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INDUCTION HEATER

Filed Sept. 13, 1960

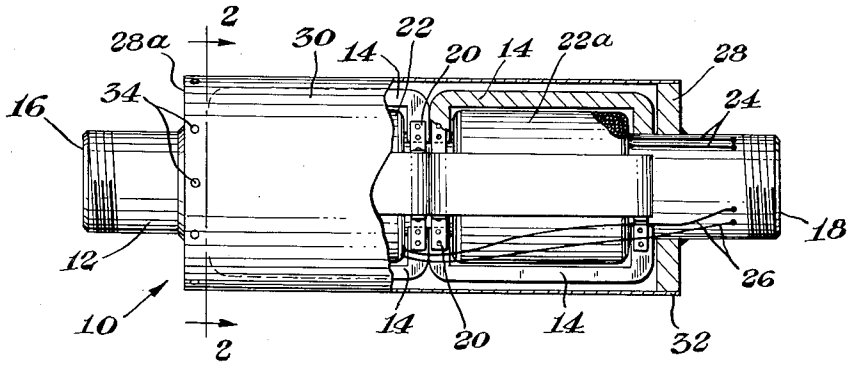


Fig. 1

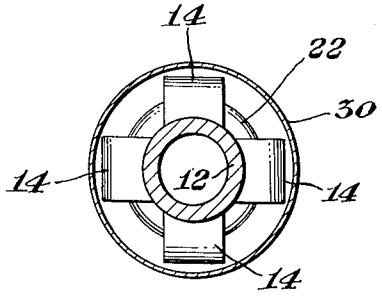


Fig. 2

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INDUCTION HEATER

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This invention relates to oil and gas well heaters and particularly to induction type heaters which are adapted for down-hole usage.

Down-hole heating tools find usage in several operations in well service. For example, heating the well casing to accelerate the setting time of cement lying between the casing and the annulus of the well bore and heating the tubing in a well to prevent the deposition of paraffin or other materials contained in formation fluids which are pumped up the tubing are uses of such devices.

Down-hole heating tools are commonly either a combustion type or are electrically energized. So called induction heating units are known for such service in wells, but have not proven as satisfactory as has been desired from either the standpoint of cost, efficiency of operation, or freedom from operational difficulties or maintenance.

Accordingly, a principal object of this invention is to provide an improved down-hole heating tool which is especially adapted for use as a tubing heater.

Another object of this invention is to provide an improved, economical and efficient down-hole heating tool.

In accordance with this invention there is provided a down-hole heating tool comprising, disposed about an axially disposed central core composed of metallic tubing of magnetic material such as mild steel or silicon steel, a plurality of magnetic core elements each comprising a number of C-shaped laminations.

The C-shaped core elements are radially mounted around the core with the open ends of the C facing and in contact with the tubing and have a coil of magnet wire disposed around the tubing between the ends of the magnetic core elements. The heater may comprise a plurality of arrays of coils and magnetic core elements disposed along the central core which also functions as part of the tubing string. The heater is provided with housing to protect it from physical harm while in the well bore. Cable leads for energization of the heater extend from the housing.

The invention, as well as additional objects and advantages thereof, will best be understood when the following detailed description is read in connection with the accompanying drawing, in which:

FIG. 1 is a side elevational view, partly in section, of a down-hole tubing heater in accordance with this invention, and

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1.

Referring to the drawings, there is shown a tubing heater, indicated generally by the number **10**, comprising a tubing nipple **12**, threaded at each end, which has a pair of arrays of C-shaped magnetic core members **14** disposed between its ends **16**, **18**. Each array of laminated core members has **4** members disposed radially at approximately 90 degree intervals around the periphery of the nipple, although a greater or lesser number of core members **14** could be used. The members **14** are held

in position by means of a plurality of somewhat U-shaped mounting brackets **20** which are bonded to the end parts of the members **14**, the base of the brackets **20** having the curvature of the outer surface of the nipple **12**.

Each of the arrays of laminated core members **14** has a coil **22**, **22***a* of magnet wire disposed around the nipple **12** between the legs of the C-shaped core members. The number of turns and size of wire used is dependent on good transformer design practice and the energization capabilities available down the well bore.

Pairs of leads **24**, **26** extend through one of the annular spacer plates **28**, **28***a* which were welded to the nipple **12** on each side of the arays of core members. A hollow cylindrical casing **30** fits closely over the peripheral surface **32** of the plates and is secured thereto by means of bolts **34**.

In operation the nipple **12** is coupled into a tubing string in the well bore near to the location where paraffin or other deposits tend to settle out on the tubing wall. The transformer core windings **22**, **22***a* are then energized by any suitable means, usually a down-hole cable connected to an alternating current source located at or near to the well head.

The nipple **12** constitutes, in addition to its function as a part of the tubing string, a single turn shorted secondary winding of the tubing heating transformer (windings **22**, **22***a* being the primary winding). The nipple is therefore heated by the large amount of current flowing through it as the primary winding or windings are energized. Because of the magnetic return provided by the laminations of the core members, the nipple **12** is heated by induction to a greater extent when the coils **22**, **22***a* are energized than occurs when electrically energized prior art heaters of corresponding size are used.

While the leads **24**, **26** are diagrammatically shown as passing along the outside of the nipple **12**, they are, in practice, coupled to suitable fluid-tight terminal means (not shown).

The invention has been illustrated as comprising a heater having two primary coils **22**, **22***a*. A single coil or more than two coils may be used, however, depending on convenience of manufacturing or the amount of energization of the heater which is intended.

While the present invention has been described in connection with the heating of down-hole tubing strings, the heater of the invention is applicable for use in other applications where a section of tubing is to be heated.

Although the magnetic return elements **14** are customarily equally spaced around the nipple section **12**, non-symmetrical spacing may sometimes be used, but with some loss in efficiency of the device.

What is claimed is:

1. A tubing heater comprising a hollow tubular section made of magnetic material, at least one electrical primary coil winding disposed around the peripheral surface of said tubular section and in close spaced relationship with respect thereto, and at least one array of generally C-shaped magnetic return elements each having a pair of open end ends, said magnetic return elements being symmetrically disposed around said tubular section with their open ends straddling said primary coil and in physical contact with said tubular section, said tubular section also being the single turn secondary winding of the tubing heater.

2. A tubing heater in accordance with claim 1, where-

in said magnetic return elements each comprise a plurality of laminations.

3. A tubing heater in accordance with claim 1, wherein said heater has a plurality of primary coils disposed in side by side relationship along said tubular section and each primary coil has an array of magnetic return elements disposed around the coil.

4. A tubing heater in accordance with claim 1, wherein said coil is disposed between spacer plates along said tubular section, and a tubular casing surrounds said coil and is secured to said spacer plates.

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