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2,203,256

RAIL FLAW DETECTOR MECHANISM

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FIG. 1.

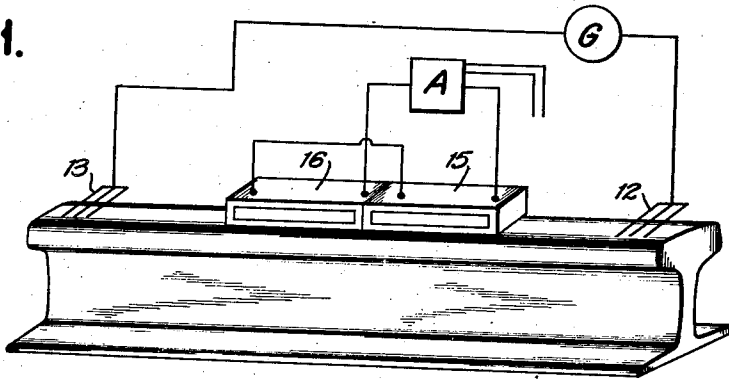


FIG. 2.

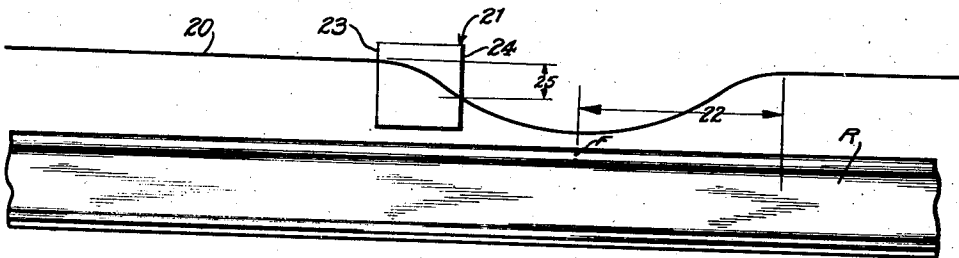


FIG. 3.

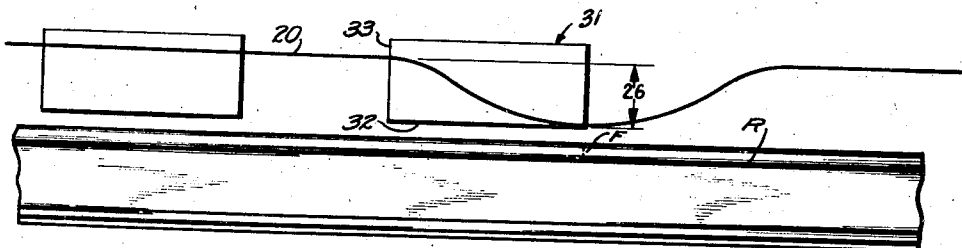


FIG. 5.

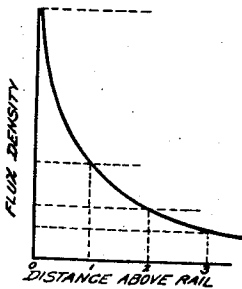
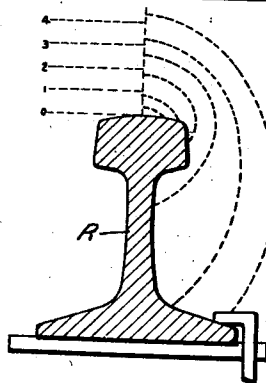


FIG. 4.



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RAIL FLAW DETECTOR MECHANISM

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14 Claims. (Cl. 175-183)

This invention relates to the art of rail flaw detection, although the term rail is used merely for the purpose of convenience and it will be found that the invention is applicable also to the testing of electrical conductors generally. The invention is particularly adapted for use on the Sperry rail flaw detector car which is now well known and which is disclosed, for example, in my Patent No. 2,133,687, granted October 18, 1938. As therein illustrated, the detector mechanism is mounted on a rail car which moves along the rails and has facilities for continuously setting up an electromagnetic field surrounding the rail, which field will be uniform except in the region of flaw. When a flaw is encountered the field is distorted and such distortion is detected by flux responsive means which preferably take the form of a pair of opposed induction coils. Said coils normally cut a constant number of lines of force but in the region of flaw they cut successively different numbers of lines of force to generate an E. M. F. which after being suitably amplified, as shown in said patent, may be caused to operate suitable indicators such as a pen on a moving chart within the car and a paint gun for spraying paint on the rails in the region of flaw.

The present invention relates to an improvement in the said detector mechanism which improvement resides in the design of the detector coils. By means of my improved design I obtain more efficient detection than was heretofore possible. The theory and construction of said coils will be more fully described in the following specification.

In the accompanying drawing,

Fig. 1 is a perspective view, largely diagrammatic, showing a portion of a rail with detector coils embodying my invention cooperating therewith.

Figs. 2 and 3 are side elevations of rails with diagrammatic representations of the theory underlying my invention.

Fig. 4 is a vertical section through a rail and a diagrammatic representation of the flux distribution surrounding the same.

Fig. 5 is a plot showing the distribution of flux density with respect to the distance above the rail-head.

Referring first to Fig. 2, there is shown a rail R having an internal fissure F indicated in dotted lines. In accordance with the construction of the Sperry rail flaw detector car described in the introduction, current is passed through a portion of said rail successively from a generator G within the car to spaced brushes 12 and 13 in sliding engagement with the rail to establish an electromagnetic field surrounding the same. The said field will be uniform except in the region of flaw where it will be distorted. A graph 20

drawn above the rail R indicates the flux intensity at various points along the rail and it will be seen that said flux intensity is constant until the region affected by flaw F is reached when it will be seen that the flux intensity diminishes. The extent of the region of flux distortion depends upon the size of the flaw. Thus, for instance, a 10% fissure, that is, a fissure occupying 10% of the area of the rail-head, will cause a distortion for a distance longitudinally of the rail about as shown in Figs. 2 and 3, that is, for about 2½ inches. A very large fissure such as a 40% fissure may cause a distortion for a distance longitudinal of the rail of as much as six inches. In the Sperry detector system the region of flaw is detected by means of a pair of opposed induction coils arranged in tandem so that first one and then the other of the coils enters the region of flaw to set up a differential E. M. F. which after being suitably amplified by amplifier A may operate recording mechanism as hereinbefore described. For this purpose I have indicated a pair of opposed detector coils 15 and 16.

Heretofore these coils took a circular form with many windings arranged spool-like on a core. The axis of the coil was positioned laterally with respect to the longitudinal axis of the rail. I have found that the best results are obtained not with a circular coil but with coils having the shape disclosed in Fig. 1, that is, rectangular coils whose horizontal or longitudinal dimension is greatly in excess of the vertical dimension so that the effect is long, flat coils lying close to the surface of the rail. The theory underlying the improved performance of such detector coils can best be explained by reference to the diagram, Figs. 2 to 5 inclusive. In Fig. 2 it will be seen that if a coil, such as coil 21, has a longitudinal dimension which is less than one-half of the length of the distorted region set up by flaw F, in other words, which is less than the distance 22, then the maximum output of coil 21 is not obtained. This is apparent because it will be seen that when the rear edge 23 of coil 21 starts into the region of distortion, the induced E. M. F. therein is opposed to the induced E. M. F. in the leading edge 24 so that the maximum generated E. M. F. of coil 21 is represented by the distance 25 on graph 20. If, however, a coil such as 31 is employed which has a dimension longitudinal of the rail equal to at least half of the length of the distortion caused by flaw F, then the maximum differential E. M. F. generated by said coil is represented by the distance 26 on graph 20, see Fig. 3. In other words, by the time the rear edge 33 of coil 31 starts to move into the field of distortion and starts to generate an opposed E. M. F., the said coil 31 has generated an E. M. F. corresponding to the difference in field intensity indicated by the distance 26. It does not matter

how much longer than one-half the distorted field the horizontal portion 32 of the coil is made, for it will be seen that no matter how great said dimension, the full differential represented by distance 26 will be obtained before the rear vertical portion 33 enters the region of flaw. It is the minimum longitudinal dimension of the coil, therefore, which is important and this minimum may therefore be defined as follows:

Assuming that the smallest sized fissure which the mechanism is designed to detect will yield a distortion longitudinal of the rail of a given dimension, then the dimension of the coil longitudinal of the rail should be not less than one-half of the said distortion. Thus, for instance, if the mechanism is designed to pick up no smaller fissures than 10% fissures, it is known that the distortion of the field longitudinal of the rail will be about 2½ inches, and therefore the horizontal dimension of coils 15 and 16 corresponding to horizontal portion 32 would be made not less than 1¼ inches. Preferably, however, the horizontal dimension should be made longer than this minimum, since by so doing none of the advantages are lost while there is gained the added advantage that there results the maximum efficiency in detecting large sized fissures. In such case the horizontal dimension longitudinally of the rail of coils 15 and 16 will be made not less than three inches since the region of distortion caused by a 40% fissure extends for a distance longitudinally of the rail equal to about six inches. In other cases it may be desired to employ coils which are designed to give the maximum output on average fissures which yield a distortion longitudinal of the rail of about four inches, in which case the longitudinal dimension of the coils 15 and 16 would be made not less than 2 inches.

As hereinbefore stated, the coils 15 and 16 are made flat so as to lie close to the rail-head. The reason for this may be seen in diagrams, Figs. 4 and 5. In Fig. 4 it will be noted that the regions 0-1 and 1-2 above the rail-head are affected only by flux in the rail-head, but in the regions 2-3 and 3-4 and beyond, flux lines from the rail web and from the base are encountered and various defects or irregularities due to their construction may effect said fields. Thus, for instance, spikes and tie-plates may readily affect regions 3-4 while irregularities in the web may affect regions 2-3. By forming the coils with short vertical dimension so that they lie close to the rail-head, it will be seen that they avoid flux lines emanating in the web and base and thus respond only to variations of flux in the rail-head.

A further advantage of this construction can be seen by reference to Fig. 5 which is a graph plotting flux density against distance above the rail. From this graph it will be seen that for equal vertical distances above the rail there is a much greater differential close to the rail-head than in the regions further away. Thus, in the region 0-1 there is a much greater difference in density than in the region 1-2, which in turn is greater than the difference in density in the region 2-3. By placing the longer coil in the region close to the rail-head, advantage is thus taken of the large flux density differentials which take place in said region and therefore the large variations in flux caused by the presence of fissures.

Thus by constructing a coil which is of predetermined length longitudinal of the rail, and causing the height of said coil to be made as

small as possible, there results a coil which is rectangular in shape and considerably longer than its height. Such a coil yields the maximum output in response to a flaw with a minimum interference from outside causes.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other equivalent means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance greater than one-half of the field distortion longitudinal of the rail caused by the presence of the smallest internal defect which it is desired to detect.

2. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the largest internal defect which the mechanism is adapted to detect.

3. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the average internal defect which the mechanism is adapted to detect.

4. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance greater than one-half of the field distortion longitudinal of the rail caused by the presence of the smallest internal defect which it is desired to detect, the portion of said coil extending in a direction normal to the rail being shorter than the portion of the coil extending longitudinally of the rail.

5. In a flaw detector mechanism for rails and

the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the largest internal defect which the mechanism is adapted to detect, the portion of said coil extending in a direction normal to the rail being shorter than the portion of the coil extending longitudinally of the rail.

6. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the average internal defect which the mechanism is adapted to detect, the portion of said coil extending in a direction normal to the rail being shorter than the portion of the coil extending longitudinally of the rail.

7. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, the portion of said coil extending in a direction normal to the rail being shorter than the portion of the coil extending longitudinally of the rail.

8. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, the vertical portions of said coil being shorter than the horizontal portions thereof.

9. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance greater than one-half of the field distortion longitudinal of the rail caused by the presence of the smallest internal defect which it is desired to detect.

10. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular

coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the largest internal defect which the mechanism is adapted to detect.

11. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the average internal defect which the mechanism is adapted to detect.

12. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance greater than one-half of the field distortion longitudinal of the rail caused by the presence of the smallest internal defect which it is desired to detect, the vertical portions of said coil being sufficiently short so as to lie wholly within the field affected only by the rail-head.

13. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the largest internal defect which the mechanism is adapted to detect, the vertical portions of said coil being sufficiently short so as to lie wholly within the field affected only by the rail-head.

14. In a flaw detector mechanism for rails and the like having means for electrically energizing the rail so as to establish an electromagnetic field surrounding the same and a detector mechanism for detecting variations in said field, said mechanism comprising a substantially rectangular coil having its axis positioned horizontally and transverse with respect to the longitudinal axis of the rail, said coil extending longitudinally of the rail for a distance substantially equal to one-half of the field distortion longitudinal of the rail caused by the presence of the average internal defect which the mechanism is adapted to detect, the vertical portions of said coil being sufficiently short so as to lie wholly within the field affected only by the rail-head.

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