July 24, 1962 G. E. ZIEGLER 3,045,708

HEAT DISTRIBUTION SYSTEM AND METHOD OF MAKING SAME

Filed Jan. 12, 1959 3 Sheets-Sheet 1

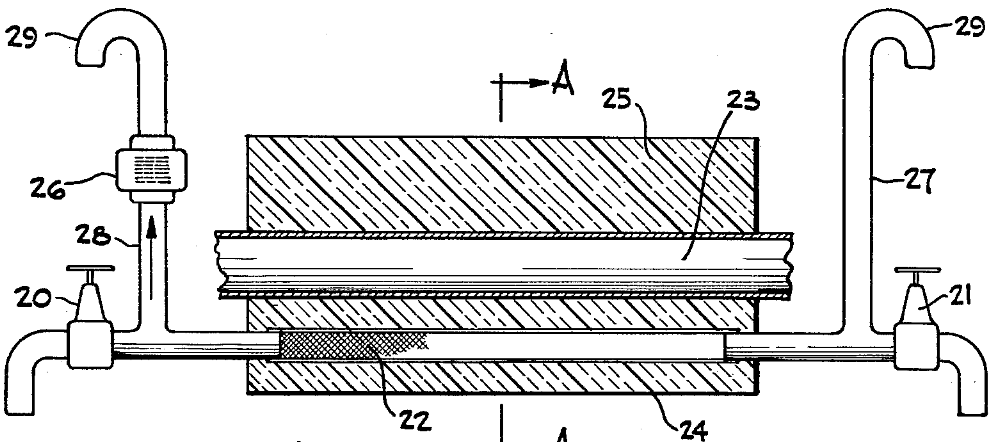

FIG. 1

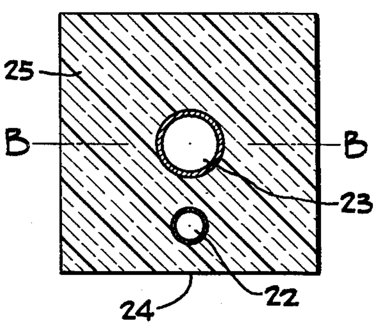

FIG. 2

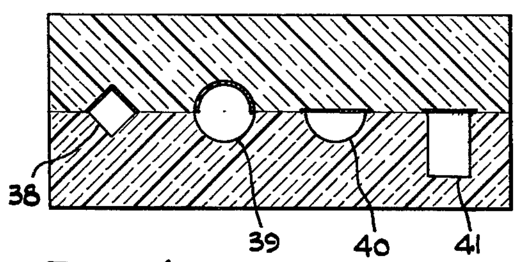

FIG. 4

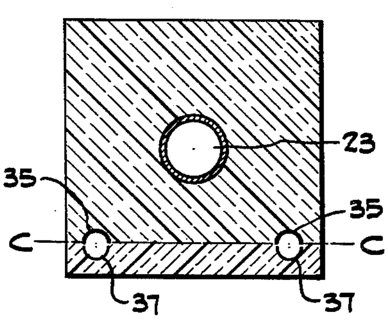

FIG. 3

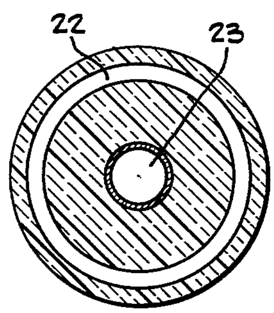

FIG. 5

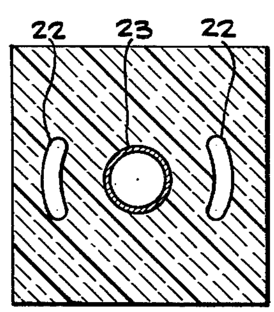

FIG. 6

GEORGE E. ZIEGLER
INVENTOR.

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FIG. 7

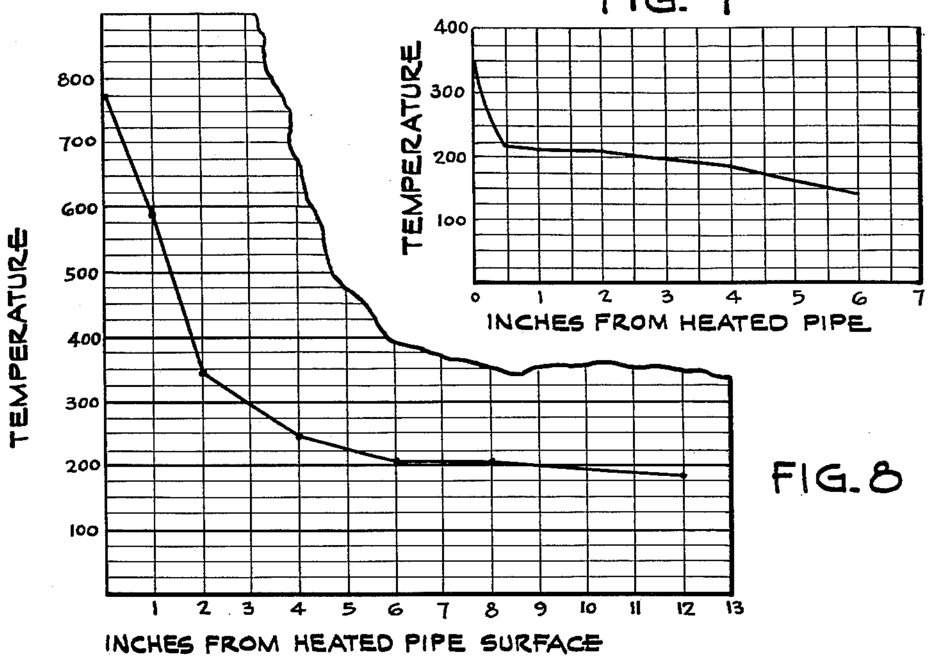

FIG. 8

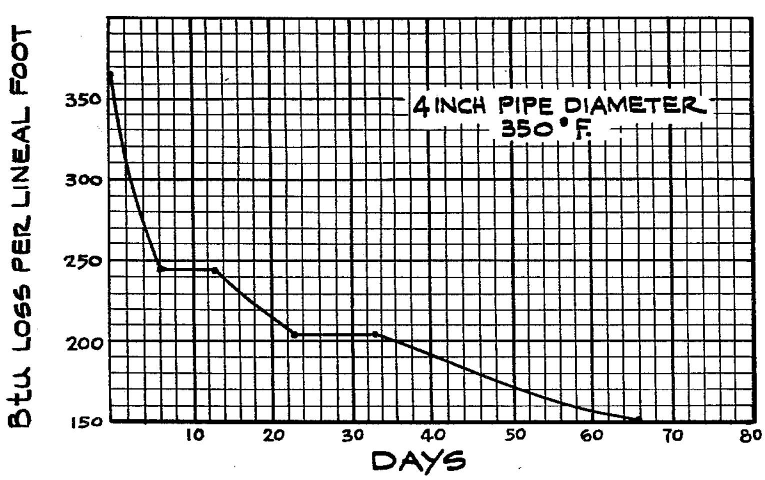

FIG. 9

GEORGE E. ZIEGLER
INVENTOR.

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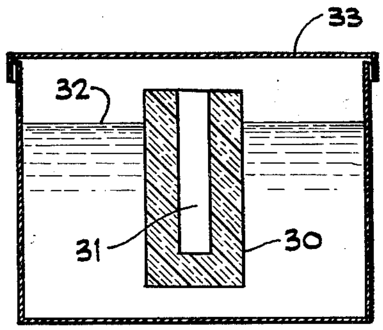

FIG. 10

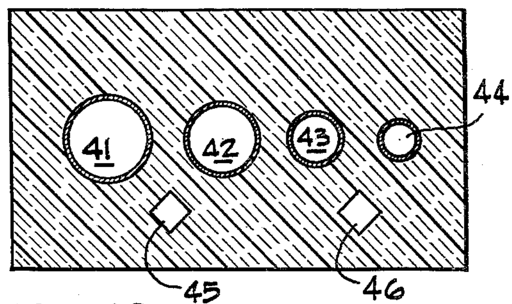

FIG. 12

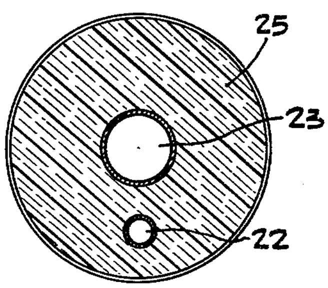

FIG. 11

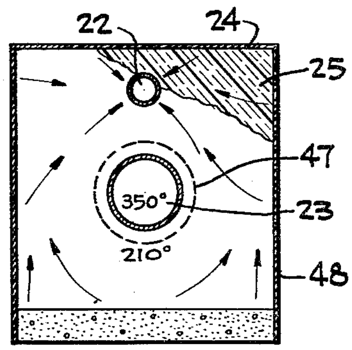

FIG. 13

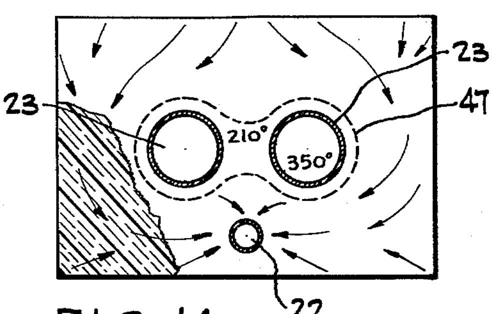

FIG. 14

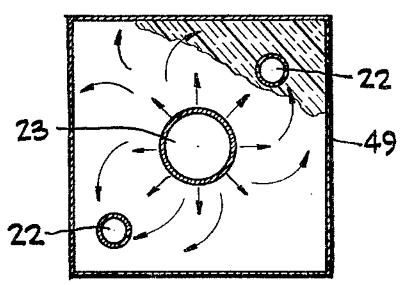

FIG. 15

GEORGE E. ZIEGLER
INVENTOR.

United States Patent Office

3,045,708

Patented July 24, 1962

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3,045,708
HEAT DISTRIBUTION SYSTEM AND METHOD OF MAKING SAME

George E. Ziegler, Evanston, Ill., assignor, by mesne assignments, to Concrete Thermal Casings, Inc., Seattle, Wash., a corporation of Washington

Filed Jan. 12, 1959, Ser. No. 786,169
5 Claims. (Cl. 138—106)

The present invention relates to improved heat distribution systems and more particularly to systems having increased resistance to deterioration by water and a method for producing same.

Heat distribution systems usually consist of one or more heated fluid-carrying pipes surrounded by suitable thermal insulation. My present invention is applicable to underground systems in which the pipe and insulation are buried in the ground, and to overhead systems in which the pipe and insulation are supported in air by suitable structures either above grade or in tunnels. In both classes of systems it has been customary to protect the insulation from infiltration of water from the ground and from rain by surrounding the insulation with a casing which may be metallic or nonmetallic. The heated fluids most commonly encountered are hot water, steam, high temperature (high pressure) hot water and heated oils.

In the past, efforts have been made to improve the water migration resistance of the thermal insulation and to devise watertight casings; nevertheless, a recent authoritative engineering study reports that in heat distribution systems now in operation, water is the major adverse factor encountered and that all systems eventually become wet. Water enters the distribution systems from internal pipe breaks, from infiltration from the ground, from flooded manholes, or from rain leaking through the casings, depending on the class of the system.

My invention is applicable to field-fabricated poured-in-place heat distribution systems. These include systems of the Goff type, Patent Number 2,355,966, in which the pipes are supported by the insulating concrete, as well as systems in which the pipes are supported on conventional guides, rollers or rockers, and the insulation consisting of insulating concrete or bituminous material which is fused or solidified by heat serve only thermal purposes.

My invention is also applicable to heat distribution systems utilizing preformed or sectional insulation placed on pipes supported on conventional supports and guides and installed in tunnels or above grade.

Heat distribution systems require protection from two types of difficulty with water. The first of these difficulties is the occasional flooding of the insulation from major breaks in the fluid distribution pipes, from unusual ground water flooding, from back pressure of water through the insulation caused by flooded manholes or from severe rains.

In this flooded condition the system can not be satisfactorily operated because of attendant violet boiling action within this insulation. This boiling action is disastrous to the physical structure of the insulation as well as prohibitively expensive as far as heat loss is concerned. The boiling action can also result in pipe corrosion.

The second difficulty is much less obvious than the flooded state with its boiling action. However, it is equally serious especially since the condition is apt to prevail during the entire operating life of the heat distribution system. This second difficulty is the more or less permanent reduction in insulation performance caused by the presence of moisture in the insulation. It is well known that the insulating values of all materials diminish rapidly with increasing moisture content. A one percent increase in moisture content will result in from two to four percent increase in thermal conductivity, with a corresponding loss

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in insulation. Thus a modest amount of residual moisture can cause a significant fuel dollar loss over a period of years.

It is therefore a first and principal object of my invention to protect heat distribution systems from water deterioration by continuously removing water and water vapor from the system at a rate approaching or even exceeding the average rate at which water enters the system.

A further and principal object of my invention is to make it possible to operate heat distribution systems with improved thermal performance without the use of protective casings surrounding the insulation.

A further object of my invention is to make possible the economical operation of heat distribution systems with semi-permeable casings surrounding the insulation.

Another object is to remove water from the thermal insulation by direct drainage.

Another objective is to remove water vapor from the thermal insulation by evaporation.

Another object is to minimize the entry of water by infiltration from flooded ground or from rain in the case of overhead systems.

A further objective is to provide a path of maximum resistance to the flow of water through the insulation.

A still further objective is to provide pipe support when such support is needed as well as providing for such requirements as thermal insulation, the inhibiting of corrosion of the pipes and associated metal supports, and in the case of underground systems, to protect the pipes from mechanical forces transmitted through the earth.

Many and further objects of the invention as well as advantages and features thereof will be apparent from the discussion of the invention which follows, and it will be understood moreover, in said discussion which more specifically describes the invention, that the same is not to be taken in a limiting sense but merely as illustrative of the invention the metes and bounds of what is to be considered patentable therein being defined by the appended claims.

A fuller understanding of the invention may be had by referring to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 shows a longitudinal cross section of a short length of heat distribution system with evaporation and drainage channel.

FIGURE 2 is a cross sectional view taken along the line A—A of FIGURE 1.

FIGURE 3 is a cross sectional view of a heat distribution system with multiple evaporation channels.

FIGURE 4 illustrates cross sections of four shapes for evaporative channels.

FIGURE 5 shows a concentric channel for the vaporization of water.

FIGURE 6 shows a modified concentric channel for the vaporization of water.

FIGURE 7 is a graph of insulation temperature as a function of distance from the surface of a 350° F. heated pipe.

FIGURE 8 is a graph of insulation temperature as a function of distance from the surface of a 750° F. heated pipe.

FIGURE 9 is a graph of thermal loss of heat distribution system.

FIGURE 10 is apparatus for measuring water migration resistance of insulation.

FIGURE 11 is a cross section of sectional preformed insulation equipped with evaporative channel.

FIGURE 12 shows a multiple pipe system with multiple evaporative channels.

FIGURE 13 shows water migration paths and isothermal curve in a heat distribution system with casing and evaporative channel.

FIGURE 14 shows isothermal curve and water migration paths for a multiple pipe system.

FIGURE 15 shows water migration paths for water from break in pipe.

The general aspects of the operation of my invention can be most easily understood by considering it in relation to past practices. In the past, attempts have been made to minimize the entry of water into the heat distribution system through the use of an external casing to keep out the water, and by waterproofing admixes added to the insulation to reduce the rate of migration of any water which might accidentally enter through the casings or come from breaks in the heat distribution pipes. Since the casings surround the insulation and are essentially continuous and relatively impervious to water vapor, no appreciable evaporation of water can take place. In fact, water accumulated in the insulation because the quantity of water as liquid that was drawn into the insulation by temperature changes through accidental openings in the casing in a given length of time is larger than the amount of water that can leave as vapor through the same opening in an equal time. In sharp contrast to this situation, my invention makes it possible to shift at will the balance between water intake and water vapor outgo so that the system on the average over an extended period of time will dry out instead of accumulating water.

In addition to providing for the evaporation of water, my invention provides for the drainage of excess or flood water from the insulation.

In the past it has not been possible to use insulation without casings in systems exposed to the weather above grade or buried underground systems because the moisture content of the insulation increased too rapidly to constitute a satisfactory system. My invention causes the removal of water vapor to be rapid enough so that the moisture content of the insulation will not build up to an objectionable level, thus making it possible to operate systems constructed without casings.

This invention represents an improvement over the pipe insulation systems broadly disclosed and claimed in the applications of Lincoln L. Loper, Jr., Serial Nos. 689,584 now abandoned and 9,036.

My invention introduces the idea of controlled rate of evaporation by placing an evaporation channel at a location in the body of the insulation where the temperature will be appropriate to produce a rate of evaporation greater than the rate at which water can enter the insulation either from small leaks in the heated fluid pipe or from infiltration from outside the system or both together. Details of this will be presented through the specific examples of my invention.

It should be pointed out that a small thermal loss is caused by the evaporation of the water from the insulation and from the warming of the air which circulates to remove the water vapor. This loss however is negligible compared to the relatively large thermal conductivity loss that can take place from the heated pipe to the surrounding ground or air if the insulation does not remain dry.

With reference to FIGURES 1, 2, 11 and 13, the evaporation channel which is a principal feature of my invention is identified by the reference character **22**, and is shown located within the insulation **25**, between the heated fluid conducting pipe **23** and the outer boundary of the insulation **24**. Other examples are identified and discussed in connection with other figures.

The present invention corrects the difficulties caused by accidental flooding of the insulation by permitting the insulation to be drained by the drain cocks **20** and **21** of FIGURE 1. The drain cocks **20** and **21** in actual practice might be replaced by any type of trap or sump with automatic pump depending on the type of service.

Although engineers would intuitively place at least one of the channels such as **22** in the lower part of the insulation, I have found that satisfactory flood drainage takes place for any location within the insulation, because in general the possible difference in level of the channel **22** inside the insulation is small compared to the normal variations in elevation introduced along a run of pipe in the average distribution system. The variation in elevation is needed to provide for internal drainage of the heated fluid distribution pipes or to take care of variations in terrain.

Even after flood water has been drained off through cocks **21**, the moisture content of the insulation remains high enough to cause excessively high heat losses. In my invention as illustrated by FIGURE 1, this moisture is evaporated from the insulation into channel **22** and removed from the channel by air which circulates either as natural draft resulting from a thermal syphon action in the vertical vents **27** and **28** or by induced draft from a fan **26**. The intake pipe **27** and the exhaust pipe **28** are protected from the entry of rain by any conventional type hood of which the inverted U **29** is one example.

The channel 22 may communicate at its ends to free or open air or it can open into ventilated manholes or basements. For long runs of pipe a multiplicity of outlets and inlets can be used as a means of increasing the rate of evaporation. These are design variations which all come within the scope of my invention.

In general the rate of evaporation of water from the insulation into the channel **22** is dependent on the average temperature and the percentage of moisture content of the insulation surrounding the channel.

FIGURES 7 and 8 show typical temperature gradients through insulations containing moisture for a direction B—B of FIGURE 2, with distances measured out from the surface of the insulation for a section of insulation as shown in FIGURE 2 for two different pipe temperatures and two different insulation thicknesses.

The moisture level in the insulation depends on a number of factors. An important factor is the resistance of the insulation to the flow of water. The resistance of flow or migration is different from capillary absorption into dry material which is often erroneously measured to give an indication of permeability of water soaked materials. With increasing resistance, the rate at which water is added to any section of the insulation becomes smaller and it is easier to overbalance the water intake with the evaporation or vapor outgo.

Water migration resistance can be measured with the apparatus shown in cross section in FIGURE 10 in which a six inch diameter, twelve inch high cylinder **30**, of the insulation provided with a cylindrical cavity two inches in diameter and eight inches deep, is immersed ten inches in water **32** contained in a closed vessel **33**. The resistance can be measured in terms of water flowing into the cavity **31** and then expressed as volume of water per unit of time per square inch of cross section of insulation.

In specific examples of my invention to be discussed later, insulation will be characterized as being of low resistance if an appreciable amount of water accumulates in the cavity in less than one hour. Insulations will be characterized as being of intermediate resistance if it requires a day to a week for any appreciable amount of water to accumulate in the cavity **31**. High resistance insulation is characterized by the fact that no appreciable moisture accumulates in the cavity **31** even after two weeks under test. It should be pointed out that even with high resistance insulation, the surface of the cavity will be sensibly damp because no evaporation takes place from the surface of the cavity because the air in the closed vessel **33** and in the cavity **31** has a relative humidity at or near 100% saturation.

Even though insulation has high resistance to the migration of liquid water, it usually has sufficient water vapor permeability so that any location in a body of insulation can gradually dry if a means is provided for removing water vapor more rapidly than water enters as liquid or vapor.

The moisture level in the insulation is also a function of the temperature. If the heated fluid conducting pipe 23 has a temperature above the boiling point of water at atmospheric pressure, then the insulation between the surface of the pipe 23 and the place in the insulation where the temperature is equal to that of boiling water will be essentially oven dry. Any free moisture in this zone of the insulation will be driven by the thermal gradient to the place where the temperature is below the boiling point of water.

The temperature gradient for a four inch diameter pipe operating at 350° F. surrounded by six inches of insulation of the configuration shown in FIGURE 2 is given in FIGURE 7 which is a plot of temperature in degrees F. vs. distance from the pipe surface in inches.

The temperature gradient for a similar eight inch diameter pipe operating at 750° F. and surrounded by twelve inches of insulation is given in FIGURE 8.

In the preferred forms of the present invention, the channel or vent passage 22 is located at a point intermediate the outside surface of the insulation and the point within the insulation where the temperature is at the temperature of boiling water. This region has been referred to as the outer zone in the succeeding discussion, and the inner zone referred to subsequently extends from the outer surface of the pipe 23 to the aforementioned point in the insulation where the temperature is that of boiling water. Within the outer zone as defined above, the preferred location for the vent passage for steam carrying systems will normally be in the range from 0.3 to 0.9 times the distance from the outermost pipe surface to the outermost boundary of the insulation.

More specifically, with steam carrying pipes operating at quite high temperatures (as exemplified in FIGURE 8) a convenient location for the channel 22 is at the area where the temperature is about 210° F. For lower temperature work, it may be located at an area having a temperature of about 170° F.

In the insulated pipe system for which the temperature gradient is given in FIGURE 7, the inner zone is approximately the first two inches going out from the pipe. The outer zone is from this two inch position out to the surface of the six inch thick insulation. In the example of FIGURE 8 the inner zone is approximately the first seven inches out from the surface of the pipe. The outer zone is from seven inches out to the surface of the twelve inch thick insulation. The exact location of the 210° F. zone in any given system will be a function of the moisture content of the system. More precisely the 210° F. zone is defined as the 210° F. isothermal surface within the insulation and its shape depends on the exterior shape of the insulation and the size and configurations of the heated pipes. This isothermal is illustrated in FIGURES 13 and 14 by the dotted line 47.

As the insulation dries out the 210° F. zone moves outward and becomes narrower. The width of the 210° F. zone is illustrated in FIGURES 7 and 8 by the essentially horizontal part of the curve at approximately 210° F. At final dryness it will be quite narrow and occupy a position proportionally located between the temperature of the pipe 23 and the temperature of the outer surface of the insulation. As an average for 350° F. heated fluid systems the inner zone or above 210° F. zone occupies approximately the first one-third to one-half of the distance out from the surface of the pipe 23. The outer zone constitutes the remaining distance out.

The moisture content of the insulation in the inner zone is negligible because any free moisture present would boil off or migrate to the cooler outer zone of the insulation where it condenses.

Thus the channel 22 when located in the inner zone receives only the limited amounts of water that can diffuse from the outer zone back into the channel 22. Also the temperature losses due to circulating air are larger than if the channel 22 were at a cooler location in the outer zone.

The most desirable location within the insulation for the evaporation channel 22 can be determined on the basis of the following considerations.

If the insulation has high resistance to the migration of water, then channel 22 can be placed far out in the outer zone where the temperature will be a minimum. This location reduces thermal losses by the air currents flowing through the channel.

If the resistance to migration of water is intermediate, then the channel 22 must be placed near the 210° F. zone to achieve maximum temperature for the consequent more rapid evaporation. With insulation of low water migration resistance, it will not be possible to evaporate water as fast as it can run into 22. In this case channel 22 would merely serve as a drain through the drain cocks 20 and 21, unless a casing is used to keep out the bulk of the water, in which case my invention can function with low resistance insulation.

The migration of water through the insulating concrete constituting an underground heating distribution conduit can be viewed analogously to the flow of electricity through a shaped conductor.

The resistance of the insulating concrete to the migration of the water is equivalent to the electric or ohmic resistance. The system can be considered to be a balanced circuit in which the water entering and passing through the solid portion of the concrete is equal to the vapor evaporation. The water movement from the external surface to the air space, is dependent in part on the total resistance. If the resistivity of the solid part of the system is relatively high, a tolerable flow of water can be obtained without casings or with a relatively low resistance coating or casing. For example, a wash of Portland cement base waterproofing paint can be used as a casing. Numerous varieties of such waterproofing paint are commercially available as cement paint to waterproof cement blocks and basement walls. If desired, an additional layer of water resistance can be added by applying over cement paint a bituminous mopping. Sufficient resistance can also be obtained with the bituminous coating alone, i.e., a water emulsion type asphalt coating can be placed on the outer surface of the insulation.

If the air current circulation through the duct is small, then the total resistivity must be relatively large. However, if a reasonable quantity of moisture is evaporated, then a lower resistance can be tolerated and it is possible to get along with the resistance of only the solid part of the insulating concrete.

FIGURE 3 shows the cross section of a specific example of my invention which was built to obtain the thermal efficiency data shown in FIGURE 9. Insulating concrete of high water migration resistance was poured around a four inch pipe coated with a parting agent to prevent adhesion of the concrete to the steel pipe. Two evaporation channels 35 are located in the outer part of the defined outer zone.

High water migration resistance insulating concrete was made with the following ingredients:

Portland cement	94 lbs.
Expanded vermiculite (small particle size, waterproofed by method of Sucetti Patent No. 2,355,966)	6 cu. ft.
Emulsified asphalt	3 gallons
Water	21 gallons

The wet density of this mix was 60 lbs./cu. ft. A layer of insulating concrete was poured approximately three inches deep or up to the level of the line C—C in FIGURE 3. A U shaped metal strip was pressed into the concrete to form U shaped grooves 37 of FIGURE 3. The shaped channel was located so that approximately one inch of insulation was present on the outside of the channel.

After the concrete hardened the U shaped metal channel was removed and inverted over the U shaped channel in the concrete, thus forming an approximate oval with the surface of the lower half of the oval being concrete and the upper half metal.

The rest of the insulation shown in FIGURE 3 was poured leaving the metal inverted U forms in place. The exact shape of the oval is of no importance to my invention.

FIGURE 4 shows a few convenient shapes 38, 39, 40 and 41 of channels that can be of any convenient construction material. If the material is permeable to water it increases the evaporation area. With any of the shapes illustrated in FIGURES 2, 3 and 4, it is desirable that the channels have a cross sectional area of less thn 15% of the cross sectional area of the insulating concrete, and preferably less than 10% of that figure.

With appropriate choice of metals in regard to the electro chemical series for metals and proper electrical connection between the pipes and the forms these inverted forms can serve the supplementary function of providing electrolytic corrosion protection for the pipes contained within the insulation. To this end, the metal of the channel should be electronegative with respect to the metal of the heat conducting pipe. The ends of the channels 37 and 38 communicated to the atmosphere with stand pipes, one pipe preferably longer than the other to aid syphon action circulation of air.

There are many additional ways in which experienced construction workers can introduce the channels. Of these possible ways, the following serve as illustrations: (1) the channels might be formed by tubes made of stiff water permeable materials such as cardboard, fiber, plasters, screening, ceramics or perforated metal. The tubes are fastened at the appropriate place in the form used to hold the insulation during the time required for setting. The joints between tubes are taped to exclude the wet concrete and the tubes are left in place.

(2) In the production of preformed factory-made sectional insulation, the channel can be formed by a mandrel in the mold so arranged that it can be removed after the insulation takes shape. FIGURE 11 shows a cross section of one example of such a preformed section. Naturally it is necessary to cement the ends of the sections together to avoid the possibility of excessive movement of water into the insulation along the radial joints between the sections.

The preformed factory made sections can be made solid as shown in FIGURE 11, in which case they are slipped on endwise over the end of the heated fluid conducting pipe or the sections can be split longitudinally in the manner that is conventional for preformed rigid sectional insulation. In this case channel 22 can be contained entirely within one of the sections or it can be placed in the longitudinal boundary between the sections so that one side of the channel is formed by one half of the sectioned insulation and the other side of the channel is formed by the other half of the sectional insulation.

The effectiveness of my invention can be demonstrated through heat loss measurements with the system illustrated by FIGURE 3.

FIGURE 9 shows the measured heat loss as a function of time.

Initially, poured in place insulating concrete has a large moisture content which results in a relatively poor initial thermal efficiency. A four inch diameter pipe operating at 350° F. is considered efficient when the heat losses are about 200 B.t.u. per hour per lineal foot of system.

After the completion of an initial warm up period, the FIGURE 3 example showed a heat loss of 364 B.t.u. per lineal foot per hour. Continued operation with normal thermal syphon circulation of air through channels 35 resulted in a lowering of the heat loss so that at six days the loss was 241 B.t.u. At this time the whole system

was flooded with water. It should be pointed out that this system has no casing. Air continued to circulate through channels 35 thus removing water by evaporation. The system was left in the flooded condition for seven days. During this time no change in the heat loss was observed, indicating that the circulating air current was able to carry away water vapor at the same rate that liquid water was entering the insulation.

At the end of the seven day flooding period the water was removed and the system continued in normal operation for ten more days. At this period the heat loss was down to 205 B.t.u. The system was again flooded for ten days and the heat loss remained steady at 205 B.t.u. At the end of this ten day flooding the water was removed and normal operation continued.

With thirty days of additional normal operation the heat loss reached an equilibrium value of the heat loss at 148 B.t.u. The system was again flooded and no appreciable change in efficiency was observed. These data are presented in FIGURE 9 where heat losses are plotted as a function of days of operation. The flooding periods are evident as the horizontal part of the curve.

Another embodiment of my invention is shown in FIGURE 12 in which four heated pipes are contained in a single unit of insulation. Two evaporative channels 45 and 46 are employed to carry off the water vapor. Either channel 45 or 46 or both can serve as the drain channel.

Still another embodiment of my invention is shown in FIGURE 13, where a single heated pipe 23 system is shown equipped with a single evaporative channel 22 placed in the top section of the insulation. The insulation in this system is given protection in the form of a Portland cement paint outer casing 48. The bottom of this system consists of a structural concrete base pad or foundation. In this case an insulating concrete of intermediate resistance to water migration can be used because the cement paint limits the infiltration of water. Cement paint is a typical example of a semipermeable casing. Bituminous coatings could be applied instead of the cement paint or on top of the cement paint.

In general, a small leak in an otherwise completely impermeable casing will cause the system to operate the same as with a semipermeable casing. The water entering the casing through a small hole will distribute itself by capillary action between the casing and the insulation. It is usually not convenient or practical to achieve a noncapillary bond between the insulation and the casing.

In FIGURES 13 and 14 typical flow lines for water infiltrating from the outside are shown. FIGURE 15 shows the less frequent, but important case of the flow lines from a break in the heated fluid pipe. FIGURE 15 also shows my invention applied to a system having an impervious casing 49.

FIGURE 5 shows the cross section of a preformed or factory-made section of insulation in which the evaporative channel has been enlarged to the place where it is a concentric ring within the body of the insulation. In this form, it is desirable that the air space 22 constitute about 5 to 50% of the space between the outer surface of the pipe 23 and the outermost periphery of the insulation, and that the outer cylinder of insulation, extending from the outer peripheral boundary of the air space to the outermost periphery of the insulation constitute about 30 to 95% of said space.

FIGURE 6 shows another possible configuration which is possible with either job formed or factory formed insulation. The factory formed section illustrated in FIGURE 11 is particularly simple and easy to fabricate. It is also easy to cement together the ends of the sections to achieve water tight joints.

While there are above disclosed but a limited number of embodiments of the structure, process and product of the invention herein presented, it is possible to produce still other embodiments without departing from the inventive concept herein disclosed, and it is desired therefore that only such limitations be imposed on the appended claims as are stated therein, or required by the prior art.

The invention claimed is:

1. In a heat distribution system comprising an impervious pipe arranged to carry a heated fluid having a temperature in excess of the boiling point of water and a monolithic jacket of lightweight, moisture vapor permeable insulating material thermally insulating said pipe about its entire periphery from a colder surrounding environment having a temperature less than the boiling point of water at the prevailing atmospheric pressure, said insulating material having at least one longitudinally extending vent passage formed in said insulating material in spaced relation to said pipe, said vent being in communication with free air, the improvement comprising providing said vent passage in the region of insulation where the temperature of the insulation is intermediate the temperature of said environment and the temperature of boiling water.

2. The system of claim 1 in which the center of said vent passage is located at a distance in the range from 0.3 to 0.9 times the radial dimension of the jacket measured from the outermost pipe surface to the outermost periphery of said jacket.

3. The system of claim 1 in which the center of said vent passage is located at a point where the temperature of the insulation is about 210° F.

4. The system of claim 1 in which the center of said vent passage is located at a point where the temperature of the insulation is about 170° F.

5. In a heat distribution system comprising an impervious pipe arranged to carry a heated fluid and a monolithic jacket of lightweight, moisture vapor permeable insulating material thermally insulating said pipe about its entire periphery from a colder surrounding environment having a temperature less than the boiling point of water at the prevailing atmospheric pressure, said insulating material having at least one longitudinally extending vent passage formed in said insulating material in spaced relation to said pipe, said vent being in communication with free air, the improvement comprising providing said vent passage in the region of insulation where the temperature of the insulation is intermediate the temperature at the outside surface of the insulation and the temperature inside said pipe, and in which said vent passage has a cross-sectional area of less than about 15% of the cross-sectional area of said jacket.

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