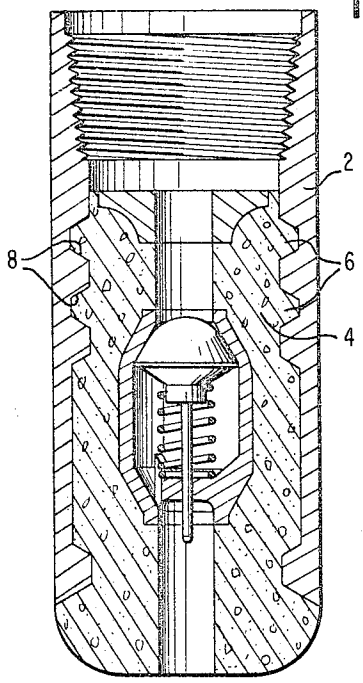
July 25, 1967 A. E. HARRIS ET AL 3,332,499

WELL CASING SHOE STRUCTURE

Filed Nov. 27, 1964

FIG. 1



PRIOR ART

FIG. 4

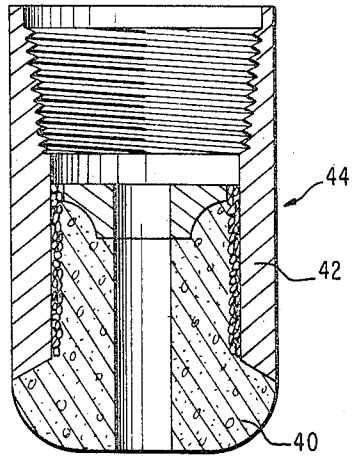


FIG. 2

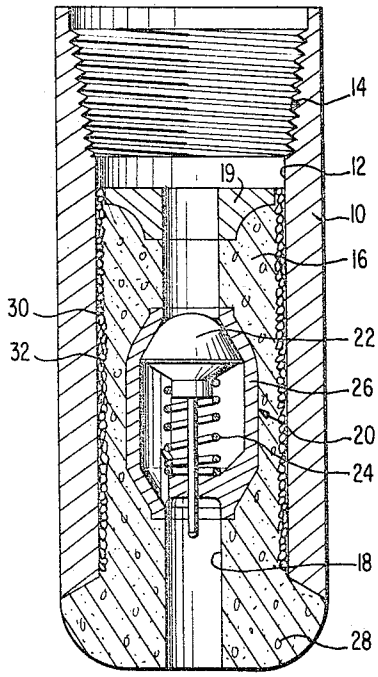
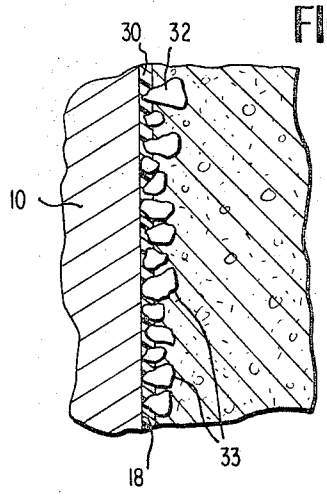


FIG. 3



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WELL CASING SHOE STRUCTURE

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ABSTRACT OF THE DISCLOSURE

An oil tool comprising a generally tubular housing, a mass of hardened cemetitious material disposed within the housing, and a bonding interface comprising matrix material interconnecting the housing and cementitious material.

General background of invention

This invention pertains to improvements in oli well tools and, more particularly, to oil well tools used to guide or float a well casing into a well, and to methods of assembly of such tools.

Oil well tools such as guide or float shoes have heretofore been available for guiding or floating a casing string into a well for cementing purposes. Such casing tools have generally comprised a tubular housing, the upper end of which was provided with threads or the like to connect the housing to a well casing string. The inner periphery of such housings were frequently provided with a plurality of discrete, vertically spaced, annular grooves. A high compressive and shear strength concrete liner was often secured within the housing and provided with a tapered portion which projected below the lower end of the housing to act as a guide.

In forming the concrete liner, cementitious material in a plastic condition was often poured within the tubular housing. The cementitious material was permitted to flow into the annular grooves of the inner periphery of the housing. When the cementitious material cured, the concrete liner was retained within the housing by virtue of the annular rims formed about the outer periphery thereof, which rims projected into the annular grooves on the inner periphery of the housing. Frequently, in forming the liner, a check valve unit was centered within and bonded to the cement liner to provide a float shoe structure.

The provision of annular grooves on the inner periphery of a housing to receive rims cast on the outer periphery of a concrete liner does provide an advantageous mechanical connection between these elements. Nevertheless, this type of mechanical connection is disadvantageous in certain respects. For example, the provision of a plurality of discrete, vertically spaced annular grooves of an appreciable depth in the housing weakens the housing at the location of the grooves. Also, in some cases, such a mechanical connection does not always provide the desired optimum structural integrity capable of resisting a substantial shear stress imposed on it. This is because not all of the liner periphery uniformly resists shear, i.e. shear resistance tends to localize near liner rims which are received in the annular grooves. Further, such connections do not always provide an efficient fluid seal at the junction of the cement liner and the housing insert.

Other problems associated with the grooved housing structure involve the practical difficulty of forming grooves which are truly concentric with the housing periphery. As large diameter casing stock used for such housings, i.e. stock of about two feet or more in diameter, is often not truly cylindrical, it is almost impossible to form a groove which is accurately concentric with the casing periphery by using conventional tools and equipment. As a result, the depth of the housing grooves tend to vary about the housing circumference. Such variations not only produce localized casing weakening at points of excessive groove depth, but also produce weak mechanical bonds and fluid seals at points of shallow groove depth.

General summary of invention

In recognition of the need for improved well tools of the type heretofore described and improved tool fabrication techniques, it is an object of the present invention to provide such well tools and techniques for their fabrication which substantially obviate or minimize problems such as those previously noted.

It is a particular object of this invention to provide well tools including a tubular housing and having a concrete liner therein wherein a shear resisting mechanical connection is provided between the housing and the liner which is structurally reliable but simple and inexpensive.

It is another object of this invention to provide such well tools wherein the provision of a mechanical connection between a housing and a liner does not result in weakening of the housing at the location of the connection.

Another object of this invention is to provide a mechanical connection between such a housing and a concrete liner that resists radial separation of the outer periphery of the liner and the housing interior.

An additional object of this invention is to provide such well tools wherein the mechanical connection between a liner and a housing also provides an efficient fluid seal therebetween.

It is still another object of this invention to provide a method of assembly of such tools wherein the mechanical connection between a tool liner and a tool housing may be achieved without tedious, expensive, fabrication or machining processes.

In achieving these and other objects as will become apparent hereinafter, the present invention provides a method of assembly and a well tool resulting therefrom, wherein the tool includes a housing which is generally tubular in configuration. Means are provided for connecting the housing to conduit means such as a well casing. A layer of matrix material is bonded to a circumferentially encircling portion of the inner periphery of the housing. A circumferentially encircling layer of particulate material is bonded to the inner periphery of the housing by the matrix material and is partially embedded within the matrix layer. The layer of particulate material comprises a plurality of particles having portions projecting outside the matrix layer, with there being irregular interstices between these portions. A cementitious mass is within the housing. These projecting portions of particulate material are embedded within the cementitious mass so as to circumferentially interlock the housing and the mass together.

In describing the invention, references will be made to a preferred embodiment illustrated by way of example in the accompanying drawing, in which:

FIGURE 1 is a vertical, cross sectional view of a float shoe having the mechanical connection between a cement liner and housing thereof usually employed in the prior art devices;

FIGURE 2 is a vertical, cross sectional view of a float shoe similar to that shown in FIGURE 1 but having a mechanical connection between a housing and cement liner according to the present invention;

FIGURE 3 is an enlarged, vertical, cross sectional view of the construction of the mechanical connection of the present invention as shown in FIGURE 2; and

FIGURE 4 is a vertical, cross sectional view of a guide shoe having a cement liner bonded to a cylindrical housing portion according to the present invention.

Referring to FIGURE 1 of the drawings, attention is invited to the mechanical connection between a housing **2** and the concrete liner **4** of the type usually employed in prior art float shoes. This mechanical connection comprises a plurality of discrete, vertically spaced, integrally formed, annular rims **6** cast on the external periphery of the liner **4**. The rims are received in annular grooves **8** cut in the inner periphery of the housing **2**. It is this type of a connection that has heretofore been discussed.

Referring to FIGURE 2, a float shoe according to the present invention comprises a metallic generally tubular housing **10** having a longitudinally extending bore or passage **12** therethrough. The upper end of the longitudinally extending passage **12** is enlarged and provided with threads **14**, or the like, for connecting the housing **10** to the threaded lower end of a tubular well casing (not shown).

Fixedly positioned within the lower portion of the longitudinally extending passage **12** is a guide nose defining liner **16**. This liner is constructed of shock resistant, high compressive and shear strength concrete as is normally utilized in such tools, such concrete being easily drillable. The liner **16** includes a centrally disposed longitudinally extending passage **18** about the upper end of which a collar-like, cement plug seat **19** fabricated of high impact plastic is positioned. The seat **19** is rigidly connected to and molded in the upper end of the liner **16**.

Rigidly fixed and molded within an intermediate portion of the longitudinally extending bore **18** is a check valve assembly **20** including a rubber-like check valve **22** urged in an upwardly direction by a spring **24** so as to be maintained in fluid sealing contact with the upper end of the valve seat and housing **26**.

The lower end of the liner **16** is provided with a tapered nose portion **28** for guiding the tool, with the well casing connected thereto, downwardly through a well bore.

Thus far it will be seen that the device according to the present invention is similar to that of the prior art device shown in FIGURE 1. However, in distinction to the devices of the prior art, the float shoe according to the present invention includes, as a shear resisting mechanical connection between the liner **16** and the housing **10**, a cylindrical layer of matrix material **30**. In the preferred embodiment, this layer is formed of a thermosetting epoxy resin adhesive or the like, bonded about and circumferentially encircling the inner periphery of the longitudinally extending passage **12** of the housing **10**. The wall portion of the passage **12** to which the resin is applied is substantially smooth throughout and the wall thickness of the housing is substantially uniform throughout the portion.

Partially embedded in, and projecting from, the inner periphery of the cylindrical layer of matrix material **30** is a cylindrical layer of particulate material **32** comprised of a plurality of discrete, angular or subangular particles, such as sand, having irregular interstices therebetween. In the preferred embodiment the particles are generally contiguous and the average size of the particles of the layer **32** is such that these particles will pass through a No. 4 standard U.S. sieve but be retained in a No. 8 sieve.

Referring to FIGURE 3, it should be noted that a substantial number, i.e. a majority or more, of randomly disposed sand particles, as at **33**, are embedded in the matrix material such that the largest diameter of the particles is spaced from the matrix material layer and the other particles. Thus, portions of these particles which enlarge away from the resin layer are keyed or interlocked to the cement liner.

It should be noted that while particularly efficacious results have been achieved with an epoxy resin matrix and sand as heretofore described, other types of matrix material and other types and sizes of particulate material may be employed in the practice of the invention.

Although the invention has been described with reference to a float shoe, it should be appreciated that advantages may be gained in application of the invention, as

shown in FIGURE 4 in connecting a concrete liner **40** to a housing **42** of the usual type of guide shoe **44**, or to a float collar, baffle collar, or differential collar. As will also be apparent, the cement may also form a solid plug or mass entirely bridging a tool housing.

The structural advantages achieved by utilization of the instant mechanical connection are numerous. It will be seen that it is not necessary to provide annular grooves about the inner periphery of the housing **10**. In this manner, weakening of the housing at the location of these grooves is circumvented and the housing wall thickness may remain uniform along the lined area.

Because the full extent of the external periphery of the concrete liner **16** within the housing is interlocked with or keyed to the particulate material, resistance to shear is provided generally uniformly along the full extent of the liner within the housing.

Still further, fluid leakage as might occur at the interface of the concrete liner and the housing caused by radially inward shrinkage of the external periphery of the liner during curing, by mechanical stress or fluid pressure at the liner and housing interface, or by differential thermal expansion of the liner and housing, is resisted. This is so because the concrete is interlocked with the particles of sand. Because this interlocking is of a circumferentially encircling nature, tendencies for one side of the housing to separate from the liner are effectively offset. This advantage is especially significant when tools are being fabricated with liners having a thickness of several inches or even a few feet, and with casings having an inside diameter of about two or more feet where radial separation problems are particularly pronounced.

With the structure and advantages of well tools of this invention having been described, tool fabrication techniques will now be considered.

In assemblying well casing tools of the type heretofore discussed according to the present invention, the interior of a housing may be cleaned, as by sand blasting or the like, prior to the application of matrix material thereon. It is sometimes desirable to apply the layer of the heretofore discussed resin material with a roller or stiff brush.

The exposed layer of applied resin material is permitted to cure until it assumes a tacky condition, at which point particulate material is distributed over the surface of the tacky matrix material. Subsequently, the particulate material may be pressed to partially embed the particles thereof in the matrix material. The particulate material-coated matrix layer is then permitted to set for a short period of time and the excess, unbonded, particulate material is displaced therefrom in any convenient manner.

It may be desirable in treating large diameter housings, to apply matrix material to only one bottom sector of the internal periphery of a housing at a time, while maintaining the housing in a horizontally disposed condition. Particulate material may be applied to this sector prior to rolling the housing to apply matrix material to the next sector then positioned on the bottom.

After the particulate material coated matrix layer has cured or, in some cases, while the matrix material is still in a tacky condition, high compressive and shear strength, drillable cement of the type normally utilized in well casing floating and guiding tools is poured within the portion of the housing having the particulate material adhering thereto and the cement allowed to cure. This cement is retained within the housing and the guide nose formed by conventional, removable mold means, (not shown). By virtue of placing the cement in a fluid condition within the housing and permitting a flow of the cementitious material into the interstices of the layer of particulate material, the cement liner and the particles are effectively keyed or interlocked together.

In fabricating well tools such as float shoes or guide shoes, it is necessary to form a central passageway extending longitudinally through the tool. If a float shoe

is being fabricated, it is necessary to embed a check valve assembly in this passageway.

Conventional molding techniques may be employed for forming a central passageway or for embedding a check valve assembly in the passageway as generally illustrated in FIGURE 2. For example, conventional, removable mold plugs may be positioned and conventionally supported within the center of the housing prior to the pouring of the fluid cement. Such mold members, when removed, will leave a passageway extending through the hardened cement. Where a check valve assembly is being embedded, such mold members may be employed to seal the upper and lower opened ends of the assembly during the molding operation.

The advantages provided by utilization of a method of assembly of a well tool according to the present invention are significant. In addition to the production of a stronger, better sealing mechanical connection between the tool housing and concrete liner, it will be appreciated that the instant method eliminates the requirement for machining annular grooves in the inner periphery of a housing and makes possible the assembly of such tools in an "on-site" job operation. The forming of such annular grooves on the internal periphery of a housing has been difficult, particularly when large diameter casings were involved and elaborate and large size groove cutting machinery had to be utilized. In the present inventive method, matrix material may be applied by a common roller and no special equipment is required to embed the particulate material. For these reasons, the instant method simplifies to a significant degree, methods of assembling well casing tools. In addition, the housing weakening and weak bond problems previously noted which resulted from uneven grooving are altogether eliminated.

While the invention has been described with reference to a preferred embodiment, it will be apparent to those skilled in the art that additions, deletions, modifications, substitutions, and other changes in the specifically described and illustrated preferred embodiment may be made which will fall within the purview of the appended claims.

We claim:

1. A well tool comprising a generally tubular housing, means for connecting said housing to conduit means, a layer of matrix material circumferentially encircling at least a portion of the inner periphery of said housing, a circumferentially encircling layer of particulate material partially embedded within and bonded to said matrix material, and a mass of cementitious material disposed radially inwardly of said housing with said particulate material being partially embedded therein, said mass of cementitious material being interlocked with said thus embedded particulate material entirely around at least a portion of the outer periphery of said mass facing said housing, said cementitious material extending at least partially across the interior of said housing and at least partially obstructing fluid flow downwardly through said tool when said tool is located within a well, said particulate material, when said well tool is positioned within a well, resisting shear force acting between said housing and said mass of cementitious material, and said inner periphery of said portion of said housing being cylindrical and substantially smooth throughout.

2. A well tool as described in claim 1 wherein said portion of said housing is cylindrical and of substantially uniform wall thickness throughout, and wherein a passage extends through said cementitious mass generally coaxially with said housing.

3. A well tool as described in claim 1 wherein said particulate material comprises sand particles of a size falling generally within four to eight mesh as measured on the U.S. sieve standard and wherein said matrix material comprises a thermosetting resin.

4. A well tool comprising a generally tubular housing, means for connecting said housing to conduit means, a layer of matrix material circumferentially encircling the inner periphery of at least a portion of said housing, a circumferentially encircling layer of particulate material partially embedded within and bonded to said matrix material, and a mass of cementitious material disposed radially inwardly of said housing with said particulate material being partially embedded therein, said mass of cementitious material being interlocked with said thus embedded particulate material entirely around at least a portion of the outer periphery of said mass facing said housing, and said layer of particulate material comprising a plurality of substantially contiguous particles, with a substantial number of said particles having portions embedded and interlocked within said cementitious mass, which portions are enlarged away from said matrix material layer.

5. A well tool comprising a generally tubular housing, means for connecting said housing to conduit means, a layer of matrix material circumferentially encircling the inner periphery of at least a portion of said housing, a circumferentially encircling layer of particulate material partially embedded within and bonded to said matrix material, and a mass of cementitious material disposed radially inwardly of said housing with said particulate material being partially embedded therein, wall means providing a passage extending through said cementitious mass generally coaxially with said housing, said mass of cementitious material being interlocked with said thus embedded particulate material entirely around at least a portion of the outer periphery of said mass facing said housing, said portion of said housing being cylindrical and of substantially uniform wall thickness throughout, said layer of particulate material comprising a plurality of substantially contiguous particles, with a substantial number of said particles having portions embedded and interlocked within said cementitious mass, which portions are enlarged away from said matrix material layer, said particulate material comprising sand particles of a size falling generally within four to eight mesh as measured on the U.S. sieve standard, said matrix material comprising a thermosetting resin, and said housing comprising a cylindrical casing having an inner diameter of about two feet or more.

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