May 20, 1941. W. C. BARNES ET AL 2,242,220

FLAW DETECTING APPARATUS

Filed June 6, 1938 3 Sheets-Sheet 1

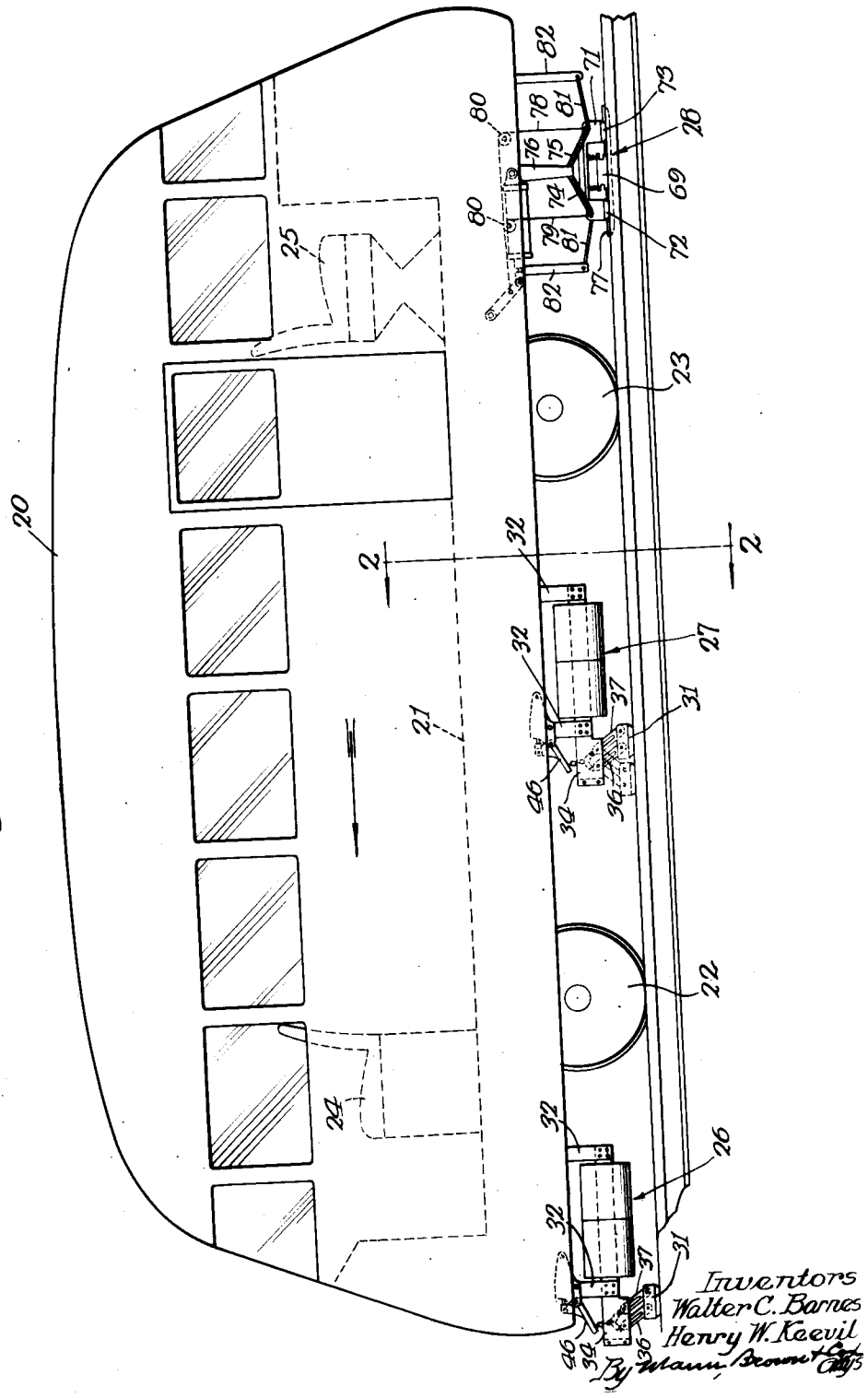


Fig. 1

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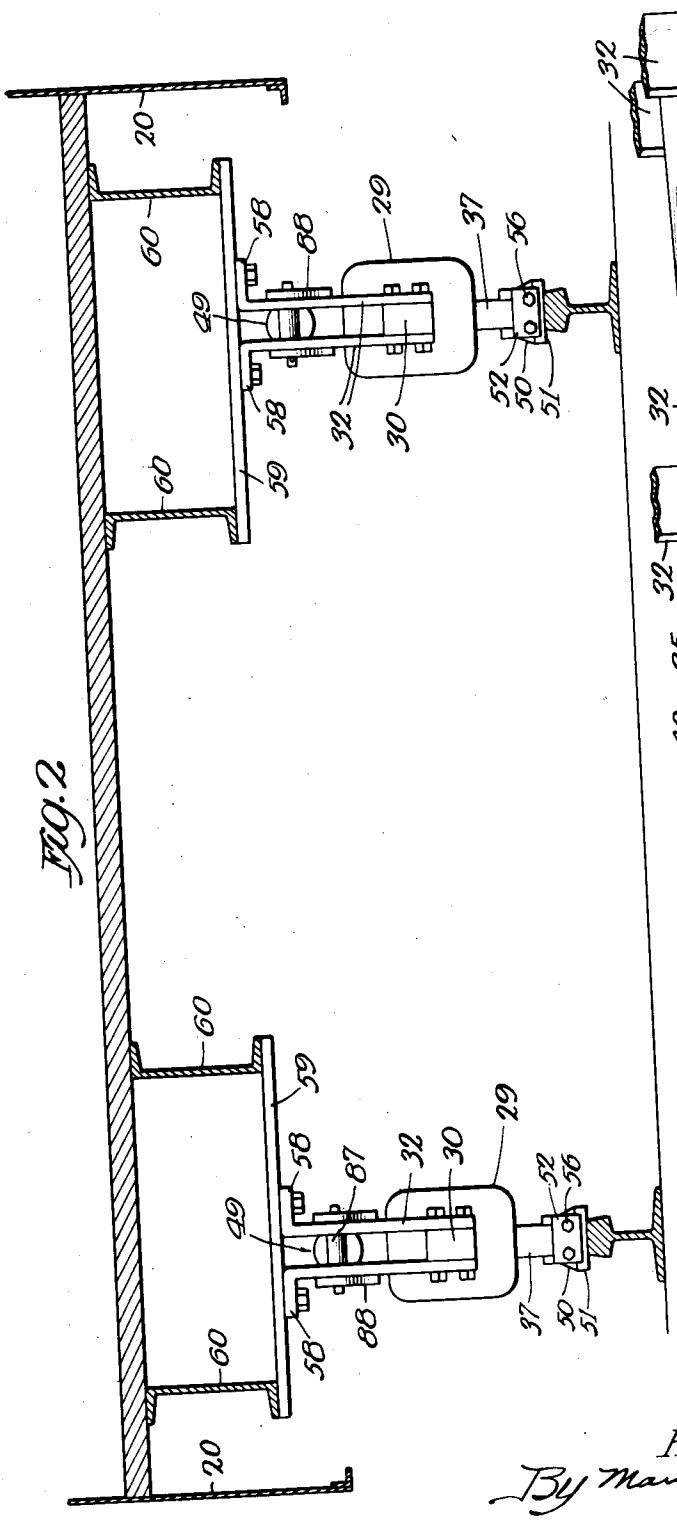


FIG. 2

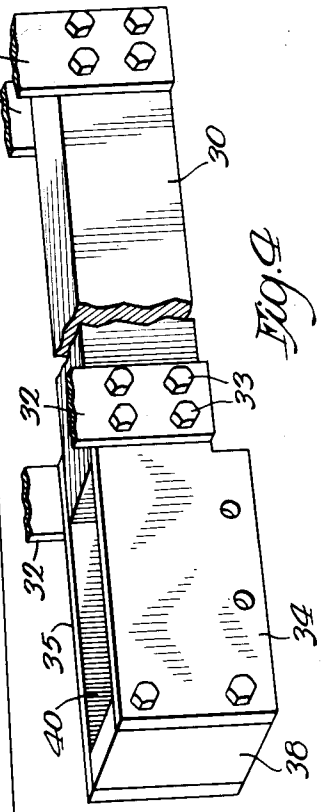


FIG. 4

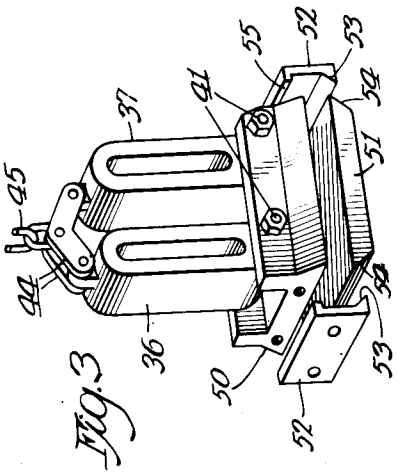


FIG. 3

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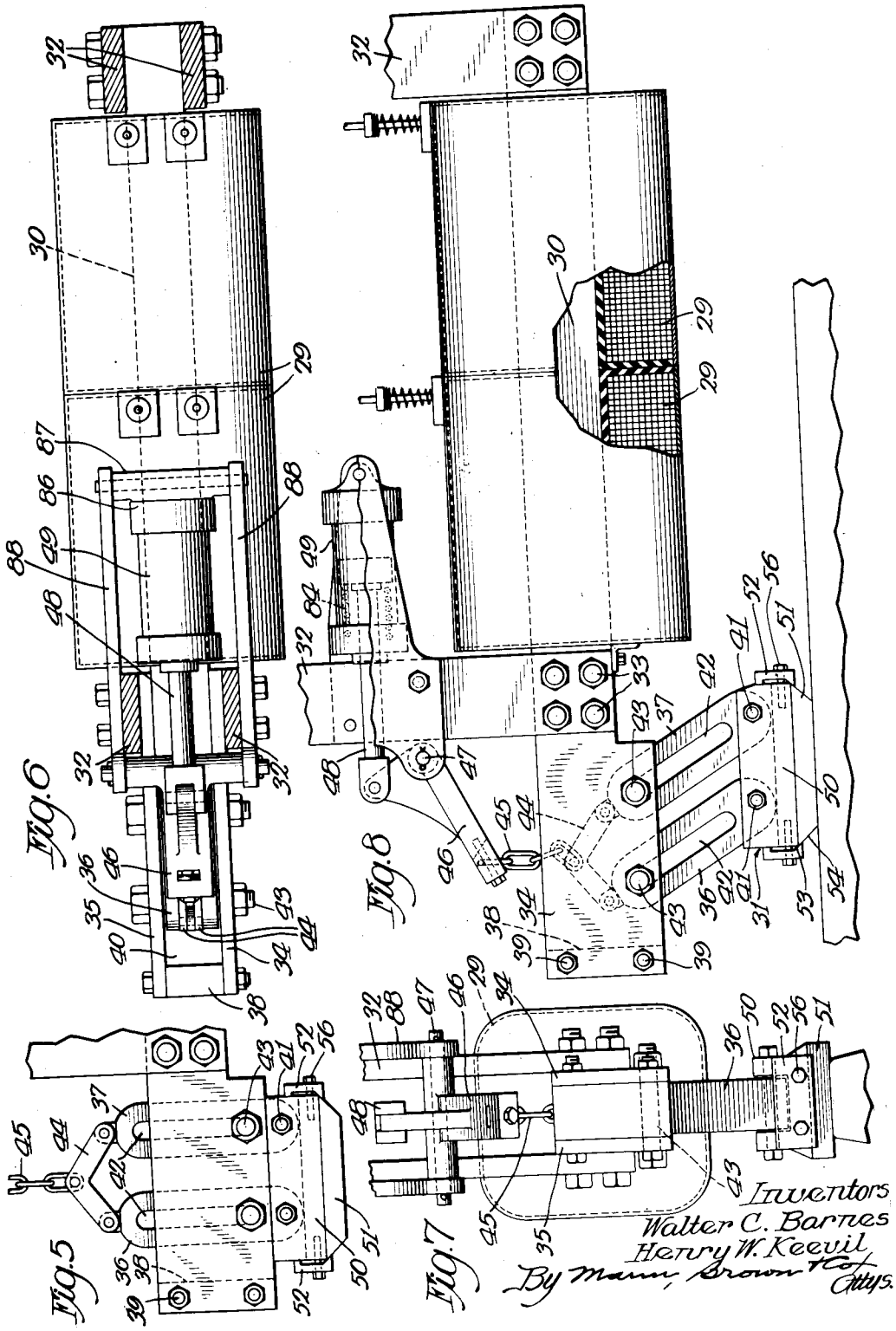


Fig. 6

Fig. 8

Fig. 5

Fig. 7

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UNITED STATES PATENT OFFICE

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FLAW DETECTING APPARATUS

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Application June 6, 1938, Serial No. 212,119

22 Claims. (Cl. 175—183)

In testing rails for flaws by the residual magnetism method, in which a detector unit is passed along a mangetized rail, the first step is to magnetize the rail. For this purpose the detector car carries one or more electromagnets adapted to cause magnetic flux to pass through the rail. To cause a high proportion of the flux available from the coil to pass through the rail, it is desirable to have one pole of the core closely and uniformly associated with the rail as by securing to the core a shoe which slides along the rail. It is necessary, however, that the magnet and its associated parts be well above the rail when not in use, and expensive and complicated mechanisms have been employed heretofore for raising and holding suspended in inoperative position the relatively heavy corresponding parts of detector cars now in use and alternatively holding them in the desired operative position with sufficient rigidity and resiliency to keep them in proper contact with the rail. Not only is this construction expensive if applied to a magnetic method of testing but the inertia of the heavy coil structure might be disadvantageous in its reaction to the irregularities of the rail surface. Without adequate means for absorbing the shock as the magnet slid over a rail joint, crossing or the like, the shock might injure the magnet or even be transmitted to the car.

According to the present invention both the objection to the expensive raising and lowering mechanism and the difficulties in connection with absorbing the shock are overcome by providing a rigidly mounted coil and core with a relatively movable extension of the core which slides along the rail when in use but which moves with respect to the core to avoid transmitting shock thereto and may be easily drawn upwardly when not in use. Because of the light weight of the movable part and because its inertia is relatively insignificant compared to its magnetic attraction for the rail, a uniform position with respect to the rail may be maintained and the raising and lowering mechanism may nevertheless be quite simple.

The mechanism provided in accordance with this invention is accordingly quite simple but it nevertheless incorporates several special features. The cross-sectional area of the core extension is kept relatively large all the way from the core to the rail so that there will not be any parts of the core which approach saturation so closely as to in effect form a constriction that would block off the flow of flux. Also, a linkage arrangement is provided which is relatively free from wear and which keeps the magnetic shoe in a position generally horizontal, though permitting slight variations therefrom.

Additional advantages and objects of the invention will be apparent from the following description and from the drawings, in which:

Fig. 1 is a side view of a detector unit equipped with one embodiment of this invention.

Fig. 2 is a transverse sectional view taken approximately on the line 2—2 of Fig. 1 and showing the rear view of the embodiment of this invention shown in Fig. 1.

Fig. 3 is a perspective exploded view of the movable pole construction of Fig. 1.

Fig. 4 is a perspective view of the fixed pole of Fig. 1.

Fig. 5 is a fragmentary side view showing the movable pole in raised position.

Fig. 6 is a horizontal sectional view looking down on the operating mechanism for the movable pole.

Fig. 7 is a front view showing particularly the movable mechanism.

Fig. 8 is a fragmentary side view partially broken away, showing various details of the illustrated embodiment of this invention.

A preferred embodiment of this invention has been shown in the drawings and will hereinafter be described all as required by section 4888 of the Revised Statutes, but the appended claims, which are required for the purpose of pointing out the invention, are not to be limited by this specific disclosure except to the extent that may be required by the prior art.

One outstanding advantage of the method and apparatus of the system for which this invention is designed is that it may be embodied in a rail car of modest size, such for example as the car shown in Fig. 1. The car comprises a house body 20 mounted on an underframe 21 which in turn is supported on front and rear wheels 22 and 23, respectively. It is of some importance that the wheels be of magnetic material, as is usual.

The car is normally driven in the direction indicated by the arrow in Fig. 1 with the driver sitting at 24 and the engineer in charge of tests sitting at 25. Since the controls form no part of the present invention, none will be described.

The principle of flaw detection in accordance with which this invention is used consists in introducing a strong magnetic flux into the rail or other magnetizable body to be tested, and after removing the energizing flux, then testing the body for traces of residual magnetism.

Each side of the car is equipped with a for-

ward electromagnet 26 and a rear electromagnet 27, the former preferably being in advance of the wheel 22 and the latter preferably being intermediate the wheels 22 and 23. Following the wheel 23 is a detector generally designated 28, and since the magnets 26 and 27, together with the detector 28 are identical with the corresponding magnets and detector on the other side of the car, only one set will be described.

The magnets 26 and 27 are also identical, and the details of their construction are shown in Figs. 2 to 8, inclusive. In explaining their construction reference may be made to one of them only, as for example the magnet 26. This magnet comprises a coil 29 preferably made in two parts to facilitate handling and replacement, and a core 30 which is provided at its forward end with a retractible pole 31 in the form of a shoe which may be lifted from the position shown in Fig. 8 (the service position) to the position shown in Fig. 5 (light-running position).

The electromagnet is supported from the car underframe by non-magnetic bars 32 preferably of stainless steel. The support bars 32 are secured to the horizontal portion 30 of the core by a plurality of bolts 33 (Fig. 8), those at the forward end of the core serving the additional function of clamping pole plates 34 and 35 to the core. These two plates together with links 36 and 37 and the magnet shoe 31 constitute an extension of the core, and all are made of annealed mild steel; or equivalent magnetic material.

The forward ends of the plates 34 and 35 are held apart by a spacer 38 through which bolts 39 pass so that an opening 40 is provided within which the links 36 and 37 may operate. The links are pivotally connected at their lower ends to the magnet shoe, as indicated at 41, and each has a slot 42 through which a guide bolt 43 passes. The upper ends of the links are connected by a clevis 44 and chain 45 to a bell crank lever 46 pivoted at 47 to the front support bars 32 and operated by plunger 48 of air cylinder 49. The lever 46 and the air cylinder parts are preferably all non-magnetic, such as bronze, with the exception of the spring 84 which is of steel.

The magnet shoe is best shown in Fig. 3 and it comprises a block 50 of mild steel, to the base of which a wear shoe or runner 51 of non-magnetic material, such as manganese or other wear-resistant steel, is secured by clamping plates 52. The plates 52 are provided with a beveled edge 53 adapted to engage a similarly beveled edge 54 of the runner 51, and a flange 55 provided along the upper margin of the plates 52 acts as a fulcrum about which the plates revolve when securing bolts 56 are screwed into the block 50. Whenever a runner requires replacement due to wear, it is only a matter of a few minutes to make the replacement due to the ease with which the plates 52 may be removed from the block 50.

The magnet block 50 with its runner 51 is made sufficiently wide so that it always maintains its proper position on the rail even when the car is rounding curves, or when there is lateral sway of the car. In normal operation, the shoe 31 rides on the top surface of the rail and accommodates itself to the unevenness in the rail surface. When the car is not being used for testing, but is traveling from one place to another at comparatively high speeds, the retractible shoe 31 is lifted to the position shown in Fig. 5 by action of spring 84 upon releasing air from the air cylinder 49.

In practice, it has been found satisfactory to energize the coils 29 from 110 volt D. C. source of electromotive force, and to provide approximately 25,000 ampere turns on each electromagnet. The core 30 preferably has a cross-sectional area of approximately six square inches, and the pole plates 34 and 35, links 36 and 37 and shoe 31 preferably have such shape and size that the energizing flux traveling through the iron circuit always has adequate cross-sectional area through which to pass. It should be understood, of course, that the mention of six square inches for the magnetic circuit is merely illustrative and that the figure may vary as service conditions demand. Also, by way of illustration, the rear end of the core 30 may be spaced above the top of the rail a distance of 5¾ inches and a distance of 14¼ inches from the car underframe, these distances having been found satisfactory.

The support bars 32 are preferably carried on the car underframe by angle flanges 58 secured to cross members 59 extending between longitudinal sills 60 of which there are two on each side of the car.

The detecting apparatus 28 used to indicate residual magnetism adjacent the rails in the vicinity of flaws, together with its mounting and the electrical circuit which connects it with the recording apparatus, is shown in Fig. 1, but since none of this apparatus is claimed per se in this application, the description of it will be limited to that which is necessary for showing the operativeness and useful combination of detecting apparatus with means for setting up residual magnetism in the rail.

One or more detector coils, with their cores, are mounted in a box 69 adjustably supported, both laterally and vertically from a detector carriage 71 having front and rear runners 72 and 73, respectively, which may be of stainless steel. Springs 74 and 75, secured at one end to a bracket 76, which projects downwardly from the car underframe outside of the gauge line of the track and at the other end to the detector carriage 71, hold the carriage in proper lateral position with respect to the rail as determined by an elongated guide runner 77 secured to the carriage.

The carriage 71 is moved from service position to light-running position by cables 78 and 79 which pass over pulleys 80 and are operated by a suitable air cylinder. The detector carriage is moved longitudinally of the rail by traction cables 81 which are firmly anchored to depending bars 82.

The electrical circuits have not been illustrated and need not be described, it being sufficient to state that a suitable amplifying and translating system is connected to each coil in the box 69 for recording the magnetic fields and for indicating on the rail the point at which a flaw has been detected.

From the foregoing the general operation of the testing equipment may be understood. First, the magnets 26 and 27 with their shoes 31 sliding on the rail magnetize the rail. The two magnets positioned on opposite sides of the wheel 22 seem to magnetize the rail more thoroughly than one magnet would alone. Subsequently, the detector unit 28, which is preferably positioned sufficiently far from the magnet 27 not to be influenced thereby directly, detects any magnetic fields adjacent the top of the rail head which may indicate flaws.

Inasmuch as the purpose of the detector unit

28 is to detect the presence of external fields caused adjacent to flaws by the residual magnetism of the rail, it is of course desirable that the rail be quite strongly magnetized. So that the intensity of the field adjacent a flaw will indicate the nature of the flaw, it is desirable that the magnetization be relatively uniform. The movable pole constructions including the shoes 31 is a very important feature in obtaining both adequate and uniform magnetization of the rails.

In order to obtain maximum magnetizing effect from a given magnet 26 one pole of the magnet should extend quite close to the rail. Surprising though it may seem, it has been found that best results are obtained by leaving the other pole of the magnet a considerable distance above the rail. The reason for this is that with the rear pole in contact with or close to the rail some of the flux would pass away from that pole in the wrong direction in the rail and hence tend to de-magnetize the rail. The shoe 51 serves the purpose of a pole constantly in magnetic proximity to the rail. Because of its movability with respect to the rigidly mounted magnet 26 it can follow any slight variations in the upper surface of the rail. In this connection it should be pointed out that it follows such variations without any damage to the magnet 26. Any jolts administered to the shoe 31 in crossing rail joints, for example, are taken up with substantial completeness by pivoting of the links 36 and 37. If it were attempted to mount the heavy coil 26 so that it, instead of a movable pole portion thereon, would follow the slight variations of the rail, the inertia of this heavy coil might give considerable trouble since it might not rise and fall nearly as readily as does the relatively small shoe 31. The shoe 31 needs no springs to force it into contact with the rail since it is drawn into firm contact therewith by the magnetic attraction between the shoe 31 and the rail. As a matter of fact, this magnetic attraction is so great that there is considerable wear on the wear plate or runner 51. For this reason the construction shown in Fig. 3, which permits the ready replacement of the runner 51, is very important.

Although the clevis 44 may comprise two independent and pivotally connected clevises, one for each of the links 36 and 37, it is preferred that it be a double clevis as seen best in Fig. 3. Such a double clevis may be formed very simply by two V-shaped plates as shown. One advantage of the double clevis is that it maintains the links 36 and 37 spaced apart the same distance as are the guide or pivot pins 43 and 41 so that the wear on the pins 43 is reduced to a minimum. If the clevis 44 were made of two separate portions pivoted to the chain 45, it would tend to draw the links 36 and 37 toward one another and make them rub with greater force on the pivots 43. Besides increasing the wear, this would increase the force required to raise the links 36 and 37 and the shoe 31. With the friction reduced by a rigid double clevis and because of the relatively small size of the shoe 31, the air cylinder 49 may be fairly small. This helps to make practical the provision of a separate air cylinder for each of the magnets. These air cylinders are very economically operated partly because of their small size and partly because the spring 84 therein normally urges the plunger into the cylinder, raising the shoe 31 so that no air is required to hold the shoe up. Accordingly, air is only used to expel the plunger 48 in lowering the shoe 31 to the rail.

The air pressure need not be continued after the magnet is energized since the magnetic attraction will hold the shoe 31 down. In fact, spring 84 can be so designed as to just support the shoe 31 and associated parts when the magnet is de-energized, in which case the energization of the magnet will pull the shoe 31 down and the air cylinder need not be provided at all.

Another advantage of the use of the rigid clevis or link 44 which maintains the links 36 and 37 properly spaced apart is that it prevents the shoe 31 from being tilted very far away from the horizontal. Of course, a reasonable amount of freedom in its movement is desirable so that it may conform to the irregularities of the rail, but the link 44 does not interfere with this slight amount of freedom.

The mounting of the air cylinder 49 is very simple. Its base cap 86 is cast with an extension 87 thereon which is pivoted to two side plates 88 secured to support bars 32. The lever 46 is also pivoted to these side plates.

It should be noted that the shoe 31 always drags rearwardly with respect to the movement of the car. Thus, as illustrated in the drawings, which assume the car to be moving forwardly, the shoe 31 drags toward the rear of the car. If, however, the car should be reversed, the slots 42 would permit the links 36 and 37 to slide upwardly on pins 43 to permit the shoe 31 in effect to pass under the pins 43 and drag in the opposite direction. This, together with the use of the heavy wear plate 51 and the heavy parts which are used throughout partly for the purpose of providing adequate cross section for the flow of flux, provides a very sturdy unit which will very rarely need any attention other than the occasional replacement of the wear plate or runner 51.

To minimize further the possibility of expensive repairs, the coils 29 are preferably provided in two or more parts so that if one of them is found to be defective or burns out it may be replaced without having to replace the other.

From the foregoing it is seen that a very satisfactory magnet construction is provided for magnetizing rails while suspended from a flaw detector car. The main body of the magnet is rigidly supported by the car while a relatively movable pole portion slides on the rail and forms an adequate magnetic path between the core and the rail. The movable portion is constructed to move so easily that it may be raised out of the service position to the light-running position simply by spring action with the result that a relatively small air cylinder may be used for lowering it. Because of the reduction in friction the wear is negligible throughout the magnet except for the readily replaceable wear plate which engages the rail. Because of the uniform spacing of the movable pole portion with the rail and because of the ease with which the shoe may follow the irregularities of the rail, the rail is efficiently and uniformly magnetized.

We claim:

1. Rail-magnetizing apparatus including a coil, a core within the coil and extending therefrom at one end, a link movable with respect to the core but magnetically connected thereto, and means carried by the link adapted to carry flux to the rail.

2. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, a pair of magnetic

links pivoted to the extension one in front of the other, and a shoe similarly pivoted to the links for engagement with the rail and movement with respect to the core.

3. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, pins on the extension one in front of the other, a slotted magnetic link slidable on each pin, and a shoe pivoted to the links for engagement with the rail and movement with respect to the core.

4. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, a pin on the extension, a slotted magnetic link slidable on the pin, and a shoe pivoted to the link for engagement with the rail and movement with respect to the core.

5. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, a pin on the extension, a slotted magnetic link slidable on the pin, and a shoe pivoted to the link for engagement with the rail and movement with respect to the core, said link being free to swing in either forward or backward direction permitting the shoe to drag rearwardly with respect to both directions of movement of the core and coil.

6. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, a pin on the extension, a slotted magnetic link slidable on the pin, a shoe pivoted to the link for engagement with the rail and movement with respect to the core, and means engaging the upper ends of the link and adapted to raise it to raise the shoe from the rail.

7. Rail-magnetizing apparatus including a coil, a magnetic core within the coil and having an extension beyond the core, pins on the extension one in front of the other, a slotted magnetic link slidable on each pin, a shoe pivoted to the links for engagement with the rail and movement with respect to the core, and means engaging the upper ends of the links and adapted to raise them to raise the shoe from the rail, the link-engaging means comprising a single link which holds the upper ends thereof in a spaced relationship corresponding to the spacing of the pivots.

8. The combination of a rail car, a magnet rigidly secured thereto and including a core, a link magnetically connected to the core but movable with respect thereto, and a shoe carried by the link and adapted to engage the rail, the shoe including a portion readily removable to permit replacement thereof.

9. The combination of a rail car, a magnet rigidly secured thereto and including a core, a link magnetically connected to the core but movable with respect thereto, and a shoe carried by the link and adapted to engage the rail and being of greater width than the rail head so as to maintain adequate contact therewith in spite of curves in the rail.

10. Rail-magnetizing apparatus including a coil, a core within the coil, a magnetic extension for the core having a passage therethrough having elongated pivot pins positioned one in front of the other and extending across the passage, a pair of slotted links approximately the width of the passage extending into the passage and during operation hanging on the pins, and rail-engaging means having pivot pins spaced the same as the first mentioned pivot pins, drawn by the links, and during operation resting on the rail.

11. The combination of a rail car, a magnet rigidly secured thereto and including a core, a link magnetically connected to the core but movable with respect thereto, a shoe carried by the link and adapted to engage the rail, and a spring supported at one end relative to the car and at the other end relative to the shoe for raising the shoe when the magnet is de-energized but too weak to raise the shoe when it is held against the rail by the magnetism of the energized magnet.

12. The combination of a rail car, a magnet rigidly secured thereto and including a core, a link magnetically connected to the core but movable with respect thereto, a shoe carried by the link and adapted to engage the rail, including a beveled wear plate and clamps adapted to engage the bevel to secure the wear plate removably to the shoe.

13. In combination, a rail flaw-detecting car having a frame member, a magnet having a core and a pole piece movable toward the rail, a support member securing the core to the frame member, a cross member carried by the support member, an air cylinder having a plunger extending from its front end and pivoted at its rear end to the support member, a bell crank lever pivoted to the cross member and connected at one end to the pole piece and at the other end to the plunger of the air cylinder.

14. Rail magnetizing apparatus including a source of magnetic flux adapted to be carried by a car and including a magnetic structure having two pole portions, one positioned well above the other so as to be positioned well above the rail, and the lower pole portion being vertically movable with respect to the upper pole portion and being adapted to ride on the rail during operation, and an air cylinder connected exclusively and substantially directly to the lower pole portion to control its vertical position.

15. In combination, a rail flaw-detecting car having magnetic wheels, a magnetic longitudinal frame member positioned approximately over the wheels, a magnet having a core and a coil and secured to the frame member by non-magnetic support members secured to the core, and a movable pole piece connected to one end of the core and extending a variable distance toward the rail and resting thereon; the other end of the core terminating at a point relatively remote from the rail but at least as close to the rail as to the frame member, and non-magnetic means for raising and lowering the pole piece, including an air cylinder secured to the support members.

16. In combination, a rail flaw-detecting car having magnetic wheels, a magnetic longitudinal frame member positioned approximately over the wheels, a magnet having a core and a coil and secured to the frame member by non-magnetic support members secured to the core, and a movable pole piece connected to one end of the core and extending a variable distance toward the rail and resting thereon; the other end of the core terminating substantially nearer to the rail than it does to the frame member.

17. In combination with a rail car, a magnet mounted upon the car, a movable pole piece capable of being raised from and lowered to the rail independently of the magnet, and means for trailing the pole piece off center its plumb position in either direction depending upon the direc-

tion in which the car is moving when the pole piece is in contact with the rail.

18. In combination with a rail car having a magnet mounted thereon, a movable pole piece for the magnet, means for raising and lowering the pole piece independently of the magnet with regard to contact with the rail, and means for maintaining the pressure of the pole piece upon the rail constant regardless of relative movement between the magnet and the rail during car movement along the rail.

19. In combination a rail car, a magnet mounted upon the car and having its core located at a fixed position on the car, a pole piece mounted on the core and adapted to be raised and lowered independently of the core and with respect to the rail, and means for supporting the pole piece a spaced distance from the rail when the pole piece is raised.

20. In combination with a rail car, a magnet mounted on the car with the core supported a predetermined distance above the rail, a pole piece associated with the core and movable with respect to the core and the rail, and means carried by the car for raising and lowering the pole piece independently of any movement of the magnet, and for supporting the pole piece in raised position.

21. In combination with a rail car, a horizontal magnet mounted on the car with the core supported a predetermined distance above the rail, a pole piece associated with the core and movable with respect to the core and the rail, means operable from inside the car for raising and lowering the pole piece independently of any movement of the magnet.

22. In combination with a rail car, a horizontal magnet rigidly secured to the car with the core thereof located a spaced distance from the rail, a pole piece mounted on the core and extending therefrom towards the rail, said pole piece being movable with respect to the core and the rail, and means for moving the pole piece towards and away from the rail independent of the magnet, said means including a device for supporting the pole piece a spaced distance from the rail when the pole piece is raised.

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