Sept. 22, 1964 G. T. ALEXANDER, JR 3,149,671

VELOCITY JOINT AND CONTAINER

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Fig. 1

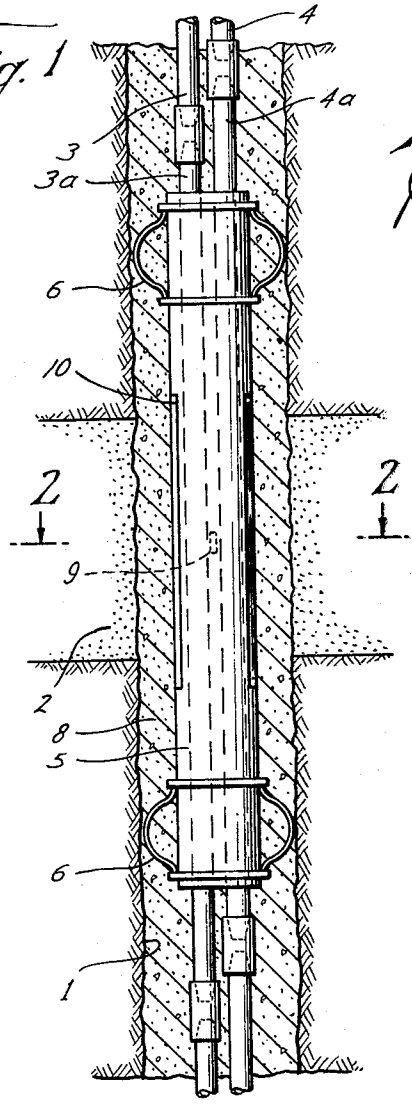

Fig. 3

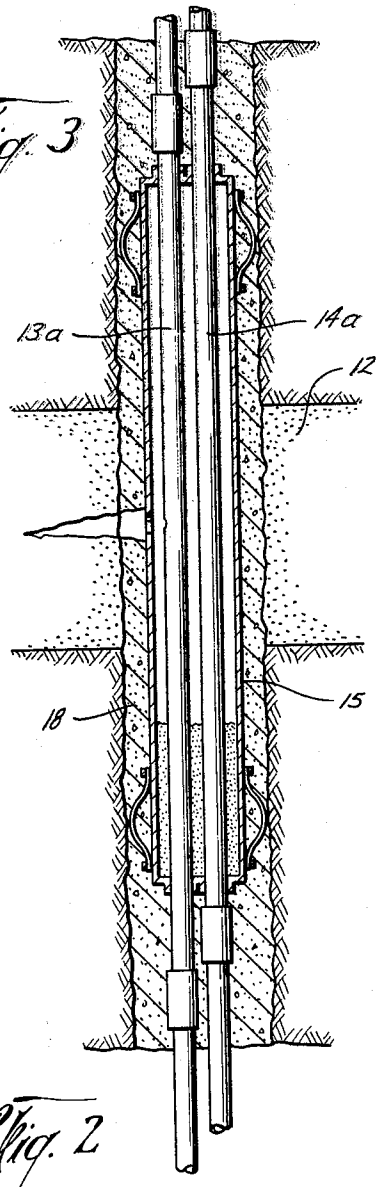

Fig. 2

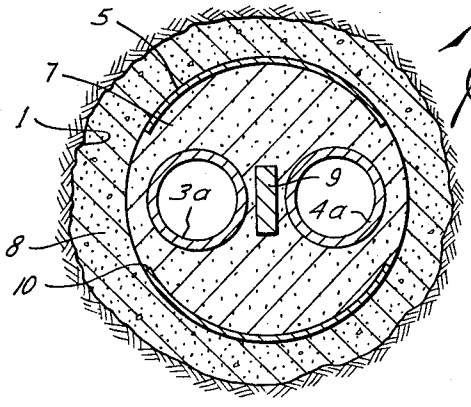

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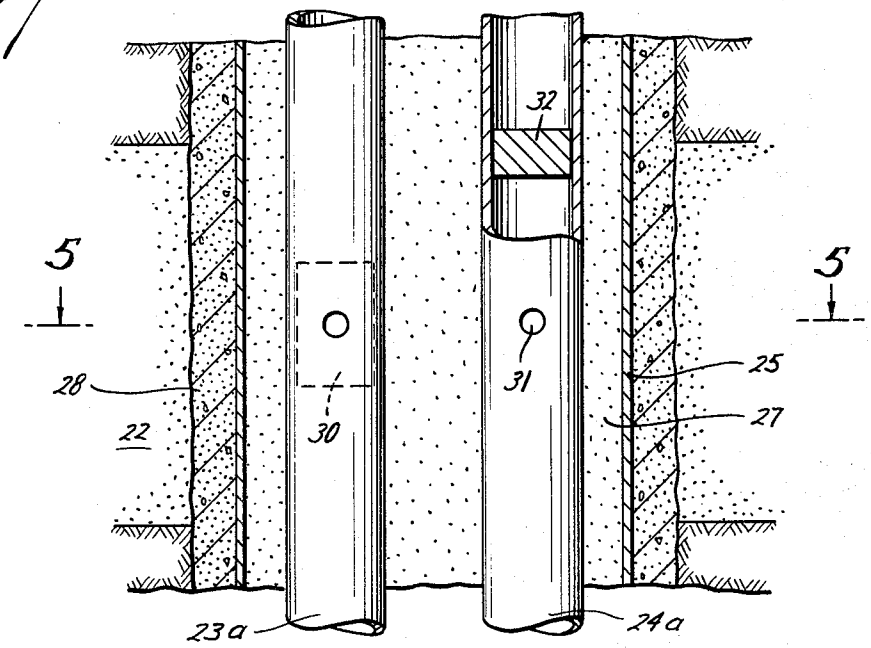
Fig. 4



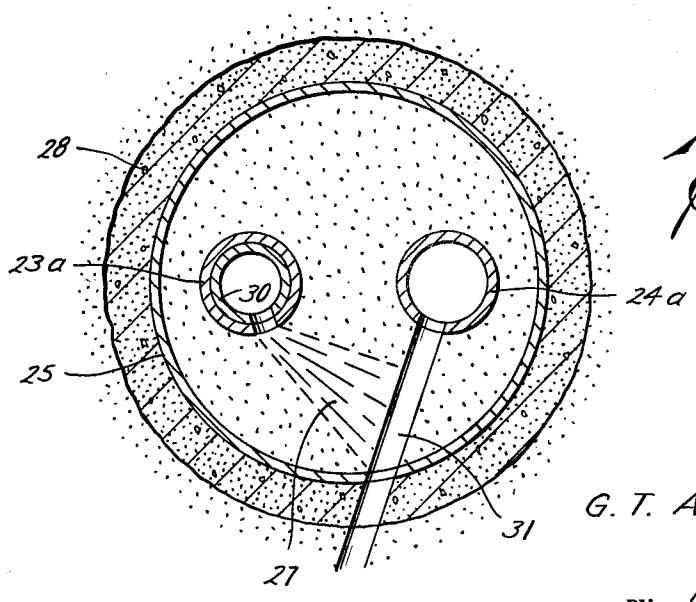


Fig. 5

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VELOCITY JOINT AND CONTAINER

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9 Claims. (Cl. 166—21)

This invention relates to well completion equipment and more particularly to a structural section or joint of well tubing string especially adapted for multiple zone permanent well completions in which either a cased or uncased well bore receives a number of production strings and is filled around the several strings and throughout the bore traversing productive zones with a cement slurry flowed under pressure and allowed to harden, after which perforations, are made from inside the respective strings at selected elevations and in predetermined directions differing as to each string and through the tubing wall and surrounding cement and into an adjacent productive formation, whereby several formations are sealed off from one another and separately opened each to a different tubing string.

It is an object of the invention to provide a tubing string assembly incorporating an elongate external enlargement or bore clearance restricting body at one or more locations in the region or regions to be cemented and which serve to increase the velocity of a cement slurry flowing through each such region and thereby preserve integrity of the mix and aid centralization with pressure equalization on all sides and throughout the constricted bore space for a more uniform cement wall thickness and avoidance of channeling effects and for better attainment of desirable final density, porosity and bonding of the hardened filling.

Another object of the invention is to provide a preformed subassembly comprising a number of tubing string sections or joints bundled in parallel side by side relation and encased except for their opposite end coupling connections within an elongate body of larger transverse dimension than the combined outside diameters of the several joints so as purposefully to reduce wall bore open space throughout substantially the length of the subassembly and to securely hold the encased tubing sections together for handling as a unit while accommodating their individual connections with other upper and lower tubing sections of the multiple strings.

A further object is to provide a velocity joint utilizing conventional tubing string sections unitized within a bore clearance constricting body which is of simple construction for economical production and is ruggedly strong to withstand normal handling stress and hydrostatic and other well bore pressures during completion operations.

Another object of the invention is to provide a multiple tubing string assembly having an enlarged bore constricting portion to be positioned at a well production formation and constituted by a porous body for flow therethrough of well fluid into one of the tubing strings while excluding movement from the formation of unconsolidated sands.

A still further object is to provide a tubing string having a chambered portion to contain a fluid under very high pressure and to be positioned adjacent a productive formation and which pressure fluid after completion of a cementing operation is released into the tubing upon performance of the usual perforating operation so that the outrush of such high pressure fluid acts against any hydrostatic pressure of fluids within the tubing and displaces the same upwardly for assisting and stimulating movement of well fluids from the formation and the self flow thereof to the surface.

Other objects and advantages will become apparent

from the following specification having reference to the accompanying drawing wherein:

FIG. 1 is a vertical sectional view of a fragment of a well bore containing a multiple tubing string shown in elevation;

FIG. 2 is an enlarged transverse section as viewed on line 2—2 of FIG. 1;

FIG. 3 is a vertical section of a fragment of a well installation illustrating a modified embodiment of the invention;

FIG. 4 is an enlarged vertical section of a fragment of a dual tubing installation completed for well flow from unconsolidated sand; and

FIG. 5 is a transverse section on line 5—5 of FIG. 4.

In the drawing, the circular wall 1 of the well bore may be considered as penetrating several oil or gas containing zones or formations, such as 2, at various distances below the surface of the earth. For multiple zone completions, a plurality of tubing strings, as shown at 3 and 4, are inserted in side by side parallel relation through the well bore, there being one tubing string for each productive zone to be produced.

As illustrated in FIG. 1, the tubing string sections or joints 3*a* and 4*a* and which may be on the order of thirty feet long, occur in the string assemblies adjacent and in traversing relation to zones to be produced and such joints 3*a* and 4*a* are bundled or held together as a unit within an enclosing tubular jacket 5 of sheet metal or the like of a diameter and length to occupy a substantial portion of the bore area throughout almost the entire length of the joints 3*a* and 4*a* except only for a short terminal portions exposed at opposite ends. Preferably, such ends are axially offset from one another for facilitating attachment and detachment of the usual coupling collars between adjoining ends of succeeding pipe joints of the several strings. This offset relation enables a close transverse spacing between multiple pipe strings, as will be desirable when many strings are to be placed in the relatively small well bore. In many instances, spring bow centralizers, such as shown at 6, can be fitted at one or more positions along the length of the enlarged tubing section 5.

In the embodiment of FIGS. 1 and 2, the elongate large diameter tubular jacket 5 encloses a solid cylindrical body 7 conveniently of moldable material such as cement or a relatively inexpensive resin plastic substance which is cast around the tubing joints 3*a* and 4*a* and completely fills the jacket as a sleeve securing the joints in fixed relation to one another. The set of joints after completion of the subassembly can be handled as a unit and the wall of the jacket 5 protectively encases the body 7 to minimize surface chipping and cracks. Upon insertion in a well bore, the body 7 backs up the jacket and resists inward collapse of its wall under hydrostatic pressure and other pressures, including those incident to a cement squeezing or other operation.

For permanently effecting completion of the well, a cement slurry is injected according to conventional practices into the free space of the well bore, particularly at each productive zone so as to span the zone and the adjoining earth layers above and below. It is important for a good seal and bond between the cement and the bore wall 1 and the tubing string that the slurry be maintained within given limits of consistency and composition and that it be moved fairly rapidly into final setting position. The enlarged elongated joint member here provided substantially decreases well bore clearance space and therefore serves materially to increase velocity of the moving cement slurry and eliminates sluggishness of flow so as more effectively to wash and scour clean the bore wall surface and insure pressure on the cement in the region which needs a good seal-off and bond immediately above and below the fluid containing formation.

Additionally, the high pressure acting circularly around the velocity joint will act equally in all radial directions for a centralizing tendency on the joint and for better assuring uniform cement wall thickness and effective resistance to channeling that sometimes occurs if the cement wall on one side is relatively thin or approaches nonexistence.

After cement injection has been completed, the well bore in the region of the productive formation **2** will be completely filled around the velocity joint with a cement body **8** which sets up and hardens and thereafter must be perforated from the casing into the productive zone **2**. Conventional wall perforating equipment can be used for that purpose, as by lowering a perforating gun from the surface through each tubing string, with suitable means for locating and orienting the direction of the gun at the time of the perforating operation in order that the tubing will be communicated through the wall thereof and through the surrounding cement into a selected formation and in a radial direction which does not intersect any other tubing string.

For co-operation with a perforating gun for locating and orienting the same, a signal element **9**, such as a magnet or a slug of radioactive material, is illustrated as being embedded within the solid body **7** intermediate the length of the velocity joint. A signal sensing element on the gun will pick up the signal for locating and directing the action of the perforating gun at a region to be produced. In the case of a velocity joint assembly which includes a set of two tubing joints, the direction of perforation from the respective tubing joints may be diametrically opposite to one another and in radial alignment with elongated slots or windows **10** formed in the jacket **5** to accommodate perforating from either joint selectively. For convenience of disclosure, FIGS. 1 and 2 illustrate a setting of the parts after the cement has hardened and prior to the final perforating operation.

In FIG. 3, the perforating operation is illustrated as having been completed into a production zone **12** and through the hardened cement sleeve **18** filling the well bore around a velocity joint subassembly. In this view, the velocity joint subassembly includes an elongate hollow or tubular member **15** encasing a pair of tubing string joints **13***a* and **14***a* and being welded thereto at both ends. The tubular member **15** provides a well bore constriction and an internal chamber of considerable length and transverse space surrounding the tubing string joints. Initially, this hollow enclosed chamber can be filled with a liquid or with air under pressure for stiffening the relatively thin walls of the tubular member **15** against inward collapse during handling and after insertion in a well bore prior to the hardening of the body of cement **18**. After the perforating operation from the inside of one of the tubing string joints and through its wall and the wall of the tubular member **15** and through the surrounding cement and into the productive formation, the hollow chamber space interiorly of the wall **15** will thereafter afford a sediment or sand collection well or trap. Sand will be collected as it drops from fluid passing from the formation through the perforated passageway and across the open chamber into the production tubing string.

For those situations in which self flow from the formation after completion of a perforating operation fails to occur due to relationship of well formation pressure and an opposing head of liquid within the tubing string, and especially a liquid consisting of heavy mud, resists well fluid production and requires conventional swabbing for reducing flow resistance, there is contemplated the use of liquid nitrogen or the like as the pressure fluid initially entrapped within the chamber enclosed by the wall **15** of the bore constricting body. Coincident with the formation as heretofore described of a perforated passageway, such previously confined high pressure fluid provides force downstream of the productive formation so as to jolt and overcome tubing string fluid pressure, whereby

swabbing or other costly and time consuming completion steps can often be eliminated. Instantaneous release of a liquid gas, such as nitrogen which rapidly expands in its conversion from liquid to gas, directs a powerful fluid stream into the tubing and counters down pressure of and elevates any liquid column standing in the tubing string, so as effectively to clear the upward path for and induce self flow of well formation fluid toward the surface.

Earth formations at a productive region occasionally involve unconsolidated sands usually of fine texture and which desirably should be held back and prevented from flow entry into the tubing string. For that purpose, FIGS. 4 and 5 show a permeable body **27** of consolidated particles such as proper sized sand or plastic or other suitable filtering material for filling a cylindrical chamber within the large tubular wall **25** of a bore constricting joint through which multiple tubing string sections **23***a* and **24***a* extend. An initially closed sleeve valve **30** is slidably mounted within the tubing section **23***a* to blank off a preformed lateral port in the tube side wall which at well completion is in alignment with a productive formation **22**. After the annulus-filling wall **28** of cement has set up within the well bore, a perforating device is lowered into the tubing section **24***a* and is caused to open a passageway **31** through the permeable body **27** and cement wall **28** and into the productive sand as a flow path. Then a bridge plug **32** is inserted and set to close the tubing section **24***a* at a selected distance above the wall perforation at the passage **31**, so that the tubing string containing the section **24***a* can be utilized for later production flow from an upper formation above the bridging plug. Actuation as by a wire line tool, of the sleeve valve **30** from its initial closed position to its open position illustrated will thereupon accommodate movement of well fluid from the perforated passage **31** and through the porous bed **27** and into the tubing string containing the section **23***a* but displacement of sand from the unconsolidated productive formation is effectively restrained.

While the foregoing specification has been of a specific nature, it will be understood that the invention is not thereby limited and that the scope of the invention is to be determined by the attached claims.

What is claimed is:

1. In a multiple completion well, a plurality of tubing string joints positioned in parallel side by side relation for insertion within a well bore and means to increase cement flow velocity about said joints during a completion operation and comprising a solid body molded in surrounding relation to and embedding therein the said joints and a protective shell jacketing said body, said jacket having windows circumferentially spaced apart in the shell wall and through which perforations may be made from within the joints and in radial directions oriented with respect to each joint, together with a signaling means embedded in said body for co-operation with a signal responsive perforating device positioned in any of said joints and for effecting directional orientation of said perforating device.

2. In a multiple completion well, a plurality of tubing string joints in side by side relation, an elongate sleeve of porous filter material surrounding said tubing string joints in unitary subassembly therewith for insertion in a well bore to a position traversing a productive formation, a body of cement closing the well bore space around said subassembly, one of said tubing string joints having a preformed side wall aperture communicating the interior of the joint with the pores of said sleeve, another of the tubing string joints being adapted for reception of a perforating tool whose operation forms a passageway completed through the cement and from the productive formation and into said sleeve and closure means to be set within the tubing string last mentioned following the formation of said passageway and at a

position above said passageway for closing same from the interior of the tubing string above said means.

3. The method of completing a well comprising assembling multiple tubing strings having therein a joint unit made up of side by side tubing sections and an elongate sleeve of porous material surrounding the tubing sections of which one section has a wall opening covered by the sleeve and positioning the joint unit at a productive formation in a well bore, flowing cement into and filling the well bore space between the joint unit and the productive formation and allowing the cement to set, then perforating a passage through the cement and said sleeve and into the formation and from within a tubing section other than said one section and thereafter setting a bridging plug above said passage and within the tubing string from which the passage was perforated.

4. In a multiple completion well, a set of separate tubing strings set within a well bore and each comprised of a succession of tubing joints, an elongate well bore constricting body of porous filter material sleeved on adjoining joints of said tubing strings, one of which joints has a side wall opening communicating with the pores of said body, a wall of cement surrounding and bonding said elongate well bore constricting body within the well bore, a passageway extending through said body and having communication with said side wall opening by way of the pores, said passageway also extending through the cement wall and into a productive formation and resulting from a perforating operation performed from within another of the adjoining joints and a bridging plug positioned in the tubing string containing the last mentioned joint and closing off the last mentioned tubing string from said passageway.

5. A tubing unit for a multiple completion well installation, including a number of side by side tubing string joints, a hollow elongate sleeve fitted exteriorly of and having axially spaced apart portions in sealed embracement with the joints, said sleeve and joints constituting a subassembly unit and providing a closed chamber space surrounding the joints and a constriction to well

bore space for increasing cement flow velocity thereacross during a completion operation and a body of high pressure fluid confined within said closed chamber space.

6. In a tubing unit as in claim 5, wherein said body of high pressure fluid comprises a liquefied gas.

7. In a tubing unit as in claim 5, one of said joints being adapted to be punctured into the chamber space and communicated with a productive formation by the operation of a perforating tool inserted within the joint.

8. In the method of completing a well, the steps of making up a tubing string containing a joint section having an elongate closed chamber filled with high pressure fluid, positioning the tubing string within a well bore with said joint section adjacent a productive formation, sealing off the well bore space at the formation and around said tubing section and then performing a perforating operation from within the tubing section and through said chamber and into the sealed-off formation.

9. A tubing string unit to be positioned within a well bore and adjacent a productive zone, said unit including a tubing string section, a tubular member sleeved on and sealed at axially spaced apart portions thereof with the tubing string section and enclosing a chamber and a body of liquefied gas confined within the chamber, said tubing string section being adapted to receive a perforating tool upon location of the tubing string section adjacent a productive zone whereby tool operation pierces a passage through the chamber and into the zone and releases the confined gas into the tubing string section.

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