July 31, 1951 R. L. STANTON 2,562,340

WEIGHT-GRADUATED WIRE CABLE

Filed June 17, 1950 2 Sheets-Sheet 1

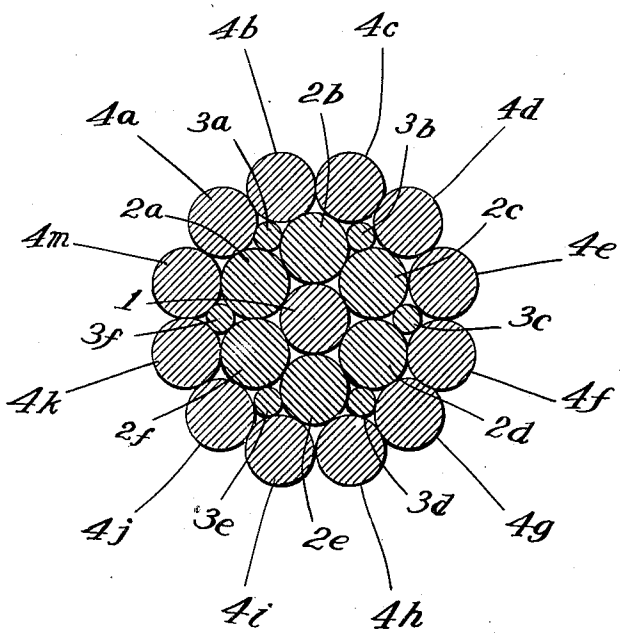


Fig. 1.

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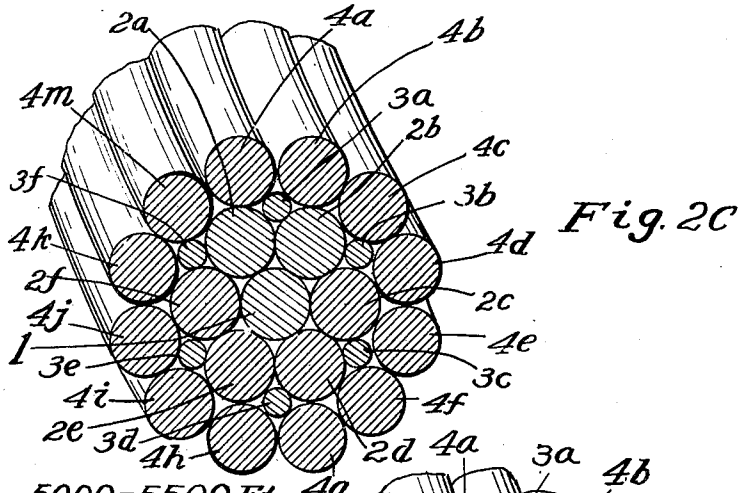


Fig. 2C

5000-5500 Ft.

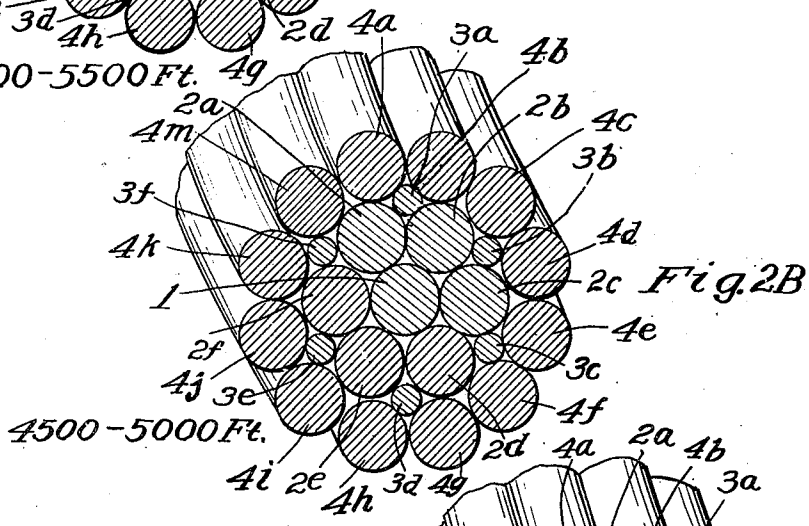


Fig. 2B

4500-5000 Ft.

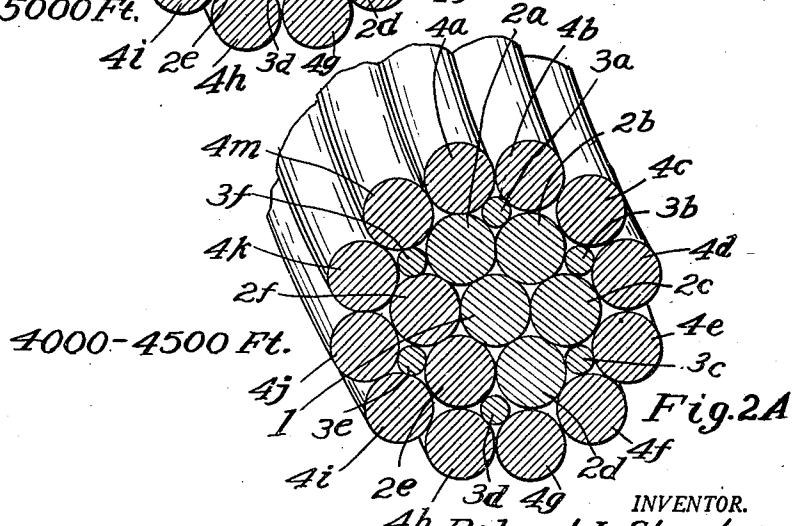


Fig. 2A

4000-4500 Ft.

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WEIGHT-GRADUATED WIRE CABLE

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5 Claims. (Cl. 57—145)

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This invention relates to wire rope or cable, and is particularly concerned with cable adapted for well drilling by the cable tool method and similar uses.

As generally practiced, the cable tool method of drilling wells such as oil and gas wells comprises the lifting and dropping by a rope or cable and appropriate hoisting means of a relatively heavy drill bit upon the formation to be drilled. This method of drilling is well adapted to relatively shallow holes and requires simple apparatus which can be easily transported over the frequently difficult terrain in which drilling proceeds. It is limited to relatively shallow holes, however, because of the weight of the cable itself which must be payed out to reach great depths. The upper portion of the cable must, of course, support not only the weight of the tools but also the weight of the cable in the hole, and even though wire cables of high tensile strength are commonly employed, the depth of a hole which can be economically drilled in this way is limited. If stronger, and therefore heavier, cables are used to permit drilling to greater depths, the weight of the cable to be transported and the size and weight of the hoisting apparatus must be correspondingly increased, which in turn increases the difficulty of transport in the field. In practice it is generally considered that the economical limit of cable tool drilling is about 6,000 feet if an adequate safety factor of cable strength is to be maintained.

The lower end of the cable in the hole carries only the weight of the drilling tools, and the weight carried by any successive section of cable increases gradually toward the top of the hole. Conventional cables therefore provide an unnecessarily large factor of safety at the bottom of the hole, and represent excess weight at this point which must be borne by the upper portion of the cable.

In the past, attempts have been made to increase the economic ultimate depth of cable tool drilling by providing a drilling cable tapering from a relatively small diameter at the bottom end to a larger diameter at the upper end, and for a given total weight these cables do permit the suspension of a drill bit and greater length of cable at a given factor of safety than is possible with conventional cable. However, tapered cables are difficult to make. Furthermore, they have not enjoyed much practical success in cable tool drilling because they do not allow the cable tool driller, or "tool pusher" as he is commonly termed, to judge the progress of drilling by his usual method. Tool pushers quite generally gauge the progress of their drilling by what they

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call "the feel of the rope"; that is, the vibration transmitted from the tools to the taut cable at the top of the hole. It has been found in practice that a tapered cable alters the character of this transmitted vibration to such an extent that it cannot be used as a guide by the tool pusher in the same manner as vibrations set up in a cable of uniform diameter. Drilling with a tapered cable, therefore, tends to be slower than conventional drilling and more prone to kinking or breaking of the cable, sticking of tools in the hole, or damage to these tools.

It is therefore an object of my invention to provide a cable for cable tool drilling which is of uniform diameter throughout its length but has a unit weight and tensile strength which increases from the bottom to the top. It is another object of my invention to provide such a cable which has a more uniform safety factor throughout its length. It is still another object of my invention to provide such a weight-graduated cable which transmits vibratory impulses in substantially the same manner as conventional drilling cables.

My invention comprises a wire cable or rope of conventional lay and conventional section having individual wires which, although of constant diameter over the length of the cable, are not homogeneous. These composite wires which form the strands, which in turn comprise the cable, are in general composed of steel at the upper end of the cable but of a metal lighter than steel at the bottom of the cable. The relative lengths of steel and lighter metal in the composite wires are adjusted so that successive cross-sections along the cable show a ratio of lighter metal to steel which increases by graduated amounts from one end to the other. A cable made according to my invention therefore exhibits a uniform diameter but progressively decreasing unit weight and ultimate tensile strength from one end to the other.

Reference is now made to the figures which illustrate the cross-section of a strand of such a cable.

Figure 1 is a cross section through a strand of a cable of my invention illustrating a conventional arrangement of wires.

Figures 2*a*, 2*b*, and 2*c* are cross sections through a cable strand embodying my invention taken through successive portions of the strand. The successive portions of the strand illustrated in this figure are tabulated in Table I following.

The strand shown is from a ⅞-inch 6-strand cable of 25 wires per strand. The center wire or core 1 is surrounded by 6 wires, 2*a* through 2*f*. Six smaller wires, known as filler wires, 3*a* to 3*f*

inclusive, are laid between successive pairs of wires 2*a* through 2*f*. The exterior of the strand is composed of 12 wires, 4*a* through 4*m*. The core wire 1 and the wires of groups 2 and 4 are shown as having the same diameter, but it is not essential to my invention that this be the case. A cable according to my invention could be made with all the 25 wires shown in the figures of composite construction. At the upper end of the cable all wires would be steel; at the lower end all wires would be metal lighter than steel. The junctions or transition points at which the composition of wire would be changed from steel to the lighter metal could be staggered along the length of the cable to provide a gradually diminishing unit weight from the top of the cable to the bottom. For cable tool drilling, however, I find it desirable to provide a cable comprising a number of wires which are steel from top to bottom, and, to obtain the desired graduation in unit weight of cable, a number of composite wires.

The three grades of steel commonly used in wire rope for drilling cable are mild plow steel having an average ultimate tensile strength of 206,000 pounds per square inch, plow steel having an average ultimate tensile strength of 230,000 pounds per square inch, and improved plow steel having an average ultimate tensile strength of 264,000 pounds per square inch. It will be understood that the steel wires in my cable may be of one, two or all of these grades of steel, or in fact of other grades if they prove economical.

The metal lighter than steel which I prefer to use is aluminum, although my invention is not limited to this metal in combination with steel, or in fact to any specific metals. The aluminum generally used for wire rope has an average tensile strength of about 70,000 pounds per square inch, and is only a little over one-third as heavy as steel. It is therefore possible to obtain a maximum over-all graduation in cable weight from top to bottom of nearly 3 to 1, and a similar graduation in cable tensile strength of between 3 and 4 to 1. Furthermore, aluminum and steel may be used together in the same strand or cable without damaging electrolytic corrosion taking place as, although aluminum is slightly anodic to steel, it quickly forms a protective coating and behaves in a more or less neutral fashion.

One embodiment of my invention is a cable 7,000 feet long comprising 6 identical strands of 25 wires, each of these strands being composed of aluminum wires of the grade above mentioned and steel wires of all three grades above mentioned, arranged as in the following table.

Table I

Strand Length	Steel Wires	Aluminum Wires
Feet		
0–2,500	4*a* through 4*m* (Mild Plow Steel).	1; 2*a* through 2*f*; 3*a* through 3*f*.
2,500–4,000	4*a* through 4*m* (Plow Steel).	1; 2*a* through 2*f*; 3*a* through 3*f*.
4,000–4,500	2*e*, 2*f*; 4*a* through 4*m* (Plow Steel).	1; 2*a* through 2*d*; 3*a* through 3*f*.
4,500–5,000	2*d* through 2*f*; 4*a* through 4*m* (Plow Steel).	1; 2*a* through 2*c*; 3*a* through 3*f*.
5,000–5,500	2*c* through 2*f*; 4*a* through 4*m* (Plow Steel).	1; 2*a*, 2*b*; 3*a* through 3*f*.
5,500–6,000	2*b* through 2*f*; 4*a* through 4*m* (Plow Steel).	1; 2*a*; 3*a* through 3*f*.
6,000–6,500	2*a* through 2*f* (Improved Plow Steel); 4*a* through 4*m* (Plow Steel).	1; 3*a* through 3*f*.
6,500–7,000	1; 2*a* through 2*f* (Improved Plow Steel); 4*a* through 4*m* (Plow Steel).	3*a* through 3*f*.

As has been mentioned, Figure 2*a* illustrates the 4000–4500 feet section tabulated above, Figure 2*b* illustrates the 4500–5000 feet section and Figure 2*c* illustrates the 5000–5500 feet section.

The strand length is measured from the end which would be at the bottom of the hole in drilling. It will be seen that a strand formed as tabulated above has a proportion of steel to aluminum that increases in steps from one end to the other. Other arrangements of wires in the strand are possible, and my invention embraces a cable constructed of several strands, each of which may consist of a different arrangement of steel and aluminum wires. In every such case, however, the diameter of the cable remains uniform from top to bottom as do the diameters of the strands and the individual wires composing each strand.

The mechanical properties of a cable comprising 6 identical strands arranged as in Table I are listed below. The tool weight assumed in calculating the safety factor was 3,500 pounds for the first 3,000 feet of hole drilled, 2,500 pounds for the next 2,000 feet, and 2,200 pounds for the last 2,000 feet. These weights correspond to actual field practice.

Table II

Cable Length	Wt./Ft.	Strength	Minimum Safety Factor [1]
Feet	*Pounds*	*Tons*	
0–2,500	.965	20	7
2,500–4,000	.965	22	7
4,000–4,500	1.06	24	7
4,500–5,000	1.11	25	7
5,000–5,500	1.15	27	7
5,500–6,000	1.20	28	7
6,000–6,500	1.25	31	7
6,500–7,000	1.27	32	7

[1] Rounded to nearest whole number.

Wire strands, according to my invention, may be conveniently manufactured in either of two ways. The first method employs separate spools of steel and aluminum wire at the strander. Stranding is commenced with steel wires, for example, if the cable is to be formed with all wires of steel at one end, or with wires of steel and wires of aluminum if it is desired to have some wires of the latter metal throughout the cable. After the desired number of feet of strand of the initial arrangement of wires is formed, the strander is stopped and the desired steel wires are cut and joined to aluminum wires of the same diameter. The stranding machine is then started up and the stranding continued for a measured footage, and the machine again stopped and additional steel wire is cut and joined to aluminum wire, and so on. The second method of manufacture, and one that I prefer to employ, requires the composite wires used in each strand to be formed in advance of the stranding. The required length of steel wire is measured, cut, and then joined to the required length of aluminum wire to form each composite strand, and these strands are reeled up on spools which are then loaded into the stranding machine. The stranding of these prefabricated composite wires can then proceed without interruption. It will be understood that the aluminum and steel wires may be joined by welding or other suitable means.

As cable formed according to my invention must be utilized so that the light end is the load-carrying end, it is necessary that the two ends of the cable be marked so that identification of the light and heavy ends respectively may be made.

Although I prefer to use aluminum as the lighter weight metal in the composite wires of my cable, other light weight metals may be used, such as magnesium, or light metal alloys such as the alloys of aluminum, zinc and magnesium.

Although I have described and illustrated the present preferred embodiment of my invention, it will be understood that the invention is not limited thereto but may be otherwise embodied or practiced within the scope of my claims.

I claim:

1. A cable composed of continuous wires, including a plurality of composite wires formed of steel at one end and a metal lighter than steel at the other, the junctions between steel and lighter metal in the composite wires being staggered over the length of the cable.

2. A cable composed of continuous composite wires formed of steel at one end and a metal lighter than steel at the other, the junctions between steel and the lighter metal being staggered over the length of the cable to provide a progressive decrease in unit cable weight from one end to the other.

3. A cable composed of continuous wires of substantially constant cross-section, including a

plurality of composite wires formed of steel at one end and a metal lighter than steel at the other, the junctions between steel and lighter metal in the composite wires being staggered over the length of the cable to provide a progressive decrease in unit cable weight from one end to the other.

4. A cable composed of continuous wires, including a plurality of composite wires formed of steel at one end and a metal lighter than steel at the other, the junctions between steel and lighter metal in the composite wires being staggered over the length of the cable to provide a cable of substantially uniform diameter but progressively decreasing unit weight from one end to the other.

5. A cable composed of continuous wires, including a plurality of composite wires formed of steel at one end and aluminum at the other, the junctions between steel and aluminum in the composite wires being staggered over the length of the cable to provide a progressive decrease in unit cable weight from one end to the other.

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No references cited.