

March 2, 1954

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2,671,197

MAGNETIZING MEANS FOR RAIL FLAW DETECTOR SYSTEMS

Filed Sept. 2, 1950

4 Sheets-Sheet 1

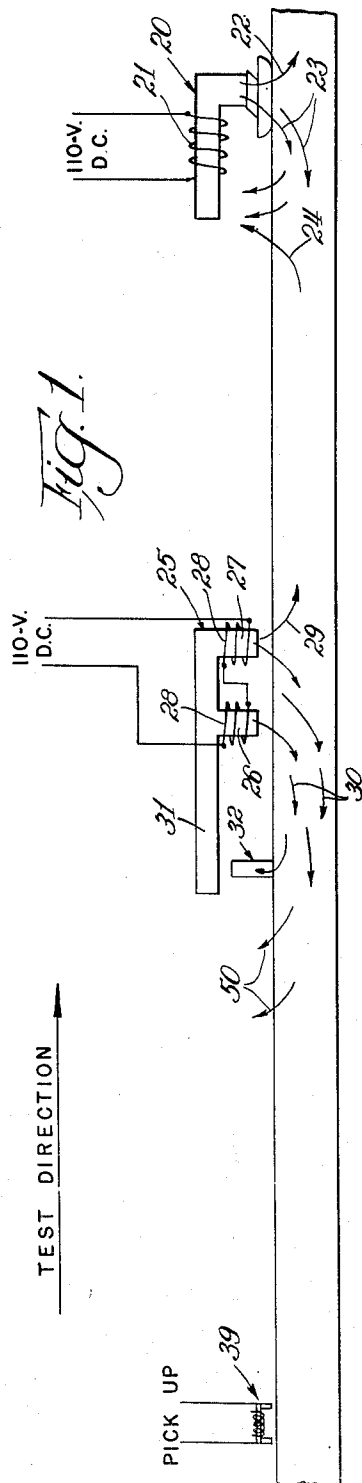
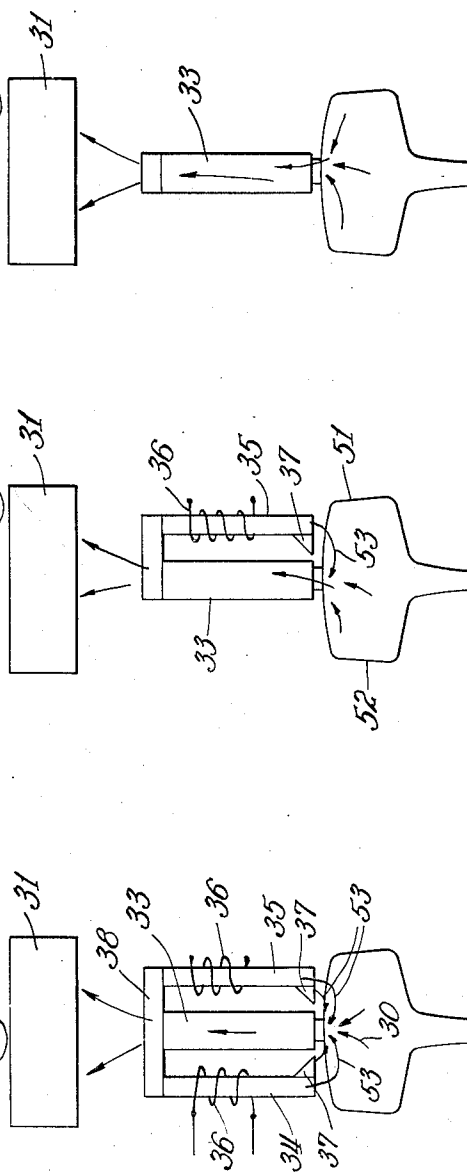


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



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Fig. 5.

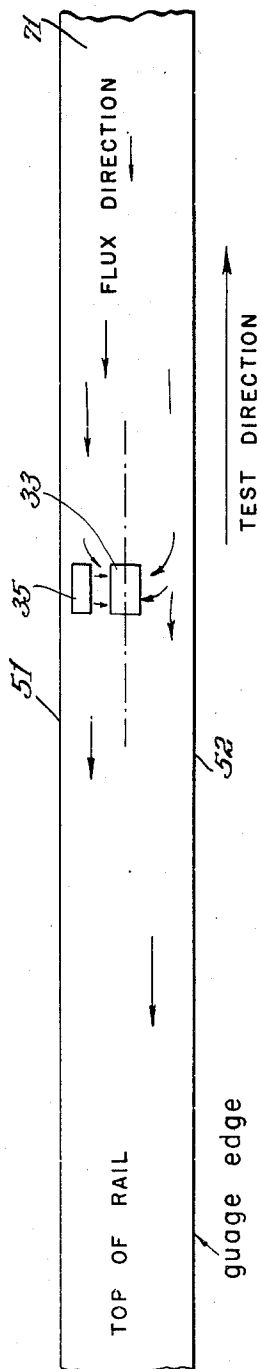
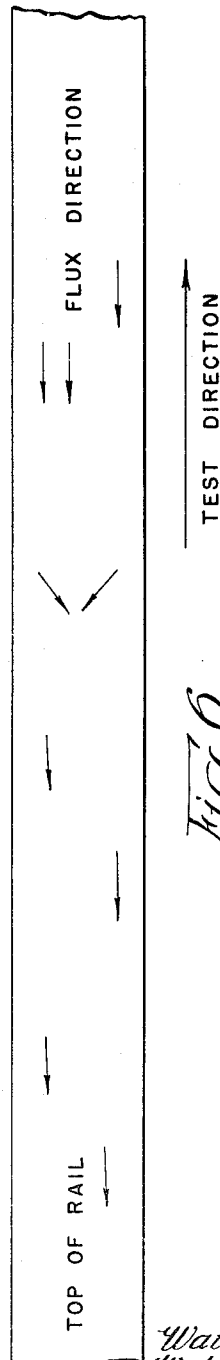


Fig. 6.



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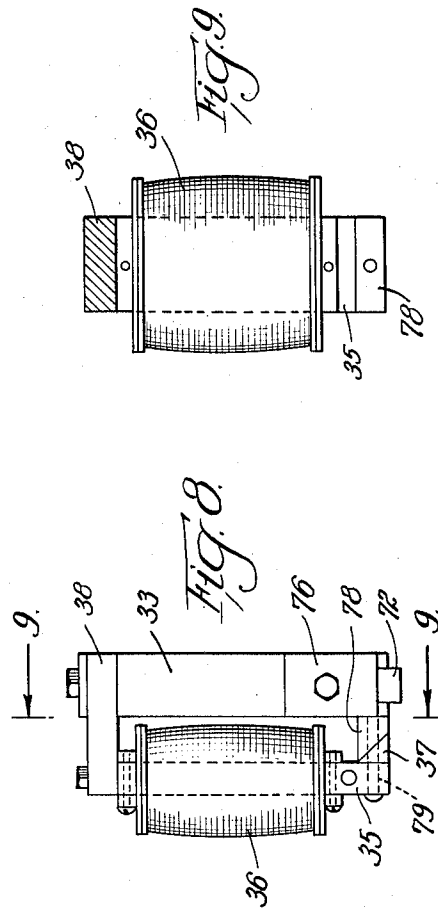
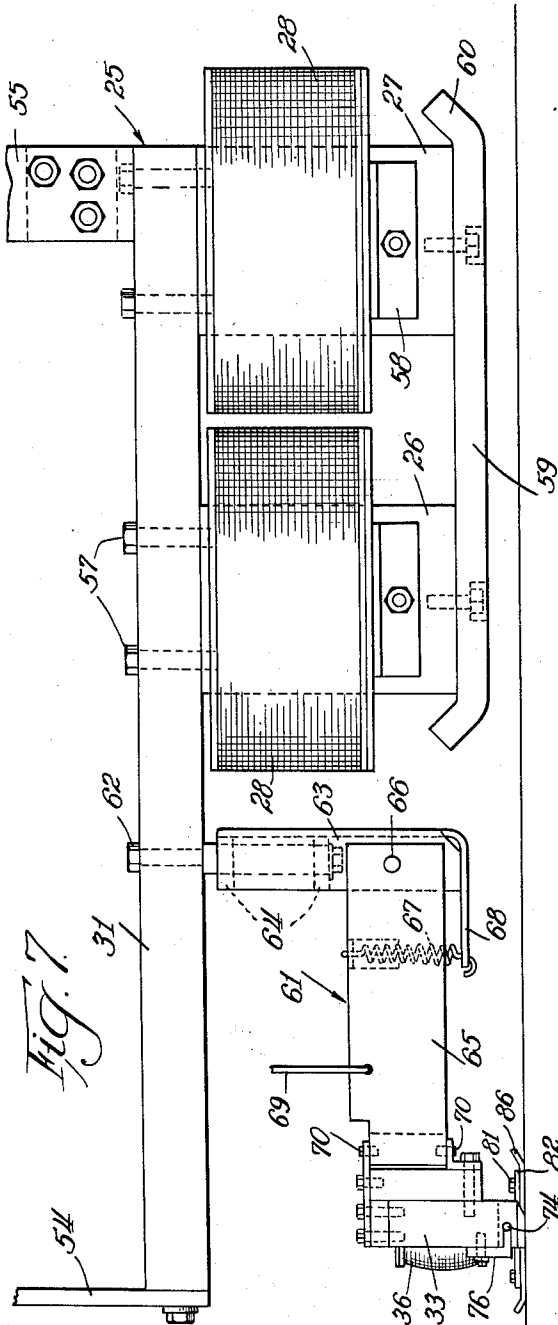
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MAGNETIZING MEANS FOR RAIL FLAW DETECTOR SYSTEMS

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4 Sheets-Sheet 3



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MAGNETIZING MEANS FOR RAIL FLAW DETECTOR SYSTEMS

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Fig. 10.

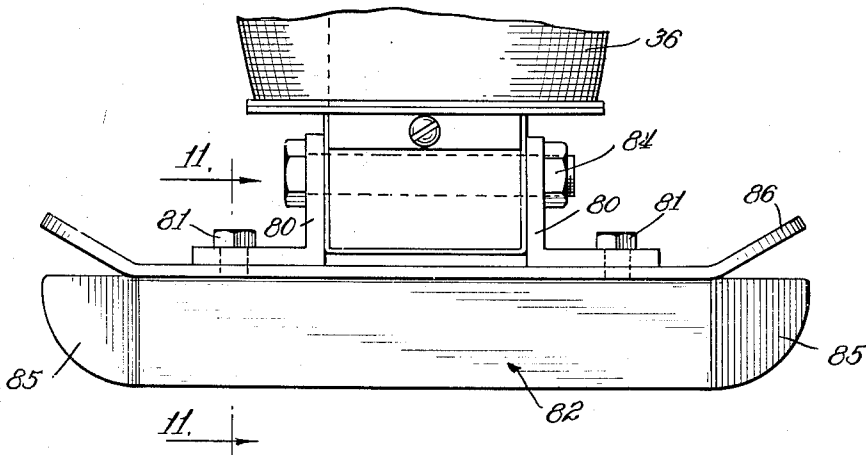


Fig. 11.

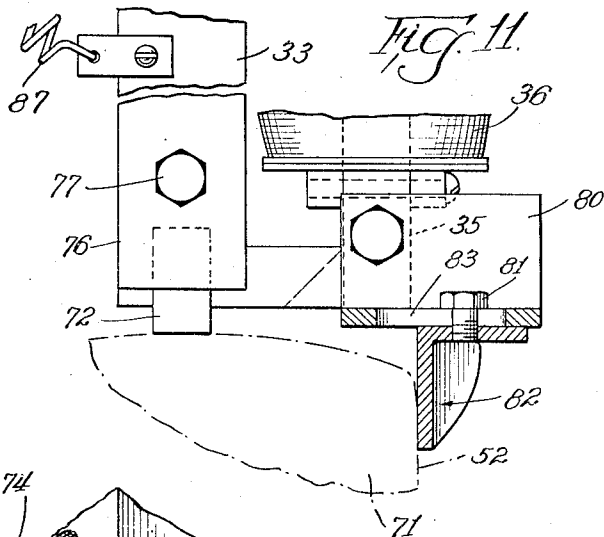
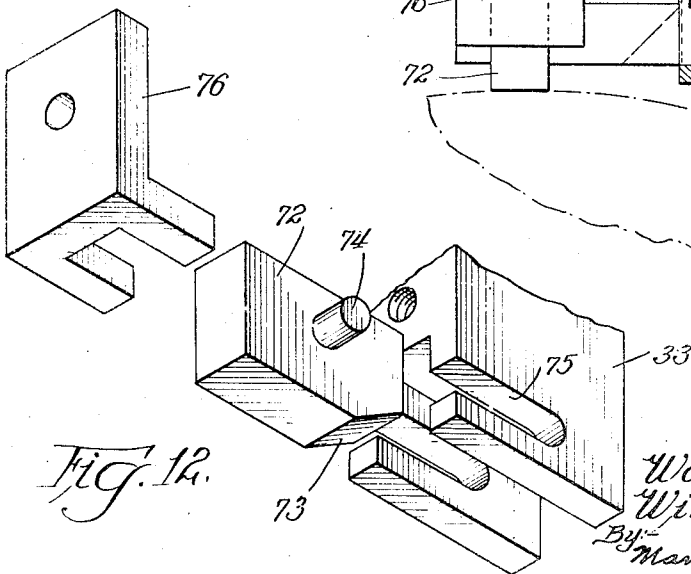


Fig. 12.



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MAGNETIZING MEANS FOR RAIL FLAW
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Application September 2, 1950, Serial No. 183,038

15 Claims. (Cl. 324—37)

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This invention relates to the so-called "residual magnetism" system of detecting flaws in rails.

In testing rails by the residual magnetism method, longitudinal magnetic flux is first introduced into the rail from a moving car, and the residual magnetism left in the rail is then explored for flux patterns that are characteristic of transverse fissures or other internal defects. The basic system is disclosed in Barnes and Keevil Patent No. 2,317,718, issued April 27, 1943, and an improved magnetizing means for introducing longitudinal flux into the rail is disclosed in Barnes and Keevil Patent No. 2,317,720, issued concurrently therewith.

In Barnes et al. Patent No. 2,317,720, the magnetizing means comprises three longitudinally spaced electromagnets each having a separate function to perform in properly magnetizing the rail. The forward magnet, or as it is usually called, the "A" magnet is a relatively powerful magnet, as is also the second magnet, ordinarily called the "B" magnet. These magnets successively introduce high intensity magnetic flux into the rail, but are spaced apart far enough so that they act more or less independently. The third magnet, commonly referred to as the "C" magnet, is not as powerful as the "A" and "B" magnets and it introduces relatively low intensity magnetic flux into the rail. The "C" magnet is sometimes referred to as a "clean-up" magnet because it has the effect of erasing certain residual fields left by the "A" and "B" magnets in the vicinity of superficial defects in the rail such as burns, gags, etc.

The present invention seeks to provide a far more effective way of introducing magnetic flux into the rail for the practice of the invention disclosed in said Barnes and Keevil Patent No. 2,317,718, and to accomplish this result with less equipment and less bulky apparatus than that employed in the Barnes and Keevil patents heretofore referred to. The improved magnetizing means also has for an object greater selectiveness in the polarizing of transverse fissures so that such internal defects are more surely magnetized to establish a characteristic magnetic field about the rail head in their vicinity; and the unimportant superficial defects are less strongly magnetized so that fewer false indications are received by the detecting equipment that explores the rail head in quest of the characteristic residual magnetic fields which are set up in the vicinity of fissures.

By this greater selectiveness in establishing the desired residual magnetic fields in the vicinity of

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transverse fissures and in attenuating the establishment of residual fields in the vicinity of superficial defects; other and further advantages are obtained; as will become apparent as the disclosure proceeds and the description is read in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagram in side elevation which will be used in explaining the principles which are believed to underlie the present invention;

Figs. 2, 3, and 4 are views showing three possible arrangements for the auxiliary flux-orienting device;

Figs. 5 and 6 are diagrams in plan which will also be used in explaining the invention;

Fig. 7 is a side elevational view of the second magnetizing means used in imparting the desired residual magnetic characteristics to the rail;

Fig. 8 is an end elevational view of the form of the auxiliary magnetic device shown in diagram in Fig. 3;

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 8;

Fig. 10 is a side elevational view of the auxiliary flux-orienting device showing particularly the gauge runner and the manner in which it is attached to the auxiliary device;

Fig. 11 is a fragmentary sectional view taken on the line 11—11 of Fig. 10; and

Fig. 12 is an exploded perspective view illustrating the manner in which a contact shoe for the auxiliary magnet is removably mounted in place.

It will be understood that the specific description of certain preferred forms of the invention is for the purpose of complying with section 112, title 35 of the United States Code, and that the invention may be variously modified within the scope of the appended claims.

General organization

Since this invention relates primarily to the magnetizing means, the description will be limited to the novel portion of such means, reference being made to said prior Barnes et al. Patents Nos. 2,317,718 and 2,317,720 for a more complete description of the entire flaw detection system.

In the present invention, the forward or "A" magnet 20 is retained; and as customary, its coil or coils (here indicated diagrammatically by a single coil 21) is energized from a suitable direct current source, preferably 110 volts D. C. Magnetic flux is introduced into the rail by the "A" magnet 20; and for reasons which are fully ex-

plained in Barnes et al. Patent No. 2,317,720, the flux pattern is characterized by a first reversed flux indicated by the arrow 22, then a strong rearward flux indicated by the arrows 23, and then a second reversed flux indicated by the arrow 24, this latter being caused as the flux rises upwardly from the rail to pass through the coil 21.

According to the present invention, the "B" and "C" magnets are dispensed with, and instead, a magnet generally designated 25 is employed which for convenience will be referred to as an "F" magnet. This magnet has two adjacent forward poles 26 and 27 upon which series connected coils 28 are wound, and these coils are energized from a suitable direct current source, preferably 110 volts D. C.

Since the coils 28 are wound in the same direction, the flux through the poles 26 and 27 will likewise be in the same direction, and assuming proper polarity connections for the coils 28 so that the flux through these poles is directed downwardly, it will be seen that the "F" magnet produces first a reverse flux indicated by the arrow 29 and then a strong rearwardly directed flux indicated by the arrows 30, and for reasons which will be explained later, there is no second reverse flux to correspond with the flux 24 of the "A" magnet.

The "F" magnet 25 has a horizontal pole 31 which is substantially parallel to the rail and preferably on the order of ten inches above the rail.

An auxiliary magnet 32 is mounted beneath the trailing end of the pole 31, and it is this magnet that is largely responsible for the unique results obtained by the improved magnetizing means of this invention. The auxiliary magnet 32 is preferably, although not necessarily, unidirectional in character, and its purpose is to conduct flux from the rail upwardly to counteract the strong vertical field that is introduced into the rail by the poles 26 and 27, and also to set up a relatively intense momentary transverse flux along the top surface of the rail which not only serves to wipe out certain undesirable residual fields introduced by the "A" magnet or by the poles 26 and 27 of "F" magnet, but also to place the rail in a more cyclic condition for the main rearwardly directed energizing flux to polarize transverse fissures.

In Fig. 2, the auxiliary magnet 32 is a direct current magnet having a central pole 33 which is part of the magnetic circuit that includes side poles 34 and 35, each of which mounts a coil 36 connected to a suitable direct current source in such manner that flux travels downwardly through the poles 34 and 35, then inwardly through triangular poles 37 to the central pole 33, and then back through the coils 36 through a top pole piece 38.

In Fig. 3, the side pole 34 and its supporting coil are eliminated, and in Fig. 4, only the central pole 33 is used. This pole may be in the form of a permanent magnet with the poles arranged for the flux to travel upwardly, or it may be a soft iron member which merely provides a path of low reluctance for the flux to return to the trailing pole 31 of the magnet 25.

Following the "A" magnet and the "F" magnet with its auxiliary magnet 32 is an induction pickup generally indicated at 39, which is located far enough behind the magnet 25 to be outside of its active field. The pickup 39 is connected to suitable amplifying and recording apparatus which forms no part of the present invention.

Improved results from use of apparatus

In any rail magnetizing equipment, it is desirable to polarize such internal defects as transverse fissures and to avoid magnetization or polarization of such superficial rail defects as burns, scale, gags, corrugations, and the like. After a rail has been magnetized, any attempt to erase the polarized conditions in the vicinity of the superficial defects necessarily involves the attendant danger of erasing or weakening the fields in the vicinity of transverse fissures.

In the present invention, test results indicate that not only are transverse fissures more fully and more strongly polarized by the magnetizing means of this invention, but at the same time, superficial defects are energized to a far lesser extent than has heretofore been possible. For example, on one test where the test apparatus had a sensitivity such as to record all known fissures in the test track, only three false indications were recorded, whereas duplicating the test using standard magnetizing means produced over thirty false indications.

One interesting benefit from this improved magnetizing means and the more certain polarization of all transverse fissures with lessened energization of superficial defects is that the detecting equipment can be run with less sensitivity to still further reduce the number of false indications that are recorded. The use of less sensitivity in the amplifier is made possible by the more certain polarization of transverse fissures by the magnetizing means of this invention.

In dealing with magnetic phenomena, it is not always possible to know for a certainty the reasons which underlie facts known to exist, and it should be understood that in the explanation that follows and in all other attempted explanation of the magnetic phenomena underlying the present invention, certain hypotheses must be made, and there is no intention of conveying the impression that these hypotheses are the only ones for explaining the improved results of the present invention.

The theory which is believed to underlie the improved results, therefore, is that the strong flux 30 (Fig. 1) which is made to travel rearwardly through the rail without any substantial subsequent reversal of flux, strongly magnetizes any transverse fissures that may be interposed in its path, and by mounting the coils 28 on the forward vertical poles 26 and 27 rather than on the horizontal pole 31 (in a manner that would correspond to the coil 21 of the "A" magnet 20), the rearwardly directed flux 30 leaves the rail very gradually as indicated by the arrows 50, and does not set up a reverse flux that would tend to weaken the polarization of the transverse fissures.

In addition to this action which more strongly polarizes the transverse fissures, the auxiliary magnet 32 enhances this action by momentarily shifting the magnetic orientation of some of the molecules in the portion of the rail over which the magnet 32 passes. However, the magnet 32 has a more important function of wiping out, or at least reducing the residual fields left in the vicinity of superficial defects, and this is believed to be due first, to the passage of some portion of the main flux 30 upwardly through the pole 33, and second, to the quick reversal or shifting of flux that takes place immediately adjacent to the top surface of the rail as flux passes laterally through the top surface of the rail head from poles 34 and 35 to the central pole 33. Appar-

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ently this sharp shifting of the flux pattern on the top surface of the rail tends to wipe out the residual magnetic conditions which exist in these areas, and this is accomplished without adversely affecting the magnetization and polarization of transverse fissures.

However, in order to be more certain that transverse fissures are not adversely affected by the lateral flux introduced into the rail by the magnet 32, the unsymmetrical arrangement of the magnet 32 in Fig. 3 is preferred with the center pole 33 being almost directly over the center line of the rail or slightly to the outer edge of the rail indicated by the reference character 51. This places the pole 35 well over the outer edge of the rail 51, and strangely enough, this arrangement of the auxiliary magnet 32 not only provides slightly improved detection of transverse fissures (which are normally found closer to the gauge edge 52 of the rail than to the outer edge 51), but also is more effective in removing false indications due to scale found on the gauge edge 52 of the rail.

The indications are that the pulling up of the main flux 30 through the core 33 accounts for possibly fifty per cent of the burn and corrugation indications that would otherwise appear on the record, with the lateral flux indicated by the lines 53 accounting for the other fifty per cent of the reduction in false indications due to these causes. For gags (which are caused by hard spots in the rail due to bending of the rails at the mill), and for scale the lateral flux 53 appears to be of considerable importance even though it is difficult to explain why indications due to scale on the gauge edge of the rail 52 are effectively eliminated by use of an auxiliary magnet of the form shown in Fig. 3 which is positioned substantially over the outer portion of the rail head. It may be due to the flux conditions indicated in Figs. 5 and 6, which show that even when the auxiliary device is assymmetrically arranged, some of the main flux is laterally diverted, which produces a quick shaking up of the molecules in the adjacent portions of the rail.

The "F" magnet

The "F" magnet 25 is best shown in Fig. 7, and it is supported from the car which carries it by stainless steel brackets 54 and 55. The pole pieces 26 and 27 are suspended from the horizontal pole 31 by bolts 57 and clips 58 hold the coils 28 in place on the poles 26 and 27. Preferably the bottom ends of the poles 26 and 27 are magnetically connected by a bridge 59 of cold rolled steel bent at the ends as indicated at 60 to assist the magnet in riding over obstacles.

Purely by way of example, the horizontal pole 31 may comprise a bar of cold rolled steel approximately 36 inches long and 2 x 6 inches in cross section, and the poles 26 and 27 may be approximately 8 inches in length and of like cross section. The coils 28 may have 2926 turns apiece of 16-gauge enamelled wire, and when energized from a 110 volt D. C. source, and connected in series, will draw approximately 2 amp. of current.

The poles 26 and 27 may be spaced apart a distance of approximately $5\frac{1}{2}$ inches.

The auxiliary magnet 32 and its mounting

The auxiliary magnet 32 is carried by the magnet 25 on a support generally indicated 61 which provides for universal movement of the magnet with respect to the "F" magnet 25. The support 61 includes a steel bolt 62 which passes through

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the horizontal pole 31 and is anchored in a stainless steel bracket 63. The bolt 62 passes through spaced collars 64 which are also secured to the bracket 63, these collars constituting a bearing support for the bolt 62 and permitting the entire support 61 to rotate about the bolt 62 as a pivot.

A brass bar 65 is pivoted at 66 to the bracket 63 and is urged downwardly by a spring 67 secured at one end to the bar 65 and at the other to a horizontally extending arm 68 of the bracket 63. The bar 65 may be lifted about the pivot 66 by any suitable means controlled from the car interior, as, for example, by a cable generally indicated at 69.

The magnet 32 is mounted at the free end of the bar 65 on a vertical pivot 70 so that the magnet can rotate about this pivot as may be required to properly follow the rail head.

The center pole 33 of the magnet 32 is preferably maintained in direct contact with the rail head 71 by means of a replaceable shoe 72 of mild steel which is beveled at 73 enabling the shoe to ride over rail joints, and which has trunnion bearing 74 adapted to be received within slots 75 (see Fig. 12) of the center pole 33. The shoe 72 is conveniently locked in place by a removable angle bracket 76 which is bolted to the poles 33 by bolt 77.

At the lower end of the pole 35 which carries the magnet coil 36 is secured the triangular pole piece 37 and for convenience, this pole piece mates with a brass piece 78, both of which are drilled to receive a securing bolt 79, that is threaded into the center pole piece 33.

Hinged to the lower end of the pole piece 35 are a pair of gauge brackets 80 which are adjustably secured by bolts 81 to a gauge runner 82 of stainless steel. The bolts 81 are mounted in slots 83 so that the gauge runner 82 may be adjusted laterally to the brackets 80 to thereby position the center pole 33 at selected positions over the rail head.

The bolt 84 which supports the brackets 80 serves as a pivot for rotation of the brackets 80 and gauge runner 82 as movement of the car with respect to the rail makes such swinging movement of the gauge runner necessary.

It will be understood that the entire support 61 is resiliently biased against the gauge edge 52 of the rail as shown diagrammatically at 87, and the ends of the gauge runner are flared outwardly as indicated at 85 and upwardly at 86 to enable the gauge runner to ride smoothly over the rail.

Purely by way of illustration, the coil 36 of the auxiliary magnet may have 10,000 turns of No. 30 enamelled copper wire, and when connected to a 110 volt D. C. source, will draw approximately .2 amp.

Although it is preferred to use direct current for the coil 36, it will be understood that under some circumstances, alternating current of the appropriate frequency may be used. A 60-cycle frequency is satisfactory.

In some practices of the invention, it may be desirable to use more than one magnet of the type exemplified by the magnet 25 to precondition the rail prior to subjecting it to the action of the "F" magnet 25 and the auxiliary magnet 32. Other means for placing the rail in a cyclic condition prior to the final flux energization of "F" magnet 25 and auxiliary magnet 32 may also be used.

We claim:

1. The method of magnetizing rails and the like to establish characteristic residual magnetic

fields in the vicinity of transverse fissures, which includes progressively passing a relatively strong, unidirectional, longitudinal flux lengthwise through the rail, and simultaneously with such longitudinal magnetic energization of the rail progressively subjecting at least a portion of the top surface of the rail head as it is being energized to the action of an independent unidirectional transverse flux.

2. The method of magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, which includes progressively passing a relatively strong, unidirectional, longitudinal flux lengthwise through the rail, and simultaneously with such longitudinal magnetic energization of the rail progressively subjecting at least a portion of the top surface of the rail head as it is being energized to the action of a unidirectional transverse flux that is introduced into the rail and passes out of the rail through said portion of the top surface.

3. The method of magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, which includes progressively passing a relatively strong, unidirectional, longitudinal flux lengthwise through the rail, and simultaneously with such longitudinal magnetic energization of the rail progressively subjecting at least a portion of the top surface of the rail head as it is being energized to the action of an independent unidirectional transverse flux that is maintained at a relatively shallow depth through said portion of the rail top surface.

4. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail and having means associated therewith for passing a unidirectional magnetic flux laterally through at least a portion of the rail head.

5. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail and having means associated therewith for passing a unidirectional magnetic flux laterally through at least a portion of the rail head, said last-named means including a direct current vertical coil positioned alongside and laterally of said vertical member, and an iron circuit associated with the coil, said iron circuit including said vertical member and being closed except for an air gap closely adjacent the top surface of the rail.

6. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said

apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail and having means associated therewith for passing a unidirectional magnetic flux laterally through at least a portion of the rail head, said last-named means including a direct current vertical coil positioned alongside and laterally of said vertical member, an iron circuit associated with the coil, said iron circuit including said vertical member and being closed except for an air gap closely adjacent the top surface of the rail, and a like vertical coil and iron circuit positioned diametrically opposed to said first-named vertical coil and iron circuit.

7. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail, and flux-producing means associated with said vertical member for passing magnet flux through said vertical member in the opposite direction from that in which flux enters the rail through said vertical pole of the main magnet.

8. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail and having means associated therewith for passing a unidirectional magnetic flux laterally through at least a portion of the rail head, said last-named means including a direct current vertical coil positioned alongside and laterally of said vertical member, and an iron circuit associated with the coil, said iron circuit including said vertical member and being closed except for an air gap closely adjacent the top surface of the rail, said air gap being defined by a pole member having a pole face inclined downwardly through the lower end of said vertical member.

9. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail, and a removeable wear shoe at the lower end of

said vertical member, said wear shoe having trunnion bearings engageable within slots in said vertical member, and means for locking said bearings within said slots.

10. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail, a removeable wear shoe at the lower end of said vertical member, said wear shoe having trunnion bearings engageable within slots in said vertical member, and a bracket for maintaining the trunnion bearings within said slots.

11. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a plurality of vertical poles mounted adjacent the forward end of the magnet, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail and with its upper end effectively spaced from said trailing end.

12. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a plurality of vertical poles mounted adjacent the forward end of the magnet, and a bar of highly permeable material joining the vertical ends of the said poles, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail.

13. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a plurality of vertical poles mounted adjacent the forward end of the

magnet, and a coil mounted on each of said vertical poles, wound in the same direction, and adapted when energized with direct flux to direct flux through said poles in the same direction, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail.

14. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, and an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail, said auxiliary device being mounted on said horizontal pole of the main magnet and having universal movement with respect thereto.

15. In apparatus for magnetizing rails and the like to establish characteristic residual magnetic fields in the vicinity of transverse fissures, said apparatus comprising a main magnet having a horizontal pole mounted over the rail and substantially parallel thereto, a vertical pole adjacent the forward end of the magnet, an auxiliary flux-orienting device located at least in part beneath the trailing end of said horizontal pole, said auxiliary device including a vertical member of relatively high permeability mounted with its lower end in substantial contact with the rail, said auxiliary device being mounted on said horizontal pole of the main magnet and having universal movement with respect thereto, a gauge runner carried by the auxiliary device, and resilient means for biasing the gauge runner against the gauge edge of the rail.

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