May 24, 1966 H. BRANDT 3,253,245

ELECTRICAL SIGNAL TRANSMISSION FOR WELL DRILLING

Original Filed Dec. 27, 1961 2 Sheets-Sheet 1

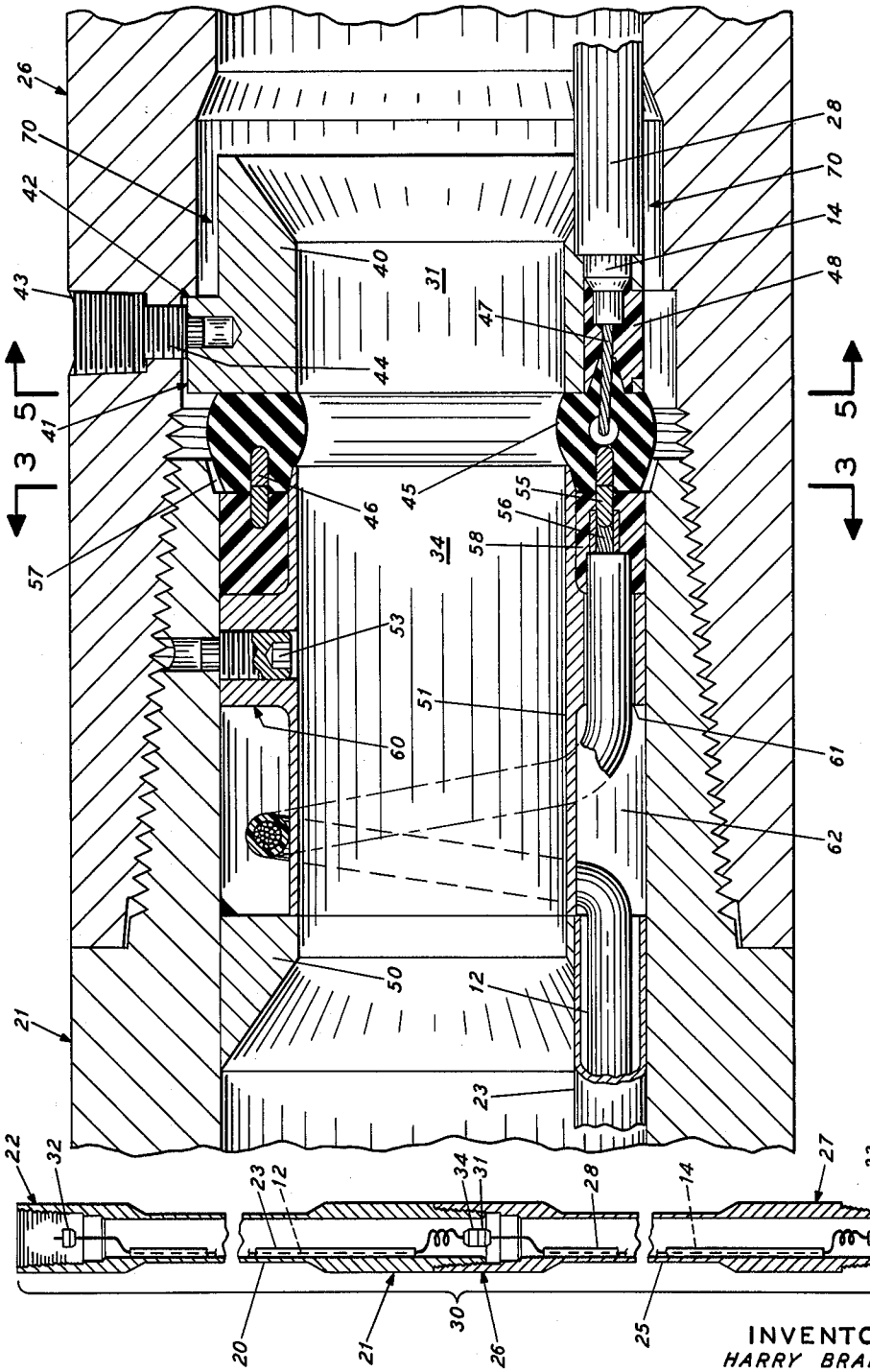


FIG. 2

FIG. 1

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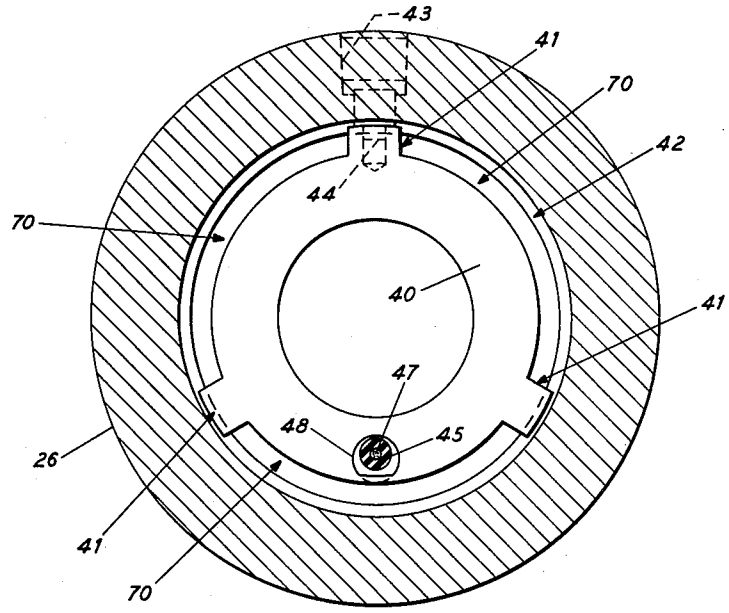


FIG. 5

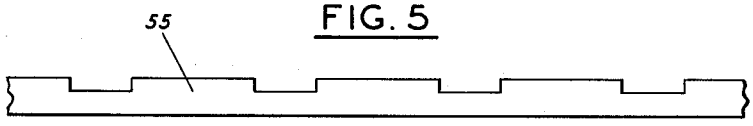


FIG. 4

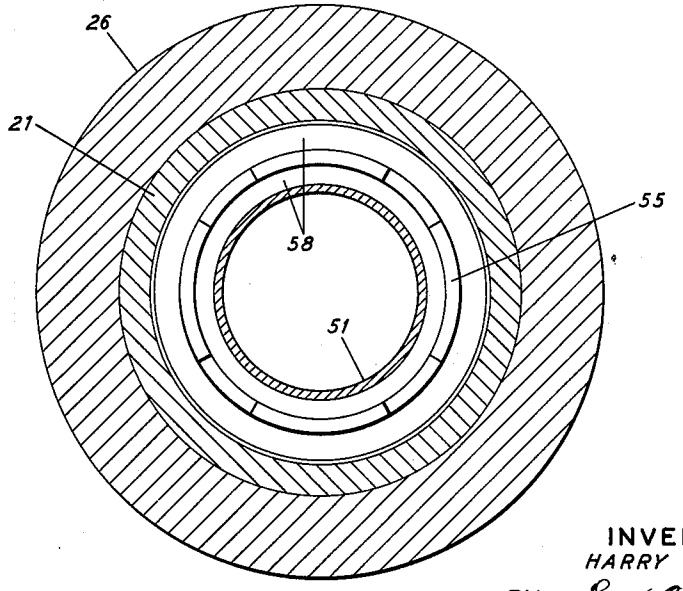


FIG. 3

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ELECTRICAL SIGNAL TRANSMISSION FOR WELL DRILLING

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Continuation of application Ser. No. 162,421, Dec. 27, 1961. This application Mar. 5, 1965, Ser. No. 445,819
2 Claims. (Cl. 339—16)

This application is a continuation of copending application Serial Number 162,421, filed December 27, 1961, and now abandoned.

This invention relates to an electrical signal transmission system for well drilling and more particularly, this invention relates to apparatus for electrically coupling drill pipes when said pipes are mechanically coupled together to form a drill string which provides an electrical transmission circuit between apparatus in the borehole on said drill string and apparatus on the earth's surface.

When drilling a borehole it is often desirable to send or receive electrical signals between the surface and downhole. For example, a force measuring device producing an electrical signal proportional to the force on a drill bit may be attached to the bit and an electrical signal transmitted to the surface to give force information to an operator. Devices producing signals proportional to temperature and resistivity are also frequently used. As is known in the art of well drilling, a borehole is advanced into the earth by the action of a drill bit against the drilling face. The drill bit is attached to a drill collar of a drill string and is supplied with rotational or reciprocating motion by the drill string and to some extent is weighted by a drill collar. The drill string is made up of drill stem sections comprising a number of drill pipes mechanically coupled together. The pipes are usually threaded together at the drilling rig as the bit progresses into the earth. Because of the number of drill pipes usually making up the drill string, and the extreme wear conditions inherent in drilling operations, transmission of electrical signals along the drill string has heretofore been a difficult problem. Attempts have been made to utilize the drill string as one conductor and an insulated conductor carried in the drill string as a second conductor. These attempts have not met with great success due in part to failure of the electrical connectors between drill stem sections.

Briefly, the present invention provides a transmission system using the drill string as one conductor and an insulated conductor secured interiorly of said drill string as the second conductor, said insulated conductor having electrical connectors at the drill pipe joints. The electrical connectors provided for by the present invention electrically couple insulated conductors carried interiorly of said drill pipes when the drill pipes are mechanically coupled in a conventional manner by the drilling crew to form a drill string. A first electrical connector and a second electrical connector are provided in each end of a section of drill pipe. The electrical connectors in a drill pipe are adapted to make electrical contact when mated with corresponding connectors in other drill pipe when the pipes are mechanically coupled to make up a drill string.

The electrical connectors are provided in the box end and the pin end of a drill pipe. The connector in the box end of the drill pipe is provided with a passageway for drilling mud drainage when the pipe is removed from the borehole and stacked near the drilling rig. The connectors are provided with a mud sealing means. The mud sealing means forms a mud-tight seal around the electrical contact formed by the electrical connectors when drill pipes are coupled, thus preventing current loss to the drill pipe or to ground. A special type connecting ring in one of the electrical connectors improves contact by removing dried mud from the connecting ring in the opposing electrical connector as the drill pipes are coupled.

It is one object of the present invention to provide an electrical transmission system for well drilling, said system comprising the drill pipes of the drill string as one conductor and an insulated conductor secured interiorly of the drill pipes as the second conductor, said insulated conductor having removably mounted electrical connectors in both ends of each drill pipe, which connectors electrically connect said insulated conductors in said drill pipes when said pipes are mechanically coupled to form a drill string.

Further objects and advantages of the present invention will become apparent from the following detailed description read in light of the accompanying drawings which are a part of this specification and in which:

FIG. 1 is a diagrammatic view of two drill pipes, said pipes electrically coupled according to the present invention.

FIG. 2 is a sectional view of a preferred form of apparatus for providing an electrical connection between drill pipes.

FIG. 3 is a section at 3—3 of FIG. 2.

FIG. 4 is a supplemental view of the connecting ring shown in FIG. 3 as it would appear if it were removed from the electrical connector and unrolled.

FIG. 5 is a section at 5—5 of FIG. 2.

To obtain a better understanding of the invention, reference is now made to FIG. 1 where a diagrammatic view of an embryo drill string **30** comprising drill pipe **20** coupled to drill pipe **25** is shown. A drill pipe has male threads on one end commonly called the pin end, and female threads in the other end commonly called the box end. The pin end **21** of drill pipe **20** is screwed into the threads provided in box end **26** of drill pipe **25**. If, for example, drill pipe **25** is the first drill stem section to be run in a borehole, a drill bit collar with a drill bit is connected at pin end **27**. Additional drill pipe is added to the drill string by screwing the pin end of each drill pipe into the box end of the uppermost drill pipe of the drill string in a manner similar to the mechanical connection provided by pin end **21** and box end **26** of FIG. 1.

According to the preferred form of the invention a conduit **23** is secured interiorly of drill pipe **20**. Conduit **23** extends substantially the length of drill pipe **20** from box end **22** to pin end **21**. In a similar manner, a conduit **28** is secured interiorly of drill pipe **25**. Conduits **23** and **28** are each adapted to receive an insulated electrical cable such as cable **12** in conduit **23** and cable **14** in conduit **28**. The electric cable **12** in conduit **23** of drill pipe **20** is electrically connected to an electrical connector represented schematically by **32** in box end **22** and to an electrical connector **34** in pin end **21**. In a similar manner the electrical cable **14** in conduit **28** of drill pipe **25** is electrically connected to an electrical connector **31** in box end **26** and to an electrical connector **33** in pin end **27**. The connector **31** in the box end **26** of drill pipe **25** is adapted to make electrical contact with connector **34** in pin end **21** of drill pipe **20** when the drill pipes are mechanically coupled as shown in FIG. 1. For convenience in description the electrical connectors similar to connector **32** and connector **31** will be called male electrical connectors and electrical connectors similar to connector **34** and connector **33** will be called female electrical connectors.

The electrical connectors and the cable are insulated from the drill pipe to provide for an electrically insulated

conductor for current flow along drill string **30**. According to the present invention each drill pipe is provided with an insulated electric cable and mateable installed electrical connectors. Therefore, an electrical circuit is developed along the drill string as each new drill pipe is mechanically and electrically coupled into the drill string.

FIG. 2 is a detailed sectional view of a preferred form of apparatus for providing an electrical connection between insulated conduits secured interiorly of drill pipes according to the present invention. As there shown, pin end **21** of a drill pipe such as drill pipe section **20** is shown mechanically coupled in operational relationship with a box end **26** of another drill pipe such as drill pipe section **25**. Interiorly of the drill pipes, an electrical contact between insulated cable **12** and insulated cable **14** is completed by the male electrical connector indicated generally by numeral **31** contacting the female electrical connector indicated generally by **34**. The terms male and female are only relative. One skilled in the art will realize that the position of the connectors could be reversed so long as the two opposed electrical connectors mate when the drill pipes are mechanically coupled.

Referring now specifically to the connector represented generally by **31**, a base ring **40** is provided with supporting shoulders **41**. Base ring **40** is slidably received in the box end **26** of a drill pipe. Base ring **40** may be easily inserted and removed when desired by locking or unlocking setscrew **44**. Thus, electrical connector **31** is removably secured in the box end of the drill pipe. The supporting shoulders **41** rest on a recess **42** located interiorly of box end **26**. As shown in FIG. 5, which is section **5—5** of FIG. 2, base ring **40** is preferably supported interiorly of pin end **26** by three or four exteriorly located shoulders, such as shoulder **41**. Base ring **40** is supported in this manner to provide drain paths **70** in the annulus formed by base ring **40** and box end **26**. These openings provide a drain for drilling mud from the male connector when a drill pipe is removed from the borehole and stacked on the surface. As is known in the art, a drill pipe is usually wet with drilling mud when pulled from the hole. A hard durable cover results on surfaces where the mud dries. The dried mud functions as an undesirable insulator on a coated surface. It is important that the mud is not allowed to collect and dry on the electrical connectors. Drill pipes are usually stacked with the box end up and the pin end down. Therefore it is important to provide a drain in the electrical connector located in the box end of the drill pipe to insure that drilling mud will not collect there to dry and coat the connecting surfaces while the pipe is stacked.

Base ring **40** is provided with a passageway for receiving conduit **28** and insulated cable **14** when base ring **40** is inserted into box end **26**. As discussed more fully below, the electrical connectors in each drill pipe may be rapidly and easily assembled in the field. Base ring **40** is held removably in place by setscrew **44** in well **43** of box end **26**. The wire **47** in cable **14** is operably connected to a connecting ring **46**. Connecting ring **46** is made of a conducting metal and is adapted to mate with a connecting ring **55** in the female electrical connector when mating ends of two drill pipes are coupled as shown in FIG. 2. Wire **47** is insulated from base ring **40** by means of insulating material **48**. Connecting ring **46** is mounted on base ring **40** in connecting ring mounting **45**. Connecting ring mounting **45** is made of a resilient material such as rubber. Connecting ring mounting **45** serves both as a mount for connecting ring **46** and as a mud sealing means for ring **46** and connecting ring **55** when the rings are mated in coupled drill pipes. The mud sealing function of mounting **45** is more fully described below.

Before describing the mud sealing means, the female connector located interiorly of pin end **21** and represented generally by **34** will be fully described. A hollow general cylindrical core **51** having a piston-like flange **60** is adapted to be inserted and removed from pin end **21**. The core **51** is supported by a support **50** secured interiorly of pin end **21**. Flange **60** is provided with a hole **61**. The hole **61** is adapted to receive insulated cable **12**. Flange **60** is also provided with a setscrew **53** which is locked to prevent the core **51** from turning after it is positioned. The setscrew **53** holds the female connector removably secured in the pin end of the drill pipe. When core **51** is inserted into pin end **21** in the position shown in FIG. 2, two annular chambers are formed by the interior wall of pin end **21** and the exterior of core **51**. The annular chambers are separated by flange **60** which extends around core **51**.

A means for taking up an extra length of insulated cable is provided by the annular chamber designated by **62**. Annular chamber **62** is adapted to contain insulated cable **12** wrapped on the exterior of core **51**. Core **51** is rotated interiorly of pin end **21** to twist cable **12** around the core **51**. This feature allows an extra length of cable **12** to be contained in the drill pipe. Thus, the drill pipe containing an insulated cable and electrical connectors of the present invention is easily assembled or repaired in the field. Assembly of a drill pipe containing electrical connectors is now described with reference to drill pipe section **20** of FIG. 1. The insulated electric cable **12** carried inside of conduit **23** is preferably about one foot longer than the drill pipe. The cable is first attached to male connector **32**. The cable is threaded through conduit **23** and male connector **32** is secured in place in the box end **22** of pipe **20**. Since the cable extends about a foot beyond the other end of pipe **20**, there is ample cable to easily connect female connector **34**. After the electrical connection between cable **12** and female connector **34** is made, the female connector is mounted interiorly of pin end **21** of drill pipe **20**. The slack in the insulated cable is taken up by rotating female connector **34** as it is inserted into position in pin end **21**. The female connector is then locked in position by suitable means. The locking means is preferably a setscrew or a similar device so that the connector is releasable from the pipe when the setscrew is unlocked.

Referring again to FIG. 2, the second annular chamber formed by core **51** and pin end **21** contains connecting ring **55** securely held in a nonconducting material **58**. A suitable material for containing connecting ring **55** is, for example, Teflon or Bakelite. Connecting ring **55** is connected to electric cable **12** by a suitable means such as electric connection **56**. Connecting ring **55** is castellated over part of its contacting surface. It has been discovered that greatly improved electrical connection with an opposing connecting ring in the resilient mounting is obtainable if the connecting ring mounted in the relatively nonresilient mounting, such as connecting ring **55** in female connector **34**, is castellated over part of its contacting surface. One theory for this is that the castellations scrape or chisel away mud which may be caked on the contacting surfaces of the opposing connecting ring as the drill pipe sections are screwed together. It is desirable that the castellated connecting ring be mounted in a manner to prevent the connecting ring from twisting when pipe sections are coupled in order that the ring better scrape clean the opposing connecting ring. The preferred form of the castellated connecting ring **55** is illustrated in FIG. 3 and FIG. 4. FIG. 3 is a sectional view at **3—3** of FIG. 2. FIG. 4 is a supplemental view of ring **55** as it would appear if it were removed from the female connector and unrolled to a flat position.

A major problem associated with electrical transmission through a drilling string is loss of current to ground at the connecting joints. The leakage problem is especially serious when the liquid in the borehole, which is usually drilling mud, is conductive. Since many drilling muds are conductive, leakage loss to ground is a common problem. The present invention provides for establishing a metal-to-metal contact by mating connecting ring

46 with connecting ring 55 and for sealing off this contact from the drilling mud by a sealing means which creates a mud seal as the opposing ends of the drill pipe sections are coupled together.

One effective mud sealing means is shown in FIG. 2. As there shown, resilient mounting 45 seals the connecting rings from drilling mud when drill pipe sections are coupled. The seal is accomplished because the connecting rings meet before the threaded pipe connection is completed. As threading of the sections is completed, resilient mounting 45 is depressed and deforms as illustrated in FIG. 2, to thus seal the connecting rings from the drilling mud. It is preferred to provide a groove such as groove 57 in the electrical connector receiving the deformable mounting ring. The ring will then deform in the groove to prevent mud from contacting the connecting surfaces. It has been determined that when a rubber mounting is used, it should be depressed about .02 or more inch by the opposing connector. A depression of the mounting ring of about .032 inch was tested for leakage resistance at various mud pressures. At mud pressures of 10,000 p.s.i.g. there was substantially the same leakage resistance as was found at atmospheric pressure. This indicates that the mud seal formed by the mounting ring is effective in sealing the electrical contacting surfaces at high pressures.

As will be apparent, various modifications may be made without departing from the spirit of the invention. These modifications are meant to be included in the appended claims.

I claim as my invention:

1. Apparatus for use in a borehole electrical transmission system comprising a drill pipe having a pin end and a box end, said pipe adapted to be connected with other drill pipes to form a drill string, an insulated cable contained interiorly of said pipe, a first electrical connector on said cable removably secured interiorly of the box end of said pipe, said first electrical connector including a first terminal insulated from electrical contact with said drill pipe, first locking means in said box end removably securing said first electrical connector in said box end, mud drain means formed between said first electrical connector and the interior of said box end of said drill pipe, a second electrical connector on said cable

removably secured interiorly of the pin end of said drill pipe, said second electrical connector including a second terminal insulated from electrical contact with said drill pipe, second locking means in said pin end removably securing said second electrical connector in said pin end and annular chamber means formed by said second electrical connector and said drill pipe for containing an extra length of cable therein.

2. Apparatus for use in a borehole electrical system comprising a drill pipe having a pin and a box end, said pipe adapted to be connected with other drill pipes to form a drill string, an insulated cable contained interiorly of said pipe, a first electrical connector connected to one end of said cable, said first electrical connector including a first annular connecting terminal insulated from electrical contact with said drill pipe, first locking means in one end of said pipe removably securing said first electrical connector in one end of said drill pipe, a second electrical connector connected to the other end of said cable, said second electrical connector including a second annular connecting terminal resiliently mounted and insulated from electrical contact with said drill pipe, second locking means in the other end of said pipe removably securing said second electrical connector in other end of said drill pipe and annular chamber means formed by one of said electrical connectors and said drill pipe for containing an extra length of said cable therein.

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