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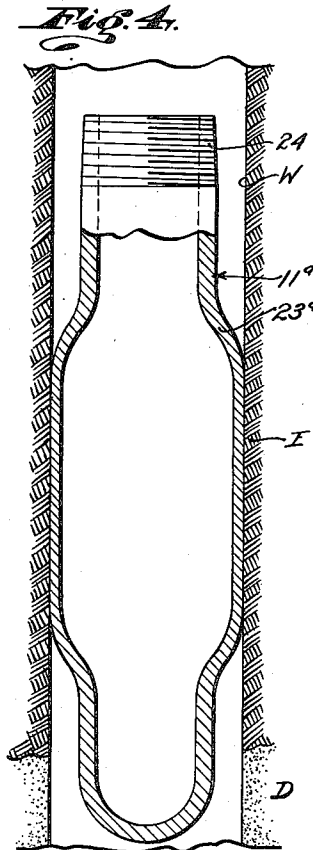
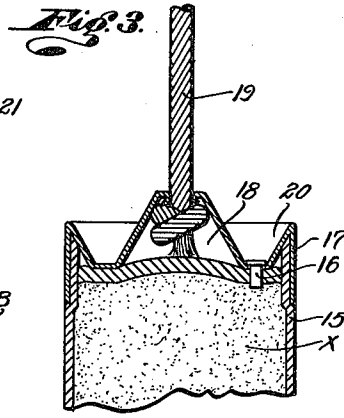
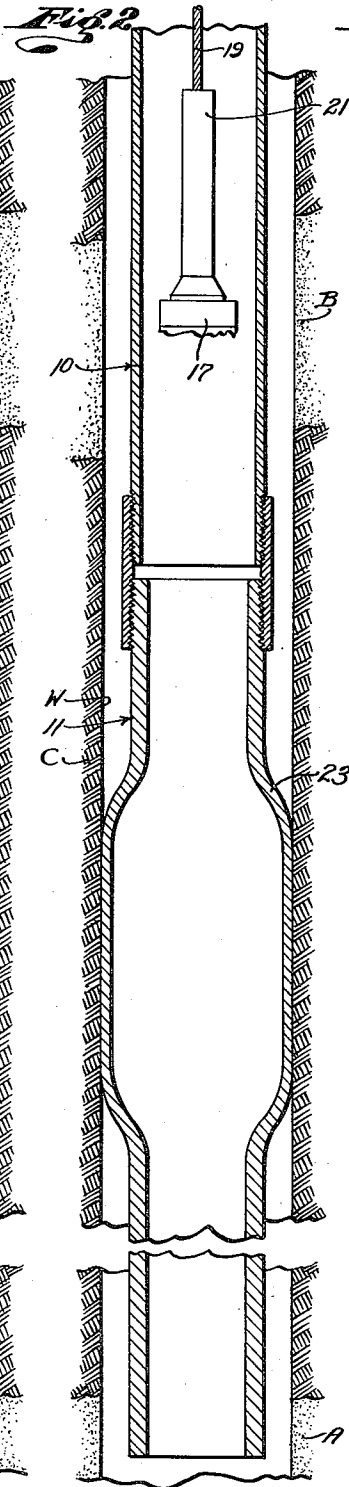
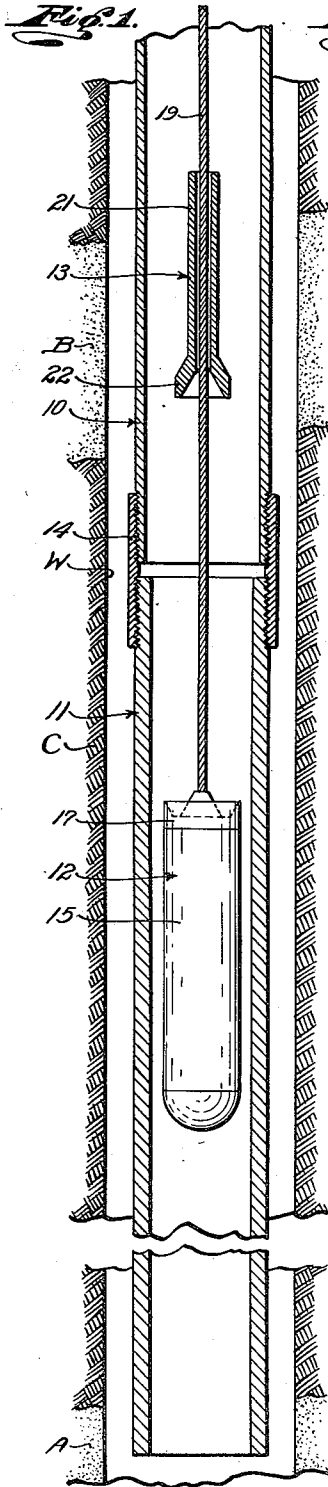
A. ENGLISH

2,214,226

METHOD AND APPARATUS USEFUL IN DRILLING AND PRODUCING WELLS

Filed March 29, 1939

2 Sheets-Sheet 1



Inventor
AARON ENGLISH
By *W. H. H. H. H. H.*
His Attorney

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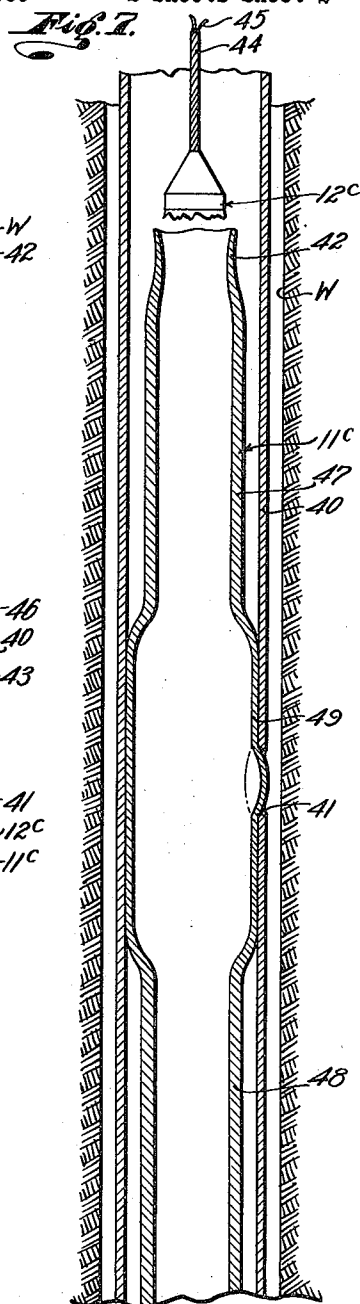
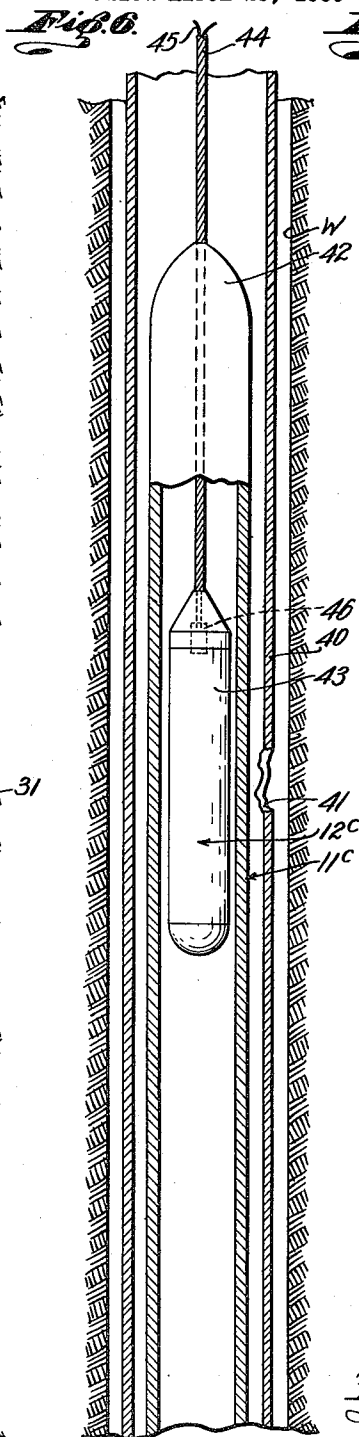
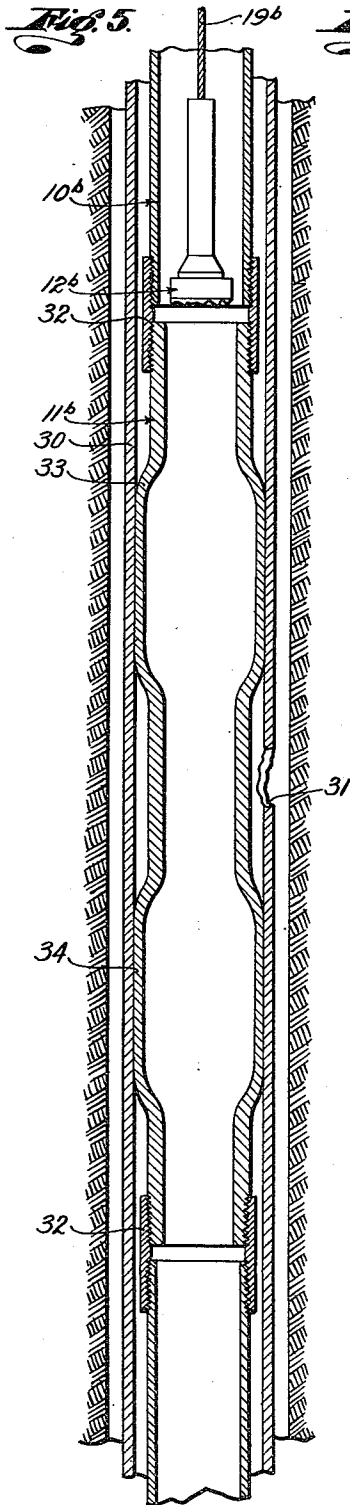
A. ENGLISH

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METHOD AND APPARATUS USEFUL IN DRILLING AND PRODUCING WELLS

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2 Sheets-Sheet 2



Inventor
AARON ENGLISH
By *W. H. Haffell*
His Attorney

UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS USEFUL IN
DRILLING AND PRODUCING WELLS

Aaron English, Bellflower, Calif.

Application March 29, 1939, Serial No. 264,769

15 Claims. (Cl. 166—1)

This invention relates to methods and means useful in drilling, equipping, producing and reconditioning wells, and relates more particularly to methods and means for expanding tubular objects in wells. A general object of this invention is to provide an efficient, practical method, and a simple, dependable and inexpensive apparatus for expanding tubular objects in wells.

In drilling, equipping, and reconditioning deep wells such as oil wells and gas wells, it is often necessary to provide seals or shut-offs in the wells. For example, it is often necessary to seal off unwanted fluids from the earth formation penetrated by a well and seals must be provided about the casings and at points of leakage in the casings. Heretofore, plastic cement has been employed to seal off the unwanted fluids, to seal about the well casings, and to repair leaking casings, etc. The equipment and operations required for such cementing operations are expensive and in many cases the cement does not provide a tight, effective seal. The mud on the walls of a well often prevents good sealing engagement of the cement with the earth formation and channels sometimes develop in the hardened cement which allow the unwanted fluids to enter the well. In some cases the plastic cement introduced into a well under pressure enters the strata bearing the wanted fluids and lessens or prevents the production from these strata.

Another object of this invention is to provide a method for expanding tubing in a well to provide an effective dependable seal or shut off.

Another object of this invention is to provide a method for expanding a metal tubing in a well in which the tubing is expanded and forced against the wall of the well, which may be the earth formation or the well casing, with great force or under great pressure, to bring the metal of the tubing into intimate sealing contact with the wall of the well and to securely lodge or fix the expanded tubing in the well to remain as an effective sealing element.

Another object of this invention is to provide a method for producing a seal in a well in which a ductile metal tube is expanded against the well wall in such a manner that it conforms to the formation or structure of the wall and is made to flow into the interstices of the well wall to be permanently secured thereto and to effectively seal therewith.

Another object of this invention is to provide a method of the character mentioned that permits a second sealing operation or a resealing operation to be performed in the event that the first

sealing operation is unsuccessful or in case the first seal is destroyed.

Another object of this invention is to provide a method of the character mentioned that may be easily and quickly carried out with simple, conventional equipment.

Another object of this invention is to provide improved apparatus for making an effective and dependable shut-off or seal in a well.

Another object of this invention is to provide apparatus for safely and effectively expanding a ductile metal tube in a well to cause the tube to seal with the wall of the well.

Another object of this invention is to provide a novel and improved sealing element for application to the lower end of a well casing to seal with the wall of the well.

Another object of this invention is to provide a novel and effective sealing element for sealing with the wall of a well to make a side wall shut-off or to repair the well casing.

A further object of this invention is to provide a novel and effective sealing element for making a bottom hole shut-off in a well.

The various objects and features of my invention will be fully understood from the following detailed description of typical preferred manners of carrying out the method and typical preferred forms and applications of the apparatus of my invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a more or less diagrammatic view of a portion of a typical well with one form of apparatus of the invention in position therein to carry out the method of the invention. Fig. 2 is a view similar to Fig. 1 showing the condition of the parts following the expansion of the sealing member. Fig. 3 is an enlarged fragmentary vertical detailed sectional view of the pressure generating means illustrated in Figs. 1 and 2. Fig. 4 is a more or less diagrammatic view of a portion of a well showing a sealing member of the invention expanded therein to make a bottom hole shut-off. Fig. 5 is a more or less diagrammatic view of a portion of a typical well with another form of equipment of the invention arranged therein in accordance with the method to repair the well casing. Fig. 6 is a more or less diagrammatic view of a portion of a typical well illustrating another form of apparatus of the invention in position for the expanding operation and Fig. 7 is a view similar to Fig. 6 showing the sealing member expanded to seal off a hole in the casing.

The method of the present invention may be employed in connection with various phases of drilling, equipping, producing and conditioning wells. In the following detailed description I will describe several typical applications of the method and several typical forms and applications of the apparatus of the invention. It is to be understood that the invention is not to be construed as limited or restricted to the specific applications of the method and forms and applications of the apparatus about to be described.

To facilitate a clear understanding of the method of the invention as carried out in the manner illustrated in Figs. 1 to 3, inclusive, I will first proceed with a detailed description of the apparatus illustrated in these figures and will follow such description with a disclosure of the method as employed with the apparatus.

The apparatus of the invention illustrated in Figs. 1, 2 and 3 may be said to comprise, generally, a tubular structure 10 to be installed in a well W, a ductile tubular member 11 associated with the structure 10, means 12 operable to generate pressure in the well to expand the member 11 into sealing cooperation with the wall of the well and thus provide a seal between the structure 10 and the well wall and means 13 for operating or setting off the pressure generating means 12.

The tubular structure 10 may be installed in the well W to line the same or to conduct fluid, or both. In practice the structure 10 may be in the nature of a well casing. The casing or structure 10 comprises a plurality of lengths or sections connected by collars and lowered into the well W as assembled, this being in accordance with the usual procedure. The casing structure 10 may be fabricated to be of such length that its lower end occurs between a productive stratum A and a stratum B producing unwanted fluid when the structure is in its final position in the well. In most instances it is practical to construct the structure 10 so that its lower end is at or adjacent a hard stratum C above the productive stratum A when finally set in the well. It is to be understood that the casing structure 10 may be handled by the hoisting equipment at the well derrick and may be supported or suspended from its upper end in accordance with the usual practice.

The tubular member 11 is an important element of the invention. The member 11 is connected in or secured to the structure 10 and is in the nature of a sealing element for sealing with the wall of the well W to provide a fluid tight and a pressure tight seal or shut-off between the well wall and the structure 10. In accordance with the invention the member 11 is expansible by internal pressure to seal with the earth formation at the well wall and is such that it retains its shape after expansion. It is preferred to construct the expansible tubular member 11 of a ductile material. In practice the tubular member 11 may be formed of a ductile metal such as copper, aluminum or its alloys, lead or its alloys, tin, soft iron, or the like. In most instances it may be found most practical to form the member 11 of copper. As initially formed or before its expansion the member 11 may be a simple, elongate, tubular element of uniform diameter and of substantial length. The member 11 may be generally the same diameter as the casing structure 10. However, it is preferred to make the wall thickness of the member 11 substantially greater than that

of the casing structure 10 to have sufficient wall thickness following its expansion. The member 11 is proportioned to pass into or through the well W with substantial clearance. The length of the member 11 may vary and in practice may depend upon the extent of the hard stratum C with which it is to seal. The ductile expansible member 11 may be secured to the casing structure 10 in any suitable manner. As illustrated in the drawings the member 11 may be attached to the lower end of the structure 10 by a threaded coupling 14. It is to be observed that the member 11 is a simple, inexpensive element readily connected with the structure 10.

The means 12 is operable to generate pressure in the element 11 to expand the same into sealing contact with the wall of the well W. The means 12 may be varied widely in character at the option of the operator and to suit varying conditions in the well. The means 12 is preferably such that it is capable of suddenly developing substantial pressure in a given zone or area within the tubular member 11 to effect an outward distortion or expansion of the member. It is preferred that the means 12 be such that it operates effectively in the mud fluid usually present in a deep well. In practice the means 12 may comprise an explosive charge X such as a charge of dynamite, trinitrotoluene, or the like, in a suitable cartridge or container 15. The active charge X of the means 12 may, if desired, be in the form of a gaseous or fluid mixture to explode or generate substantial pressure upon ignition or when subjected to other special treatment. In the case illustrated it may be considered that the means 12 includes a charge X of dynamite or the like adapted to be exploded by a detonating cap or percussion cap 16.

The cartridge or container 15 for the charge X is, of course, frangible and is initially water-tight and fluid-tight. The container 15 is proportioned to readily pass down through the structure 10 and into the member 11. The upper end of the container 15 may be closed by a cap or cover 17. The cover 17 may be shaped to have a rope socket 18 for receiving and retaining the end of a cable or line 19 for lowering the means 12 into the well. The cover 17 may be depressed downwardly and inwardly from adjacent its periphery to have an upwardly facing annular groove 20 and its central portion may be raised to provide the socket 18 in its under side. The percussion cap 16 may be set in an opening in the cover 17 to project upwardly to the bottom of the groove 20. The means 12 may be readily lowered into the well on the line 19 to its position in the member 11. The line 19 may be measured as the means 12 is lowered into the well to locate the means 12 in the correct position in the member 11.

The means 13 is provided to fire the percussion cap 16 to set off the charge X in the container 15. The means 13 comprises a weight element or go-devil 21 adapted to be dropped down the line 19 to strike the cap 16. The go-devil 21 is tubular and is designed to freely pass down the cable 19. The lower portion of the go-devil 21 is flared at 22 to fit or enter the groove 20 and to strike and fire the cap 16.

The method of the invention as practiced with the apparatus illustrated in Figs. 1, 2 and 3 may be said to comprise, generally, the attachment of the member 11 to the casing structure 10, the arrangement of the structure 10 in the well W, the positioning of the pressure generating means 7

12 in the member 11 and the actuation or discharging of the means 12 to expand the member 11 into effective sealing cooperation with the wall of the well W.

5 The sealing member 11 may be readily connected with the structure 10 by the coupling 14 and the structure carrying the member 11 may be run into the well W in the usual manner. The location of the hard stratum C may have
10 been previously determined by surveying and locating methods accompanying the drilling operations and the structure 10 may be assembled and run into the well to bring the expansible member 11 to a position in that portion of the well W passing through the stratum C. The
15 pressure generating means 12 is then secured to the line 19 and run down through the structure 10 on the line. The cable or line 19 is measured so that the means 12 is brought to the selected
20 position between the ends of the expansible member 11. When the means 12 has been arranged in place the go-devil 21 is run or dropped down the line 19 from the surface of the ground to set off the charge X in the container 15. The go-
25 devil strikes and fires the percussion cap 16 to set off the charge X of the means 12.

It is to be understood that the well W may contain a column of mud, fluid or other liquid employed in the drilling operations and that this column may be of substantial height. The column of fluid in the well W serves to confine the pressure resulting from the discharge of the means 12 so that the pressure generated by the means 12 is exerted laterally to effectively
30 expand the member 11. The means 12 may be of substantial length so that its discharge results in the expansion of a substantial vertical portion 23 of the member 11. Fig. 2 of the drawings illustrates the condition of the member 11 following the discharge or actuation of the means 12. The pressure suddenly generated by the means 12
35 evenly and fully expands the portion 23 of the member 11 to bring its outer surface into tight intimate contact with the wall of the well W. The pressure generated by the means 12 may be sufficient to cause the metal of the ductile member 11 to flow into and fill the crevices and interstices of the earth formation at the wall of the well W. Accordingly, the member 11 is expanded
40 into tight sealing engagement with the wall of the well W and this engagement is such that the member is securely held against movement in the well. It will be seen that the member 11 provides a full, dependable and lasting shut off
45 or seal at the lower end of the structure 10 to prevent the contamination of the fluid produced from the stratum A. Following the actuation or discharge of the means 12 the line 19 carrying the go-devil 21 and the cover 17 and any other
50 remaining parts of the container 15 is withdrawn from the well. If desired or necessary the above operations may be repeated to provide the member 11 with two or more sealing portions 23.

The well W may be allowed to produce from the stratum A and any other lower productive strata until the same are depleted. If at any time it is desired to remove or replace the casing structure 10 the ductile sealing element 11 may be easily and inexpensively cut free from the
55 structure 10 by a ripper, or the like, or it may be readily drilled up by an expansible drilling tool such as an under-reamer, wall scraper, or the like. Following the removal or disconnection of the member 11 the structure 10 may be lowered,
60 removed or handled in other manners.

In Fig. 4 of the drawings I have illustrated an expansible sealing member 11^a that has been expanded in the well W by the method of the invention to make a bottom hole shut-off. The member 11^a is a hollow elongate element open at its upper end and closed at its lower end. The
5 lower end of the member 11^a may be rounded or partially spherical and is fully closed. The member 11^a is proportioned to fit the open portion of the well W with suitable clearance so that it
10 may be easily run to the selected point in the well. The member 11^a is expansible being formed of a readily deformable or ductile material such as copper, aluminum or its alloys, lead or its alloys, etc. The upper portion of the member 11^a
15 has means for facilitating its connection with a setting string (not shown) for arranging the member in the well. In the case illustrated a lefthand thread 24 is provided on the upper portion of the member 11^a to mate with a thread on
20 the lower end of a string of pipe, or the like, which may be employed to position the member 11^a in the well.

In carrying out the method of the invention with the member 11^a illustrated in Fig. 4 the member 11^a is detachably connected with the lower end of a suitable setting string (not shown) and is lowered into the well on the string to a point above the stratum D producing the unwanted fluid. It is preferred to position or arrange the member 11^a in a portion of the well W passing through a hard stratum E. Means for generating pressure is then lowered into the well to a position in the member 11^a and is actuated or discharged to expand the member. The pressure generating means may be of the same type as the means 12 and may be discharged by the means 13 described above, or if desired, may be of the type illustrated in Fig. 6 of the drawings to be discharged by electrical ignition. The actuation or discharge of the pressure generating means expands the member 11^a to a condition such as illustrated in Fig. 4 of the drawings so that it has a substantial portion 23^a expanded into tight, even sealing engagement with the wall of the well W. The expanded member 11^a is firmly held in contact with the well wall to be immovable in the well. The line or string carrying the pressure generating means is withdrawn from the well W following the expansion of the member 11^a and the setting string (not shown) is detached from the member 11^a and pulled from the well. The expanded member 11^a is firmly lodged or secured in the well W so that the lefthand thread of the string may be easily
55 unthreaded from the thread 24 to permit the removal of the string from the well.

The member 11^a is adapted to remain in the well W to fully and dependably shut off the fluid from the stratum D so that it cannot contaminate
60 the fluids produced from higher strata. The member 11^a being constructed of a relatively soft ductile material may be easily and quickly destroyed or drilled up by drilling tools, or the like, if it is desired to deepen the well or carry
65 on other operations below the member.

In Fig. 5 of the drawings I have illustrated one manner of employing the method and apparatus of the invention to prevent the entrance of unwanted fluid into the well W at a point between
70 the upper and lower ends of the well. In this case the well W is equipped with a casing 30 and the casing 30 has a leak or opening 31 admitting unwanted fluid from the well W to its interior. It is to be observed that the casing 30 forms the 75

wall of the well W and that the means and method are utilized to seal off the well to prevent the entrance of fluid or to provide a shut off.

The apparatus of the present invention illustrated in Fig. 5 of the drawings includes, generally, a tubular string or structure 10^b adapted to be run into the well, an expansible tubular member 11^b connected in the structure 10^b and means 12^b for expanding the member 11^b to seal with the casing 30.

The string or structure 10^b may be in the nature of a plurality of tubing or casing sections connected together to form a casing within the casing 30. The sealing member 11^b is a tubular section of ductile or expansible material interposed in the structure 10^b. The member 11^b is formed of copper, aluminum or its alloys, tin, lead or its alloys, or other ductile material capable of expansion by internal pressure. The member 11^b may be connected in the string 10^b by suitable threaded couplings or collars 32. The diameter of the member 11^b may be substantially the same as that of the pipe or casing sections of the structure 10^b. The wall thickness of the member 11^b is preferably greater than the wall thickness of the structure 10^b. It is preferred to make the member 11^b of substantial length to extend a considerable distance above and below the opening 31 when in position in the casing 30.

While the member 11^b formed of a relatively soft ductile material of the character referred to above is adapted to have effective sealing contact with the interior of the casing 30 when expanded, it may be found desirable to provide a layer or coating of synthetic rubber or other sealing material on the member 11^b to seal with the casing 30 and to lessen or eliminate an electrolytic action between the member and the casing. The means 12^b for generating pressure to expand the member 11^b may be the same as the means 12 described above, or may be of the type illustrated in Fig. 6 of the drawings.

In carrying out the method of the invention with the apparatus illustrated in Fig. 5 of the drawings the structure 10^b is assembled and run down through the casing 30. The expansible member 11^b is assembled or connected in the structure 10^b as the latter is assembled. The location of the leak or opening 31 in the casing 30 having been previously determined, the member 11^b is arranged in the structure 10^b to extend above and below the opening 31 when the string or structure 10^b is in place in the well. When the structure 10^b has been lowered to the proper position the means 12^b is lowered down through the structure 10^b on a line 19^b and is actuated or discharged to expand the member 11^b. The member 11^b may be expanded at two vertically spaced points or zones 33 and 34 above and below the opening 31 to seal with the casing 30 above and below the opening and thus prevent the entrance of fluid through the opening 31.

The member 11^b may be expanded at the two zones 33 and 34 by separate successive operations involving the employment of two separate pressure generating means 12^b or the expansion of the two zones 33 and 34 may be accomplished by employing a special generating means having two vertically spaced charges to be set off simultaneously or in succession. Following the actuation or discharge of the means 12^b the line 19^b is withdrawn from the well. The expanded portions or zones 33 and 34 of the member 11^b evenly and tightly seal with the internal surface of the casing 30 to completely shut off the opening 31. The

expanded portions or zones 33 and 34 may be of substantial length to dependably prevent the passage of fluid between the member 11^b and the casing 30.

Figs. 6 and 7 of the drawings illustrate another form of apparatus of the invention and another manner of carrying out the method of the invention to repair or close off a leak in a well casing. In Figs. 6 and 7 the well W is equipped with a casing 40 having a leak or opening 41 admitting unwanted fluid. The apparatus of the invention illustrated in Figs. 6 and 7 comprises an expansible member 11^c to be arranged in the casing 40 and pressure generating means 12^c for expanding the member 11^c to seal off the leak or opening 41 in the casing 40.

The member 11^c is an elongate element or structure adapted to be passed down through the casing 40 to a position at the opening 41. It is preferred to make the member 11^c of substantial length to extend some distance above and below the opening 41 when in position in the casing 40. The member 11^c may be open at its lower end and its upper end may be closed by a rounded or tapered head 42. It is preferred to make the member 11^c of substantial wall thickness so that its expanded part will have sufficient strength and thickness. The member 11^c is formed of an expansible and ductile material such as copper, aluminum and its alloys, lead and its alloys, tin, or the like. The external surface of the member 11^c may be coated with synthetic rubber or may be provided with other sealing material, if desired.

The means 12^c for expanding the member 11^c is in the nature of a pressure generating means located within the hollow member 11^c. The means 12^c includes a charge of explosive or other material adapted to be ignited or set off by ignition to develop a substantial pressure. The charge of the means 12^c is contained in a frangible container 43. The container 43 fits in the member 11^c with suitable clearance and is preferably spaced between the ends of the member. The charge containing cartridge or container 43 is secured to the lower end of a cable or line 44. The line 44 may serve to carry the expansible member 11^c so that the member 11^c and the pressure generating means 12^c may be simultaneously run into the well on the line. The cap or head 42 of the member 11^c may form a rope socket for attaching the member 11^c to the line 44. The line 44 extends upwardly from the charge container 43 and passes through the head 42. Electrical conductors 45 extend downwardly along or through the line 44. The conductors 45 may be associated with the line 44 in any suitable manner and are insulated to be unaffected by the fluid in the well. The conductors 45 extend to a suitable ignition means 46 for setting off the charge in the container 43. The ignition means 46 may be contained in the upper portion of the container 43 and is an electrical ignition means of any suitable type. The invention is not primarily concerned with the details of the ignition means 46 and these details are omitted.

In carrying out the method of the invention with the apparatus illustrated in Figs. 6 and 7 of the drawings the location of the leak or opening 41 is first determined. The means 12^c and the member 11^c are then secured to the line 44 and are run down through the casing 40 on the line. The apparatus is lowered to a position such as illustrated in Fig. 6 of the drawings where the expansible member 11^c extends a considerable distance above and below the opening 41. The

line 44 may be measured as the equipment is lowered into the well to bring the member 11^c to the desired position. The circuit carried by the conductors 45 is then controlled to actuate the ignition means 46 so that the explosive charge in the container 43 is set off. The pressure generated by the means 12^c operates to expand the member 11^c and to drive it outwardly into tight sealing contact with the internal surface of the casing 40. Fig. 7 of the drawings illustrates the manner in which an intermediate portion of the member 11^c may be expanded by the means 12^c to tightly seal with the casing 40 and to close the opening 41. The member 11^c may be expanded in such a manner that it has a wall portion driven or bent into the opening 41. The column of fluid standing in the well may serve to confine the pressure generated by the means 12^c so that it acts to effectively expand the member 11^c radially into sealing contact with the casing 40 throughout its circumference.

Following the actuation or discharge of the means 12^c the line 44 is raised and withdrawn from the well. The head or upper portion of the container 43 may remain on the lower end of the line 44 following the discharge of the means 12^c and when the line is raised this portion of the container may open or spread the head 42 and pass through the head. The head 42 may be weakened, slotted or otherwise constructed in such a manner that a substantial upstrain on the line 44, following the expansion of the member 11^c into secure engagement with the casing 40, may break or spread the head to allow upward movement of the line and to permit the upward withdrawal of the remaining portion of the container 43. Then the line 44 is withdrawn from the well. If desired or necessary the unexpanded upper and lower portions 47 and 48 of the member 11^c may be removed to leave the expanded portion 49 in sealing contact with the casing 40 to close off the opening 41. A ripper, or a suitable cutting tool may be operated in the well to cut the portions 47 and 48 free from the expanded portion 49 and the freed portions of the member 11^c may be withdrawn from the well.

Having described only typical preferred forms and applications of the apparatus and manners of carrying out the method of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. The method for sealing and securing a tube of ductile material to the wall of an oil or gas well comprising positioning the tube of ductile material in the well, and then suddenly expanding the tube to grip and seal with the wall of the well by discharging an explosive charge in the tube.

2. The method of providing a seal between a string of well casing and the wall of an oil or gas well comprising connecting a ductile tubular member with said string, bringing said string to the desired position in the well, and then expanding the tubular member into intimate sealing contact with the wall of the well by generating fluid pressure in the member.

3. The method of providing a seal between a tubular structure and the wall of an oil or gas well comprising connecting a ductile tubular member with said structure, bringing said structure to the desired position in the well, and then

expanding the tubular member into sealing contact with the wall of the well by exploding a charge in the tubular member.

4. The method of sealing with the wall of an oil or gas well comprising providing a hollow ductile metal member, arranging the member in the well, lowering an explosive charge into the member, and then setting off the charge to expand the member into sealing engagement with the wall of the well.

5. The method of repairing a leak in a well casing comprising arranging a tubular member of ductile material in the casing, and then expanding the member to seal with the casing at the leak by actuating a fluid pressure generating means in the member.

6. The method of repairing a leak in a well casing comprising arranging a tubular member of ductile material in the casing, and then expanding the member to seal with the casing above and below the leak by actuating fluid pressure generating means in the member.

7. The method of making a shut-off in an oil or gas well comprising providing a hollow member of ductile material, lowering the member into the well on a well string, expanding the member to seal with the well wall by firing an explosive charge in the member, disconnecting the string from the member, and then withdrawing the string from the well.

8. The method of sealing with the wall of an oil or gas well comprising providing a hollow ductile member, providing an explosive within the member, running the member and the explosive into the well, and then expanding the member into sealing contact with the well wall by setting off the explosive.

9. Apparatus for providing a seal in an oil or gas well comprising an expansible hollow member for arrangement in the well designed and proportioned to expand against the wall of the well, and means for generating pressure in the member to expand the member against the well wall, said means comprising a charge of explosive in the member, and means for setting off the charge.

10. In apparatus of the character described a tubular structure for insertion in an oil or gas well, a hollow ductile metal member connected with the structure designed and proportioned to expand against the wall of the well, and explosive means for expanding the member against the wall of the well to provide a seal between the structure and the well wall.

11. Apparatus for use in an oil well or other earth well comprising a tubular member of ductile material designed and proportioned to expand against the wall of the well, means for running the member into a well, and means for expanding the member to seal with the wall of the well comprising fluid pressure generating means to be run into the member in the well, and means for actuating the pressure generating means.

12. Apparatus for making a shut-off in a well comprising a hollow member of ductile material having a closed lower end and an open upper end, a well string for lowering the member into a well, and means for expanding the member radially to seal with the wall of the well including an explosive charge to be fired in the member.

13. The method herein described for providing a seal between a tube and the wall of an oil or gas well comprising arranging the tube in the well, and then expanding the tube to seal

with the well wall by discharging an explosive charge in the tube.

14. In apparatus of the character described for use in an oil or gas well a tubular member of ductile metal designed and constructed to expand into sealing contact with the wall of the well, means for running the member into the well, and means for expanding the member to seal with the wall of the well comprising an explosive charge carried by the first named means and located in the member, and means for exploding the charge.

15. In apparatus of the character described for use in an oil or gas well a tubular member of ductile metal designed and constructed to expand into sealing contact with the wall of the well, means for running the member into a well, and means for expanding the member to seal with the wall of the well comprising a line to be run into the well, an explosive charge on the line for entering the member, and an element to be dropped down the line to explode the charge.

AARON ENGLISH.