

Nov. 14, 1933.

E. C. THRUPP

1,934,955

NATURAL GAS WELL HEATER

Filed July 6, 1931

3 Sheets-Sheet 1

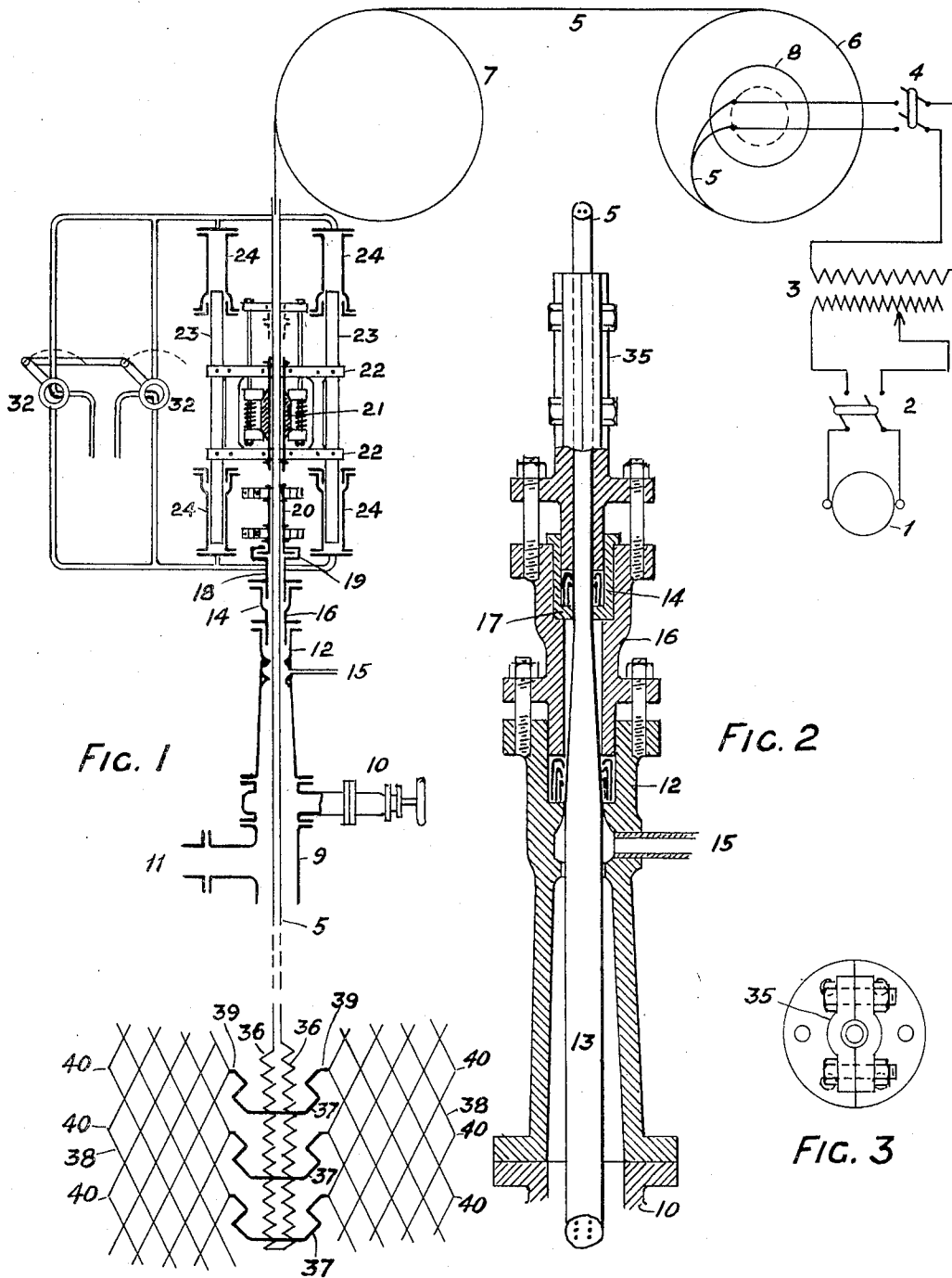


FIG. 1

FIG. 2

FIG. 3

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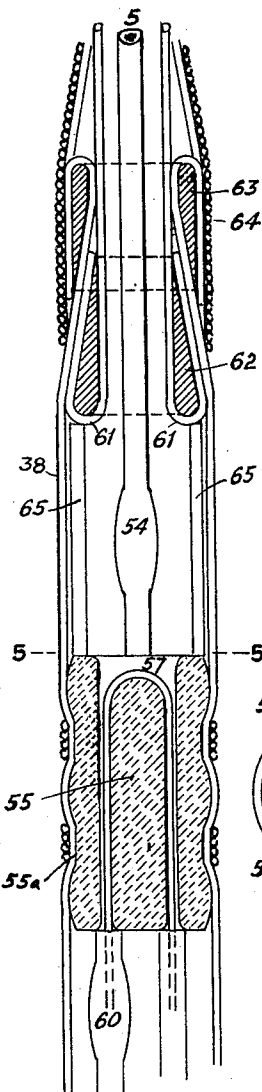


FIG. 4

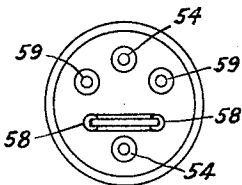


FIG. 6

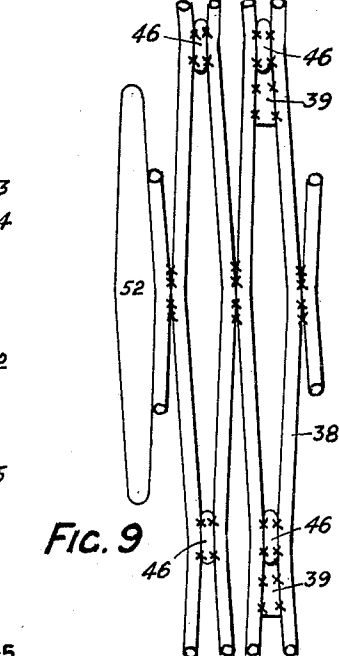


FIG. 9

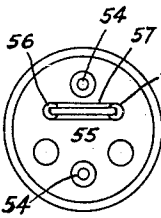


FIG. 5

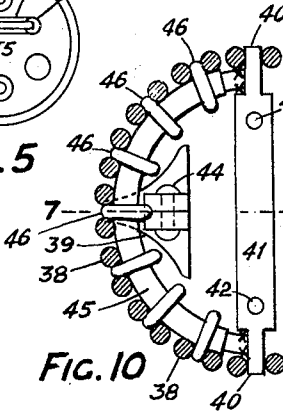


FIG. 10

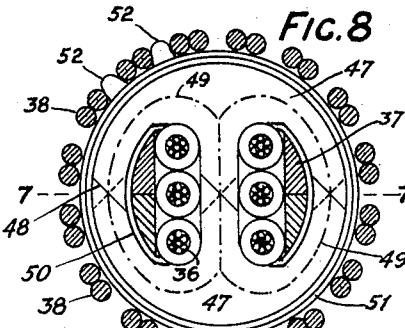


FIG. 8

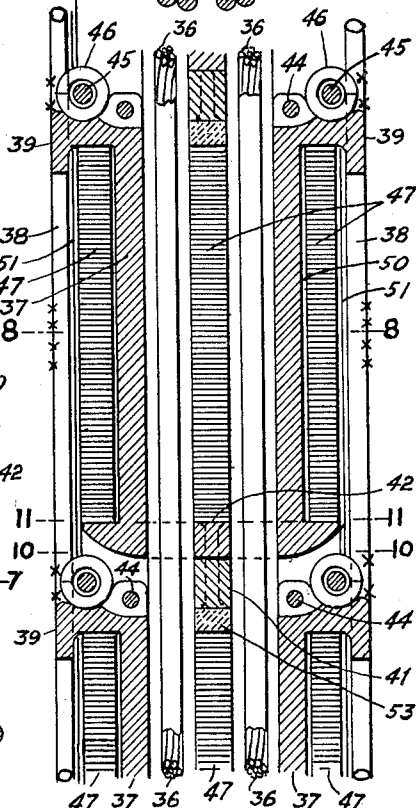


FIG. 7

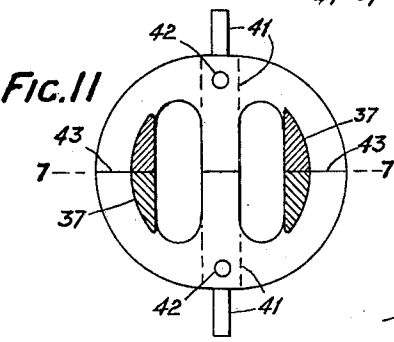


FIG. 11

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3 Sheets-Sheet 3

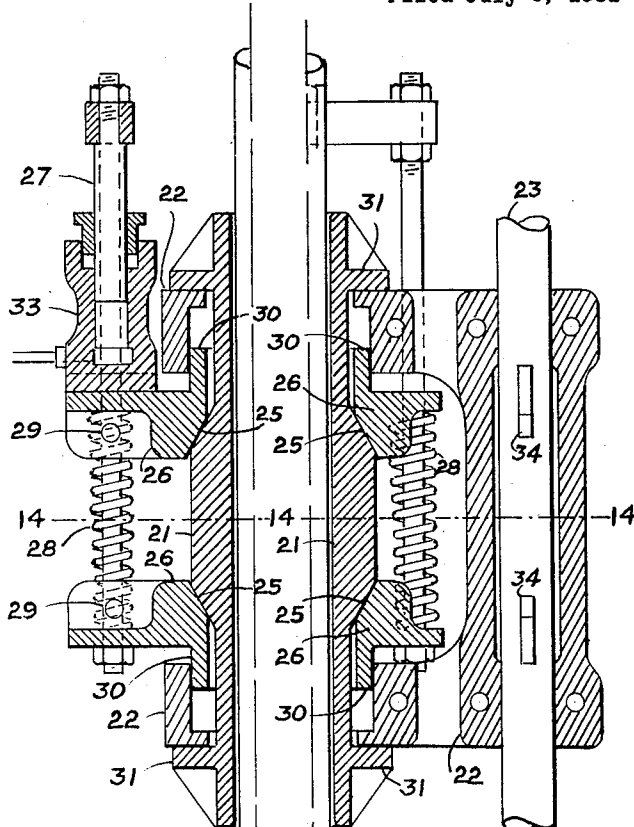


FIG. 12

FIG. 13

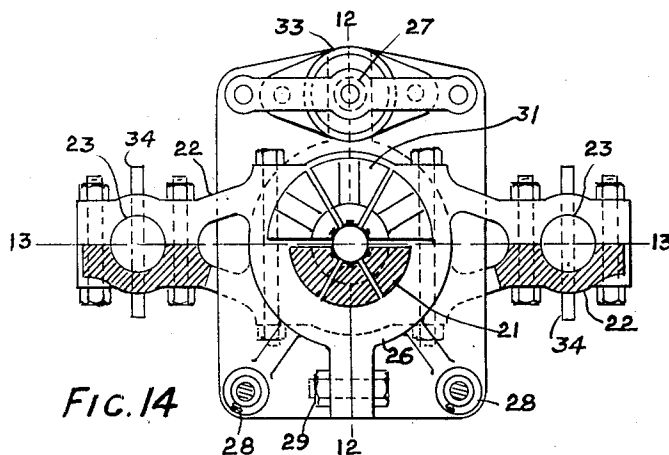


FIG. 14

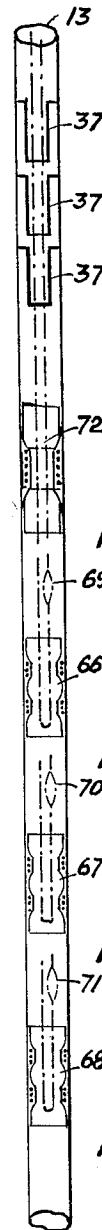


FIG. 15

FIG. 16

FIG. 17

FIG. 18

FIG. 19

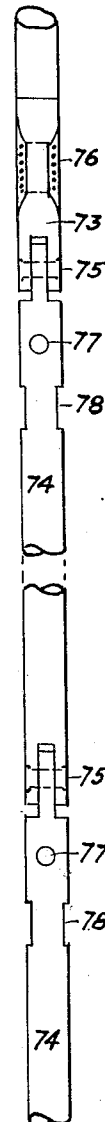


FIG. 20

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UNITED STATES PATENT OFFICE

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NATURAL GAS WELL HEATER

Edgar Charles Thrupp, Vancouver, British
Columbia, CanadaApplication July 6, 1931, Serial No. 548,812, and
in Canada June 25, 1931

4 Claims. (Cl. 219—33)

My invention relates to apparatus for the prevention of freezing in deep oil and gas wells.

In oil wells yielding natural gas or a mixture of oil and gas, a difficulty sometimes occurs owing to the cooling action of the gas issuing at a high pressure from the bearing strata which gradually lowers the temperature of the well by the cumulative effect resulting from successive volumes of gas being cooled in the strata before issuing into the well, by the action of the gas which issued earlier having cooled the strata surrounding the well. The result of this cumulative cooling action (which is similar to that used in well known apparatus for liquefying gases) is to freeze any moisture which may happen to be present in the gas, if the gas pressure in the strata is high enough to produce that effect, and the ice so produced sometimes blocks up the passage in the well and the interstices of the strata, and reduces or stops the production of gas or oil. The cooling effect of the gas expansion is modified by the heat contained in the accompanying oil, and if the ratio of oil to gas is high enough, the temperature will not fall to freezing point. This condition may be expected to occur with a ratio of one pound of oil to less than three pounds of gas.

It is the main object of my invention to supply sufficient heat in the well to counteract the cooling action of the expanding gas when the ratio of the weights of gas to oil is more than three to one, and to concentrate the supply of heat chiefly to that part of the well which is situated in the strata from which the gas issues.

Hitherto troubles due to freezing, such as described, have been dealt with by firing shots of explosives in the boreholes to dislodge the frozen strata around, or by drilling again through the ice and employing tools to remove the material, or by putting back pressure on the well to reduce the cooling by expansion. These methods are crude and unscientific, interrupting the operation of the well, are sometimes only temporary in their results, and may do permanent harm to the well. Several methods have been adopted for heating oil wells which have become incrustated with a coating naphtha. These have involved the use of steam, burning oil jets, electric glow bars in closed tubes, and electric currents passed to earth. None of these are suitable for dealing with freezing troubles a mile below the surface.

The present invention is intended (for use particularly in gas wells) to supersede all these methods by providing a hot column or cable in that part of the well where the cooling occurs,

and constructing that column in the form of a plurality of static transformers supplying a large amount of current to a secondary circuit system at a very low voltage, usually about three or four volts, under conditions permitting the exposure of the heated circuits direct to the gas carrying a spray of oil, which helps to maintain the insulation and prevent any appreciable leakage to earth away from the place where the heat is required, or corrosion of any points of contact with the earth.

To accomplish these results I employ an alternating current of electricity conveyed down the well to the gas-bearing strata by a pair of insulated conductors of low resistance, such as those used for underground electrical supply cables, and through the borehole in the gas bearing strata by conductors forming the primary circuit of an elongated static transformer constructed preferably with a circular cross section having an external diameter considerably less than the diameter of the borehole, to leave space for the passage of gas and oil out of the well.

The primary circuit may consist of one complete turn in the transformer, or it may have two, three or more turns. The primary circuit is surrounded by a core of laminated iron sheets arranged to give a magnetic flux circuit similar to that used in ordinary transformers for electric lighting purposes, but the core is divided into unit sections to serve a plurality of secondary circuits. Usually a large number of secondary circuits will be required, each secondary circuit being served by a short length of the primary circuit with its enclosing magnetic core.

The secondary circuits passing through the core may have one, two or more turns, but the usual construction will have only one turn passing through the core with terminals brought out to the circumference of the core or its covering. The remainder, or external parts of the secondary circuits carrying a current of low voltage to produce heat, are arranged on the circumference of the transformer by connecting to longitudinal wires forming an outer protecting shield to the transformers and also assisting the primary conductors in carrying the weight of the whole transformer when suspended in the well. The longitudinal wires are spaced apart and insulated from one another for the greater part of their length, but are connected at certain points in zig-zag fashion to provide a network circuit of the required length from one terminal of the internal (or generating part) of the secondary circuit to the other terminal thereof.

The pair of low resistance conductors above the gas-bearing strata may with advantage be enclosed in steel armoured tape or wire to make a cable of considerable tensile strength to carry its own weight and that of the transformer section below.

Passing the cable into the well against gas pressure is done through suitable stuffing boxes provided on top of the well casing, and this stuffing box structure at the well head is another object of the invention.

For convenience the whole cable is wound on a drum mounted on an axle and arranged so that the terminals of the insulated conductors can be connected to the source of supply of electricity without unwinding the cable completely off the drum when a sufficient length is lowered into the well. Some means of regulating the supply of current to the cable is desirable because there may be a difficulty in estimating the exact amount of heat required, and fluctuation in the gas flow may occur.

An alternating current supply from some central source at constant voltage may be used, and the regulation done by using an alternating transformer with the primary circuit divided into several sections, some of which can be switched out of action when not required.

The dimensions of the conductors and the quantity of heat to be supplied depend upon the pressure under which the gas issues from the strata and on its volume. In round numbers the leading data are that the drop in temperature is about half a degree Fahrenheit for each atmosphere of pressure, or 50 degrees for 100 atmospheres, and one pound weight of average quality of natural gas will occupy about twenty cubic feet at ordinary atmospheric pressure, and will have a specific heat about 0.60. One million cubic feet of gas will therefore weigh about 50,000 pounds, and will require, 1,500,000 British thermal units to raise its temperature 50 degrees Fahrenheit.

Each million cubic feet of gas issuing in 24 hours will therefore require the thermal equivalent of about 25 horse power to completely counteract the cooling effect of expansion from 100 atmospheres pressure, but some of that heat will naturally come from the strata round the well and from the oil issuing with the gas, which may have a normal temperature of about 150 degrees Fahrenheit before coming to the well, so the quantity of heat to be supplied by electricity to prevent the temperature from falling below 32 degrees Fahrenheit, (the freezing point of water) may be considerably less than the equivalent of 25 horse power per million cubic feet of gas per day under the conditions named. When the strata surrounding the well have been lowered to about 32 degrees Fahrenheit, the issuing gas will tend to drop another 50 degrees and escape at a temperature near 20 degrees below zero. These are the conditions which have been observed when troubles have arisen from ice blocking boreholes. The working temperature of the external secondary circuit in the well to convey the necessary heat to the gas will usually be somewhere between 200 and 600 degrees, but no definite limit should be laid down, because special conditions may be met which can be dealt with by this invention with temperatures outside these limits. The drawings herewith will, however, be more readily understood when it is explained that they are intended to apply to apparatus working at a

temperature not exceeding 600 degrees Fahrenheit.

I will now describe my invention with reference to the drawings.

Fig. 1 is a general schematic diagram of the apparatus, which cannot be shown clearly on a single scale drawing owing to the parts extending over several thousand feet.

Fig. 2 is a section of the stuffing boxes at the well head and the clamp (partly in elevation) used to hold the suspended transformer structure in position when lowered to the operating depth.

Fig. 3 is a plan view of the top of the clamp shown on Fig. 2.

Fig. 4 is a section of the construction at the lower end of the twin conductor cable where the conductors are connected to the turns of the primary circuit of the transformer structure below.

Fig. 5 is a plan view at line 5, 5 in Fig. 4 of a porcelain support to the upper end of one of the transformer primary circuit turns, with passages for the other primary conductors.

Fig. 6 is a similar plan view of the porcelain support to another primary circuit turn situated below the one shown on Figs. 4 and 5.

Fig. 7 is a vertical section of one of the transformer units with a portion of another unit below. This section is taken on the line 7, 7, in Figs. 8, 10, and 11.

Fig. 8 is a horizontal section at the centre of one of the transformer units at the line 8, 8, in Fig. 7.

Fig. 9 is an elevation of a portion of the external secondary circuit network which forms the heating element exposed to the gas.

Fig. 10 is a part plan on line 10, 10 of Fig. 7 showing the method of tying in the wires of the external secondary circuit network to the circular shape near the points of connection to the terminals of the internal secondary circuit.

Fig. 11 is a plan of the construction of the internal secondary circuit at the base of one of the transformer units at line 11, 11 of Fig. 7.

Fig. 12 is a half vertical section of the details of the clamping device for thrusting the transformer structure into the well head stuffing boxes, which is shown schematically in Fig. 1, and is taken on the line 12, 12 in Fig. 14.

Fig. 13 is another vertical half section of the same clamping device taken at right angles to the view in Fig. 12 and on line 13, 13, in Fig. 14.

Fig. 14 is a plan of the same clamping device shown partly in plan at the top of the clamp, and partly in section at the middle of the clamp, or in plan at the top of Figs. 12 and 13 and on the line 14, 14, in Figs. 12 and 13.

Fig. 15 is a diagrammatic vertical view of the construction at the lower end of the transformer structure showing the relative positions of the three primary circuit turns.

Fig. 16 is a plan of an insulator block situated below the lowest transformer unit, showing the arrangement of the primary circuit conductors at that point.

Figs. 17, 18, and 19 are plans of the insulator blocks at the lower ends of the three primary circuit turns.

Fig. 20 is a view of the method of attaching the weight bars to the transformer structure at the lower end of same below the insulator block shown in Figs. 15 and 19.

The combination of parts numbered on the drawings as 12, 14, 16, 17, 18, 19, and 35, together with the necessary minor accessories are referred

to in a general way in this specification and claims as the "stuffing box structure".

The combination of parts shown on Figures 4, 5, 6, 7, 8, 9, 10, 11, and 15 are referred to in a general way in this specification and claims as the "transformer structure" or "transformer column".

The clamps numbered 20 and 21, and the rams numbered 23 and 27 on the drawings, together with their operating accessories and minor details of construction are referred to in a general way in the claims as "clamps and rams and means for operating same".

Referring to Fig. 1, an alternating current generator 1 supplies current through the switch 2 to the supply transformer 3, shown in conventional manner indicating a transformer with regulator in the primary circuit. The secondary circuit of this supply transformer is connected through a switch 4 to the terminals of the well service cable 5, situated at convenient points on a drum 6, upon which the well service cable is wound for transportation, and unwound for delivery over the second drum or wheel 7 to the well head. The drum is provided with means for steadily turning on an axle to wind up or unwind the cable, and a brake on a side drum 8 for safety in unwinding. The diameters of the drums 6 and 7 are made large enough to carry the cable 5 and the well transformer column which is suspended from the cable. These drums with their supports and appurtenances may be designed in accordance with ordinary practice in large cable work and mine winding gear.

The cable and transformer column have to be inserted into the well against gas pressure, and therefore special means are provided for accomplishing this operation. In the first place the well head 9 is provided with a stop valve 10 above the gas and oil outlet 11. Above the stop valve there is provision for two stuffing boxes, one box 12 suited to the diameter of the transformer column 13 (Figs. 2, 12, 13 and 15) and the other box suited to the smaller diameter of the service cable 5.

It is intended that the gas should be carried off through the outlet 11 to some convenient point of discharge at the time of inserting the apparatus, and should have sufficiently large area of passage to bring the gas pressure at the well head down to a low figure to permit the convenient insertion of the heater. If necessary a second outlet should be provided in addition to the ordinary service outlet. The transformer column is necessarily a flexible structure when made to wind on a large drum, and needs special treatment while being inserted through the stuffing box against the gas pressure. This can be done partly by suspending rigid weight bars below the transformer column, and partly by special clamps to grip the column in line with the well, and force it down through the stuffing box in a perfect straight line. Part of the first weight bar can be put through the stuffing box 12 while the stop valve is closed. A small pipe 15 is provided below the stuffing box, through which wax or thick grease may be injected under pressure to assist in making the packings gas tight. The casting 16 (Figs. 1 and 2) serves as the gland for the stuffing box 12 and also as the socket of the stuffing box 14 when a cup shaped liner 17 is inserted to make the stuffing box 14 a smaller diameter than 12. This cup shaped liner 17 and the cup leather packings are made in halves to assemble round the cable 5.

Before the liner 17 is put in place and while the weight bars and transformer column are being inserted, another casting 18 (Fig. 1) also made in halves, is placed in the socket of gland 16 and has extensions upwards to form a holder 19 for the flanges at the bottom of the lower clamp 20. These flanges serve to prevent the suspended weight bars or transformer from sliding down or being blown up by gas pressure when the clamp 20 is screwed up, or pressed tight to grip the suspended bars or transformer. Another clamp 21 (Figs. 1, 12, 13 and 14) is provided higher up, and is carried on a crosshead 22 which is attached to two rams 23 working in four outside-packed oil pressure cylinders 24.

The clamp 21 is shown roughly in Fig. 1, and more in detail in Figs. 13 and 14. Fig. 14 shows, above its centre line, a half plan on top of the upper clamp mechanism, and below its centre line, a half sectional plan through the centre of the clamp at lines 14, 14, of Figs. 12 and 13. The gripping part 21 is made in six segments with rubber or other suitable grip facings dovetailed into the castings and having small clearance spaces at the segment joints. The segments have conical tapered shoulders 25 engaging in corresponding cone recesses in two collars 26 which can be pulled together vertically by two oil pressure rams 27 (one of which appears on Figs. 12 and 14) and pushed apart by springs 28 when the oil pressure is released.

The collars 26 are made in halves and bolted together by the bolts 29, and are constrained to move concentrically with the stuffing boxes below by having turned projections 30 engaging in corresponding turned recesses in the crosshead 22, which is moved rigidly in line by the rams 23. The supports for these rams in relation to the well head, and other details, are omitted from the drawings for the sake of clearness, as they are only matters of ordinary structural design.

In Figs. 12 and 13 the clamp segments 21 are extended upwards and downwards through the crosshead, and have flanges 31 abutting on turned surfaces on the crosshead, which flanges carry the upward or downward thrust or suspended weight. Oil under pressure from a suitable source is supplied to, and discharged from the cylinders 24 (Fig. 1) through "three-way" valves 32 and through a similar valve and flexible piping to the cylinders 33 (Figs. 12 and 13) mounted on the upper collar 26 of the clamp. The crossheads 22 are made in halves and bolted together as shown, and the thrust of the rams 23 is taken by suitable cotter pins 34. The lower clamp 20 (Fig. 1) might also be constructed to operate by conical contacts, springs, and oil pressure rams if desired.

The procedure in inserting the weight bars and transformer is to grip the lower clamp while setting the upper clamp at the top of its stroke, then grip by the upper clamp, release the lower clamp, and by regulating the oil valves 32, lower the rams 23 with their load to the end of the down stroke, then grip the lower clamp again while re-setting the upper clamp at the top of the next stroke. The brake drum on the cable drum 6 (Fig. 1.) is a safety appliance as a security in case of a clamp slipping. When all the weight bars and transformer sections have been inserted in the well, it becomes necessary to connect up the well service cable 5.

The joint for this is shown on Fig. 4 and described later on. As the cable 5 is of smaller diameter than the transformer, the stuffing box

14 must be completed. To do this, the upper clamp is refitted with a different set of gripping segments to suit the smaller diameter, and then gripped to hold the weight while the lower clamp 5 is similarly refitted, and also the casting 18 is replaced by a similar one with its inside diameter and lower end extension suited to fit as a gland to the stuffing box 14 after the liner 17 and the cup leathers have been put in. This operation is done while the tapered joint of the cable 5 to the transformer column 13 is held as shown in Fig. 2, with the larger diameter filling the stuffing box 12. The lowering operations can then be continued as before, and if the weight of the material already inserted is not then more than sufficient to balance the gas pressure on the area of the throat of the stuffing box 12 it will generally do so immediately on the reduced area of the box 14, and then the lowering may be done by the more rapid method of turning the drum 6 and using the brake 8. When the correct depth has been reached the lower clamp and casting 18 are again dismantled and the holding clamp 35 shown at the top of Fig. 2 and in plan on Fig. 3 can be put in to hold the cable in place. Packing blocks or plates can be put under the flanges of the clamp 35 and the casting 16 to keep the weight off the gland packings.

Figs. 4, 5, and 6 illustrate the construction of the connection between the well service cable 5 which has a pair of conductors, and the transformer structure below, which requires several turns of these conductors to make up the primary circuit of the transformers and will be better understood after explaining the structure of the transformers illustrated in Figs. 7, 8, 9, and 11. The lower end of Fig. 1 shows a schematic diagram of the arrangement of the electric transformers with the primary circuits 36 in series, and the secondary internal circuits 37 connected to a common network of external heating circuits 38, putting all the secondary circuits in parallel in accordance with the construction shown in Figs. 7, 8, 9, 10 and 11. Only three transformer sections or units are shown in the diagram, but in practice there will usually be a much larger number, and sometimes several hundred.

The network is continuous all round the circumference of the transformers and is connected to the terminals 39 of the internal circuits at points diametrically opposite to each other.

In Fig. 1 the two portions of the network 38 shown on the right and left of the transformers are supposed (for illustration purposes) to be unfolded from quadrants of the circumference and to be actually connected together at the neutral points 40. The other two quadrants of the network are omitted from Fig. 1. In the construction shown in Figs. 7, 10 and 11, the neutral points 40 of the network are also connected to the neutral points of the internal circuits by the bars 41 passing through the structure and riveted to the lower ends of the internal circuits by the rivets 42. This item of construction is only for the purpose of strengthening the tie between the network and the transformer and has no electrical significance. The internal secondary circuit is constructed as a forging or casting in two parts, meeting along the line 43 in Fig. 11 (which is a plan of the lower end) to enable the parts to be assembled from opposite sides of the continuous primary circuit conductors 36, and those two parts are held together by the bars 41

and rivets 42 and also by the rivets 44 shown in Figs. 7 and 10.

Electric welding might be used to join these two parts of the secondary circuit 37. An elevation of part of the external secondary circuit network is shown in Fig. 9. The crosses on this figure show the spots where the wires are welded together and to the terminals 39 of the internal secondary circuit and to the rings 46.

Fig. 10 shows a plan of one terminal 39 at the top of the internal secondary circuit in relation to the external network 38 and to the bar 41 which is riveted to the lower (or neutral) end of the next unit above. For the sake of preserving the alignment of the meshes of the network 38 and to tie them into the transformer, a semi-circular bar 45 is welded on to each side of the bar 41 at the points marked by crosses in Fig. 10 which are always neutral points in the circuit.

The bars 45 are wrapped with asbestos insulation along the rest of their length, and split metal rings 46 are turned round the bars 45 and electrically welded to successive points on the network 38, which are subject to fluctuation of potential above and below the neutral point. For instance, the first ring may fluctuate $\frac{1}{2}$ a volt above and below the neutral, the second ring 1 volt, the third $1\frac{1}{2}$ volts and the fourth ring 2 volts at the point where it joins the network 38 and also the terminal of the internal circuit 39. The voltage on the opposite side of the centre line will vary in the same proportion in the other direction, making a total difference at the terminals of the internal circuit four volts in the case assumed for illustration.

In Fig. 7 the horizontally shaded parts 47 represent the laminated core of the transformer, and in Figure 8 the shape of the sheets is shown in the unshaded area 47, these sheets being assembled from opposite sides of the primary and secondary internal circuits and overlapped at their joints 48 in the usual way. A dot and dash line 49 indicates the approximate centre of the lines of magnetic flux. The core is in general harmony with ordinary transformer practice, except that shellac and paper are not used, on account of the temperature being liable to damage those materials. Asbestos and mica sheets are used to insulate the edges of the laminated core where it adjoins the secondary circuit at 50 and between the core and the network 38 at 51. Shields of steatite may be placed in the diamond mesh spaces of the network as shown in elevation at 52 in Fig. 9, and in plan on Fig. 8. Another piece of steatite is placed at 53 (Fig. 7) on top of the centre section of the core and under the bar 41. All other spaces between the parts of the transformers already mentioned are filled with asbestos, talc, or other insulating material not liable to become charred, and which can be easily packed and afterwards impregnated with oil. The primary circuit conductors 36 are insulated with asbestos in several layers to provide insulation suitable for 1000 volts or sometimes more. Fig. 8 shows three turns of the primary circuit and one secondary turn. It will be readily understood that the planning of these circuits is amenable to variations without altering the main feature of the invention, which is the combination of a primary circuit in series through a number of separate transformer units with the secondary internal circuits, generating a very low voltage current, delivered to separate or parallel external circuits, and all built up in a column or cable suitable for suspension in a gas well. Any

alteration of grouping of the parts of the transformer units which does not change their functions, and is within the scope of known practice in ordinary transformer construction, is intended to be included as a possible part of this invention. Another point capable of variation is the feature described for holding the network by the bars 45 and rings 46. This is designed to suit the cases where it is desired to keep the transformer units close together.

In some cases this is not necessary, and if they are spaced a few inches apart, the network wires can be bent inwardly and bound tight in a recess of a reel shaped block of insulating porcelain, silica, or steatite, such as shown on Figs. 15 and 16 at 72, by some binding wire with insulating material inserted over the network to prevent short circuiting the wires.

Having described the arrangement of primary conductors in the units of the transformers with three turns, the features of Figs. 4, 5 and 6 will be more clearly understood. The service cable 5 shown at the top of Fig. 4 may be a twin conductor cable, insulated for 1000 volts or more, with material not necessarily suited to high temperatures, but not using rubber or other material liable to deteriorate when exposed to oil, unless protected by lead sheathing. The cable must, however, have a very strong external armoring of steel wire or tape in one or more layers, to bear the tensile stresses of suspension in the well.

This service cable is therefore not usually suitable for extension through the transformers as a primary circuit, and is therefore jointed to the primary circuit as shown in these figures. The twin conductors from 5 are spliced to the terminals of the transformer primary at 54 in Fig. 4, where one conductor is behind the other as shown in Fig. 5, which is a plan on top of a porcelain, silica or glass block 55 having holes for the passage of conductors, one pair of holes 56 having a connecting slot 57 near the top of the block with a semi-circular bearing for one conductor to turn over from one hole 56 to the other hole 56. This is the support for one pair of the primary circuit conductors, the insulated conductor being stripped bare to pass up through the block, over the bearing and down the other hole to be spliced to another insulated conductor below the block. The third pair of holes shown in Fig. 5 is not used, but a second block of the same pattern is placed a little lower down with the situation of the slotted pair of holes reversed, as shown in Fig. 6, to receive the next turn of the primary circuit at 58, while the turn which passed at 56 in Fig. 5 is spread to 59 in Fig. 6. This construction is adopted to give ample space to make the splice as at 60 in Fig. 4 without having another splice side by side, and to have the turn in the slot plugged with insulating material and ample space to make the insulation good for several hundred volts. The blocks 55 have recesses 55a on the outside circumference into which the suspending wires are bent and held by binding wires. Below the second block Fig. 6 the six conductors are re-arranged into parallel plan shown in Fig. 8 and the intervening spaces packed with insulation. The wire armoring 61 of the cable 5 is bent back over a tapered thimble 62 and gripped in that position by the network wires from below being turned over a similar thimble 63 tapered the other way, and held by the binding wire 64 spliced and welded to take the suspended load. In making this joint, the space round the splices 54 is packed with insulating material, and hard

segments of steatite 65 are inserted between the thimble 62 and the block 55. The first, or uppermost unit of the transformer, below the primary suspension block 55, is placed at a sufficient distance to give a network resistance, from the top of the transformer terminals to the block 55, not less than the normal resistance on the zig-zag mesh circuit from the terminals to the neutral point. A similar precaution is taken below the lowest transformer to the porcelain blocks 66, 67 and 68 (Fig. 15) which provide turning points for the three pairs of primary conductors (shown in dot and dash lines) with space for splices 69, 70 and 71, and slots for the turns arranged as shown in the plans of the blocks 66, 67 and 68 in Figs. 17, 18, and 19. Another porcelain block 72 may be used (Figs. 15 and 16) below the bottom transformer unit with an insulating binding over the network of the same kind as used for the alternative binding between the transformers when there is room for that construction.

Three of the lowest transformer units are indicated on Fig. 15 by the U shaped internal secondary circuits 37.

Below the block 68 comes the terminal metal fork 73 Fig. 20, to which the weight bars 74 are attached by pins 75. The metal fork has a neck into which the network wires are bent and bound at 76. The weight bars are preferably solid and have holes 77 and flats 78 provided to facilitate handling at the well head. The whole of the transformer section may be impregnated with oil, and also bound up in tarred fabric for protection in transportation and insertion to the well. When the heat is applied the tar will melt off and the fabric disintegrate, leaving the network 38 directly exposed to the gas and oil spray.

The normal condition in operating the apparatus is to regulate the voltage at the supply transformer 3 (Fig. 1) to obtain a temperature of the gases issuing from the well with a margin of a few degrees above freezing point.

Various details of the construction, as hereinbefore described and illustrated in the drawings may be modified without departing from the scope and intention of the invention, the novel features of which I claim as follows:—

1. In a natural gas well suspended heater operated by electricity, the combination of a multiple system of alternating transformers arranged in a vertical column with the high voltage primary circuit placed in passages surrounded by the laminated iron cores of a plurality of transformer units, and said primary circuit passing in series through said units and bending over insulating blocks at the top and bottom of said column to form turns in the circuit, each transformer unit having a separate internal secondary circuit with the active portions placed in the same passages through the cores, and having terminals brought to the outside circumference of said cores, and there connected to the external heating circuits assembled round the said transformer units.

2. In a natural gas well suspended heater operated by electricity, the combination of a multiple system of alternating current transformers arranged with the high voltage primary circuit passing in series through a plurality of transformer units having their internal secondary circuits separate from one another, and arranged to supply a low voltage current to external heating circuits, forming part of the combination, assembled round the said transformer units, and combined with a stuffing box structure at the well

head, to prevent the escape of gas at that point, and mechanical devices consisting of clamps to grip the transformer structure and suspending cable, and rams to force the said structure and cable through the stuffing box structure, and means of suitable type for operating the said clamps and rams to insert the said transformer structure and suspending cable into the well against a gas pressure.	80
3. In a natural gas well suspended heater operated by electricity, the combination of a multiple system of alternating current transformers arranged with the high voltage primary circuit passing in series through a plurality of transformer units having their internal secondary circuits separate from one another, and arranged to supply a low voltage current to external heating circuits, forming part of the combination, assembled round the said transformer units, and combined with a stuffing box structure at the well head, to prevent the escape of gas at that point, and mechanical devices consisting of clamps to grip the transformer structure and suspending cable, and rams to force said structure and cable through the stuffing box structure, and means of suitable type for operating the said clamps and rams to insert the said transformer structure and suspending cable into the well against a gas pressure, and combined with weight bars attached to the lower end of the said transformer structure to assist the process of insertion of the said transformer structure and suspending cable through the said stuffing box against the gas pressure.	85 90 95 100 105
4. In a natural gas well suspended heater operated by electricity, the combination of a multiple system of alternating current transformers arranged with the high voltage primary circuit passing in series through a plurality of transformer units having their internal secondary circuits separate from one another, and arranged to supply a low voltage current to external heating circuits, forming part of the combination, assembled round the said transformer units, and combined with a stuffing box structure at the well head, to prevent the escape of gas at that point, and mechanical devices consisting of clamps to grip the transformer structure and suspending cable, and rams to force said structure and cable through the stuffing box structure, and means of suitable type for operating the said clamps and rams to insert the said transformer structure and suspending cable into the well against a gas pressure, and combined with weight bars attached to the lower end of the said transformer structure to assist the process of insertion of the said transformer structure and suspending cable through the said stuffing box against the gas pressure, and combining the feature of having the external secondary circuits of the transformer units connected in parallel as a network of wires assembled round the transformer structure and while acting as the heating elements in direct contact with the gas, also serving as a suspending support to the said structure.	110 115 120 125 130 135 140 145 150

E. C. THRUPP.