UNITED STATES PATENT OFFICE.

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METHOD OF THAWING GROUND.

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To all whom it may concern:

Be it known that I, JOHN H. MILES, a citizen of the United States, residing at Trinity Center, in the county of Trinity and State of California, have invented a certain new and improved Method of Thawing Ground; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification.

This invention, in its narrowest aspect, relates to placer gold mining, but since the invention is believed to be a pioneer one in its own field, it may properly be stated to relate broadly to a simple and efficient method of thawing ground for any purpose whatsoever.

The object of the present invention is to provide some means for thawing ground at such a low expense as to enable certain operations to be performed which have hitherto been impracticable owing to the fact that the cost of thawing, and the subsequent operations, whatever they may be, plus a necessary profit, are greater than the return from the work. The object of the present invention may also be stated as the provision of a process which will utilize the well-known, but little appreciated, contraction of earthy ice masses when warmed from a temperature of, say, 28° Fahrenheit to a temperature of 39° or 40° Fahrenheit and the utilization of the porous space caused by such contraction for the constantly shifting stream of thaw-producing water; in other words, the change in the process of thawing from transference of heat by conduction and radiation to such transfer by convection.

In order that the great value of the present invention may be thoroughly understood it will be necessary to describe very briefly the present method of placer mining and the principal obstacles to it which obstacles have been shown by an entire season's practical work to have been entirely overcome by the utilization of the method of the present invention. The particles of gold found in the beds of streams are found almost exclusively just at bed rock, although sometimes the percentage of values at bed rock will be only, say, 80% of the total with 10% occurring just below bed rock, six or eight inches at the most, and the other 10% located in one or more strata between bed rock and the surface of the ground.

The gold is obtained by first thawing the portion of the ground to be operated upon in advance of the dredge which floats in a small lake or rather pool of water. The dredge digs down to bed rock and usually about eighteen inches below that level in order to be certain of securing the values that may be in small pockets or indentations in the upper surface of the bed rock which it will be understood is slightly hummocky and but rarely is as smooth as the seashore at a sandy beach. The gold is separated from the earth as it passes through the dredge and the sludge is deposited at the rear end of the dredge so that the pool of water constantly moves with the dredge.

The most successful previous practice of thawing is to drive down steam pipes at close intervals and to thaw the ground by the delivery of heat by the condensation of the steam, and the subsequent cooling of the condensate, it being found wisest in practice to use merely saturated but not superheated steam. This process results in the formation of an area of thawed ground extending right down to bed rock, where the mouth of the steam pipe is placed, and while fairly large at the top surface of the ground the thaw unfortunately is of the shape of an inverted cone so that even when the steam points are placed very close together there are still formed or rather left in place numerous pinnacles of frost, these pinnacles themselves being of conical formation but with the point uppermost. These pinnacles or ice cones not only cause damage to the bottom of the dredge at times but also necessitate their cutting away by the dredging apparatus which is an extremely hard task for the mechanism. In fact it has been stated that the digging away of a solid ice pillar is as wearing on a dredge as an entire month's working in thoroughly thawed ground.

With the thaw holes a reasonable distance apart the cost of thawing by the use of saturated steam is found to average somewhere about 25¢ per cubic yard where fuel is readily available which added to the normal cost of dredging of about 6¢ or 7¢ makes it impossible to handle earth that will
yield values of only 30¢ or 35¢, frequently necessitating the abandonment of prospects that could be worked with a good profit appreciable amount. This has been done by the present method which after an entire season’s work shows an average cost of less than 2¢ per cubic yard which will render available for work large areas of good quality prospects absolutely worthless at the cost of the other systems of thawing, and furthermore will open up territory where fuel is not available since the heat units necessary for my method are supplied by nature.

Figure 1 shows a vertical cross section through the center of an area thawed by the process described herein. Fig. 2 shows side by side four thaws made respectively with superheated steam, saturated steam, warm water and with cold water.

Fig. 3 is an enlarged view of the steel shoe or cutting point. Fig. 4 is a plan view.

In Fig. 1, 10 represents the surface of the ground, the dot and dash line 11 locates the lower limit of the tundra or muck which is a mass of organic matter, fine sand and water, all solidly frozen and usually covered with a heavy blanket of moss, and the lower dotted line 12 indicates the approximate level of the bed rock on which the greater percentage of the gold values is found.

The pipe 14, for locations where the bed rock is at a distance of from forty to fifty feet from the surface, is about two inches in internal diameter and is provided at its upper end with a suitable connection 16 for joining the pipe 14 to a flexible hose 17 leading from the main 18, the latter delivering water to a plurality of similar pipes 14 all simultaneously thawing. When the operation is completed the plan view would appear to be a plurality of staggered circles entirely overlapping so that there is no unthawed area in the entire surface of the ground so treated, it being noted from Fig. 1 that the surface of thaw is roughly cylindrical, the thaw at bed rock being as great in area, or greater, than at the surface.

The method I used in sinking the holes consisted of taking a short section of, say, twelve or fourteen feet of standard two-inch pipe 14 and having fitted on the bottom the steel point 15, which it will be noted consists of a sleeve of metal threaded as at 30 to the lower end of the pipe 14 and provided at its lower edge with a plurality of cutting teeth 31 bounding a central orifice 32 of somewhat less diameter than the bore of the pipe. The purpose of this is that, should an occasional limestone slab be met, the teeth 31 would cut through it, leaving a core, but the core being much smaller than the bore would not prevent the passage of water down through the pipe. It is well understood that I do not limit myself in any way to this construction, but am simply describing in detail the exact method I have previously used and found quite successful. I have also used a cruciform bit and find that I can sink the pipe somewhat quicker, especially if the pipe is subjected to a pile driver action during the sinking operation. For example, I have found that by taking an eighty pound pressure of water at 82° Fahrenheit and delivering blows to the pipe with an eighty pound weight at the rate of sixty per minute, I can sink the pipe about thirty feet per hour by revolving the pipe twenty times per minute. The pipe is extended as it sinks by adding sleeves 34 and other sections of pipe, as is usual in this work. When the pipe has been sunk to bed rock with the lower pointing resting on the bottom, the pipe is then used as a thaw pipe with the water at whatever pressure may be desired, and the flow continued for about two hundred hours or a little less time than this until the hole has a diameter of about eighteen feet or so, which has been found the most efficient size, all factors considered. When the desired area has been thawed the pipe is simply pulled out of the hole, which operation offers no difficulty, since the freshly thawed earth is quite soft and offers practically no obstruction to the passage of the sleeves 34 and the shoe 15.

The surface water from the ditches, creeks or pump is conveyed to the main 18 so as to have a slight head of anywhere from a one-quarter of a pound up, a forty foot head being found in practice to be a very advantageous one. This surface water having a temperature from 33° to 52° or even higher, is delivered right at the surface and into the bed rock through the shoe 15 and finds its way back to the surface by cutting a little channel all around the pipe 14 and emerging at the edge of the pipe for a short time. This water at natural temperature melts the ice found around the pipe, expanding it very slightly from its initial temperature of about 28° to the thaw point 115 of 32° and then causing it to contract one-tenth its volume on melting and then to contract at a definite rate up to a little more than 39° Fahrenheit at which point water is found to have its maximum density expanding from then on, up to the boiling point and having at a temperature a little over 46° Fahrenheit the same volume as it had when first melted at freezing. In the present process we do not heat the earth to the temperature just mentioned, so its volume is always less than at 39°, and we find that the soil falls or sinks very appreciably after thawing, the normal depression being rated usually at about 7% of the distance.
from the surface to bed rock. In other words, in a forty foot thaw the ground level would sink over two feet.

While the pipe is sinking into the ground, the water cuts a path cylindrical in form and coaxial with the pipe and invariably follows the pipe as closely as possible directly to the surface of the ground. When the pipe has reached bottom, however, a rather interesting phenomenon has been found to exist. The water gradually returns to the surface at a little distance from the pipe maintaining the form of an annular ring substantially concentric with the pipe, but ever increasing in diameter, and it has been found that practically no water returns to the surface in proximity to the pipe after the ring has started to form away from the pipe. The explanation of this phenomenon is believed to be that a porous path or labyrinth is formed directly at the frost line or thaw margin which offers a much freer passage to the water than it can find at any other place. Apparently what happens is this; the portions of rock, which portions may be considered as a grain of sand, a small gravel, or a large fragment of rock,—the action in each case being the same—is exposed to the water current at a point nearest the pipe, but is secured in the ice at its opposite side. The passing water delivers heat units to the exposed portion and also delivers heat units to the ice mass surrounding the gravel, the result being that heat is radiated through the entire body of the stone, but is not radiated at all through the ice mass, since the thermal units are utilized in the latter case in overcoming the latent heat of fusion which is about 140 B. T. U. The effect of this is that the ice in the rear of the pebble starts to melt at almost the same rate that the ice is melting where directly exposed to the water, provided, of course, that the pebble is of small size. After a given interval of time, the ice will have melted to an appreciable extent, so as to provide a passage completely around the stone, but the stone will for a time be held in its position by the contact it has with other, as yet un-thawed, similar stones, and also with the partly thawed and perforated ice. As the icy mass begins to melt or to disintegrate, the needles of ice will be the last to give way on account of their greater specific heat and the enormously greater number of thermal units necessary to melt them and will consequently hold the stones and gravel in position, but will leave a lattice work of ice needles through which the water may readily pass. The completely thawed sand, gravel, etc., naturally occupies a smaller volume than it did when frozen, but part of the almost thawed rock cannot collapse due to small ice needles holding it in place until they become melted and in case the stone is then entirely free it falls across the current of water to join the thawed mass but in so doing leaves a path on the opposite side, that is, the frozen mass side that permits the passage of water through the relatively free labyrinth or porous path.

The water is found in actual practice to emerge from the ground mainly in a ring or annulus, gradually increasing in diameter during the process until it reaches its final extent which is determined by the size of the pipe since a given quantity of water at a given temperature will thaw a given amount of surface, and since this surface is gradually increasing in diameter and, therefore, still faster in units of area, say, square feet, a point is finally reached at which the quantity of water that can be delivered through the pipe 14 becomes insufficient to thaw the greatly extended area of the thaw hole, the maximum diameter of hole having been taken for practical reasons at about eighteen feet, but can run considerably larger.

The diagrams shown in Fig. 2 are copied from actual work and were made in the following way: The four pipes were inserted in each case down to the bed rock in case “a” superheated steam was delivered to the hole for 156 hours; in case “b” saturated steam was delivered for 98 hours; in case “c” warm water at a temperature of a little over 100° Fahrenheit was delivered for 67 hours, while in case “d” cold water at a temperature of 52° Fahrenheit was delivered at a rate of 20 gallons per minute under a forty foot head for 192 hours. In each case the thawing was stopped when it was thought that maximum efficiency had been secured which accounts for the varying numbers of hours of delivery of the fluid. The profiles shown in Fig. 2 were obtained by thawing the holes as stated and then after the surface water had become frozen (ground that has been thawed will remain thawed for many months) excavation was made right on the center line of each of the holes and the results are shown in that figure, there always being a very well defined frost line indicating the margin between the thawed and un-thawed portions, bearing in mind, of course, that the thaw gradually freezes again from the outer margin, possibly at a rate of a foot per month.

Referring again to Fig. 2 it will be noticed in case “a” that for some reason, at present not known, the superheated steam will not penetrate the bed rock, in spite of the great number of hours it was used, and it will also be noted that there is a very restricted neck at 20 from which point to the surface the thawing area is in the shape of an inverted cone. The bed rock is most frequently a sericite schist usually massive and blocky in character and has to be dug to a distance of at least eighteen inches, so that it is very...
essential that this bed rock be thawed, if this can possibly be done. The apparent reason for the restricted neck is that the high temperature of the pipe and the escaping steam, which at this point seems not to have yet been condensed, has baked the clay so thoroughly that it acts as an almost perfect heat insulator. In fact, the most plausible reason for the failure of the superheated steam method is that the heat units are delivered so rapidly that the material in contact with the steam expands sufficiently to more than take up the large contraction caused by the thawing of the ice in the mass, such ice averaging somewhere in the neighborhood of three hundred pounds to the cubic yard, the weight of the earth in the same volume being about three thousand pounds or nine tenths of the total weight.

In case "b" the saturated steam also leaves a constricted portion indicated at 21 at the end of the lower bulb, which, while considerably larger than the equivalent portion of the superheated steam thaw, is still of very small diameter compared to the depth of the cut. Here, too, the general contour is that of an inverted cone,—a very objectionable form on account of the pinnacles formed betweenthaws.

The warm water thaw shows much greater evenness of diameter and in the middle or central portion is found to be of the desired shape, i.e., cylindrical, but it flares materially at the top, and while the constricted portion 22 is not nearly so noticeable as in cases "a" and "b" it is still sufficiently large to cause the formation of pinnacles unless the holes are made so close together as to render the cost of thawing exorbitant.

Illustration "d" is the same as Fig. 1, but is drawn to the same scale as the other illustrations of Fig. 2. Here we have practically ideal conditions. The thaw has extended a considerable distance beneath the surface of the bed rock line 12 and the constriction at 23 may be due to some irregularity in the soil itself, although, as far as could be ascertained the strata from about seven feet above the bed rock to a point about 22 feet above the bed rock appeared to be quite uniform. The constriction in each case occurred at a point about twelve feet above the bed rock. The constriction at 23, just mentioned, was found to be approximately the same diameter as the upper constriction 24 at the lower level of the tunnel or muck.

In thawing these areas by this cold water process, now known in practice as the "Miles method," the distance apart of the pipes 14 is preferably so regulated that with a thaw area eighteen feet in diameter at levels 23 and 24, the areas will entirely cover the surface of the ground to be thawed. This will, of course, mean that that part of the ground already thawed will again be subjected to the thawing action, but apparently no waste of energy is occasioned thereby, since the water emerging from the ground in the constantly increasing diameter, substantially ceases to flow when the annular orifice of the water touches an already thawed area, the water in such cases continuing to flow through the unh thawed portions and, but little or none flowing through the area of the circle extending into the previously thawed region. While this result was quite unexpected, it matches well with the theory of operation as previously explained; that is, that a porous path or passageway is formed through which the water flows and, as more of the earth is thawed, this passage gradually increases in diameter, as previously described, so that the heat conveying water is invariably in direct contact with the portion of the earth to be thawed and delivers the heat necessary to melt the ice, directly to the ice itself, not relying in any way upon conduction and radiation, as in the old methods. Even with the warm water thaw, the temperature of the water as it emerges is relatively high, say, about 70° F.; so that the contraction due to the heating from 32° to 40° is far more than made up by the expansion due to the increased heat over 40°. In thawing a hole when the ever increasing margin reaches the already thawed portion of another hole, such previously thawed portion has already settled and offers no space for the passage of the water but in the four arcuate margins where the thawing of the present hole meets solid, unthawed, and therefore still expanded portions, such porons spaces do exist and the water flows through those alone.

The quite extended description that I have just given of my process is due to a desire that the method shall be completely disclosed and thoroughly understood, it having been my experience that even practical men and those who knew the conditions thoroughly have been invariably unconvinced until they had actually seen a thaw made by my process. There are, of course, numerous other ways in which the process may be carried out, and I wish the foregoing description understood to be merely a description of the work as I have actually carried it out in practice. Those familiar with operations will understand that my process is equally applicable to shallow, deep and even to drift mining, and they will also appreciate the fact that it is often not necessary to drive the pipes into the ground, but merely to hold them vertically at the surface of the ground for a short while when the pipe will sink to a sufficient depth to hold itself erect and will continue to sink without being held up in any way save by its contact with the earth. My invention is not to be taken as limited to
any of the specific details I have referred to, it being as far as it has been possible to ascertain, a pioneer invention, and is to be limited in scope only as called for in the claims following.

What I claim is:

1. A process of thawing ground which consists in delivering water at a temperature but slightly above that of the frozen area to approximately the lowest point below the surface to be thawed and at a slight pressure and in such quantity that the water shall return to the surface in a substantially cylindrical path ever increasing in diameter as the thawing progresses, said path corresponding with the margin of the frozen area.

2. The method of thawing ground by convection which consists in delivering water to the frozen ground in such quantities and at such temperature as to cause the formation of a path of least resistance for the water at the constantly shifting margin of the frozen area.

3. The process of thawing earthy material for mining operations, which consists in delivering water to the frozen ground at a point beneath the surface at such a rate that the water will emerge at the surface at a temperature at or below approximately 40°F, through an annular path of constantly increasing diameter.

4. The process of thawing ground for mining operations, which consists in conveying water under pressure to approximately the lowest point to be thawed at a rate of delivery of water such that the temperature of the thawed material should be at approximately the temperature of water at its maximum density.

5. The method of thawing ground, which consists in delivering water to it at a temperature below approximately 60°F., and at a sufficient rate of flow to maintain the current at approximately the marginal line between the frozen and thawed portions, whereby the frozen ground will have heat delivered to it solely by convection, substantially as described.

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