

PATENT SPECIFICATION

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(54) ELECTROMECHANICAL TRANSDUCERS

(71) We, FONOFILM INDUSTRI A/S., a Danish Company, of Trommesalen 5, Copenhagen, Denmark, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electromechanical transducers, and is more particularly concerned with replaceable mechanical input assemblies therefore, for example replaceable stylus assemblies of stereophonic phonograph record-playing cartridges.

Such a cartridge may have a magnetic structure defining an airgap and comprising four magnetic legs, each surrounded by an individual coil, together with permanent magnetic means for producing a magnetic field in said airgap in which a stylus-carrying armature is pivotally mounted. By arranging the magnetic legs in two pairs defining respective planes perpendicular to each other the signals produced by movements of the stylus can be resolved into two components corresponding respectively to the two recorded tracks of a disc-form stereophonic record.

In one such cartridge, or pick-up assembly, the armature itself is constituted by a permanent magnet. However, the requirements as to reproduction of signals at the upper end of the audio frequency spectrum have led to the development of a pick-up assembly in which the effective stylus mass has been reduced by using a permanent magnet placed outside the oscillating stylus system for producing the magnetising force, so that the armature may be constituted by a light tube of magnetically conductive material such as soft iron. The armature is coupled magnetically in series with the coil-carrying legs, so that signal-producing flux changes are produced by al-

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terations of the overall reluctance of the magnetic circuit caused by movements of the armature.

According to one aspect of the present invention there is provided an electromechanical transducer device, comprising a pair of permanent magnet portions arranged to provide respective components of magnetic flux that are similarly directed in an airgap between the permanent magnet portions, yoke means providing a magnetically conductive connection between respective pole faces, or like polarity, of the permanent magnet portions, electrical output coil means surrounding portions of the yoke means for delivering electrical output signals induced by flux changes produced in the yoke means, and an armature made of magnetic material mounted adjacent to the permanent magnet portions so as to act thereon as a magnetic shunt taking up the said respective components of magnetic flux, the armature being capable of movement with respect to the permanent magnet portions so as to alter, relatively to one another, the respective shunting effects of the armature on the two permanent magnet portions and thereby produce said flux changes, wherein the yoke means and the electrical output coil means form parts of an electrical output assembly of the device, and the said permanent magnet portions and the armature form parts of a replaceable input assembly which is removably attached to the electrical output assembly.

According to a second aspect of the present invention there is provided, for use with the electrical output assembly of a device according to the said one aspect of the present invention, a replaceable input assembly as specified in the last preceding paragraph.

A device according to the said one as-

pect of the present invention can be embodied in a monophonic pick-up assembly. A stereophonic pick-up assembly embodying the invention further comprises a second pair of permanent magnet portions arranged to provide in the said airgap, which extends therebetween, respective components of magnetic flux that are directed similarly to those mentioned in the last but one preceding paragraph, the magnet portions of the second pair being spaced apart in a direction transverse to that in which the magnet portions of the pair mentioned in the last but one preceding paragraph are spaced apart, the said yoke means providing a magnetically conductive connection between respective pole faces, of like polarity, of the permanent magnet portions of the second pair, and the electrical output assembly having second electrical output coil means surrounding further portions of the yoke means for delivering second-channel electrical output signals induced by flux changes produced in the yoke means, the said armature being also adjacent to the permanent magnet portions of the second pair so as to act thereon as a magnetic shunt and being capable of movement with respect to the second pair of permanent magnet portions so as to alter, relatively to one another, the respective shunting effects of the armature on those permanent magnet portions and thereby produce said flux changes that induce the said second-channel electrical output signals when the assembly is in use, the said further portions not forming part of the magnetically conductive connection specified in the last but one preceding paragraph, and those portions specified in that last but one preceding paragraph not forming part of the said magnetically conductive connection between the permanent magnet portions of the second pair. When such a cartridge is assembled ready for use the permanent magnet portions, yoke means and armature are preferably perfectly symmetrical about a central longitudinal axis of the armature when in a rest position.

The said permanent magnet portions may be constituted by respective bar magnets. Alternatively they may be constituted by respective integral parts of an annular permanent magnet, for example a hollow cylindrical body which is made of magnetisable ceramic material, which is permanently magnetised parallel to its central axis and surrounds the said airgap.

According to a third aspect of the present invention there is provided a replaceable stylus assembly for a phonograph record-playing cartridge, the assembly comprising a support member carrying an elongate armature made of magnetic

material, pivotally connected to the support member by means of a ring of resilient material through which the armature extends, and an axially-magnetised annular permanent magnet attached to the support member so as to be coaxial with the armature when it is in an equilibrium disposition with respect to the support member, the annular permanent magnet having at a rearward axial end thereof a pole face which is free to be brought into abutment with forward ends of magnetic core members of the cartridge when the stylus assembly is brought into operative engagement with the cartridge.

Reference will now be made, by way of example, to the accompanying drawings, in which:—

Figure 1 shows a central longitudinal section (in a vertical plane) through a record-playing carriage (pick-up assembly), including a replaceable stylus assembly, embodying the present invention.

Figure 2 shows to a larger scale a partial section in a plane corresponding to line II-II of Figure 1, and

Figure 3 shows a perspective view, partly cut-away, of parts of the cartridge of Figure 1, seen from underneath and forward of a front end (the left-hand end in Figure 1) of the cartridge with the stylus assembly partially withdrawn.

The illustrated cartridge includes, in addition to the stylus assembly, an electrical output assembly which comprises a housing member 1 cast in a suitable plastics material. At the rear end (the right-hand end in Figure 1) the housing member has a recess 7 in which is mounted a contact support 2 provided with four connection pins 3, of which only two are seen in Figure 1. The replaceable stylus assembly is mounted at the front end of the housing member, and comprises a cast plastics support body 4 having a projecting hollow guide pin 5, of non-circular cross-section, which is engaged and retained frictionally within a recess 6 formed in the housing member 1 and having the same cross-section as the pin 5.

Between a lower part of the recess 7 and the front face of the housing member 1 is provided a through-going passageway with a rear portion 8, of substantially square cross-section, and a front portion 9 the cross-section of which, as indicated in Figure 2, comprises a middle circle and four peripheral circles tangential to the middle circle and symmetrically disposed about the centre of the middle circle.

The said through-going passageway (8, 9) extends obliquely downwards from the rear to front of the housing member 1, and serves as accommodation for a magnetic structure which comprises four relatively

thin cylindrical rods 10 of permalloy, front portions of which are disposed respectively in the cylindrical peripheral portions of the passageway portion 9 and which extend rearwardly through the passageway portion 8. The rear ends of the rods 10 are attached to and interconnected magnetically by a cross-piece 11, for example a cruciform cross-piece, also made of permalloy, so as to serve as magnetic yoke means. About each rod 10 is disposed a coil 12 which is mounted in the passageway portion 8, and the coils of each diametrically opposed pair are connected to one another in series between two of the pins 3 by means of leads 13.

In the lower portion of the support body 4 of the stylus assembly is formed an obliquely inclined cylindrical throughgoing passageway 15, the front end of which constitutes an opening in an underface of the body 4, arranged to form an extension of the central cylindrical part of the passageway 9 in the housing member 1. In this passageway 15 is secured a tube 16 of a non-magnetic material, for instance aluminium, which projects from the support body 4 and, when the stylus assembly is fitted, enters the cylindrical central part of the passageway 9. An annular permanent magnet 14, of hollow cylindrical form, which is magnetised in an axial direction thereof and consists of a ceramic magnetically-anisotropic material, is fixedly mounted coaxially on the outside of the tube 16 so as to have one axial end thereof, being the forward pole-face of the magnet, against a rearward face of the support body 4. When the stylus assembly is fitted operatively to the electrical output assembly, as shown in Figure 1, the magnet 14 is accommodated in an enlarged part of the passageway portion 9, at the front of the housing member 1, with its rearward pole-face in abutment with the free ends of the magnetic core rods 10.

Within the tube 16 is a tubular soft iron armature 17 is mounted by means of a ring of resilient material 18, for instance of rubber or neoprene, to be freely pivotable in all directions about a point disposed in or adjacent to the centre of the ring. The armature 17 is longer than the annular magnet 14, which is mounted with its forward pole-face adjacent to the resilient ring 18, and is disposed co-axially and symmetrically with respect to that magnet. To the armature is attached one end of a tubular, thin-walled aluminium stylus arm 19 extending through the passageway 15. The free end of the stylus arm 19 projecting outwardly of the support body 4 is flattened and carries a stylus 20.

On an underface of the housing member 1 is mounted a magnetic screen 21 which

extends upwardly along the front face of the housing member, between the housing member and the support body 4 of the stylus assembly.

Thus, in contrast to the pick-up assembly (cartridge) described and illustrated in the main patent specification no 1,293,636, wherein the annular permanent magnet 14 is fixed to the housing member 1, in the present case the magnet 14 is a fixed part of the replaceable stylus assembly. This enables the cartridge's operating characteristics to be altered by replacement of a first stylus assembly by a second stylus assembly having a magnet 14 of a type different from that of the first stylus assembly.

In a modified form of the cartridge illustrated in the present drawings, the armature consists of, or includes, a permanent magnet having its poles positioned respectively adjacent to the magnetically opposite poles of the annular magnet 14. In such a case it is important that the armature magnet should be properly positioned relative to the annular magnet 14 when the cartridge is in use, and such correct relative positioning of the magnets is more readily ensured, on replacement of the stylus assembly, if the annular magnet 14 is a fixed part of the stylus assembly rather than of the electrical output assembly.

The magnetic attraction of the annular magnet 14 to the free ends of the core rods 10 tends to aid the retention of the stylus assembly in its operative position with the rearward pole-face of the magnet 14 abutting against those free ends.

The principle of operation of the presently illustrated cartridge is as described in the main patent specification no. 1,293,636, with reference to Figure 4 thereof. Thus, the anisotropic ceramic annular magnet 14 shows great reluctance in all directions perpendicular to its axis and is therefore magnetically equivalent, so far as one half of the electromagnetic system is concerned, to two permanent bar magnets disposed at the end, and in extension, of respective rods 10 of a diametrically opposed pair. Assuming the two bar magnets to be of equal strength, and to have their respective north pole faces abutting against the free ends of the two rods 10, the magnetically conductive connecting yoke formed by the rods 10 and the cross-piece 11 will have the same magnetic potential at its two end faces, when the armature 17 is in its rest position, so that no flux will pass along the path provided by the connecting yoke. A relatively high flux will pass from the north pole of each such bar magnet through the armature to the south pole of the bar magnet, and as the ar-

mature has a much lower reluctance than the ceramic magnets, and the spaces between the armature and the magnets in actual practice are very small, this flux may with some justification be described as a short circuit flux.

If the armature, as a result of oscillatory movement of the stylus, approaches one such bar magnet, thereby reducing the reluctance in the short circuit flux path for that magnet and simultaneously moving away from the other bar magnet, the short circuit flux of that other magnet meets increased reluctance. In other words, the short circuit flux of the one bar magnet will be increased and that of the other bar magnet will be reduced. On account of the relatively high inherent reluctance of such bar magnets this will cause the magnetic potential at the north pole of the one bar magnet to be reduced, while the magnetic potential at the north pole of the other bar magnet will be increased. Thus a magnetic potential difference is created between the two ends of the magnetic conductor path provided by the yoke (10, 11, 10) in response to the armature movement, which results in a change of magnetic flux in that conductor path, inducing in the coil windings 12 electrical voltages. Thus the oscillations of the armature in the plane of the diametrically opposed pair of rods 10, as the stylus tracks a stereophonic recording groove, can produce electrical signals, in the associated coils 12, which together represent a sensed sound channel signal.

Armature oscillations resulting from the other sound channel are effectively in a plane perpendicular to the plane of the aforesaid diametrically opposed pair of rods 10 and are converted in the same manner to electrical voltages in the other two coils of the electromagnetic system, which coils surround the two rods 10 whose axes lie in that perpendicular plane.

The magnetic yoke components 10 and 11 carry only the effective signal flux, which changes direction in response to the armature oscillations, and the rods 10 can therefore be made very thin without risking deviation of the magnetic point of operation from the rectilinear part of the magnetisation curve. This thinness of the rods 10 permits the use of signal output coils 12 having low resistance and capacity.

The stereo cartridge shown in Figures 1 to 3 of the drawings can, in principle, be changed into a mono pick-up assembly merely by removing one diametrically opposed pair of the rods 10 and rotating the remaining pair through an angle of approximately 45°, about the central axis of symmetry of the magnetic structure, with respect to the stylus assembly.

In the cartridge illustrated the armature

17 is constituted by a thin-walled tube of soft iron, so that the effective inertia of the oscillating stylus arrangement is minimised. It is possible, however, as indicated hereinbefore, to replace or supplement the soft iron armature by a permanent magnet, which may be tubular or rod-shaped, poled oppositely to the fixed ceramic magnet 14, so that it increases the short circuit flux. In this way the sensitivity of the cartridge can be increased to some degree.

It will be understood that it would be possible to modify the structure in various other respects. Thus, for example, the core rods 10 may be square or rectangular in cross-section, instead of circular, the armature may have other cross-sectional shapes.

WHAT WE CLAIM IS:—

1. An electromechanical transducer device, comprising a pair of permanent magnet portions arranged to provide respective components of magnetic flux that are similarly directed in an airgap between the permanent magnet portions, yoke means providing a magnetically conductive connection between respective pole faces, of like polarity, of the permanent magnet portions, electrical output coil means surrounding portions of the yoke means for delivering electrical output signals induced by flux changes produced in the yoke means, and an armature made of magnetic material mounted adjacent to the permanent magnet portions so as to act thereon as a magnetic shunt taking up the said respective component of magnetic flux, the armature being capable of movement with respect to the permanent magnet portions so as to alter, relatively to one another, the respective shunting effects of the armature on the two permanent magnet portions and thereby produce said flux changes, wherein the yoke means and the electrical output coil means form parts of an electrical output assembly of the device, and the said permanent magnet portions of the armature form parts of a replaceable input assembly which is removably attached to the electrical output assembly.

2. A device as claimed in claim 1, wherein the replaceable input assembly further comprises a second pair of permanent magnet portions arranged to provide in the said airgap, which extends therebetween, respective components of magnetic flux that are directed similarly to those specified in claim 1, the magnet portions of the second pair being spaced apart in a direction transverse to that in which the magnet portions of the pair specified in claim 1 are spaced apart, said yoke means providing a magnetically conductive con-

mature has a much lower reluctance than the ceramic magnets, and the spaces between the armature and the magnets in actual practice are very small, this flux may with some justification be described as a short circuit flux.

If the armature, as a result of oscillatory movement of the stylus, approaches one such bar magnet, thereby reducing the reluctance in the short circuit flux path for that magnet and simultaneously moving away from the other bar magnet, the short circuit flux of that other magnet meets increased reluctance. In other words, the short circuit flux of the one bar magnet will be increased and that of the other bar magnet will be reduced. On account of the relatively high inherent reluctance of such bar magnets this will cause the magnetic potential at the north pole of the one bar magnet to be reduced, while the magnetic potential at the north pole of the other bar magnet will be increased. Thus a magnetic potential difference is created between the two ends of the magnetic conductor path provided by the yoke (10, 11, 10) in response to the armature movement, which results in a change of magnetic flux in that conductor path, inducing in the coil windings 12 electrical voltages. Thus the oscillations of the armature in the plane of the diametrically opposed pair of rods 10, as the stylus tracks a stereophonic recording groove, can produce electrical signals, in the associated coils 12, which together represent a sensed sound channel signal.

Armature oscillations resulting from the other sound channel are effectively in a plane perpendicular to the plane of the aforesaid diametrically opposed pair of rods 10 and are converted in the same manner to electrical voltages in the other two coils of the electromagnetic system, which coils surround the two rods 10 whose axes lie in that perpendicular plane.

The magnetic yoke components 10 and 11 carry only the effective signal flux, which changes direction in response to the armature oscillations, and the rods 10 can therefore be made very thin without risking deviation of the magnetic point of operation from the rectilinear part of the magnetisation curve. This thinness of the rods 10 permits the use of signal output coils 12 having low resistance and capacity.

The stereo cartridge shown in Figures 1 to 3 of the drawings can, in principle, be changed into a mono pick-up assembly merely by removing one diametrically opposed pair of the rods 10 and rotating the remaining pair through an angle of approximately 45°, about the central axis of symmetry of the magnetic structure, with respect to the stylus assembly.

In the cartridge illustrated the armature

17 is constituted by a thin-walled tube of soft iron, so that the effective inertia of the oscillating stylus arrangement is minimised. It is possible, however, as indicated hereinbefore, to replace or supplement the soft iron armature by a permanent magnet, which may be tubular or rod-shaped, poled oppositely to the fixed ceramic magnet 14, so that it increases the short circuit flux. In this way the sensitivity of the cartridge can be increased to some degree.

It will be understood that it would be possible to modify the structure in various other respects. Thus, for example, the core rods 10 may be square or rectangular in cross-section, instead of circular, the armature may have other cross-sectional shapes.

WHAT WE CLAIM IS:—

1. An electromechanical transducer device, comprising a pair of permanent magnet portions arranged to provide respective components of magnetic flux that are similarly directed in an airgap between the permanent magnet portions, yoke means providing a magnetically conductive connection between respective pole faces, of like polarity, of the permanent magnet portions, electrical output coil means surrounding portions of the yoke means for delivering electrical output signals induced by flux changes produced in the yoke means, and an armature made of magnetic material mounted adjacent to the permanent magnet portions so as to act thereon as a magnetic shunt taking up the said respective component of magnetic flux, the armature being capable of movement with respect to the permanent magnet portions so as to alter, relatively to one another, the respective shunting effects of the armature on the two permanent magnet portions and thereby produce said flux changes, wherein the yoke means and the electrical output coil means form parts of an electrical output assembly of the device, and the said permanent magnet portions of the armature form parts of a replaceable input assembly which is removably attached to the electrical output assembly.

2. A device as claimed in claim 1, wherein the replaceable input assembly further comprises a second pair of permanent magnet portions arranged to provide in the said airgap, which extends therebetween, respective components of magnetic flux that are directed similarly to those specified in claim 1, the magnet portions of the second pair being spaced apart in a direction transverse to that in which the magnet portions of the pair specified in claim 1 are spaced apart, said yoke means providing a magnetically conductive con-



nection between respective pole faces, of like polarity, of the permanent magnet portions of the second pair, and the electrical output assembly having second electrical output coil means surrounding further portions of the yoke means for delivering second-channel electrical output signals induced by flux changes produced in the yoke means, the said armature being also adjacent to the permanent magnet portions of the second pair so as to act thereon as a magnetic shunt and being capable of movement with respect to the second pair of permanent magnet portions so as to alter, relatively to one another, the respective shunting effects of the armature on those permanent magnet portions and thereby produce said flux changes that induce the said second-channel electrical output signals when the device is in use, the said further portions not forming part of the magnetically conductive connection specified in claim 1, and those portions of the yoke means that are specified in claim 1 not forming part of the said magnetically conductive connection between the permanent magnet portions of the second pair.

3. A device as claimed in claim 1 or 2, wherein the said armature is mounted so as to have a rest position extending along an axis about which the said permanent magnet portions are substantially symmetrically distributed and so as to be capable of pivotal oscillatory movement with respect to the said permanent magnet portions.

4. A device as claimed in claim 3, wherein the armature is mounted so as to be capable of such pivotal movement in all directions about a pivot point which is on the said axis but is spaced therealong from the mid-point, as measured along the axis, of the structure constituted by the permanent magnet portions.

5. A device as claimed in claim 3 or 4, wherein the armature is supported, so as to be capable of such movement, by a ring of resilient material through which the armature extends along the said axis.

6. A device as claimed in any one of claims 3 to 5 when they are read as appendant to claim 2, wherein the permanent magnet portions of the pair specified in claim 1 have respective magnetic axes that lie in a first plane, and the magnet portions of the said second pair have respective magnetic axes that lie in a second plane which is perpendicular to the said first plane and intersects it along the said axis.

7. A device as claimed in claim 6, wherein the said axis is parallel to and equidistant from the respective magnetic axes of the four permanent magnet portions.

8. A device as claimed in any one of claims 3 to 7, wherein the electrical output assembly includes a housing member within which are mounted the yoke means and the electrical output coil means and which is formed with a passageway extending along the said axis, which is an axis of symmetry of the magnetic structure constituted by the permanent magnet portions and yoke means together, so that the said airgap is constituted by a part of the passageway, the electrical output coil means being connected with output terminals which are fixedly mounted on the housing member.

9. A device as claimed in claim 8, wherein the said replaceable input assembly is removably attached to the said housing member by virtue of frictional engagement between respective mating portions of the housing member and the input assembly.

10. A device as claimed in claim 9, wherein the input assembly includes a non-magnetic tube within which the armature is mounted to extend, when at rest, along the axis of the tube, the tube being received in the said passageway but being withdrawn therefrom with the rest of the input assembly when the said mating portions are disengaged.

11. A device as claimed in any preceding claim, wherein the armature comprises magnetically soft material.

12. A device as claimed in any preceding claim, wherein the armature comprises a permanent magnet.

13. A device as claimed in any preceding claim, wherein the armature is tubular.

14. A device as claimed in any preceding claim, wherein the said permanent magnet portions are constituted by respective integral parts of an annular permanent magnet which is permanently magnetised parallel to its central axis and surrounds the said airgap, being coaxial with the armature when at rest.

15. A device as claimed in claim 14 read as appendant to claim 10, wherein the said tube extends coaxially through the annular permanent magnet, which is fixedly mounted on the tube.

16. A device as claimed in claim 15 read as appendant to claim 5, wherein the annular permanent magnet is mounted with a forward pole face thereof adjacent to a rearward axial end of the said ring of resilient material, which is mounted within the said tube.

17. A device as claimed in any one of claims 1 to 13, wherein the said permanent magnet portions are constituted by respective bar magnets.

18. A device as claimed in any pre-



- ceding claim, wherein the yoke means comprise elongate magnetic core portions which are equal in number to the said permanent magnet portions and which are
- 5 arranged as respective longitudinal extensions thereof and which are magnetically interconnected at their ends remote from the said permanent magnet portions and which have their other ends
- 10 arranged to abut respectively against the said permanent magnet portions and which provide those portions of the yoke means that are surrounded by the electrical output coil means.
- 15 19. A device as claimed in claim 18, wherein the elongate magnetic core portions are constituted by relatively thin rods of a high permeability material and are interconnected at their ends remote from the
- 20 said permanent magnet portions by a common cross-piece.
20. A device as claimed in claim 18 or 19, where each of the elongate magnetic core portions is of circular cross-section.
- 25 21. A device as claimed in claim 18, 19 or 20, wherein the two elongate magnetic core portions that abut respectively against the permanent magnet portions of claim 1 extend axially through first and
- 30 second coils respectively, which coils are connected together in series to constitute the electrical output coil means of claim 1.
22. A device as claimed in claim 21 when read as appendant to claim 2,
- 35 wherein the two elongate magnetic core portions that abut respectively against the permanent magnet portions of the said second pair extend axially through third and fourth coils respectively, the third and
- 40 fourth coils being connected together in series to constitute the said second electrical output coil means.
23. A device as claimed in any preceding claim, wherein the replaceable input
- 45 assembly further comprises a record-playing stylus connected mechanically to the armature for imposing such movement on the armature, as the stylus tracks an impressed audio recording, thereby to cause
- 50 the electrical output coil means to deliver electrical output signals which can be used to reproduce the recorded matter audibly.

24. A pick-up assembly, on or for use on a pick-up arm of a record-playing unit, comprising a device as claimed in any one of claims 1 to 22.

25. A stereophonic pick-up assembly for use in playing stereophonic records, comprising a device as claimed in claim 2, 6, 7, or 22, or as claimed in any one of

60 claims 3 to 5 and 8 to 21 when they are read as appendant to claim 2.

26. A pick-up assembly, comprising a device as claimed in claim 2, substantially as hereinbefore described with reference to

65 Figures 1 to 3 of the accompanying drawings.

27. For use with the electrical output assembly of a device as claimed in any one of claims 1 to 23, a replaceable input as-

70 sembly as specified in that one claim.

28. A replaceable stylus assembly for a phonograph record-playing cartridge, the assembly comprising a support member carrying an elongate armature made of

75 magnetic material, pivotally connected to the support member by means of a ring of resilient material through which the armature extends, and an axially-magnetised annular permanent magnet attached to the

80 support member so as to be coaxial with the armature when it is in an equilibrium disposition with respect to the support member, the annular permanent magnet

85 having at a rearward axial end thereof a pole face which is free to be brought into abutment with forward ends of magnetic core members of the cartridge when the stylus assembly is brought into operative

90 engagement with the cartridge.

29. A replaceable stylus assembly as claimed in claim 28, substantially as hereinbefore described with reference to

95 Figures 1 to 3 of the accompanying drawings.

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