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J. D. CHESTNUT ET AL

2,279,287

APPARATUS FOR CEMENTING WELLS

Filed Feb. 4, 1939

3 Sheets-Sheet 1

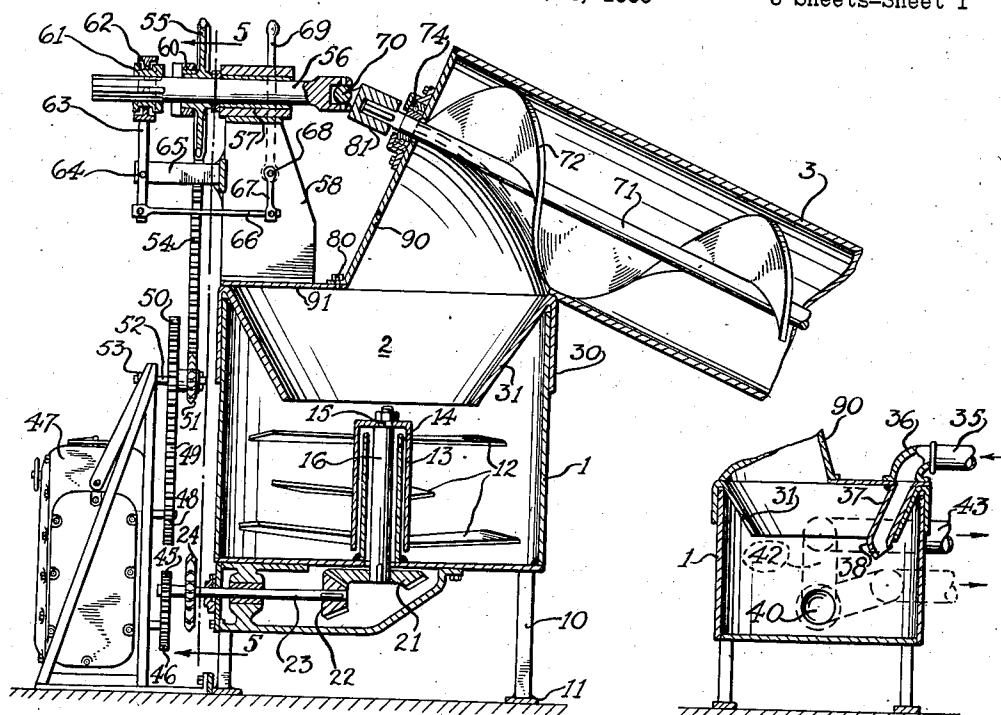


Fig. 1

Fig. 6

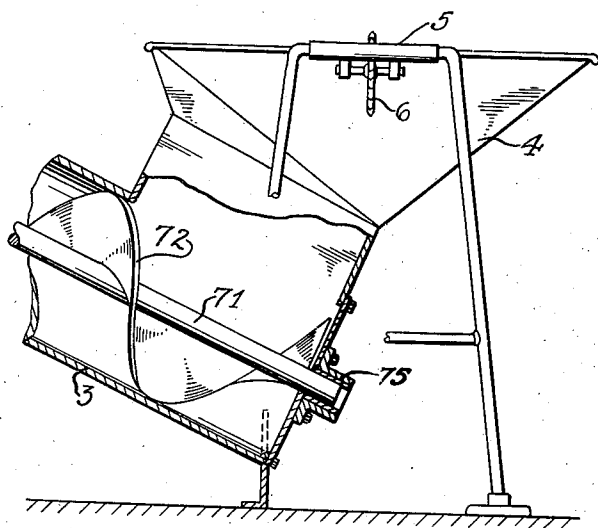


Fig. 2

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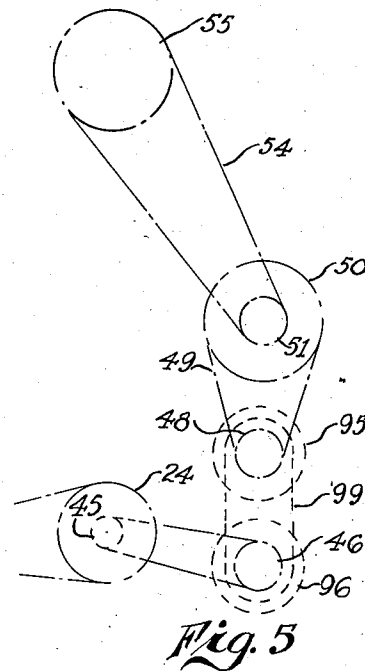
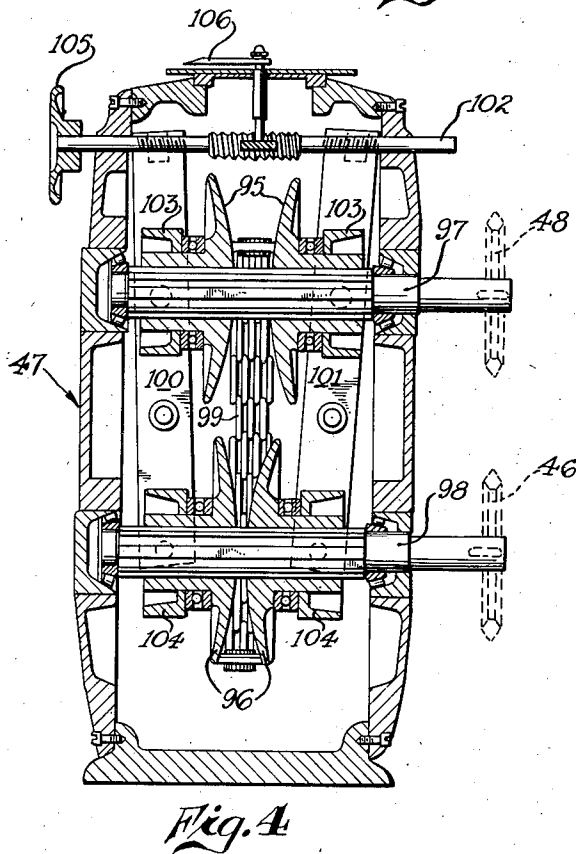
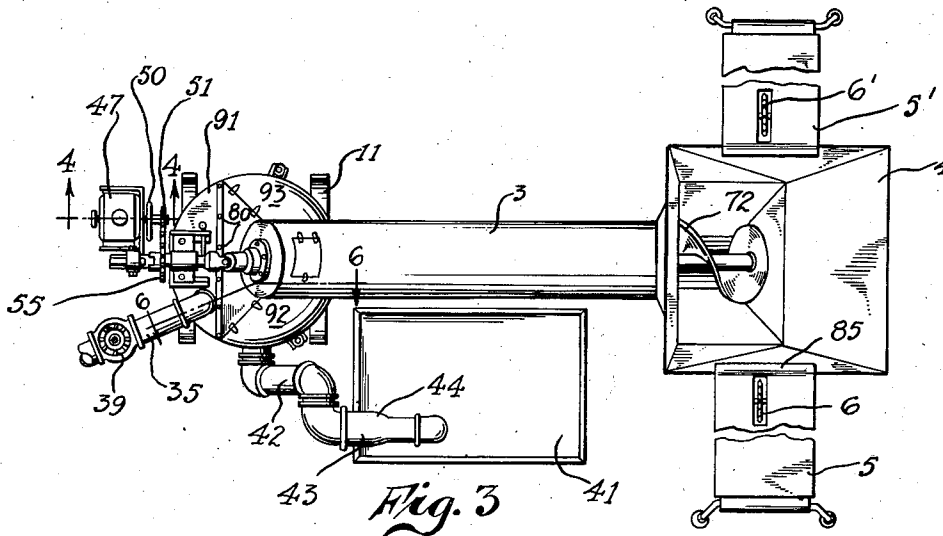
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3 Sheets-Sheet 3

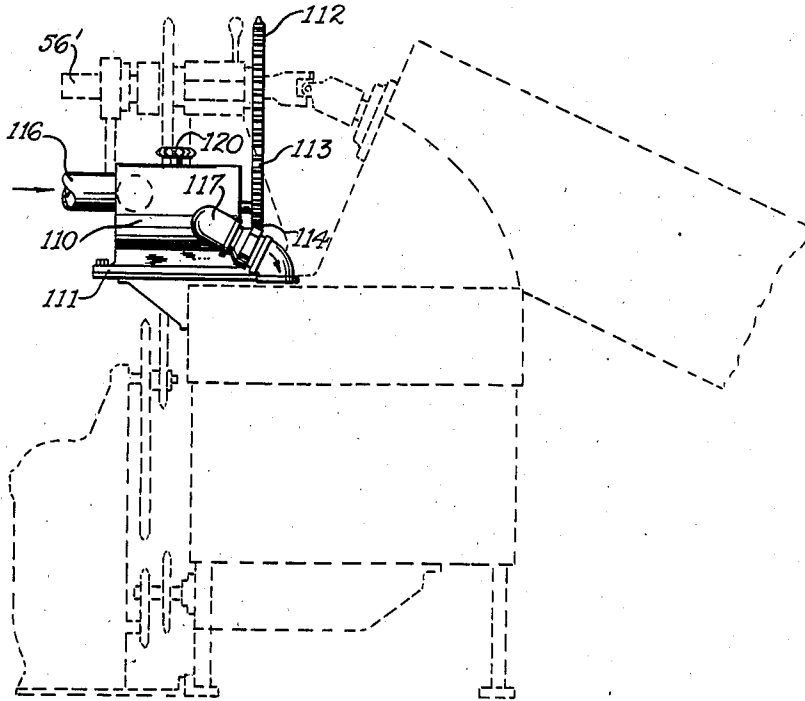


Fig. 7

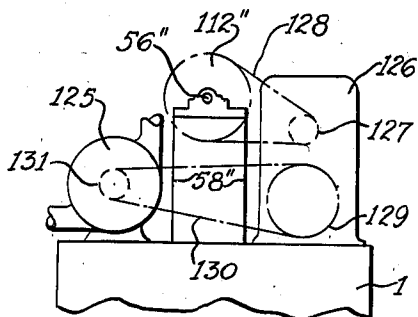


Fig. 8

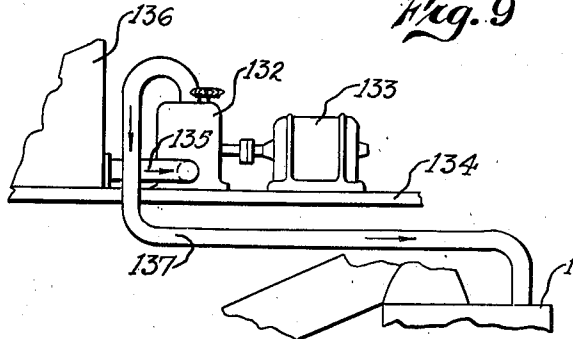


Fig. 9

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APPARATUS FOR CEMENTING WELLS

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Application February 4, 1939, Serial No. 254,652

5 Claims. (Cl. 259—154)

This invention relates generally to oil well cementing, and is directed particularly to improvements in apparatus of mixing cement slurry or for preparing an aqueous mixture of cement and sand for cementing oil wells.

Because of the unusual conditions encountered in cementing oil wells, a cement mixer must fulfill certain exacting requirements not ordinarily present, in order to meet with success in this field. The time element is an important factor in cementing oil wells, inasmuch as the mixture must be pumped a considerable distance, usually several thousand feet, and the relatively high temperatures often encountered accelerate setting of the cement. Consequently, the mixer must be capable of handling a large volume in a short period of time, and the volume must be capable of being varied to suit varying conditions. The capacity of a successful mixer should be variable between 300 and 1800 sacks of cement per hour.

Of major importance, however, is the control of the consistency of the mix, as determined by the cement-water ratio. Well-cementing practice requires that the mixing be a continuous process, as distinguished from a batch process, and the volume requirements per unit of time are so high that if the control of the cement-water ratio is haphazard large volumes of slurry of improper consistency will be introduced into the well. Varying conditions at different wells necessitate different cement-water ratios, and at a single well the ratio may be changed progressively through a range from approximately 0.4 to 1 cubic foot of water per cubic foot of dry material. In order to obtain predetermined cement-water ratios, the rate of feed of both the dry material and water to the mixer should be measured while supplying continuous streams of both.

It is a principal object of this invention to provide a cement mixer for well-cementing operations in which the rate of feed of both dry material and water may be accurately controlled and in which each may be controllably varied to provide a wide range of cement-water ratios, while supplying continuous, measured quantities of each to the mixer. A further object is to provide a mechanical cement mixer having, in addition to power-operated mixing means, a power-operated measuring and feeding means for the dry material and a metering device for the water supply, so arranged that the rates of feed of dry material and of water may be varied independently of each other and independently of the mixing rate, whereby the speed of the entire operation may be suitably varied in accordance with conditions

existing at individual wells, and the rates of feed of dry material and of water may be correlated to provide the desired cement-water ratios.

A still further object is to provide a mechanical cement mixer capable of delivering large volumes of properly mixed cement slurry in a wide range of predetermined consistencies.

An additional limitation imposed by the operating conditions is the height of the feed hopper above the working level. It is customary to stack the required number of sacks of cement for the particular job in close proximity to the mixer, and to feed them by hand to the feed hopper. The rapid mixing rate, oftentimes as high as 25 to 35 sacks per minute, requires very rapid handling of the sacks, and inasmuch as the standard sack of cement weighs 94 pounds it is wholly impracticable to locate the top of the feed hopper more than 3 feet above the working level. The time element as well as the manual exertion required thus impose, for all practical purposes, a height limitation of not more than 3 feet. Mechanical cement mixers best adapted to well-cementing are either of the vertical cylinder or the horizontal cylinder type, each having rotatable paddles or other agitating and mixing means therein. In the vertical type the open upper end of the mixer serves as a hopper, and, if accurate control of the rate of delivery of cement is not required, the sacks may be emptied directly into the mixer, a preferred embodiment of which is approximately 30 inches high. However, if accurate control of the rate of delivery is desired, it is necessary to provide a storage hopper and a metering device between the hopper and the mixer to constantly feed the cement at a uniform rate, the capacity of the hopper being sufficiently large to insure that the metering device is constantly supplied with cement in spite of irregularities in the rate of emptying the sacks into the hopper. Obviously, it would be impracticable to superimpose a metering device and a hopper of sufficient capacity above a vertical mixer, because of the aforementioned height limitation. Consequently, the discharge of the hopper is necessarily located below the top of the mixer, requiring elevating means therebetween.

It is a further object of this invention to provide a mixer having a storage hopper delivering to a combined metering and elevating device discharging into the mixer, the mouth of the hopper being sufficiently low to enable it to be charged manually. It is a further object to provide in such a mixer a driving means for the metering and elevating device from a source

common to the mixer drive, but controllably variable independently of the mixer drive, whereby the metering and elevating device may be driven at any one of a plurality of speeds from the power source used to drive the mixer and while the latter is driven thereby at a constant speed.

Although it is well known that an aqueous mixture of cement and sand when set has a much higher strength than a straight cement grout, up until the present time it has been impossible to use a cement-sand mixture in cementing oil wells chiefly because of the lack of equipment capable of properly mixing cement, sand, and water under the conditions encountered in oil well cementing. It is a still further object of this invention to provide a method and apparatus for thoroughly mixing large quantities of cement, sand, and water within a short space of time while maintaining the proportions of the ingredients within close but controllably variable limits.

Our novel method comprises essentially the steps of introducing dry materials in suitable proportions into a dry mixing zone wherein three important steps are performed simultaneously—that is, the dry materials are thoroughly mixed while being transported and metered to a wet mixing zone wherein the dry mixture is mixed with water which is also metered to the zone. By combining the dry mixing, conveying, and metering steps in point of time, it is possible to obtain a mixing speed which meets the requirements of oil well cementing. The correlation of the steps is also such that relatively small, lightweight, portable apparatus may be employed. It will be readily apparent to those familiar with oil well cementing practice that portability of the equipment is not only highly desirable but is an essential requirement.

Other objects and advantages will be apparent from the following description, taken in conjunction with the accompanying drawings wherein there is illustrated an apparatus capable of being used for mixing either cement grout or a mixture of cement, sand, and water.

Fig. 1 is a partial vertical sectional view of one form of the mixing apparatus showing the mixing chamber and the discharge end of the conveyor;

Fig. 2 is a view, partly in vertical section and partly in elevation, showing the hopper and the intake end of the conveyor;

Fig. 3 is a plan view of the apparatus of Fig. 1;

Fig. 4 is a vertical sectional view through the plural speed transmission, taken substantially on line 4—4 of Fig. 3;

Fig. 5 illustrates diagrammatically the gear train from the power take-off sprocket to the conveyor drive sprocket, as viewed from line 5—5 of Fig. 1;

Fig. 6 is a vertical section taken substantially on line 6—6 of Fig. 3, showing the water inlet pipe and the vertically adjustable slurry discharge pipe;

Fig. 7 is a view in elevation of a modification using a variable capacity pump in lieu of a graduated water valve;

Fig. 8 illustrates diagrammatically a further modification; and

Fig. 9 illustrates diagrammatically a still further modification.

Referring to Figs. 1 to 3 of the drawings, the mixer comprises generally a mixing drum 1 and a superposed throat piece or funnel 2 through which dry material is fed to the mixing cham-

ber by an inclined screw conveyor 3, the discharge end of which overlies the throat piece. The conveyor extends downwardly to merge with a storage and feed hopper 4, into which dry materials are dumped by members of the cementing crew. In Fig. 3 there are shown two sack-cutting platforms 5 and 5' attached to opposite sides of the hopper 4 and having sack cutters 6 and 6' mounted near their inner ends. The cutters are illustrated as disk cutters freely rotatable on the platforms and projecting slightly above the upper surfaces thereof to engage the sacks and rip them open as the latter are slid along the platforms toward the hopper. It will be understood that when mixing only cement and water, only a single platform may be used if desired, and in this case it is preferably attached to the side of the hopper opposite the conveyor 3.

The mixing chamber 1 comprises a vertically disposed cylinder supported on legs 10 to which are welded a pair of skids 11. Rotatably mounted within the cylinder are a plurality of paddles 12 attached to a sleeve 13 journaled, as diagrammatically illustrated in Fig. 1, on an up-standing hub 14 secured in fluid-tight relation to the base of the cylinder and coaxial therewith. In order to rotate the sleeve 13, the upper end thereof has a noncircular opening therein through which extends a similarly shaped stud 15 formed integral with a shaft 16 rotatably mounted within the hub 14 and projecting downwardly through a central opening in the base of the cylinder. A ring gear 21 keyed to the lower end of the shaft meshes with a pinion 22 keyed to a shaft 23 having keyed thereon a drive sprocket 24 adapted to be connected to any suitable power source. The hub 14 extends upwardly above the level of the mixture of cement and water or of cement, sand, and water in the chamber, whereby leakage through the opening in the base is avoided.

The throat piece 2 comprises a cylindrical sleeve portion 30 snugly fitting over the upper portion of the mixing chamber, and a funnel 31 integral therewith extending downwardly within the mixing chamber and confining the stream of dry material to the central portion thereof. As shown in Fig. 6, a water inlet pipe 35 is secured to an elbow 36 welded to the top of the throat piece in communication with a conduit 37 extending downwardly along the inner surface of the funnel 31. The conduit may be a short section of pipe welded to the funnel, as shown, or it may be formed as an integral part of the funnel. The lower discharge end of the conduit is preferably bent slightly outwardly as at 38, so as to direct the stream of water away from the axis of the chamber. Water is supplied to the pipe 35 from a suitable source, the rate of flow being regulated to supply a constant, measured supply. For this purpose any suitable regulating means may be provided, such as a graduated valve 39, as shown in Fig. 3, or a displacement pump, as shown in Figs. 7 to 9, or a gravity meter.

The rotation of the paddles 12 thoroughly mixes the water and dry material and also exerts a slight downward force on the mixture, due to the slight inclination of the paddles from their planes of rotation. The slurry is discharged through an opening 40 in the wall of the chamber adjacent the base thereof, into a tank 41 from which it is drawn by a pump (not shown) and forced into the well. In order to regulate the rate of discharge from the mixing chamber, the discharge pipe leading from the opening 40 to

the tank 41 comprises two sections 42 and 43, the section 42 being swiveled to the chamber outlet to swing in a vertical plane, and the section 43 being swivelly mounted on section 42 on a parallel axis. In Fig. 6 the discharge pipe is shown in two alternative positions, but it is apparent that it may be adjusted to any position within the range of adjustment. By this arrangement the effective height of the outlet may be varied to provide the desired rate of discharge from the mixing chamber. A predetermined back pressure is provided by reducing the diameter of the discharge pipe at 44.

The screw conveyor 3 is driven from the shaft 23 at any one of a plurality of speeds. For this purpose, a sprocket 45 keyed to the end of shaft 23 is connected to a sprocket 46 on the input shaft of a variable speed transmission 47. A unit known as the Link-Belt P. I. V. gear (positive infinitely variable) has been found suitable for this purpose, although it will be understood that any other positive drive transmission providing a wide range of speeds may be used.

A sprocket 48 is keyed on the output shaft of the transmission and is connected by a chain 49 to the larger of two sprockets 50 and 51 constituting a speed reduction unit, the sprockets being connected together and journaled on a stub shaft 52 carried by a supporting bracket 53. The small sprocket 51 is connected by a chain 54 to a sprocket 55 loosely journaled on a shaft 56 journaled in a bearing 57 mounted on a bracket 58 secured to the top of the funnel 2. In order to selectively connect the sprocket 55 in driving relation with the shaft, suitable clutch mechanism is provided. As shown in Fig. 1, a jaw clutch member 60 is keyed to the hub of the sprocket and is adapted to be interengaged with a clutch member 61 splined to the shaft. The clutch member 61 is shifted into or out of engagement with clutch member 60 by a thrust collar 62 engaged by a shipper lever 63 pivoted at 64 to a bracket 65. Suitable linkage 66, 67, 68 connects the shipper lever to an operating lever 69.

The shaft 56 is connected through a universal joint 70 to the shaft 71 of a screw 72 constituting the impeller of the conveyor 3. A combined radial and thrust bearing 74 supports the shaft 71 at its upper end, the lower end being journaled in a radial bearing 75 in the end plate of the conveyor housing. The inclination of the conveyor tube 3 is so correlated to the pitch of the conveyor screw 72 that during the travel of material up the tube it is thoroughly admixed, producing an intimate mixture of the ingredients thereof.

The mixing device is so constructed as to be separable into units convenient to transport, and capable of being quickly set up and connected together. The transmission 47 is mounted on a base adapted to be bolted to the adjacent skid 11. By removing the chain connecting sprockets 45 and 46, and also chain 54, the transmission unit may be detached. The upper end of the conveyor housing is bolted at 80 to the top of the funnel 2 so as to be detachable therefrom, and the conveyor shaft 71 has a splined upper end portion slidable within an internally splined sleeve 81 integral with the universal joint 70. The conveyor 3 and hopper 4 are thus detachable from the funnel 2, the bracket 58 and shaft 56 remaining on the funnel. The funnel is also detachable from the mixing drum. The platform 5 is provided with a lip 85 which engages over the

rear edge of the hopper 4, and may be readily detached therefrom.

In order to confine within the mixer the cloud of cement dust which may form as the cement discharges from the conveyor, the upper end of the mixer and conveyor are wholly enclosed. The end plate 90 of the conveyor housing extends downwardly and is flared outwardly, as shown in Fig. 3, the lower edge being bolted to an arcuate top plate 91 welded to the funnel member 2. Conical segments 92 and 93 close the lateral spaces between the conveyor housing and the upper edge of the mixer, the segments being hinged to the end plate 90 to provide access to the interior of the mixer after the conveyor unit has been connected thereto, and to permit inspection during the mixing operation.

The transmission 47 comprises generally two pairs of opposed conical wheels 95 and 96 (Fig. 4) splined to parallel shafts 97 and 98. A chain 99 connects the pairs of wheels, the effective diameter of each pair being changeable under load to change the speed ratio by varying the distance between the opposed conical faces of each pair of wheels. A pair of pivoted levers 100, 101 are oppositely threaded on an adjusting screw 102 and engage pairs of thrust collars 103, 104 journaled on the wheels 95 and 96 to effect adjustment of the latter. A hand wheel 105 is provided on the adjusting screw, and an indicator 106 indicates the speed ratio. This type of transmission is particularly adapted for the present purpose because of the capability of changing the speed ratio under load without interrupting the drive.

Referring now to Fig. 7, a modification of the water metering means is shown in the form of a variable capacity, positive displacement pump 110. The apparatus is otherwise similar to the form shown in Figs. 1 to 3, and hence is shown only in dotted outline. The pump 110 is mounted on a bracket 111 secured to the plate 91 of Fig. 1, and is driven in synchronism with the conveyor by means of a sprocket 112 keyed to the conveyor drive shaft 56', a chain 113 and a sprocket 114 keyed to the pump impeller shaft. A water inlet pipe 116 is connected to a source of supply, and a discharge pipe 117 communicates with the conduit 31 of Fig. 6. The pump may be of any type having variable capacity at constant speed, such as the adjustable swash-plate type or one having an eccentric axis, the eccentricity of which may be varied. Manipulation of hand wheel 120 varies the output capacity of the pump.

Fig. 8 illustrates diagrammatically a modification of Fig. 7, using a positive displacement pump 125 wherein the output capacity is varied by varying the speed. For this purpose, a change speed mechanism 126 is interposed between the drive sprocket 112' on the conveyor shaft 56' and the pump impeller. The change speed mechanism 126 may be of the same type as the transmission 47 of Figs. 1 to 3, the driving sprocket 127 on the input shaft being connected to sprocket 112' by a chain 128, and the driven sprocket 129 on the output shaft being connected by a chain 130 to a sprocket 131 on the pump impeller shaft. For convenience, the pump 125 and the transmission 126 may be mounted on the top of the mixing chamber 1 on opposite sides of the upstanding brackets 58' supporting the conveyor drive shaft 56'.

The two forms of the invention shown in Figs. 7 and 8 have the advantage of synchronizing the

conveyor speed and the pump speed while also providing for variation of the pump speed relative to that of the conveyor. With these arrangements the desired cement-water ratio may be obtained by adjustment of the variable capacity pump 110 of Fig. 7 or of the variable speed transmission of Fig. 8, and subsequent manipulations of the variable speed transmission 47 for the purpose of correlating the conveyor speed to the rate of filling the hopper 4 will have no effect on the cement-water ratio.

Figure 9 illustrates diagrammatically a still further modification employing a variable capacity pump 132 as in Fig. 7. In this case, however, the pump is driven at a constant speed by an electric motor 133. The pump and motor may be conveniently mounted on the cementing truck 134, with the pump intake pipe 135 connected to the water supply tank 136, and the outlet of the pump connected by flexible hose 137 to the water inlet opening of the mixing chamber 1. In this form of the invention the water rate is positively controlled and the pump is driven by an independent prime mover. For this reason, the pump and motor may be located at any convenient point. There is not provided, however, the synchronization between the cement and water rates obtainable with the forms of the invention shown in Figs. 7 and 8. In this respect the form shown in Fig. 9 is quite similar to that shown in Figs. 1 to 3, using a graduated valve, although with the use of a pump closer control over the water rate is obtainable.

The mode of operation of the mixing device will be apparent from the foregoing description. When the sprocket 24 is rotated by a suitable power source, such as the propelling motor of the cementing truck, the paddles 12 will rotate. It will be observed that the paddles are inclined slightly from their planes of rotation, and preferably are rotated in a direction to exert a slight downward propelling force on the mixture. Water is admitted through the inlet pipe 35 at a predetermined rate, and dry material is fed to the mixer by the screw conveyor, the rate of feed and consequently the cement-water ratio being determined by the setting of the variable speed transmission. Alternatively, the cement-water ratio may be varied by varying the rate of delivery of water while maintaining a constant delivery rate of dry material. The variable speed transmission may be used to obtain the proper correlation between the conveyor speed and the rate at which dry material is dumped into the hopper, and after this is properly adjusted the cement-water ratio may be controlled through the water control means. Sufficient dry material is maintained in the hopper 4 to insure that the conveyor will always be full, thus providing a uniform rate of delivery to the mixer.

As the cementing operation progresses, it is frequently necessary or desirable to vary the cement-water ratio progressively through the entire range from 0.4 to 1 cubic foot of water per cubic foot of dry material. This may be accomplished with the mixer shown by simply adjusting the variable speed transmission 47, without stopping the mixer and without so much as interrupting the conveyor drive, or alternatively by varying the water delivery rate. In view of the high speeds at which well cementing operations are often necessarily carried on, mixing as high as 2400 sacks of cement per hour, the advantages derived from avoiding any interruption in the mixing process will be readily apparent. The

successful completion of a well cementing job depends on maintaining close correlation of the various steps being performed simultaneously—that is, the delivery of water and of dry material to the mixer at the proper rates, the rotation of the agitating means, the feeding of dry material to the hopper 4, and pumping the slurry down the well. The ability to provide various predetermined cement-water ratios with the elimination of all guess-work, and without interrupting the cementing operation while changing the ratio, marks an outstanding contribution to the well-cementing art.

When mixing cement, sand, and water, a practical and convenient method of supplying cement and sand to the hopper 4 in the desired proportions consists in providing a supply of sand in sacks each of the proper weight to produce the desired cement-sand ratio when one sack of sand to each sack of cement is dumped into the hopper. For example, a mixture having a 35% sand content may be produced by providing 50-pound sacks of sand and feeding one sack into the hopper for each of the standard 94-pound sacks of cement.

Prior to the start of an oil well cementing operation the required number of sacks of cement and of sand are stacked near the well, the sand being placed as close to one of the platforms 5 or 5' as possible, and the sacks of cement being stacked adjacent the other platform. Members of the crew feed the material to the hopper by sliding the sacks along the platform and over the cutters 6, 6' whereby the paper sacks are ripped open and their contents dumped into the hopper. By opening sacks of sand and of cement in unison, the desired ratio of sand to cement is established in the hopper 4. It will be understood, of course, that any other desired procedure may be followed for accomplishing this result.

As long as an adequate supply of material is maintained in the hopper 4, the screw conveyor 12 will operate at full capacity and will transport the mixture to the mixing drum 1 at a predetermined constant rate whereby the desired consistency of the final mix may be accurately controlled by controlling the delivery of water to the mixing drum. A feature of decided importance in oil well cementing is that during the conveying and metering steps the cement and sand are also intimately mixed as they travel through the conveyor tube 3. For this reason the time required for mixing a given quantity of cement, sand, and water is no greater than that required to mix a straight mixture of cement and water. Furthermore, by performing these steps within a single element of the apparatus, the number of pieces of equipment is greatly reduced and the overall weight and size of the apparatus is kept within limits of easy portability.

The arrangement disclosed presents a compact unit occupying a minimum of space and consequently capable of being mounted on a truck or on a trailer as an adjunct to the main cementing truck on which the pumps, power units, and water tank are mounted. The unit is composed of sub-assemblies readily detachable from each other if it is preferred to transport them dismantled and to assemble them at the site of each operation. Furthermore, an arrangement has been provided whereby accurate control of the rate of feed of the dry material is attained with the preferred vertical type of mechanical mixer, while at the same time the top of the feed hopper is main-

tained at a low level convenient for handling the sacks.

This application is a continuation-in-part of our earlier-filed application for Cement mixer Serial No. 180,816, filed December 20, 1937.

We claim:

1. Apparatus for cementing oil wells comprising, in combination: a hopper adapted to receive dry cement and an added dry ingredient in predetermined proportions and having a discharge opening in the lower portion thereof; a closed conveyor tube having its inlet end connected to the discharge opening of said hopper, said tube being inclined upwardly and having a discharge opening at its upper end; a spiral conveyor rotatably mounted in said tube in a direction to convey material upwardly therein, the charging end of said conveyor being disposed in the lower portion of said hopper and the conveyor blades having a relatively close clearance with the inner wall of said tube to effect positive displacement of the material therein, and the upward inclination of the tube being so correlated to the pitch of the blades that intimate admixture of the material is effected during its passage through the conveyor tube; a wet mixing chamber having its inlet disposed beneath the discharge opening in said conveyor tube; a mixing element rotatably mounted in said chamber; a conduit for supplying water to said chamber; means interposed in said conduit for controllably varying said water supply; common driving means for said mixing element and said spiral conveyor; a variable speed transmission in the driving connection from said common driving means to said conveyor whereby the delivery capacity of said conveyor can be varied independently of the actuation of said mixing element; and a discharge connection from said mixing chamber to the point of use.

2. Apparatus as defined in claim 1, in which said last-named discharge connection includes a vertically adjustable discharge conduit whereby the rate of discharge from said mixing chamber may be controllably varied.

3. Cement mixing apparatus comprising: a vertically disposed mixing chamber, a funnel detachably secured to the upper end of said chamber, a conveyor having its discharge end detachably secured to said funnel whereby cement discharged from the conveyor passes through the funnel and into the chamber, driving means for said conveyor including a shaft journaled in a bearing supported on said funnel, a separable driving connection between said shaft and said conveyor, and driving means for said shaft.

4. Cement mixing apparatus as defined in claim 3, in which said last-named driving means includes a driving element rotatably mounted on said mixing chamber, and a separable driving connection between said driving element and said shaft.

5. Cement mixing apparatus comprising: a mixing chamber, a mixer rotatable therein, actuating means for said mixer including a driving element rotatably mounted on said chamber, a conveyor having its discharge end detachably secured to the inlet of said chamber, a driving connection between said driving element and said conveyor including a unitary change speed mechanism detachably secured to said mixing chamber, a separable driving connection between said driving element and said change speed mechanism, and a separable driving connection between said change speed mechanism and said conveyor.

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