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RAIL FISSURE DETECTOR

Filed Aug. 26, 1931

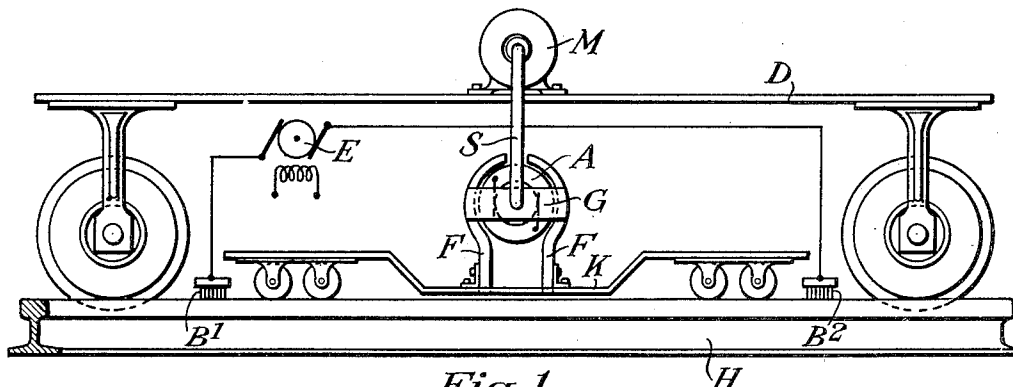


Fig. 1.

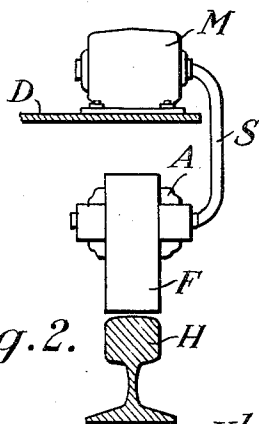


Fig. 2.

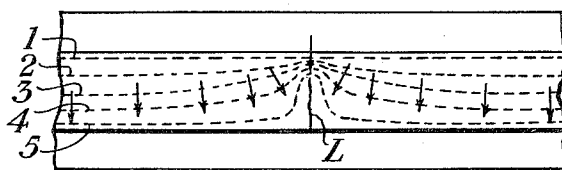


Fig. 3.

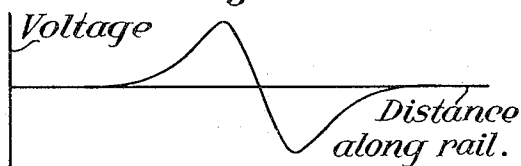


Fig. 4.

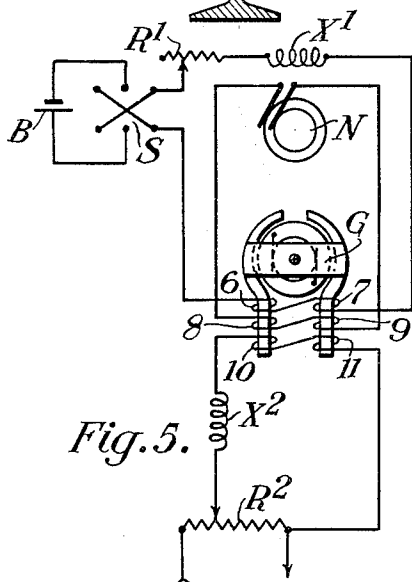


Fig. 5.

To Field Circuit
of Generator E.

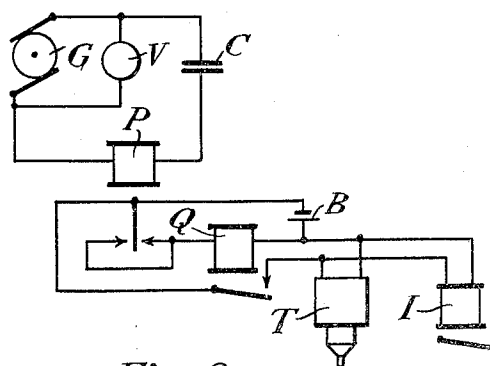


Fig. 6.

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RAIL FISSURE DETECTOR

Application filed August 26, 1931. Serial No. 559,380.

Our invention relates to means for automatically detecting flaws and fissures in metallic bars, and more specifically, to the detection of flaws and fissures in railway rails.

5 The purpose of our invention is to provide detecting means of such character that rail fissures of relatively small magnitude can be readily detected. In this manner, dangerous rails can be discovered and removed before
10 the fissure becomes of such magnitude as to endanger railway traffic.

One feature of our invention is that apparatus of an extraordinary degree of sensitivity is not necessary. Another feature is
15 that relative motion of the detecting apparatus with respect to the rail is not required, so that tests for rail flaws can be made at very low speeds of the test car relative to the rail, and can also be made with the test car at
20 standstill. This result is of marked practical advantage and is obtained because the effectiveness of apparatus embodying our invention increases as the speed of the test car decreases. A further feature of our inven-
25 tion is that compensation for offending influences which might decrease the effectiveness of the detecting apparatus can be readily made.

30 We will describe one form of apparatus embodying our invention, and will then point out the novel features thereof in claims.

In the accompanying drawing, Fig. 1 is a diagrammatic view showing the general fea-
35 tures of a test car and a portion of the detecting equipment resting on a rail to be tested.

Fig. 2 is an enlarged end view of a part of the apparatus shown in Fig. 1.

40 Fig. 3 is a view looking downwardly on the top of a rail, in which the current distribution around a fissure in the head of the rail is shown.

Fig. 4 is a curve of induced voltage in the detecting equipment as the rail fissure of Fig.
45 3 is passed by the test car.

Fig. 5 is a diagrammatic view showing several means which can be used to compensate for stray influences which might affect the operation of the detecting equipment.

50 Fig. 6 is a diagrammatic view showing the

electrical connections for one arrangement of the detecting apparatus.

Referring to Figs. 1 and 2, the reference character D designates a test car arranged to
55 travel upon the rails H of a railroad and propelled by any suitable means such as an internal combustion engine, not shown in the drawing. Mounted upon the floor of the test car is a motor M having a flexible driving
60 connection S with armature A of generator G. The test car D also carries a generator E capable of producing a heavy direct or alternating current which is introduced into a section of the rail H by brushes B¹ and B².
65 The generator G is mounted upon a carriage K in such manner that field poles F are in close proximity to the rail surface. It will be noted that no magnetizable connection exists between the lower ends of field poles
70 F of generator G, so that there exists an open magnetic circuit resulting in no appreciable voltage being generated in armature A when motor M is operating, under normal conditions. As shown, armature A is an ordinary
75 direct current generator armature having a drum winding and a commutator. However, it will be apparent that the winding of armature A may be of any suitable form for inducing a voltage therein, provided suitable
80 apparatus responsive to that voltage is used. For example, an alternating current generator winding could be used on armature A and a rectifier interposed between the slip ring output and the direct current indicat-
85 ing devices.

Horizontal motion of car D along the rails H is transmitted to the carriage K by a suitable mechanical connection which is not shown in order to simplify the drawing. This connection should be of such character
90 that vertical vibratory motions of car D will not be transmitted to carriage K as it is of great importance to keep the pick-up generator G at a constant height above the rail, and provision should also be made for raising
95 the carriage away from the rails at such times as tests are not being made in order to eliminate unnecessary wear when the test car is being rapidly driven to the operating location. Generator E may be used to supply
100

current to both track rails and motor M may be coupled to drive a second generator, such as G, mounted upon an independent carriage K and cooperating with the second track rail, so that both rails may be tested during one run of the test car. The reason for using a separate carriage for each pick-up generator is to eliminate as much as possible the effect of road shocks and vibration from being transmitted from one generator to the other. An alternate method for driving the pick-up generators is to use an air turbine mounted directly on each carriage K and coupled by means of an air hose to a tank and compressor carried upon car D.

We shall now describe the manner in which the apparatus thus far referred to functions in the presence of a rail fissure. The underlying principle of operation is that a voltage can be induced by the magnetic flux in the immediate vicinity of a fissure, which flux is associated with a heavy current introduced into the rail. According to our invention, this flux induces a voltage in a pick-up coil or coils carried on the test car, due to a motion other than that of the test car itself, thereby making it possible to perform rail fissure tests with the car at a standstill. As noted hereinbefore the magnetic circuit of pick-up generator G is open at the bottom, there being no backstrap from one field pole to the other, and the poles are placed in line with the rail length, so that if these poles are subjected to an external magnetic field which is parallel to the rail length, a voltage will be induced in armature A. The magnetic field produced by the rail current which is introduced into the rail from generator E does not thread the armature of the pick-up generator, unless this current is deflected by a fissure. It should be understood that our invention is not limited to the particular position of the field poles F with respect to the rail which is shown in the drawing, because the field poles F may be positioned in any suitable manner as long as the flux associated with the rail current when this current is deflected by a fissure in the rail gives rise to a voltage output in armature A, the position of the field poles F being determined by the direction of flow of the undeflected rail current, which in turn is determined by the location of brushes B¹—B² with respect to the rail.

In order to detect magnetic poles in the rail resulting from residual magnetism localized at portions of the rail where the permeability is not uniform, the rail can first be tested with no rail current being fed from generator E. Since the flux set up by alternate north and south poles in the rail will have a direction generally parallel to the rail length, this flux will link the winding of generator G and the induced rotational voltage will indicate the presence and location of

such poles. In this manner these poles can be distinguished from rail fissures which are the only factors giving rise to a voltage in generator G after the residual poles are wiped out by the heavy rail current flowing during the second or repeat run.

Reference to Fig. 3 will show how, in a simple case, a rail fissure L in the head of a rail deflects the rail current, assumed to be direct current for purposes of illustration and indicated by broken lines 1, 2, 3, 4 and 5, to produce a component of magnetic field parallel to the rail length. The arrows in Fig. 3 indicate the general direction of the magnetic field. Thus, as the pick-up generator moves over the fissure L from left to right, it will have a voltage induced in its armature, of the character indicated in Fig. 4. The magnitude of this voltage is, for a given distribution of rail current, practically independent of the motion of the test car, the rate of cutting of the flux lines being predominantly established by the speed of rotation of armature A. It is this feature which primarily distinguishes my invention from systems which employ a car-carried coil suitably arranged with respect to the magnetic field of the rail current and which rely upon the motion of the car for an output voltage in the coil in going over a fissure.

The output voltage of the pick-up coil in a system of the latter type thus approaches zero as the car speed approaches zero, and increases in direct proportion with that speed. However, advantage can not be taken of a high speed of operation of the test car in such a system because there are several factors which limit this speed, among which can be mentioned the time required for the current to penetrate into the rail (high inductance of the large magnetizable mass of the rail) and the speed of operation of indicating devices controlled by the output from the pick-up device. Thus, in such systems there is an optimum speed of operation. If the car speed is above this value, the rail current will have insufficient time to penetrate into the rail and the current density at an internal fissure will be small. Furthermore, the indicating devices may be too slow to respond at this speed. If the car speed is below the optimum value, the sensitivity of the pick-up device falls off. In a system embodying our invention, since the pick-up generator voltage is practically independent of car speed, there exists no urgent necessity for operating the test car at speeds which are disadvantageously high, so that such limitations are removed and the net sensitivity of detection increases with decreasing car speed and approaches its maximum as the car speed approaches zero. Another advantage of the generator type of pick-up is that at a given car speed, the output voltage per turn of the armature or pick-up coil is higher than

that of a simple, non-rotating car-carried coil. This result follows because the effective component of the magnetic field at a fissure is cut much more rapidly by the rotating coils of the pick-up generator, in consequence of which, complete elimination of amplifying equipment, or at least a substantial reduction in the degree of amplification required, becomes practicable.

In making use of the generator type of pick-up there are several sources of stray magnetic fields, the effect of which it is desirable to annul in order that the pick-up generator output will not be influenced. One method of compensating for each of three such fields is shown in Fig. 5, and we shall describe in connection with each offending field the method which we prefer to use for its compensation.

Earth's field.—Since there will generally be a component of the earth's field cutting the armature coils, some output will arise from this source. The earth's field is relatively uniform over large areas and its effect can be eliminated by coils such as 6 and 7 wound on the generator field structure. A direct current may be sent through these coils from a battery B in such a direction as to neutralize the effect of the earth's field. The direction and magnitude of this current can be controlled by a reversing switch S and a variable resistance R^1 at the operator's location. The purpose of the reactor X^1 will be explained hereinafter.

Residual magnetism in iron of pick-up generator field.—After being exposed to magnetic fields of appreciable magnitude, the field iron of the pick-up generator will retain some magnetization which will give rise to an output from the generator. This may in part be overcome by coils similar to 6 and 7 and controlled in a manner analogous to that used in compensating for the earth's field. However, a more effective and preferable method is to superimpose an alternating current flux upon the field structure by means of two coils 8 and 9 excited from a suitable alternating current generator N. Generator N may be driven from the same source which drives generator E of Fig. 1. The frequency of the current supplied by generator N may be 60 cycles or some value between 60 and 500 or more cycles. The magnitude of the alternating current should be sufficiently high to keep the iron of the generator field demagnetized, on the average, in the absence of any external magnetizing force such as would exist at a fissure. To prevent appreciable alternating currents from being induced in adjacent circuits, such as that which includes coils 6 and 7 for example, a current limiting reactor X^1 may be used to suppress such currents. The alternating current magnetization supplied by generator N to the pick-up generator will result in an al-

ternating current output. Therefore, a sufficiently high frequency must be chosen for generator N so that the indicating equipment shown in Fig. 6 will not have sufficient time to respond between pulses of this output. If the generator N is of low frequency, then means must be provided in the form of suitable series reactors or shunt condensers, or both, to filter out the undesirable output.

Stray fields from electromagnetic apparatus on board the test car.—These magnetic fields may come, for example, from the field of the rail current generator E, or from the heavy current leads connecting this generator to the rail brushes B^1 and B^2 . These fields produce an effect similar to the earth's field and may in part be controlled by coils such as 6 and 7. However, since the magnitude of these fields is subject to variation, other more effective means must be provided. To compensate for the stray field from the field structure of generator E, we prefer to employ neutralizing coils 10 and 11, also wound on the field structure of generator G, which coils carry a fixed proportion of the field current of generator E. The magnitude of the neutralizing current in coils 10 and 11 is controlled by a potentiometer R^2 which is adjusted by the operator until compensation is obtained. Any fluctuations in the field current of generator E, which would produce fluctuations in the stray field about the pick-up generator, and hence possible fluctuations in the output, are automatically neutralized by this arrangement. The reactor X^2 serves a similar purpose to that of reactor X^1 in suppressing induced high frequency currents from generator N in the field circuit of generator E.

Compensation for the stray field from the heavy current rail leads of generator E, which field is also subject to fluctuation, can be obtained in a similar manner to that just outlined in connection with the field current of generator E. Additional coils such as 10 and 11 can be applied in like manner to neutralize the effect of any other offending circuits which may be present. Although we have shown all three types of neutralization applied to the pick-up generator, these may not all be necessary, and various combinations of the neutralizing apparatus may be used, as required. Furthermore, the neutralizing coils need not necessarily be wound directly on the field structure of the pick-up generator, but may be placed in the vicinity of this generator in such manner that their magnetic fields are effective.

The arrangement of apparatus illustrated in Fig. 6 shows one method in which the output from the pick-up generator G can be utilized to operate detecting equipment on board the test car. As shown, this output is fed directly from the pick-up generator G through a condenser C to a sensitive polar-

ized relay P, which in turn controls a less sensitive neutral relay Q having a fast pick-up and a slow releasing time. Polarized relay P is biased in any suitable manner by gravity or by a spring to the position illustrated, in which both of its associated contacts are open. The purpose of having relay Q release slowly is to enable its front contact to remain closed during a reversal of polarized relay P when a fissure is passed. Relay Q may be used to control any suitable devices such as an electrically controlled paint spray T, and a visible or audible indicator I. The purpose of the paint spray is to mark the rail at the location of the fissure.

If a condenser, such as C, is not used in a circuit of the type shown in Fig. 6, it will be found necessary to neutralize stray fields very accurately, otherwise any steady stray output will cause relay P to remain energized, with the result that the polarized contact of this relay will remain closed to one side or the other. This situation is improved by using the series condenser C which blocks any steady output, yet permits the pulses which occur at a fissure to affect relay P. If greater sensitivity is required, the circuit of Fig. 6 can be modified by inserting an amplifier in any of several well known ways between the output generator G and the indicating equipment. If this amplifier involves reactive or transformer coupling at any stage, the action will be similar to that of Fig. 6 with the blocking condenser, and the indicating equipment will respond to pulses only. If a strictly "direct current amplifier" is used, the action will be similar to that of Fig. 6 without the blocking condenser. The purpose of the voltmeter V which is connected across the terminals of generator G is to provide an indication that all stray fields have been neutralized. As long as stray fields are present, in the absence of a rail fissure, the voltmeter V will show a deflection, indicating that the neutralization is not complete. Another function of voltmeter V is to indicate the relative magnitude of a fissure, which fact can be determined from the magnitude of the deflection produced when a fissure is passed. The voltmeter V also makes it possible to perform rail fissure tests with the test car at a standstill, when condenser C is used, in which case the voltmeter deflection will indicate a fissure even though relay P does not respond, due to the steady output from generator G being blocked by condenser C.

It is obvious that apparatus embodying our invention will function at a rail joint, which can be considered as a fissure of extraordinary magnitude. One advantage resulting from rail joint detection is that it furnishes a check upon the operative condition of the apparatus while a test is in progress.

Furthermore, if a moving chart is used, operatively connected to a wheel of the test car, on which marks which will indicate rail joints and fissures are made by suitable indicating equipment, then the paint spray can be dispensed with and the fissure located accurately with respect to a rail joint by scaling the distance from a rail joint to a fissure on the chart.

Although we have herein shown and described only one form of apparatus embodying our invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. Apparatus for detecting flaws in rails comprising a test car movable along the rail, means carried upon the car for passing a direct current through a section of the rail being tested, a movable winding carried by said car, means for imparting a motion to said winding independent of the motion of said car for cutting lines of flux associated with said current when and only when the current becomes diverted by a flaw in said rail whereby a voltage of greater magnitude than that due to the motion of the car alone is induced in said winding, and indicating means responsive to said voltage.
2. In a flaw detector for metallic bars, means for passing a direct current of substantially constant magnitude through the bar being tested, a winding arranged when rotated to cut lines of flux associated with said current when and only when said current is diverted by a flaw in said bar, means for rotating said winding, means for moving said winding progressively along said bar, and indicating means responsive to a change in the voltage induced in said winding when the winding passes a flaw in said bar.
3. In a flaw detector for metallic bars, means for passing a direct current through the bar being tested, a winding, means for rotating said winding to cut lines of flux associated with said current when and only when the current becomes diverted by a flaw in the bar, and indicating means responsive to the voltage induced in said winding.
4. In a flaw detector for metallic bars, means for passing a direct current lengthwise through the bar being tested, a generator comprising an open magnetizable field structure arranged in close proximity to said bar whereby said field structure becomes linked by flux associated with said current when and only when said flux has a component in a direction parallel to the bar length, a winding for said generator arranged when rotated to cut the lines of flux linking said field structure, means for rotating said winding,

and indicating means responsive to the voltage induced in said winding.

5. In a flaw detector for metallic bars, means for passing a direct current in a given direction through the bar being tested, a generator comprising an open magnetizable field structure arranged in close proximity to said bar whereby said field structure becomes linked by flux associated with said current if and only if the current direction becomes changed due to a flaw in said bar, a winding for said generator arranged when rotated to cut the lines of flux linking said field structure, means for rotating said winding, and indicating means responsive to the voltage induced in said winding.

6. In a rail flaw detector, the combination of means for supplying a direct current to the rail, a winding arranged when rotated to cut lines of flux associated with said current when the current is diverted by a flaw in the rail, adjustable means including a source of energy for causing a direct current to flow in proximity to said winding whereby a field is created for neutralizing the effect of substantially steady stray fields in the vicinity of said winding, means for rotating said winding, and indicating means responsive to the voltage induced in said winding.

7. In a rail flaw detector, the combination of means for supplying a direct current to the rail, a winding arranged when rotated to cut lines of flux associated with said current when the current is diverted by a flaw in the rail, adjustable means for neutralizing a variable stray field comprising a resistor connected into the circuit producing the stray field and a circuit energized from the drop across an adjustable portion of said resistor for causing a current to flow in proximity to said winding whereby said variable stray field becomes substantially neutralized, means for rotating said winding, and indicating means responsive to the voltage induced in said winding.

8. In a rail flaw detector, the combination of means for supplying a direct current to the rail, a first winding arranged when rotated to cut lines of flux associated with said current when the current is diverted by a flaw in the rail, means for neutralizing a variable stray field comprising a second winding connected into the circuit producing the variable stray field for creating a field in proximity to said first winding whereby said variable stray field becomes substantially neutralized, means for rotating said first winding, and indicating means responsive to the voltage induced in said first winding.

9. In a rail flaw detector, the combination of means for passing a direct current in a given direction through the rail being tested, a generator comprising an open magnetizable field structure arranged in close proximity

to the rail whereby said field structure becomes linked by flux associated with said current if the current direction becomes changed due to a flaw in said rail, a winding on said field structure arranged to be constantly energized with alternating current of sufficient magnitude and frequency to cause said field structure to become substantially free of residual magnetization, an armature winding for said generator arranged when rotated to cut the lines of flux linking said field structure, means for rotating said armature winding, and indicating means responsive to the voltage of relatively low or zero frequency induced in said armature winding from the rail flux but incapable of responding to the voltage of relatively high frequency resulting from said alternating current superimposed on the field structure.

10. Apparatus for detecting flaws in rails comprising a test car movable along the rail, means carried upon the car for passing a direct current through a section of the rail being tested, a movable winding carried by said car, means for imparting a motion to said winding independent of the motion of said car for cutting lines of flux associated with said current when the current becomes diverted by a flaw in said rail whereby a voltage of greater magnitude than that due to the motion of the car alone is induced in said winding, a polarized relay responsive to said voltage, a slow releasing relay which becomes energized when said polarized relay is energized in one direction or the other, and indicating means controlled by said slow releasing relay.

11. In a flaw detector for metallic bars, means for passing a direct current through the bar being tested, a winding, means for rotating said winding to cut lines of flux associated with said current when the current becomes diverted by a flaw in said bar, a polarized relay responsive to the voltage induced in said winding, a slow releasing relay which becomes energized when said polarized relay is energized in one direction or the other, and indicating means controlled by said slow releasing relay.

12. In a flaw detector for metallic bars, means for passing a direct current of substantially constant magnitude lengthwise through the bar being tested, a winding arranged in close proximity to said bar and adapted for rotation about an axis at right angles with the bar length which axis is substantially parallel to the surface of the bar adjacent said winding, means for rotating said winding, means for moving said winding progressively along said bar, and indicating means responsive to a change in the voltage induced in said winding when the winding passes a flaw in said bar.

13. In a flaw detector for metallic bars, means for passing an electric current length-

wise through the bar being tested, a generator comprising an open magnetizable field structure the poles of which are disposed in line with the bar length and in close proximity to said bar whereby said field structure becomes linked by flux associated with said current when and only when said flux has a component in a direction parallel to the bar length, a winding for said generator arranged when rotated to cut the lines of flux linking said field structure, means for rotating said winding, and indicating means responsive to the voltage induced in said winding.

14. In a flaw detector for magnetizable bars, a winding arranged in close proximity to the bar being tested and adapted for rotation about an axis at right angles with the bar length which axis is substantially parallel to the surface of the bar adjacent said winding, means for rotating said winding, means for moving said winding progressively along said bar, and indicating means responsive to the voltage induced in said winding when the winding passes a residually magnetized portion of said bar.

15. In a flaw detector for magnetizable bars, a generator comprising an open magnetizable field structure the poles of which are disposed in line with the bar length and in close proximity to the bar whereby said field structure becomes linked by flux due to a residually magnetized portion of the bar, a winding for said generator arranged when rotated to cut the lines of flux linking said field structure, means for rotating said winding, and indicating means responsive to the voltage induced in said winding.

In testimony whereof we affix our signatures.

DAVID C. BETTISON.
FRANK H. KEATON.