This invention relates to apparatus for producing a well, and more particularly to apparatus for separating solid material that may be entrained in well fluid preliminary to pumping the well fluid to the surface of the ground without returning the solid material into the fluid producing formation. While this invention is useful in separating solid particles contained in various well fluids, it is especially adapted to the separation and isolation of solid material, such as entrained sand, from oil in an oil well before the oil is transmitted to the surface of the ground.

During the production of oil from an oil well it often happens that sand and other solid substances from the well bore and producing formation will accumulate in the bottom hole. As these accumulations build up in the well bore, the productivity of the well will decrease, necessitating a well “clean out” operation. This is usually the case where the well bore penetrates a more or less consolidated producing formation. When such a condition occurs, the producing equipment is withdrawn from the well bore and the “clean out” operation is performed by the use of drill bits, bailers, sand pumps, and the like. It will be obvious that this is a laborious and costly procedure, resulting in expensive shut downs in many instances. Also, as the fluid level recedes and approaches the bottom of the well bore, it becomes increasingly difficult to loosen sand accumulations prior to their removal from the well.

Coincident with a low fluid level condition in a well bore, it is essential that the sand accumulations be removed to permit the lowering of producing equipment to a proper depth in the well bore in order that the oil may be transmitted to the surface of the ground.

From the foregoing, it will be obvious that it is of extreme importance that the well bore be maintained in proper condition in order that the well may produce in an effective and efficient manner. The practice of the instant invention affords a number of distinct advantages over methods and equipment employed heretofore in the production of a well. Basically, the invention contemplates separating solid material from well fluid, in which it is entrained, depositing the separated solid material in a receptacle in the well bore, and transmitting cleansed well fluid to the surface of the ground. In this manner, I am also able to eliminate excessive wear on the moving parts of the principal pumping means, which wear is mostly due to the abrasive action of solid particles contained in the well fluid. This invention therefore constitutes an improvement over the invention set forth in my copending application, Serial No. 369,936, patented September 28, 1943, No. 2,330,336.

It is the primary object of this invention to remove and isolate solid material that may be entrained in well fluid preliminary to transmitting the fluid to the surface of the ground. Another object of this invention is to maintain a well bore in an efficient producing condition at all times by preventing sand and other solid particles in the well fluid that is being produced from depositing in the well bore.

A further object of this invention is to provide apparatus whereby the solid content of well fluid may be readily and effectively separated from fluid in the well bore and then removed upon the withdrawal of the apparatus from the well bore.

This invention has for a still further object the provision of apparatus of the character indicated, which apparatus is simple in design, rugged in construction, and relatively inexpensive to manufacture and maintain.

These and additional objects and advantages will be readily apparent to persons skilled in the art upon an examination of the following description and annexed drawing which comparatively describe and illustrate a preferred embodiment of the apparatus for practicing the invention, and wherein

Figure 1 is an elevation view of the invention partly in cross section;

Figure 2 is an enlarged elevation view, partly in cross section, of the portion of the invention disposed below line 2—2 of Figure 1; and

Figure 3 is a transverse cross section view taken along line 3—3 of Figure 2.

Referring to the drawing, and more particularly to Figure 1 thereof, I have denoted a well bore 10 within which is a string of well casing 11 that extends downwardly from the surface of the ground 12 and communicates with a hydrocarbon oil-bearing reservoir 13. A string of flow tubing 14 is suspended within the casing and is removably connected at its lower extremity to a chamber 15 that contains a submersible electric motor 16 having a drive shaft 17. A pair of electric leads 18 that are protectively encased in a suitable insulating sheath 19 places the motor in electrical connection with a source of electrical energy 20 at the surface of the ground. An indicator or control device 21, whose function will be fully set forth further along, forms part of the electrical circuit. A rotary pump 22, which may be in the nature of a conventional type of centrifugal pump or positive displacement rotary
pump, is mechanically connected to motor 18 and a centrifuge 23 in a housing 24 by means of a common shaft 25 that constitutes an extension of the shaft 17. The pump is provided with a fluid inlet 26 that communicates with the lower portion of chamber 15 and a fluid outlet 27 that communicates with the upper portion of the chamber and flow tubing 14.

Turning next to Figure 2 of the drawing for details of construction of the apparatus positioned below chamber 15, it will be observed that housing 24 consists of a downwardly and inwardly tapering side wall 28 which is threadedly connected to the lower end of chamber 15, a top formed by a removable ring 29 having a central passage 30, and a base 31 supporting a tubular member 32 which has a flange 33 at its upper end. The portion of the interior of the housing between side wall 28 and tubular member 32 constitutes a chamber 34 wherein solid particles that are separated from the well fluid are deposited.

A rotary pump 35 of any desired type is positioned in tubular member 32 and is operatively connected to shaft 25. A separator base member 36, having an inlet passage 31 and an apron 38 that extends into chamber 34, is attached to shaft 25. Suitable bearings 39 are placed between base 36 and flange 33 for the purpose of minimizing friction during operation. A separator top member 40, having an outlet passage 41, is also attached to shaft 25; and another set of suitable friction reducing bearings 42 is employed between this member and ring 28.

Intermediate separator end members 36 and 40 and fixedly connected to shaft 25 is a plurality of spaced frusto-conical discs 43, each of which is provided with a plurality of openings 44 that are disposed equidistant from the shaft. It will be noted that the openings in each disc are substantially the same in size, but that the openings in a particular disc are smaller than in the discs below it, but larger than the openings in the discs above it. For optimum operating results, it is recommended that the discs be oriented on shaft 25 so that openings 44 in each disc shall be in alignment with corresponding openings in all other discs; and, also, that one set of disc openings shall be in alignment with inlet passage 37 in base member 36 and outlet passage 41 in top member 40.

For the purposes of outlining the mode of operation of the present invention, let us assume that the apparatus is assembled and suspended in the well casing, as illustrated in the drawing, with housing 24 positioned adjacent to the bottom of the well bore and below the level of the liquid in the well bore. The electric circuit is now completed, thereby energizing electric motor 18 which simultaneously imparts rotation to pump 22, centrifuge 23, and pump 35 through the cooperation of motor drive shaft 17 and shaft 25. Well fluid with any sand or other solid particles in suspension is forced upwardly by pump 35 through tubular member 32 and separator inlet passage 37. As the fluid with entrained solid particles enters openings 44 in lowermost disc 43, centrifugal action, due to the rotation of the disc, tends to throw the solid particles to the outer periphery of these openings. Since the motion of the fluid is principally parallel to the axis of shaft 25 and since the centrifugal action is at right angles thereto, the solid particles will pass upwardly and outwardly, striking the under surface of each disc successively. Also, since the outer edge of the openings in each disc is nearer the axis of rotation than the corresponding edge of each higher opening, the solid particles in the fluid passing through each successively higher opening are thrown outwardly toward wall 28 of the housing, whence these particles move downwardly and are deposited in chamber 34. As a result of the centrifugal action imparted to the fluid in passing through centrifuge 23, the solid materials are separated therefrom, and fluid which is substantially free of solid particles passes upwardly through separator outlet passage 41, central passage 30, and into the lower portion of chamber 15. The fluid thus transmitted into chamber 15 is admitted into principal pumping means 22 through inlet 26, and is discharged from this pumping means through outlet 27, whence it is forced upwardly through the upper portion of chamber 15 and flow tubing 14 to the surface of the ground. As the depositions of solid material accumulate in chamber 34, the level of the same will eventually reach the lower edge of apron 38. This will result in an increase in torque on the rotating members, due to the drag of the apron in the solid particles. If an indicating device, such as an ammeter, is used at 21 in the electrical circuit, an indication corresponding to the increased torque will be indicated by the ammeter. This will signify that chamber 34 is full of solid particles. Instead of using an ammeter, any other type of indicating or signaling device may be employed. Also, if desired, an automatic cut-out may be used at 21 to break the electrical circuit when chamber 34 is filled. In any event, when this chamber becomes filled, the electric circuit is opened, permitting the motor out of service. The string of flow tubing and equipment suspended thereby is removed from the well bore and the solid material is dumped or otherwise removed from the housing. While the use of the illustrated equipment contemplates the removal of the housing at the threaded connection between the lower end of chamber 15 and side wall 28, it is to be understood that an opening having a readily removable cover may be provided on any desired part of the housing structure. It is also to be understood that various types of pumps, other than rotary, may be employed in the practice of this invention, as it would merely be a matter of mechanical skill to substitute one type of pumping means for the rotary type indicated above.

From the foregoing, it is believed that the apparatus for practicing my invention will be readily comprehended by persons skilled in the art. It is to be clearly understood, however, that various changes in the apparatus hereinafter shown and described may be resorted to without departing from the spirit of the invention as defined by the appended claims.

I claim:

1. In well apparatus of the character indicated wherein rotary pumping means is positioned in a well bore and is employed to raise well fluid upwardly therethrough to the surface of the ground, the improvement comprising centrifugal separator means adapted to extend below and rotate with the pumping means in the well bore and including inlet means and outlet means adapted to communicate with the well bore and the interior of the pumping means, respectively, said separator means being adapted to separate solid material from well fluid admitted thereto through the inlet means and to transmit well
fluid substantially free of solid material through the outlet means to the pumping means, a receptacle adapted to be disposed in the well bore for receiving and retaining the separated solid material, and means for indicating a predetermined rise in level of separated solid material in the receptacle.

2. In well apparatus of the character indicated wherein rotary pumping means is positioned in said well bore and is employed to raise well fluid upwardly therefrom to the surface of the ground, and comprises means for continuously separating centrifugal means adapted to extend below and rotate with the pumping means in the well bore and including inlet means and outlet means adapted to communicate with the well bore and the interior of the passage means, respectively, said separator means being adapted to separate solid material from well fluid admitted thereto through the inlet means and to transmit well fluid substantially free of solid material through the outlet means to the pumping means, a receptacle adapted to be disposed in the well bore for receiving and retaining the separated solid material, and means operable upon a predetermined rise in level of separated solid material in the receptacle for placing the separator means out of service.

3. Apparatus for use in an oil well comprising a housing; centrifugal separator means in the upper portion of the housing and including an inlet, an outlet, a rotatable shaft in the housing, and means secured to the shaft and spaced from the housing to form a passage therethrough that communicates with the lower portion of the housing, said last mentioned means being adapted upon rotation of the shaft to separate solid material from oil transmitted thereto through the inlet, the separated solid material being passed to the passage and then received and retained in the lower portion of the housing while oil that is substantially free of solid material is discharged from the housing through the outlet; and means including a member carried by the shaft and extending into the annular space for indicating a predetermined rise in level of separated solid material in the annular space.

4. Apparatus for use in an oil well comprising a housing; centrifugal separator means in the upper portion of the housing and including an inlet, an outlet, a rotatable shaft in the housing, and means secured to the shaft and spaced from the housing to form a passage therewith that communicates with the lower portion of the housing, said last mentioned means being adapted upon rotation of the shaft to separate solid material from oil transmitted thereto through the inlet, the separated solid material being passed to the passage and then received and retained in the lower portion of the housing while oil that is substantially free of solid material is discharged from the housing through the outlet; and means operable upon a predetermined rise in level of separated solid material in the lower portion of the housing for placing the separator means out of service.

5. Apparatus for use in an oil well comprising a housing including a side wall, a bottom wall and a top wall; a conduit extending upwardly from the bottom wall and communicating therethrough with the exterior of the housing; centrifugal separator means in the housing above the conduit and including an inlet communicating with the conduit, an outlet communicating with the exterior of the housing, a rotatable shaft in the housing, and means secured to the shaft and spaced from the housing to form a passage therewith that communicates with the annular space, said last mentioned means being adapted upon rotation of the shaft to separate solid material from oil transmitted thereto through the inlet, the separated solid material being passed to the passage and then received and retained in the annular space while oil that is substantially free of solid material is discharged from the housing through the outlet; and means including a member carried by the shaft and extending into the annular space for indicating a predetermined rise in level of separated solid material in the annular space.

6. The combination in accordance with the preceding claim and including a rotary pump in the conduit and connected to the shaft for transmitting oil from the well to the inlet of the separator means.

7. Apparatus for use in an oil well comprising a housing including a side wall, a bottom wall and a top wall; a conduit in the lower portion of the housing and spaced from the side wall to form an annular space therewith, said conduit extending upwardly from the bottom wall and communicating therethrough with the exterior of the housing; centrifugal separator means in the housing above the conduit and including an inlet communicating with the conduit, an outlet communicating with the exterior of the housing, a rotatable shaft in the housing, and means secured to the shaft and spaced from the housing to form a passage therewith that communicates with the annular space, said last mentioned means being adapted upon rotation of the shaft to separate solid material from oil transmitted thereto through the inlet, the separated solid material being passed to the passage and then received and retained in the annular space while oil that is substantially free of solid material is discharged from the housing through the outlet; and means operable upon a predetermined rise in level of separated solid material in the annular space for placing the separator means out of service.

WILBUR J. CRITES.