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COMPOSITE CONDUCTOR

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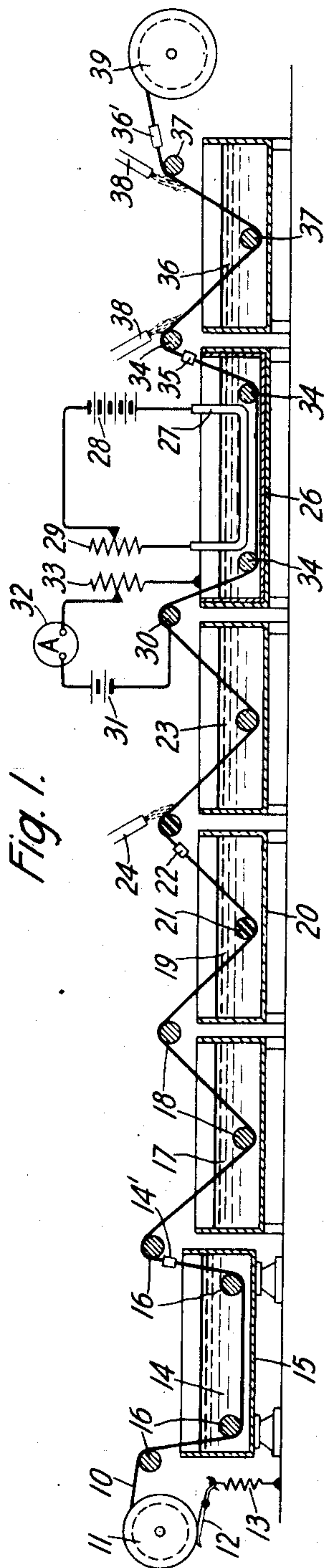


Fig. 3.

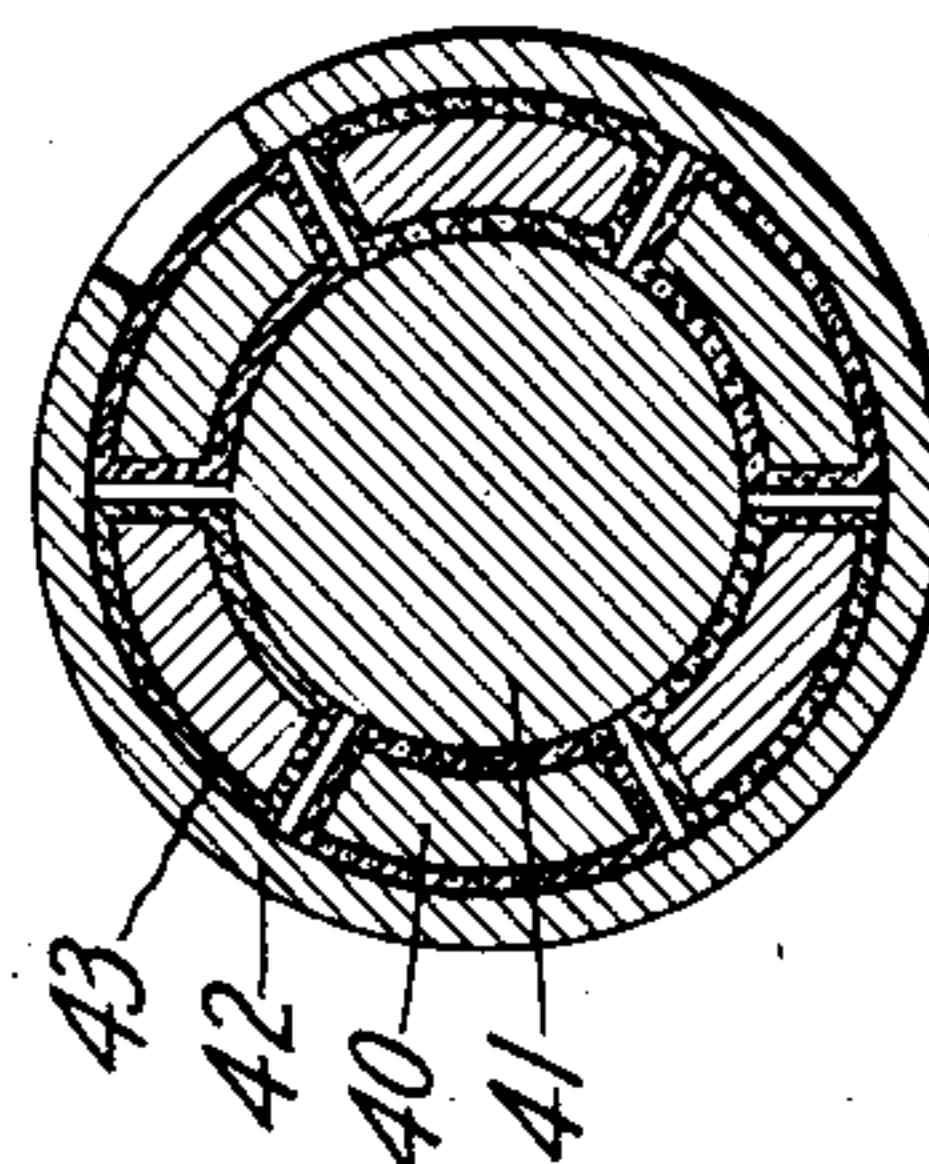
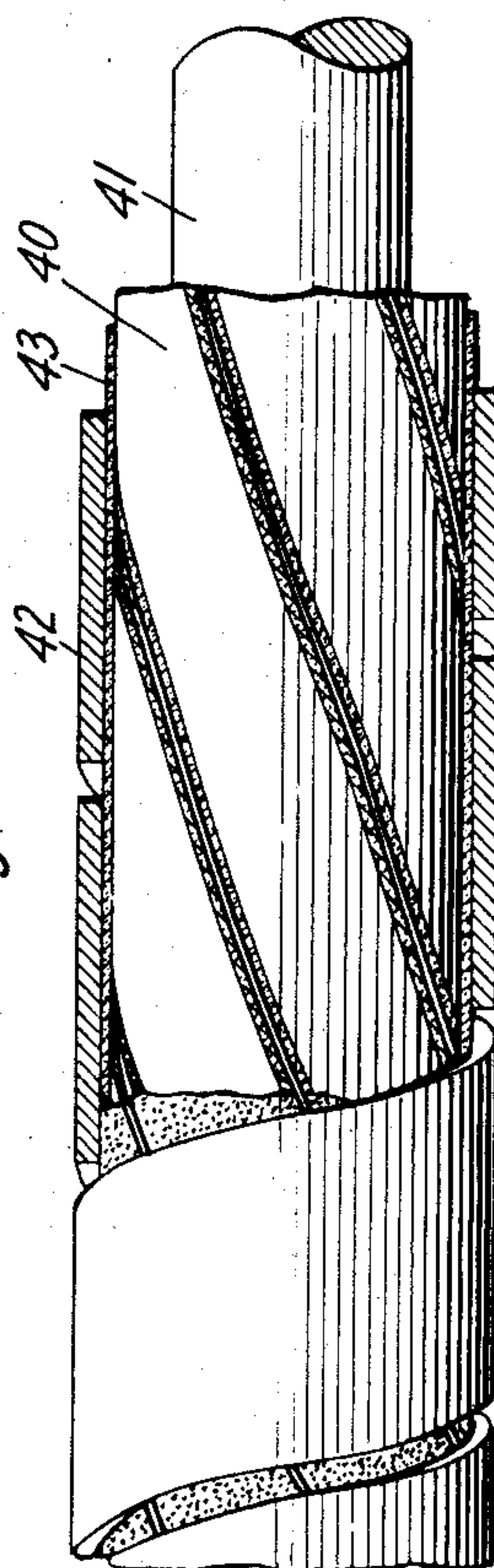


Fig. 2.



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COMPOSITE CONDUCTOR

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This invention relates to the construction of signaling conductors and more particularly to the construction of such conductors continuously loaded with magnetic material.

5 The loading of signaling conductors with magnetic material to improve the transmission characteristics of signaling circuits is now well known. Certain alloys containing nickel and iron are now being used for this
10 purpose. These alloys, when properly heat treated, are peculiarly desirable for loading material by virtue of properties, some of which vary when the material is strained, as is incidentally done by changing its form in
15 applying it to a conductor. It is, therefore, best to perform the heat treating operation upon the loaded conductor, but even then certain structural precautions must be taken for best results.

20 A structural precaution provided in accordance with this invention resides in a powder-like separator between the conductor and the loading material, the separator being an electrochemical deposit from a solution of
25 ammonium molybdate converted into a powder by the application of heat.

Another feature of the invention relates to the method of preparing such a loaded conductor which comprises, first depositing a
30 continuous coating on either the individual strands from which the conductor is to be prepared, the solid or stranded conductor itself, or the unapplied loading material in a sufficiently adherent form to remain in place
35 except when the surface to which it is applied is sharply bent, and then applying the loading material over the conductor. The loaded conductor is then subjected to a heat treatment, which causes the continuous or
40 coherent coating to be converted into a powder-like consistency, and the loading material to acquire desired magnetic properties. Electrodeposition is the preferred process for obtaining an adherent coating.

45 A more detailed description of the inven-

tion follows and is illustrated in the accompanying drawing in which:

Fig. 1 illustrates a continuous process for depositing the coating on a single strand;

Fig. 2 shows a section of a loaded conductor 50 with a portion cut away to illustrate details of construction; and

Fig. 3 is a cross-sectional view of the conductor of Fig. 2.

Until comparatively recently, iron has been 55 considered to be the only material suitable for the continuous loading of a signaling conductor. It has been discovered, however, that material in general more suitable than iron may be produced in the form of alloys. 60 When nickel and iron are alloyed in proper proportions and the alloy is given a proper heat treatment, a material having properties peculiarly suited for continuous loading of signaling conductors is obtained. One alloy 65 which is desirable because of its high permeability has a composition comprising 78½% nickel and 21½% iron. Another magnetic alloy which exhibits very great constancy of permeability under the conditions encountered in signaling circuits comprises 45% 70 nickel, 30% iron and 25% cobalt. However, in order to bring out the desirable qualities of these alloys they must be properly heat treated. For a detailed description of these 75 loading materials, see an article in the Journal of the Franklin Institute, Volume 195, Number 5, for May, 1923, by Messrs. Arnold and Elmen, entitled "Permalloy, an alloy of remarkable magnetic properties," and the 80 copending application of G. W. Elmen, Serial No. 119,622, filed June 30, 1926, and which has issued as Patent No. 1,715,646, on June 4, 1929.

When it is attempted to employ these ma- 85 terials either in the form of tape or wire for continuously loading a conductor, difficulties are encountered. Desired qualities which are attainable by proper heat treatment prior to the placing of the material upon the con- 90

ductor are deleteriously affected by the mechanical strains incident to the application process; hence, the finished conductor is heat treated. A suitable heat treatment for obtaining the desired properties of both the nickel-iron and nickel-iron-cobalt alloys comprises heating the alloy to approximately 900° C. after it has been applied to the copper conductor. During such process, a condition arises which prevents desired magnetic or electrical properties of the loading material, as for example, high attainable permeability, from being attained.

The present invention is one of a series of inventions which have been made with the object of avoiding this condition.

The preferred process of continuously forming by electrodeposition a coherent coating on a conductor is shown in Fig. 1, in which the conductor 10, to be coated, is supplied from a rotatable reel 11. A brake lever 12 engaging the reel and a tension spring 13 regulate the rotation of the reel 11. The conductor 10 enters a hot alkali bath 14, contained in a metallic tank 15, guided by a plurality of iron pulleys or rollers 16.

The alkali bath consists of approximately one pound of caustic soda to each gallon of water to form a cleansing solution to remove foreign substances from the metallic conductor 10. The conductor is drawn through a water bath 17 for washing after leaving the alkali bath and a wiper 14' surrounds the conductor adjacent the end of the alkali bath to prevent an excess of alkali solution from being carried into the water bath. The rollers 18 engaging the conductor during the washing operation are preferably of brass or bronze to prevent injurious oxides being formed at these points and being applied to the portion of the conductor in contact with the rollers.

The conductor 10 is then drawn through the acid dip bath 19, to remove scale and etch the conductor prior to the coating operation. This bath comprises from one to two pounds of concentrated hydrochloric acid to each gallon of water but may be a concentrated hydrochloric acid bath, and is preferably contained in a glass or porcelain tank 20. The rollers 21 for this bath are preferably of rubber which is substantially unaffected by the acid. A wiper 22, also of rubber, removes the excess acid solution from the conductor 10 after it leaves the acid bath. The next bath 23 is the same as the bath 17, namely, a clear water bath to rinse the conductor after the acid bath. A suitable tap 24 may be positioned over the conductor to supply a constant flow of water to wash the conductor.

The conductor 10 then enters the coating bath 25 which is contained in a lead-lined tank 26. This bath consists of a solution of ammonium molybdate formed by dissolving

molybdic acid in sufficient ammonium hydroxide to form a clear solution of the formula $(\text{NH}_4)_2\text{MoO}_4$ and diluting with water to the proper strength. Solutions having from 2% to 6% of the molybdic acid have been found suitable as electrolytes for forming the molybdate scale coatings. This bath is maintained at a temperature of from 60° to 70° C. by a heater enclosed in an oil filled glass tube 27, or any suitable type of immersion heater. The heater is connected to a source of current, such as a battery 28. The current supply is controlled by a variable resistance 29. A copper or bronze roller 30 is supported adjacent to the entrance of the coating bath, to form the cathode contact for the conductor 10. The cathode contact roller 30 and the lead lining of the tank 26 which acts as the anode of the bath are connected to a source of current 31 through an ammeter 32 and a variable resistance 33. The current density of the solution is maintained at the required values to form an adherent coating on the conductor 10 which is the cathode of the electrolytic bath, by virtue of its contact engagement with the roller 30. The values of the current density of the bath which have been found desirable are approximately 10 to 15 amperes per square foot of anode surface. Suitable porcelain or glass rollers 34 guide the conductor 10 through the electrolytic bath.

The coherent coating which is deposited on the conductor 10 as it passes through the bath, is probably an oxide or a molybdate of the metal to be coated, or it may be a mixture of molybdate and oxide. Whatever the composition of the coating, a reasonably uniform thickness of an adherent metallic scale is formed on the conductor since the coating becomes fairly nonconducting after a certain thickness has been formed and terminates the forming process. After the coated conductor leaves the bath, a wiper 35 removes the excess solution from the conductor to prevent the pollution of the washing bath 36 through which the coated conductor is guided by the brass rollers 37. Auxiliary washing streams of water are supplied from taps 38 arranged so that the water flows over the conductor and into the final washing tank. A drying wiper 36' surrounds the conductor after it leaves the washing bath 36 and the conductor is wound on a take-up reel 39. This arrangement forms a continuous process for treating and coating the metallic conductor to form by electro-deposition a coherent coating, probably of molybdate, on the surface thereof.

Referring to Figs. 2 and 3, a plurality of flat conducting strands 40, which have applied thereto the molybdate coating 43, are helically wrapped on a solid conducting core 41, and a magnetic tape 42 is applied over the conducting strands to form a composite con-

ductor which may be heat treated to improve the magnetic properties of the tape 42. The high temperatures employed during the heat treatment cause the adherent uniform coating 43 on the strands to be reduced to a non-adherent powder. Nevertheless, the molybdate powder adequately separates the strands and the tape during the heat treatment and thereby prevents contact therebetween.

While the invention has been described with respect to the continuous process of treating and depositing the coating on a single strand or conductor, it is apparent that a large number of strands or conductors may pass through the process simultaneously. Furthermore, the coating may be deposited on a solid conductor, such as the core 41 and the magnetic tape 42 applied directly to the coating on the solid conductor.

It is to be understood that the expression "molybdate scale," where used in the specification and claims, is not to be taken as a definite representation of the chemical composition of the scale. Such expression is used merely to define the deposit produced under certain conditions and assumed to be a metallic molybdate.

A possible explanation of the deleterious effects produced by the heat treating process is that unless precautions are taken, adhesion takes place between the copper conductor and the loading material. In the process of heating the loaded conductor at about 900° C. the copper expands considerably more than the surrounding loading material and when there is not sufficient slack in the loading material very close contact is established between the two, either in the furnace or just after the conductor enters the cooling chamber. Contraction of the loading layer is rapid in the latter stage of the heat treatment due to the cooling medium coming in contact directly with this layer. Due to the increased molecular activity at the elevated temperature of 900° C. diffusion between the two metals appears to be established and welding or adhesion takes place over portions at least of the contact surfaces. Upon cooling of the copper conductor the latter tends to draw away from the magnetic loading material and since this material partially adheres to the copper, stresses are set up which are great enough to deleteriously affect properties of the loading material.

While the invention has been particularly described with reference to loaded signaling conductors it may be employed in other types of composite strands which are subjected to high temperature conditions and in which contact between the individual strands during the heating or subsequent cooling gives rise to deleterious effects.

What is claimed is:

1. A signaling conductor comprising a plurality of component strands in close contact,

and a thin layer of molybdate powder between the component strands.

2. A signaling conductor comprising a plurality of component strands in close contact, and an electrodeposited coating of molybdate on at least one of said strands.

3. A composite signaling conductor comprising a central copper strand, a magnetic strand wound thereon, said magnetic strand being subject to adhesion to said central strand during heat treatment, and a thin layer of loosely adherent metallic molybdate between said strands.

4. A loaded signaling conductor comprising a conducting strand, a magnetic loading material wrapped about said strand, said loading material requiring heat treatment to develop high permeability therein and the permeability being sensitive to strain, and a coating of molybdate separating the loading material from said conducting strand.

5. A loaded signaling conductor comprising a central conductor, a plurality of conducting strands spirally applied to said conductor, a layer of magnetic loading material surrounding said strands, said signaling conductor being subjected to heat treatment to increase the permeability of said loading material, and an electrodeposited coating of molybdate scale between said loading material and conducting strand.

6. A continuously loaded signaling conductor comprising a conducting strand, a magnetic strand, and an adhering coating on one of said strands to separate it from the other of said strands, said coating being a high melting point, metallic composition of the type which is obtained by electrodeposition from an ammoniacal solution of a metallic acid which may be transformed into a powder when heated below fusing.

7. The method of separating two conducting bodies with an insulating layer comprising depositing a molybdate scale adherently to one of the conducting bodies, and then placing said bodies in close proximity to each other.

8. The method of producing a composite metallic strand free from adhesion between the component strands during heat treatment, which comprises electrolytically producing a molybdate deposit on one of the component strands, and superimposing another strand on said coated strand.

9. The method of producing a composite strand free from adhesion between the component strands during heat treatment which comprises passing one of the component strands through a solution of ammonium molybdate, forming electrolytically from said solution a coherent metallic coating on said strand and superimposing another strand on said coated strand.

10. The method of producing a signaling conductor free from adhesion between the

separate strands of said conductor during heat treatment, which comprises coating one of the strands electrolytically with a molybdate on the metal of said strand, and winding another strand in contact with said coated strand.

11. The method of producing a signaling conductor comprising a conducting strand and a magnetic strand, said strands being subject to adhesion during heat treatment, which consists in producing a molybdate coating on the conducting strand by electrochemical deposition, and winding the magnetic strand in contact with said conducting strand.

12. The method of providing a non-coherent separator between adjacent strands of a composite signaling conductor, which comprises electrolytically depositing on one of said strands from an ammoniacal solution a coherent coating of a metallic composition said coating having a high melting point, building up said conductor to include said adjacent strands, and then breaking up said coating by applying heat to said conductor.

13. The method of providing a powder-like, refractory separator between adjacent strands of a composite signaling conductor, which comprises electrodepositing from an ammoniacal solution a metallic compound on one of said strands, building up the conductor from said strands, and then heating the compound to a temperature below fusing.

14. The method of producing a signaling conductor comprising a conducting strand and a magnetic strand, said strands being subject to adhesion during heat treatment, which consists in electrolytically producing a molybdate deposit on the conducting strand, winding the magnetic strand in contact with said conducting strand, and heating said signaling conductor to improve the properties of said magnetic material, said molybdate deposit being reduced to a loosely adherent powder.

15. The method of loading a signaling conductor with magnetic material which requires heat treatment to improve its magnetic properties which comprises, forming a layer of molybdate on the conductor, and wrapping the magnetic material in contact with said molybdate layer.

16. The method of loading a signaling conductor with magnetic material which requires heat treatment to increase the electrical characteristics of the magnetic material, which consists in electrolytically depositing a molybdate coating on the conducting strand, wrapping said strand spirally on a central strand, and wrapping a layer of magnetic loading material about said depositing strand.

17. The method of loading a signaling conductor with a magnetic material which comprises passing the conducting core through

an ammoniacal solution of molybdic acid, forming electrolytically in said solution a molybdate coating on said core, applying the magnetic material about said coating and heating the loaded conductor to improve one of its properties and to reduce said coating to a powder-like condition.

In witness whereof, I hereunto subscribe my name this 24th day of November, A. D. 1926.

FRANK F. FARNSWORTH.