April 26, 1955 C. H. VAN HARTESVELDT 2,707,029

APPARATUS FOR OBTAINING LIQUIDS FROM DEEP WELLS

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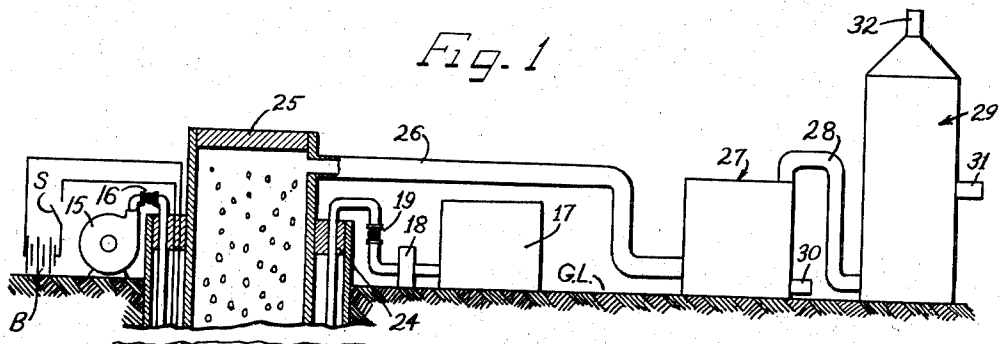
Fig. 1



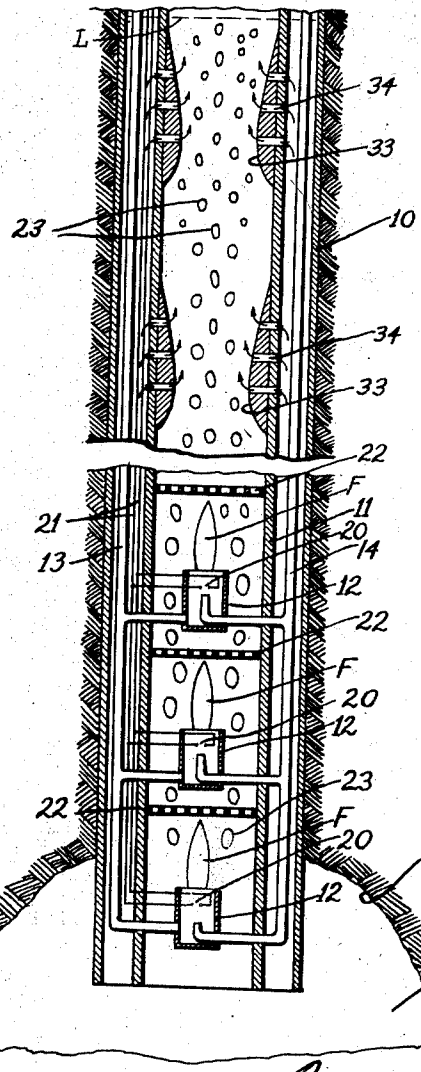


Fig. 3

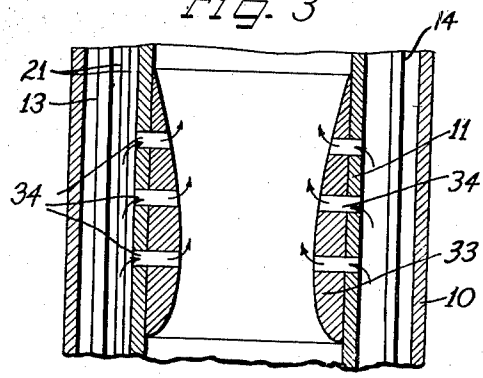
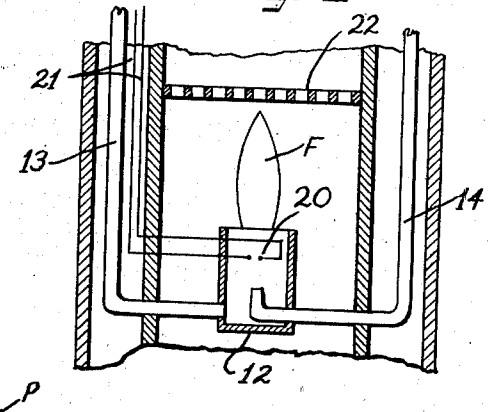


Fig. 2



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APPARATUS FOR OBTAINING LIQUIDS FROM DEEP WELLS

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2 Claims. (Cl. 166—59)

This invention relates to the delivery of liquids, such as water, brine, petroleum, or the like from wells that are too deep for economical pumping.

Specifically, the invention deals with the delivery of a liquid from a deep well by a gas lift obtained from burning a combustible mixture in the lower end of the well.

While the invention is generally applicable to the delivery of liquids of any type through a generally vertical conduit, it will be hereinafter specifically described as embodied in an oil well, but it should, of course, be understood that the invention is not limited to this particular preferred use.

The invention includes apparatus whereby an inner conduit or pipe and a surrounding conduit or pipe provide continuous paths from a level below the oil level in a well to a higher delivery level. The inner pipe is equipped with burners near its lower end. These burners are of the sub-surface type, such as those used for submarine cutting of metal. Fuel and a gas for supporting combustion are fed to the burners to produce flames in the lower end of the inner pipe for creating sufficient amounts of hot gases of combustion to produce a gas lift effect on the oil in the inner pipe. This inner pipe extends to a level below the level of the oil in the well and the gas lift effect of the combustion gases raises the oil through the inner pipe toward the delivery level. As the oil and gas mixture ascends in the inner pipe, the pressure thereon decreases and the hot gases eventually heat the oil sufficiently to cause it to boil. At the boiling level in the inner pipe, the velocity of the oil increases and this increased velocity effect is utilized to induct oil from the outer pipe into the inner pipe by venturi action. For this purpose, the inner pipe is equipped with one or more venturi throats and an oil flow by inductor action is thereby obtained in the outer pipe. The oil from the outer pipe cools the boiling oil in the inner pipe to condense some of the vapor in the boiling oil. The mixture of the petroleum liquid and vapor, together with the products of combustion from the burners is led to a separator and the vapors are conducted to a bubble tower for recovery in accordance with conventional refinery practice. The heat of combustion provided to accomplish the pumping therefore also serves in the refining process.

It is, then, an object of this invention to provide an apparatus for raising liquid on a gas lift principle by creating the lifting gas through the combustion of fuel in the lower end of a conduit for the liquids.

Another object of the invention is to provide an apparatus for removing liquids from deep wells by burning a combustible mixture in the bottom of the well to obtain a gas lift of the liquid through an inner pipe and inducting liquid from a surrounding outer pipe at a level in the inner pipe where the gases of combustion cause the liquid to boil.

Another object of the invention is to provide an apparatus for removing oil from deep wells by supplying a fuel and a combustion supporting gas to the lower end of the well to create a gas lift effective to raise the oil out of the well.

Another object of the invention is to provide apparatus for raising oil from a deep well by burning a liquid fuel and an oxygen-containing gas in the bottom of the well at a sufficient rate and under sufficient pressure to create a gas lift effective to raise the oil from the bottom of the well to a delivery level.

A still further object of the invention is to provide apparatus for removing oil from deep wells by a gas lift created from products of combustion in the bottom of the well and effective to heat the oil sufficiently to assist in refining.

Another object of the invention is to provide apparatus for removing liquids from deep wells including burners in the lower end thereof, inductors near the upper end thereof, and inner and outer conduits extending from below the level of liquid in the well to a delivery level.

Another object of the invention is to provide apparatus for removing oil from deep wells which produces a gas lift in the bottom of the well and a liquid inductor action in the upper portion of the well.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawings which, by way of a preferred example only, shows one embodiment of the invention.

On the drawings:

Figure 1 is a broken diagrammatic elevational view, partly in vertical section, illustrating an oil well equipped with the apparatus of this invention for carrying out the method of the invention.

Figure 2 is an enlarged view in vertical section of the burner section of the apparatus.

Figure 3 is an enlarged view in vertical section of the inductor section of the apparatus.

As shown on the drawings:

As shown in Figure 1, a casing **10** and concentric inner pipe **11** extend from above the ground level (G. L.) to below the liquid level (L) of oil (P) from an oil producing subterranean cavity (C).

The lower end of the pipe **11** is equipped with a plurality of burners **12** in spaced superimposed relation. An air pipe **13** and a fuel pipe **14** extending through the space between the pipe **11** and casing **10**, respectively, supply each burner with air and fuel to create a combustible mixture and form a flame F on each burner. The burners **12** are of the sub-marine type which are adapted to burn in a liquid. A compressor **15** supplies air to the pipe **13** in amounts metered by a valve **16**. Fuel from a tank **17** supplies a pump **18** which furnishes the fuel to the pipe **14** under amounts controlled by a valve **19**.

Sparks for igniting the burners are provided by spark plugs **20** in each burner and these plugs receive electric current through a cable **21** in the space surrounding the pipe **11** in the casing **10**. A battery B along with conventional equipment for obtaining high voltage energizes the wires in the cable, and a switch S is provided to control the energizing circuit.

A screen or grid **22** is provided above each flame F to control the size of bubbles **23** formed by the gases of combustion in the oil pipe **11**. These bubbles must pass through the screen. Any suitable means for controlling bubble size can be used in place of the screen or grid.

The branches from air pipe **13** and fuel pipe **14** leading to the burners are fitted with internal orifices. The size of these orifices in the leads to each burner are set to produce the same amount of combustion at each burner despite different pressures at each burner level in pipe **11**.

As shown in Figure 1, the lower ends of both pipes **10** and **11** extend below the liquid level L of the oil and the upper end of the pipe **10** is closed by a cap **24** receiving the upper end of the pipe **11** therethrough. The upper end of the pipe **11** has a fitting **25** thereon connected through a pipe **26** with a refinery separator **27**. Vapors from the separator **27** are conducted through an outlet **28** to a bubble tower **29**. Liquids from the separator are discharged through an outlet **30** in the bottom of the separator. The bubble tower **29** has a liquid outlet **31** in the side thereof and a vapor outlet **32** in the top thereof.

Sufficient pressure is available at the bottom of the well to push oil to liquid level L in pipes **10** and **11**, and the burners **12** are effective to create a gas lifting of the oil in the pipe **11**. As the bubbles **23** of the gaseous products of combustion from the burners **12** rise in the pipe **11**, they lift the oil therewith and simultaneously

heat the oil. Therefore, the bubbles become smaller as they are cooled down when they transfer their heat to the oil. The heated oil eventually reaches its boiling point and as it ascends in the pipe **11** to a point where the pressure thereon decreases sufficiently it may actually boil in the pipe. At this point, the pipe is equipped with venturi throats **33**. Several such throats may be provided in spaced superimposed relation. These throats have holes **34** therethrough on the downstream side thereof past the throat constriction, and an inductor effect is created in the space between the pipe **11** and the casing **10**. This inductor action will pull oil through this space in the casing surrounding the pipe **11** and will feed the oil from the space into the pipe **11** as shown by the arrows in Figures 1 and 3. The rising column of oil thereby created around the pipe **11** will be heated by the contact with the hot pipe **11** and at the same time will have a cooling effect on the pipe. As the oil enters the pipe **11** through the holes **34** it may condense some of the vapors in the boiling oil in the pipe **11**. The mixture of petroleum liquid, vapor, and products of combustion are fed from the upper end of the pipe **11** to the pipe **26** and thence to the separator **27**. The vapors and gases will be removed from the liquid in the separator **27** and the fully liquid material will be discharged at **30**. The products of combustion and vapors are then fed through the bubble tower **29** which condenses the vapors to discharge them at **31** while the gases of combustion are removed at **32**. The heat of combustion provided by the burners **12** therefore not only accomplishes pumping of the oil out of the well but also serves to furnish enough heat for assisting in the refining process. Of course, if desired, supplementary heat can be added to the hot oil in the refinery process.

If desired, the fuel-air mixing chambers of burners **12** may be external to pipe **11** with the combustible mixture issuing into pipe **11** from a jet or hole in the wall. Electric spark ignition and the jet or hole size would be set to result in the flame occurring inside pipe **11** as before. This method of installation has the advantage of minimizing an obstruction to upward flow of oil and removing upper burners from the corrosive effect of heated oil and products of combustion.

If desired, the valves **16** and **19** can be regulated to supply sufficient air and fuel to the burners **12** for heating the oil to a high enough temperature to cause it to crack and reform. If desired, fluid catalysts of the type used in fluid catalytic cracking can be supplied to the hot oil to facilitate cracking. Gaseous products formed from such cracking process would supplement the air lift effect of the products of combustion from the burners.

The fuel supplied the burners may be supplemented or substituted for by combustibles from the oil itself. When the oil pumped has sufficient volatile components this supplementation or complete substitution is most readily accomplished. Complete substitution would eliminate the need for fuel line **14**. The burners would then be altered to induct oil and mix it with air to produce the combustible mixture.

In the event that the rate of flow of oil from a well by the method of this invention is not voluminous enough to operate a complete refining process, the effluent from a plurality of adjoining wells can be piped to a central refining unit.

It is preferred that the fuel supplied to the burners by the pipe **14** be of a type which will produce a maximum of so-called "fixed gases," viz., a high carbon content fuel, where the combustion gases are accomplishing the major part of the lifting. If vaporization of the liquid being pumped is largely relied upon for lifting the liquid, then the fuel should be of a type having a high heating value, viz., a high hydrogen content fuel. High hydrogen content of the fuel is also desirable in obtaining the vaporization of the petroleum in the well from the steam distillation effect of water produced by combustion.

In some applications of this invention the lift pipe can be the casing **10** itself. Under this arrangement the air line **13** and the fuel line **14** when needed are located within the casing **10**. In operation the gas lift then occurs in the well itself and is supported by the liquid pressure at the bottom of the well.

From the above description, it should therefore be understood that this invention provides method and apparatus for delivering liquids, and especially volatile liquids, from wells by producing, in the bottom of the well, hot gases of combustion which create a gas lift and heat the liquid to produce a supplemental vapor lift, and an induction lift. The heat in the liquid delivered from the well is also utilized to refine the liquid.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. Apparatus for removing liquids from deep wells which comprises an inner lift pipe, a surrounding casing, a burner in said lift pipe in the lower end thereof, means defining a venturi throat in said lift pipe at a level above the burner, means providing passages in said venturi throat connecting the inner pipe with the surrounding casing, means for supplying a combustible mixture to said burner, and means for igniting said mixture.

2. Apparatus for raising oil from wells which comprises an inner lift pipe, a surrounding casing, the lower end of said lift pipe and casing adapted to communicate with a source of oil in a well for providing an inner passage through the lift pipe and an outer passage in the casing around the lift pipe, a burner in the lower portion of said lift pipe, means for supplying a combustible mixture to said burner, means for igniting said mixture, the passage in said casing being in communication with the passage in the lift pipe at a restricted area level above the burner, and means for inducing flow into the lift pipe from the casing by upward flow in the lift pipe to raise oil through both passages for discharge out of the upper end of the lift pipe.

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