

Feb. 7, 1933.

R. P. SIMMONS

1,896,107

UNDERREAMER WELL DRILLING APPARATUS

Filed Oct. 23, 1929

4 Sheets-Sheet 1

Fig. 1

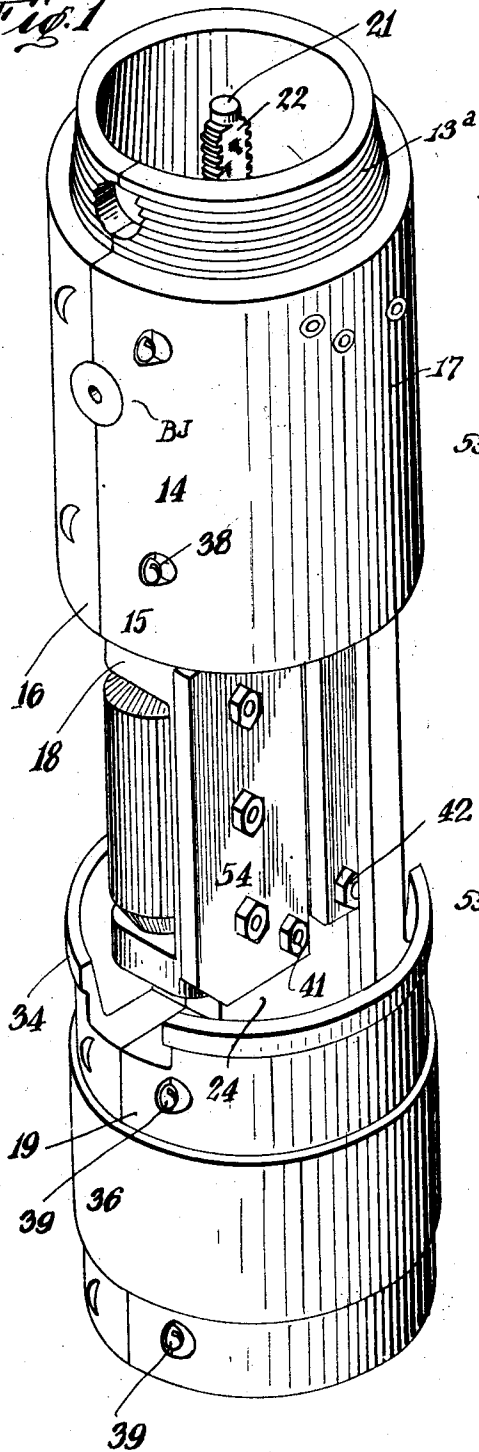


Fig. 6

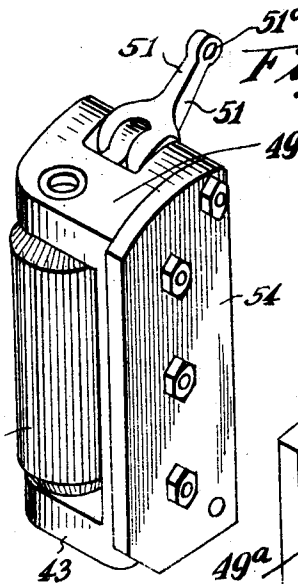


Fig. 7

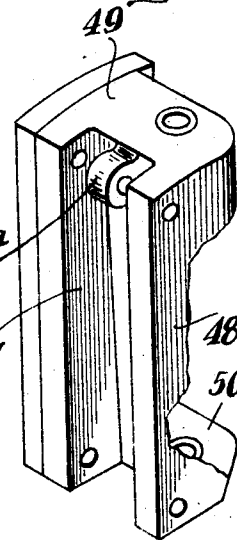


Fig. 8

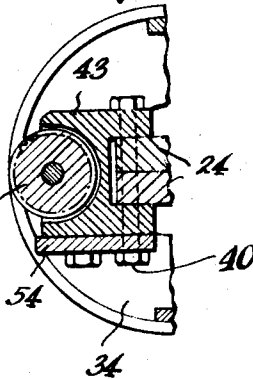
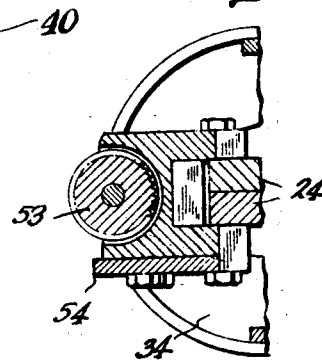


Fig. 9



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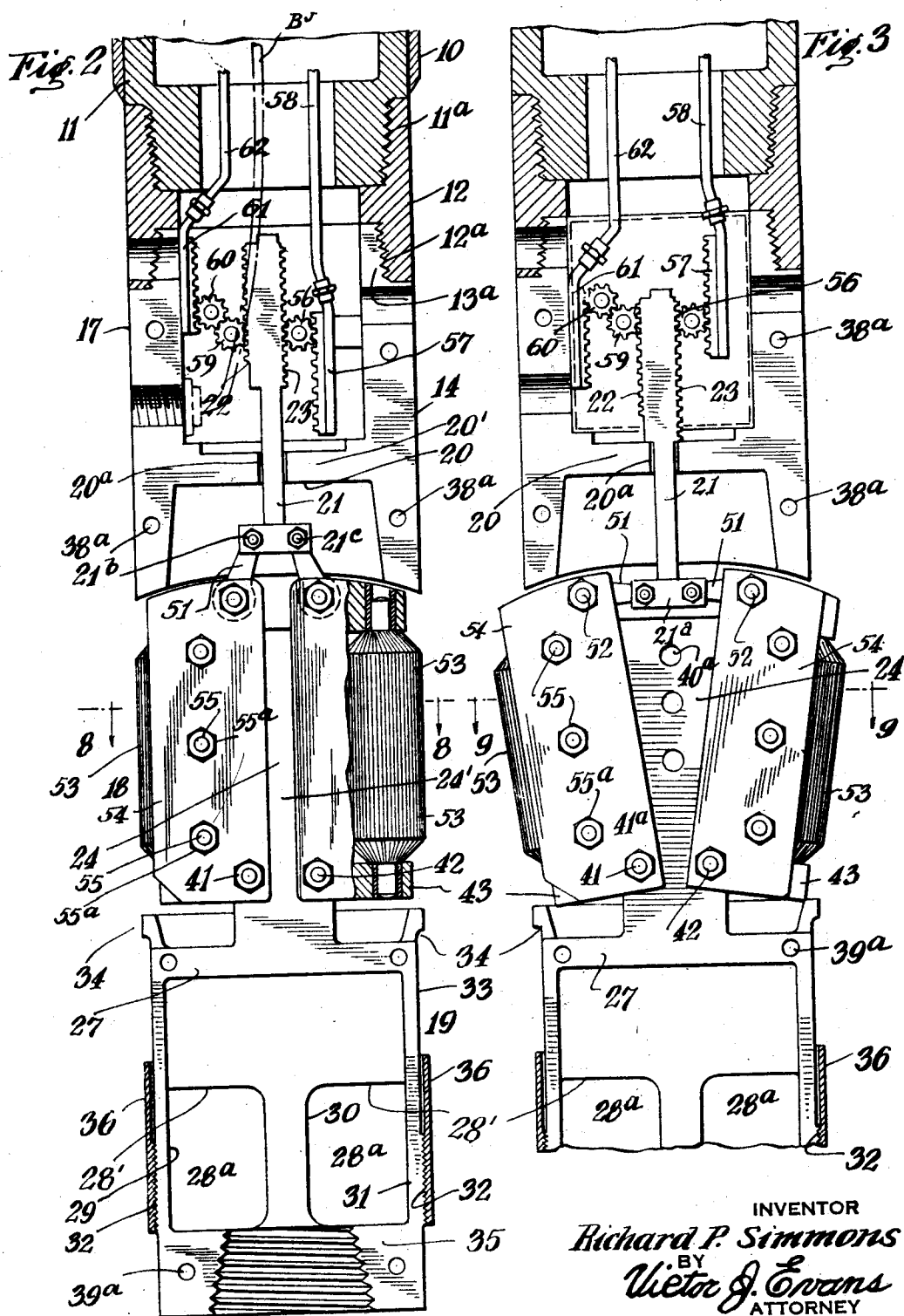
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UNDERREAMER WELL DRILLING APPARATUS

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4 Sheets-Sheet 2



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UNDERREAMER WELL DRILLING APPARATUS

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4 Sheets-Sheet 3

Fig. 4

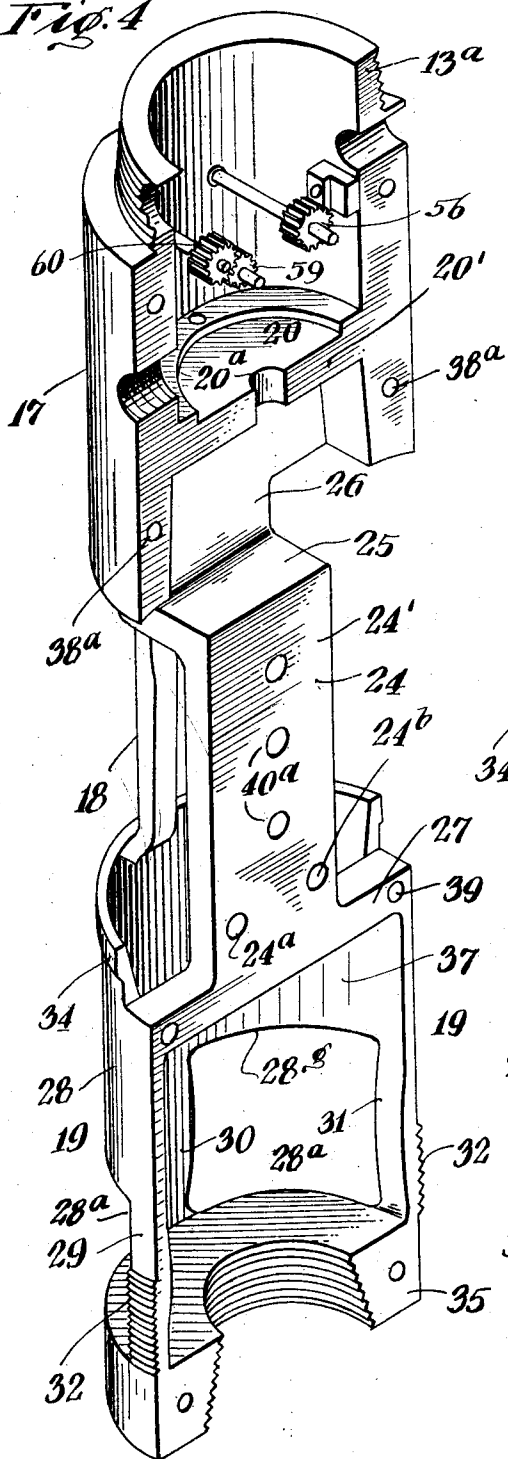
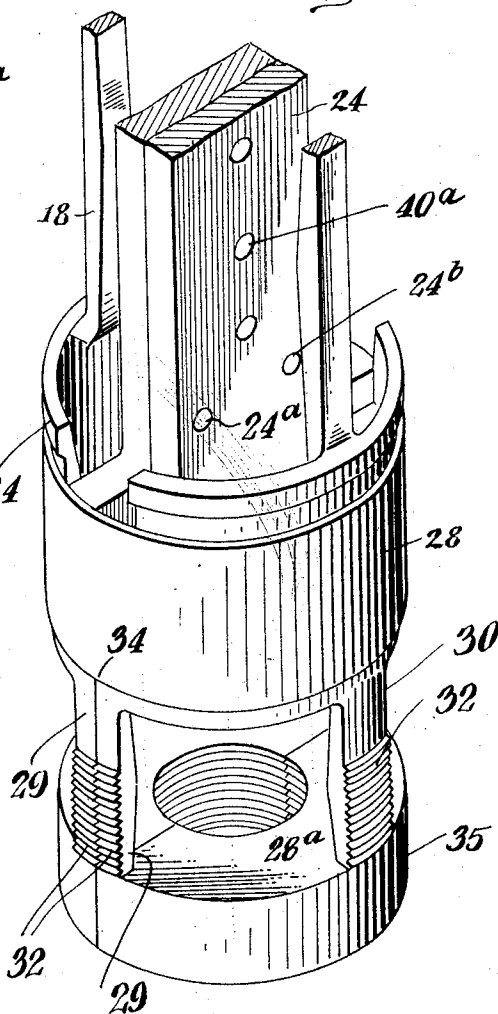


Fig. 5



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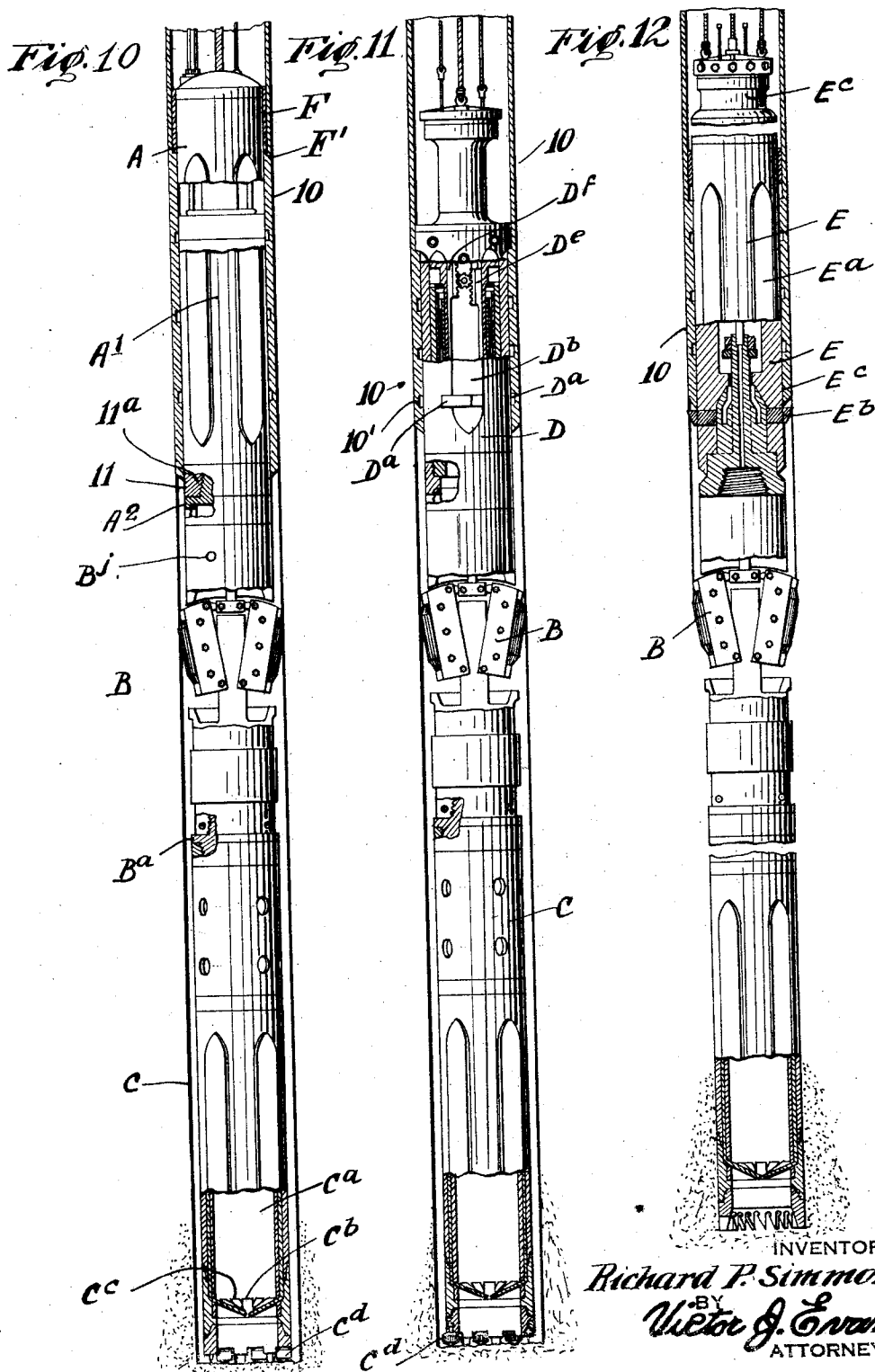
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UNDERREAMER WELL DRILLING APPARATUS

Filed Oct. 23, 1929

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

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UNDERREAMER WELL DRILLING APPARATUS

Application filed October 23, 1929. Serial No. 401,925.

This invention relates to improvements in under reamers for cutting a plane for a well casing, so that it may be lowered into the well with a minimum of resistance, and one of its objects is to provide means for supporting a plurality of reamer bits, capable of shifting the reamer bits to outward well reaming positions or to inward retracted positions, to permit of the withdrawal of the entire reamer unit from the well casing, without requiring the withdrawal from the well of the well casing.

Another object of the invention is the provision of a reamer housing having earth detaching means capable of enlarging the bore of the well, as the housing is progressively lowered into the well, and earth collecting and holding means so arranged that the earth detached by the earth detaching means will be retained from again falling into the well, and may be removed when the reamer housing is raised to the well top and opened up.

A further object of the invention is the provision of scrapers for completing the detachment of earth from the bore wall of the well, arranged to follow the reamer tools, and located above the inlet for the earth holding chamber, to cause the detached earth to fall into this chamber.

Another object of the invention is the provision of a reamer unit with a housing in which a pair of frames are pivoted, each of which carries a reamer bit tool, and means whereby the frames are rocked upon their pivots under remote control, so as to shift the reamer tools from retracted positions in the housing to downwardly converging positions, so that they progressively enlarge the bore of the well as the housing and reamer tools are forced downwardly.

Another object of the invention is the provision of a housing in which mechanical means may be installed for shifting the reamer tools from their inoperative to their cutting positions, or retracting them from the latter to the former, or pneumatic or equivalent means may be substituted, without changing the toggle joint between the frames of the reamer tools.

A still further object of the invention is

to provide means for interlockably connecting the reamer housing to the well casing to permit of the withdrawal of the reamer housing and the coupling thereto of additional well working units and its subsequent interlocking with the well casing.

Another object of the invention is the provision of a sectional housing for the reamer, the sections of which can be positively bolted together, yet separated to replace, repair, or adjust the parts enclosed thereby.

Other objects and advantages of the invention will be hereinafter specifically pointed out, or will become apparent, as the specification proceeds.

With the above indicated objects in view, the invention resides in certain novel constructions and combinations and arrangements of parts, clearly described in the following specification and fully illustrated in the accompanying drawings, which latter show embodiments of the invention as at present preferred.

In the drawings:—

Figure 1 is a view in perspective.

Figure 2 is a vertical sectional view thereof, showing the reamer tools retracted.

Figure 3 is a similar view showing the reamer tools in their expanded or cutting positions.

Figure 4 is a view in perspective of one of the sections of the reamer tool housing.

Figure 5 is a view in perspective, partly in section of the lower portions of the two housing sections.

Figure 6 is a perspective view of one of the rocker frames and its individual reamer bit.

Figure 7 is a perspective view of a rocker frame with the reamer bit removed.

Figure 8 is a detail cross sectional view taken on line 8 of Figure 2, looking in the direction of the arrows showing the reamer bit retracted.

Figure 9 is a similar view taken on line 9 of Figure 3, showing one of the bits expanded.

Fig. 10 is a vertical sectional view through a well under construction, showing a series of combined units, mainly in elevation, and partly in vertical section.

Fig. 11 is another similar view, showing a different grouping of units.

Fig. 12 is still another similar view, showing still another grouping of units.

5 Referring to the drawings in detail, 10 designates the lower end of a well follower casing, in which a motor driven head 11 is longitudinally and slidably interlocked for withdrawal, leaving the well casing 10 disposed in the well.

10 This well casing comprises a series of sections coupled to each other in the manner described in my copending applications hereinafter designated. The lower end of the head 11 includes an externally threaded coupling member or element 11a to which the coupling sleeve 12 is threaded. This sleeve or union is provided on its lower end with coupling means 12a, designed to receive the upper tapered externally threaded end 13a of the split housing 14, which comprises the companion longitudinal sections 15 and 16.

15 Each housing section comprises an upper part 17, an intermediate part 18, and a lower part 19. Each housing section is constructed like the other, as to general operating details, so only one will be described in particular.

20 The upper part 17 is constructed so that one-half of the externally threaded coupling end 13a will be carried by it, the two sections, when placed in abutting relation, providing the completed coupling member. An integral wall section 20, is formed on each housing section, and this is formed with an axial recess 20a, and the two recesses of the companion housing sections thus make a circular opening to receive the operating rod or shaft 21, which carries on its upper end portion the gear racks 22 and 23, on opposite sides thereof. Each wall section has a flat transverse face 20', so that the two sections will meet at a median line through the complete housing.

25 The intermediate part consists of the centrally located vertical web 24, which is formed with a flat inner face 24', the upper end of which is connected integrally to the upper part 17 by the horizontal brace portion 25, which is spaced vertically below the upper part 17 and extends outwardly to connect integrally with the pendant portion 26 of the wall of the upper part. The outer wall portions of the sections of the upper part form a cylindrical body.

30 The lower end portion of the vertical web 24 is integrally connected to the cross bar 27, the outer ends of which are integrally connected with the curved or semi-cylindrical wall 28 of the lower part 19. This semi-cylindrical wall 28 is formed with relatively large earth openings 28a, shown to be two in number for each half portion of the lower part of the complete housing, thus providing three radially spaced posts 29, 30, and 31, on which the external screw threads 32 are

70 formed. These screw threads extend for only a limited distance longitudinally on the three posts, thus leaving an unthreaded portion 33 between the upper edge portion 28' of the earth openings 28a and the external shoulder 34 formed on the lower part 19. The lower end of the sectional housing is provided with a split coupling socket 35. When the two housing sections are connected to each other the sleeve 36 is threaded upon the external threads 32 so as to close the earth openings 28a and hold any earth collected in the earth pocket 37 between the socketed coupling head 35 and the cross bar 27. This sleeve may be shifted from its normal closing position upwardly of the earth openings 28a to a position adjacent the flange or shoulder 34.

75 The two housing sections are bolted to each other by means of the bolts 38 which are extended through registering transverse openings 38a formed in the upper parts of the two sections, and through bolts 39 extended through transverse openings 39a in the lower part 19 of the two sections, above and below the normal position of the sleeve 36.

80 The two housing sections are further secured to each other by the additional bolts 40, which are extended through the registering bolt openings 40a formed in the webs 24. The abutting central webs 24 are formed with registering pivot holes 24a and 24b, located near the lower ends thereof, which are engaged by the pivot bolts 41 and 42 of the rocker frames 43 and 44, which carry the reamer tools 53.

85 Each rocker frame is like the other and includes parallel side walls 47 and 48 and integral end walls 49 and 50. The upper end wall 49 is formed with an integral lug 49a which is located midway of the opposing faces of the walls 47 and 48 and to this lug the bifurcated end of the toggle link 51 is pivoted by the bolt 52. The inner end of this link is provided with an eye 51a. The rocker frame swings from an inoperative position to an operative or expanded cutting position upon the pivot bolt 41, which extends through the holes 24a in the coupled webs 24.

90 On the rocker frame, the reamer tool 53 is mounted for rotative movement. This reamer tool is a cylindrical body and is formed with a series of radially spaced teeth to cut into the bore wall of the well. A scraper blade 54 is mounted against each rocker frame by the bolts 55, and the pivot bolt 41, through the medium of nuts 55a and 41a.

95 The links 51 of the two rocker frames are pivotally connected at their inner ends to the cross head 21a of the rod 21 by means of the bolts 21b and 21c. In its lowermost position this cross head occupies an axial relation to the links 51, so as to hold the rocker 130

frames in their outermost positions. When the rod 21 and its cross head is in its uppermost position the rocker frames will be held in a retracted or non-cutting position.

The operation of the rod 21 is accomplished by means of the gear 56 which engages the rack 23, and which is actuated through the vertical rack 57, carried by the pull and push rod 58, which extends to gear rack D^c of Figure 10. The rack 22 is engaged by the pinion gear 59 which is rotated by means of the pinion gear 60, and this is actuated by means of the vertical rack 61 on the sectional pull and push bar 62, which extends to gear rack D^c Figure 10.

By operating the rods 58 and 62, the reamer tools may be shifted to outward cutting positions, or retracted, as the toggle movement composed of the links 51 and the cross head 21a of the rod 21 force the rocker frames to an upwardly diverging relation, moving the rotary reamer tools to cutting engagement with the bore wall of the well, when the rod 21 is moved downwardly, or will swing the rocker frames and their reamer tools inwardly when the rod 21 is moved upwardly.

In the practical use of the under reamer, it is necessary to support it below the lower or head section of the well casing, so that the reamer tools will cut a plane for the easy and true lowering of the well casing, but the under reamer itself is limited to lateral cutting against the wall of the well bore, and before it can be advanced the obstructed earth must be drilled or loosened, detached and transported from place.

I have, therefore, devised a combined or series unit system, including the under reamer and an earth detaching and conveying means, which is coupled to the under reamer, and withdrawable from the well casing with the under reamer.

In Fig. 10 I show a combination between the under reaming unit, consisting of the structure previously described, which will be here designated as well apparatus unit B, the motor head unit at the top thereof being designated unit A, and the core barrel unit at the base of the under reamer unit being designated as unit C. The motor head unit is provided with a casing or housing A¹, which is interlocked to the lower section of the well casing, by means of longitudinal keys and keyways. In this housing an electrical motor is arranged, the shaft of which extends to a reduction gearing enclosed by said housing, and motion is transmitted from this reduction gearing to the coupling union A², which unites the well apparatus units A and B. By this driving connection the reamer unit B will be rotated in the formed well, while the housing of the motor head unit A will be locked in the well casing against relative rotative movement.

The core barrel unit C is coupled to the

under reamer unit B by means of the coupling union Ba, so that the two units will rotate together. The core barrel unit is equipped with a dirt holding chamber Ca, in which dirt is trapped by means of the flexible metal strips Cb, which strips are forced into this chamber through slots Cc in the wall of said chamber, by means of pneumatic operated reciprocating mechanism contained in the housing of the core barrel unit C as shown in my copending application Ser. No. 401,447, hereinafter referred to. The core barrel unit C carries drilling means Cd on the lower end thereof.

The motor head unit mechanism will simultaneously rotate the under reamer unit B and the core barrel unit C, so that the earth is detached or loosened by the action of the end drilling tools, and forced into the dirt holding chamber Ca. This permits of the lowering of the core barrel unit A with the progress of the excavation thus made.

As the core barrel is filled it is removed, together with the under reamer unit and the motor head unit, by withdrawing the whole series of units through the well casing. The equipment is then returned to working position at the lower end of the well casing, and the operation repeated.

As the core barrel excavates and conveys the earth to form the well bore, the under reamer descends, and as it is being rotated while it is moving downwardly, the bore of the well is enlarged progressively to accommodate the diameter of the well casing, which can be progressively lowered into the well, without straining.

The interlocking connections between the motor head unit and the well casing is such that the under reamer unit and the core barrel unit cannot drop into a sand pocket, and become lost, or perhaps force the abandonment of the well, but are safely suspended by the integral stops formed at the ends of the longitudinal keyways of the well casing.

This interlocking connection permits relative longitudinal movement of the motor heads unit A in the well casing, so that the combined well apparatus, consisting of the coupled units A, B and C, can be reciprocated by hoisting and lowering the coupled units, thus producing any advance in drilling which particular conditions demand. The core barrel unit is equipped with means in its housing to reciprocate the flexible earth trapping strips which enter the earth holding chamber Ca.

In Fig. 11 I show my improved combined coupling and locking head D, which is interlocked to the lower section of the well casing against longitudinal movement in either direction, and against relative rotative movement. This interlocking action is accomplished by the same system of longitudinal

keys and keyways described, involving radially spaced integral keys on the exterior of the housing of the unit D, and radially spaced integral keys on the inner side of the lower section of the well casing, the two sets of keys being interlocked by sliding action, and this interlocking serving to prevent relative rotation of the unit D in the well casing. This unit D is equipped with movable keys *Da*, operated by mechanism carried by said unit, and controlled by suitable cables or operating devices extending to the surface of the well, for moving these units into and out of the transverse keyways 10' formed in the lower section of the well casing. The mechanism for shifting the keys *Da* from positions in longitudinal alignment with the external longitudinal keys *Db* thereof to positions lateral of said keys, includes companion gear racks *De* and *Df*, which work vertically in opposite directions to shift cams which move the keys *Da* from one of their positions to the other of their positions; all of said keys *Da* being shifted circumferentially in the same horizontal plane, so that the coupling head D is interlocked simultaneously to the well casing at a plurality of radially spaced points, against relative longitudinal movement, as well as against relative rotative movement.

The under reamer unit B is coupled to the lower end of the combined coupling and locking head D, and to this under reamer unit the core barrel unit C is coupled, in the manner already described with reference to Fig. 11.

In Fig. 12 I show a shrapnel drilling unit E coupled directly to the lower well casing section, by means of its external longitudinal keys *Ea* and the corresponding keys formed in the well casing section. This particular shrapnel drilling unit embodies inventions of an advanced order elsewhere described by me, in my copending application Ser. No. 401,446 referred to hereinbelow and includes radially shiftable drill bits *Eb*, which are operated by means of cams vertically shiftable by controls extending to the top of the well, from the head *Ec*.

The unit is coupled to the under reamer unit B, which is coupled to the core barrel unit C. In this combination of well apparatus units the percussive action of the shrapnel drilling unit is transmitted to the under reamer, and thence to the core barrel unit. To facilitate its excavation of the earth the core barrel unit is provided with endwise drilling teeth, adapted to penetrate the ground when pressure in the form of a percussive action or otherwise is applied against the housing of this unit.

The under reamer clears or cuts a plane which permits the well casing to be progressively lowered, and additional sections coupled thereto as this lowering takes place.

The core barrel provides means for rapidly loosening the earth and conveying it from the well, instead of compacting it in place, which would be apt to increase the resistance to further penetration of the well casing.

The combined well apparatus units permit accurate vertical well drilling, so that there is a minimum of deflection of the axis of the well casing as it is progressively lowered in the ground.

Experience has established the fact that irregularities of strata and the varying hardness of material encountered in well drilling, partly the inclined or sloping layers of matter of such varying hardness, causes a significant deflection of the drilling tools, which progressively follow each deflection. This results in increasing the total length of the well from its top to the oil or withdrawing level, and the entry of the bore of the well in many cases to mineral property belonging to some other than the owner of the well being driven.

By means of the forced longitudinal guiding action set up between the lower section of the well casing and the series of well apparatus units, which may be coupled thereto, and wholly suspended thereby, against all possibility of being lost by being detached from the well casing, the drilling is held as nearly as it is possible to do so, in a true vertical plane. The well casing thus acts as a rifle or tubular guide to hold the cutting means in a path of action parallel to its own axis.

Any irregularities in the axis of the well which may result from uneven cutting of the core barrel unit, are corrected by the reaming action which the rotating reamer tools produce against the bore of the well. The well casing is therefore shifted vertically into a clean well of a diameter and axis to permit rapid straight lowering of the well casing, and to reduce, if not actually eliminate breakage between the coupled sections of the well casing.

Well casing which makes a bend, due to deflection of the well from the vertical, is more difficult to turn than if it was all vertical, and the length of the well casing needed to line any well naturally increases with the deflection it makes from the vertical. The greater the deflection, the greater the breakage of the casing sections, the greater the cost of drilling and the longer it takes to complete the drilling so that the well can be turned to productive uses.

In this system of well drilling the casing itself performs a guiding and sustaining function. It guides the drilling units to produce a vertical well, and sustains the wall of the bore thus produced against collapse, and remains in place so that progressive operations can be carried on without danger of

losing the excavational work previously accomplished.

It is not necessary to reciprocate the well casing for driving the well itself, as this work is produced by means of excavating and drilling equipment calculated to provide a true vertical path for the progressive lowering of the well casing, and the well casing is not crowded into the ground so that it sets up other tendencies to deflect the well from its predetermined vertical path.

The under reamer unit B is equipped with an air jet B', through which compressed air is supplied to the well chamber to support the wall thereof, below the well casing, against collapse, when the under reamer and core barrel are removed, or when the unit or units coupled to the motor head are withdrawn. The compressed air jet B' is supplied with compressed air from a flexible conduit, which extends to the transfer or wiping joint as shown in Fig. 10. This wiping joint consists of a band of packing F disposed in surrounding relation to and secured to the motor head unit A. It fits snugly in the well casing and when the motor head unit is in place in the latter, it rests at the lower edge on the seat F', thus sealing the casing at this point against escape of air and thus preventing the dissipation of the air pressure supply by the air jet B'. Through this joint compressed air is supplied from the surface of the well, by conduits which extend to the well top.

The air pressure used would be determined by the depth of the well and the character of the material encountered. If this material had low cohesive power or stability then it would be necessary to maintain the air pressure, so that the wall of the well below the well casing would be internally supported against collapse, when the well drilling units were withdrawn through the well casing, leaving the latter in place.

The top of the well casing is sealed by means of a gland joint against leakage of the compressed air.

The motor head unit A, shown in Fig. 10, is disclosed in detail in my copending application for patent, Ser. No. 401,445, filed October 22, 1929. The core barrel unit C shown in said Fig. 10 is disclosed in my copending application for patent, Ser. No. 401,447, filed October 22, 1929. The locking head unit D shown in Fig. 11 is disclosed in my copending application for patent, Ser. No. 386,354, filed August 16, 1929. The percussive drilling unit E, shown in Fig. 12, is disclosed in my copending application for patent, Ser. No. 401,446, filed October 22, 1929.

Other features of the invention than those just above referred to are disclosed more fully in my copending applications herein identified; and attention is directed thereto

for certain features of the invention shown here, but claimed there.

The hereinbefore described constructions admit of considerable modification without departing from the invention; therefore, I do not wish to be limited to the precise arrangements shown and described, which are, as aforesaid, by way of illustration merely. In other words, the scope of protection contemplated is to be taken solely from the appended claims interpreted as broadly as is consistent with the prior art.

I claim as new:—

1. An under reamer comprising a housing made in companion longitudinal sections and providing earth receiving compartment, a pair of frames pivoted to said housing above the compartments, links connected to the upper end of each frame, a plunger having pivotal connection with the links, means for securing the housing sections to each other, reamer tools rotatably mounted on the frames, and means for operating the plunger.

2. An under reamer comprising a housing, a frame pivoted at its lower end to the housing, a plunger slidable in the housing, link connections between the plunger and the frame, a reamer tool mounted for rotation on the frame, and means for operating the plunger to move the reamer tool to cutting position and to withdraw the same from said position said housing having an opening to receive detritus cut by said reamer tool.

3. An under reamer comprising a housing, a pair of frames pivoted to the housing at the lower ends, a plunger slidable in the housing, a toggle joint connecting the plunger to the frames, and a rotary reamer tool carried by each frame said housing having an opening to receive detritus cut by said reamer tool.

4. An under reamer comprising a housing, a pair of frames pivoted to the housing, a rotary reamer tool mounted on each frame, a plunger slidable in the housing, a toggle joint pivotally connecting the plunger to the frames on the end opposite their pivotal connections, and means for operating the plunger from a distance said housing having an opening to receive detritus cut by said reamer tool.

5. An under reamer comprising a housing, a pair of frames pivoted to the housing, a plunger slidable in the housing, means connecting the plunger to the frames whereby the frames are moved inwardly and outwardly when the plunger is shifted, a reamer tool mounted on each frame, and a scraper blade mounted on each frame adjacent to the reamer tool.

6. An under reamer having earth receiving pockets, an expansible and contractible reamer tools mounted above said pockets

said reamer tools including movable cutting elements.

7. An under reamer having earth receiving pockets, expansible and contractible reamer tools mounted above said pockets, and scrapers mounted above said pockets to move with said reamer tools.

8. An under reamer comprising a housing, frames pivoted to the housing at the lower ends thereof, reamer tools mounted on said frames, a plunger, pivotal connections between the plunger and the frames, said plunger having a gear rack, a pair of independently movable gear operating racks, and gearing connecting the operating gear racks to the gear rack whereby the plunger may be moved in both directions to expand or retract the reamer tools.

9. An under reamer comprising a housing, frames pivoted at their lower ends to the housing, a scraper blade mounted on each frame, a rotary reamer tool mounted on each frame adjacent the scraper blade thereof, a link connected to the upper end of each frame, a plunger movable vertically in the housing and provided with a cross bar pivotally connected to each link, and gear mechanism for moving the plunger.

10. A well underreamer consisting of a frame, an underreaming tool pivotally carried by the frame, means for moving said tool laterally of the frame, and a dirt holding chamber located below the tool.

11. An underreamer for wells consisting of a frame, underreaming tools mounted thereon for rotation, means for moving the tools laterally of the frame, and a dirt holding chamber located below the tools.

12. A well underreaming tool consisting of a frame, an underreaming tool rotatably and expansibly mounted thereon, and a dirt holding chamber located below the tool, the whole being designed to be operated without liquid circulation in the well to cause dirt and rock to drop below the tool when detached thereby from the wall of the well.

13. Means for drilling deep wells consisting of a frame, tools carried thereby for cutting against the wall of the well, and means located below the tools for receiving dirt detached from the wall of the well, the whole being constructed to be operated against dry material and without the aid of a circulating liquid and a vertically reciprocable plunger operatively connected to said cutting tools to angularly expand and retract said tools from a considerably remote point.

14. In combination, a well casing, an underreamer well drilling unit, means for locking the unit to the casing to prevent relative movement between the two, means carried by the underreamer for enlarging the well bore, and a detritus collecting chamber incorporated in the underreamer unit.

15. In combination, a well casing, a lock-

ing head interlocked with the casing to preclude relative movement between the two, and combined underreamer and core barrel well drilling units coupled to said locking head, and a detritus collecting chamber incorporated with the underreamer unit.

16. The combination of a well casing, a housing supported therein and having a rotatable end member, an underreamer well drilling unit coupled to the end member in pendent relation thereto, and a core barrel drilling unit coupled to the underreamer unit, the latter having a detritus collecting chamber positioned to receive the detritus removed by the underreamer.

17. The combination with a well casing, of a housing supported therein, motive means in the housing, a shaft rotated by the motive means, and companion superposed underreaming and core barrel drilling units coupled to said shaft, the underreamer unit incorporating a detritus collecting chamber.

18. The combination with a well casing, of a motor driven unit interlocked with the well casing to preclude relative movement of the two, an underreamer coupled to the motor driven unit to be rotated thereby and enlarge the well bore below the plane of the lower end of the well casing, and a core barrel drilling unit coupled to the underreamer for rotation with the same, the underreamer incorporating a detritus receiving chamber disposed between it and the core barrel.

19. The combination with a well casing, of a motor head unit having a housing interlocked to the wall of the casing to preclude relative movement of the two and a shaft extending below the well casing, an underreamer coupled to said shaft and provided with an air jet for supplying compressed air to the well chamber below the well casing, an underreamer unit coupled to said shaft and provided with an air jet for supplying compressed air to the well chamber below the well casing to support the well bore against collapse, and means for sealing the well against the escape of said air.

In testimony whereof I hereby affix my signature.

RICHARD P. SIMMONS.