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CELLULAR SUCKER ROD STRING

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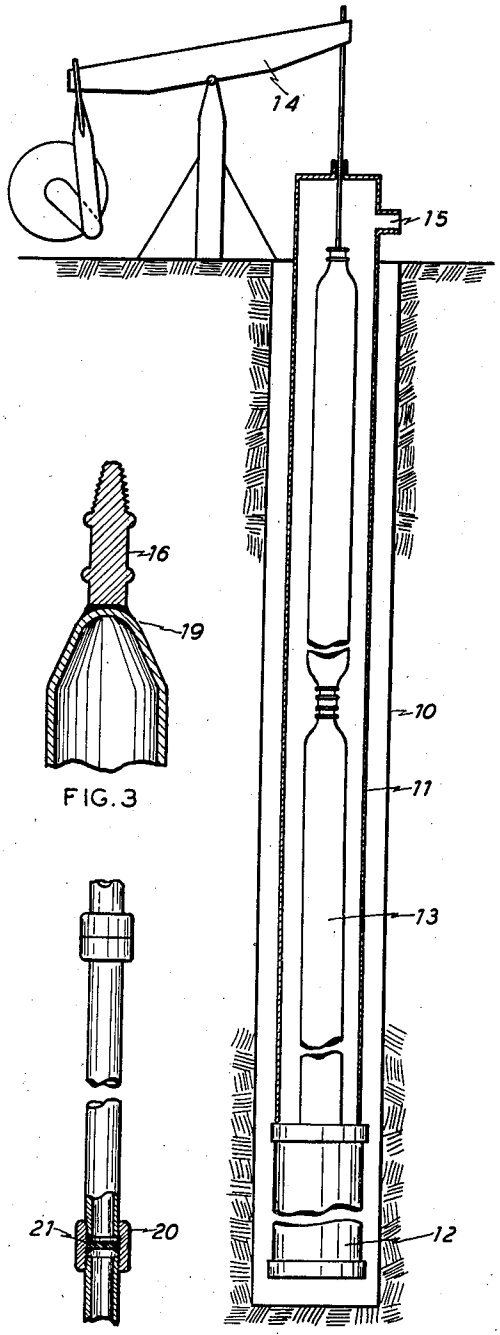


FIG. 3

FIG. 4

FIG. 1

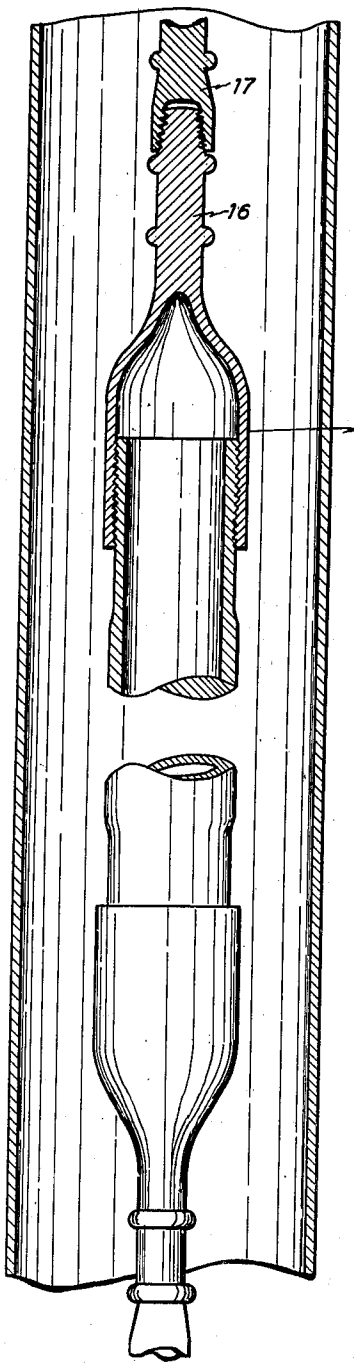


FIG. 2

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CELLULAR SUCKER ROD STRING

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5 Claims. (Cl. 255—28)

The object of the invention is to provide a new and improved form of sucker rod for actuating deep well pumps.

The specific object of the invention is to provide a sucker rod having increased tensile strength per unit of cross sectional area than the forms heretofore used, together with increased displacement of liquid by the submerged rod string by which its effective weight is materially decreased.

These objects are attained, in general terms: first, by the use of a hollow or substantially tubular rod instead of the solid rod customarily used; second, by tightly sealing the tube against the ingress of liquid whereby its buoyancy is maintained; third, by dividing the tubular rod into sections sealed away from each other in such manner that any one accidental leak can cause the flooding of but a minor portion of the length of the rod.

The invention may best be explained with reference to the attached drawing, in which Fig. 1 is a diagram representing fragments of a deep well including sections of the cellular sucker rod while Figs. 2, 3, and 4 are details showing various manners in which the rod sections may be constructed and joined to form a rod string.

For the pumping of deep wells, as for example oil wells, a string of tubing, to the lower end of which is attached the barrel of a plunger pump, is inserted in the casing with the pump at the level from which it is desired to pump the liquid. The upper end of the tubing string is supported in a fixed position at or by the upper end of the casing. The lower end of a string of pump rods, the sucker rod string, is attached to the plunger of the pump while the upper end is supported from a walking beam, jack or other device by which the rod string and the pump plunger are vertically reciprocated.

In Fig. 1 of the drawing the well casing is indicated at 10, the tubing string at 11, the pump barrel at 12, the rod string (in my improved form) at 13, and a walking beam at 14. With the exception of the form of the rod string this is wholly conventional equipment.

The pump discharges the pumped liquid through the tubing string to the surface of the earth, where it is discharged as through any outlet 15. The tubing string is therefore continuously filled with liquid (water or oil as the case may be) and the effective weight of the rod string is its actual weight in air less the weight of the quantity of liquid which it displaces.

It is the ordinary practice to form the sucker rods of lengths of solid steel rod of relatively small diameter, as for example ⅞", the ends of the rod lengths being welded to or forged integral with screwed fittings by which the lengths of rod are joined to form a continuous string. Such fittings are illustrated at 16 and 17 in Fig. 2.

The conventional solid rod construction offers no impediment to the pumping of relatively shallow wells, but at the extreme depths reached in many present day oil wells the maintenance of the rod string becomes a matter of serious difficulty.

As the depth of the well increases the stresses imposed on the rod string, and particularly on its upper portions, become correspondingly more severe. At the lower end of the rod string the static load is the hydraulic head of the liquid column in the tubing times the area of the pump plunger to which this head is applied. At the beginning of the upstroke there is an additional load due to the inertia of the liquid column which must be set in motion. These loads are transmitted to the upper end of the rod string, at which point there is a further static load due to the dead weight in liquid of the rod string and an additional pulsating load corresponding to the weight of the rod string and measured by the inertia of the rod and the rapidity with which its direction of movement is reversed.

All of these loads, as measured at the upper end of the rod string, increase directly with increased pumping depth, and in wells of considerable depth the strength of the rod, i. e., its resistance to fatigue, may well be the limiting factor in determining the net area of the pump plunger and the rapidity of its stroke, these two factors determining in turn the maximum amount of fluid which may be pumped per unit of time.

In making the rods hollow, as herein described, the factor of dead weight of rod string may be reduced to any degree desired by increasing the ratio of external diameter to wall thickness. To this progressive reduction there are two obvious limitations: the first, that it is not desirable that the weight of the displaced liquid should exceed the weight of the rod, i. e., that the rod should actually float, as a material dead weight is required to effect the down stroke and prevent buckling and whipping of the string. The second limitation is the collapsing strength of the hollow sections, which will be exceeded by the hydrostatic head of the liquid column in the lower portion of the tubing if the sections be of too great diameter in relation to their wall thickness.

Against this collapsing stress I make two pro-

visions in the case of deep wells in which the hydrostatic head on the lower end of the string is excessive. Of these provisions, the first is to reduce the external diameter of the hollow sections, by steps, as they approach the level of the pump, the hydrostatic head increasing in that direction. The wall thickness may be maintained constant or may even be increased as the external diameter is reduced, both the decrease of diameter and the increase of wall thickness tending, though in varying degrees, to increase resistance to collapse. Such stresses are subject to rather exact calculation from any given set of conditions, taking into account the properties of the metal employed in the hollow sections.

The second provision, which is either alternative or additive to the first, is to fill at least the lower sections of the string with a fluid which is materially lighter than the liquid which is being pumped. This filling fluid may be a very light liquid, as for example propane (specific gravity approximately 0.57 in liquid form) or butane (specific gravity as liquid approximately 0.60). These liquids are sealed into the sections under such pressures as to maintain them in liquid form, the sections being substantially filled with the liquid. As such liquid fillings are substantially incompressible they afford complete protection against collapse and permit any desired ratio between external diameter and wall thickness, the latter being limited only by the requirement for tensile strength.

Alternatively, the filling fluid may be a gas, as for example air or hydrogen, under a high superatmospheric pressure, as for example from two hundred to several hundred pounds per square inch. Such compressible fillings obviously offset collapsing pressure by an amount exactly equal to the internal presure, but are very much lighter than the lightest known liquids having a critical temperature above atmospheric.

It is well known to pump shallow wells, as for example water wells having windmill actuated pumps, by the use of pipe strings in place of solid rods. So far as I am aware, however, such pipe strings used as pump rods have been put together with ordinary couplings and have afforded a continuous channel for fluid from end to end. Such continuous pipe strings are of no avail for pumping deep wells as it is obvious that even the most minute single leak will more or less rapidly cause the entire pipe to fill with the liquid being pumped and thus destroy the desired effect of buoyancy resulting from displacement. It is essential to the successful practice of my invention to divide the length of the rod string into independent sections or cells having no communication, and to connect these sections by solid (imperforate) joints in such manner that the taking down and making up of these joints cannot cause leakage into any cell.

The individual cells or sections may be of any preferred length which, however, should not exceed the length of a "stand", i. e., the length which can be handled in the derrick without breaking the section itself. If preferred, the sections may be of the length of a single joint of pipe, from twenty to forty feet. While any individual section may spring a leak and consequently flood with liquid, such flooded sections may readily be detected by their increased weight on the occasion of pulling the well and may then be emptied and resealed or replaced as the case may be.

The individual cells or sections which join to make up the rod string may be formed in various ways. Thus in Fig. 2 a bell reducer or long collar is swaged down at its outer end to form one element of the conventional pin joint **16—17**. One of these fittings is placed on each end of a pipe of sufficient length to make the section, intermediate pipe collars being used if necessary to make up the desired length. It will be evident that great care must be taken with the threads used in this form.

Fig. 3 shows a modified form in which the end of the pipe section itself is swaged until tightly closed as at **19** and the half of the pin joint fitting **16** is then welded to the closed end or forged integral therewith.

Fig. 4 shows another modified form in which the sections are joined by screwed collars **20** and are separated by bridge plates **21** nonleakably welded within the collars. This form is inconsistent with the use of any filling material and is less desirable than the other forms shown inasmuch as the maintenance of tightness against leakage depends on the care with which the stands are made up after the well is pulled. This latter drawback may be avoided by the use of two such collars separated by a short nipple at each point at which the string is to be broken in pulling.

The above forms are suggestive only as it will be evident that the object to be attained—the division of the string into separate or separable sealed cells—may be reached in a number of strictly alternative ways.

By the use of the cellular rod string herein disclosed the effective weight of the string may be very substantially reduced, often to the minimum fixed by the requirement for weight to effect the return stroke.

In deep well pumping practice the weight of solid rods may constitute as much as 80% of the total weight of rods and fluid; so that making the rods buoyant will very greatly reduce the total load.

By thus decreasing the weight it is made possible to keep stresses within the fatigue limit, thus preventing failure under conditions where otherwise this would be impossible. It is also made possible to reciprocate the string at a more rapid rate, or to use a larger diameter pump, or both, thus increasing the pumping capacity of the installation.

The tubular form is slightly higher in tensile strength than a solid rod of equal cross sectional area and of the same metal, and is very much stiffer, thus reducing the danger of corkscrewing if the string should part or be dropped. All of these important advantages are attainable at a very slight increase in first cost over that of the conventional string of solid rods.

I claim as my invention:

1. A well pump actuating rod string consisting of individually sealed hollow sections joined end to end, the ratio of external diameter to wall thickness of said sections decreasing by steps from the upper end toward the lower end of said string.

2. As a new article of manufacture, a rod string of great length for actuating deep well pumps, said string being adapted for operation with minimum effective weight and without collapse when immersed in fluids at extreme depths, and comprising a multitude of individually sealed hollow elongated units connected together at their adjacent ends, the uppermost unit having a relatively maximum ratio of external diameter

to wall thickness and the successive lower units progressively decreasing in a downward direction in their relative ratios of external diameter to wall thickness to correspondingly increase the tensile strength per unit of cross-sectional area and to graduate the cross-sectional area of the string as a whole from the upper end thereof towards the lower end of the same.

3. As a new article of manufacture, a rod string of great length for actuating deep well pumps, said string being adapted for operation with minimum effective weight and without collapse when immersed in fluids at extreme depths, and being in part hollow, sealed, and progressively decreasing in external diameter from the upper end of the string towards the lower end of the same.

4. As a new article of manufacture, a rod string of great length for actuating deep well pumps, said string being adapted for operation with minimum effective weight and without collapse when immersed in fluids at extreme depths, and being sectionally sealed and hollow, and progressively decreasing in external diameter from the upper end of the string towards the lower end of the same, the thickness of the walls of the sections being at least equal in thickness to that of the wall portion of greatest external diameter.

5. As a new article of manufacture, a rod string of great length for actuating deep well pumps, said string being adapted for operation with minimum effective weight and without collapse when immersed in fluids at extreme depths, and being sectionally sealed and hollow, and progressively decreasing in external diameter from the upper end of the string towards the lower end of the same, the thickness of the wall of each lower section being increased relatively to the thickness of the wall of the section immediately thereabove.

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