This invention relates to improvements in well swab cups, and more particularly to improvements in the placement and securing of metal reinforcement members within the resilient material of the cups.

It is the principal object of this invention to provide improved reinforced cups capable of longer service under severe operating conditions, and more resistant to disintegration in the well, the cups also being cheaper and easier to manufacture.

It is a major object of the invention to provide a cup having an increased number of metal reinforcing members around its outer periphery, as compared with the number shown in prior-art teachings, so that the resilient material of the cup is more firmly supported against cold flow thereof which displaces the material outwardly between the reinforcements at the base of the cup and permits pinching and wearing away thereof, the resilient material of the cup comprising a rubber-type material such as natural rubber or synthetic rubber.

Another major object of the invention is to provide a cup reinforced by metal members which at their lower ends are pivotally captivated to the cup in such a manner that if one or more of said metal members is torn from the side of the rubber cup and bent or reversed downwardly with respect thereto, the displaced metal member will remain captivated to the cup so that it cannot fall inside the tubing being swabbed and become a working hazard causing damage to other equipment therein.

A further major specific object of the invention is to provide a cup reinforcing structure which pivotally secures the lower ends of the metal members to a simple annular ring to provide a type of reinforcement that is cheaper to manufacture than some of the securing members of the prior art which employ machined rings having annular flanges with holes bored therearound to receive the lower ends of reinforcing wires. The present structure is also stronger than the machined ring structure which tends to be broken off in places when a reinforcing wire snaps and becomes reversed. The assembly of the cup during manufacture is simplified by the present structure wherein, in one form of the invention, the reinforcing members comprise wires having their lower ends bent about the annular ring and crimped tightly enough thereon so that the wires and the ring form a self-supporting open-work cage around which the charge of rubber material can be molded without requiring the individual support of all of the reinforcing elements during such molding, as is the case during the manufacture of swab cups wherein the reinforcing wires loosely engage larger holes in the flange and are therefore not supported thereby before the rubber body is added.

The present improved structure applies to the type of cup in which the reinforcing elements extend upwardly beyond the rubber, as well as to the type of cup in which the reinforcing elements terminate within the length of the rubber, the latter type of cup being easier to manufacture since the upper ends of the wires do not have to be bent inwardly after molding of the rubber, and since there is no need for after-trimming of the rubber between the wires of the vulcanized cup to give it a neat appearance.

Still another primary object of this invention is to provide an improved cup having a plurality of reinforcing elements each of which has its lower end captivated by an annular ring, the particular improvement comprising the elongation radially of the cup of the opening in the lower end of each element through which the annular ring passes so that each reinforcing element can move radially outwardly not only at its top end to contact the tubing, but can also move outwardly at its bottom end as the rubber body of the cup expands under heavy fluid loading. By this improved structure, substantially the entire length of the cup can expand into contact with the tubing being swabbed to provide a greater contact area therewith than is possible in prior-art cups where only the upper end of the cup can expand because the metal reinforcements are restrained by the retaining ring from expansion at their lower ends.

Yet another object of the invention is to provide metal reinforcing elements having improved wear characteristics obtained by making the elements of rectangular cross-section wire or of sheet metal stampings having a greater thickness of metal disposed for wear in the radial direction of the finished cup.

Other objects and advantages will become apparent during the following detailed discussion of the drawings, wherein:

FIG. 1 is a longitudinal sectional view through a cup according to the present invention;
FIG. 2 is a longitudinal sectional view through a cup similar to that shown in FIG. 1 but showing the cup within a well tubing and supported on a mandrel, the cup being distorted outwardly to contact the tubing in the position it assumes when lifting a liquid;
FIG. 3 is a sectional view of the wire reinforcing cage used in the cups of FIGS. 1 and 2;
FIG. 4 is a sectional view through a cup similar to FIG. 1 but showing a modified type of metal reinforcing element;
FIG. 5 is a cross-sectional view through a still further modified type of reinforcing element;
FIG. 6 is a longitudinal sectional view through a cup similar to that shown in FIG. 1 but having a modified form of reinforcing-element captivating means;
FIG. 7 is a longitudinal sectional view through a cup similar to that shown in FIG. 4 but having a further modified captivating means functionally similar to that shown in FIG. 6;
FIG. 8 is an elevation view of a reinforcing element of the type used in FIG. 7;
FIG. 9 is a sectional view of a cup of the type shown in FIG. 7, supported on a mandrel within a well tubing, and showing the cup expanded into contact with the well tubing along substantially its entire length;
FIGS. 10 and 11 show modifications of the cup in which the reinforcing elements do not extend upwardly beyond the rubber body; and
FIGS. 12, 13 and 15 show parts of a prior-art cup to be compared with similar parts of the present cup illustrated in FIGS. 14 and 16.

Referring now to the drawings, FIG. 1 shows a longitudinal cross section taken through a swab cup built and reinforced according to the present invention. The swab cup 1 comprises a rubber body 1a having an upper bore 1b located above a smaller bore 1c, and the cup being gen-
generally cylindrical in cross section. Near the lower end of the cup is an annular rigid ring embedded and vulcanized in the rubber and serving to cap the lower end of a plurality of metal reinforcing members. Each of these reinforcing members as shown in Fig. 1 includes a bent lower end 2a which encircles the ring 3 and captivates the lower end of each of the reinforcing members thereon. The upper ends 2b of the reinforcing members are bent inwardly so as to prevent the reinforcing members 2 from snagging in the tubing while being swabbed by the cup. In general, this structure is similar to the structure shown in Bowerman Patent 2,518,275 and is intended to serve a similar purpose.

In Fig. 1, it will be seen that the cup 1 is in a relaxed condition, and the outside of the cup is cylindrical in shape over most of its length with the reinforcing members 2 embedded in the periphery of the rubber body 1 so that they are substantially tangent to the outer periphery of the rubber 1a.

In Fig. 2, this same cup is illustrated within oil well tubing T and mounted on a mandrel M of conventional design, the structure of this mandrel forming no part of the present invention but being similar to the mandrel illustrated in Patent 2,862,776 to Bowerman. In the present drawing the lower end of the mandrel M is threaded and screwed into a sucker rod coupling K in a well known manner. The mandrel is reciprocated within the tubing T, and when it is pulled upwardly it seals the cup 1 against the upper end of the coupling K and seals the cup thereto during lifting of the fluid column located above the cup 1. As the cup rises, the downward fluid pressure therewithin pushes the rubber body 1a of the cup outwardly and in so doing pivots the reinforcing members 2 outwardly about the ring 3 supporting their lower ends. The operation of the cup need not be further described here in view of the well known nature thereof.

Fig. 3 shows a cage made of circular-cross section wires comprising the reinforcing members 2 inwardly attached to the ring 3, the rubber body 1a being omitted as so to show the nature of the internal reinforcements therein.

As stated in the objects of this invention, it is an important purpose of the present structure to provide positive captivation of the reinforcing members 2 on the ring 3 so that even if they are torn from the rubber body and bent out of shape or reversed downwardly from the rubber body, they will still remain captivated to the ring 3 so that they cannot be entirely separated from the cup 1 and fall downwardly into the well to create a working hazard that cannot be easily removed.

Moreover, in manufacturing the cup, the lower portions 2a of the metal reinforcements can be bent around the ring 3 and crimped tightly enough thereto so that they tend to support themselves to form the open-work cage shown in Fig. 3 to which the resilient body 1a can be conveniently added. This avoids the necessity of individually supporting each of the wires 2 during forming of the vulcanized rubber cup as is necessary in the case of structures where each of the wires is merely passed through a hole in the flange, which hole is a loose fit on the wire and therefore does not actually support it in the desired position until the rubber ring is added thereto. There is no disadvantage in crimping the lower ends 2a of the wires 2 rather tightly on the ring 3 in view of the fact that the pressures within the oil well are so tremendous that they will cause outward pivoting of each wire about the ring 3 even though the wires feel tightly crimped thereto.

Fig. 4 shows a modified form of cup which is somewhat similar to that shown in Fig. 1 except that the ring 3 in this case capitulates a different type of metal reinforcing member 6 each of which members comprises a sheet-metal stamping having an opening 6a through the lower end thereof to receive the ring 3.

The ring can be either split and the sheet-metal stampings have been threaded onto the initially open loop. In either case, after the stampings are threaded onto the ring 3 the rubber body 7a is built up around the reinforcing cage comprised by the stampings 6. This is done by inserting the end of body 7a may either be similar to the body 1a or may be modified in one way or another, for instance to provide a single continuous bore 7b as distinguished from a stepped bore as shown at 1b and 1c in Fig. 1. The stampings are superior to the wire reinforcing member 8 similar to the members 2, but made of a longer wearing structure than the round wires 2, for instance as shown in Fig. 2.

Fig. 5 shows a cross-sectional view through a wire reinforcing member 8 similar to the members 2, but made out of wire of rectangular cross-section rather than wire of circular cross-section as shown in Fig. 1. The wire of rectangular cross-section as shown in Fig. 5 has the advantage that it presents a larger and longer-wearing surface to the walls of the tubing T which will provide longer wear for the wires than if wire of circular cross-section is used, the latter wire wearing about one-third of the way through its diameter very quickly in view of the relatively small surface area presented by each circular wire to the inside of the tubing T when the cup is new.

Fig. 6 shows a cup similar to that illustrated in Fig. 1 and having a substantially identical rubber body 1a including a stepped bore 1b and 1c. A retaining ring 9 is embedded in the lower end of the body. However, Fig. 6 is in fact a modification wherein the opening formed by the bent lower end 9a of each reinforcing wire 9 is not circular, but is elongated radially of the cup so as to permit the lower end in the vicinity of each loop 9a of a wire 9 to move laterally outwardly when the cup is subjected to internal pressure by the weight of the fluid column thereabove which the cup is lifting.

Figs. 7 and 8 illustrate another modification in which the rubber body 7a is similar to that illustrated in Fig. 4, but supports a plurality of sheet-metal stampings which bear the reference numeral 10. These stampings each have openings 10a at their lower ends which are elongated radially of the cup and are molded in place when the rubber body 7a is cured with the reinforcing member 10 normally located inwardly in the position shown in Fig. 7. The reinforcing members 10 may be provided with occasional holes 10b through which to provide a better bonding of the reinforcing members 10 to the rubber cup 7a in a manner well known per se.

Referring now to Fig. 9, which figure shows a different type of mandrel M' and coupling K' supporting the cup within the tubing T, it will be seen that when the cup is heavily loaded from above, the reinforcing members 10 can not only move outwardly at their upper ends to establish contact with the tubing T as illustrated in Fig. 2, but can also move outwardly at their lower ends in the vicinity of the openings 10a so that the cup can spread outwardly along its entire cylindrical length in order to provide a much larger surface area between the outer periphery of the cup and the inner surface of the tubing T for the purpose of greatly increasing the life of the cup by distributing the wear over a larger surface area and thereby reducing the rate at which the cup is abraded away. Note that either form of the invention as shown in Fig. 6 or 7 or 8 can be used as shown in Fig. 9, although other engagements between reinforcing members and retainers are possible.

Figs. 10 and 11 illustrate still further modifications in which the reinforcing wires do not extend upwardly beyond the rubber bodies 12 or 13, but actually terminate entirely within the rubber. In these modifications, the wire rings 11 respectively capitulate the lower ends of wire reinforcing members 13 or sheet-metal stamped rein-
forcing members 14 in a manner analogous to the structures shown in FIGS. 1 and 4 respectively.

As stated above, one important object of the invention is to provide an increased number of reinforcing members around the periphery of the cup. FIG. 12 shows one preferred form of cup in which a plurality of holes are drilled through the base F, the machined ring R and the wires W are simply passed through the holes in the flange F. This structure is illustrated in FIGS. 12, 13 and 15, and it will be seen that the number of wires W that can be installed around a cup using this form of structure is strongly limited by the fact that the webs X between the holes H tend to break away unless a considerable amount of metal is left between these holes. In other words, if very many holes are drilled around the flange F, the flange will not be strong enough to hold the wires when subjected to severe working pressures. On the other hand, if the structure shown in FIGS. 14 and 16 is used, it will be noted that a reinforcing ring 3 can support a great number of wires 2 which can be applied thereon so closely that the inner peripheries of the wires are substantially in contact with each other, see FIG. 16. Consider the difference between the number of wires which can be used in the structure shown in FIG. 16 and the greatly reduced number of wires that can be used in the structure according to FIG. 15.

This increase in total number of reinforcing elements is quite important as can be seen by inspection of FIG. 13. In this figure the wires W which are passed through the flange F are relatively far apart as illustrated in FIG. 15, and the result is that when the rubber body B is strongly pressurized from above, the body tends to bulge outwardly in the vicinity of the portion labeled Z in FIG. 12, and this rubber bulge at Z gets pinched off between the side of the tubing T and the outer periphery of the flange F, with the result that over a period of time a void V is created in the lower periphery of the cup as shown in FIG. 13, and this void weakens the cup so that it can eventually blow out at this point.

On the other hand, if there is a greater number of reinforcing wires 2 as shown in FIGS. 14 and 16, the rubber body 1a is supported better at the bottom of the cup by the greater number of wires which are closer together, and therefore the rubber does not tend to bulge outwardly around the lower outer periphery of the cup and be pinched off, or otherwise abraded away. Experience shows that the principal zone of wear in the rubber cup is around the lower periphery thereof, which wears forms voids such as shown at V in FIG. 13, and the present improvement virtually eliminates this type of wear.

I do not limit my invention to the exact forms shown in the drawings, for obviously changes may be made therein within the scope of the following claims.

I claim:

1. A reinforced swab cup to be mounted on a mandrel for swabbing tubing consisting entirely of a generally cylindrical resilient body of diameter slightly smaller than said tubing and having an axial bore therethrough to receive said mandrel; an annular ring embedded in said lower end; and a plurality of independent reinforcing elements each comprising a narrow strip embedded in said body substantially tangent with the outer periphery thereof, and each strip including near the lower end of the body a retaining portion having an opening therethrough to receive the ring substantially encompassing the same to captivate the element to the cup.

2. In a cup as set forth in claim 1, the engagement between the ring and each retaining portion being snug longitudinally of the cup and loose radially of the cup, thereby permitting the elements to move outwardly and contact the tubing along substantially the full length of each element when the body is expanded into contact with the tubing.

3. In a cup as set forth in claim 2, said elements each comprising a wire having its lower end bent around said ring to form a loop elongated radially of the cup.

4. In a cup as set forth in claim 2, said elements each comprising a sheet-metal member lying in a plane including the longitudinal axis of the cup and having said opening in its lower end elongated transversely of the length of the element.

5. A swab cup comprising an annular body of resilient material having outer wall portions disposed substantially parallel to the axis of the cup; a retaining ring embedded in the resilient material of the cup immediately adjacent to the lower outer periphery thereof; and a plurality of narrow independent reinforcing elements each disposed longitudinally of the cup and embedded in said outer wall portions substantially flush therewith, said elements each having a retaining portion with an opening therethrough located near the lower end of the cup and substantially encompassing the ring for pivotally captivating the element thereto.

6. In a swab cup as set forth in claim 5, said elements comprising an annular series wherein the spacing between elements is no greater than the thickness of an element as measured annularly of the cup.

7. In a swab cup as set forth in claim 5, the engagement between the ring and each retaining portion being snug longitudinally of the cup and loose radially of the cup, thereby permitting the elements to expand radially outwardly of the cup while remaining substantially mutually parallel.

8. In a cup as set forth in claim 7, said elements each comprising a wire having its lower end bent around said ring to form a loop elongated radially of the cup.

9. In a cup as set forth in claim 2, said elements each comprising a sheet-metal member lying in a plane including the longitudinal axis of the cup and having said opening in its lower end elongated transversely of the length of the element.

10. A swab cup comprising an annular body of resilient material having wall portions disposed substantially parallel to the axis of the cup; a plurality of reinforcing elements disposed longitudinally of the cup and embedded in the wall portions, each element having a retaining portion located near the lower end of the cup and having an opening therethrough; and retaining means anchored in the cup material and passing through the openings in said retaining portions, the engagement between said means and said portions being snug in the longitudinal direction of the cup, but loose in the radial direction of the cup, whereby when the cup is radially expanded by pressure from within the reinforcing elements can move outwardly in substantially mutually parallel relationship.

11. In a cup as set forth in claim 10, said elements each comprising a wire having its lower end bent around said ring to form a loop elongated radially of the cup.

12. In a cup as set forth in claim 10, said elements each comprising a sheet-metal member lying in a plane including the longitudinal axis of the cup and having said opening in its lower end elongated transversely of the length of the element.

13. In a swab cup as set forth in claim 10, said elements comprising an annular series wherein the spacing between elements is no greater than the thickness of an element as measured annularly of the cup.

14. A reinforcing cage for a swab cup, comprising an annular series of substantially parallel reinforcing elements each having an opening through its lower end; and a closed ring passing through said openings and lying substantially in the plane of the lower end of the cup near the outer periphery thereof, the elements at said openings substantially encompassing the ring to captivate themselves thereto.

15. In a cage as set forth in claim 14, said elements each comprising a wire bent at its lower end around said ring.
16. In a cage as set forth in claim 15, said wires being rectangular in cross-section.

17. In a cage as set forth in claim 14, said elements each comprising a sheet-metal member lying in a plane including the longitudinal axis of the cage and having said opening through its lower end.

18. In a cage as set forth in claim 14, the engagement between the ring and the lower end of each element at said opening being snug longitudinally of the cage and loose radially of the cage.

19. In a cage as set forth in claim 14, said elements being located in close mutually-adjacent relationship around said ring.

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