March 14, 1944. R. C. BAKER 2,344,120

METHOD AND APPARATUS FOR CEMENTING WELLS

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Fig. 1.

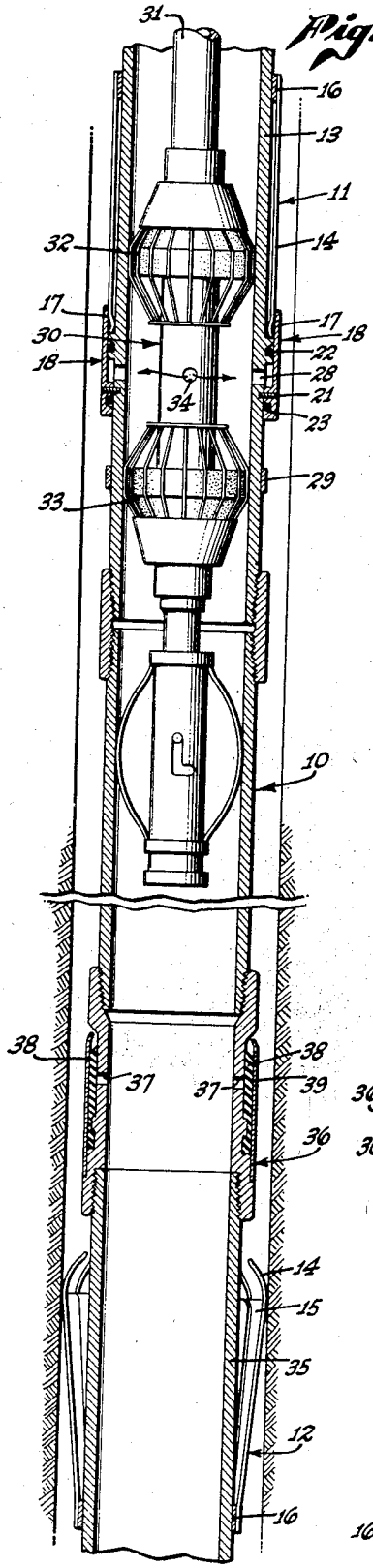


Fig. 2.

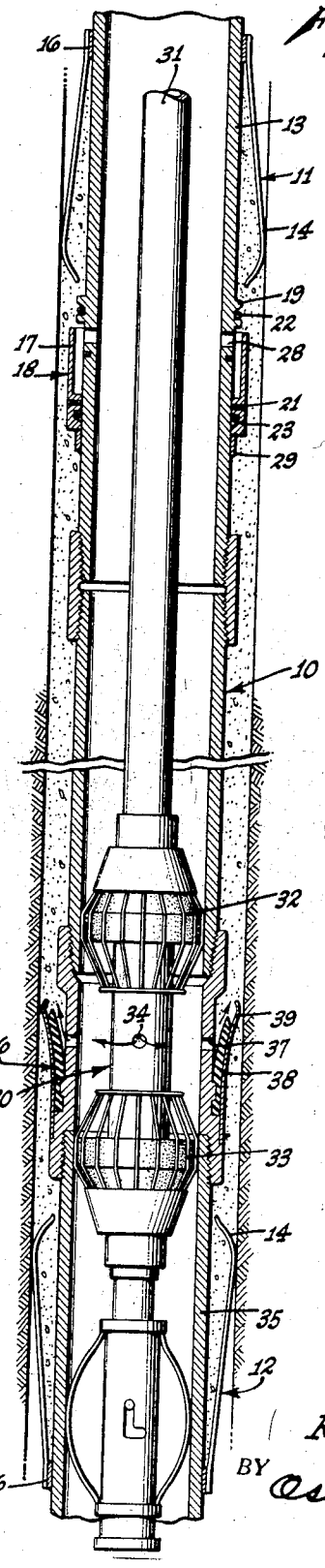
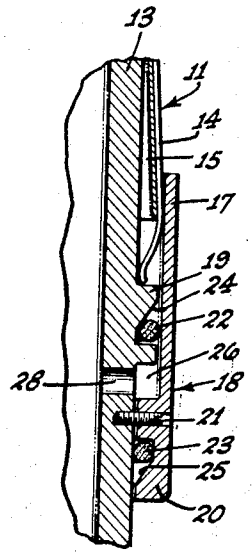


Fig. 3.



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METHOD AND APPARATUS FOR CEMENTING WELLS

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Fig. 4.

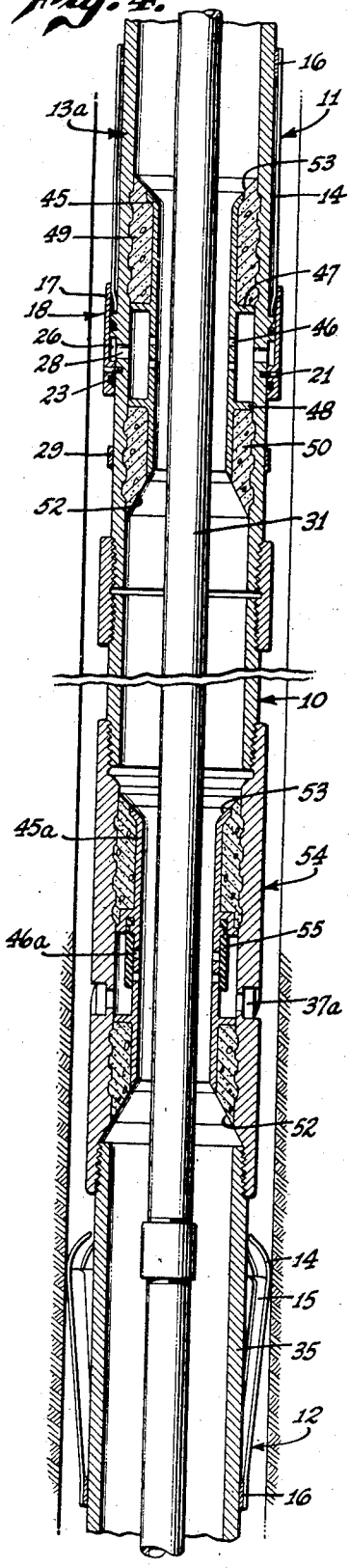
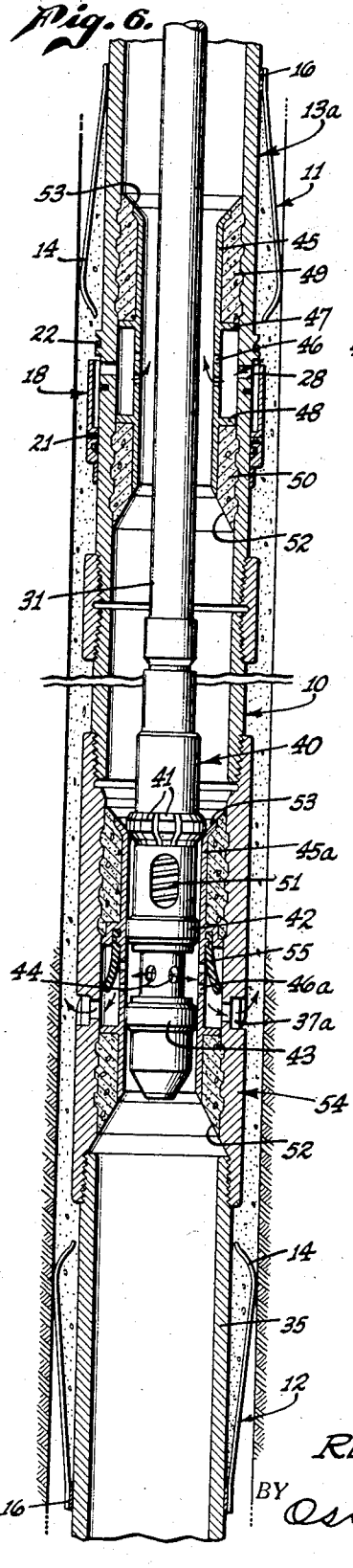


Fig. 6.



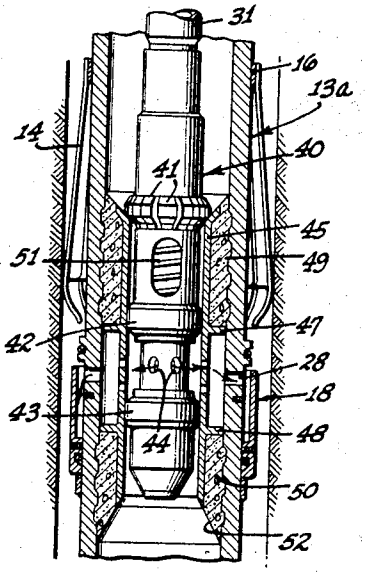


Fig. 5.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR CEMENTING WELLS

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Application April 21, 1941, Serial No. 389,591

17 Claims. (Cl. 166—1)

This invention relates to devices employable in well bores, and is particularly concerned with devices capable of forming an annular bridge or barrier between a well casing and the wall of a confining bore hole. Apparatus of this general character are disclosed in my prior Patents 1,561,768 and 2,117,538, and also in my application, Serial No. 343,584, filed July 2, 1940, for "Casing bridging devices," Patent No. 2,275,936.

In the drilling and completion of oil and similar wells, it is common practice to cement a casing or liner string in the well bore. In some instances, one or more annular barriers are provided between the casing and wall of the bore hole to confine cement slurry to a particular region along the casing. It is desirable for such barriers to be in retracted position while the casing is being run in the hole, in order to avoid frictional contact with the hole wall and damage to the parts of the device. Some annular barriers now used are of generally frusto-conical form when in expanded condition, and may include a "petal" basket, as described in my Patent 2,117,538. An upright basket of this type, or one diverging in an upward direction, can be lowered in the casing in its inherently expanded condition, since the "petals" will readily slide over the wall of the bore hole without damage. However, the "petals" of an inverted basket, or one diverging in a downward direction, may dig into the hole wall upon lowering of the casing string, and may produce failure of the basket parts, besides breaking down the wall of the well bore.

Accordingly, it is an object of the present invention to provide an apparatus in which a casing barrier or basket arrangement can be held in retracted position while the casing is being lowered in the bore hole, release of such basket being effected hydraulically whenever desired. Although particular reference has been made to the holding of an inverted barrier in retracted position while lowering the casing in the hole, an upright basket may also be held retracted and released hydraulically in a similar manner.

Longitudinally separated upright and inverted opposed barriers or baskets are employed to provide confined annular spaces around the casing in which cement may be deposited. This arrangement may be used for only a single stage cementing operation, or for several longitudinally separated locations along the bore of the hole, as where more than one oil bearing strata is encountered and it is desired to separate such strata by cementitious seals. It has heretofore been difficult to properly wash the area between an upright and an inverted basket by use of a tubing string and connected mandrel, because of the fact that the latter members must be positioned below the inverted barrier and within a ported collar adjacent the upright barrier to perform the washing operation, and in passing through the collar carrying the inverted basket, its release has been effected, allowing its expansion into engagement with the formation and precluding passage of circulating and washing fluid upwardly along the casing beyond the basket. As a result, it has been difficult to properly condition the confined well space for reception of cement slurry.

Accordingly, it is a further object of the invention to provide a casing barrier or cement basket arrangement which can be held in retracted position as long as desired, and without regard to the passage of cementing or other tools through the casing. By means of the invention, it is possible to maintain an inverted annular casing barrier in retracted position until after the drilling or other fluid has been flushed from the well bore. Following the washing operation, the inverted basket may be released hydraulically, as by employing a tubular string and mandrel, and the cementitious material deposited behind the casing along the locations defined by the baskets. In this connection, if a series of locations separated longitudinally by sets of upright and inverted barriers or baskets is employed, washing of each location or zone, release of its inverted barrier, and cementing of the zone preferably takes place in upward sequence, to avoid restrictions to the upward passage of circulating fluid by an upper, previously released, basket.

This invention is also concerned with an improved method for washing and cementing a formation zone defined between annular casing bridges or baskets by washing such zone prior to expansion of its upper annular bridge, releasing this bridge, and then depositing the cement slurry in the zone or location being operated upon.

This invention has other objects that will become apparent from a consideration of the embodiments shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figure 1 is a longitudinal section through a

portion of a well bore and a liner or casing contained therein, illustrating a lower basket in engagement with the wall of the bore hole, and an upper inverted basket in retracted position prior to being released hydraulically;

Figure 2 is a longitudinal section similar to Figure 1 disclosing the inverted basket in released and expanded position, and a cementing mandrel in position for depositing cementitious material behind the casing along the location or zone defined by the baskets;

Figure 3 is a partial longitudinal section on an enlarged scale showing the upper basket in retracted position;

Figure 4 is a view similar to Figure 1 of another form of the invention, employing apparatus such as described in my Patents 2,187,480 and 2,187,483;

Figure 5 is a longitudinal section similar to Figure 4 disclosing the cementing mandrel on the lower end of a tubing string in operative position for releasing the initially retracted, inverted cement basket; and

Figure 6 is a longitudinal section similar to Figure 4 illustrating the ejection of cement from the cement mandrel and the lower cementing collar after the inverted basket has been released.

As disclosed in the drawings, a casing or liner string 10 is positioned in a well bore, carrying one or more annular barriers 11, 12 for forming a bridge between the casing and wall of the bore hole. In the present instance, an upper inverted barrier 11 of the "petal" type, described in my Patent No. 2,117,538, is secured to the exterior of a casing section or collar 13, the basket consisting of leaf springs 14 secured to the exterior of overlapping basket "petals" 15, with the ends of these members attached to a ring 16 welded or otherwise mounted on the collar. The springs 14 and "petals" 15 inherently tend to assume an expanded, generally frustoconical or bucket shape.

The inverted basket ring 16 is fastened to an upper collar 13 with its attached depending "petals" and springs held initially in retracted position against the casing. As shown in the drawings, the skirt 17 of a retainer sleeve 18 encompasses the free ends of the leaf springs 14 and "petals" 15, extending downwardly from this point along an outwardly projecting collar flange or piston 19, and terminating in an inwardly directed sleeve head 20 initially secured to the collar by one or more shear screws 21. The flange and head are provided with suitable seals for preventing leakage of fluid between the sleeve and collar. Such seals may consist of round elastic rings 22, 23 positioned in oppositely tapered grooves 24, 25 formed in the flange and head, the rings having slidable sealing engagement with the inner surface of the skirt 17 and the collar exterior, respectively.

When expansion of the inverted basket 11 into engagement with the formation is to be permitted, pressure is supplied from a point within the collar 13 to the fluid in the annular cylinder space 26 formed between the piston 19, skirt 17, head 20 and collar, this fluid entering the cylinder space through one or more lateral ports 28 in the collar between the piston and head. Upon increase in the fluid pressure to the proper magnitude, the shear screws 21 are disrupted and the sleeve 18 then shifted downwardly along the collar from engagement with the leaf springs 14 and "petals" 15, permitting their inherent outward expansion into contact with the wall of the bore hole. The extent of this downward shifting is limited by a stop ring 29 secured to the collar a sufficient distance below the initial position of the retainer sleeve 18 to allow its upper end to move from engagement with the piston seal 22 and open the lateral ports 28 to the passage of fluid between the interior and exterior of the casing.

As disclosed in Figure 1, the fluid under pressure necessary for tripping the retainer sleeve and releasing the upper inverted basket can be supplied through a suitable perforation cementer or mandrel 30 secured to the lower end of a tubing string 31. This cementer includes opposed packing members or swabs 32, 33 adapted to slidably seal with the wall of the casing for confining the fluid pressure to the interior of the casing between the packing members. Fluid can exit from the cementer mandrel 30 through the lateral cementing port 34 between the packing members 32, 33.

To effect release of the retracted basket 11, the cementing mandrel 30 is run in the casing on the tubular string 31 until its opposed packings are in sealing engagement with the casing on opposite sides of the collar ports 28. Pressure may then be applied to the fluid within the tubing, and this will be transmitted through the fluid in the confined space between the packing members 32, 33 to the interior of the sleeve 18, disrupting the shear screws 21 and lowering the sleeve sufficiently to free the ends of the basket and permit its expansion against the wall of the hole, in the manner heretofore described.

Although specific reference has been made to release of an inverted barrier or basket, it is apparent that an upright member 12 could similarly be held in retracted position, and its release effected in the same manner as the inverted basket 11. The identical collar with retracted basket attached need only be reversed so that the free ends of the basket face in an upward direction.

The hydraulically releasable inverted basket 11 can be employed in conjunction with a spaced upright basket 12 to isolate a formation zone along a specified distance. This arrangement is made up on the casing string with the inverted basket 11 secured to its upper collar 13 and the upright basket 12 mounted on a spaced lower collar or casing section 35 below a suitable cementing collar 36 having lateral ports 37 through which fluid may be ejected into the bore surrounding the casing. These ports are closed by a suitable back pressure valve, which is herein disclosed as consisting of an elastic sleeve 38 secured at one end to the cementing collar 36 and with its free end adapted to be forced outwardly by fluid under pressure within the casing against the action of circumferentially spaced leaf springs 39, whose lower ends are attached to the collar 36. Cement slurry or other fluid issuing from these ports 37 will travel upwardly along the casing toward the inverted basket 11, its return flow being prevented by snug engagement of the rubber sleeve 38 against the exterior of the ported collar area.

The string of casing 10 is run into the well bore until its longitudinal section between the upper and lower baskets 11, 12 is positioned opposite the formation zone along which the cement seal is to be provided. The perforation cementer 30 on the end of the tubing string 31 is lowered into the casing until its opposed pack-

ing members 32, 33 are disposed on opposite sides of the cementing ports 37. Circulation may then be established through the tubing for outward passage through the cementing port 34 between the packings, and through the casing or collar ports 37 for upward passage along the casing beyond the inverted basket 11. This circulation will effectively wash the wall of the bore hole and condition the well for the cementing operation.

After washing has been completed, the cementer 30 is elevated within the casing until its opposed packings 32, 33 are disposed on opposite sides of the lateral releasing ports 28. Pressure built up in the tubing string and mandrel 30 is confined to the casing space between the packing cups, being transmitted to the fluid within the sleeve cylinder 18 to shear the screws 21 and shift the sleeve downwardly to its fullest extent against the stop ring 29, in which position the sleeve clears the piston packing 22 to open the releasing ports 28. Upon release of restraint, the "petals" and springs of the inverted basket 11 inherently expand into engagement with the wall of the formation, so as to prevent fluids and other material from moving upwardly along the casing beyond the basket.

Following release of the upper inverted basket, the cementer 30 is lowered in the casing until its opposed packings 32, 33 are again disposed on opposite sides of the cementing collar ports 37, and the proper amount of cement slurry ejected through the mandrel ports 34 and cementing ports 37 into the annular space between the upper and lower baskets 11, 12. The washing fluid contained between these baskets precedes the cement in its upward movement for passage through the open releasing ports 28 and into the casing for delivery to the surface of the well bore. Any excess cement also passes through these upper ports or passages for flushing from the casing. After sufficient cement has been disposed behind the casing between the baskets 11, 12, release of pressure within the cementing tool 30 and tubing 31 allows the rubber sleeve 38 to seal over the ports 37 and prevent return flow of the slurry into the casing.

If more than one casing section is to be cemented, the tubing string is moved to the new location in the casing, and the aforementioned operations repeated. That is, washing of the formation and casing exterior is followed by release of the inverted basket 11, after which the cement is deposited along the specified zone through the lower cementing collar 36. It is preferred that such multiple stage or series cementing operations be performed in upward sequence, to prevent an upper, previously released basket from interfering with the washing of a lower zone.

As disclosed in Figures 1 and 2, it is possible to perform single stage or series washing and cementing operations, and also effect release of retracted baskets or annular casing barriers at will by means of a tool capable of sealing within an unrestricted casing, and of proper positioning opposite its various sets of lateral ports. A second form of the invention is disclosed in Figures 4, 5 and 6, in which the same basket arrangement as was heretofore described is employed, but in which the releasing collar for the inverted basket 11 is modified in order to provide a restriction in the casing and permit the use of the cementing mandrel and collar design specifically described in my Patent 2,187,483.

Essentially, this mandrel 40 consists of a plurality of retractable latches 41 and a pair of sealing rings 42, 43 disposed on opposite sides of mandrel cementing ports 44. The latches 41 are adapted to seat upon the upper end of a stop sleeve 45 secured in the upper collar 13a adjacent its outer ports 28 for the purpose of positively locating the mandrel sealing rings 42, 43 on opposite sides of the stop sleeve ports 46, which will direct fluid under pressure from the mandrel outlets 44, through the stop sleeve openings 46 and outer collar ports 28 into the retainer sleeve cylinder 26, producing shearing of the screws 21 and shifting of the retainer sleeve 18 to basket releasing position. The stop sleeve 45 is suitably secured in spaced relation to the inner surface of the collar 13, as by upper and lower flanges 47, 48 on opposite sides of its ports 28, which are engageable with upper and lower annular cement plugs 49, 50 anchored to the collar to hold the stop sleeve against longitudinal movement in either direction within the casing.

Although the stop sleeve 45 is of materially reduced diameter when compared with the internal diameter of the casing or collar, the cementing mandrel 40 is able to pass completely through this sleeve when its latches 41 are retracted. As explained in Patent 2,187,483, these latches are initially held retracted in a positive manner until the cementing mandrel passes through all of the restricted collars within the casing, whereupon the latches are released to permit their retraction against the force of a spring 51 only upon moving upwardly into engagement with the tapered undersides 52 of the restricted collars. However, after having once been released, these latches 41 do not retract to permit movement of the mandrel downwardly through the restricted collars, but seat upon the tapered shoulder 53 formed at the upper end of the stop sleeve 45 and upper cement plug 49, to locate the mandrel seals 42, 43 on opposite sides of the sleeve ports 46, in order to release the basket 11, as described above.

The lower cementing collar 54 is of a similar construction to the releasing collar 13a, but additionally carries a back pressure valve in the form of an elastic sleeve 55 positioned over the exterior of the stop sleeve ports 46a. As is fully described in Patent 2,187,483, when the released mandrel latches 41 rest on the upper end of the inner stop sleeve 45a, its opposed packing members 42, 43 are disposed on opposite sides of the cementing ports 46a allowing cement slurry or other fluids to open the back pressure valve 55 for ejection under pressure through the sleeve ports and passage through the collar ports 37a into the bore surrounding the casing.

In Figure 4, the tubing string 31 is disclosed as extending completely through both the upper and lower collars 13a, 54. When in this position, a cementing operation at a lower stage in the casing might be performed, and release of the mandrel latches 41 effected. After the performance of a lower cementing or other operation, or release of the latches, the tubing string is elevated, the mandrel latches 41 engaging the lower inclined portion 52 of the lower collar, which will produce their retraction and permit movement of the mandrel to a position just above this collar. Lowering of the tubing string and mandrel causes its latches 41 to seat upon the upper collar shoulder 53 and locate its packing members 42, 43 on opposite sides of the sleeve cementing ports 46a.

A washing operation can now take place, the fluid passing upwardly from the ports 37a of the lower collar along the casing and beyond the inverted basket 11, which is still in its retracted position. Following the washing operation, the tubing string 31 and mandrel 40 are elevated through the upper collar 13a and the mandrel latches 41 positioned upon the shoulder 53 on the upper stop sleeve 45 (as shown in Figure 5), permitting release of the retainer sleeve 18 in the manner aforementioned, and expansion of the inverted basket springs and "petals" into engagement with the formation.

The tubing string 31 and mandrel 40 are then removed from the well bore, and the latches 41 relocked in retracted position to permit downward passage of the mandrel once again through the restricted collars. Upon reaching a position below the releasing collar 13a, the latches 41 may again be tripped and released in order that they can be expanded outwardly and rest upon the lower shoulder 53 of the cementing collar sleeve 45a and establish the seals on opposite sides of the sleeve ports 46a once more. The necessary amount of cementitious material may now be ejected from the mandrel, through the sleeve ports 46a and collar ports 37a for upward passage along the casing or liner toward the released and expanded inverted basket 11. The fluid preceding this cement slurry flows inwardly through the open retainer ports 28 and upper sleeve ports 46 for upward passage around the tubing to the surface of the bore hole. As was described in connection with the other form of the invention, any excess cement slurry also moves through these ports for flushing to the surface of the bore.

The arrangement disclosed in Figures 4, 5 and 6 is applicable to a single stage, and also to a plurality of stages, depending upon whether it is desirable to perform a multiple stage cementing operation along the length of the casing, or whether a series cementing operation at separated zones along the casing is necessary. Here again, as in connection with the other form of the invention, it is preferred to perform the necessary washing operation, release of the inverted basket, and deposition of the cement slurry through each stage in an upward sequence.

Following the performance of all of the cementing operations, the tubing and cementing mandrel may be removed from the casing and the cement allowed to set and harden. The stop sleeves 45, 45a are made of drillable material, so that the restricted casing portions may be drilled out to provide an unrestricted and unobstructed casing bore.

From the foregoing description, it is apparent that an apparatus has been provided by means of which a retracted annular barrier or basket may be released at will, enabling the casing string to be lowered safely in the bore to the desired position. Thorough washing along any specified formation zone can occur prior to release of the inverted basket, giving greater assurance that the cement seal formed in that particular zone will be leak-proof.

I claim:

1. In combination with a tubular well casing, a well device mounted on said casing for bridging the annular space between said casing and the surrounding wall of a well bore, means for holding said device in retracted position, means for sliding said holding means along said casing to release said bridging device and allow its expansion into engagement with the wall of said bore hole, and means within said casing for feeding fluid under pressure to said sliding means.

2. In combination with a tubular well member adapted to form part of a casing or liner string, a well device mounted on said member for bridging the annular space between said member and the surrounding wall of a well bore, means for holding said device in retracted position, means for shifting said holding means and device with respect to each other to release said bridging device and allow its expansion into engagement with the wall of said bore hole, said casing being provided with means for feeding fluid under pressure to said shifting means.

3. In combination with a tubular well casing, an annular inherently expansible well-bridging device mounted on said casing, means for retaining said device in retracted position, and means within said casing for producing relative sliding movement along said casing between said bridging device and retaining means to permit outward expansion of the former.

4. In combination with a tubular well casing, an annular inherently expansible well bridging device mounted on said casing, means for retaining said device in retracted position, and means including instrumentalities within said casing for shifting said retaining means to release said bridging device and allow its outward expansion.

5. In combination with a tubular well casing, a generally frusto-conical basket mounted on said casing, fluid pressure responsive means for retaining said basket in retracted position adjacent said casing, and means for feeding fluid under pressure to said means to effect its release from said basket and permit outward expansion of the latter.

6. In combination with a tubular well casing, a generally frusto-conical basket mounted on said casing, means slidable on said casing for retaining said basket in retracted position adjacent said casing, said casing being provided with means for feeding fluid under pressure to said retaining means to effect its release from said basket and permit outward expansion of the latter.

7. In combination with a tubular well casing, a generally frusto-conical basket mounted on said casing, means on said casing for retaining the larger end of said basket in retracted position adjacent said casing, said casing being provided with means for feeding fluid under pressure to said retaining means, whereby its release from said basket is effected and outward expansion of the latter permitted.

8. In combination with a tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, a sleeve on said member embracing the larger end of said basket to hold it in retracted position adjacent said member, said sleeve being constructed and arranged to be slidable in response to fluid pressure, means providing a slidable seal between said sleeve and member, and means for feeding fluid under pressure to said sleeve to slide it along said member and effect its release from said basket.

9. In combination with a ported tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, a retaining sleeve on said member having slidable sealing engagement therewith on opposite sides of its ports to form an annular cylinder, said sleeve embracing the larger end of said basket to hold it in retracted position ad-

jacent said member, whereby fluid under pressure from within said member may be fed into said cylinder to shift said sleeve from engagement with said basket and permit outward expansion of the latter.

10. In combination with a ported tubular well member adapted to form part of a casing or liner string and having a substantially unrestricted bore, a generally frusto-conical basket mounted on said member, a retaining sleeve on said member embracing the larger end of said basket to hold it in retracted position adjacent said member, said sleeve having slidable sealing engagement with said member on opposite sides of its ports to form an annular cylinder, whereby fluid under pressure from within said member may be fed into said cylinder to shift said sleeve from engagement with said basket and permit outward expansion of the latter.

11. In combination with a tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, means for retaining said basket in retracted position adjacent said member, and hydraulically actuated means for moving said basket and retaining means with respect to each other to permit outward expansion of the basket.

12. In combination with a tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, a sleeve on said member embracing the larger end of said basket to hold it in retracted position adjacent said member, and hydraulically actuated means for moving said basket and sleeve with respect to each other to free the larger end of said basket and permit its outward expansion.

13. In combination with a tubular member having a discharge port and adapted to form part of a casing or liner string, a tubular stop device secured therein adjacent said port and having a medial portion of reduced external diameter forming, with the wall of the member, an annular chamber with which said port communicates, said device being provided with a lateral passage communicating with its bore and with said chamber, a generally frusto-conical basket mounted on said member, a retaining sleeve on said member embracing the larger end of said basket to hold it in retracted position adjacent said member, said sleeve having slidable sealing engagement with said member on opposite sides of its port to form an annular cylinder, whereby fluid under pressure from within said tubular stop device and chamber may be fed into said cylinder to shift said sleeve from engagement with said basket and permit its outward expansion.

14. The method of cementing a casing string in a well bore, which comprises establishing a barrier to bridge the annular space between the casing string and well bore, circulating fluid through the annular space above said barrier, then establishing a second barrier above said first barrier to bridge the annular space between said casing string and well bore, and cementing said annular space between said barriers.

15. The method of cementing well casing in a well bore along separated upper and lower formation zones, which comprises establishing a barrier at the lower end of said lower zone to bridge the annular space between the casing and well bore, circulating fluid through the annular space above said barrier, then establishing a second barrier at the upper end of said lower zone to bridge the annular space between said casing and well bore, cementing said annular space between said barriers, establishing a third barrier at the lower end of said upper zone to bridge the annular space between said casing and well bore, circulating fluid through the annular space above said third barrier, then establishing a fourth barrier at the upper end of said upper zone to bridge the annular space between said casing and well bore, and cementing said annular space between said third and fourth barriers.

16. In combination with a tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, and fluid operated piston and cylinder means on said member for retaining said basket in retracted position adjacent said member, said means being responsive to fluid under pressure for effecting its release from said basket.

17. In combination with a tubular well member adapted to form part of a casing or liner string, a generally frusto-conical basket mounted on said member, means for retaining said basket in retracted position, and cooperable annular cylinder and piston means on said member for effecting release of said retaining means from said basket.

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