

Feb. 10, 1931.

G. H. PERRYMAN

1,791,973

DIRECTION FINDER

Filed Dec. 5, 1928

2 Sheets-Sheet 1

Fig. 1.

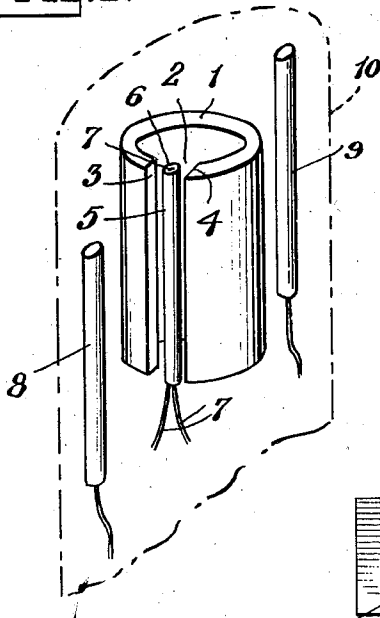


Fig. 2.

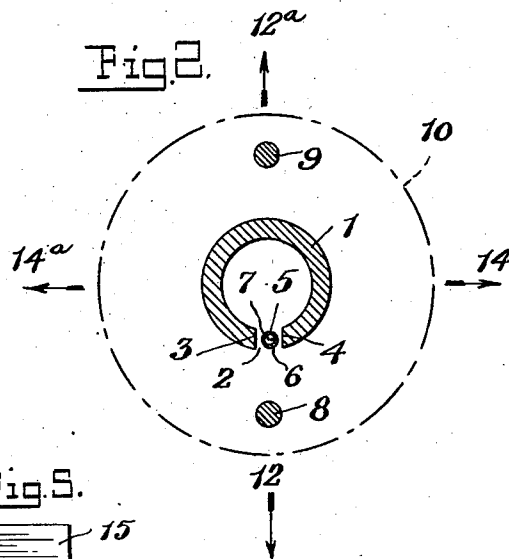


Fig. 5.

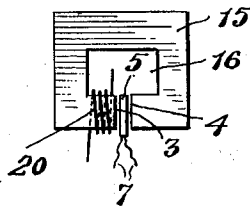


Fig. 3.

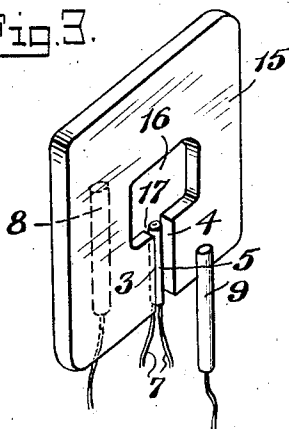
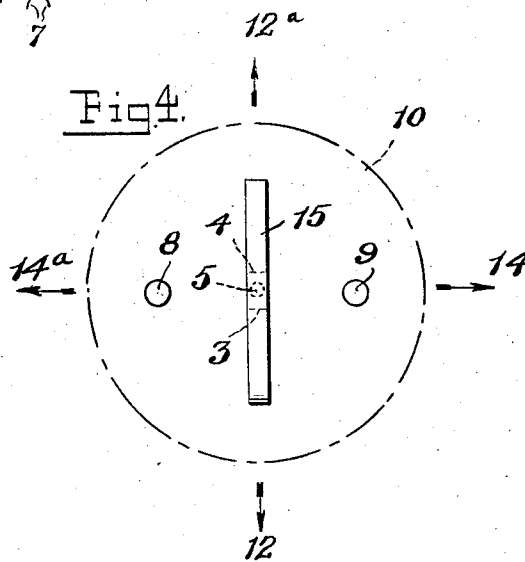


Fig. 4.



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2 Sheets-Sheet 2

Fig. 6.

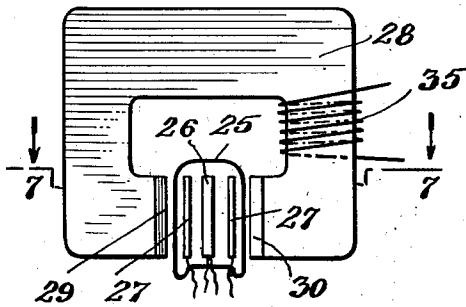


Fig. 7.

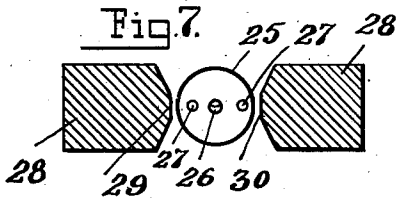


Fig. 8.

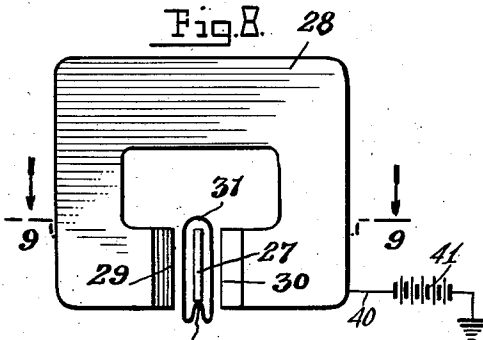


Fig. 9.

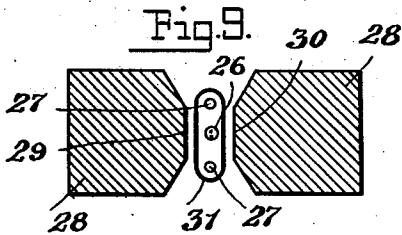


Fig. 10.

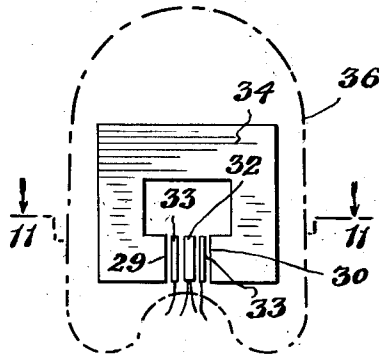


Fig. 11.

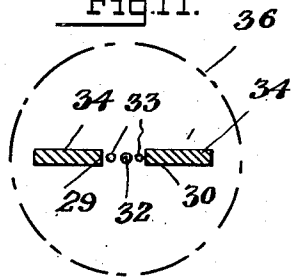
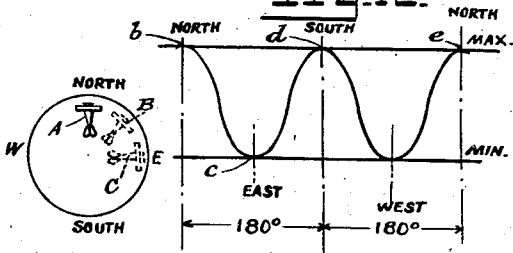


Fig. 12.



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## UNITED STATES PATENT OFFICE

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## DIRECTION FINDER

Application filed December 5, 1928. Serial No. 324,048.

This invention relates to an improvement in compasses or direction finders particularly adapted for use upon aircraft, ships or other craft, and has for its object to provide such a device in which no moving parts are utilized, and in which the primary and important elements of the device may be contained within a vacuum tube.

In my improved direction finder or compass, I utilize the earth's magnetic forces or field for operation upon an electron stream. It is well understood that a magnetic field influences the flow of current from a cathode to an anode in a vacuum. Both electrons as well as positive particles or ions are deflected by magnetic fields. My improved device takes advantage of these known facts for the purpose of direction finding and indicates position by the value of space current. The device which I present is of great simplicity and extremely unlikely to become inoperative as is the case with present day direction finding devices which are usually quite readily rendered inoperative or damaged by engine vibration and other causes.

Referring to the accompanying drawing wherein my improved direction finding device is diagrammatically shown,

Figure 1 is a perspective diagrammatic view of one embodiment of the main elements of my device;

Figure 2 is a transverse sectional view of the same;

Figure 3 is a perspective view of a modification of my invention;

Figure 4 is a plan view of the same;

Figure 5 shows a modified structure;

Figure 6 is a further modification in which the electron-emitting means is contained within a vacuum tube while the magnetic control member is located externally thereof;

Figure 7 is a sectional view on the line 7—7 of Figure 6, looking in the direction of the arrows;

Figure 8 shows a structure somewhat similar to Figure 6, with a variation in tube shape and disposition of the anodes therein;

Figure 9 is a sectional view on the line 9—9 of Figure 8, looking in the direction of the arrows;

Figure 10 shows a structure which is wholly contained within a vacuum tube and in which the cathode and anodes are so disposed as to lie within the plane of the magnetic control member;

Figure 11 is a sectional view on the line 11—11 of Figure 10, looking in the direction of the arrows; and

Figure 12 shows a chart for the purpose of illustrating the operation of my improved compass.

Throughout the various views of the drawings, similar reference characters designate similar parts.

In the embodiment of my invention as disclosed in Figures 1 and 2 of the accompanying drawing, wherein I have diagrammatically illustrated the position of the parts relative to one another, all of the main parts of my device are contained within a vacuum tube. In said structure, 1 indicates the magnetic control element. The same is preferably made of any suitable metal or other material which will possess extraordinary permeability insofar as temporary magnetism in weak fields is concerned. There are many varieties of metal possessing this unique feature, that most commonly used being known as "permalloy". The metal to be selected as most desirable for the purpose should be one which possesses no permanent magnetism but one which possesses extraordinary magnetic permeability at extremely low flux densities.

The control member 1 may be made in many shapes and dimensions, several of which are disclosed in the drawings and for the purpose of convenience and compactness, I have shown the same in Figures 1 and 2 in the form of a short tubular body, continuously slotted as at 2 in its side wall so that the opposite sides of said slot provide opposing poles 3 and 4. While this member is shown as being of a single piece of material, it is obvious that the same may be "built up" or laminated if such a construction is found preferable. This control member is supported in any well-known way within a vacuum tube. Located between said poles is an electron-emitting member 5 which may be a filament or a coated tubular

member 6 heated by an internal filamentary member 7 which derives its heating source from a battery or other source of current. I recommend the use of a cathode made of nickel or other magnetic material since in a filamentary cathode, the magnetic field created by the heating current is quite large. The use of a nickel cathode gives an abundance of electron emission while at the same timesupplies a magnetic shielding which eliminates to some extent the effect of the magnetic field normally created by the heating current. The electron-emitting member forms a cathode and anodes 8 and 9 are shown which upon being electrically charged, serve to cause an electron flow from the electron-emitting member 5 to these anodes. It will be understood that the anodes may be of any suitable shape, as for instance, a rod, bar or plate, and that the same are merely diagrammatically illustrated in the drawing.

The entire apparatus just described may be contained within the usual air-evacuated glass envelope indicated in dotted lines as at 10. In places where it is desired to render the device critical, an amount of inert gas may be contained within the tube envelope.

From the foregoing, the operation of my improved direction finder will be readily understood.

The device is placed in a suitable fixed position upon an aircraft or marine vessel and connected to a suitable source of current for heating the filament or other type of electron emitter and placing a potential upon the anodes. It may be in some instances, found desirable to place a potential upon the control member 1 for the purpose of rendering the apparatus more critical in operation. This is, of course, entirely feasible and is in fact quite common in vacuum tube practice and can be readily done in such cases where it is found necessary or desirable. I have illustrated the application of such potential in Figure 8, where I have shown a wire 40 connected to the member 28 and extending from a battery 41 or other source of current.

When the craft is progressing so that the earth's poles are located as at 12 and 12<sup>a</sup> with respect to the position of the direction finder (Figures 2 and 4) it will be obvious that there is a minimum flow of the earth's magnetic force across the two poles 3 and 4 of the control member 1. Thus, there being a minimum flow of magnetic force across the electron stream flowing from the cathode 5 to the anodes 8 and 9, said electron stream will be at its maximum. When the craft shifts its position whereby the north and south poles of the earth are at right angles to their former position, or in other words are located substantially at 14 and 14<sup>a</sup> it will be seen that the maximum of the earth's magnetic force is caused to flow across the poles 3 and 4 of the control member 1. This acts to retard the

electron flow from anode to cathode, a galvanometer connected into the anode circuit immediately detecting a decrease in the electron flow.

From the statements just made, it is apparent that any position of the craft with respect to the earth's magnetic poles is immediately ascertainable by the relative magnitude of the electron flow. Any deviation from north and south is at once detected by the variation in electron flow and vice versa. The embodiment of my invention disclosed in Figures 3 and 4 differs in construction from that shown in Figures 1 and 2 by the utilization of a flat plate-like member 15 for the control member. This member has a central opening 16 and is slotted from said opening to the edge of the plate thus providing the two poles 3 and 4 between which the cathode 5 is located. In all other respects this embodiment of my invention may be similar to that shown in Figures 1 and 2 and operates in a similar manner.

The designs of the control element herein revealed have for their object:

First. The intensification and concentration of the earth's magnetic field when passing through the space current field.

Second. Great variation in the magnetic field strength through the space current field by the orientation of the control element with respect to direction.

The first object is achieved by the selection of proper magnetizable material and forming it into a contour of low magnetic reluctance which provides small cross-sectional areas at the gap of short span, which includes the space current field.

The second object is attained by selecting a contour through which a large number of the earth's magnetic lines of force will pass in one direction and through which a small number of the earth's magnetic lines of force will pass when the element is at right angles to the first position.

The limitation of my improved direction finder resides only in the fact that it indicates merely with respect to the magnetic meridian at the instantaneous location. In other words, the space current will have the same value for headings at the same angles to the magnetic east and west directions regardless of whether such angles are with respect to the north or to the south. This apparent shortcoming of my structure is however not to be construed as a serious defect since, as illustrated in Figure 12 and explained in detail below, an aviator can readily determine the difference between these two headings by an instantaneous ruddering of his plane slightly to the left or right, taking notice during such swerving movement whether the space current increased or decreased.

Referring now to the diagram disclosed in Figure 12, and assuming that an airplane,

indicated at A, is proceeding directly north. When so proceeding the maximum value of space current will be noted as at *b* on a suitably calibrated instrument. As the plane turns as indicated in dotted lines at B, the value of the space current decreases until the plane is heading directly east, at which time the poles of my direction finder are facing directly east and west and at right angles to the earth's magnetic poles. When in this position (at C Figure 12) the minimum value of space current is arrived at, as indicated at *c*, Figure 12.

As the plane continues its turning movement from east to south, the same space current values will be obtained for the various headings as were obtained during the turning movement during the quadrant located between north and east, as indicated by the curve between *c* and *d*. It will be readily observed however, that the pilot could note immediately whether he passed through either the zero or maximum point if he was flying in some direction between north and east or between east and south by making a slight turn in one or the other direction and noting the value of space current on his meter.

It will be seen that the curve shown in Figure 12 to indicate space current values is similar through each half of the 360 degrees. That is, the easterly curve from north to south (from *b* to *d*) is exactly the same as the curve *d* to *e* on the west side. This is unavoidable but entirely remediable by use of a checking compass such as the ordinary magnetic compass which is entirely adequate for roughly indicating north and south and wholly satisfactory to prevent an 180 degree error in heading. Intermediate headings between north and south are determined with extreme accuracy by my improved direction finder, a performance wholly impossible with the ordinary magnetic compass.

In Figure 5 I show a further embodiment of my invention wherein I utilize a magnetic coil 20 wound about one of the pole pieces. This is entirely feasible and in fact a magnetic coil may be used on the control member in various other ways in cases where the use of such coil is found desirable. The use of such a magnetic coil is especially desirable in cases wherein an amplification of the earth's magnetic force on the control member is desirable. The utilization of a magnetic coil also tends to add sensitivity to the control member thus aiding in effecting in some cases an easier reading or determination of the extent of the earth's magnet flux exerted on the device.

While I have previously mentioned the fact that it may be found desirable to locate all of the primary parts of my device within a vacuum tube, it is also wholly possible to locate some of the parts externally thereof. As an instance of this, attention is directed to the structure disclosed in Figures 6 and 7

wherein is disclosed a vacuum tube 25 containing the electron-emitting means in the form of a cathode 26 and anodes 27. The magnetic control member is disclosed at 28, the same being generally similar in shape and function to that disclosed in Figures 3, 4 and 5. This control member is located externally of the tube 25. It will be here seen that the control member is provided with two pole pieces 29 and 30, the space between these poles being sufficient to accommodate the tube 27. The member is also preferably made of sufficient thickness by the building up of laminations if necessary so that the tube and its interior elements may if desired lie wholly within the plane of the magnetic control member. The control member 28 is shown provided with a magnetic winding 35 which as was explained in reference to the structure shown in Figure 5, may be used when found necessary or desirable.

In Figures 8 and 9, a structure quite similar to that of Figures 6 and 7 is disclosed. Here the tube 31 containing the electron-emitting means previously described with respect to Figures 6 and 7, is different in shape, or elongated in cross-section whereby the electron stream is transverse to the poles. In this structure the poles, disclosed at 29 and 30, can be located in close proximity due to the tube shape.

In Figures 3 and 4 is disclosed a structure wherein the cathode is located within the plane of the magnetic control member and the anodes located externally thereof. While this results in an efficient structure, one in which possibly greater efficiency is attainable, is disclosed in Figures 10 and 11. Here the entire assembly is contained within the tube envelope 36 and the cathode is disclosed at 32 and the anodes at 33. The magnetic control member or plate is disclosed at 34, the same being similar in general shape to the control members disclosed in Figures 3 to 9 inclusive. It will be noted that the cathode 32 and the anodes 33 are so disposed that the same are in substantial alignment between the two poles 29 and 30 of the control member and within the plane of the member.

It will be obvious that my device may be made in many other forms and arrangements; it has no moving parts to be affected by engine vibration and is immediately replaceable since either all or most of its parts may be contained within a vacuum tube.

What I claim is:

1. A direction finder comprising electron-emitting means, and a magnetizable means of high permeability at low flux densities sensitive to the earth's magnetic force adapted to act magnetically upon the electron flow emitted by said electron-emitting means.

2. In a direction finder, electron-emitting means, and a poled electron-control means of high permeability at low flux densities

susceptible to earth magnetic flow adapted to magnetically act upon the electron flow of said electron-emitting means.

3. In a direction finder, a vacuum tube, 5  
electron-emitting means therein, a poled electron-emitting control element composed of a metal of high permeability at low flux densities which is temporarily magnetizable and sensitive to earth magnetic flow, said 10  
member being adapted to act upon the electron flow of the electron-emitting means.

4. In a direction finder, a slotted poled member composed of material of temporary magnetic permeability in weak fields, a vacuum tube containing an electron-emitting 15  
member located between the poles of said member, and an anode co-operating with the electron-emitting member for causing an electron flow.

5. In a direction finder, electron-emitting means, an electron control element magnetically susceptible to earth magnetic flow adapted to magnetically act upon the electron flow of said electron-emitting means, said control element being electrically potentialled and being fixed relative to the electron-emitting 25  
means.

6. In a device of the class described, an envelope containing an inert gas, electron-emitting means therein, and magnetic means magnetically susceptible to earth magnetism contained within the tube and fixed relative to the electron-emitting means and adapted to act upon the electron-emitting means. 30

7. In a device of the class described, electron-emitting means, a control member sensitive to earth magnetism adapted to magnetically act upon said electron-emission, and a magnetic coil connected to said control member. 35

8. In a device of the class described, electron-emitting means having an anode and a cathode, a control element sensitive to earth magnetic field, said control element having 40  
poles between which the cathode is located, a magnetic coil embracing one of said poles.

9. In a device of the class described, an anode and a cathode creating an electron stream and a poled control member fixed relative to the anode and cathode and adapted to exert its maximum magnetic control over said electron stream when the poles of said control member are aligned with the earth's magnetic poles. 45

10. In a direction finder, electron-emitting means, a poled magnetizable member fixed relative to the electron-emitting means and sensitive to earth's magnetic field adapted to exert a magnetic force upon the electron flow emitted by said electron-emitting means. 50

11. In a direction finder, electron-emitting means, magnetizable means fixed relative to the electron-emitting means and sensitive to the earth's magnetic field adapted to exert a variable control over the electron emission, 55

the extent of such control being dependent upon the position of the finder relative to the magnetic poles of the earth.

12. In a direction finder, a poled control member formed of a metal of high permeability at low flux densities which is temporarily magnetically sensitive to earth magnetism. 70

13. In a direction finder, means for causing electron emission and a poled metallic control member fixed relative to said electron-emitting means and formed of a metal sensitive to earth magnetism adapted to apply the earth's magnetic influence to said electron emission. 75

14. A device of the class described comprising means for causing electron emission and means fixed relative thereto for applying a maximum of magnetic influence over said electron emission when said means is aligned with the north and south magnetic poles of the earth. 80

15. A device of the character described comprising electron-emitting means, and a poled control means fixed relative to the electron-emitting means and arranged to exert a maximum of magnetic influence over said electron emission when the poles on said control member are aligned with the magnetic poles of the earth, and adapted to exert a minimum of magnetic influence when the poles of said member are at substantial right angles to the earth's magnetic poles. 85

16. In a direction finder, a vacuum tube containing electron-emitting means, and a control member sensitive to earth magnetic force located externally of the tube and fixed relative to the same and adapted to exert a magnetic force for varying the electron emission of said electron emitting means contained within the tube. 90

17. In a direction finder, a poled control member of high permeability at low flux densities magnetically sensitive to earth magnetic force, and a vacuum tube containing means for causing an electron emission located between the poles on said member. 95

18. In a direction finder, a poled control member sensitive to earth magnetism, said member being wound with a magnetic coil and means for creating an electron emission located between the poles of said control member. 100

19. In a direction finder, a control member sensitive to earth magnetism and having poles, means for creating an electron emission located between said poles and wholly disposed within the magnetic field between the poles of said control member. 105

20. In a direction finder, electron-emitting means, control means magnetically sensitive to earth magnetism adapted to magnetically act upon the electron emission with an increasing magnetic force when the finder is swung toward the magnetic north and south 110

poles of the earth and adapted to act with diminishing magnetic force when the device is swung away from the north and south magnetic poles of the earth.

5 21. In a device of the class described, an electron emitter having a fixed magnetic shield which prevents the magnetic influence of the heater current from disturbing the electron flow.

10 22. A control member poled by the earth's magnetism, and a device arranged between the poles of said control member and fixed relative thereto and adapted to indicate changes in intensity of the earth's magnetism  
15 as found in different positions.

20 23. A control member of high permeability sensitive to the earth's magnetism, said member having poles, and a device arranged between said poles which will indicate changes in direction or location due to variations in the magnitude of the earth's magnetism.

25 24. A control member of high permeability sensitive to the earth's magnetism for intensifying and concentrating the effect of the earth's magnetism and a device placed between the poles of said member and cooperating therewith for indicating position or direction.

Signed at the city of New York, county of  
30 New York, and State of New York, this 4th day of December, 1928.

G. H. PERRYMAN.

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