FLUID LIFTING APPARATUS

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This application is a continuation-in-part of my co-
pending United States patent application Serial No. 271,
975 filed April 10, 1963, now abandoned.

The present invention relates to a new and improved fluid
lifting apparatus for lifting fluids in a well.

Many problems inherent in ordinary rod and tubing
pumps such as wear of the sucker rods, tubing, and check
valves are eliminated by the present invention which
employs an actuating fluid rather than moving parts
to lift the fluid in the well.

An object of the present invention is to provide a new
and improved fluid lifting device in which an actuating
fluid is provided for imparting movement to a well fluid
or other primary fluid.

An important object of the present invention is to
provide a new and improved apparatus in which an actu-
ating fluid is introduced into a first chamber and cir-
culated through a choke or chokes into a second chamber
to move a fluid in the second chamber in the direction
in which the actuating fluid is injected directly through the choke
or chokes.

Another object of the present invention is to provide
a new and improved fluid lifting system in which an actuating
fluid is jetted in a well pipe to cause other fluid in the well pipe
to move therewith in the well pipe.

And still a further object of the present invention is
to provide a new and improved pumping arrangement in
which an actuating fluid is pumped upwardly through a
venturi opening into a string of production tubing to
draw other fluid in the production tubing upwardly
through the venturi opening.

Another object of the present invention is to provide
a pumping system for raising fluids in a well pipe in which
an actuating fluid is pumped through a plurality of venturi
nozzles arranged in a well pipe to lift other fluid in the well
pipe.

And another object of the present invention is to pro-
vide a pumping system in which an actuating fluid is
pumped under high pressure through one or more venturi
nozzles in a pipe in a well communicating the strata
from which fluid is being pumped to draw fluid from such
strata and move it upwardly through the pipe to the earth's
surface.

A particular object of this invention is to provide a
new and improved fluid lift apparatus wherein a venturi
and a nozzle are mounted in a pipe string, the venturi
being tapered downwardly and outwardly, and the nozzle
extending into the venturi taper but less than one-half
the length of the taper, said nozzle having an upwardly
and outwardly directed discharge opening, whereby the
actuating fluid discharging from the nozzle creates a fluid flow
at the central portion of the nozzle for lifting oil or other
fluid therewith through the nozzle while avoiding the
creation of an excessively high pressure in the venturi
which might restrict the inflow of the oil or other fluid
being lifted.

The preferred embodiment of this invention will be
described hereinafter, together with other features thereof,
and additional objects will become evident from such
description.

The invention will be more readily understood from a
reading of the following specification and by reference
to the accompanying drawings forming a part thereof
wherein an example of the invention is shown and where-
in.

FIG. 1 is a view partly in elevation and partly in sec-
tion of the device of the present invention in a well bore;
FIGS. 2A and 2B are vertical sectional views of the upper
and lower portions, respectively, of the pumping unit of
the present invention taken on line 2A—2A, B of
FIG. 5;
FIG. 3 is a horizontal sectional view taken on line
3—3 of FIG. 2A showing construction details of one form
of the present invention;
FIG. 4 is a horizontal sectional view taken on line
4—4 of FIG. 2A showing additional construction details
of the present invention;
FIG. 5 is a horizontal sectional view showing construc-
tion details of another form of the present invention;
FIG. 6 is a schematic view, partly in elevation and
partly in section, illustrating a modified form of
the present invention, wherein multiple tubing strings are
illustrated for simultaneously producing from multiple
formations;
FIG. 7 is a detailed elevation, partly in section, illus-
trating one of the preferred fluid lifting devices of FIG. 6;
and
FIG. 8 is a horizontal cross-sectional view taken on
line 8—8 of FIG. 7 to illustrate further details thereof.

In FIG. 1 of the drawings, the letter A designates gen-
erally the apparatus of this invention. Briefly, such ap-
paratus A includes one or more hydrostatic chokes or
pumps P of the invention which are preferably supported
in a well W for lifting well fluid such as oil to the surface
S of the well from the level L of such well fluid in the
well. As will be explained hereinafter in detail, actu-
tuating fluid such as salt water, air or other fluid under pres-
sure is discharged through the hydrostatic chokes P to
urge the well fluid upwardly toward the well surface S.

In one form of this invention as illustrated in FIGS.
2A and 2B of the drawings, each of the hydrostatic chokes
or pumps P comprises a body member or housing 12
having threaded portions 12a at each end for connecting
the member 12 to connector pipes 14 which connect and
support hydrostatic chokes or pumps P in the well W.
The connector pipes 14 also establish communication be-
tween the pumps P which are connected together.

A plurality of channels 16 (FIGS. 2A and 3) extend
longitudinally through the body 12 to convey the well fluid
such as oil which is being pumped by the pump P. Each
channel 16 extends from a lower bore 12b to an upper
bore 12c so as to form together a well fluid chamber. A
plurality of chokes or venturi tubes 17 are connected in
a header 18 which may be connected to or integral with
the upper end of the body 12 which are in commu-
nication with the bore 12c. Each choke 17 has a frusto-conical interior configuration with the smaller
diameter end extending upwardly into the connector
14 and the large diameter end opening into the bore
12c. Each venturi tube 17 is preferably secured by threads 17a
for easy removal or replacement. Each venturi 17 has a
restriction 17b of uniform diameter at its upper end which
merges with an internal tapered bore 17c which is tapered
downwardly and outwardly.

A plurality of passages or fluid conductors 21 are
longitudinally disposed in the body 12 in alternate cir-
cumferentially spaced relationship to the channels 16
(FIG. 3) so as to prevent direct communication there-
between. The lower end 21a is closed to prevent fluid
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3 from the bore 12b from flowing into the passages 21. A nozzle 22 for each venturi 17 is threaded by threads 22a or is otherwise secured in the body 12 at the upper end 22b of each passage 21 to discharge fluid through the venturi 17 located therapeutically. Laterally extending ports 23 are provided for each passage 21 for introducing the actuating fluid to each passage 24 from the tubing T or other area outside of the body 12. Each nozzle 22 has a lower bore 22a, a restriction 22c and an upper outwardly and upwardly flared discharge opening 22d. Each nozzle 22 extends into a choke 17 but not more than one-half the length of the bore 17c. By reason of such construction of the nozzle with the flared opening 22d and the position of the nozzle 22 in the taper 17c, the actuating fluid flows at a higher velocity at the center of the choke 17 and an effective lift is created to lift the oil with the actuating fluid.

As illustrated in FIGS. 1 and 2b of the drawings, in the preferred form of this invention, a screen 24 is supported in the well at the lower end of the tubing T at approximately the depth of the formation F from which well fluid is being drawn. A hollow screen support housing 26 supports the screen 24 at the lower end of the tubing T. The screen support housing 26 has internal threaded portions 26a and 26b at each end for connecting the upper end of the housing 26 to the tubing T and for connecting the lower end of the housing 26 to the screen support housing 24. A sleeve 30 formed of rubber or other resilient material extends circumferentially around the inner wall 26c of the housing 26. The rubber sleeve or liner 30 is restrained against longitudinal travel by an annular restraining flange 27 extending circumferentially of the inside of the screen support housing 26 between the threaded portions 26a and 26b of the housing 26. The central openings 30a and 27a formed in the sleeve 30 and the restraining flange 27, respectively, are tapered to receive a tapered sealing block 32 which is threadedly attached to the lower end of the conductor pipe 14 to engage the sleeve 30 to seal the actuating fluid in the tubing T from communication with the screen 24 and the formation F from which well fluid is being drawn. A sealing ring 34 which may either be floating or formed integrally with the sleeve 30, is provided above the sleeve 30 for engagement by the annular shoulder 35 of the tapered block 32 to urge the sleeve 30 downward against the restraining flange 27 to increase the sealing pressure between the tapered block 32 and the sleeve 30.

The tapered sealing block 32 has a central opening or passage 33 which is aligned with the connector 14 to facilitate rapid communication of tubing T to the screen 25 with the chamber 16 in the connector 14.

The screen 24 may be formed of a foraminous material with perforations 25 of any convenient size.

In the operation or use of the form of the invention shown in FIGS. 1-4, an actuating fluid, such as salt water, is pumped under pressure downwardly in the well W through the tubing annulus between the tubing T and the pump or pumps P. The actuating fluid is admitted through the ports 23 to the passages 21 in the pump body 12 and then is discharged under pressure by the nozzles 22 through the venturi tubes 17. As the actuating fluid is discharged under pressure by the nozzles 22 through the venturis 17, well fluid such as oil in the chamber defined by the upper bore 12c, passages 16, and the lower bore 12b will be drawn through the venturis 17 due to the low pressure area created in the throat of each venturi 17 by the velocity or jetting of the salt water or other actuating fluid. The mixture of the oil and salt water is thus discharged at high velocity from the upper ends of the venturis 17 into the connecting pipe 14 therefrom and from there to either another pump at a higher elevation or to the surface S or other discharge point. Normally, a plurality of pumps P are used at four-hundred-foot intervals, although such spacing and the number of pumps will vary depending upon operating conditions. Thus, by raising well fluid and actuating fluid from one pump to the next successive pump, well fluid may be lifted or pumped from the stratum or formation from which it is drawn to the surface of the well.

Either the nozzle 22 or the venturis 17 bore may be easily removed for repair or cleaning in the event of clogging, or other nozzles or venturis of various sizes and diameters may be interchanged as desired for handling various fluids under various conditions.

In FIG. 5, a cross-section of a modified form of the invention is shown wherein the body 112 corresponds with the body 12, but only one channel 116 and one passage 121 is provided instead of the plurality of channels 16 and passages 21 shown in FIGS. 1-4. It will thus be evident that the number of channels and passages in the body of the pump P may be varied for regulating the volume flow and pressure conditions in any particular situation.

Also, as the pumps P are interchangeable, a pumping system may be arranged wherein one or more of the pumps P may have a single number 116 and a single passage 121 in a certain stage of the lifting or pumping operation and one or more of the pumps P may have a plurality of chambers 16 and passages 21 at another stage of the pumping operation.

Another form of the invention is illustrated in FIGS. 6-8. In FIG. 6, a well bore W-1 is illustrated with a plurality of producing well formations F-1, F-2 and F-3. A plurality of tubing strings T-1, T-2 and T-3 are illustrated as being disposed in the well bore W-1. A conventional seal S-1 formed of rubber or other similar material is disposed in the well bore W-1 below the tubing string T-1. The tubing strings T-2 and T-3 pass through the seal S-1 so that only the oil or other fluid from the formation F-1 is in communication with the lower end of the tubing string T-1. The well formation F-2 is sealed off by a second seal or packing S-2 which is also of conventional construction, and through which only the tubing string T-3 passes. Thus, the formation F-2 is in communication with the lower end of the tubing string T-2 while the formation F-3 is in communication with the lower end of the tubing string T-3. It will be understood that although the tubing strings T-1, T-2, and T-3 are spaced from each other and disposed in substantially the same plane, in actual practice, they are arranged very close together and are grouped within the minimum amount of space. Likewise, the well bore W-1 may be an extremely slim hole which is common today in multiple zone production.

Within the tubing string T-1, a pipe string P-1 is disposed. Likewise within the tubing string T-2, a pipe string P-2 is disposed, and within the tubing string T-3 another pipe string P-3 is disposed. Each of the pipe strings P-1, P-2 and P-3 are preferably made in the same manner and therefore an explanation of only the pipe string P-1 will be provided.

At the lower end of the pipe string P-1, a packer or seal 130 is provided which may correspond exactly with the packer or seal 30 shown in FIG. 2b, or it may be any other suitable type of packing element to prevent the flow of fluid from the formation F-1 into the tubing T-1, but instead to direct it to the bore of the pipe string P-1 as best seen in FIG. 6. The annulus between the tubing string T-1 and the pipe string P-1 is provided for the introduction of an actuating fluid in the same manner as heretofore described in connection with FIG. 1. A plurality of hydrostatic chokes H-1 and H-2 are provided in the pipe string P-1, one at each end thereof as illustrated in detail in FIGS. 7 and 8. Thus, in the preferred embodiment of the hydrostatic choke H-1, a venturi 117 is provided, which basically corresponds with the venturi 17 of FIG. 2a. The venturi 117 has an upper bore 117b which provides a restriction and is of a uniform diameter through-out its length. Such restriction 117b merges with a downwardly and outwardly tapered bore 117c in the venturi
The venturi 117 has external threads 117c which are connected to an adapter section 118, which in turn is threaded or otherwise connected to a body section 112 therebelow. The lowermost section shown in FIG. 7 is indicated at 114 as being threaded to the lower end of the body 112, and it can be the portion which extends down through the packer 120 (FIG. 6), or alternatively, it can be connected to the upper end of a venturi section 117 disposed therebelow.

The body section 112 has a bore 121 therein which is closed at its lower end 121a, and it is in communication with a plurality of ports 123 so that fluid from the annulus between the pipe string P-1 and the tubing string T-1 may flow inwardly into the bore 121.

A nozzle 122 is disposed at the upper end of the bore 121 and is preferably connected thereto by threads 122a. Each nozzle 122 has an inner bore 122b therethrough, which merges with a discharge opening 122c having its surfaces tapered or flared upwardly and outwardly at an angle which is opposite to that of the tapered bore 117c.

It is to be noted that the nozzle 122 extends upwardly into the tapered bore 117c, but it does not extend up beyond one-half of the length of the tapered bore 117c. It has been found that effective lifting action of oil or other fluid is accomplished with the construction just described since the actuating fluid which passes through the discharge nozzle 122 is moving at a high velocity in the central portion, but due to the flare 122c, the velocity at the outer portion of the nozzle 117c is reduced and a high pressure is avoided which might otherwise interfere with the intake of oil flowing upwardly from around the nozzle 122, as will be more evident hereinafter.

The oil comes upwardly from the formation P-1 through the body section 114 and passes through one or more longitudinal passages 112a, none of which are in communication with the ports 123 or the bore 121. Therefore, the oil and the actuating fluid are kept separately from each other until after the oil has reached the level of the nozzle 122. Thus, the oil accumulates in the chamber 112c and as the actuating fluid is discharged upwardly from the nozzle 122, the oil is lifted by the lifting action of such actuating fluid around the exterior of the nozzle 122 and upwardly with the actuating fluid through the choke or venturi 117c. It is to be noted that the diameter of the nozzle 122 is less than the diameter of the tapered bore 117c so as to provide the annular passage for the upward flow of the oil as it is lifted by the actuating fluid discharging from the nozzle 122.

The hydrostatic choke H-2, and any other hydrostatic chokes which may be employed in the pipe string P-1 are preferably formed in the same manner as heretofore described in connection with the choke H-1 and therefore the same numerals have been applied thereto in FIG. 6. Also, the pipe strings P-2 and P-3 have the same or similar hydrostatic choke constructions to that illustrated in FIGS. 7 and 8.

With the form of the invention illustrated in FIGS. 6-8, multiple zones may be produced simultaneously or separately, using the actuating fluid introduced at the surface of the well to effect a lifting of the oil or other fluid from each formation as desired.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. Fluid lifting apparatus for use in a well, comprising:
   (a) a pipe string adapted to extend downwardly into a well,
   (b) a tubing string disposed substantially concentrically around the pipe string and spaced annularly therefrom to form an annulus therebetween,

(c) a venturi choke disposed in said pipe string and having a downwardly and outwardly tapered lower bore,

(d) a nozzle extending longitudinally into said tapered inner bore for a distance slightly less than one-half of the length of said tapered inner bore,

(e) said nozzle having an external diameter less than the diameter of said tapered inner bore to provide an externally tapered annular passage around the nozzle in the tapered inner bore,

(f) said nozzle being formed with a flow passage which terminates at its upper end in an upwardly and outwardly flared surface,

(g) a first fluid passage means in said pipe string for admitting actuating fluid from the annulus between the tubing string and the pipe string into said nozzle, and

(h) a second fluid passage means in said pipe string for flowing well fluid upwardly to said nozzle for the lifting thereof upwardly above the nozzle by the actuating fluid as it discharges from the nozzle into the venturi choke.

2. Fluid lifting apparatus for use in a well, comprising:
   (a) a pipe string adapted to extend downwardly into a well,
   (b) a tubing string disposed substantially concentrically around the pipe string and spaced annularly therefrom to form an annulus therebetween,

(c) a plurality of hydrostatic chokes disposed at longitudinally spaced intervals in said pipe string, each hydrostatic choke including:
   (1) a venturi choke disposed in said pipe string and having a downwardly and outwardly tapered lower bore,
   (2) a nozzle extending longitudinally into said tapered inner bore for a distance slightly less than one-half of the length of said tapered inner bore,
   (3) said nozzle having an external diameter less than the diameter of said tapered inner bore to provide an annular externally tapered passage around the nozzle in the tapered inner bore,
   (4) said nozzle being formed with a flow passage which terminates at its upper end in an upwardly and outwardly flared surface,
   (5) a first fluid passage means in said pipe string for admitting actuating fluid from the annulus between the tubing string and the pipe string into said nozzle, and
   (6) a second fluid passage means in said pipe string for flowing well fluid upwardly to said nozzle for the lifting thereof upwardly above the nozzle by the actuating fluid as it discharges from the nozzle into the venturi choke.

3. Fluid lifting apparatus for use in a well, comprising:
   (a) a pipe string adapted to extend downwardly into a well,
   (b) a tubing string disposed substantially concentrically around the pipe string and spaced annularly therefrom to form an annulus therebetween,

(c) a plurality of venturi chokes disposed at substantially the same elevation in the pipe string, each of said venturi chokes having a downwardly and outwardly tapered lower bore,

(d) a nozzle extending longitudinally into the tapered bore of each venturi choke for a distance slightly less than one-half the length of each such bore,

(e) said nozzle having an external diameter less than the diameter of said tapered inner bore to provide an externally tapered annular passage around the nozzle in the tapered inner bore,

(f) said nozzle being formed with a flow passage which terminates at its upper end in an upwardly and outwardly flared surface,

(g) a first fluid passage means in said pipe string for...
admitting actuating fluid from the annulus between
the tubing string and the pipe string into said nozzles, and

(h) a second fluid passage means in said pipe string for
flowing well fluid upwardly to said nozzles for the
lifting thereof upwardly above the nozzles by the
actuating fluid as it discharges from the nozzles into
the venturi choke.

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