

June 2, 1970

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HIGH LIFT MUD HOPPER

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2 Sheets-Sheet 1

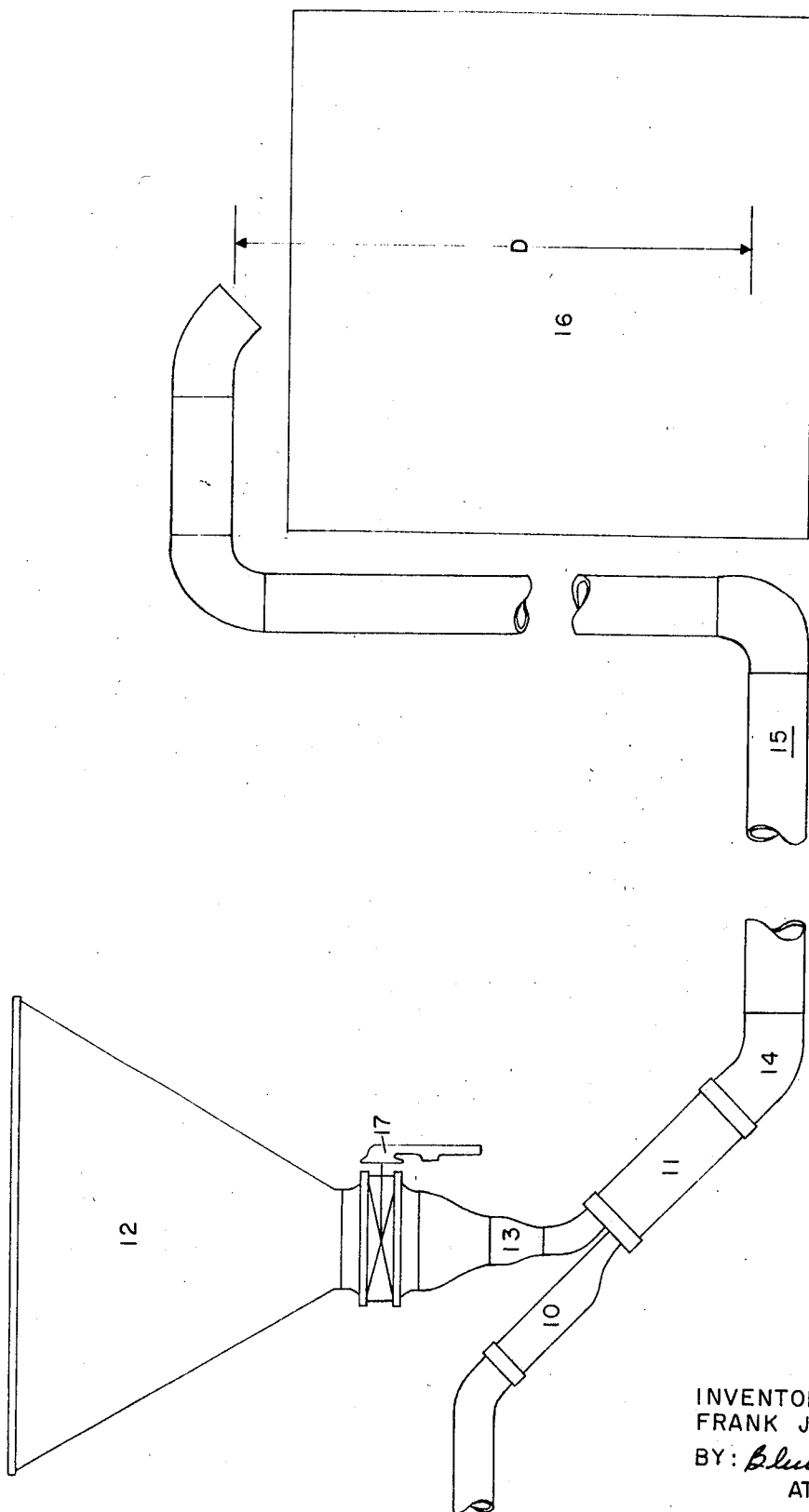


FIG. 1

INVENTOR:
FRANK J. SCHUH
BY: *Blucher & Sharp*
ATTORNEY

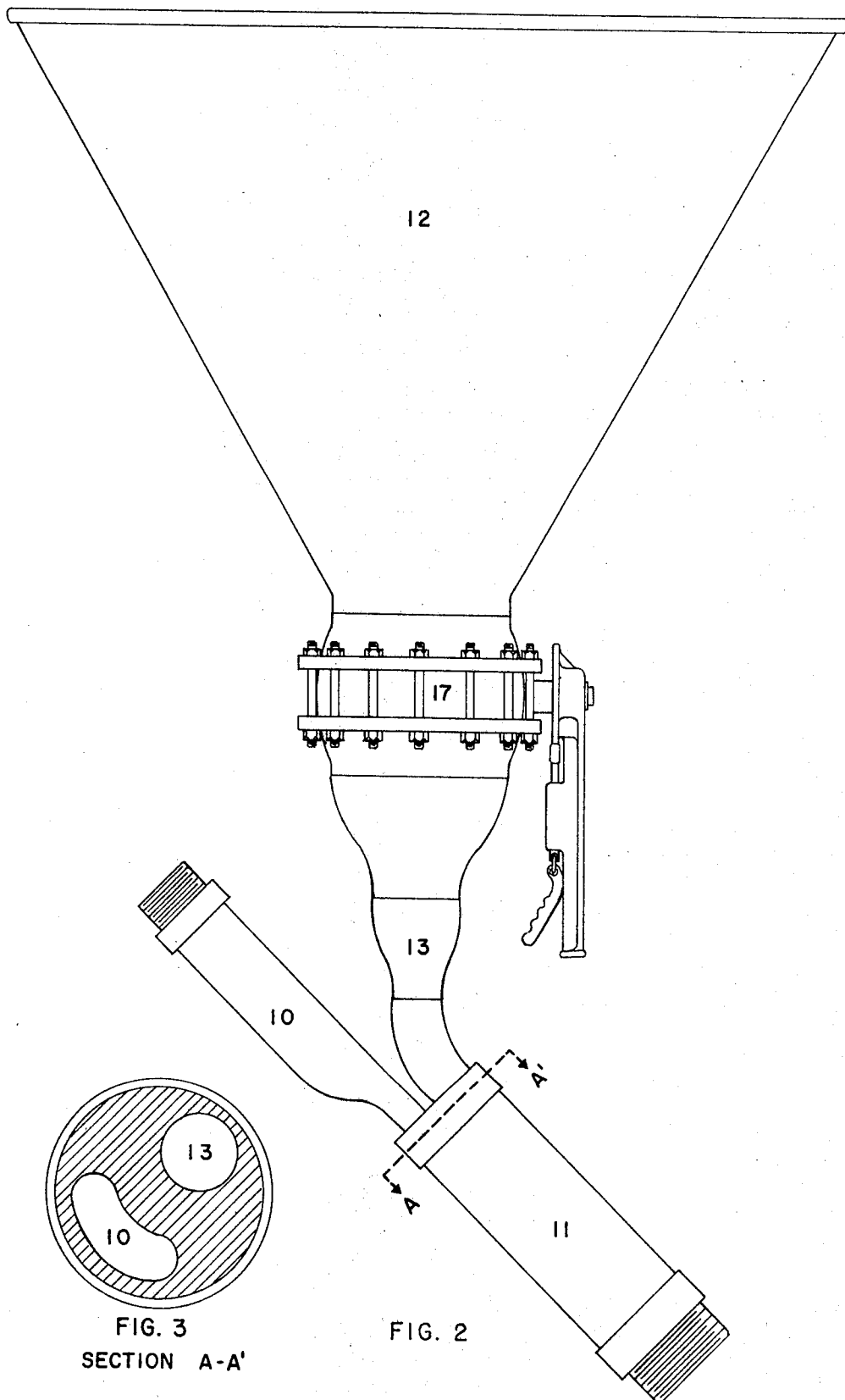
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HIGH LIFT MUD HOPPER

Frank J. Schuh, Dallas, Tex., assignor to Atlantic Richfield Company, Philadelphia, Pa., a corporation of Pennsylvania

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3 Claims

ABSTRACT OF THE DISCLOSURE

Adding ingredients from a hopper to drilling mud circulating in a pipe. The flow of the drilling mud through a jet nozzle into an expansion chamber causes a vacuum to be applied to the hopper sucking the ingredients into the expansion chamber. The drilling mud may be discharged against a positive back pressure by employing an expansion chamber and a jet nozzle which have predetermined cross-sectional areas relative to each other while controlling the flow rate of drilling mud through the jet nozzle. Plugging of the hopper nozzle is prevented by inclining the expansion chamber with respect to the horizontal and introducing the ingredients in the downward direction of the incline above and parallel to the flow of the drilling mud.

BACKGROUND OF THE INVENTION

The invention pertains to dispensing with fluid flow discharge and particularly relates to adding ingredients to drilling mud by aspirator action.

In rotary drilling operations drilling mud is pumped from a storage tank or mud pit down through the drill stem and out the bit. As the drilling mud rises to the surface, it is reconditioned and returned to the pit. Materials are added to the drilling mud to adjust the viscosity, increase its density, or otherwise restore the physio-chemical properties required for various conditions in the well.

The most common mixing device for adding ingredients to drilling mud is the jet hopper. With this device mud or fluid is pumped through a nozzle or orifice into an expansion chamber connected to the hopper nozzle, i.e. outlet. Expansion to a larger diameter stream causes a vacuum to be applied to the hopper nozzle sucking the ingredients into the expansion chamber. Therefore, selected materials may be introduced continuously as the drilling mud is circulated toward the pit solely by means of aspirator action.

The jet hopper generally performs satisfactorily so long as no attempt is made to discharge the drilling mud at an elevation much higher than that of the expansion chamber. A positive back pressure of any magnitude curtails the effectiveness of the aspirator action so that it may no longer be possible to introduce the ingredients at the desired rate, if at all.

In the past this problem has been avoided—rather than solved—by the expediency of locating the hopper at the top of the mud pit. However, on offshore platforms, drilling barges, or ships it is inconvenient to mount the hopper above the mud storage tank since this usually necessitates hand carrying sacks of ingredients from the deck to the hopper (typically a vertical distance of about 10 feet).

Another problem of the jet hopper is that the ingredients tend to plug or clog the hopper nozzle. Prior art hoppers are all built with the expansion chamber in a horizontal plane and the hopper nozzle in a vertical position. Addition of the ingredients causes the drilling mud to splash, wetting the ingredients in the hopper. This condition leads to caking with the result that the hopper nozzle may be completely plugged.

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SUMMARY OF THE INVENTION

The present invention provides a high lift mud hopper that can be placed at the base of a storage tank and still discharge the drilling mud against a positive back pressure at the top of the tank. The invention further provides an improved hopper design whereby the efficiency of the mixing operation is increased so as to keep the ingredients from plugging the hopper nozzle.

Applicant made an engineering study of the mechanics of mud hoppers which resulted in the derivation of the following equation:

$$P_2 - P_1 = \frac{231 Q_j^2 W_1}{43,200 A_2^2 g} \left[\frac{A_2}{C_j A_1} - (1+r)(1+f) \right]$$

where:

$P_2 - P_1$ = pressure difference between the drilling mud downstream of the hopper and the vacuum pressure applied to the hopper, p.s.i.;

Q_j = flow rate of the drilling mud through the jet nozzle, gals./min.;

W_1 = density of the drilling mud, lb./gal.;

A_2 = cross-sectional area of the expansion chamber, in.²;

g = gravitational constant, ft./sec.²;

C_j = jet nozzle coefficient (the product of C_j and A_j gives the effective cross-sectional area of the jet nozzle).

A_j = cross-sectional area of the jet nozzle, in.²;

r = ratio of the density of the ingredients divided by the density of the drilling mud; and

f = ratio of the flow rate of the ingredients through the hopper nozzle to the flow rate of the drilling mud through the jet nozzle.

By increasing the pressure difference " $P_2 - P_1$ " the drilling mud can be discharged against a positive back pressure at a preselected elevated location. This is accomplished by adjusting parameters of the system according to the foregoing equation in order to maintain the pressure of the drilling mud at a sufficient level to lift the drilling mud the desired distance.

The above relationship shows that the pressure of the drilling mud downstream of the hopper can be increased, while still applying suction to the hopper, by decreasing " A_2 ," increasing " Q_j ," and/or decreasing " A_j ." Thus, by employing an expansion chamber and a jet nozzle which have predetermined cross-sectional areas relative to each other, while controlling the flow rate of drilling mud through the nozzle the pressure of the drilling mud can be raised to whatever extent necessary to lift the mud to the top of the storage tank.

In another aspect of the invention, applicant has determined that plugging of the hopper nozzle can largely be prevented by inclining the expansion chamber with respect to the horizontal and introducing the ingredients in the downward direction of the incline above and parallel to the flow of the drilling mud. Applicant's hopper design for this purpose has the expansion chamber inclined with respect to the horizontal and the hopper nozzle above the jet nozzle at the top of the incline such that their bores are essentially parallel to the longitudinal axis of the expansion chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 pictorially shows a mud hopper connected to a pipe discharging into a tank against a positive back pressure.

FIG. 2 illustrates a mud hopper constructed according to the invention to have an inclined expansion chamber.

FIG. 3 is a cross-sectional view taken along A-A' in FIG. 2 showing the hopper nozzle and jet nozzle in relation to each other.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to illustrate the high lift mud hopper invented by applicant reference is made to FIG. 1.

Drilling mud is pumped through jet nozzle 10 into expansion chamber 11. Expansion of the drilling mud to a larger diameter stream produces a vacuum in chamber 11. Ingredients in hopper 12 are sucked through hopper nozzle 13 and mixed with the drilling mud. The resulting mixture travels through coupling elbow 14 to pipe 15 which discharges into storage tank 16. Addition of the ingredients is controlled by adjusting butterfly valve 17.

As distance D increases, the pressure of the drilling mud downstream of hopper 12 must be maintained at a sufficient level to discharge the drilling mud against the correspondingly increasing back pressure. This can readily be accomplished selecting the cross-sectional areas of expansion chamber 11 and jet nozzle 10 to provide the desired performance. Alternatively, downstream pressure can be maintained by increasing the flow rate of the drilling mud through jet nozzle 10. This is done by utilizing a more powerful or more efficient pump (not shown) to circulate the drilling mud.

Referring further to FIG. 1, it will be seen that expansion chamber 11 is inclined with respect to the horizontal and that the ingredients are introduced in the downward direction of the incline above and parallel to the flow of the drilling mud. As already explained, this process increases the rate and extent of mixing so as to keep the ingredients from plugging hopper nozzle 13.

This aspect of the invention can better be seen from FIGS. 2 and 3. Expansion chamber 11, FIG. 2, is inclined approximately 45 degrees with respect to hopper 12 and, hence, the horizontal. When suction is applied to butterfly valve 17, ingredients feed into hopper nozzle 13 and are released at the top of the incline. Referring to FIG. 3, one can see that hopper nozzle 13 is located above jet nozzle 10 such that their bores are aligned essentially parallel to the longitudinal axis of expansion chamber 11. This arrangement has been found to greatly increase the efficiency of the operation by preventing costly shutdowns.

To summarize: Applicant has developed a process whereby it is possible to design a high lift hopper to meet any job requirements. An equation defining the parameters of the system has been given and procedures have been given for discharging drilling mud against a positive back pressure in actual practice. Additionally, applicant has invented a new process and apparatus which increases the efficiency of any jet hopper (conventional or high lift) by preventing plugging of the hopper nozzle.

What is claimed is:

1. In a process for adding ingredients from a hopper to drilling mud circulating in a pipe whereby the flow of the drilling mud through a jet nozzle into an expansion chamber causes a vacuum to be applied to the hopper sucking the ingredients into the expansion chamber, the improvement which comprises increasing the rate and

extent of mixing so as to keep the ingredients from plugging the hopper nozzle by inclining the expansion chamber with respect to the horizontal and introducing the ingredients in the downward direction of the incline above and parallel to the flow of the drilling mud.

2. Apparatus for adding ingredients from a hopper to drilling mud circulating in a pipe whereby the flow of the drilling mud through a jet nozzle into an expansion chamber causes a vacuum to be applied to the hopper sucking the ingredients into the expansion chamber, wherein the improvement comprises having the expansion chamber inclined with respect to the horizontal and locating the hopper nozzle above the jet nozzle at the top of the incline such that their bores are essentially parallel to the longitudinal axis of the expansion chamber.

3. Apparatus for adding ingredients from a hopper to drilling mud circulating in a pipe whereby the flow of the drilling mud through a jet nozzle into an expansion chamber causes a vacuum to be applied to the hopper sucking the ingredients into the expansion chamber, wherein the improvement comprises employing an expansion chamber and a jet nozzle which have predetermined cross-sectional areas relative to each other as defined by the following equation:

$$P_2 - P_1 = \frac{231 Q_j^2 W_j}{43,200 A_2^2 g} \left[\frac{A_2}{C_j A_1} - (1 + rf)(1 + f) \right]$$

where:

$P_2 - P_1$ = pressure difference between the drilling mud downstream of the hopper and the vacuum pressure applied to the hopper, p.s.i.;

Q_j = flow rate of the drilling mud through the jet nozzle, gals./min.;

W_j = density of the drilling mud, lb./gal.;

A_2 = cross-sectional area of the expansion chamber, in.²;

g = gravitational constant, ft./sec.²;

C_j = jet nozzle coefficient;

A_1 = cross-sectional area of the jet nozzle, in.²;

r = ratio of the density of the ingredients divided by the density of the drilling mud; and

f = ratio of the flow rate of the ingredients through the hopper nozzle to the flow rate of the drilling mud through the jet nozzle.

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M. CARY NELSON, Primary Examiner

R. J. MILLER, Assistant Examiner

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