July 15, 1969 W. S. FUJITSUBO 3,456,245

MULTIAPERTURE CORE CONNECTOR

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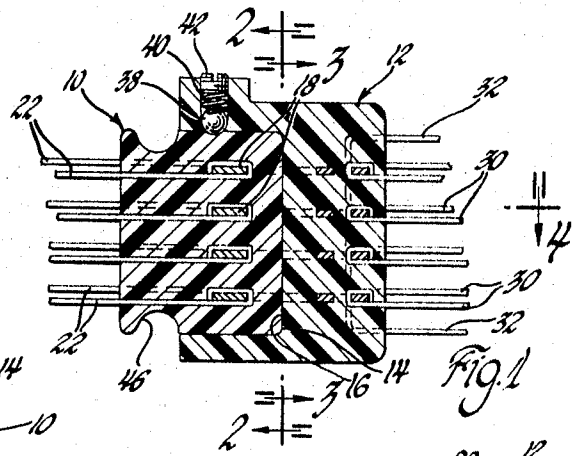


Fig. 1

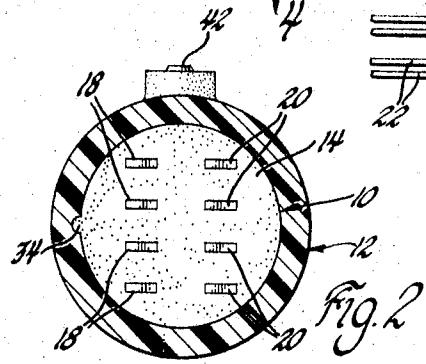


Fig. 2

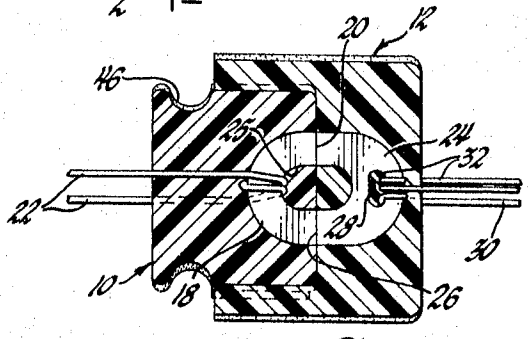


Fig. 4

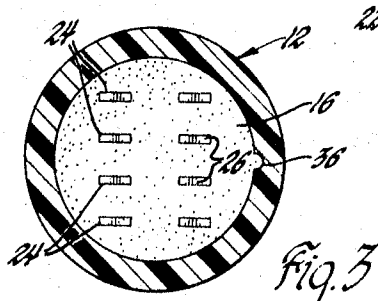


Fig. 3

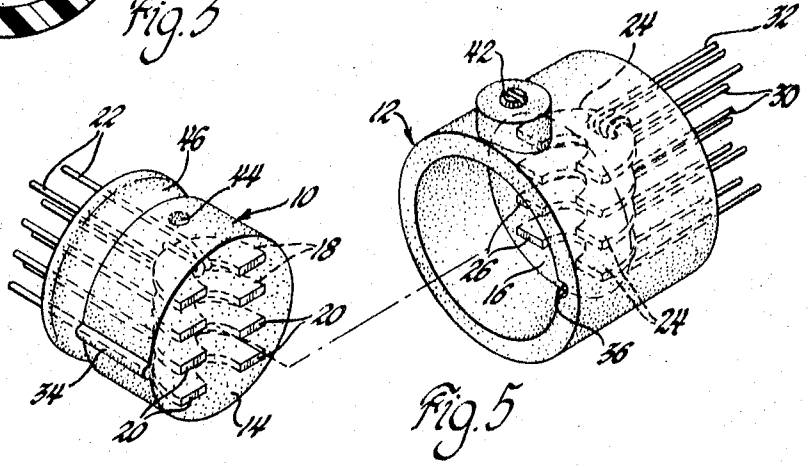


Fig. 5

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MULTIAPERTURE CORE CONNECTOR

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ABSTRACT OF THE DISCLOSURE

A magnetic core connector for digital information communication paths. Matable connector members are joined to complete a multiaperture core representing a magnetic signal transfer path. In the unjoined state, one connector retains signal information in one or more partial cores containing closed flux paths.

SUMMARY OF THE INVENTION

This invention relates to electrical signal conveying apparatus and more particularly to such signal conveying apparatus as employs transfer means in the form of high remanence magnetic flux elements of such a nature that the conveyed information may be retained even after a connection is broken.

Conventionally, electrical connections between two or more electrical units are made by way of connectors including conductive pins adapted to be mated with conductive sockets. Since information transfer by way of such connectors depends upon electron movement between the pin and socket, the signal conveyance is lost if the conductive connection is broken. It is often critical that the information content of the signal conveyed be retained even if the connection between the particular electrical units involved is broken. The conventional pin-socket connector may not be employed in such a situation. Further, many situations arise where it is not convenient or possible to maintain the two or more electrical units between which signals are to be conveyed in close proximity.

In accordance with one specific form of the present invention, the information content of electrical signals conveyed between two or more electrical units may be retained even if the physical connection between the units is broken. This is accomplished by way of connector apparatus in which electrical signals are magnetically transferred by way of first and second magnetic elements of high magnetic remanence which, when brought into contact through predetermined terminal surfaces, form a closed magnetic flux path through which electrical information may be inductively conveyed. In accordance with the invention, the second or receiving magnetic element has formed therein an aperture defining a closed flux path which includes a portion of the flux path which is formed whenever the first and second elements are brought into contact. In accordance with the operation principles applying to the well-known "transfluxor" element, the flux path formed by contact between the two elements may be operated in a control mode to block or unblock the closed flux path about the aperture in the second element according to the remanent magnetic state into which the elements are placed by suitable input signals. Since the elements remain in the remanent state in which they are last placed, it is possible to remove the magnetic elements from mutual contact without a resulting loss in the value of information conveyed between the elements.

Thus it may be seen that the connector apparatus which is provided by one form of the present invention incorporates a memorization faculty which allows the physical connection to be broken without resulting loss of information.

In a particular embodiment of the invention, a multichannel signal conveying apparatus may be provided through the provision of a plurality of the first and second magnetic elements occupying predetermined positions in input and output connector means such that joining the connectors establishes a plurality of signal channels through contacting magnetic elements.

The invention may be best understood by reference to a description of a specific embodiment thereof. Such a description is given in the following specification which is to be taken with the accompanying figures of which:

FIGURE 1 is a cross-sectional view of a specific embodiment of the invention adapted to provide a plurality of signal channels:

FIGURE 2 is a view of the embodiment shown in FIGURE 1 taken along a section line 2—2 thereof;

FIGURE 3 is a view of the other of the connector members shown in FIGURE 1 and taken along a section line 3—3 thereof;

FIGURE 4 is a top cross-sectional view of the embodiment of FIGURE 1 more clearly illustrating the nature of the magnetic elements used therein; and

FIGURE 5 is an isometric view of the connector members of the specific embodiment indicating the manner in which physical connection may be accomplished.

The drawings show a specific embodiment of the invention having four information channels through which signals may be transferred between two or more electrical units. Referring specifically to FIGURE 1, the signal conveying apparatus includes a cylindrical male connector member **10** and a female connector member **12** having a cylindrical recess which is adapted to receive the male connector member **10**. The connector members **10** and **12** may be made of an insulative plastic such as Bakelite. As shown in FIGURES 2 and 5, the male connector member **10** has a planar mating surface **14** and, as shown in FIGURES 3 and 5, the female connector member **12** has a planar mating surface **16**. The mating surfaces **14** and **16** are brought into abutment whenever the connector members **10** and **12** are joined as shown in FIGURE 1.

The male connector member **10** has molded in place therein four U-shaped magnetic elements **18** made of a material exhibiting a high magnetic remanence. For example, elements **18** may be made of ferrite. Each of the elements **18** defines an open magnetic flux path ending at terminal surfaces **20**. The elements **18** are disposed in the connector member **10** such that the terminal surfaces **20** of the elements **18** are accessibly adjacent the mating surface **14**, which is to say that the terminal surfaces **20** are exposed such that direct contact may be made therewith. Preferably, the terminal surfaces **20** are flush with mating surface **14** rather than projecting, thus to eliminate the possibility of being inadvertently broken off. As shown in FIGURES 1, 4, and 5, each of the magnetic elements **18** is linked with an individual input winding **22**. The windings **22** are current carrying conductors which are wound around the U-shaped elements **18** to carry current pulses for producing flux changes in the elements **18**.

As shown in FIGURES 1, 3, 4, and 5, the female connector element **12** has molded in place therein four generally horseshoe-shaped magnetic elements **24**, which may also be made of ferrite, each of which defines an open magnetic path of high magnetic remanence. Each of the magnetic elements **24** has two terminal surfaces identified in FIGURE 3 at **26**. These terminal surfaces are accessibly adjacent mating surface **16** of connector member **12** so as to be capable of being brought into contact with the terminal surfaces **20** of magnetic elements **18**. Again, the terminal surfaces **26** of elements **24** are preferably flush with mating surface **14** such that when connector members **10** and **12** are joined in the

manner shown in FIGURE 1 the magnetic elements **18** and **24** form a plurality of closed flux paths around a major aperture **25** as best shown in FIGURE 4.

Each of the magnetic elements **24** has formed therein a minor aperture **28** which defines a closed flux path around the aperture **28**. This closed flux path in each of the elements **24** is linked by an output winding **30** on which voltage signals are produced corresponding with the flux changes which are induced in the flux path around the minor aperture **28**. In addition, each of the apertures **28** of the magnetic elements **24** is linked by an AC drive line **32**. Drive line **32** carries an alternating current which is effective to produce a time varying flux pattern in the closed flux path surrounding the aperture **28** in each of the elements **24**, except when that closed flux path is effectively blocked by signals on input lines **22** as is further discussed in the following.

As best shown in FIGURE 4, when the connector members **10** and **12** are joined such that mating surfaces **14** and **16** are in contact, the terminal surfaces **20** and **26** of the magnetic elements **18** and **24**, respectively, are also brought into contact. Under these circumstances, the open flux paths defined by each of the magnetic elements **18** and **24** are effectively closed by the mating element. The closing of the two open flux paths defined by elements **18** and **24** produces a closed control path which intersects the closed path surrounding aperture **28** in each of the elements **24**. As will be apparent to those skilled in the art, the joined elements **18** and **24** produce a magnetic element which is commonly given the term "transfluxor." In this type of element, the minor flux path surrounding aperture **28** may be effectively blocked or unblocked in accordance with the remanent condition of the major flux path running through both of the elements **18** and **24**. Accordingly, a current signal of one polarity and of the proper magnitude on input lines **22** may block the minor flux path around aperture **28** such that no transformer action takes place between the signals on AC drive line **32** and the output line **30**. On the other hand, a current signal of opposite polarity may be produced in input lines **22** to unblock the minor flux path surrounding aperture **28** thus to allow a transformer action between AC drive line **32** and output line **30**. Under these circumstances the output line **30** is effective to produce a voltage waveform which substantially follows the AC drive signal in line **32** in waveform.

Since elements **18** and **24** are made of a highly remanent material such as ferrite, it can be seen that element **24** will remain in the magnetic state into which it was placed by the last signal occurring on input line **22**. Thus, if element **24** is placed in the unblocked condition by the last occurring signal on input line **22**, the element **24** will remain in that condition whether or not element **18** is taken out of contact with element **24**. Therefore, the male and female connector elements **10** and **12** may be disconnected without a resulting loss in information. This is due to the fact that element **24** remains in the unblocked condition and it remains possible to transfer information between AC drive line **32** and the output line **30** by transformer action. Similarly, if the last occurring signal on input line **22** blocked the minor flux path around aperture **28**, the element **24** would remain in this condition despite the fact that connector members **10** and **12** were disconnected.

It can be seen that the signal conveying apparatus which is provided by the present invention thus contains a memory faculty which allows the connector members **10** and **12** to be disconnected and remotely separated without any resulting loss in information.

In order to effectively set up the four signal transfer paths by way of the elements **18** and **24**, it is of course necessary that upon connection of members **10** and **12** the terminal surfaces **20** of elements **18** be in contact with terminal surfaces **26** of element **24**. Accordingly, elements **18** and elements **24** are correspondingly aligned in the connector members **10** and **12**, respectively. In addition, connector member **10** is provided with a radially protruding and axially extending ridge **34** which is adapted to mate with a correspondingly positioned keyway **36** in the receiving connector member **12** to insure the proper alignment of elements **18** and **24**. In addition, means are provided to maintain the connector members **10** and **12** in the connected position. This means includes a radially extending opening in connector member **12** which receives a metal ball **38** and the combination of a tensioning spring **40** and adjustment screw **42**. Connector member **10** has formed therein a shallow dentent **44** which is adapted to receive the ball **38** to provide a holding force tending to maintain the members **10** and **12** in the connected position. This force may be easily overridden by an axially extending separating force which may be conveniently applied to the members **10** and **12** by way of an annular grip **46** which is formed in the outer cylindrical surface of connector member **10**.

The specific embodiment shows signal conveying apparatus having four signal channels. It is to be understood that a greater or lesser number of signal channels may be provided in accordance with the specific application of the invention. It may further be seen that each of the signal channels may be separately employed or, in the alternative, various coded combinations of the signal channels may be provided. Such coded combinations may be accomplished by linking various combinations of elements **18** and **24** with the particular windings **22**, **30**, and **32**. In a somewhat different form of the invention, it may be desirable to divide the magnetic material of elements **18** and **24** across the controlled flux aperture **28** rather than across the control aperture formed jointly by elements **18** and **24** as shown in FIGURE 4. According to this form of the invention, the input lines **22** may be used to preprogram each of the channels of information by switching the residual flux around the above defined control aperture in one direction or the other. Depending on the residual flux direction, the flux path around split minor aperture **28** will be blocked or unblocked, thus allowing the same memorization faculty previously described to be accomplished by the combination of magnetic elements and drive line and input and output lines.

Since various other modifications may be made to the specific embodiment without departing from the spirit and scope of the invention, it is to be understood that this above description is not to be construed as in a limiting sense. For a definition of the invention reference should be had to the appended claims.

I claim:

1. Electrical signal conveying apparatus including a first high remanence magnetic element defining a first open magnetic flux path having two terminal surfaces, a second high remanence magnetic element defining a second open magnetic flux path having two terminal surfaces, the second element having formed therein an aperture defining a closed flux path including a portion of the second open flux path, connector means for placing the terminal surfaces of the first and second elements in contact thereby linking the first and second open flux paths to form a control path capable of blocking or unblocking the closed flux path according to the remanent state of the second element, an input winding linking the first element for controlling the remanent state of the control path, an output winding linking the closed path for producing signals representing the flux changes therein, and a drive winding linking the closed path for producing a time varying flux pattern therein.

2. Multichannel electrical signal conveying apparatus including a plurality of first high remanence magnetic elements each defining a first open magnetic flux path having two terminal surfaces, a plurality of second high remanence magnetic elements each defining a second open magnetic flux path having two terminal surfaces, each of

the second elements having formed therein an aperture defining a closed flux path including a portion of the second open flux path, connector means for placing the terminal surfaces of individual first elements into contact with the terminal surfaces of corresponding second elements to form, in combination, a plurality of control paths for blocking or unblocking the closed flux paths of the second elements according to the remanent flux states thereof, input lines linking the first elements for controlling the remanent states of the control paths, output lines linking individual second open flux paths for producing output signals representing flux changes therein, and a drive winding linking the closed paths for producing a time varying flux pattern therein.

3. Electrical signal conveying apparatus including a first connector member having a first mating surface, a first high remanence magnetic element defining a first open magnetic flux path having two terminal surfaces, the element being affixed to the first connector member with the terminal surfaces accessibly adjacent the first mating surface, a second connector member having a second mating surface adapted to receive the first mating surface, a second high remanence magnetic element defining a second open magnetic flux path having two terminal surfaces, the second element also having formed therein a minor aperture defining a closed magnetic flux path including a portion of said second open magnetic flux path, the second magnetic element being affixed to the second connector member with the terminal surfaces accessibly adjacent the second mating surface thereby to mate with the terminal surfaces of the first magnetic element when the first and second mating surfaces are in proximity to form a closed magnetic flux path from the first and second open flux paths, an input winding linking the first magnetic element for inducing flux changes in the element according to input current signals in the winding, an output winding linking the closed flux path of the second magnetic element for producing output signals representing the flux changes in the closed path, and a drive winding linking the closed flux path for producing a time varying flux pattern in the closed path.

4. Multichannel electrical signal conveying apparatus including a plurality of first high remanence magnetic elements each defining a first open magnetic flux path having two terminal surfaces, a first connector member for carrying the first elements in a predetermined disposition, a plurality of second high remanence magnetic elements each defining a second open magnetic flux path having two terminal surfaces, a second connector member for carrying the second elements in a predetermined disposition and adapted to be joined with the first connector member thereby to place the terminal surfaces of individual first elements into contact with the terminal surfaces of corresponding second elements to form, in combination, a plurality of control flux paths for blocking and unblocking the closed flux paths of the second elements according to the remanent flux states of the control paths, a plurality of input lines linking the first elements for controlling the remanent states of the control paths, a plurality of output lines linking individual second open flux paths for producing output signals representing flux changes therein, and a drive winding linking the closed paths for producing a time varying flux pattern therein.

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336—155