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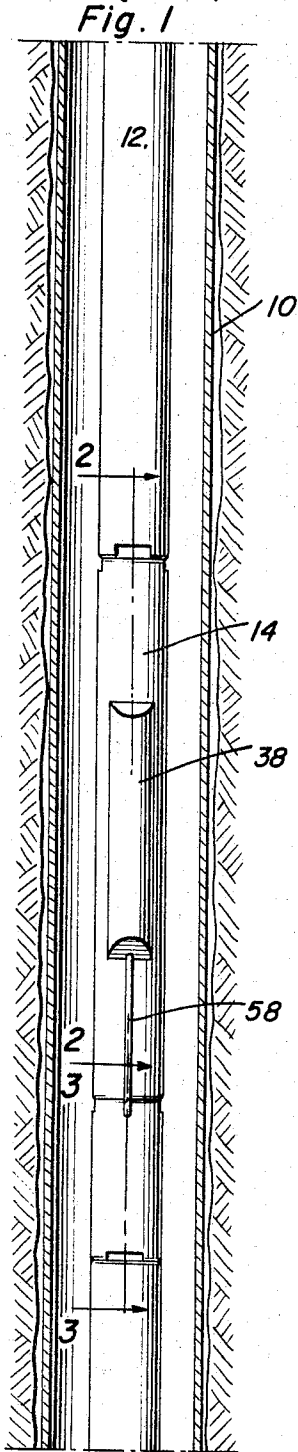
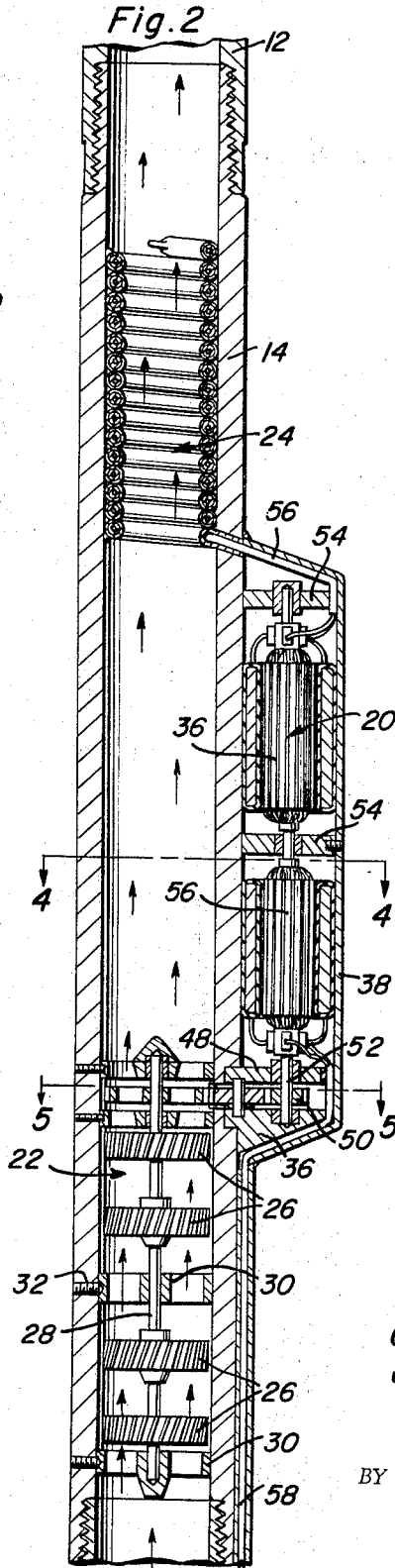
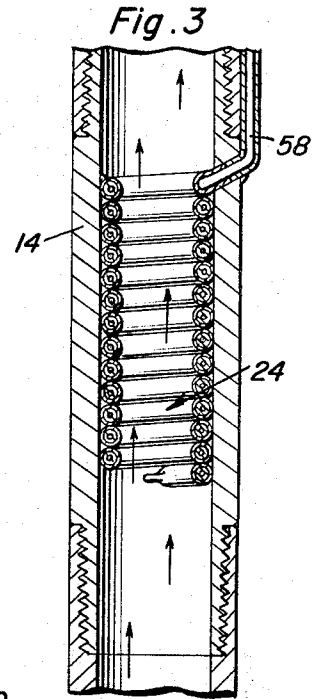
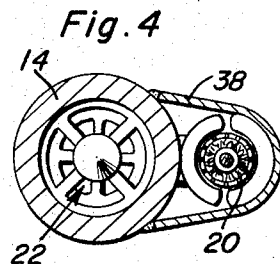
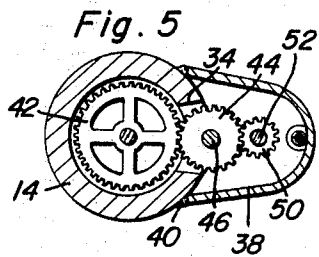
G. S. COTTER ET AL

3,342,267

TURBO-GENERATOR HEATER FOR OIL AND GAS WELLS AND PIPE LINES

Filed April 29, 1965

2 Sheets-Sheet 1



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Fig. 6

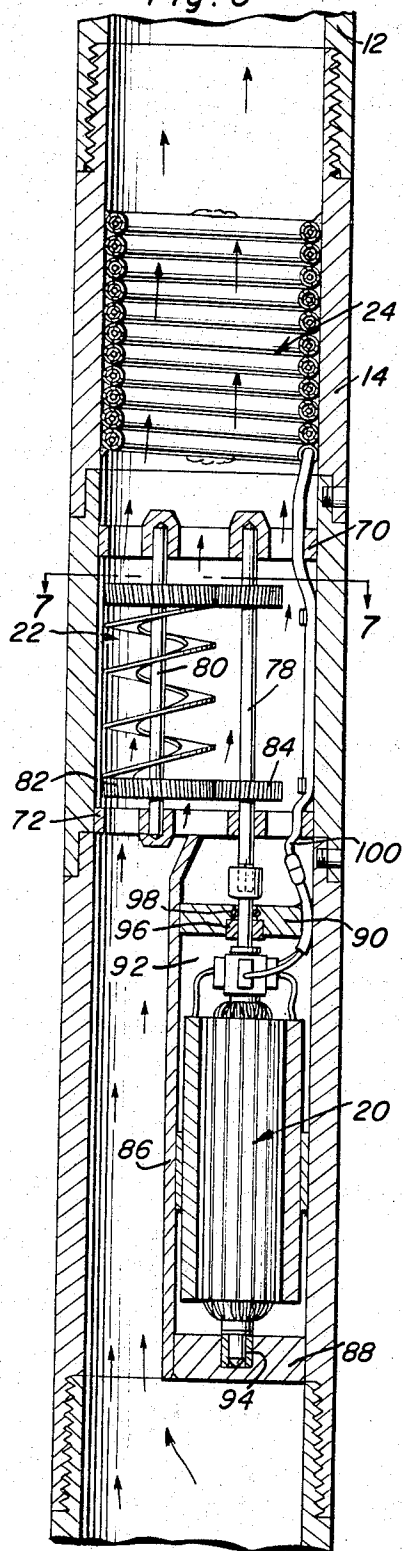


Fig. 7

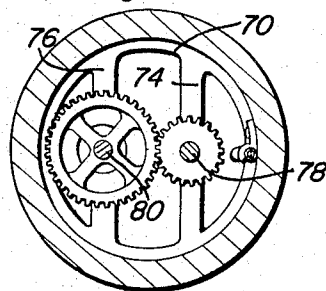
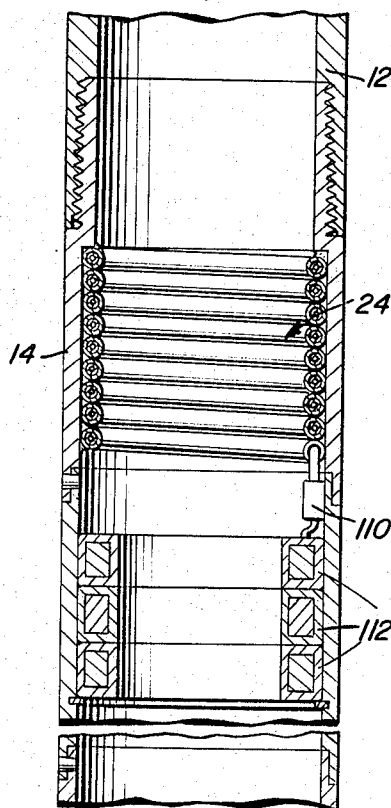


Fig. 8



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TURBO-GENERATOR HEATER FOR OIL AND GAS WELLS AND PIPE LINES

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ABSTRACT OF THE DISCLOSURE

A device associated with the production tubing string of oil wells or oil carrying pipe lines for applying heat thereto, such as for preventing or removing paraffin deposits, by providing a pipe line or production tubing associated turbo-generator powered by the flow of fluid in the pipe line or production tubing whereby electrical current so generated is utilized to actuate an electrical heating means.

This invention comprises a novel and useful turbo-generator heater for oil and gas wells and pipe lines and more specifically relates to a device associated with the production tubing string of oil wells for applying heat thereto for various beneficial purposes.

In deep wells for producing petroleum and in pipe lines a problem often arises from the condensing of paraffin from the oil during its flow through the tubing string or pipe line thereby forming paraffin deposits which obstruct or even cut off flow through the tubing string or cause other problems necessitating an expensive shut-down and repairs before the well can be restored to normal operation. Further, in some instances water or other fluids may freeze in the tubing string or pipe lines.

It is therefore the primary object of this invention to provide a device which may be readily incorporated into or associated with tubing strings and pipe lines in an intimate heat exchange relation such that adequate heat may be supplied to the adjacent portion of the string for elevating the temperature of the oil sufficiently to preclude the formation of or to remove paraffin deposits, to prevent freezing or to heat the flowing oil for other purposes.

A further object of the invention to provide a device in accordance with the preceding object which shall be incorporated into the tubing string or pipe line to form a part thereof thereby facilitating locating of the device at any predetermined region in a well bore which requires thermal treatment.

A still further object of the invention is to provide a means in accordance with the foregoing objects whereby the heating unit may be so associated with the tubing string that it may form a part thereof and be manipulated thereby in a well bore and yet will offer a minimum obstruction to flow through the tubing string itself.

A still further important object of the invention is to provide a device in accordance with the preceding object wherein the means for generating the heat may be disposed entirely in the well bore and preferably within or upon the tubing string so as to be completely independent from the source of energy at the surface of the well bore.

A further and more specific object of the invention is to provide a device in compliance with the foregoing objects which shall include an electric generator which is energized by a turbine subject to and operated by the flow of well fluid in the tubing string or flow of fluid in a pipe line and which generator shall supply electrical energy to heating coils disposed in intimate heat exchange relation with the tubing string.

A still further and more specific object of the invention is to provide an installation in accordance with the preced-

ing objects therein the electrical heating coils are incorporated into a tubing string or pipe line and may be energized by electric storage cells likewise incorporated into a tubing string.

A further and more general object of the invention is to provide a heating means adapted to be associated generally with pipe lines for the purpose of heating the fluid flowing therethrough and adapted to be energized by a turbine in turn operated by the fluid flowing through the pipe line or from any other source of electrical energy.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a view in vertical central section through a portion of a well bore showing therein a tubing string having the turbo-generator heater of this invention incorporated therein;

FIGURE 2 is an enlarged detail view taken in vertical transverse section substantially upon a plane indicated by section line 2—2 of FIGURE 1 and showing a preferred installation of the heating means in accordance with this invention;

FIGURE 3 is a further detail view taken upon an enlarged scale in vertical transverse section substantially upon the plane indicated by section line 3—3 of FIGURE 1 and showing in particular the heating coil arrangement of the invention.

FIGURES 4 and 5 are horizontal sectional views taken substantially upon the plane indicated by section lines 4—4 and 5—5 respectively of FIGURE 2;

FIGURE 6 is a view similar to FIGURE 2 but showing a modified construction in which the generator unit is housed within the tubing string;

FIGURE 7 is a detail view in horizontal section taken substantially upon a plane indicated by section line 7—7 of FIGURE 6; and

FIGURE 8 is a fragmentary view in vertically longitudinal section showing a still further modification in which the heating coils are powered by electric storage battery means.

Reference is made first to the embodiment of FIGURES 1—5 which exemplifies a preferred installation adapted for a producing oil well. It is to be emphasized however, that a well tubing is merely one particular form of pipe line to which this invention is applicable and that the showing and description of the invention to a well tubing as set forth hereinafter is not to be construed as limiting the invention thereto.

In the accompanying drawings there are disclosed three exemplary manners for carrying out and practicing the principles of this invention. Thus, FIGURES 1—7 disclose an electrical heater element in good heat exchange relation with a tubing string or pipe line and energized by an electrical generator which in turn is driven by a fluid turbine subjected to the flow of fluid through the tubing string or pipe line. Whereas in the embodiments of FIGURES 1—5 the generator is shown mounted upon but exteriorly of the tubing string or pipe line, in FIGURES 6 and 7, it is shown as housed therein. In the embodiment of FIGURE 8 the electric heating element and the source of electrical energy are both shown as housed within the tubing string or pipe line with the heating source consisting of electric storage batteries or cells. All forms of the invention are characterized by the close proximity of the source of electrical energy to the heating element and the location of the energy source remote from the surface of the well bore containing the production tubing or the end of a pipe line upon which the installation is mounted.

Embodiment of FIGURES 1-5

The embodiment of FIGURES 1-5 is illustrated as a heating installation incorporated into a production tubing string within an oil well bore. It will be appreciated, however, that the installation is equally applicable to any pipe line through which a fluid flows which is to be heated and is not limited to the illustrated environment of location within a well bore.

As illustrated, there is shown a conventional cased well bore 10 in which is positioned a production tubing string 12 by means of which oil produced by the well bore is brought to the surface of the ground. The invention is equally applicable to production tubing strings of wells which flow under their own formation pressure or to wells in which an artificial flow producing means is required. In either event, in this form of the invention, the energy of the fluid flowing through the production tubing string is utilized as a source of power to generate electrical energy for effecting the heating operation which is the primary purpose of this invention.

With more particular reference now to FIGURES 2 and 3 it will be observed that the tubing string 12 includes a tubing section 14 or if desired a plurality of detachably connected tubing sections, and which support and carry the various components of this heating installation. Thus, there is provided an electrical generating means indicated generally by the numeral 20 and which is operatively connected to a power source indicated generally by the numeral 22 and which preferably comprises a fluid turbine of the axial flow type together with heating elements each indicated generally by the numeral 24 which as illustrated consists of a pair of electrical resistance heating coils disposed at spaced locations within the tubing section or sections.

It will be appreciated that a single coil may be provided if it is desired to heat only one location within the tubing string or a plurality of such coils or heating elements may be utilized when it is desired to provide a more extensive heating region or a plurality of separate heated regions within the tubing string.

It is usually preferable to dispose the heating elements 24 within the tubing string in the interest of compactness, protection of the heating element and to facilitate their installation in a well bore. However, it is evident that tubing strings of unusually small diameter are employed and it is desired to not restrict their volume of flow, the heating elements may be disposed upon the exterior thereof in suitably protective housings and coverings.

Any suitable type of turbine 22 may be utilized for the purpose of this invention. In interest of adaptability to small diameter tubing strings, however, an axial flow type of turbine will usually be satisfactory of the multiple stage construction. Thus, by way of illustration, a plurality of axially spaced turbine rotors 26 are mounted upon a suitable turbine shaft or shaft sections 28 which in turn is journaled in suitable bearing means 30 within the tubing section or sections. The rotor cylinder may be detachably secured within the tubing sections as by means of removable fasteners 32 engaging the bearing members 30. The turbine is so disposed as to offer a minimum obstruction to flow through the tubing sections so as the fluid flows upwardly therethrough either under a formation pressure or under some artificial flow producing means, it will through its energy of flow operate the turbine rotors and thus impart rotation to the turbine shaft 28.

The turbine shaft in turn is mechanically connected to the electric generator unit 20 as for example by the gearing assembly shown in FIGURE 5. As will be noted, the tubing section or sections 14 have an opening 34 in one wall thereof and a mounting bracket 36 is disposed adjacent this opening. An enclosing housing as at 38 which may be removably secured and sealed to the tubing string, or may be permanently united thereto as by welding at 40.

A driving gear 42 fixed to the turbine shaft 28 engages an idler gear 44 suitably journaled upon an axle 46

mounted in the bracket 36 and a further mounting bracket 48, this idler gear in turn engaging a drive driven gear 50 fixed to a generator driving shaft 52. Within the housing 38 there is provided suitable bearing means such as those as indicated at 54 which rotatably journal the generator armatures 56. In order to reduce the cross-sectional area, the generators are preferably of an axially elongated type and one or more units may be disposed in axial alignment in order to give the requisite electrical capacity while maintaining the cross-sectional area at a minimum. The generators in turn are connected electrically as by conduits 56 and 58 to the heating element 24 disposed adjacent thereto.

It will thus be apparent that this installation offers the advantage that the heating source for the electrical heating element is disposed closely adjacent to the latter, that the heating element and the related heating source are all mounted upon and carried by the tubing string so that they will be readily manipulated into position in the well bore by appropriately positioning the tubing string therein and by properly installing and locating the heating installation during the makeup of the tubing string. A further advantage inherent in this construction is that the usual necessary electric cables to the surface or other means for supplying electrical energy to the heating elements and for controlling the application of such energy with the mechanical disadvantage attending such installations when the heating element is located in a deep well bore is completely overcome. The installation described can be readily controlled as by throttling the flow or velocity of flow in the tubing string thereby controlling the operation of the turbine.

Of course, if desired, other control means are to be applied to the generator itself for effecting the electrical energy applied to the heating elements and thus the heat output of the heating elements.

Embodiment of FIGURES 6 and 7

In the embodiment of FIGURES 1-5, the generator assembly of the installation was shown mounted upon the exterior of the tubing string. This is particularly advantageous when relatively small diameter tubings are utilized and there is insufficient cross-sectional area within the tubing string for the desired flow of fluid and for housing the generator unit. However, where the internal diameter of the tubing string is not a limiting factor, it will generally be found preferable to house the generator unit within the tubing string since this will eliminate obstructions and projections from the exterior of the tubing string thereby facilitating its manipulation within a well bore or in other environments. Such an arrangement is illustrated in the embodiments of FIGURES 6 and 7. Here the tubing string 12 is shown having tubing section or sections 14 in which is housed the components of the installation including the heating element or elements 24, the turbine assembly 22 and the generator unit or assembly 20. For convenience of illustration only one heating element 24 is illustrated although it will be understood that any desired number of heating elements may be provided as in the preceding embodiment.

In this embodiment, as shown in FIGURE 7, the interior of the tubing string section or sections 14 are provided with axially spaced supporting rings or spiders 70 and 72 each of which has a pair of transversely extending bearing supports 74 and 76. The supports 74 and 76 of the two spiders serve to rotatably journal the generating unit drive shaft 78 and the turbine driving shaft 80. The two shafts operatively connected together as by driving gears 82 on the turbine shaft engaging driven gears 84 upon the generator drive shafts.

In the lower portion of the tubing section or sections 14 there is provided an enclosing housing 86 having transversely extending partition plates as at 88 and 90 which extend entirely thereacross and thus isolate and seal a chamber 92 which contains the armature and coils

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of the generator unit 20 in a fluid tight sealed manner. Suitable bearings as at 94 and 96 and a sealing means as at 98 are provided in these partitions to rotatably journal the generator armature and to establish a fluid tight seal and isolation of the chamber 92.

It will thus be apparent that the turbine is disposed within the flowing fluid of the tubing string for operation thereby and in turn serves as a source of power to drive the generator 20, which latter is connected electrically as by the conduit means 100 to the heating element or elements 24 for energizing the latter. The operation of this form of the invention is identical to that previously described except for the location of the generator unit within the tubing string rather than upon the exterior thereof. However, as in the preceding form, the generator and the turbine may be disposed in axially aligned sections rather than as single units as illustrated for convenience in FIGURE 6.

Embodiment of FIGURE 8

In the two preceding embodiments, the source of power by which electrical energy is generated and supplied to the heating elements consisted of a fluid turbine operated by the energy derived from the flow of fluid through the production tubing. However, in some instances, it may be advantageous to employ a source of electrical energy which does not require the flow of fluid through the tubing string in order to generate the energy. Such an arrangement is illustrated in the embodiment of FIGURE 8 wherein the tubing string 12 is shown having an attached section or sections 14. With these sections there is disposed the heater 24 which as in the preceding embodiment may conveniently comprise an electrical resistance coil which is electrically connected by an attachable electrical connection 110 to a source of electrical energy such as a plurality of electric cells or storage batteries 112 each carried by the tubing section or sections. In the arrangement illustrated, these cells are shown of an annular configuration and disposed upon the interior of the tubing section or sections in such a manner as to offer a minimum resistance to flow of fluid therethrough and where they will be protected by the tubing string. It will be appreciated, however, that in other instances it may be preferred to mount either or both of the heating elements and the electrical energy source upon the exterior of the tubing string in suitable housings provided for that purpose. In this form of the invention, however, it will be understood that any suitable control means may be provided which can be actuated from the surface in order to selectively connect the cells 112 to the heating element 24 when the heating operation is desired. This arrangement is particularly useful in work-over installations wherein a string of tubing or pipe is utilized to effect a limited heating operation in a well bore or the like.

The cells 112 may be charged from a suitable source of line current, or they may derive their energy from a solar battery source at the surface of the ground, for example.

In the three specific embodiments just described, the application of the invention was particularly set forth in connection with the production tubing string of a well bore. However, it will be apparent that the same principles of generating and applying heat to a fluid flowing in a conduit is useful for other conduits than production tubing. Accordingly, it is to be understood that the same constructions and variations thereof previously described may be equally applied to any other pipe line regardless of whether the pipe line is in a well bore or in some other environment, for the purpose of effecting a heating in selected regions of the pipe line. With the invention applied to pipe lines in general, it will be observed that the same advantages as to consolidation of the heat source with the heating means at a particular region is obtained, while the generation of the heat can be effected

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either by utilizing the energy of a fluid flowing through the pipe line as in the embodiment of FIGURES 1-5 and 6, 7 or by a self-contained source of electrical energy such as the fuel cells of FIGURE 8 or from any other suitable source.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. An oil well production tubing heater adapted to be operatively associated with a well tubing at a point remote from the surface of the ground and comprising in combination a section of oil well tubing through which oil is produced, an electric heating element mounted upon said tubing section in good heat exchange relation therewith for heating production fluid flowing upwardly therethrough, a production fluid actuated source of electrical energy mounted upon said tubing closely adjacent said heating element and electrically connected to and energizing the latter for energizing said heating element from within the well, said energy source comprising an electric generator and driving means coupled thereto, said heating element being disposed within said tubing and of an annular configuration thereby presenting a minimum resistance to the flow of fluid therethrough, said driving means comprising a production fluid actuated turbine disposed within said tubing and operated by production fluid flowing upwardly through said tubing.
2. The combination of claim 1 wherein said generator is mounted upon and disposed exteriorly of said tubing.
3. The combination of claim 1 wherein said generator is mounted upon and disposed within said tubing.
4. An oil or gas pipe line heater installation comprising a pipe line section through which well production fluid and the like flows, an electric heating element mounted upon said section in good heat exchange relation therewith for heating fluid flowing therein, a source of electrical energy mounted upon said section closely adjacent said heating element and electrically connected to and comprising the sole source of electrical energy for energizing the heating element, said heating element being of an annular configuration thereby presenting a minimum resistance to the flow of fluid therethrough, said heating element being disposed within said tubing and comprising a helical electrical resistance element, said energy source comprising an electric generator and driving means coupled to said generator, and said driving means comprising an axial flow fluid turbine disposed within said tubing and operated by said well production fluid flowing through said tubing.
5. The combination of claim 4 wherein said generator is mounted upon and disposed exteriorly of said tubing.
6. The combination of claim 4 wherein said generator is mounted upon and disposed within said tubing.
7. The combination of claim 1 wherein said heating element is a helical electrical resistance coil having its outer diameter generally contiguous with the inner diameter of said tubing.
8. The combination of claim 1 wherein said production fluid actuated turbine comprises an axial flow turbine including a plurality of axially spaced turbine rotors mounted on a common shaft rotatably journaled relative to said tubing.
9. An oil well production tubing heater adapted to be operatively associated with a well tubing at a point remote from the surface of the ground and comprising, in combination, a section of oil well tubing through which oil is produced, an electric heating element mounted upon said tubing section in good heat exchange relation there-

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with for heating production fluid flowing upwardly there-
through, a source of electrical energy mounted upon said
tubing closely adjacent said heating element and electri-
cally connected to and energizing the heating element sole-
ly from within the well, said heating element being of an
annular configuration thereby presenting a minimum re-
sistance to the flow of fluid therethrough and said energy
source comprising storage cells.

10 10. An oil or gas pipe line heater installation compris-
ing a pipe line section through which well production fluid
and the like flows, an electric heating element mounted
upon said section in good heat exchange relation there-
with for heating fluid flowing therein, a source of elec-
trical energy mounted upon said section closely adjacent
said heating element and electrically connected to and
comprising the sole source of electrical energy for ener-
gizing the heating element, said heating element being of

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an annular configuration thereby presenting a minimum
resistance to the flow of fluid therethrough, said heating
element and said source being disposed within said tub-
ing, said heating element comprising a helical electrical
resistance element, and said energy source comprising
storage cells.

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