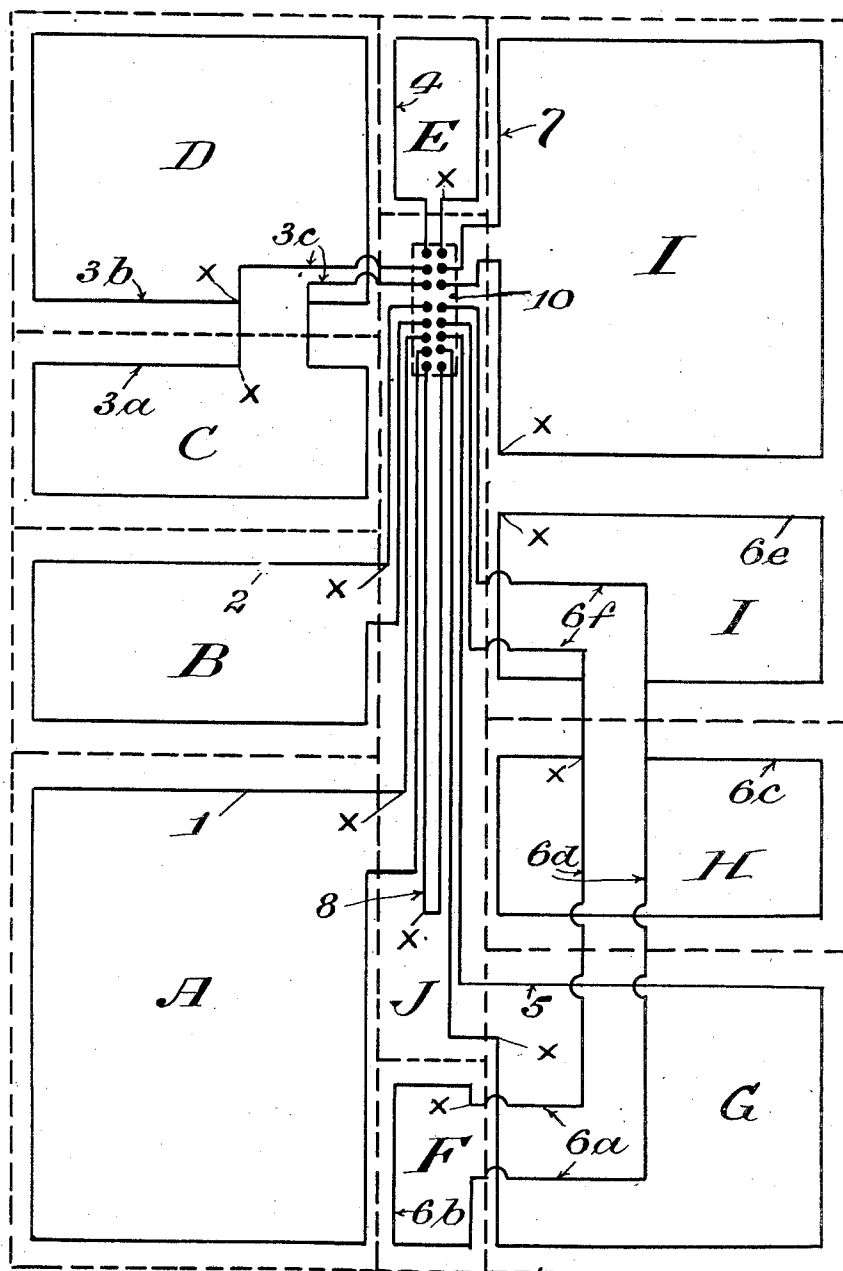
2,042,742

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6 Sheets-Sheet 2

Fig. 2.



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ELECTRICAL HEATING SYSTEM FOR BUILDINGS

Filed April 20, 1934

6 Sheets-Sheet 3

Fig. 3.

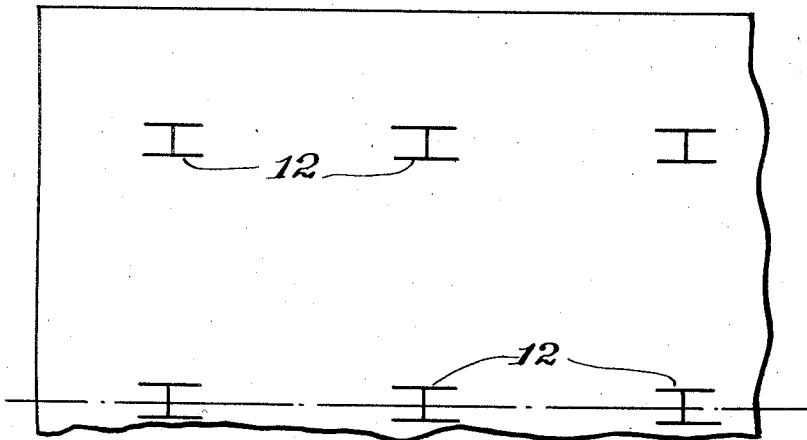


Fig. 4.

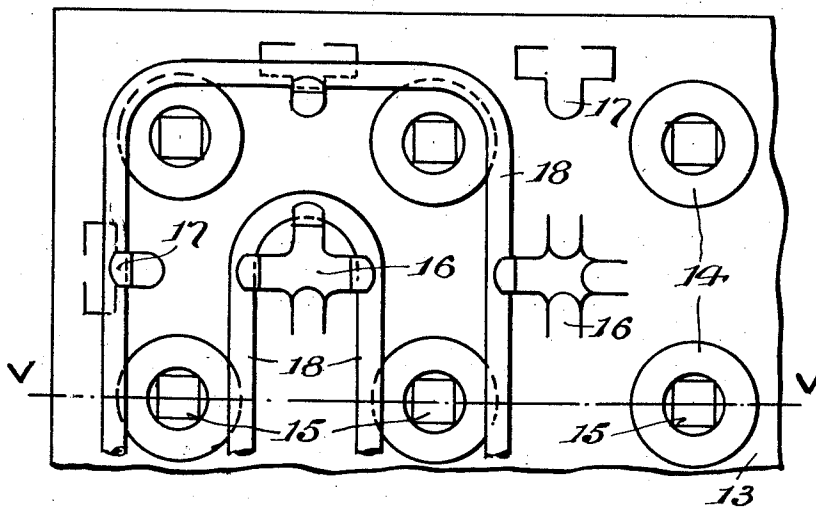
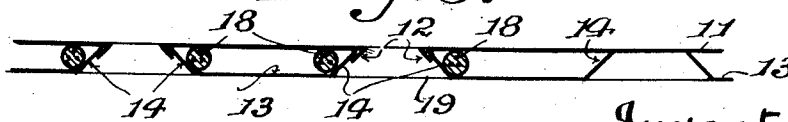


Fig. 5.



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ELECTRICAL HEATING SYSTEM FOR BUILDINGS

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Fig. 6.

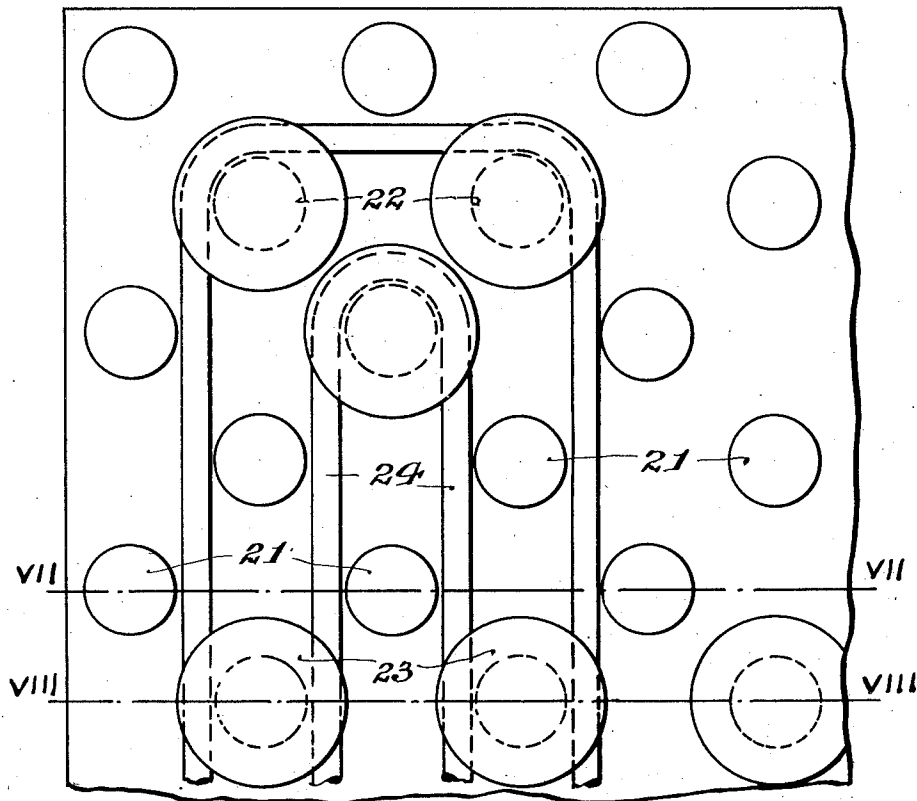


Fig. 7.

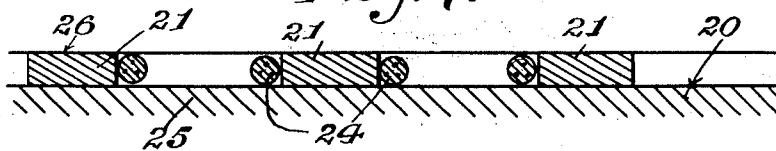
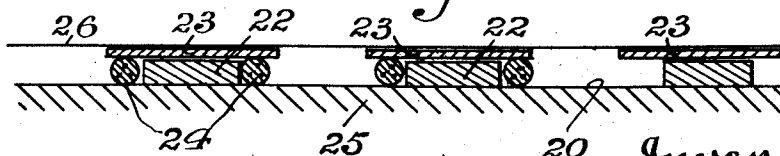


Fig. 8.



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ELECTRICAL HEATING SYSTEM FOR BUILDINGS

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Fig. 9.

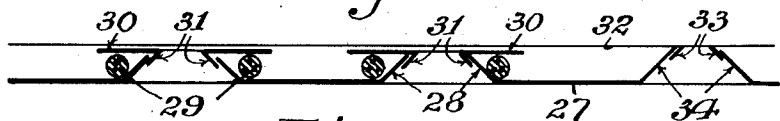


Fig. 10.

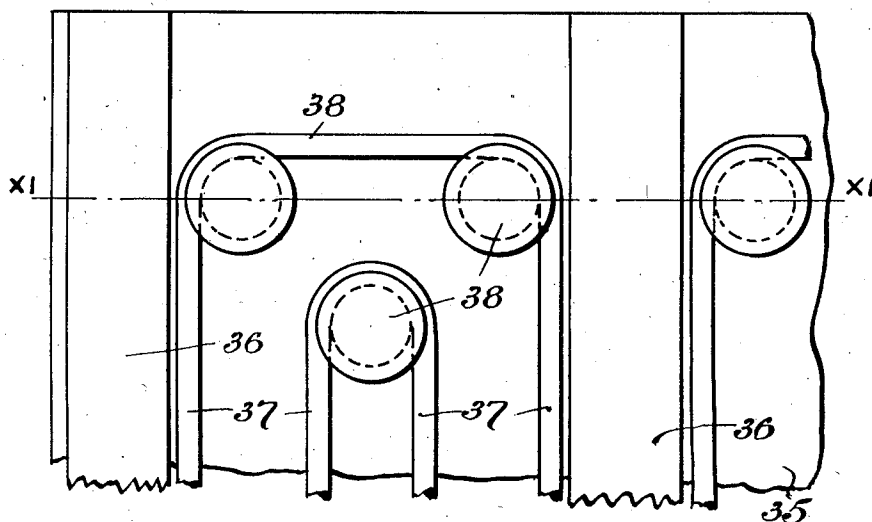


Fig. 11.

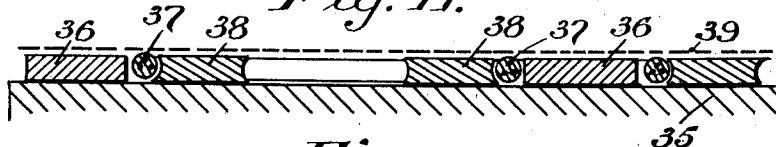


Fig. 12.

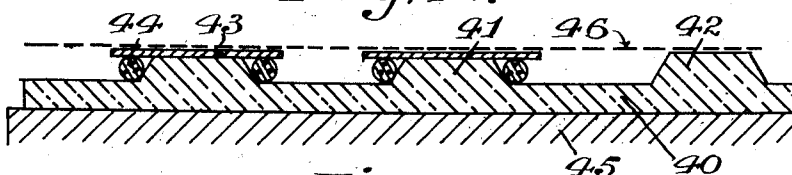
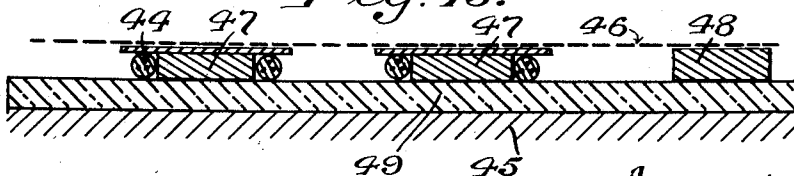


Fig. 13.



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ELECTRICAL HEATING SYSTEM FOR BUILDINGS

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Fig. 14.

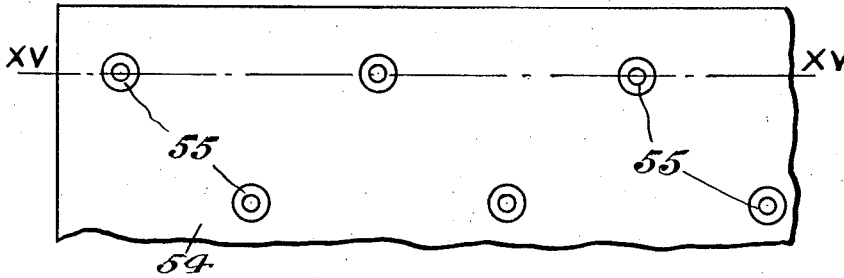


Fig. 15.



Fig. 16.

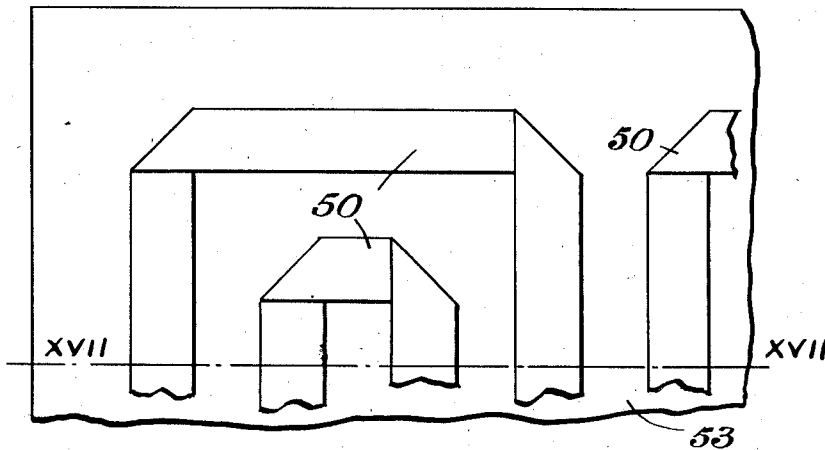


Fig. 17.

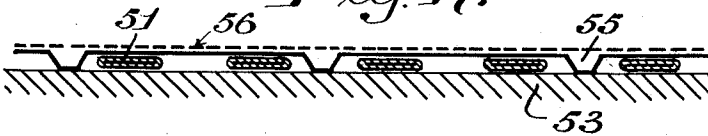
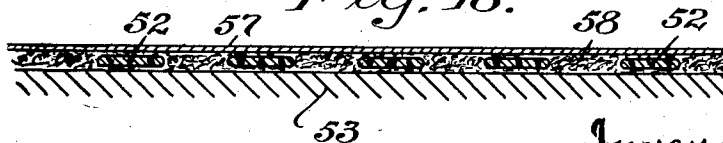


Fig. 18.



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UNITED STATES PATENT OFFICE

2,042,742

ELECTRICAL HEATING SYSTEM FOR BUILDINGS

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Application April 20, 1934, Serial No. 721,632
In Great Britain June 15, 1932

3 Claims. (Cl. 219—19)

This invention relates to the heating of buildings, vehicles, ships, or other structures by means of electricity.

The prior methods of heating by electricity may be divided generally into two main classes. Firstly the radiator or heater units which operate at a high temperature and secondly the relatively low temperature or panel heaters. In the first of the above mentioned classes it is usual to employ conductors of high specific resistance of more than 90 microhms per cm. cube such as nickel chrome alloys containing a high chromium content to enable the requisite resistance to be crowded into relatively small spaces. For example, the conductors may consist of a coil or coils of single strand wire of extreme thinness and relatively short length operating at a temperature of 1400° to 1600° F.

In the panel type of heater element the conductors insulated and protected in various ways have usually been embedded in the plaster or other material forming the ceilings, walls, or floors of a building or enclosed within panels or casings which have been sunk into or fixed upon such surfaces. While with such systems stranded conductors may be employed to keep the temperature of the conductors at a relatively low figure it is in general, usual to employ the said high specific resistance conductors of relatively short length for the required loading to be obtained in the available space. When embedded the heat of the conductors has been transmitted to and distributed through the material in which they are embedded and the conductors are usually so rated as to produce surface temperatures of the distributing material approximating those of hot water or steam radiators. Various expedients have been adopted to distribute and convey the heat uniformly to the radiating surface and to reinforce the plaster or other finished surface to prevent cracking and to reduce the fire risk.

As examples of such relatively low temperature heaters, it has been proposed to provide a low resistance copper conductor comprising a single strand of 25 S. W. G. wire having a sectional area

of 0.00031 square inch or of 0.00025 square inch insulated by a double cotton covering wound round an insulating core and loaded to produce an operating temperature of about 200° F. Such an arrangement necessitates a piece of apparatus acting as a relatively low temperature radiator having a heating surface of approximately one square inch per watt consumed.

It has also been suggested to provide a heating panel containing a resistance conductor spaced in air for insulating purposes and run at a temperature such that the radiating surface of the panel from which the heat is diffused preferably does not exceed a temperature of 130°–150° F. Taking into account the heat gradient between the air spaced conductors and the said surface as well as their relative sizes it will be clear that the temperature of the conductor will be very considerably higher.

In one further example an insulated conductor was used which was formed of a fusible metal alloy which fuses between 150° and 200° F. and was embedded in the ceilings, walls, and the like of rooms with the object of raising large surfaces to an outer radiating temperature of 90°–100° F. We make no claim herein to any system of embedded conductors which are intended to fuse when the temperature therein is of the order of 150° F. to 200° F.

It is also well-known to warm the ground for horticultural or other purposes by means of what are commonly termed in the art soil heating cables. As far as we are aware these cables have been constructed of resistance conductors of small-cross-sectional area of the order of .000452 square inch or less, in lengths of approximately 50 yards for a supply voltage of 230 volts, the conductor being insulated by asbestos which is externally covered by paper and lead sheathing. Each of the above mentioned lengths in effect, therefore, forms a flexible resistance element, the wire of which has a length of 150 feet for a loading of about 700 watts. For other voltages the length may be adjusted pro rata, for example with a supply voltage of 115 volts the length of the

cable should be halved and the resultant load will be half that above mentioned.

In other cables intended primarily for heating soil but also stated to be usable for heating buildings it has been proposed to provide an electric cable comprising a conductor of a material of high ohmic resistance, an insulated covering of heat resisting material such as asbestos or mica and an outer sheath of magnetic material having a high hysteresis and eddy current loss the purpose of this sheath being to increase the heat generated on the outside of the cable on the passage of current therethrough. I make no claim herein to an insulated cable having an outer magnetic sheath designed for the purpose of producing a high hysteresis and eddy current effect.

All the above described heaters may therefore be considered as heating units necessitating special constructional features to which units the supply voltage is applied by means of high conductivity conductors forming part of wiring systems of known types. These wiring systems conform to definite regulations and comprise insulated cables, the insulation of which has a definite minimum dielectric resistance. For example, in the United Kingdom the insulating dielectric of such wiring systems must be such as to withstand a pressure test of 1,000 volts alternating current applied for 15 minutes between conductors. The insulating dielectric normally used in such known wiring systems may consist of a non-hygroscopic material such as vulcanized india rubber or of a hygroscopic material such as impregnated paper or fibre sheathed with a closely fitting water-tight cover of lead.

It is the object of this invention to provide improved systems of heating for buildings or other structures by means of electricity which are considerably cheaper to install and which are further more efficient in operation than those hitherto adopted and moreover to provide a heating system which can be built up "in situ" merely by the act of applying to the existing structure insulated cables which are comparable with the known wiring systems above mentioned for distributing electrical energy.

In the system of the present invention the property inherent to electricity, namely that it will maintain a uniform heating effect from end to end of a uniform conductor no matter what the length of that conductor may be is advantageously utilized and it is this property possessed by no other heating medium which makes possible the attainment of the primary object of the invention, namely the distribution of heat from relatively large surfaces which are maintained at a relatively low temperature above that of the surrounding atmosphere without any deleterious effect on the insulation of the conductors.

It is here pointed out that the present invention is confined to the utilization of insulated cables in the ordinary use of that term, namely where the conductor of the cable is provided with an insulating covering of the above mentioned character and does not include bare conductors with air insulation or bare conductors embedded in insulating media, other than the cable dielectric, which are built into the structure of the building.

According to the present invention heat is developed in insulated metallic cables mounted on or within ceilings, walls, or like members of the structure other than embedded cables and connected in a continuous circuit across a source

of supply without the inclusion of any additional heating element or medium, the said conductors being so dimensioned relatively to the supply potential that the loading does not exceed 3 watts per foot run in the case of conductors having a cross sectional area of 0.001 square inch, the maximum loading per foot run in the case of conductors of other sizes being directly proportional according to their respective surface areas.

In the case of conductors formed of a plurality of strands the surface area thereof will be assumed to correspond to that of a single strand conductor of the same sectional area.

Where the conductors are embedded within plaster, concrete, or other substances, the loading in accordance with the invention does not exceed $1\frac{1}{2}$ watts per foot run for conductors having a cross sectional area of 0.001 square inch, and for other conductors the maximum loading will be directly proportional according to their respective surface areas.

Preferably the conductors will have a cross sectional area of more than 0.001 square inch.

Where the conductors of the cables are insulated by a non-hygroscopic material such as vulcanized india rubber the loading is preferably such that the temperature of the cable never exceeds 100° F. and where the insulation comprises a hygroscopic material such as impregnated paper or fibre sheathed with a closely fitting water tight cover such as lead or otherwise rendered waterproof, the loading is preferably such that the temperature of the cables never exceed 130° F.

The conductors may be dimensioned so as to produce a constant heating effect per unit length, i. e., a constant wattage per unit length and may consist of simple and/or compound circuits of different loadings and lengths all having the same heating effect per unit length. The different loadings with a constant supply voltage are obtained with the same heating effect per unit length and at substantially the same temperature by varying the length and specific resistance of the conductors of the insulated metallic cables but maintaining them with substantially the same sectional area and surface area.

In applying this invention the conductors employed are made of metals and/or alloys of various specific resistances, or the strands thereof may be composed of different metals and alloys and also combinations of such conductors may be employed in any circuit. The conductors may be stranded or of ribbon formation to provide the largest possible surface area in relation to their sectional area. They will generally be of low specific resistance and will be of adequate sectional area to provide the requisite mechanical strength which it is necessary for conductors employed in a wiring system to possess. In the case of conductors which are provided with insulation and protective covering, the protective covering may be corrugated or ribbed to increase the heat diffusivity.

The cables may be made up in reels, coils, or the like and may be marked at intervals with the resistance of the conductor remaining on and/or withdrawn from the reel, coil, or the like, so that all requisite information as to the heating value is readily discernible without recourse to testing, measuring or calculation.

Further the coils may be marked or labelled with the rated capacity in thermal units, resistance, length, size, wattage, voltage, current, tem-

perature rises of external surface above atmosphere under various conditions, and/or with any other information which may be desirable or requisite for correct application.

5 The combination of relatively large sectional and surface area, and considerable length enables the loading, and resultant heating effect of the conductor to be reduced to any desired minimum even down to a fraction of one watt per hour per
10 foot run of cable and it is therefore possible to provide heating at a lower temperature distributed over a greater area than has previously been the case and to obtain all the resultant advantages, such as increased radiant heat comfort,
15 greater purity and freshness of atmosphere, reduction of heat losses from the structure and the like. The low temperature of the cables also makes it possible without detrimental effect to use the actual building structure as a component
20 part of the heating system by enclosing the insulated cables within cavities and the like in the structure, the cables transmitting the heat to the structure which in turn absorbs, diffuses and retransmits the heat to the rooms or other places.

25 In the prior heaters of the radiator type it has been customary to use the higher specific resistance wires containing a high percentage of chromium owing to their ability to stand up to the high temperatures at which the radiators operate, but in contra-distinction thereto, the system of the present invention is adapted also for the employment of conductors of lower specific
30 resistance and thus of conductors containing a low percentage of chromium or of totally different and cheaper materials. By this means circuits of very considerable lengths can be provided with the result that the percentage length of the circuit located outside of the room or place to be
35 heated extending to and from the ends of conductors at which the supply of energy is delivered or distribution board is reduced to a negligible minimum of the whole circuit.

40 The insulated cables of the system of the present invention may be run adjacent to, on, or within the surface from which distribution is to be effected, or they may be disposed in the space between partitions as for instance in the space
45 between the ceiling of a lower room and the floor of an upper room, in partitions forming walls, above ceilings and under floors, or floors may be double boarded or otherwise be provided with spaces between which the cables may be suitably
50 inserted.

55 The general practice with heating installations is to provide sufficient capacity to maintain an inside temperature determinedly higher (usually one of about 60° F.) than the outside and therefore a considerable proportion of the initial outlay is for excess equipment to deal with occasional cold spells due to the inability of the equipment to otherwise cope with the occasional increased load. A feature of great value in my invention is
60 that it is only necessary to provide equipment for the normal conditions, as due to the low temperature at which the system operates, it can deal with the occasional lower outside temperatures which arise by increasing the normal temperature of the system. This can be accomplished by the
65 provision of a step-up transformer operating upon the entire installation or by the provision of series-parallel switches operating upon a portion of each circuit so that the portion of the circuit or circuits outside that under switch control

will be automatically increased or reduced in temperature due to the action of the switch upon the circuit controlled thereby. It is not desired to limit the invention to the particular methods
5 above mentioned for enabling the temperatures to be varied, as other methods are or may be available, but for practical reasons the methods described are preferred, but any form of control may include the provision of thermostats to bring the system into or out of operation as conditions
10 demand.

It will be apparent that in some cases it will be desirable to run the insulated cable circuits from points of distribution and to connect these points to the ends of conductors at which the supply of
15 energy is delivered by the usual high conductivity insulated feeders.

The invention presents the great practical advantage that it enables low temperature radiant heat to be distributed and diffused from a very
20 large surface area and that the whole of the cable constituting a circuit may be utilized for heating purposes, since any length of insulated cable between the actual room or place concerned and point of distribution or supply will assist in heating
25 any other room, corridor, or the like through which it may pass.

In the application of known wiring systems in which conductors carry electrical currents or current consuming devices, the sectional area of the
30 conductors is varied according to the load connected and the length of the circuit. For example, four current consuming devices each rated at 2.5 amperes (or 2 at 4 amperes and 2 at 1 or any similar variation) when connected in parallel to a final sub-circuit, necessitates that the sectional area of the final sub-circuit conductors shall be appropriately increased to carry 10 amperes with a predetermined drop of potential
35 which varies according to the sectional area of the conductor and the length of the circuit. Further, the usual regulations stipulate that every final sub-circuit shall be connected to a sub-distribution board. Every sub-distribution board
40 shall be connected to a separate way on a main distribution board with conductors of greater sectional area. Each main distribution board shall in turn be connected either to a separate way on a main switch-board, or to one way of a distribution
45 board for larger currents, with conductors of still greater sectional area, such distribution board for larger currents in turn being connected to the main switchboard with still larger conductors, or to one way of a distribution board for
50 still heavier currents.

The number of such distribution boards, with interconnecting cables of appropriate sectional area intervening between the final sub-circuit distribution boards and the main switchboard is
55 dependent upon the size and disposition of the installation.

In the present electric heating installation the conditions are entirely different, and the methods
60 of installation outlined above would be both unduly costly and lacking in efficiency from the heating point of view.

In such an installation when fitted in self-contained buildings and places, which are heated
65 throughout it is generally a costly disadvantage to employ conductors of large sectional area in any part of the system, with the exception of the length of large sectional area conductors which are necessary for connecting up the system at the
70 75

source of supply, as conductors of large sectional area do not serve any adequate low temperature heating requirement. It is generally an advantage to only employ one size of conductor and to build up compound circuits with conductors of various specific resistances designed to accommodate the different loadings which are necessary for the actual heating requirements.

By running out the circuits in the manner described a considerable economy can be effected. For example in the case of a 100 k. w. installation connected to a 200 volt supply service, the cost of a pair of large sectional area 100 k. w. cables amounts to three or four times as much as 33 pairs of 3 k. w. cables and only provides about one tenth of the heating effect due to the decrease in surface area. In the case of smaller installations corresponding economies can be effected.

In the application of the system conductors of various specific resistance known in the trade under the trade-marks "Brightray", "Glowray", "Dullray", "Ferry", "Zodiac", "Grade 1", "Mangonic", as well as nickel, phosphor bronze, aluminium and copper may be used and are hereinafter referred to by way of example but other conductors of any desired specific resistance can also be employed.

The individual conductors may have coatings or marks of different colours so that the same are readily identifiable.

Installation tables and/or charts may be prepared in known manner, giving details of various heating effects (wattage per foot run of conductor) ohms per foot, amperes, volts per foot, together with total resistance in ohms. Total wattages, and total length of circuit at various supply pressures (voltages) in respect of conductors of various specific resistances such as those referred to above and of various sectional areas. Such tables and/or charts form a ready means for determining the most suitable conductors to use in the various branch circuits of any given system of heating under specified conditions.

It has been determined from numerous tests that three .029" insulated and protected cables when loaded to 1 watt per foot and stretched in air with usual spacings within rooms will rise in temperature approximately 25° F. above the room temperature. Therefore, in a room in which the temperature is maintained at 60° F. the approximate temperature of the insulated cable under the above conditions would be 85° F. In ordinary cases this would be a desirable operating temperature for normal winter conditions as assuming the permissible normal maximum running temperature of cables insulated in the method employed to be 100° F. it would permit of the loading of the conductors being increased to 1½ watts per foot run and thus reaching an approximate temperature of 97½° F. during cold spells.

The following tables have therefore been prepared on the basis that three .029" cables of different metals or alloys formed a suitable and the preferred size of conductor for producing a heating effect at the desired low temperature. It is of course evident that other tables can be prepared in a similar manner with varying conditions such as different voltages, heating effects and the like. It is further to be noted that the figures given in this and other tables and calculations hereinafter set forth are only approximate and are not claimed to be mathematically exact.

TABLE No. 1

Relative capacities of three .029" heat wire circuits at a rating of 1 watt per foot run

Type of conductor	Ohms per foot	Amperes	Volts per foot	Total wattage and length in feet of circuit at 200 v.
Glowray.....	.271	1.92	.52	334
Brightray.....	.265	1.95	.516	330
Dullray.....	.227	2.1	.476	420
Ferry.....	.123	2.85	.344	570
Zodiac.....	.092	3.3	.303	660
Grade 1.....	.079	3.6	.284	720
Mangonic.....	.040	5.01	.198	1002
Pure nickel.....	.0253	6.3	.159	1260
Phosphor bronze.....	.0253	6.3	.159	1260
Aluminium.....	.008	11.2	.09	2222
Copper.....	.0042	15.45	.065	3082

TABLE No. 2

Relative capacities of three .029" heat wire circuits at a rating of .5 watt per foot run

Type of conductor	Ohms per foot	Amperes	Volts per foot	Total wattage of circuit at 200 v.	Total length of circuit at 200 volts
Glowray.....	.271	1.36	.368	271	542
Brightray.....	.265	1.38	.365	274	548
Dullray.....	.227	1.48	.336	298	596
Ferry.....	.123	2.0	.246	407	814
Zodiac.....	.092	2.33	.214	467	934
Grade 1.....	.079	2.52	.199	503	1006
Mangonic.....	.040	3.53	.1412	708	1416
Pure nickel.....	.0253	4.45	.112	893	1786
Phosphor bronze.....	.0253	4.45	.112	893	1786
Aluminium.....	.008	7.9	.063	1587	3175
Copper.....	.0042	11.	.046	2164	4329

It will be clear that by suitably increasing or reducing the length of the circuit in conformity with the voltage, circuits at the above ratings can be provided for any desired voltage.

The above tables relate to simple circuits but would also provide the requisite information for building up compound circuits of any desired formation. The usual procedure in the latter case would be to add together the current in amperes of the branch circuits; to select a conductor of equivalent or nearest higher carrying capacity for the main circuit; to obtain total length of main circuit in feet which when multiplied by ohms per foot would give resistance of main cable which is to be installed and when multiplied by volts per foot would give the reduction in the voltage of the branch circuits which would in turn enable the length, wattage and resistance of cable which is to be installed in each branch circuit to be arrived at.

In the case of a compound circuit in which all the conductors are of the same sectional area and loaded to approximately the same wattage per foot run, the loading in the main circuit would vary according to the number of branch circuits which were simultaneously switched into use, reaching its maximum loading when all the branch circuits are in use simultaneously. The loading of the branch circuits would also vary to a negligible extent according to the number which are in use simultaneously.

Compound circuits could also be built up with conductors of different sectional areas and/or different specific resistances, and wherein the conductors of the various circuits have a dif-

ferent heating effect (wattage per unit length).

The loading of the conductors can be increased in known manner by means of a step-up transformer or alternatively suitable switching provision can be made to accomplish this.

In the event of a transformer being employed this can also be used to reduce the loading of the conductors during mild weather by stepping down the voltage, alternatively the loading may be reduced by suitable switching provision. Under these conditions the loading of the conductors would be variable and could be arranged to conform with the actual heating requirements with the advantage that extensively distributed gentle radiant heat at the appropriate temperature could be almost constantly in use thus providing the perfect degree of continuous gently radiant heat-comfort which is so highly desirable and beneficial during the winter months.

As an alternative to producing the above desirable heating conditions by varying the loading of the conductors, the present system also lends itself to producing a similar result with a fixed conductor loading by the provision of two or more circuits in any room or other place, each separately controlled and distributed at alternative spacings over the whole area to which the heating is applied. Under these circumstances the heating installed will require to be sufficient for the maximum winter requirements which are approximately 50 per cent greater than the normal winter requirements. In cases where the heating is intermittent this arrangement would have the advantage of a quicker operation.

While, as above stated, the temperature rise of three .029" insulated and protected cables when stretched in air is approximately 25° F. when such cables are installed within casings or containers composed of or wholly or partly covered with a good heat conducting material such as metal, the temperature rise of the insulated cables where in heat conductive contact with said material is considerably reduced due to the heat conductive effect of the metal container and/or cover, so that the actual temperature of the insulated cables when installed in certain forms of container is considerably below the temperature of said cables when stretched in air and the heating is consequently effected at a lower temperature as the heat diffusion is more rapid.

The invention will be more fully described with reference to the accompanying drawings in which:—

Fig. 1 is a wiring diagram for an electric heating installation in accordance with the invention for a typical building;

Fig. 2 is a wiring diagram for a heating installation for the same building modified for a different rating;

Figs. 3, 4 and 5 illustrate one manner of applying the electric heating installation;

Fig. 3 shows a plan view of the cover; Fig. 4 a plan view of the base; and Fig. 5 is a section on the line V—V of Fig. 4;

Figs. 6, 7 and 8 are views respectively of a modified container, Fig. 7 being a section on the line VII—VII of Fig. 6 and Fig. 8 a section on the line VIII—VIII of Fig. 6;

Fig. 9 is a transverse section of a further modification;

Figs. 10 and 11 show a further form of container, Fig. 10 being a plan of the base with the cover removed and Fig. 11 a section on the line XI—XI of Fig. 10.

Fig. 12 is a transverse section of a modified casing;

Fig. 13 is a transverse section of a slightly different form of casing;

Figs. 14–17 show a form of container adapted to hold flat or ribbon like insulated conductors, Figs. 14 and 15 being a plan and transverse section of the cover element; Fig. 16 being a plan view of the base with the cover removed; and Fig. 17 a transverse section on the line XVII—XVII of Fig. 16 with the cover in position;

Fig. 18 is a transverse section of a somewhat modified arrangement of container.

The distribution board 10 is assumed to be in the basement directly below the position indicated on Figure 1 and is connected up to the source of supply with a pair of main copper conductors each 10 feet long.

The heat requirements are assumed to be approximately $\frac{1}{2}$ watt per cubic foot calculated upon the total cubic content of each room and the corridor.

The conductors are all assumed to be three .029" of various metals or alloys insulated with rubber compound and protected with tape, tape and braiding or other forms of suitable insulation and protection such as additional thickness of rubber compound, cab tyre sheathing and the like and calculated to operate at a loading of 1 watt per foot run of conductor when connected to a source of supply which is at a potential of 200 volts.

The main conductors are assumed to be seven .064" copper similarly insulated and protected.

The insulated cables within the rooms and in the corridor are assumed to be installed in suitable containers or casings as more fully described which, when applied upon any or all of the ordinary finished internal surfaces of the rooms and the corridor, enable considerable lengths of insulated conductor to be quickly and cheaply installed and which, when completely assembled, form the finished surface of the ceiling, wall, floor, or other part and entirely conceal the cables. The casings also provide a heat screen between the building structure and the interior, absorb the heat of the cables, and re-radiate the same. The cables where passing between rooms or into the corridor to switch and/or thermostat positions and to the distribution board in the basement and/or any position where containers are not provided, would be installed in known manner in conduits or otherwise.

The general method of application of the heating installation would be to distribute the cables within containers applied over the entire ceiling areas of the rooms or places to be heated. Thus, in the case of a building similar to that indicated in Figure 1, the cubic content of which is assumed to be 22,200 cubic feet, if the height of the rooms is 10 feet, the superficial area of the ceilings would be approximately 2,200 square feet. The total length of the insulated cable in accordance with the details of Table No. 3 is calculated as 11,878 feet rated at 1 watt per foot run and the total loading is therefore 11,878 kilowatts. 11,878 feet of cable if evenly spaced over an area of 2,200 square feet would provide an average of approximately 5.35 feet of cable and a loading of 5.35 watts per square foot of surface area, thus providing an exceptionally large area of low temperature radiant heat. Furthermore in cases where the heating medium is entirely confined to the ceilings there is a maximum of radiant heat and a minimum of convected heat and as

radiant heat is altogether more effective than convected heat, for producing a condition of heat-comfort, this method of application is highly desirable.

- Although the general method of application would be upon the ceilings, the heating medium may in addition be extended over other surfaces or it may be applied entirely upon other surfaces. For example, if the insulated heating conductors and containers were distributed over all the ceilings and also the friezes around the rooms in the building indicated in Figure 1, the result would be that the loading per square foot of surface area would be reduced to considerably less than 5.35 watts per square foot of surface area. If extended over all the ceilings, walls, and floors, the loading would be correspondingly further reduced. Certain of the containers may be arranged to form panels or mouldings upon walls, ceilings, or other surfaces.

- In place of applying the insulated cables in containers upon the internal surfaces, they may be embedded in the ordinary plaster or other finished surfaces, or be fixed behind woodwork, panelling or tiling, or be fixed within cavities, between ceilings, and floors, above ceilings, under floors and in partition walls as due to the low temperature at which the cables are operated and

Referring to Figure 1, it will be seen that there are five circuits each connected to the distribution board 10. Circuit No. 1 includes the heating cable for rooms A and B, the respective parts of the circuit being denoted by 1a, 1b, 1c. The latter part 1c comprises the leads passing through room B and therefor assisting in heating the same which supply current to 1a and 1b. In the same way circuit No. 2 includes the heating cable for rooms C, D and E and their supply leads from the distribution board denoted respectively by 2a, 2b, 2c, 2d, 2e. Circuit No. 3 comprises the heating cable for rooms F, G, and H and their connecting leads denoted by 3a, 3b, 3c, etc. Circuits 4 and 5 are simple circuits. Switches and/or thermostats may be introduced at the points marked X.

Table No. 3 gives the installation details relating to Fig. 1, the specified length of insulated cable within the rooms and the corridor being represented by continuous lines.

In the particular application illustrated only one heating circuit is provided within each room. In alternative application the installation could be suitably designed to provide two or more separately controlled circuits in each room; the heat provided could be greater or less than $\frac{1}{2}$ watt per cubic foot of content.

TABLE No. 3

Installation details relating to Figure 1

Ratings

- Heat Conductor loading..... Approximately $\frac{1}{2}$ watt per cubic foot of content
Approximately 1 watt per foot run

General

- Distribution board assumed to be in basement and connected up to the source of supply with a pair of copper conductors each 10 feet long.
Supply voltage..... 200 volts

Position	Cubic-foot content	Circuit No.	Type of conductor	Ohms.	Size	Length in room	Length in corridor	Length in basement	Watts in room	Watts in corridor	Watts in basement
Room A.....	4000	1	Aluminium	17.22	Three, .029"	2152			2152		
Room B.....	1500	1	Grade 1.....	55.06	do.....	697					
			1.....	.42	do.....	20	50	30	717		
Room C.....	1000	2	Ferry.....	67.89	do.....	552			552		
Room E.....	900	2	Glowray.....	89.97	do.....	332			332		
Room D.....	2500	2	Nickel.....	30.86	do.....	1220					
		2	Glowray.....	10.84	do.....	40					
Room F.....	600	2	Aluminium.....	.56	do.....	20					
Room G.....	2500	3	Glowray.....	83.73	do.....	309	20	30	1280		
		3	Nickel.....	29.02	do.....	1147			309		
		3	Glowray.....	10.84	do.....	40					
Room H.....	1500	3	Aluminium.....	.16	do.....	20			1207		
		3	Grade 1.....	51.90	do.....	657					
Room I.....	5000	3	Aluminium.....	1.44	do.....	40	110	30	697		
Corridor J.....	3000	4	Copper.....	12.94	do.....	3012	40	30	3012		
Basement mains.....		5	Nickel.....	31.87	do.....		1230	30		1450	
			Copper.....		Seven, .064"			20			170
	22,200 cubic feet					10,258 1450 170	1450	170	10,258 1450 170	1450	170
						11,878 feet 3959 yards.			11,878 kilowatts.		

- the extensive areas over which they are distributed, the transmission of the heat can be effected through all such surfaces without undue increase in the temperature of the insulated cables and without any detrimental effect to the structure. In cases where cables are installed above ceilings, under floors or in other such positions, double boarding or insulating materials may be employed to confine the heat as far as possible to the rooms or places for which the heat is provided. Owing to the great flexibility of the system the methods of application are almost without limit.

Figure 2 is a wiring diagram illustrating an alternative form of application of the electric heating installation to the same typical building illustrated in Figure 1 and Table No. 4 gives the installation details relating to Figure 2.

In Figure 2 the conductor loading is assumed to be $\frac{1}{2}$ watt per foot run of cable in place of 1 watt per foot run as illustrated in Figure 1. In all other respects the information given in relation to Figure 1 is also applicable to Figure 2, the various component parts of the circuits being denoted in the same manner.

TABLE No. 4

Installation details relating to Figure 2

Ratings

Approximately $\frac{1}{4}$ watt per cubic foot of content 5
Approximately $\frac{1}{2}$ watt per foot run

General

Distribution board assumed to be in basement and connected up to the source of supply with a pair of copper conductors each 10 feet long.
Supply voltage..... 200 voltsSwitch and/or thermostat 10
X.....

Position	Cubic-foot content	Circuit	Type of conductor	Ohms.	Size	Length in room	Length in corridor	Length in basement	Watts in room	Watts in corridor	Watts in basement
Room A.....	4000	1	Copper.....	18.18	Three .029"	4208	91	30	2104		
Room B.....	1800	2	Manganic.....	35.82	do.....	1326	60	30	683		
Room C.....	1000	3	Grade 1.....	77.89	do.....	966			493		
Room D.....	2500	3	Aluminium.....	24.86	do.....	3108					
		3	Copper.....	.37	do.....	40	20	30	1874		
Room E.....	600	4	Dullray.....	135.3	do.....	526	40	30	263		
Room G.....	2500	4	Aluminium.....	25.40	do.....	3024	121	30			
		6	Dullray.....	6.81	do.....	30			1527		
Room F.....	600	6	Dullray.....	114.4	do.....	604			252		
Room H.....	1800	6	Manganic.....	52.16	do.....	1304					
		6	Dullray.....	6.81	do.....	30			685		
Room I.....	5000	6	Ferry.....	94.71	do.....	770					
		6	Aluminium.....	1.36	do.....	40	100	30			
		7	Copper.....	18.18	do.....	4258	41	30	2534		
Room J.....	3000	8	Aluminium.....	25.40	do.....		3145	30		1809	
Basement mains..					Nineteen .52"			20			130
	22,200 cubic feet					20,190	3618	260	10,095	1809	130
						3618			1309		
						260			130		
						24,068 feet.			12,024 kilowatts.		
						8023 yards					

Figs. 3, 4 and 5 illustrate a form of container for enclosing and concealing considerable lengths of insulated conductors. The container may be in sheet zinc, aluminium or other suitable material. Cover 11, Figure 3 is provided with clips 12 cut in the material for holding the cover in position. Figure 4 illustrates the base 13 which is provided with embossed raised circular discs 14 formed with square openings 15 in the top suitable to receive the clips 12. Discs 14 also space the cover from the base. Clips 16 and 17 are stamped out in the base and hold insulated conductors 18 to the base member.

The base 13 is fixed to the ceiling, wall or other surface 19 and the cover is secured to the base by clips 12 turned back within discs 14. The covers may then be covered with wall paper or other decorative finish.

Figs. 6, 7 and 8 illustrate another form of container of built up construction the base member 20 being of perforated sheet zinc, or of other suitable material. Discs 21 and 22 of wood or other material are attached to the base 20. Discs 21 are thicker than discs 22 so that when thin washers 23 of fibre or other material are attached to discs 22, the washers lie at about the same level as discs 21. The insulated cable 24 is secured in position by washers 23.

The base 13 is fixed to the ceiling, wall or other surface 25 and the cover 26 which may also be of sheet zinc or other material is fixed to discs 21. The cover may then be papered or dis-tempered or otherwise treated.

It will be appreciated that certain of the features of Figs. 3-5 may be combined with certain features of Figs. 6-8, for example as shown in Fig. 9 wherein a base 27 provided with embossed part conical projections 28 as in Figs. 3-5 receives the insulated cables 29 which are held in position by washers 30 secured to the hollow projections by clips 31 in the same manner as cover 11 was secured by clips 12. A cover 32 is also

attached by clips 33 to higher standing projections 34.

Figs. 10 and 11 show another form of container in which the ceiling, wall, or other surface is utilized as the base member.

In Fig. 10, 35 denotes the base formed by the ceiling, wall or other surface to which spacing strips 36 of wood or other suitable material are attached. To the base 35 are also secured grooved discs 38 of insulating material suitable for receiving the cables 37.

The assembly of the wood strips takes place after the cables are laid in position against the discs and the whole container is then covered over with a perforated metal cover 39.

In Fig. 12 the base member 40 consists of wall boarding such as asbestos composition, wood fibre, etc., having moulded or otherwise provided in the material, circular raised discs 41, and 42. The discs 41 are of less depth than discs 42 to accommodate holding plates 43 of thin fibre or other material for holding cables 44 in position. The base member 40 is secured to the wall, ceiling or the like 45 and a cover 46 which may be of perforated zinc or sheet zinc or other material is secured to the raised discs 42.

This form of container may have the base member 40 of any thickness and in addition to being a container for the heating cables may also act as a substitute for the usual lath and plaster or other ceiling and wall surfaces. Furthermore, this form of container provides useful insulation between rooms in buildings and also when attached to outside walls increases the insulation of the structure.

Fig. 13 is identical with Fig. 12 excepting that the moulded discs 41 and 42 are omitted and wood or other discs 47 and 48 are attached to a plain baseboard 49.

In the above mentioned types of container circular discs may be provided at the ends of long sheets of container base material to enable a number of circuits of cables to be diverted at right

angles into other channels within said containers, but as such diversion is necessary only at the ends of the containers the circular discs may be omitted from the remainder of the base member and strips of wood or other suitable material may be substituted in the zones intermediate the ends. The heating cables are preferably secured in position by flat washers mounted on some of the circular discs.

- 10 Figs. 14-18 illustrate the method of application preferably adopted when insulated conductors of ribbon, tape, foil or separate wire strand conductors are employed and made up in flat formation in the forms indicated at 50, 51 and 52. Such ribbon like insulated conductors may be externally coated with an adhesive material so that they can readily be attached to base surfaces such as ceilings, walls and the like and can then be securely held in position with suitable covers of sheet metal, wall-paper or other material.

In Figs. 16-18 53 represents the ceiling, wall, or other surface to which heating cables 50, 51 or 52 are attached for example by adhesive.

- 25 One form of cover 54 of sheet metal is shown in Figs. 14 and 15 in which embossed or countersunk depressions 55 are formed so as to space the cover from the ceiling, wall, or other surface and also to serve as fixing holes for securing the covers. If desired, an additional covering such as ceiling paper 56 may be provided.

- 30 In Fig. 18 ribbon like cables 52 are covered with a suitable flock or other thick paper or other material 57 which is secured to the ceiling, wall, or the like in the usual manner with paste or fixing solution 58, the whole being rolled to a flat surface into which the cables 52 become embedded. The conductors 52 are in this case shown as separate wire strands, in ribbon like insulation.

- 35 In the specification and claims the term "source of supply" is to be taken to include any of the following.

- 40 (a) The ends of the electric conductors situate upon any consumers' premises at which the supply of energy is delivered to the premises from the generating system.

- 45 (b) Any distribution board arranged on the premises for distribution to, protection and control of final sub-circuits fed from a main or branch circuit.

- 50 (c) The points of the electric conductors at which a supply voltage is made available for use at any part of the consumers' premises.

- 55 Although the invention has been stated to include the provision of circuits of insulated cables from a source of supply and back thereto without the interposition of any further heating media, there may be provided in the circuits, control switches, fuses, indicating devices such as lamps constructed for series connection, imitation fire effects, thermostats or other devices. Furthermore, in the event of the heating cable circuits passing underground or overhead or in any other case where heat is undesirable, the heating effect may be reduced to a minimum at such points by employing conductors of lower specific resistance and/or larger sectional area.

- 60 In the event of heating circuits being connected to distribution boards which also supply lamps or other current consuming devices, the feeders to such distribution boards will require to be of suitable section to carry the total load without fall in pressure below that which is prescribed in the usual regulations.

- 65 Certain of the surfaces of the containers may be coated with metal paint or metal foil to in-

crease the heat conductivity and improve the heat diffusion, also the covers may be embossed to increase the diffusion surfaces or to give direction to the heat rays. In cases where containers are applied to all the wall, ceiling and floor surfaces of a room, it is equivalent to inserting a heat screen within the interior which entirely isolates the cold building structure which it is impracticable to heat quickly. The consequence of this is that owing to the surface of the containers heating up much more rapidly than the solid structure could possibly be heated up, it is possible with this method of heating to quickly produce comfortable warmth within the interior. Proportionate results are obtainable according to the area over which the heating is spread.

The containers may also be employed for installing the whole of the small conductors used for the lighting power, telephones, bells, and all other electrical services and thus considerably reduce the cost of such services.

In cases where the heating cables are run within cavities and spaces the insulated and protected conductors may be suitably disposed within the spaces without any further enclosure or they may be inserted in containers, envelopes, or other suitable enclosures. They may either be supported clear of the structure or may be arranged in contact with the same. Covers or divisions of insulating materials may be employed to separate the circuits in cases where for example the cavity between the ceiling of a ground floor room and the floor of a first floor room is utilized for heating the two rooms.

The heating cable circuits would generally be so arranged that each room or place could be separately controlled within the room or place.

It will be recognized that in the practical application of the invention various methods or arrangements other than those above mentioned may be adopted, the exact form of conductor employed, the manner of its insulation the form of container or protector if such is required and so forth depending upon the requirements of and the circumstances obtaining in, in any particular case.

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

1. An electrical heating arrangement for building interiors and the like, comprising heat distributing covered containers arranged on ceilings, walls and other structural parts and having exposed therein, as continuous insulated conductors without being imbedded or provided with insulating media other than the cable dielectric, insulated cables electrically charged with current in the proportions of not more than three watts per foot run to a conductor of 0.001 square inch section, the covers of said containers providing a heat screen between the structural parts and the building interior.

2. An electrical heating arrangement according to claim 1, wherein over the selected part of the interior to be heated the cover of the container forms part of the inner surface thereof.

3. In a panel heater a metal container comprising a base plate having a plurality of apertures therein bordered by inturned lip portions, insulated electrical cable wound about said lip portions, and a cover plate over said base plate and having inturned attaching lips engaged with certain of said base plate lip portions to interlock said base and cover.

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