June 28, 1955 J. H. CRAGGS, JR 2,711,598

HYDRAULIC EXCAVATOR

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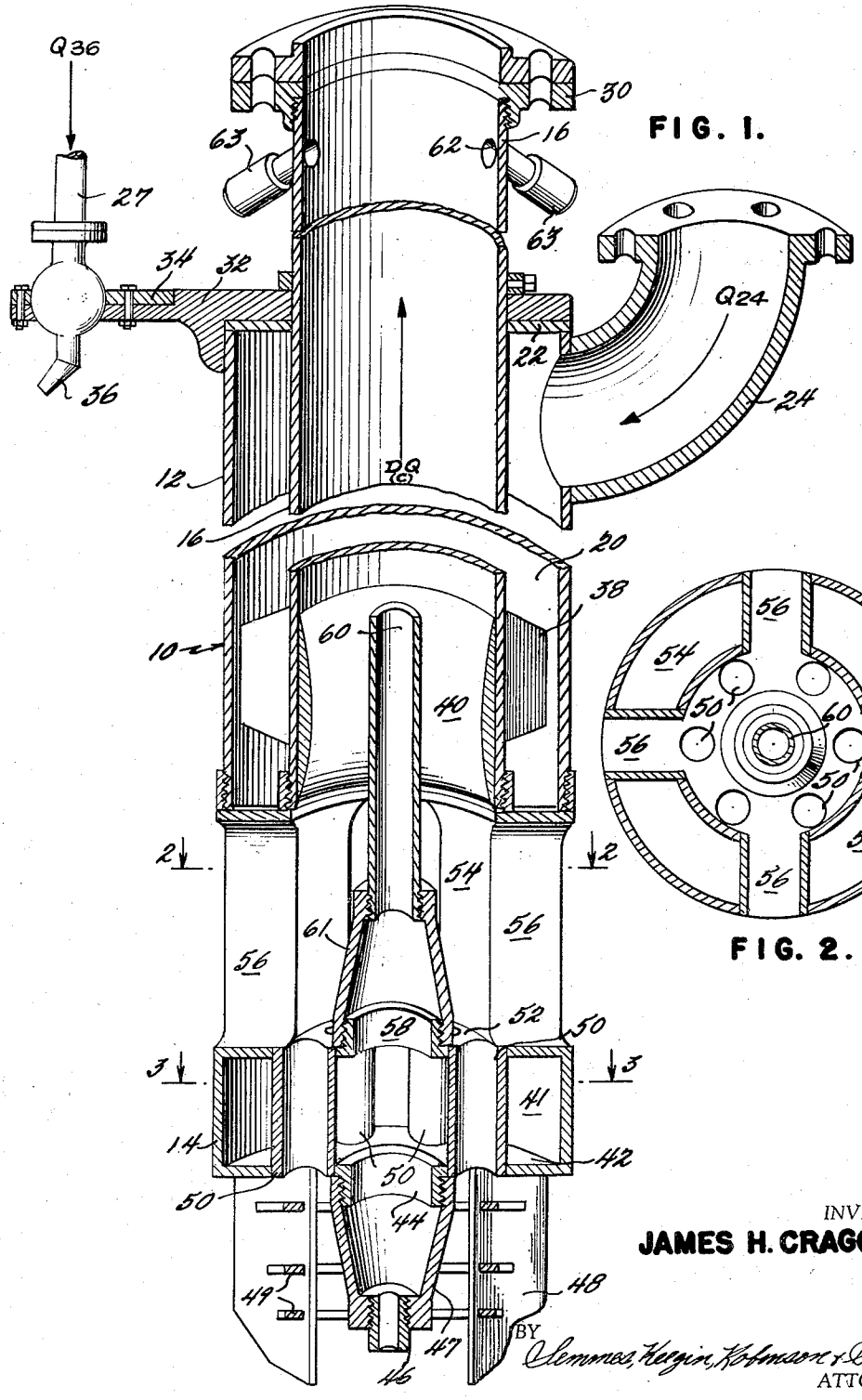


FIG. 1.

FIG. 2.

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FIG. 4.

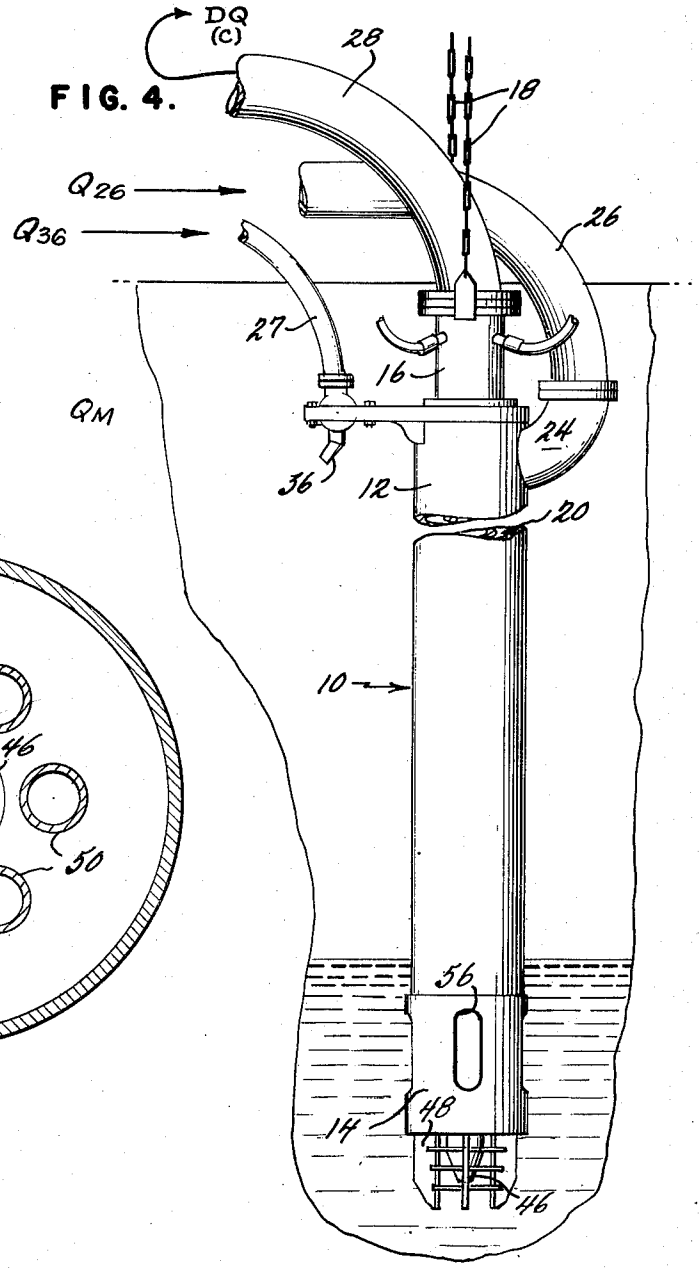
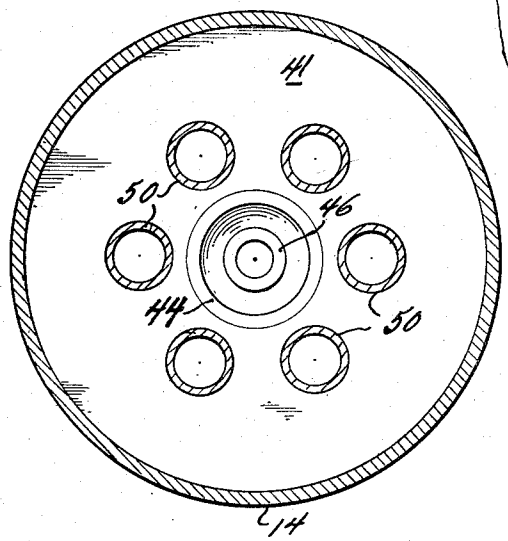


FIG. 3



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HYDRAULIC EXCAVATOR

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5 Claims. (Cl. 37—62)

This invention relates generally to excavating apparatus and more particularly to a hydraulic excavator for subterranean deposits accessible by the open pit method.

In many areas throughout the United States, as in the north Florida area, there are limerock formations which contain deposits of clay and sand. These deposits occur in vast numbers and comprise irregular vertical cavities in the limerock ranging from a few inches to forty feet in diameter and from two to seventy feet in depth.

Hydraulic excavators are well known in the art and are generally constructed for use in completely submerged dredging operations, etc. Structural and other limitations prevent their successful use in the open pit subterranean excavations described due to the erratic conditions encountered.

Accordingly, the chief object of the present invention is to provide a hydraulic excavator for only partially submerged use in subterranean excavating operations and which will successfully meet the varying conditions encountered.

Another important object of the present invention is to provide an improved hydraulic excavator which includes static and sump jets which cooperate with a hose jet to expeditiously and efficiently excavate by the open pit method, clay and sand deposits of any shape from limerock and other formations.

A further important object of the invention is to provide an improved hydraulic excavator in which the capacity of the means for removing the material being excavated exceeds the volumetric displacement of all the water jetted into cavities by the static, sump, and hose jets plus the cubic displacement of the sand and clay excavated.

Another object is to provide an improved hydraulic excavator having an interchangeable nozzle for meeting varying excavating conditions.

Other objects and advantages of the invention will become apparent during the course of the following description.

In its broadest aspects, my invention comprises a nozzle adapted to be suitably suspended in a limerock cavity wherein the sump jet continually digs a sump allowing the excavator to remain below the exposed clay walls, a hose jet washes away the clay walls, and the static jet exerts a pumping action to excavate the clay and water mixture from the sump.

In the drawings, I have shown one embodiment of the invention. In this showing:

Figure 1 is a central vertical sectional view of the hydraulic excavator comprising my invention;

Figure 2 is a horizontal sectional view thereof taken on the line 2—2 of Figure 1;

Figure 3 is a horizontal sectional view thereof taken on the line 3—3 of Figure 1; and

Figure 4 is a view in side elevation showing the hydraulic excavator suspended in a limerock cavity.

Referring to the drawings, numeral 10 designates the excavator as a whole which comprises an outer tubular

casing 12, an inner concentric tubular casing 16, and having a nozzle 14 screw-threadedly connected to their lower ends, the assembly being suitably suspended by chains 18 from a derrick, etc.

The inner and outer casings 12 and 16 form between them a manifold chamber 20 which is closed at its upper end by an annular plate 22 below which a water inlet pipe 24 has connection with the chamber 20. Water is furnished to the excavator by flexible conduits 26 and 27 while the mixture of water and clay is removed from the limerock cavity through the casing 16 and a flexible conduit 28 which is connected to the flanged upper end 30 of the casing 16.

A plate type bracket 32 is rotatably mounted on the plate 22 and pivotally supports, as by locking plate 34, a jet nozzle 36 to which the conduit 27 is connected. The jet nozzle 36 is ordinarily directed angularly away from the casing 12 in order to direct a water jet against surrounding clay walls. The outer surface of the lower end of the casing 16 is provided with a plurality of angularly spaced water stabiling fins 38 which function to minimize turbulence in the manifold chamber 20. A venturi sleeve 40 is positioned within the casing 16 adjacent its lower end and cooperates with the static jet, as will be described, to discharge the mixture of clay, sand and water from the nozzle 14.

The detachable nozzle 14 comprises an annular drum 41, the lower surface 42 of which is provided with a central annular depending flange 44 which is exteriorly threaded. The sump jet 46 has a screw-threaded connection with a tapered restricting sleeve 47 which is connected to the annular flange 44. A a plurality of vertically depending nozzle supporting fins 48 connected by bars 49 are fixed to the bottom of the drum surface 42 and act to support the entire assembly in the pit or cavity being excavated. A plurality of vertical inlet pipes 50 extend through the drum 41 and connect with an inner material receiving chamber 52, the walls of which are formed by a plurality of vertical water passages 54 which connect the manifold chamber 20 with the drum 41. A plurality of material inlet openings 56 are formed between the water passages 54 and constitute the major material receiving inlets of the excavator, the vertical inlet pipes 50 having a function in addition to that of admitting material to the excavator as will be explained.

The upper sleeve of the drum 41 is provided with an upwardly extending threaded annular flange 58 on which the static nozzle 60 is supported by means of a tapered constricting sleeve 61. It will be noted that the upper end of the static jet 60 is adjacent the upper end of the venturi sleeve 40. If desirable during operation in order to assist the lifting action of the static jet, air may be supplied through a plurality of annularly spaced ports 62 formed in the upper end of the inner casing 16 through conduits 63.

It will now be readily apparent that water may enter the inlet pipe 24, may pass through the inlet pipe 24 into the manifold chamber 20 through the vertical water passage 54 around the side inlets 56 and down into the drum 41 where it enters the opposed nozzles 46 and 60. The flow through the static jet and the sump jet 46 is then regulated by the diameter of each. The purpose of the sump jet is to continually dig a sump allowing the excavator to always remain below the exposed walls of clay. As explained, the function of the hose jet 36 is to break away the surrounding material and allow it to fall or slough downwardly until it is picked up at a lower level by the static jet, the water level being maintained a few inches above the inlet openings 56.

It is important in the operation of the device that a capacity imbalance be maintained wherein the cumula-

tive capacity of main discharge casing **16** exceeds the volumetric displacement of internal and external hydraulic displacement means plus material excavated.

In providing this capacity imbalance the invention assures the maintenance of a liquid operating level, in the excavated cavity, at a controlled elevation relative to the upper portion of inlet openings **56**. Normally, as stated, the desired level will be slightly above inlet openings **56** as a result of spasmodic downward sloughing of quantities of excavated material. Nevertheless, because of the capacity imbalance, this level will often fall below the upper portion of inlet openings **56**, admitting air, which in turn regulates and maintains this minimum lower level. At such times the total volumetric discharge of casing **16** is equal to the volumetric displacement of the static jet only. By design there is thus maintained at all times a column of hydraulic fluid within the inner casing **16**. In actual operation there is a continuing fluctuation between the levels recited above.

The above is exemplified by the following formula in which C represents capacity of main discharge casing **16**; Q_{24} represents total quantity of internal fluids fed to sump jet **46** and static jet **60**; Q_{36} represents quantity of fluid introduced externally to the cavity through jet **36**; Q_m represents the quantity of excavated material.

$$(C)>Q_{24}+Q_{36}+Q_m$$

See Figure 4.

It will be apparent from the foregoing that the capacity imbalance assures a quantitative balance between volumetric displacement of the main discharge casing on the one hand and on the other hand the volumetric displacement of internal and external hydraulic displacement means plus materials excavated. This quantitative relation of components is established by the formula

$$DQ=Q_{24}+Q_{36}+Q_m$$

where DQ=total quantity of all fluid and material discharged from the device.

It is believed that the operation of the apparatus described is readily apparent. A small portion of the water entering the hydraulic excavator by way of the inlet pipe **24** will pass out the sump jet which continually digs a sump allowing the excavator to always remain below the exposed walls of clay. The major portion of the water will be discharged through the static jet **60** and the venturi to create a pumping action for elevating material through the cylindrical casing **16** into the discharge conduit **28**. As stated, and where necessary for the purpose of assisting the lifting of the material to heights above the lifting effect of the static jet, air may be admitted through the ports **62**. Meanwhile, a jet of water is discharged from the nozzle **36** against the walls of the cavity to wash clay and sand into the sump where it may be picked up by the nozzle. The largest portion of the material removed from the cavity is jetted down into the sump by the nozzle **36**.

An important feature of the invention resides in the maintenance of the water level a few inches above the static nozzle and the water level varies according to the depth that the head of the excavator is in the cavity or pit. That is, the capacity of the pumping or lifting action of the excavator provided by the static jet and venturi must exceed the volumetric displacement of all water jetted into the cavities by the sump jet, the static jet, and the hose jet plus the cubic displacement of the material excavated. The condition below the level of the nozzle is essentially static. The major portion of water and excavated material enters the nozzle through the openings in the sidewall. Thus, the nozzle is not a suction device of the usual type designed to pull solid material from the bottom of the sump, and is only a partially submerged operation. The level of water is maintained at substantially the level of the openings in the sidewalls of the nozzle, subject to the conditions hereinbefore described.

In the preferred form of the invention the total area of the openings **56** and pipes **59** will be more than twice the area at the venturi. Then, the material excavated may flow readily into the suction chamber and be lifted for discharge from the upper end of the excavator. If the individual openings **56** are large it is desirable to provide them with suitable partitions to prevent clogging of the venturi.

It will now be readily apparent that the hydraulic excavator comprising the present invention will efficiently and continuously excavate mixtures of water and the clay, sand, etc. from open pits or cavities in limerock formations under varying conditions by controlling the flow of water and air to the various nozzles in accordance with the principles set forth. Where unusual excavating conditions are encountered, a different nozzle embodying different relative dimensions between the various openings and jets may be readily attached to the lower end of the casing **16**. In any such construction, the dimensional relationship between elements will of necessity be in substantial accord with the foregoing whereby to provide a fully operative construction.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A hydraulic excavator for subterranean deposits accessible by the open pit method, comprising a casing adapted to be lowered into a cavity, a nozzle connected to the lower end of said casing and having a concentric material receiving chamber formed therein, a series of radially disposed, material inlet openings formed in said nozzle and placing said chamber in communication with said cavity, a static jet in said nozzle projecting upwardly through said chamber into said casing, venturi means positioned in said casing above the material receiving chamber and encircling the end of said jet, a sump jet projecting downwardly from said nozzle, vertical ports in said nozzle, connecting said chamber with the area beneath said nozzle adjacent the sump jet, an excavating jet mounted externally of said casing above said nozzle and directed towards the walls of the cavity, and conduit means communicating with the respective jets for furnishing pressure fluid thereto, whereby material forming the cavity walls is dislodged by said excavating jet, a sump is formed beneath the excavator by said sump jet, and the material dislodged by said last-named jets is drawn into said chamber, respectively through said radial openings and vertical ports, entrained through said venturi and discharged through said casing.

2. A hydraulic excavator for subterranean deposits accessible by the open pit method, comprising a casing adapted to be lowered into a cavity, an inner casing spaced from said first casing and forming a manifold chamber therewith, a plate closing one end of said chamber, a nozzle closing the other end of said chamber and having a concentric material receiving chamber formed therein, radial material inlet openings formed in said nozzle and placing said material receiving chamber in communication with said cavity around the nozzle, a fluid pressure receiving drum forming the bottom of said nozzle and having vertical inlet pipes extending therethrough, connecting said material receiving chamber with the cavity beneath the nozzle, a static jet having its discharge end projecting upwardly through said chamber into said inner casing, venturi means positioned in said inner casing and having its discharge end encircling the discharge end of said static jet, a sump jet projecting downwardly from said nozzle, said jets being operatively connected with said fluid pressure receiving drum, an excavating jet mounted externally of said casing above said nozzle and directed towards the walls of the cavity, conduit means communi-

cating with the excavating jet for furnishing pressure fluid thereto, means placing said drum in communication with said manifold chamber and conduit means for furnishing pressure fluid to said last named chamber, whereby material forming the cavity walls is dislodged by said excavating jet, a sump is formed beneath the excavator by said sump jet, and the material dislodged by said last named jets is drawn into said material receiving chamber, respectively through said radial openings and vertical inlet pipes, entrained through said venturi and discharged through said inner casing.

3. A hydraulic excavator for use in subterranean deposits accessible by the open pit method wherein a controlled operating sump is maintained beneath the point of excavation, comprising an outer casing adapted to be lowered into a pit cavity, an inner discharge casing concentric and co-extensive with the outer casing, a nozzle assembly connected to the lower ends of said casings and having a concentric material receiving chamber formed therein, the walls of said chamber defining a series of radially disposed, material inlet openings in said nozzle assembly placing said chamber in communication with said pit cavity, a static jet in said nozzle assembly projecting upwardly through said inner discharge chamber into said casing, venturi means positioned in said discharge casing above the material receiving chamber, the throat of the venturi means encircling the end of said jet, a sump jet projecting downwardly from said nozzle assembly, an excavating jet mounted externally of said outer casing above said nozzle assembly and directed toward the walls of the pit cavity, and conduit means communicating with the respective jets for furnishing pressure fluid thereto, dimensionally the cumulative capacity of said discharge casing and venturi means exceeding the volumetric displacement of the pressure fluid furnished to said jets, plus the displacement of the material excavated, whereby the liquid level in the pit cavity is maintained at a controlled elevation below the static jet.

4. Apparatus as claimed in claim 2, wherein the walls of said material receiving chamber are formed by a plurality of annularly arranged water passages, connecting said manifold chamber with said drum, said radial, material inlet openings being formed between respective water passages.

5. In a hydraulic excavator for use in subterranean deposits by the open pit method and wherein a controlled operating sump is maintained at all times beneath the point of excavation: an outer casing and a discharge casing spaced inwardly from the outer casing, a nozzle assembly joining the lower ends of said casings; internal and external hydraulic displacement means connected to said casings including: hydraulic excavating means mounted upon the outer casing member at an upper end thereof, entraining means mounted at the lower end of said casings internally of the nozzle assembly, venturi means secured within the lower end of the discharge casing, surrounding said entraining means in coacting relation therewith, hydraulic sump means mounted internally of the nozzle beneath the entraining means; said discharge casing having a dimensional capacity greater than the sum of internal and external hydraulic displacement capacities plus material excavated at any given period whereby capacity imbalance provides a quantitative balance between volumetric displacement of the discharge casing and the volumetric displacement of internal and external hydraulic displacement means plus materials excavated.

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