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DRILL ROD STEEL AND ARTICLES THEREOF

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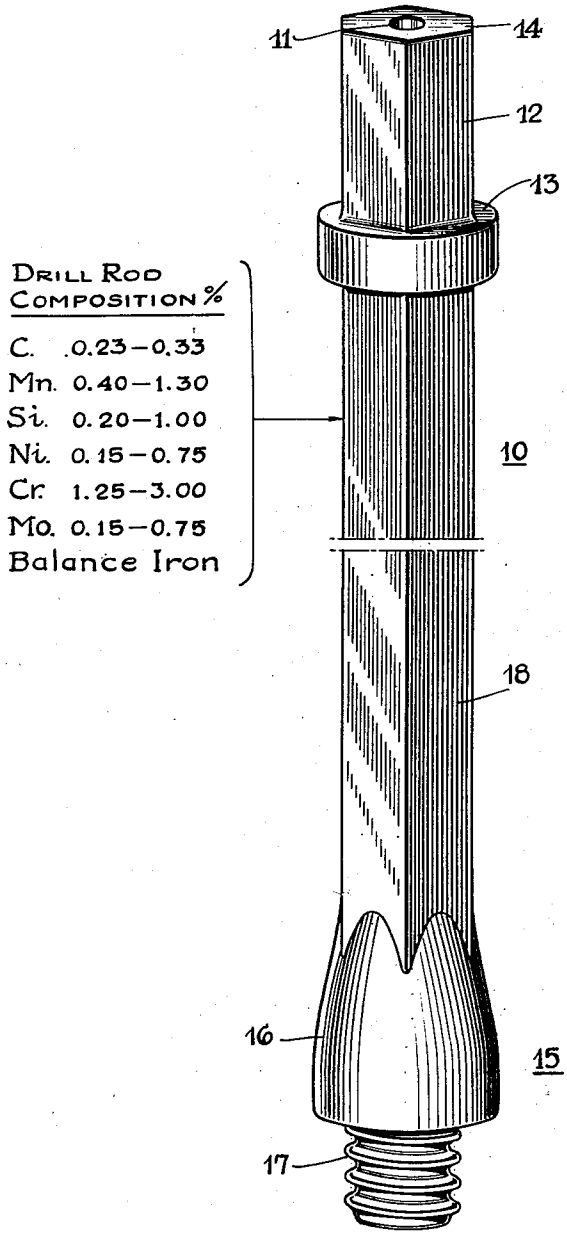

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DRILL ROD STEEL AND ARTICLES THEREOF

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This invention pertains to improvements in low alloy steel especially adapted for use in drill rods and to drill rods thereof, such as are employed in rock drilling, mining, quarrying and the like.

Hollow drill rod has been used for many years in connection with drilling for mining and general excavation, the drill rod serving as the means of transmitting the impact from the piston of the pneumatic hammer to the cutting edge of the tool which actually makes the hole, as well as the means of carrying compressed air down to the working face of the hole to push away from the cutting edge of the tool the debris resulting from the cutting of the rock. For many years it has been the practice to forge an end of the rod to a chisel or star-shaped cutting edge, and to heat treat this forged end to obtain maximum cutting efficiency. It was necessary, therefore, for the steel of the drill rod to be quite high in carbon so that the cutting edge could be hardened by heat treatment to at least Rockwell "C" 60.

Within the last twenty years or so, the use of detachable bits has become more and more popular in mining and excavating practice, for economic reasons. The early detachable bits were made primarily of high carbon steel of fairly low hardenability, and the working edges of the bit forging were fully hardened by quenching the steel from an appropriate temperature in water, whereas the top end of the bit which was threaded so that it could be attached to the drill rod, was left relatively soft so that it would be tough enough to withstand the repeated blows transmitted to it by the drill rod. More recently, the detachable bit has been made with cemented carbide tips brazed in a heat treated alloy steel bit-body.

During the time the cutting end of the drill rod assembly has been undergoing these changes, some changes also have been made in the drill rod proper. For instance, some low carbon alloy drill rod has been in use for some time. However, to a very large degree, the same type of hollow drill rod is being used today with modern detachable bits, as had been used for the integrally forged bit assembly in the past. These drill rods have been far from satisfactory because they fail frequently before the detachable bit has reached the end of its usefulness. Although in the past the rod out-lived many replaceable bits, now that

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the carbide-tipped bit is being used, the bit outlives the rod, and the rod has become replaceable. It is the object of this invention to provide a rod which will have much better endurance in rock drilling service than present rods.

There are three zones of functional importance in the drill rods constructed for use with detachable bits, namely

1. The attachment end to which the drill bit is threadedly received, which generally is upset forged, annealed, machined, and heat treated.

2. The body of the rod which is in the condition "as rolled" at the steel mill.

3. The tappet or striking end of the rod. This may or may not have a collar or lug associated with it. If a collar or lug is required, this end of the rod is heated to a forging temperature, and the collar or lug is upset forged. The end of the rod to a position slightly below the collar or lug is then heat treated. The rod without collar or lug is heated to a position about several inches beyond the end of the rod for heat treating.

As indicated above, one of the required properties of the drill rod is good forgeability so that the attachment end, and where necessary the tappet end, can be forged with a minimum of difficulty. This is important particularly because the forging is frequently done in the field where facilities for forging are not always the best.

After the attachment end of the bar is forged it has to be turned and threaded so that it will fit into the threaded end of the detachable bit. It is necessary, therefore, that this part of the bar after being forged should be machinable. It would be ideal if the rod was machinable as cooled in air or in loose insulating material, for example mica or lime, after the forging operation. For ready machinability, the hardness after such cooling should be under Rockwell "C" 30. At the worst the forged rod should be machinable after a relatively simple annealing operation such as a subcritical heating for several hours. Long involved annealing cycles to make the forged rods machinable are not practical because of the lack of adequate furnace and control equipment at most mine properties where drill rods are used.

Experience indicates that the attachment and tappet ends of the drill rod should have a hardness after heat treatment of Rockwell "C" 40

minimum and "C" 53 maximum. If the hardness is under "C" 40 the threads and the striking end will fail fairly rapidly by upsetting in service. If the hardness is over "C" 53, the steel has inadequate toughness and the threads and striking end will either chip or break. It is desirable that this hardening should be obtained by an oil quench, and preferably by an air cool so that there will be minimum risk of cracking and distortion in the threads.

The body of the rod has to withstand many vibrations during drilling operations and it is desirable, therefore, that it should have high resistance to fatigue which means that it should have high hardness as rolled, namely about Rockwell "C" 43 to 52.

The rods that are most commonly used at present are of the following approximate compositions:

Table

Grade	Analysis, Percent by Weight							
	C	Mn	Si	Ni	Cr	V	Mo	Bal.
A	.80	.30	.15	------	------	------	------	Fe
B	.80	.25	.15	------	------	.20	------	Fe
C	1.00	.30	.25	------	1.25	------	.25	Fe
D	.28	.95	.25	2.25	.70	------	.30	Fe
E	.33	.60	.25	3.10	.35	------	.25	Fe
F	.43	.60	.25	3.10	.35	------	.25	Fe

Grade A is the most simple steel and is used in largest tonnage. It is easy to forge and to anneal and it hardens satisfactorily by an oil quench. However, if the steel is high in residuals, say over .25 Ni, .15 Cr. and .05 Mo, it may harden to too high a degree and cause trouble. Furthermore, if the steel is quenched in water, inadvertently, it is far too hard and brittle for drill rod service. The most important short-coming of Grade A drill rod is its low hardness as rolled which gives it relatively poor resistance to fatigue and to permanent deformation under severe bending stresses.

Grade B, because of its vanadium content, is lower in hardenability than Grade A and is, therefore, less likely to be too hard after heat treatment. It has the same deficiency as Grade A, however, in being relatively soft as rolled and, therefore, inadequate in fatigue resistance.

Grade C hardens satisfactorily when quenched in oil but of course is much too hard when quenched in water. Its hardness as rolled is better than that of Grades A and B and, therefore, it has better resistance to fatigue, and to deformation under bending stresses, but it is not as high as desired. Furthermore, because of its as rolled structure of very fine pearlite with a carbide network, this type of drill rod tends to shatter when subjected to severe bending stresses and thus may be dangerous to workers using the rod.

Grades D, E, and F are quite different from the first three in that they have much lower carbon content and much higher alloy content. The lower carbon assures an adequate hardness without any risk of attaining too high a hardness if the rod is inadvertently quenched in water in the hardening operation. The higher alloy content assures good hardness in the as rolled steel, and also permits hardening of the ends of the rod by an air blast, which is preferable to an oil quench. However, these steels because of their high nickel contents develop a very tenacious undesirable scale when they are heated, and they also are difficult to anneal for easy machining after forging.

Now I have invented a hollow drill rod steel of the following "broad" and "preferred" compositions:

	Analysis, Percent by Weight	
	Broad	Preferred
C	.23/.33	.25/.30
Mn	.40/1.30	.60/.80
Si	.20/1.00	.50/.80
Ni	.15/.75	.30/.50
Cr	1.25/3.00	1.75/2.25
Mo	.15/.75	.25/.35
Bal	Fe	Fe

In the as rolled condition this drill rod steel has a minimum hardness of Rockwell "C" 40, and a maximum hardness as water quenched from temperatures over 1500° F. of Rockwell "C" 55. It can be hardened to Rockwell "C" 40 to 52 by an air cool from temperatures between 1500° and 1800° F. It can be annealed to a maximum of Rockwell "C" 30 by a holding at temperatures from about 1250° to 1350° F. for about 1 hour or longer, followed by an air cool. Furthermore, it is readily forgeable at temperatures from about 2000° to 2200° F.

In the annexed drawing, the single figure thereof illustrates, in perspective, a hollow drill rod, of the detachable bit type, made of the alloy steel in accordance with the invention.

Referring to the drawing, there is shown generally at 10, a hollow drill rod, of the detachable bit type, and of hexagonal cross sectional configuration although any other sectional shape may be employed, such as round, octagonal, etc. Extending axially through the rod is the drill hole 11, for transmitting air under pressure to the drill bit as aforesaid. The tappet or striking end of the rod is shown at 12, and in the embodiment illustrated, is upset forged, to provide a collar 13 disposed several inches below the upper end 14 of the rod. The attachment end of the rod, to which the drill bit is threadedly secured, is shown generally at 15, and this end also, is upset forged, annealed and machined, to provide an enlarged shoulder portion 16, against which the drill bit bears, and a terminal threaded portion 17, onto which the drill bit is threaded. The body portion of the rod, extending between the tappet and attachment ends is shown at 18, and is left in the "as rolled" condition with a minimum hardness of "C" 40 Rockwell.

Following the forging operation on the tappet end 12, and the forging, annealing and machining operations on the attachment end 15, these ends are hardened within the range of Rockwell "C" 40 to 52, by heating to about 1500° to 1800° F., followed by an air cool to atmospheric temperature.

I claim:

1. A drill rod alloy steel of substantially the following composition: 0.6 to 0.8% manganese; 0.5 to 0.8% silicon; 0.3 to 0.5% nickel; 1.75 to 2.25% chromium; 0.25 to 0.35% molybdenum; 0.25 to 0.30 carbon, and the balance iron.

2. A drill rod for rock drilling and the like comprising an elongated bar made of an alloy steel of substantially the following composition: 0.4 to 1.3% manganese; 0.2 to 1% silicon; 0.15 to 0.75% nickel; 1.25 to 3% chromium; 0.15 to 0.75% molybdenum; 0.23 to 0.33% carbon, and the balance iron.

3. A drill rod for rock drilling and the like comprising an elongated bar made of an alloy steel of substantially the following composition: 0.6 to 0.8% manganese; 0.5 to 0.8% silicon; 0.3 to 0.5% nickel; 1.75 to 2.25% chromium; 0.25 to 0.35% molybdenum; 0.25 to 0.30% carbon, and the balance iron.

4. A hollow drill rod for rock drilling and the like comprising an elongated bar, having a threaded terminus for detachably securing a drill bit thereto, said bar being made of an alloy steel of substantially the following composition: 0.4 to 1.3% manganese; 0.2 to 1% silicon; 0.15 to 0.75% nickel; 1.25 to 3% chromium; 0.15 to 0.75% molybdenum; 0.23 to 0.33% carbon, the balance iron, each end of said bar, for a distance of several inches from the end thereof, having a hardness of about Rockwell "C" 40 to 52, and the remaining portion of said bar intermediate said ends being in the as rolled condition and having a minimum hardness of about Rockwell "C" 40.

5. A hollow drill rod for rock drilling and the like comprising an elongated bar, having a threaded terminus for detachably securing a drill bit thereto, said bar being made of an alloy steel of substantially the following composition: 0.6 to 0.8% manganese; 0.5 to 0.8% silicon; 0.3 to 0.5% nickel; 1.75 to 2.25% chromium; 0.25 to 0.35% molybdenum; 0.25 to 0.30% carbon, the balance iron, each end of said bar, for a distance of several inches from the end thereof, having a hardness of about Rockwell "C" 40 to 52, and the remaining portion of said bar intermediate said ends being in the as rolled condition and having a minimum hardness of about Rockwell "C" 40.

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