Aug. 29, 1961 R. M. STEPHENS 2,998,069

OIL WELL HEATER

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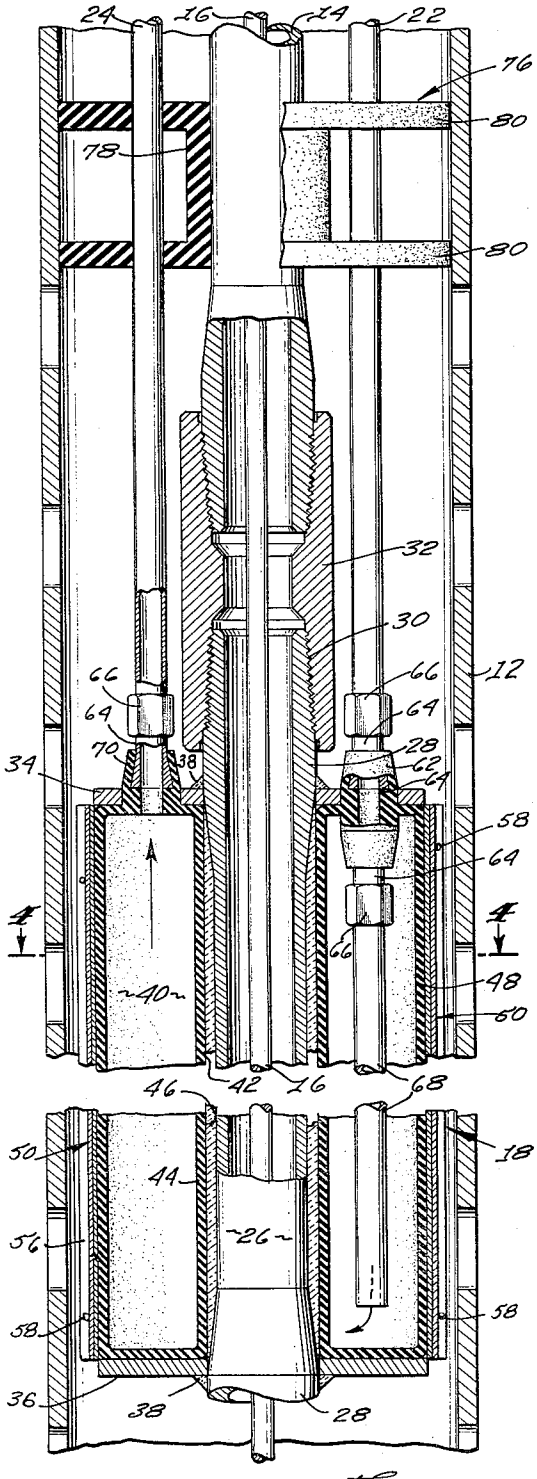


Fig. 2.

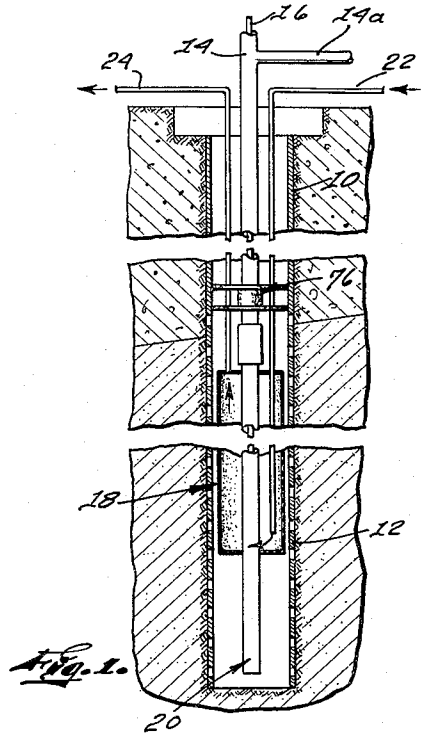


Fig. 1.

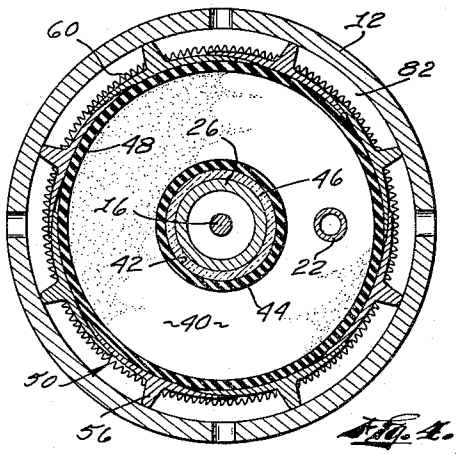


Fig. 4.

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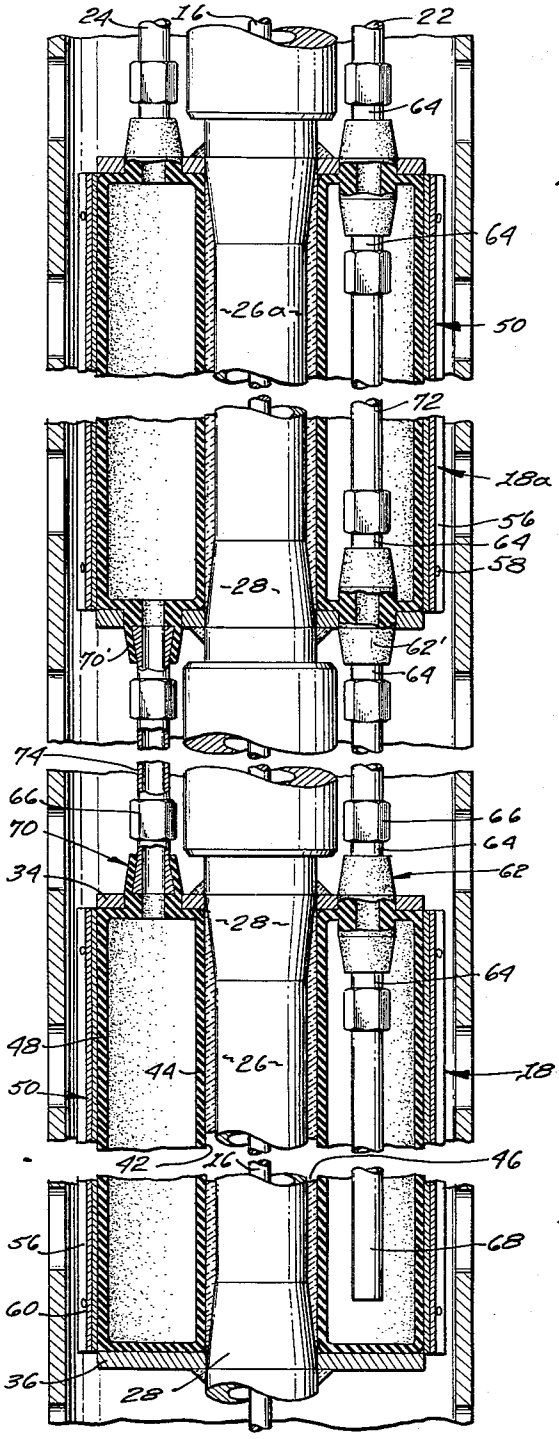


Fig. 3.

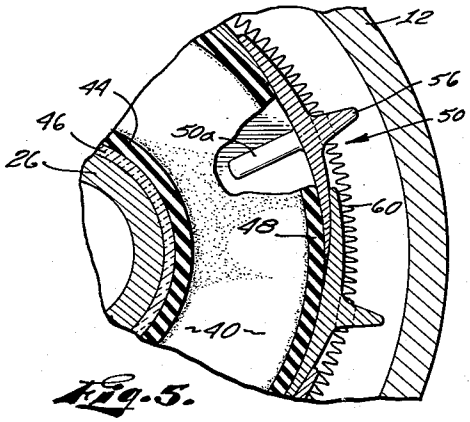


Fig. 5.

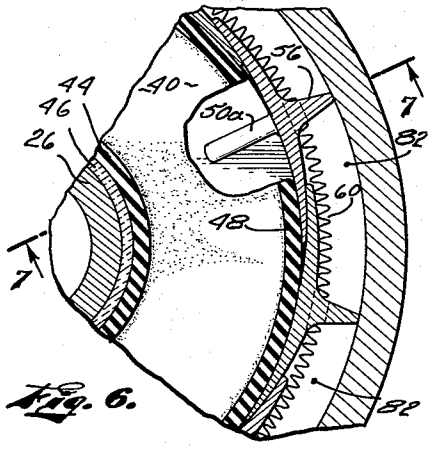


Fig. 6.

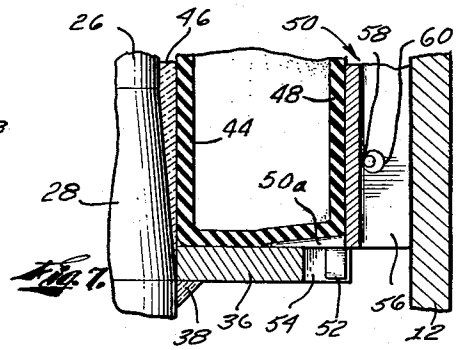


Fig. 7.

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OIL WELL HEATER

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13 Claims. (Cl. 166—61)

The present invention relates generally to oil well equipment and particularly to oil well heaters.

In oil producing wells it is well known practice to supply heat in the vicinity of the producing zone or zones in order to facilitate the flow of oil from the oil bearing sand and its pumping to the surface. In some geographic regions, due to the viscosity of the oil, such practice is necessary to enable the oil to be produced by pumping and accordingly a variety of oil well heater devices have heretofore been devised and marketed.

An object of my invention is to provide an improved oil well heater of the circulating hot-water type that is particularly useful in shallow wells down to approximately 2,000 feet, although not limited in use to shallow wells.

Another object of the invention is to provide a heater of this type that very readily can be lowered or raised in the well casing along with the oil string without any danger of being hung up. For this purpose I have devised a heater that when inoperative occupies a diameter substantially less than the casing but that when operative is expanded to engage the casing. This arrangement also facilitates recovery of the heater for purposes of repair thereto or to the pump, for other maintenance activities or in stripping the well.

Yet another object of the invention is to provide a heater of greatly improved heat-exchanging characteristics for a more efficient production of oil by pumping. By contrast with previously available devices, my improved heater is adapted to not only heat such oil as has penetrated the perforated liner but also the liner itself and thus the adjoining portion of the oil zone. This can advantageously be done with my invention since hot water rather than live steam is employed so that any danger of coking the oil sand is eliminated. This arrangement does not entail commingling of water or steam condensate with the oil or oil sand such as heretofore occurred inasmuch as the invention employs a closed circuit for the hot water which is entirely independent of the oil pumping circuit.

These and other objects and advantages of my invention will be apparent from the following description of a presently preferred embodiment thereof when taken in conjunction with the annexed drawings in which:

FIGURE 1 is a vertical central longitudinal section through an oil well schematically showing an embodiment of the present invention therein;

FIGURE 2 is a vertical central longitudinal sectional view on an enlarged scale of the heater device in operating condition;

FIGURE 3 is a view similar to FIGURE 2 showing a plurality of improved heater devices in use in a single oil well for heating the same or different oil bearing strata of a well;

FIGURE 4 is a transverse sectional view taken on the line 4—4 of FIGURE 2 and particularly showing the expanded condition of the heater;

FIGURE 5 is a partial transverse sectional view similar to FIGURE 4 on a further enlarged scale and showing the relative position of the parts of the heater when the heater is in retracted condition to permit its movement through the oil well casing;

FIGURE 6 is a view similar to FIGURE 5 but showing the relationship of parts when the heater is in fully expanded condition; and

FIGURE 7 is a partial vertical sectional view taken on the line 7—7 of FIGURE 6 and illustrating certain interior details of construction of the heater.

Referring to FIGURE 1, a producing oil well is shown having the usual casing **10** extending downwardly from the well head and a perforated liner **12** hung in an oil bearing zone. In order to lift the high viscosity oil from the oil bearing zone the well is provided with an oil string or pump tube **14** the lower end of which communicates with the barrel of a suitable pumping apparatus **20** of the sucker rod type, the sucker rod being indicated by the reference character **16**. As is usual the sucker rod **16** is adapted to be reciprocated by means (not shown) at the well head in order to lift oil through the pump tube **14** and a branch **14***a* to a suitable reservoir.

The heater, indicated generally by the numeral **18**, is adapted to be mounted integrally with one of the tube lengths making up the pump tube **14** and is positioned above the pump **20**. In general, the heater **18** comprises an annular hot water chamber of an expandable and contractible nature which is communicated with a source of hot water at the surface through suitable input piping **22** from which source hot water is pumped by means (not shown) down to the heater **18**. Suitable return piping **24** is provided to return water from the heater **18** upwardly to the surface to be re-cycled through a heat source and the input pump means and thence back through the input pipes **22**.

The details of construction of heater **18** can best be seen in FIGURE 2. In order to mount the heater in such a manner that it does not interfere with the communication of the pump **20** and pump tube **14** a mounting member **26** is employed which is a length of tube of the same size as the tubing comprising the pump tube **14**. In order to mount the heater **18** integrally with the pump tube **14**, the opposite upset ends **28** of member **26** are exteriorly threaded as indicated by the numeral **30** to be joined to the pump tube **14** at opposite ends of heater **18** by means of a coupling member **32**. With this arrangement the effective length of the pump tube **14** extends without interference from the well head to the pump **20** so as not to interfere with the free lifting of oil therethrough and the operation of sucker rod **16** therein.

A pair of annular plates **34** and **36** are concentrically rigidly affixed, as by welding **38**, to the upset ends **28** at the upper and lower ends respectively of the mounting tube **26**. These plates are adapted to support therebetween a tubular heater bag **40** of the same length as the vertical distance included between the plates **34** and **36**. As is indicated in FIGURE 2, the bag **40** is made of a resilient waterproof material molded in such a manner as to define a longitudinally extending central passage **42** through the bag preferably having the same diameter as the external diameter of the upset ends **28** of the mounting member **26**. An annular space is thus defined between the inner wall **44** of bag **40** and the reduced diameter portion of mounting member **26** adapted to be packed with an insulating jacket **46** of a suitable material adapted to prevent the exchange of heat between the hot water in bag **40** and the oil passing upwardly through the pump tube **14**. The heat of the hot water pumped into the bag **40** is thus utilized in inducing the flow of oil from the oil strata into the pump rather than being used in heating oil already present within the pump system.

The bag **40** is confined around its outer wall **48** by a plurality of vertically extending slat members **50** which are mounted on the plates **34** and **36** for movement in a radial direction by tongue and groove means such as are seen in FIGURE 7. This figure shows the lower end of a slat member **50** formed with a downwardly extending tongue **52** adapted for slidable engagement

with a radially extending slot 54 formed in the lower plate 36. Although not shown, it is to be understood that a similar tongue and groove connection 52, 54 is defined at the upper end of each slat 50 with the upper plate 34. A web 50*a* is formed at each end of slats 50 on the rear face thereof to slidably engage the plates 34, 36 whereby the slats are held by the plates against vertical displacement.

The configuration of slats 50 can best be seen in FIGURES 4 through 7, in which it will be observed that each slat 50 is substantially arcuate in transverse section and formed with a longitudinally extending central rib 56 on its outer face. Each slat 50 is adapted for overlapping slidable engagement along the opposite longitudinal edges thereof with each of its neighboring slats 50 in the manner shown in FIGURES 5 and 6. When the heater 18 is inoperative so that the bag 40 is empty of water as indicated in FIGURE 5, the outer wall 48 of bag 40 defines a diameter such that the slats 50 can be moved radially inwardly to a position in which the diameter defined by the outer edges of ribs 56 is substantially less than the inside diameter of the liner 12, thus permitting free vertical movement of the heater 18 within liner. In order to maintain the slats 50 in this contracted position when the heater 18 is inoperative, each rib 56 is formed with an aperture 58 in each end thereof, as indicated in FIGURE 7, adapted to receive a compression spring 60 that encircles all of the slats 50.

In order to communicate the interior of bag 40 with the hot water input pipe 22, the bag at its upper end has integrally formed therein a nipple 62 which extends both inwardly and outwardly through a suitable aperture of the upper plate 34. A flared end of a tubular stud 64 is molded into each end of nipple 62, the other end of each stud 64 being exteriorly threaded whereby the upwardly or exteriorly extending stud 64 can be joined to the lower end of input pipe 22 by a union nut 66, and the downwardly or interiorly extending stud 64 similarly joined to a tailpipe 68. Hot water from the surface source is thus admitted to bag 40 and due to the tailpipe extension of input pipe 22 is discharged into the lower interior region of the bag to subsequently flow upwardly towards the bag outlet.

After the water heat has been utilized to induce the flow of oil adjacent to the heater, the water passes from bag 40 to an outlet nipple 70 in the bag's upper end. The nipple 70 is formed similarly to inlet nipple 62 but extends only upwardly or exteriorly through an aperture of upper plate 34 and has but one stud 64 which is connected to return pipe 24 by another nut 66. A hot water circuit is provided by this arrangement which does not involve an escape of water into the oil being heated.

An arrangement is shown in FIGURE 3 for utilizing a plurality of heaters in a single well. For this purpose substantially identical heaters can be employed, the only modification being in the provision of additional segments of hot water input and return pipes, and suitable coupling means therefor.

The lowermost heater illustrated in FIGURE 3 is identical to the heater 18 previously described and therefore includes the tailpipe 68 through which the hot water first escapes from the input pipe system 22. Every higher heater 18*a* is preferably adapted to pass the input pipe system 22 therethrough without receiving any hot water and for this purpose each heater 18*a* includes at its lower end a nipple 62′ having studs 64 axially aligned with the similar nipple 62 at the upper end of the heater. The inwardly extending studs 64 are communicated by a length of pipe 72 connected to the studs by nuts 66, and the exterior stud 64 at the lower end of the higher heater 18*a* is communicated with the next lower heater (in this case with lowermost heater 18 by a suitable length of pipe 74 held at each end on studs 64 by other nuts 66.

For receiving its hot water supply and for returning water to the surface, the bag of each higher heater 18*a* is formed with a nipple 70′ in its lower end similar to the upper end nipple 70. Another pipe 74 communicates the stud and nipple 70 of lower heater 18 with the stud and nipple 70′ of the higher heater 18*a* and is securely held in place by nuts 66.

In the use of the heater 18 it is joined up with the oil string or pump tubing 14 at the surface and with its piping 22, 24 is lowered into place along with the tubing 14. At a point just above heater 18 a double walled insulator 76 (see FIGURE 2) is mounted on the string of tubing 14. The insulator 76 is preferably made of an elastomeric material and includes a central hub portion 78 adapted to concentrically mount the insulator 76 on the pump tubing 14. At opposite ends of the hub portion 78 a pair of radially extending walls 80 are formed in the insulator, the walls 80 having diameter appreciably greater than the inner diameter of the liner 12 so that when the insulator is in place in the liner the peripheral edges of the walls 80 are compressed against the liner to substantially define a fluid seal therebetween. The insulator 76 and the space between the walls 80 prevent heat loss of the oil thereunder in the liner 12 and the insulator 76 also acts as a packer to prevent any upward migration of the oil. It will be observed that insulator 76 is provided with suitable aligned apertures through the walls 80 thereof to permit the passage of the pipes 22 and 24 therethrough.

During the lowering of the device in the well casing, the springs 60 confine the slats 50 and the rib portions 56 thereof to a diameter less than the inner diameter of the casing 12 whereby the device can freely be lowered to the desired position. When the heater 18 is in place opposite an oil bearing strata, the pipes 22, 24 are hooked up in a recycling circuit which includes a source of a heated fluid, preferably water, which is then pumped down through the input pipe system 22 to be discharged from the tailpiece 68 into the lowermost region of bag 40. In response to the pressure of this fluid, the slats 50 are forced to expand until the ribs 56 thereof contact the liner 12 whereby the slats 50 and the liner define a series of vertically extending passageways 82 around heater 18 through which oil can migrate downwardly in heat exchanging relationship with the heater. Heat from the circulating fluid is absorbed by the slats 50 which transmit a portion of the heat to the liner 12 through the medium of the ribs 56. With this arrangement the portion of the oil bearing strata outwardly adjacent the liner 12 is subjected to heat in order to liquify the heavy oil present in this strata which then migrates through the perforations of liner 12 and downwardly in heat exchanging relationship with heater 18. At the same time, the insulating jacket 46 inhibits the exchange of heat between the circulating fluid contained in bag 40 and oil being pumped upwardly through the pump tubing 14 so that more of the heat of this circulating fluid is utilized in causing the migration of oil downwardly past heater 18 towards the pump 20.

When the oil strata opposite which heater 18 is disposed is depleted, the heater can be lowered to a productive portion of the oil strata by collapsing the bag 40 and slats 50. This can be accomplished by first evacuating water from the circulating system comprising pipes 22, 24 and the bag 40 by connecting a source of air pressure, for example, to one of the pipes 22, 24 to evacuate the water through the other of these pipes and force it back to the surface. After all water has been evacuated from the system the springs 60 will then cause collapse of the heater 18 to a diameter smaller than that of the casing whereby it can be lowered to the desired new position (or lifted out of the well). In the event that the springs 60 do not collapse the heater 18 a vacuum source can be connected to one of the pipes 22, 24 in order to reduce the internal pressure of the bag 40 and thus permit springs 60 to contract the slats 50.

When a series of heaters is employed as in FIGURE 3, the input hot water is discharged through the tailpipe **68** of the lowest heater **18**, thereafter to circulate upwardly through the higher heaters **18***a* via the return pipe system including the pipe **74** and studs and nipples **70'**. Although a difference in temperature is present as between water contained in the lowest heater **18** and water contained in the highest heater **18***a*, this difference is compensated for somewhat by the fact that the pipes **72** which carry input hot water through the higher heaters **18***a* are uninsulated whereby fluid in the higher heaters **18***a* absorb some heat from water passing downwardly through the pipes **72** and this arrangement will tend to even out the temperatures as among the several heaters employed.

It will be apparent to those skilled in the art that many widely differing embodiments of the present invention can be made. It is to be understood that the invention is not intended to be limited to the specific details illustrated and described herein, other than as set forth by the spirit and scope of the following claims.

I claim:

1. Well heating apparatus, comprising: means mounted on a tubular string of a well adapted to define an annular heating chamber around said string and having an expandable outer wall normally defining a diameter less than the diameter of a well bore in which said apparatus is to be set to facilitate movement of said apparatus to a desired position in said bore; and means for circulating a heated fluid under pressure through said chamber to expand said outer wall into contact with said bore.

2. Well heating apparatus, comprising: a tubular expandable bag defining an annular heating chamber and having a passage adapted to receive a tube therethrough; means for mounting said bag around said tube; a plurality of rigid members extending longitudinally of said bag and circularly grouped therearound to substantially confine said bag around said tube, said members being movably mounted on said bag mounting means; means yieldably confining said members and bag to a diameter less than the diameter of a well bore in which said apparatus is to be set to permit free movement of said apparatus in said bore; and fluid circulation means for communicating the interior of said bag with a source of heated pressure fluid whereby said bag can be expanded under the pressure of said fluid when said fluid is circulating to move said members outwardly into engagement with said bore.

3. Well heating apparatus, comprising: double walled means defining a substantially fluid sealed annular heating chamber, the outer wall of said means being adapted for expansion and retraction in response to internal fluid pressures in said chamber, said means in unpressurized condition occupying an outer diameter less than the diameter of a bore in which said apparatus is to be set to facilitate movement of said means in said bore during installation and removal thereof; means for circulating a heated fluid through said chamber, the outer wall of said chamber expanding in response to the pressure of said heated fluid to contact said bore in heat exchanging relationship; and a means for supporting said double-walled means in said bore.

4. Oil well heating apparatus, comprising: a tubular support adapted to be coupled into communication with an oil string to substantially comprise a portion of said string; double walled generally tubular means mounted on said support defining an annular fluid sealed heating chamber around said support and including an expandable outer wall that normally defines an outer diameter less than the inner diameter of a well casing to permit movement of said tubular means during installation and removal of said apparaus; insulating means interposed between said support and an inner wall of said tubular means to inhibit the exchange of heat between said heating chamber and oil in said support; and means for circulating a heated fluid through said chamber, the outer wall of said chamber expanding in response to the pressure of said heated fluid to contact said casing in heat exchanging relationship.

5. Oil well heating apparatus, comprising: a generally tubular expandable bag of a resilient material defining an annular substantially fluid sealed heating chamber and having a central axial passage adapted to receive a portion of an oil string therethrough; means at opposite ends of said bag for concentrically supporting said bag on said oil string; a plurality of rigid members movably mounted on said support means adapted to lie adjacent an outer wall of said bag to substantially enclose said bag; means yieldably confining said members to a diameter less than the inner diameter of a well casing in which said apparatus is to be set to permit free movement of said apparatus in said casing; and means for circulating through the interior of said bag a heated pressure fluid whereby said bag is expanded under the pressure of said fluid to move said members outwardly into engagement with said casing.

6. Oil well heating apparatus, comprising: a tubular expandable bag of a flexible material defining an annular heating chamber and having a central axial passage adapted to receive a portion of an oil string therethrough; means at each end of said bag for concentrically supporting said bag on said oil string; a plurality of elongate, rigid members movably mounted on said bag support means and adapted to confine said bag between said members and said oil string, each of said members on the outer face thereof having a projecting portion adapted for engagement with a well casing when said bag and members are radially expanded whereby oil passage means is provided between said members and said casing for oil to pass in heat exchanging relationship therebetween; spring means on said members yieldably confining said members to a total diameter less than the inner diameter of said casing; and means for circulating through the interior of said bag a heated pressure fluid whereby said bag is expanded under the pressure of said fluid to move said members outwardly for engagement of said projections with said casing.

7. Oil well heating apparatus, comprising: an elongate tubular support having opposite ends adapted for coaxially coupling said support into an oil string; a pair of annular plates each of which is concentrically rigidly affixed to one of the ends of said support; an expandable bag made of an elastic material concentrically mounted around said support between said plates, said bag defining a fluid sealed heating chamber and said bag being formed with an axial central passage through which said support extends, the inner wall of said bag defining said passage having a diameter greater than the outer diameter of the intermediate portion of said support between said ends thereof; a layer of an insulating material in the annular space defined between the inner wall of said bag and said support to inhibit the exchange of heat between said heating chamber and oil passing upwardly through said support; a plurality of elongate slat members movably mounted at opposite ends thereof on said plates and adapted to circumferentially enclose said bag between said slat members and said support, said slat members when said bag is in uninflated condition defining an outer diameter which is less than the interior diameter of a casing in which said apparatus is to be set; and means communicating the interior of said bag in a circulatory system with a source of a heated fluid, the pressure of said fluid causing radial expansion of the outer wall of said bag and said slat members whereby said slat members engage said casing.

8. An oil well heating apparatus, comprising: an elongate tubular support adapted to be coupled into communication with an oil string to comprise a portion of said string; a pair of rigid annular plates each of which is concentrically affixed to an end of said support; a tubu-

lar bag of an elastic material concentrically mounted on said support between said plates and defining an annular fluid sealed expandable heating chamber; insulating means between an inner wall of said bag and said support to inhibit the exchange of heat between said bag and oil in said string; a plurality of slat members slidably mounted at opposite ends thereof on said plates and adapted to circumferentially enclose said bag; a pair of springs encircling opposite ends of said slat members to yieldably restrain said slat members to a diameter less than the inner diameter of a casing in which said apparatus is to be set; and means communicating the interior of said bag to a source of a heated fluid in a circulatory system, the pressure of said fluid expanding said bag and moving said slat members outwardly into engagement with said casing.

9. An oil well heating apparatus, comprising: an elongate tubular support adapted to be coupled into communication with an oil string to comprise a portion of said string; a pair of rigid annular plates each of which is concentrically affixed to an end of said support; a tubular bag of an elastic material concentrically mounted on said support between said plates and defining an annular fluid sealed expandable heating chamber; insulating means between an inner wall of said bag and said support to inhibit the exchange of heat between said bag and oil in said string; a plurality of slat members slidably mounted at opposite ends thereof on said plates and adapted to circumferentially enclose said bag; a pair of springs encircling opposite ends of said slat members to yieldably restrain said slat members to a diameter less than the inner diameter of a casing in which said apparatus is to be set; and an input pipe and a return pipe communicating with the interior of said bag in a circulatory system with a source of a heated fluid, said input pipe communicating with said bag through a tailpipe that extends from the upper end of said bag and discharges heated fluid adjacent the lower end of said heating chamber, the pressure of said fluid expanding said bag and moving said slat members outwardly into engagement with said casing.

10. Oil well heating apparatus, comprising: an elongate tubular support adapted to be coupled into an oil string to comprise a portion of said string, said support being formed with enlarged outer diameter ends; top and bottom annular plates rigidly concentrically affixed to the upper and lower enlarged diameter ends respectively of said tubular support; a tubular bag made of an elastic material that is concentrically mounted around said support between said plates, the inner wall of said bag having an inner diameter approximately equal to the outer diameter of said enlarged diameter ends of said support to define an annular space between said inner wall and the intermediate portion of said support; a layer of an insulating material interposed in said annular space defined between said bag and said support; a plurality of elongate slat members each of which at both ends thereof has slidable tongue and groove connection with both of said plates for radial movement of said slats, each of said slat members having an overlapping slidable engagement with the pair of slats on opposite sides thereof whereby all of said slats circumferentially enclose said elastic bag, and each of said slats on the outer face thereof being formed with a central rib extending longitudinally of said slat whereby when said slats are moved outwardly upon expansion of said bag said ribs engage a casing in which said apparatus is set to define a plurality of oil passages between said slats and said casing through which oil passes in heat exchanging relationship to said casing and said slats; a pair of coil springs each of which encircles all of said slats at opposite ends thereof to yieldably restrain said slats to a diameter defined by said ribs which is less than the inner diameter of said casing; input pipe means communicating the interior of said bag with a source of a heated fluid, said input means including a tailpipe interiorly disposed in said bag that discharges said heated fluid into a lower interior portion of said bag; return pipe means communicating the interior of said bag with said source; and a double walled insulating member mounted on said oil string above said top plate that is made of a flexible material having a pair of walls concentrically related to said oil string and yieldably engaging the interior diameter of said casing, said pair of walls defining an insulating air space therebetween and adapted to prevent the migration of heated oil upwardly in the annular space between said oil string and said casing.

11. Oil well heating apparatus for use with means to circulate a heated fluid in and out of a well casing, comprising: means defining a fluid sealed heating chamber in communication with said circulating means to receive circulating heated fluid therefrom and having a rigidly reinforced outer wall contacting said casing in heat-exchanging relationship, the outer surface of said wall having a configuration adapted to define with said casing at least one vertically extending oil passage between said wall and said casing to pass oil therethrough in heat-exchanging relationship with said casing and outer wall; and means to support said chamber-defining means in said casing.

12. In a well heater the improvement comprising: a substantially fluid-sealed, expandable heating chamber having a normal cross-sectional area less than that of a well bore in which said chamber is to be positioned to facilitate movement of said chamber in said bore; means to support said chamber in said bore; and means to expand said chamber into heat exchanging contact with said bore comprising a recirculatory circuit for a heated pressure fluid, said circuit including said chamber.

13. In a well heater the improvement comprising: a substantially fluid-sealed, heating chamber having an expandable outer wall means and having a normal cross-sectional area less than that of a well bore in which said chamber is to be positioned to facilitate movement of said chamber in said bore, said wall means having a configuration adapted to define with said bore at least one vertically extending passage between said wall means and said bore when said wall means is expanded into contact with said bore; means to support said chamber in said bore; and means to expand said wall means of said chamber into contact with said bore comprising a source of heated pressure fluid in recirculatory fluid communication with said heating chamber.

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