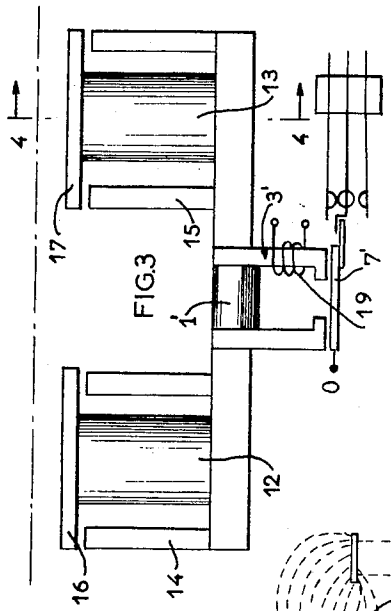
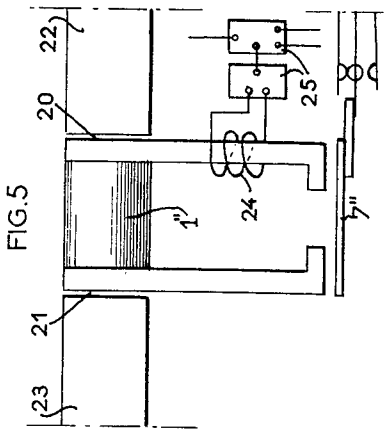
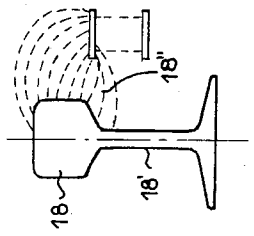
March 6, 1962 G. HOURS 3,024,411

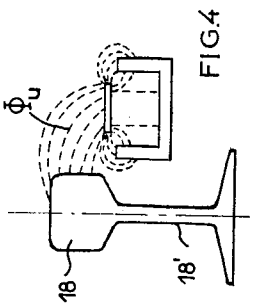
MAGNETIC SWITCHING DEVICE

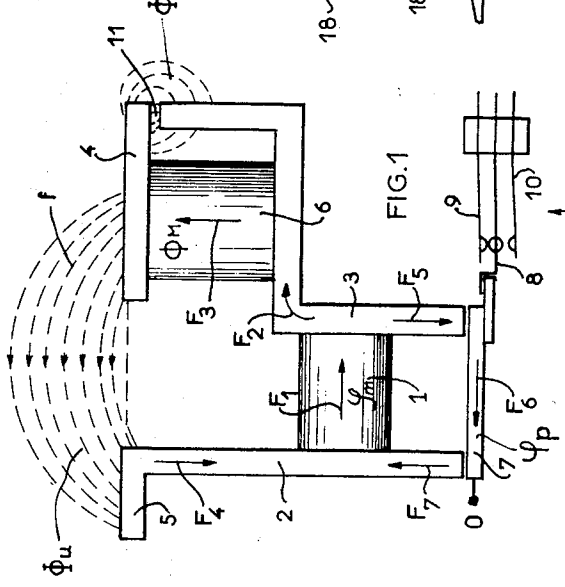
Filed Feb. 20, 1958

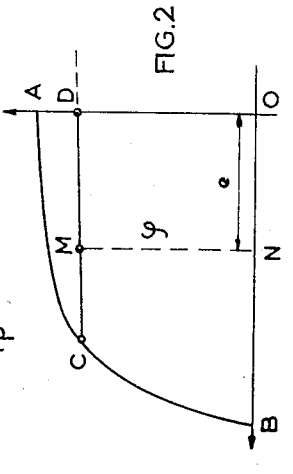












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MAGNETIC SWITCHING DEVICE

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7 Claims. (Cl. 324—34)

This invention relates to a magnetic switching device and refers more particularly to a magnetic apparatus capable of causing a switching or change-over operation as the result of a passage of a mass of iron, or the like, in the vicinity of the device.

The present invention is based on the known principle that when an iron mass is placed in the air gap of a magnetic circuit a change takes place in the reluctance of the circuit and, consequently, there is a change in the magnetic flux which passes through the circuit. Attempts have been made in prior art to utilize this effect for the purpose of detecting a passage of a mass of iron at a given point, such as, for example, the passage of a railway car over a certain point of the railway tracks. However, prior art devices do not have sufficient sensitivity and, therefore, are not suitable in practice to assure a release of an operation involving the actuation of forces which may be rather considerable.

Devices known for use in railroads include so-called magnetic pedals which provide a variation of flux in a magnetic circuit sufficient to release a switching operation, due to the presence of an inductor located upon the tracks and a magnetic circuit carried by the vehicle traveling upon the tracks, whereby the passage of the vehicle is utilized to produce the switching operation.

Magnetic pedals of this type have been described by the applicants in their French Patent No. 992,445 issued July 11, 1951, and in a co-pending United States patent application Serial No. 565,246, filed February 13, 1956. While these devices operate quite satisfactorily, their use is restricted to a limited number of specific applications. A drawback of these devices is that they require a special equipment carried upon each of the vehicles for the purpose of actuating them.

An object of the present invention is the provision of a magnetic switching device which is capable of detecting the passage of any mass of iron in its immediate proximity, and which is sufficiently sensitive to provide a switching action, even one requiring a substantial mechanical effort.

Another object is the provision of an apparatus of the described type which does not require for its functioning the use of any parts, elements or devices on the mass of iron which causes the operation.

Other objects of the present invention will become apparent in the course of the following specification.

In accomplishing the object of the present invention, it was found desirable to provide a magnetic switching device which includes a primary magnetic circuit which contains in series at least two generators of magnetic flux and an air gap; the apparatus also contains a secondary magnetic circuit connected to the terminals of one of these generators in shunt with the primary circuit, as well as means responsive to variations of the magnetic flux in the secondary circuit and capable of releasing the desired switching operation.

Due to this arrangement, as soon as a mass of iron is introduced into the air gap of the primary circuit, a substantial drop in the difference of the magnetic potential takes place at the terminals of the generator which is shunted by the secondary circuit and, consequently, there is a substantial reduction of the magnetic flux passing therethrough.

It is apparent that the variation of the magnetic flux in the secondary circuit will be that much greater the smaller is the derived flux in relation to the total flux supplied by all the generators. Consequently, it is possible to increase at will the sensitivity of the system by increasing the total flux, namely, the number of generators and/or the power of those generators which are not in shunt with the secondary circuit.

According to a preferred embodiment of the invention it is possible to select the number and/or the power of the generators, and the size of the air gap in such a manner that the introduction of a mass of iron of a predetermined size into this air gap will substantially annihilate the magnetic flux in the secondary circuit.

A device of this nature, particularly when applied to railroads, offers a certain number of essential advantages by comparison to prior art magnetic pedals hereinabove described, independently of its sensitivity, which for practical purposes is limited solely by the maximum size which it is desired to provide for the apparatus. The fact that the apparatus of the present invention will function merely by introducing a simple mass of iron into the air gap of the primary magnetic circuit, makes it possible to detect the passage at any point of a railway track of any wheel of a railroad vehicle. Consequently, the magnetic switch of the present invention has a large number of applications in the art of controlling railway traffic. In particular, the apparatus may be advantageously used as a substitute for the usual prior art mechanical switches, not only to initiate a switching operation upon the passage of a locomotive, but also for the counting of axles in a block system, for preparing a circuit by the first axle of a vehicle or train, while establishing this circuit by the last axle thereof, etc. Such uses are described in detail in our co-pending U.S. patent application Serial No. 678,209, filed August 14, 1957, and now abandoned.

According to one embodiment of the present invention, the switching element consists of a movable blade or contact which is normally held in an attracted position by the magnetic flux passing through the secondary circuit, and which is continuously urged to a retracted position by a retracting spring, for example. With such a device, when a mass of iron is introduced into the air gap of the primary circuit, the rapid drop of the secondary flux which, as stated above, can be eliminated altogether, makes it possible for the retracting spring to move the blade into a retracted position. When the iron mass leaves the air gap the secondary flux is again increased and moves the blade back to the attracted position.

In the case of railroads the passage of wheels through the air gap of the apparatus can take place within extremely short times amounting sometimes to a few thousandths of a second. Consequently, in accordance with an embodiment of the present invention, the apparatus is provided with means maintaining the blade in its retracted position for a sufficiently long time period so as to assure the desired switching operation.

According to one structural embodiment, when a blade is freed it is held in the retracted position by the retracting spring and the movement of the blade to the attracted position is assured by a separate bobbin. It suffices for that purpose that the normal secondary flux should be sufficient to maintain the blade in the attracted position, but not sufficient to cause the attraction of the retracted blade.

According to one embodiment of the present invention, a winding is provided around the secondary magnetic circuit, wherein flux variations produced by the passage of the iron mass create an induced electromotive force which is that much greater the faster is the passage

of the iron mass. By way of example, this electromotive force can be utilized to assure directly a switching operation in cooperation with the blade. Actually, when the speed is slow, the induced electromotive force will be too weak so as to be conveniently utilized. However, in that case the blade is retracted and produces, by rapidly opening the secondary magnetic circuit, a rapid variation in the flux of this circuit, thereby creating a substantial electromotive force which is, for all practical purposes, independent of the speed of passage of the iron mass. When speeds are high, even if the blade had no time to become detached, the principal electromotive force will be in operation. Consequently, this apparatus makes it possible to provide a secure switching operation, irrespective of the speed of passage of the iron mass.

It will be noted that the induced electromotive force which is obtained in the above-described manner, can be utilized for operating an indicator, or any other controlling device.

In the magnetic switch of the present invention, the introduction of an iron mass into the air gap of the primary circuit tends to produce a drop in the difference of magnetic potential at the terminals of each of the generators of the primary circuit.

To increase still further the sensitivity of the apparatus, the present invention provides that means having a constant magnetomotive force be used as generators, with the exception of the one generator which is in shunt with the secondary circuit.

According to a particularly inexpensive and simple embodiment of the present invention which, nevertheless, provides perfect functional security, all the generators of the primary circuit consist of permanent magnets; the generator which is shunted by the secondary circuit is a permanent magnet of small dimensions by comparison with the other generators and each of the latter is shunted by such an additional magnetic circuit that it will maintain substantially constant the magnetomotive force of the associated magnet, irrespective of the fact whether the mass of iron is present in the air gap of the primary circuit or is absent therefrom.

According to another characteristic feature of the invention it is possible to provide for these additional shunt circuits a form which concentrates upon the trajectory of the mass of iron the lines of forces which pass through the air gap.

Finally, in accordance with the present invention it is possible to provide on both sides of the generator of magnetic flux which is shunted by the secondary circuit, small gaps causing drops of the magnetic potential, each of which is substantially equal to one-half of the magnetomotive force of said generator. This arrangement makes it possible to eliminate for all practical purposes leakages which otherwise take place between the iron pieces supplying the primary flux to said generator, with the result that the sensitivity of the system is still further increased.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing, by way of example, some preferred embodiments of the inventive idea.

In the drawings:

FIG. 1 is a diagrammatic side view showing a magnetic switch constructed in accordance with the present invention in one of its most simple forms.

FIG. 2 is a diagram showing the curve of the magnetic flux as a function of the magnetomotive force of a permanent magnet for the purpose of explaining the principle of the magnetic switch in accordance with the present invention.

FIG. 3 is a diagrammatic side view of a somewhat differently constructed apparatus in accordance with the present invention, the construction being improved and more sensitive than that illustrated in FIG. 1.

FIGS. 4 and 4*a* are diagrams illustrating methods of concentrating a magnetic flux for certain specific applications, namely, for the rails of railroads; and

FIG. 5 is a partial side view showing a detail of the construction of a magnetic switch in accordance with the present invention, which is associated with an electronic controlling device.

The apparatus illustrated diagrammatically in FIG. 1 comprises a permanent magnet **1** which is mounted between two iron pieces **2** and **3**. A tie plate or flange **5** constitutes a continuation of the member **2**. A tie plate or flange **4** constitutes a continuation of the member **3**, although in the example illustrated the members **3** and **4** are separated by a small air gap **11**. The tie plates **4** and **5** are located close to the trajectory of the mass of iron, the passage of which it is desired to detect. The iron pieces **2** and **3** provide for the magnetic flux which is produced by the magnet **1**, two passages constituting closed circuits; both circuits pass through the magnet **1**, as indicated by the arrow F_1. One of these circuits, which in the present description is designated as the primary circuit, is indicated by the arrows F_2, F_3, and F_4. Thus this circuit passes through a second permanent magnet **6** which is interposed between the iron pieces **3** and **4**, and then passes through an air gap formed between the tie plates **4** and **5**, as indicated in FIG. 1 by lines of forces *f*, which represent flux in the air gap. It is thus apparent that the primary circuit is constituted only by a part of the flux of the magnets **1** and **6** which operate in series.

The second passage for the flux, which in the present description is designated as the secondary circuit, is indicated by the arrows F_5, F_6, and F_7, so that it passes through a movable contact or blade **7** which is pivoted at O. In the example illustrated, the movable blade **7** may be held at a distance from the iron pieces **2** and **3** by a movable contact spring **8** which engages one end of the blade **7**. The movable contact spring **8** may be brought into engagement with any one of two fixed contacts **9** and **10** under the action of the blade **7**.

Furthermore, in the example illustrated, the magnet **6** is greatly shunted by a part of the iron piece **3**, although it is separated from the other metal member constituting the tie plate **4** by the small air gap **11**. As will be described in detail hereinafter, this arrangement has the purpose of maintaining constant the magnetomotive force of the magnet **6**.

In order to set forth more clearly the principles upon which the apparatus of the present invention operates, it is advisable to consider in the first place certain characteristic features of permanent magnets.

In FIG. 2 the curve AB represents the magnetic curve of a certain magnet.

OA represents the residual flux.

OB represents the coercitive force.

It is known that a magnet can be always obtained, the characteristic point of functioning of which is located upon the straight line CD which is designated as the line of recoil.

For a definite regulation, let the characteristic point be at M, for example.

MN represents the total flux in the interior of the magnet designated as φ.

ON represents the magnetomotive force provided at the terminals of the magnet, designated as *e*.

In modern magnets the slope of the straight line CD is very small. Consequently for very small variations in the flux φ, there will be a great variation of the force *e*.

If the flux φ is increased, the magnetomotive force *e* diminishes; it can become zero, and even become negative when the point M passes to the right of the axis OA.

In the following discussions the variations of φ which are quite small have been disregarded in order not to complicate calculations unnecessarily, and the flux φ in the magnet will be considered as being constant.

If the total flux produced by the magnet **1** of FIG. 1 be

designated as φ_m while the flux which passes through the blade **7** be designated as φ_p, and the flux which passes through the primary circuit and particularly in the gap between the tie plates **4** and **5** be designated as Φ_u, then by discarding the weak variations of φ_m and the magnetic losses, it may be written that at any instant,

$$\varphi_m=\Phi_u+\varphi_p=\text{constant} \quad (1)$$

In these conditions the diminution of the reluctance of the primary circuit, which is produced by introducing the mass of iron in the air gap between the tie plates **4** and **5**, and which results in an increase of Φ_u, produces an equal diminution of the absolute value of φ_p.

Thus Φ_u depends upon the reluctance of the primary circuit, as well as upon the sum of magnetomotive forces e of the magnet **1** and E of the magnet **6**. If the size of the magnet **6** be selected sufficiently great by comparison to that of the magnet **1**, or if several other magnets are interposed in series with the magnets **6** and **1**, it is possible to attain a very high value of E and, consequently, of e plus E, and furthermore of Φ_u.

If in addition it is possible to maintain constant the value of E in the presence of a mass of iron in the air gap between the tie plates **4** and **5**, the new value of the flux Φ_u will depend solely upon the diminution of the reluctance of the primary circuit.

It will be noted that the shunt of the magnet **6** shown in FIG. 1 has precisely the effect of maintaining substantially constant the magnetomotive force of said magnet. Actually, small variations of the flux Φ_u produce merely a negligible variation in the total flux of the magnet **6**, due to the provision of a constant very high flux produced in the shunt by the magnet **6**.

Furthermore, if Φ_u is very high in comparison to φ_p, equal variations in the absolute value of these two fluxes will obviously correspond to a high percentage variation of φ_p for a small percentage variation of Φ_u, since their sum is constant.

Thus, for example, if the relative values are:

$\Phi_u=10$ and $\varphi_p=1$, then

$\varphi_m=10+1=11$, and an increase of 10% of Φ_u results in $\Phi_u=11$ and $\varphi_p=0$.

With relative values of 1 and 100, it is possible to eliminate φ_p by increasing Φ_u solely by 1%.

In view of these circumstances, the functioning of the apparatus shown in FIG. 1 is readily apparent:

If there is no mass of iron in the air gap between the tie plates **4** and **5**, the secondary circuit is formed by a flux which can be easily set in such manner that it will maintain the blade **7** in its attracted position in which it holds the contact spring **8** in engagement with the fixed contact **9**.

As soon as an iron mass is introduced into the air gap between the tie plates **4** and **5**, the magnetic resistance of the primary circuit is diminished with the result that the flux of the primary circuit is increased and the absolute value of the flux of the secondary circuit is equally diminished. If the relative values of these two fluxes are conveniently selected in the manner indicated hereinabove, then this diminution will suffice to free the blade **7**, which will be moved by the spring **8** to a retracted position in which the spring **8** will be in engagement with the fixed contact **10**. This switching operation can be utilized for any desired purposes.

The general equations on which the construction is based are as follows:

By applying the laws of magnetic circuits and disregarding drops in potential in the iron construction pieces, as well as local losses, the general equations may be written as follows, and the value of the flux φ_p in the blade **7** as a function of other elements, may be calculated as follows:

Assume that e is the magnetomotive force of the magnet **1**.

E is the magnetomotive force of the magnet **6**.

Φ_f is the flux of the shunt circuit of the magnet **6**.

R_f is the reluctance of this circuit.

R_u is the reluctance of the primary circuit.

R_p is the reluctance of the secondary circuit.

Then the following equations appear:

$\varphi_m=\Phi_u+\varphi_p=\text{constant}$

$\Phi_M=\Phi_u+\Phi_f=\text{constant}$

$E=\Phi_f R_f$

$e=\varphi_p R_p$

$E+e=\Phi_u R_u$

By considering φ_p as the function and R_u as the variable, the following equation is obtained:

$$\varphi_p=\varphi_m-\frac{R_f\Phi_M+R_p\varphi_m}{R_u+R_f+R_p} \quad (2)$$

The last member of this equation is Φ_u. It will be noted that φ_p depends on R_f. Therefore, in the construction of the apparatus it is possible to provide for a regulation of φ_p by the regulation of the shunt of the magnet **6**.

The above Equation 2 shows all the conditions which are required to obtain the best possible results, in a practical construction.

In the first place it is necessary that φ_m and Φ_u be quite great in relation to φ_p. Thus a high sensitivity is obtained. The last member of the equation represents Φ_u which depends on the variable R_u. In order to provide that Φ_u varies greatly with R_u, it is necessary that R_f+R_p be small in relation to R_u.

A small value of R_f implies a substantial shunt of the magnet **6**. The magnet **6** will then have a very substantial cross-section and Φ_M will be quite high. On the other hand, a small value of R_p implies minimum air gaps for the movable blade **7** and substantial areas of the poles.

The following numerical example is of interest:

The indicated data have been used in an actual construction of the apparatus herein-described.

Let it be assumed that:

$\Phi_M=99{,}000$ maxwells (hereinafter designated as mw.) (net cross-sectional value of the magnet **6** is 10 cm.^{2}).

$\varphi_M=35{,}000$ mw. (net cross-section of magnet **1** is 3.5 cm.^{2}).

$R_u=10/100$ (normal value).

$R_p=1/100$ with $\varphi_{po}=4{,}000$ mw. (regulating value).

$\Phi_u=\varphi_m-\varphi_{po}=31{,}000$ mw.

$\Phi_f=\Phi_M-\Phi_u=68{,}000$ mw.

$E+e=\Phi_u R_u=3{,}100$ oerstedt (hereinafter designated as oe.).

$e=\varphi_{po}R_p=40$ oe.; consequently $E=3{,}060$ oe.

$$R_f=\frac{E}{\Phi_f}=\frac{3{,}060}{68{,}000}=\frac{4.5}{100}$$

When the Formula 2 is applied, the result is

$$\varphi_{po}=35{,}000-\frac{4{,}455+350}{\frac{10+4.5+1}{100}}=35{,}000-31{,}000=4{,}000 \text{ mw.}$$

To determine the new value of φ_p when a mass of iron approaches which will vary R_u by 15%, R_u will be equal to

$$0.85\times\frac{10}{100}=\frac{8.5}{100}$$

Then the formula gives the following results:

$$\varphi_p=35{,}000-\frac{4{,}455+350}{\frac{8.5+4.5+1}{100}}=35{,}000-34{,}300=700 \text{ mw.}$$

This is a diminution of the flux in the blade **7** by 82.5%.

If it will be noted that the force of attraction of the blade **7** is proportional to the square of the flux which

passes through it, it is apparent that this force will become weaker by about 32 times.

It is easily possible to reduce φ_p to a zero value for a value of R_u reduced by 18%, namely,

$$R_u=\frac{8.2}{100}$$

FIG. 3 show a construction wherein the magnet 6 of the diagram shown in FIG. 1 is replaced by two magnets 12 and 13 which are placed symmetrically on opposite sides of the magnet 1' and which are connected in series with the magnet 1'. Furthermore, each of the magnets 12 and 13 is shunted by means of iron pieces 14 and 15 which enclose either partially or completely the magnets associated therewith, namely, the magnets 12 and 13. The apparatus also includes tie plates 16 and 17. This arrangement has the advantage of concentrating the flux Φ_u in the region located immediately above the tie plates 16 and 17, consequently, in the zone through which passes the mass of iron which it is desired to detect.

The application of the magnetic switch constructed in accordance with the principles of the present invention to railroad purposes, is illustrated in the diagrams of FIGS. 4 and 4*a*, showing in side view the apparatus illustrated in FIG. 3. As shown in FIG. 4, the principal flux Φ_u is concentrated in the zone above the head of the rail 18, that is, in the zone through which will pass the flange of the wheels of a vehicle traveling upon the rail 18'.

On the other hand, if the shunt of the magnets 12 and 13 of FIG. 3 is not attained by the pieces surrounding it to the level of the tie plates 16 and 17, then a part of the flux will be deviated downwardly, as indicated at 18'' in FIG. 4*a*, with the result that the sensitivity of the apparatus is reduced to a substantial extent.

By correctly tracing the lines of force, the position of the shunts which is most favourable, can be readily determined. For practical purposes since the flux Φ_f is quite high, the pieces which surround the tie plates can be arranged at a distance of a few millimeters therefrom, and they will concentrate the flux in the desired region. The extension of the flux will be absorbed by a regulating device which can consist of a simple iron screw (not shown).

This arrangement makes it possible to attain substantially better results, to reduce the size of the magnets and the general construction of the apparatus.

In connection with the construction shown in FIG. 1, a specific arrangement of the movable blade 7 was described, wherein the blade 7 is constantly urged to a retracted position by resilient means, such as the movable contact spring 8; on the other hand, when the mass of iron moves beyond the gap between the tie plates 4 and 5, the secondary flux suffices to move the blade 7 to its attracted position against the action of the resilient contact 8. In certain applications, particularly when it is desired to detect the passages of wheels of railway vehicles at a very high speed, this arrangement results in a very quick actuation of the contacts with the result that the reestablishment of the flux in the secondary circuit which takes place practically immediately, will immediately re-attract the blade 7.

Under such conditions it is advisable to use the arrangement shown in FIG. 3 wherein a winding 19 is provided. The winding 19 is mounted, by way of example, around the iron piece 3' of the magnet 1'. According to this arrangement, the blade 7' cannot be attracted merely by re-establishing the normal value of the flux in the secondary circuit. However, attraction is assured at any desired instant by an impulse of direct current directed into the winding 19 and suitable to increase sufficiently the normal value of the secondary flux φ_p so as to assure the attraction of the blade 7'.

Due to this arrangement, the contacts may be maintained in an open position irrespective of the speed of passage of the wheels for as long as it is necessary to assure the proper functioning of the devices controlled by the contacts.

FIG. 5 illustrates a somewhat different construction wherein the apparatus is provided with magnetic joints formed, by way of example, of thin sheets of foil interposed in narrow air gaps 20 and 21 located on opposite sides of the magnet 1'', namely, between the magnet and the end portions 22 and 23 of iron pieces constituting the primary circuit. These joints are calculated in such manner that the total additional reluctance which they introduce into the primary circuit traversed by the flux ϕ_u provides a tension drop equal to e which is the magnetomotive force of the magnet 1''.

Consequently, the potential of the right-hand yoke (looking in the direction of FIG. 5) is identical to the potential of the left-hand yoke, since the drop in the potential in the joints is equal to the potential difference e, but has the opposite sign. This arrangement makes it possible to eliminate the loss of flux between the two yokes 22 and 23. Since the value of e is very small in relation to the value of E, which is the magnetomotive force of one or more magnets mounted in series with the first-mentioned magnet in the primary circuit, the action of the magnetic joints 20 and 21 is negligible as far as the functioning of the apparatus is concerned.

FIG. 5 also shows a winding 24 which is wound around one of the iron pieces of the secondary circuit and the ends of which are connected to the entry terminals of an electronic device 25, which is suitable for the purpose of detecting and amplifying electromotive forces induced in the winding 24 in response to variations of flux in the secondary circuit.

It is apparent that the induced electromotive forces will be that much greater, the greater is the speed of passage of the mass of iron in the gap of the primary circuit.

Consequently, this apparatus may be advantageously utilized when the masses of iron which are to be detected pass in front of the apparatus at a very great speed. On the other hand, when the speeds are slow the electromotive forces can become too weak to be detected by the electronic device 25. It is then advantageous to retain the movable blade 7'', the quick retraction of which produces a rapid and noticeable variation in the secondary flux, whereby this variation can then be utilized to provide adequate functioning of the electronic device 25, even in the case of very reduced speeds.

Hereinabove it was stated that the magnetic switch in accordance with the present invention is capable of a large number of applications for railroad purposes. However, the utility of this apparatus is in no way limited to this type of application. The switch of the present invention makes it possible to provide different apparatus adapted to solutions of various problems. By way of example, the following may be indicated:

The counting of pieces and objects of ferrous metals: wagons, carriages, etc.

The detection of the passage at predetermined points of various apparatus, such as elevators, rolling bridges, etc., and in a general manner the control of positions of all movable pieces, such as machine tools, etc.

It is apparent that the subject of the present invention is in no way limited to the described and represented examples. The invention is capable of numerous variations which will be apparent to one skilled in the art, for example, according to the applications hereinabove set forth, without departing from the scope of the invention.

Particularly, in order to maintain at a substantially constant value the magnetomotive force of one or more magnets connected in series with the magnet 1, it is possible to provide a winding through which direct current is passed. However, for security reasons, particularly in applications pertaining to railroads, it is advantageous to use the shunted magnet arrangement described hereinabove.

As far as the application of the magnetic switch of the present invention to railroads is concerned, it is possible in certain cases to utilize the rail as a part of the primary circuit. However, such an arrangement cannot be recommended when the rail may be subjected to the passage of substantial currents, such as electric traction, block system using the track, as a control circuit, etc. Such currents may produce parasitic fluxes which, passing directly in the primary circuit, may disturb the functioning of the apparatus. In such cases it is advisable to utilize the arrangement shown in FIG. 3, which is mounted inside the rail, or outside of the rail and parallel thereto, as shown, by way of example, in FIG. 4.

What is claimed is:

1. A magnetic apparatus for detecting the passage of a mass of iron in the proximity thereof, said apparatus comprising means constituting a primary magnetic circuit and comprising at least two permanent magnets which are interconnected in series and an air gap; means connected in shunt with the opposite poles of one of said permanent magnets and constituting a secondary magnetic circuit, said one permanent magnet having a weak magnetomotive force relatively to the sum of the magnetomotive forces of the permanent magnets in said primary circuit, a signalling armature associated with said secondary circuit and movable from a closed position to an open position and vice versa, and means biasing said armature towards said open position, said one permanent magnet being adapted to produce in said secondary circuit a magnetic flux capable of holding said armature in its closed position against said bias, whereby an increase of the primary circuit flux due to the passage of the iron mass in said gap causes a decrease of the secondary circuit flux to a value at which the secondary circuit flux is insufficient to hold the armature in said closed position, wherein the other permanent magnet has a substantially constant magnetomotive force irrespective of the presence or absence of said mass of iron in said air gap, further comprising means constituting an additional magnetic circuit in shunt with said other permanent magnet.

2. An apparatus in accordance with claim 1, wherein said additional magnetic circuit concentrates the lines of force in said air gap in a zone within the trajectory of said mass of iron.

3. A magnetic apparatus for detecting the passage of a mass of iron in the proximity thereof, said apparatus comprising means constituting a primary magnetic circuit and comprising at least two permanent magnets which are interconnected in series and an air gap; means connected to the opposite poles of one of said permanent magnets and constituting a secondary magnetic circuit, a signalling armature associated with said secondary circuit and movable from a closed position to an open position and vice versa, and means biasing said armature towards said open position, said one permanent magnet being adapted to produce in said secondary circuit a magnetic flux capable of holding said armature in its closed position against said bias, whereby an increase in the primary circuit flux due to the passage of the iron mass in said gap causes a decrease of the secondary circuit flux to a value at which the secondary circuit flux is insufficient to hold the armature in said closed position, wherein the means biasing the armature towards the open position comprise a spring of such strength that the armature will be maintained in the closed position by the flux of the secondary circuit but will not be attracted thereby from the open position, said apparatus further comprising an electrical winding adapted to receive an electrical current to increase the secondary circuit flux sufficiently to ensure attraction of the armature from the open position.

4. An apparatus in accordance with claim 3, wherein the last-mentioned means comprise a movable blade member and a switch, said blade member and said winding being connected in parallel with said switch.

5. A magnetic apparatus for detecting the passage of a mass of iron in the proximity thereof, said apparatus comprising in combination, two spaced iron pieces, one of said iron pieces having a flange, a tie piece located opposite said flange and separated from said other iron piece by a small air gap, said flange and said tie piece being located close to the trajectory of the mass of iron the passage of which is to be detected, a permanent magnet extending between said iron pieces, a second permanent magnet extending between said other iron piece and said tie piece, whereby said second magnet is connected in series with the first-mentioned magnet and whereby a primary magnetic circuit is constituted by said two magnets and the air space between said flange and said tie piece, a blade pivotally mounted adjacent to said iron pieces opposite to said flange and said tie piece, a secondary magnetic circuit being constituted by the first-mentioned magnet, said blade and the adjacent portions of said iron pieces, said blade being movable from a closed position to an open position and vice versa, a movable contact spring engaging said blade, and two fixed contacts on opposite sides of said contact spring, said contact spring biasing said blade toward said open position in which said contact spring engages one of said contacts, the first-mentioned magnet being adapted to produce in said secondary circuit a magnetic flux capable of holding said blade against said bias in its closed position in which said contact spring engages the other one of said contacts, whereby an increase in the primary circuit flux due to the passage of the iron mass in said air space causes a decrease of the secondary circuit flux to a value at which the secondary circuit flux is insufficient to hold the blade in said closed position.

6. A magnetic apparatus for detecting the passage of a mass of iron in the proximity thereof, said apparatus comprising in combination, a magnet, two other magnets located symmetrically on opposite sides of the first-mentioned magnet, iron plates carried by said two other magnets and located opposite each other, an iron member carrying said two other magnets and engaging opposite sides of the first-mentioned magnet, iron pieces carried by said member and having ends located close to said plates for shunting said two other magnets, two iron extension pieces connected to said member and located on the side opposite to said two other magnets, a blade pivotally mounted adjacent to said extension pieces, whereby a primary magnetic circuit is constituted by said magnets and the air space between said plates and whereby a secondary magnetic circuit is constituted by the first-mentioned magnet, said extension pieces and said blade, a winding upon one of said extension pieces, said blade being movable from a close position to an open position and vice versa, a movable contact spring engaging said blade, and two fixed contacts on opposite sides of said contact spring, said contact spring biasing said blade toward said open position in which said contact spring engages one of said contacts, the first-mentioned magnet being adapted to produce in said secondary circuit a magnetic flux capable of holding said blade against said bias in its closed position in which said contact spring engages the other one of said contacts, whereby an increase in the primary circuit flux due to the passage of the iron mass in said air space causes a decrease of the secondary circuit flux to a value at which the secondary circuit flux is insufficient to hold the blade in said closed position.

7. A magnetic apparatus for detecting the passage of a mass of iron in the proximity thereof, said apparatus comprising in combination, a magnet, two yokes on opposite sides of said magnet, said yokes being separated by air gaps from said magnet, sheets of foil in said air gaps, two iron extension pieces connected to said magnet, a blade pivotally mounted adjacent to said extension pieces, whereby a primary magnetic circuit is constituted by said magnet and said yokes and whereby a secondary magnetic circuit is constituted by said magnet, said extension pieces

and said blade, a winding upon one of said extension pieces, an electronic device connected to said winding, said blade being movable from a closed position to an open position and vice versa, a movable contact spring engaging said blade, and two fixed contacts on opposite sides of said contact spring, said contact spring biasing said blade toward said open position in which said contact spring engages one of said contacts, the first-mentioned magnet being adapted to produce in said secondary circuit a magnetic flux capable of holding said blade against said bias in its closed position in which said contact spring engages the other one of said contacts, whereby an increase in the primary circuit flux due to the passage of the iron mass in said air space causes a decrease of the

secondary circuit flux to a value at which the secondary circuit flux is insufficient to hold the blade in said closed position.

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