Feb. 16, 1960 G. DE G. COWAN ET AL 2,925,552

RAIL FLAW DETECTOR MECHANISM

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FIG. 1

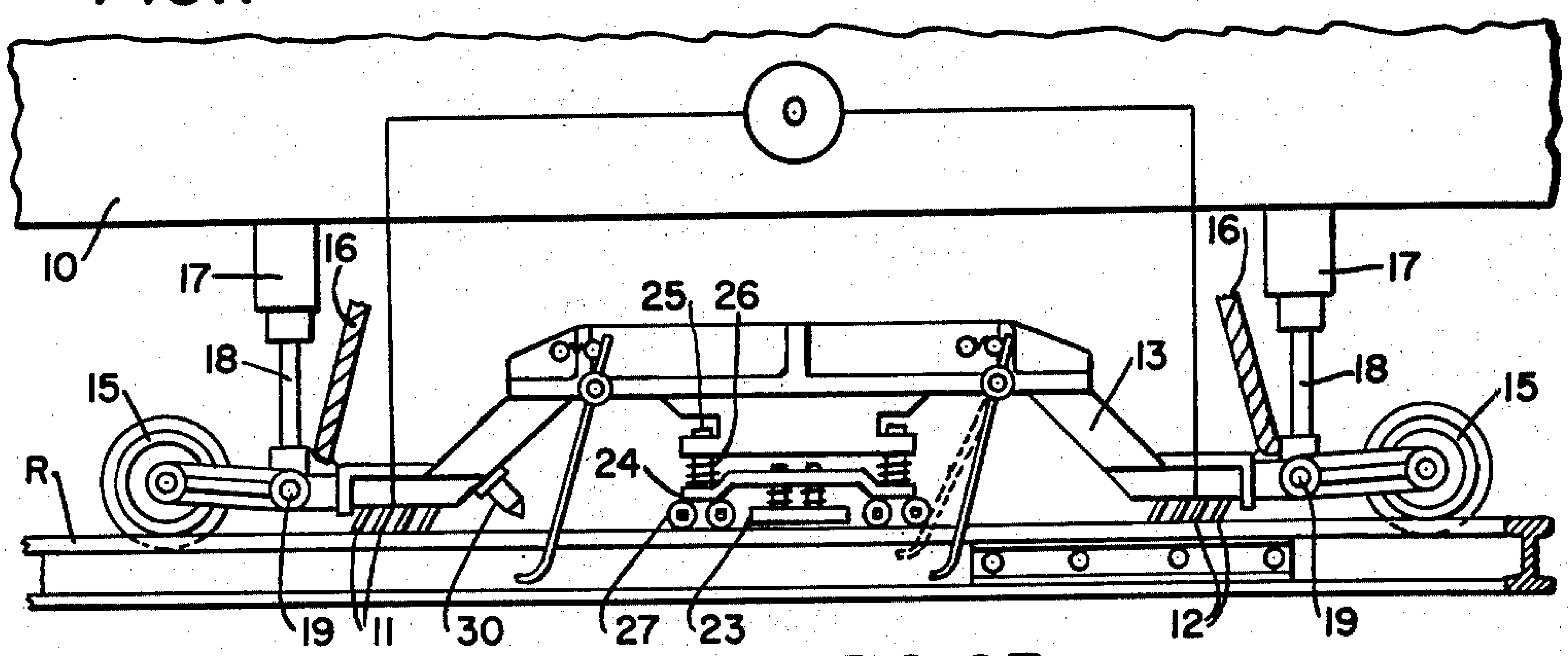


FIG. 2A

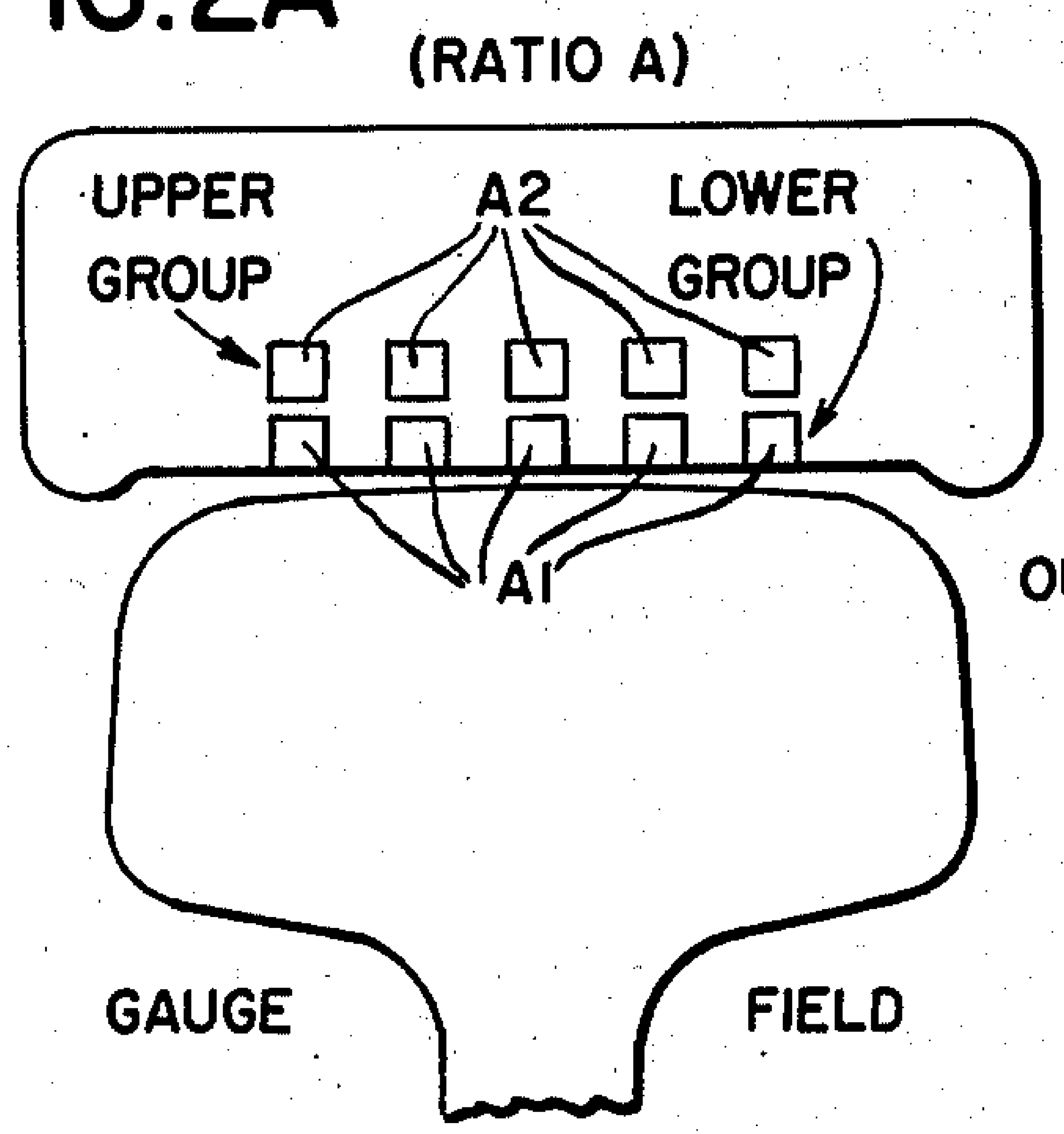


FIG. 2B

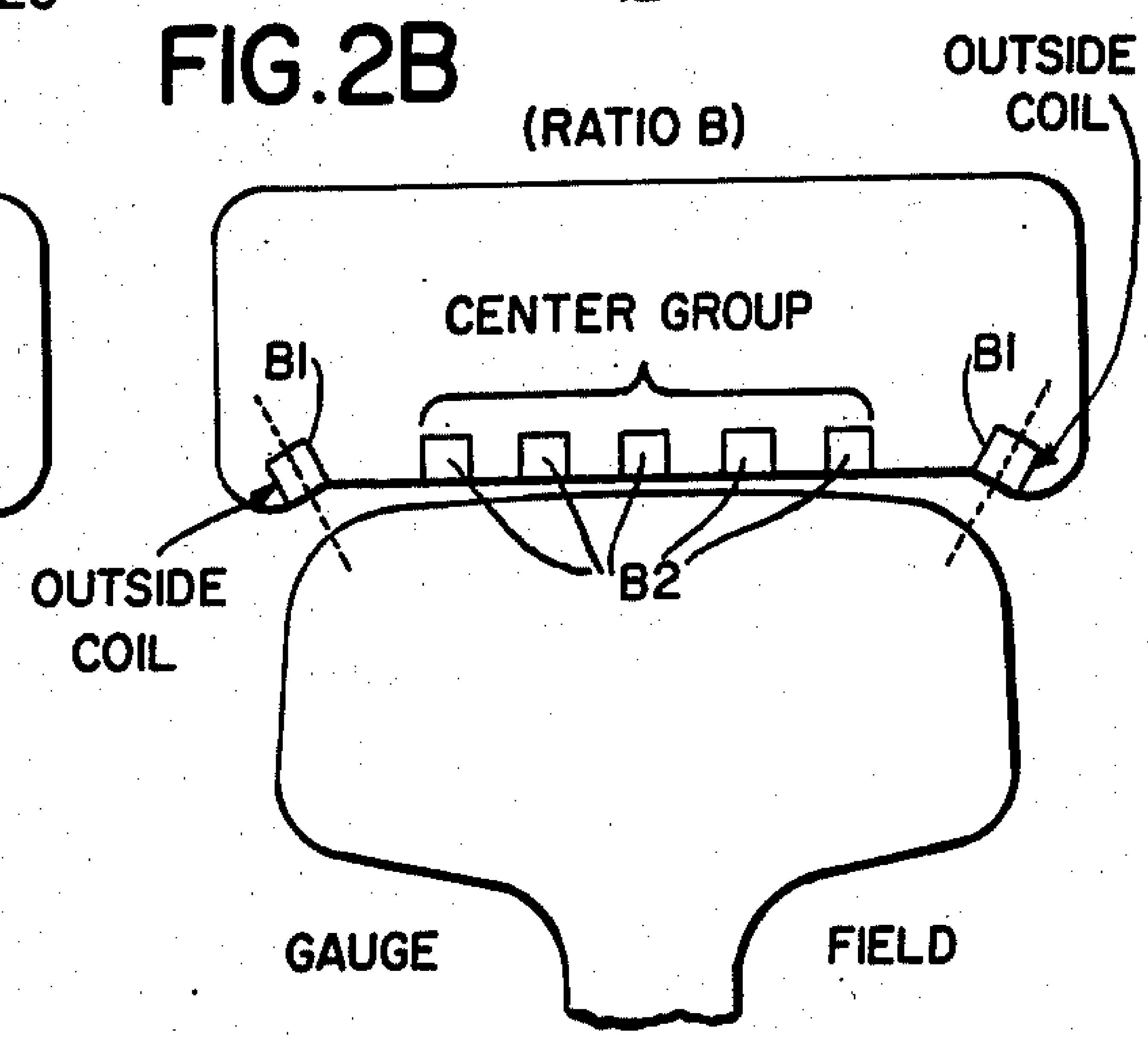
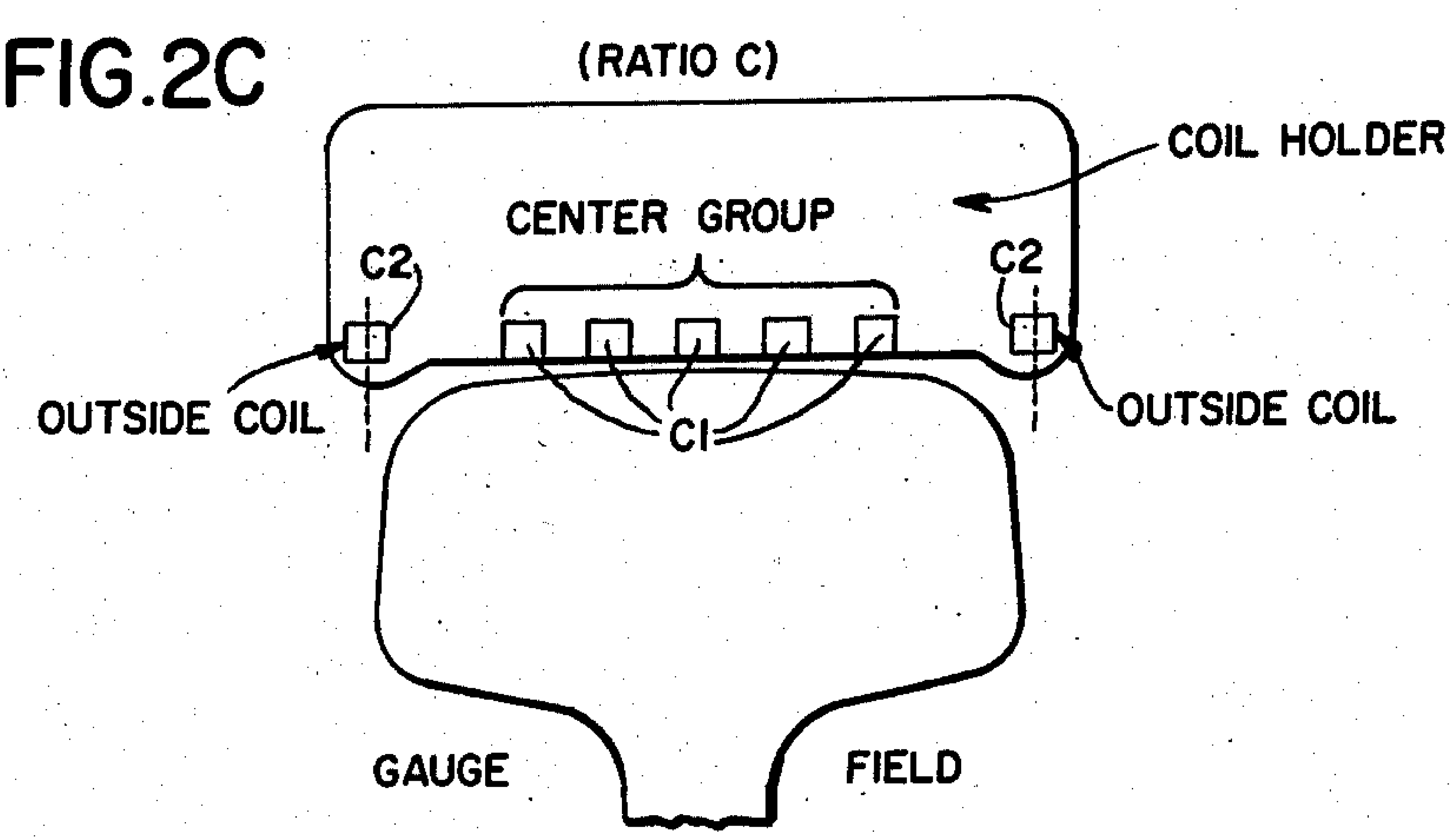


FIG. 2C



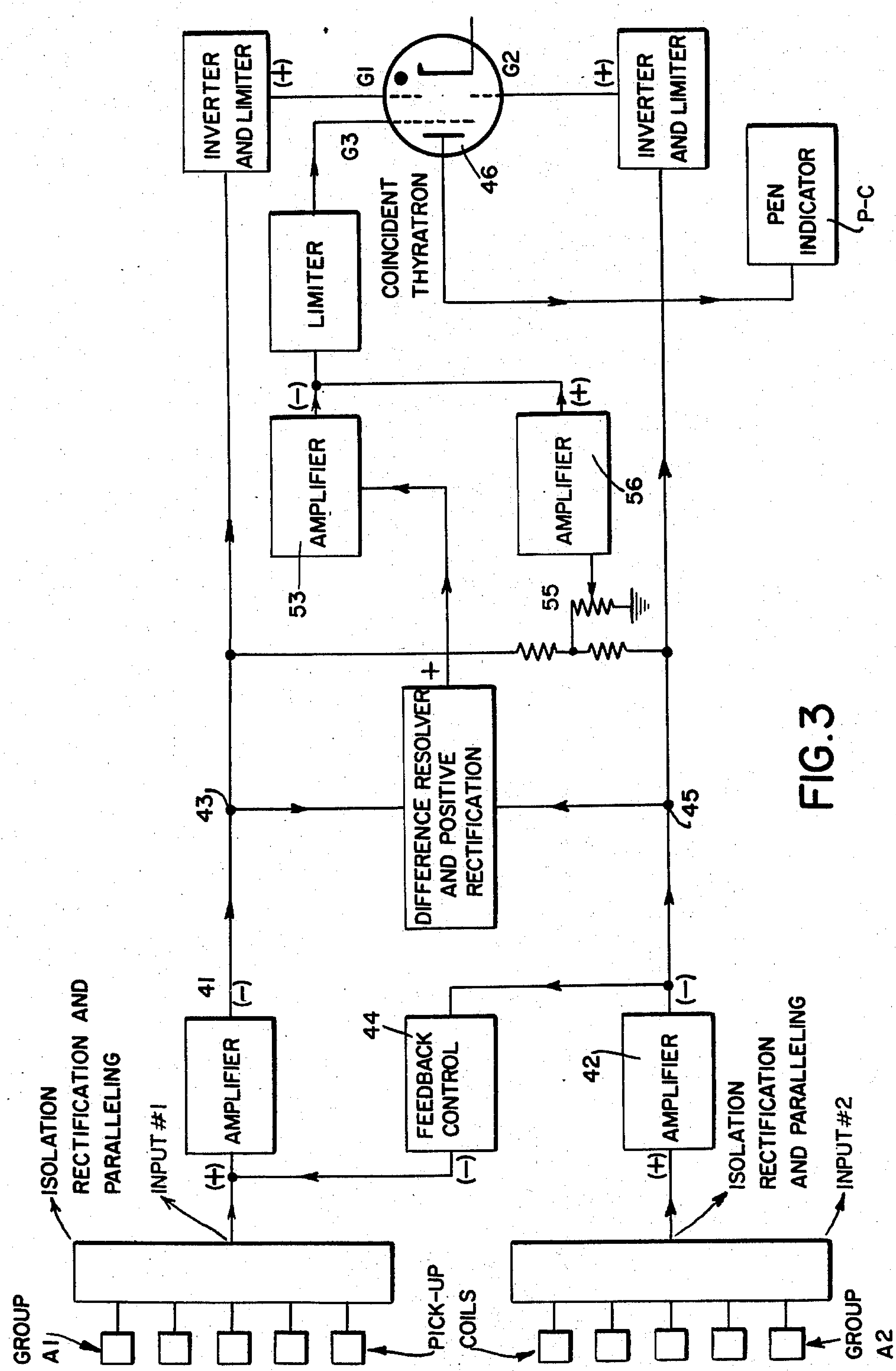

INVERTER AND LIMITER
(+)
G1
G2
G3
46
COINCIDENT THYRATRON
INVERTER AND LIMITER
(+)
PEN INDICATOR
P-C
LIMITER
(-)
(+)
AMPLIFIER
AMPLIFIER
56
53
55
+
DIFFERENCE RESOLVER AND POSITIVE RECTIFICATION
43
45
41
(-)
44
FEEDBACK CONTROL
(-)
42
AMPLIFIER
(-)
AMPLIFIER
(+)
(+)
ISOLATION RECTIFICATION AND PARALLELING
INPUT #1
ISOLATION RECTIFICATION AND PARALLELING
INPUT #2
GROUP A1
PICK-UP COILS
GROUP A2

FIG. 3

RAIL FLAW DETECTOR MECHANISM

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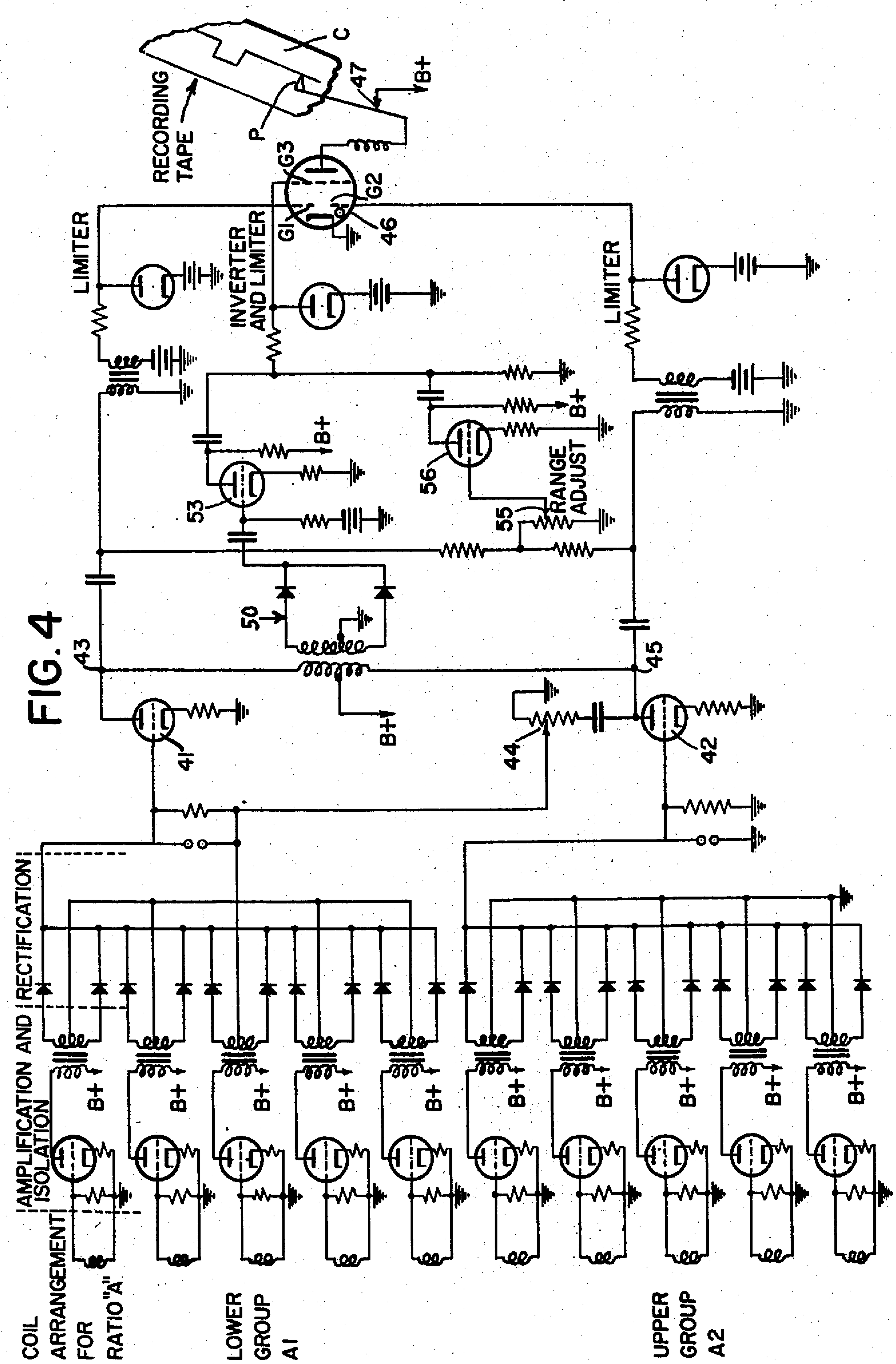

FIG. 4

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FIG. 6

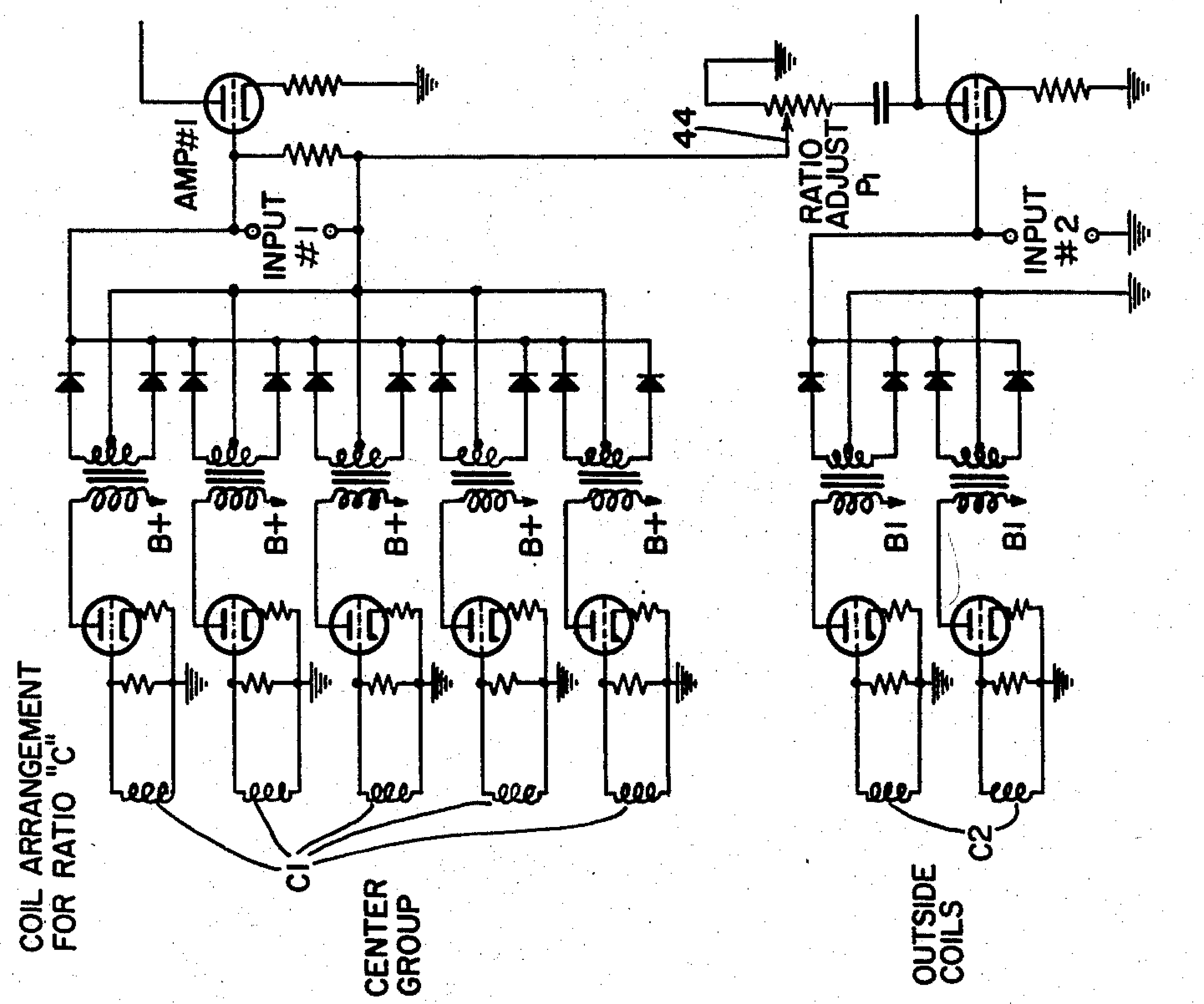
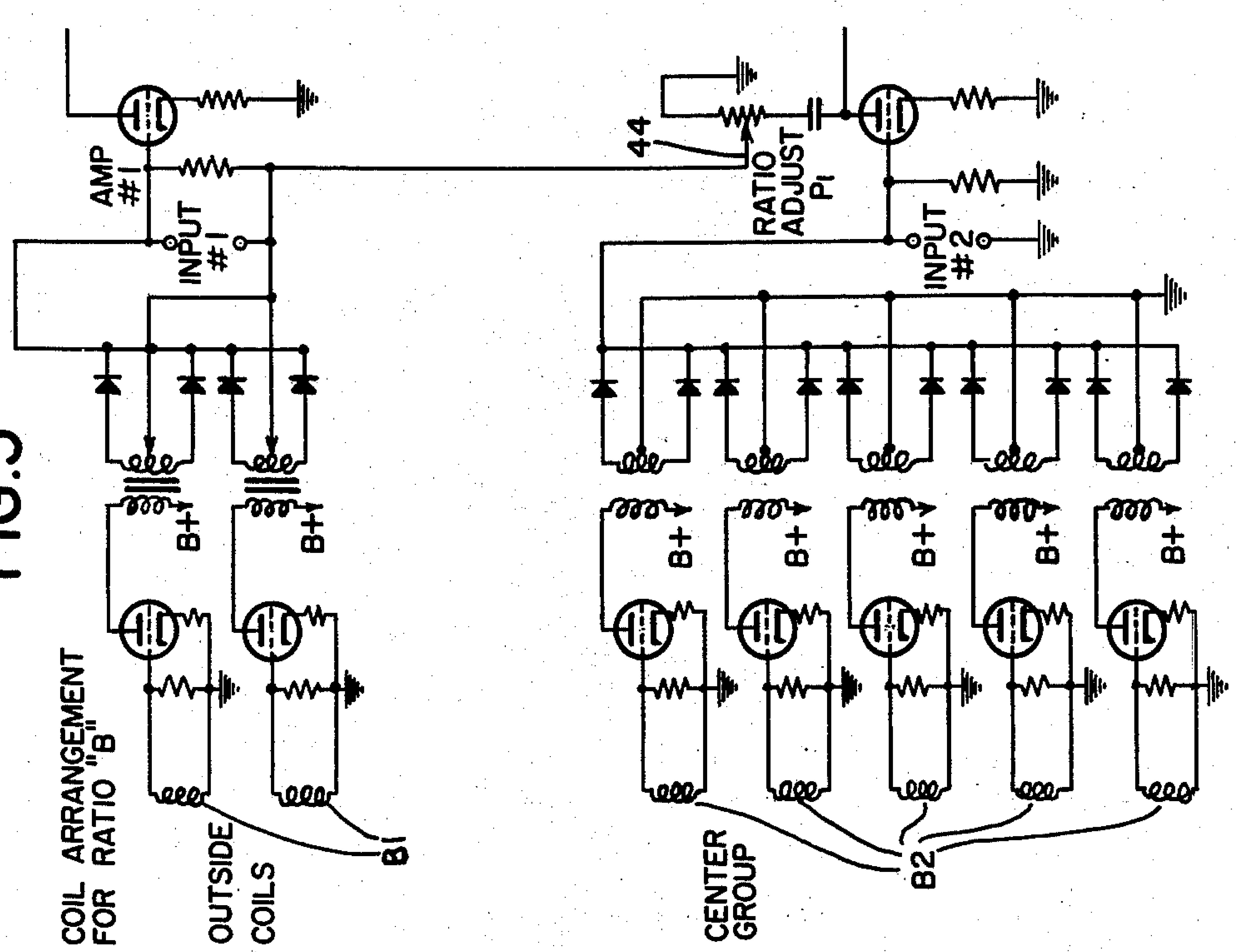


FIG. 5



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RAIL FLAW DETECTOR MECHANISM

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Application November 29, 1957, Serial No. 699,545

6 Claims. (Cl. 324—37)

This invention relates to rail flaw detector mechanisms, and more particularly to the type of detector mechanism employed on the Sperry rail flaw detector car. This car operates upon the principle of energizing the rail with flux, as, for instance, by passing direct current through the rail to establish an electromagnetic field surrounding the same, and exploring said field by inductive means to discover any irregularities caused by the presence of internal fissures or other discontinuities in the rail. Such irregularities will cause the inductive means to generate an E.M.F. which, after being suitably amplified, may be caused to operate an indicator, such as a recorder, within the car and a paint gun for marking the rail with paint in the region of flaw.

The particular problem which presents itself here arises from the fact that variations in the electromagnetic field surrounding the rail are set up not only by internal fissures which it is the function of the mechanism to detect, but also by surface irregularities, such as burns, shelly rail, flowed rail and slivers, which are not detrimental to the use of the rail and which it is not the object of the car to detect.

The operator within the car, seeing the indication upon the recording tape and the rail must therefore use his own judgment derived from viewing the rail from the car to determine whether the mark has been caused by a surface defect or by an internal fissure. Frequently this results in many unnecessary stops of the car for the purpose of hand testing the region where indications are made.

It is therefore the principal object of this invention to provide a method and means which may be employed on detector cars of the Sperry type which will enable an operator to distinguish between the types of defect which it is desired to detect from those defects which it is desired to eliminate from the indicating mechanism.

Further objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a side elevation of a portion of a rail fissure detector car having this invention applied thereto.

Fig. 2A is a vertical section through a rail head showing in diagrammatic form one arrangement of detector coils for distinguishing between certain types of internal rail defects and certain types of surface defects.

Figs. 2B and 2C are views similar to Fig. 2A for distinguishing certain types of internal rail defects from certain other types of surface defects.

Fig. 3 is a block diagram of the components of the invention.

Fig. 4 is a wiring diagram embodying the Fig. 2A arrangement of coils.

Fig. 5 is a wiring diagram similar to Fig. 4 embodying the Fig. 2B arrangement of coils.

Fig. 6 is a view similar to Figs. 4 and 5 and embodying the Fig. 2C arrangement of coils.

Referring to Fig. 1 of the drawings, there are shown

the parts of a standard Sperry rail fissure detector car which includes a car body **10** operating along the rails R. Fissure detection is accomplished by energizing the rail with flux by passing high amperage, low voltage current through each rail from a generator O within the car body, supply current to spaced current brushes **11** and **12** supported upon the current brush carriage **13** which, when in lowered or effective position, is adapted to ride upon the rails by means such as wheels **15**. The current brush carriage **13** is normally held in elevated or ineffective position by means of springs, not shown, and cable **16**, but when it is desired to lower said carriage, fluid pressure, such as compressed air, is supplied to the cylinders **17** to force out pistons **18** which are pivotally connected at **19** to the current brush carriage **13**. The current passed through the rail by way of spaced brushes **11** and **12** will establish an electromagnetic field surrounding the rail, and this field will be uniform except in the region of flaw where it will be distorted. Such distortions of the electromagnetic field are detected by a flaw responsive mechanism which may take the form of a plurality of induction coils supported in a housing **23** at a constant distance above the rail surface by means of a carriage **24**. Said carriage **24** is mounted on current brush carriage **13** by means of loosely fitting bolts **25** and springs **26** to permit said carriage **24**, while riding on the rail on means such as wheels **27**, to move independently of carriage **13** so that said carriage **24** may at all times maintain parallelism with the rail surface regardless of irregularities thereof. The induction coils within housing **23** normally cut the same number of lines of force, but on entering a region of flaw, they will cut a different number of lines of force to generate an E.M.F. which may be caused to operate a pen P operating on a chart C (see Fig. 4) and to actuate a marking means such as paint gun **30** mounted on the current brush carriage **13** for spraying the rail in the region of flaw with paint.

As stated in the introduction hereto, the inductive means will respond to variations in the electromagnetic field caused not only by the presence of internal fissures which deflect the path of the current and therefore vary the electromagnetic field surrounding the rail, but said coils will also respond to variations in the field caused by surface irregularities of the type enumerated in the introduction hereto, i.e., surface burns, shelly and flowed rail, and slivers.

We have therefore devised the method and means to be described hereinafter whereby we are enabled to distinguish between those true internal defects which we desire to detect and various types of surface defects which we do not desire to detect. The principle of our invention is based upon the fact that the ratios of simultaneous signals developed by two or more discretely located coils passing over internal defects differ from the ratios of signals developed over surface defects. The positioning of the related coils will depend upon the type of defect which it is desired to detect and the type of defect which it is desired to eliminate from the indicating mechanism. Thus, the arrangement of coils shown in Fig. 2A will detect large and small transverse defects, large detail fractures, horizontal split heads and vertical split heads, but will not indicate engine burn fractures, engine burns and centrally located slivers. The arrangement shown in Fig. 2B will indicate detail fractures, but will not indicate large and small transverse defects, horizontal split heads, vertical split heads, engine burn fractures, engine burns, shell, flow, centrally located slivers, and large detail fractures. The arrangement shown in Fig. 2C will indicate large transverse defects and engine burn fractures, but will not indicate small transverse defects, detail fractures, horizontal split heads, vertical split heads, burns, shell, flow and centrally located slivers.

These arrangements may be used simultaneously, depending upon the nature of the defects which are to be indicated or eliminated from the indication.

The principle involved in each of the forms Figs. 2A, 2B and 2C is the same. Referring first to the form disclosed in Fig. 2A, there is a lower group of coils A1 (here shown as five in number) spaced transversely across the rail head, and an upper group of similar coils A2 similarly positioned. In this arrangement the ratio of signal voltage response of the lower group of coils to the upper group of coils is substantially lower when passing over an internal defect than when passing over a surface defect. Thus while the ratio when passing over an internal defect may be on the order of 2:1, the ratio when passing over a surface defect may be on the order of 10:1. It is this variation in ratios that makes it possible to distinguish between the types of defect which it is desired to indicate and the types which it is not desired to indicate. One means by which this differentiation may be accomplished is disclosed in Figs. 3 and 4. Here it will be seen that the lower group of coils and the upper group of coils each pass through an amplification and isolation stage, after which they pass through a rectifier stage so that only positive output is obtained. The positive outputs of each group are combined, and each combined output is amplified by the separate amplifiers **41** and **42**. The input to the amplifier **41** for the lower group of coils A1 which produces the larger signal is reduced by feedback from the output of the amplifier **42** for the upper group of coils A2 to such extent that the outputs from both amplifiers are the same when the coils pass over an internal defect of the type which it is desired to detect. Thus, although the output of the lower group of coils to the upper group of coils may be 2:1, sufficient negative voltage is fed back to the positive input to the amplifier of the lower group so that the outputs from both amplifiers are the same. This establishes that with a ratio of 2:1 (in the example chosen) there will be no differential output between points **43** and **45**. The degree of feedback may be controlled by potentiometer **44**. The outputs from the two amplifiers **41** and **42** will place simultaneous positive voltages on the twin grids G1 and G2 of the coincidence thyratron **46**, causing it to fire and operate the pen P on the moving chart C. The actuation of pen P breaks the circuit through the thyratron at **47**.

In the example chosen, it was assumed that the ratio 2:1 was the desired ratio at which the pen should be operated as indicating an internal defect. If the ratio were greater or less than 2:1 the outputs of the two amplifiers would not be the same and there would be a differential at points **43** and **45**. This differential voltage would be rectified by a full wave rectifier **50** and amplified by a third amplifier **53**. Since the output from the rectifier is positive, the output from the amplifier **53** is negative, and this negative voltage is applied to grid G3 of the thyratron **46** to prevent firing of the thyratron. Thus, only when the selected ratio (in this case, 2:1) of output voltages of the lower and upper coils exists can the pen P be operated. However, the ratio of lower to upper groups of coils in response to internal defects varies within a specified range, and cannot be limited to a single ratio. To obtain such range there is provided a range adjustment whereby the negative voltage which would be applied to the grid G3 is neutralized to any desired extent, thereby providing a range of any desired extent within which the thyratron will fire. For this purpose a potentiometer **55** draws a desired portion of the sum of the voltages at **43** and **45** and applies it as a negative voltage to a fourth amplifier **56** whose positive output is opposed to the negative output of the third amplifier **53** to render the grid G3 ineffective within the desired range. Thus, the ratios of lower coils to upper coils which will indicate may be from 1.5:1 to 3:1, this range still being substantially different from the ratios due to surface defects. The latter therefore will continue to develop negative voltages on grid G3 to prevent actuation of the pen P, but ratios within the preselected range will be indicated on the chart.

As stated hereinbefore the arrangement of coils shown in Fig. 2A is particularly adapted for detecting large and small transverse defects, large detail fractures, horizontal split heads and vertical split heads, while eliminating from the indicating means any response due to engine burn fractures, engine burns and centrally located slivers. The principle described hereinbefore may be applied to other arrangements designed to give indications for certain conditions while eliminating indications due to other conditions. Thus in Fig. 2B there is shown an arrangement which will indicate detail fractures, but will not indicate large and small transverse defects, horizontal split heads, vertical split heads, engine burn fractures, engine burns, shell, flow, centrally located slivers, and large detail fractures. The same principle of utilizing two groups of discretely located coils, one adjacent the type of defect which it is desired to locate and indicate, and the other located remote therefrom. The ratio of response of the first group relative to the second group in the presence of the desired defect will be smaller than the ratio of these groups in response to other types of defects. Thus in Fig. 2B it is desired to locate detail detail fractures—a type of defect which is found in the region of the upper curved edges of the rail section. Therefore one group of coils B1 is located with the axis of each coil substantially normal to the curved edge, in which position these coils will yield the maximum response in the presence of a detail fracture. A second group of coils B2 is positioned substantially parallel to the upper surface of the rail between the coils B1 and spaced from the latter coils. By these arrangements a detail fracture will give a low ratio of response of coil B1 to coils B2. Defects other than detailed fractures however will give a much higher ratio of response of coil B1 to coil B2.

Therefore substantially the same electrical system disclosed in Fig. 4 for the form of invention shown in Fig. 2A may be employed for the form of invention shown in Fig. 2B, necessitating, as shown in Fig. 5, only the substitution of coils B1 for coils A1 and of coils B2 for coils A2. The operation of the system from this point on is the same as in Fig. 4 arrangement, the ratio adjustment being set by the potentiometer **44** at whatever the desired ratio may be and the range adjustment being set by potentiometer **55**. Thus only defects occurring within the desired range of ratios will operate the pen P to indicate a detail fracture while all other responses will be eliminated from the indicating means.

Another application of the principle is disclosed in Fig. 2C. Here it is desired to indicate large transverse defects and engine burn fractures but it is desired to eliminate small transverse defects, detail fractures, horizontal split heads, vertical split heads, burns, shell, flow and centrally located slivers. For this purpose there is again employed two sets of discretely located coils, one set highly responsive to large transverse defects and engine burn fractures, and the other set less responsive to such defects. Therefore there is employed a set of coils C1 substantially parallel to the upper surface of the rail and coacting with the central portion thereof, and a second set of coils C2 positioned with their axis substantially vertical and coacting with the outer limits of the rail. By such arrangement the ratio of coils C1 and C2 in response to large transverse defects and engine burn fractures will be relatively low, whereas the ratio of response of C1 to C2 to other types of defects will be relatively high. The differentiation in response to these two types of defects can be effected by the Fig. 4 electrical system by merely substituting coils C1 for coils A1 and coils C2 for coils A2. The ratio adjustment **44** is employed as before as well as the range adjustment **55**, whereby only responses within the set range of ratios will operate the indicating means but all other ratios outside the set range will yield no indication.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. A rail flaw detector mechanism comprising means for energizing the rail with flux and a plurality of inductive means spaced from the rail and movable relative thereto so as to respond to variations in flux and generate signal voltages, said inductive means generating signal voltages in response to internal rail flaws and to surface defects, one of said inductive means being positioned closely adjacent the region of internal rail flaw, the other of said inductive means being positioned relatively remote from the region of internal rail flaw, whereby the ratios of signal voltages generated by the first inductive means with respect to the signal voltages generated by the second inductive means will be relatively low for internal rail defects and relatively high for surface defects, means for combining the responses of said first and second inductive means in opposed relation whereby a ratio of response is obtained, indicating means, means for actuating said indicating means, and means for rendering said actuating means effective only in response to said relatively low ratios.

2. A rail flaw detector mechanism as specified in claim 1, including means for varying said last named responsive means to vary the range of ratios to which it responds.

3. A rail flaw detector mechanism as specified in claim 2, in which said first inductive means comprises a plurality of coils positioned across the rail head between the outer edges thereof, and said second inductive means comprises a plurality of coils similarly positioned with respect to the rail head but at a greater distance therefrom than the coils of said first inductive means.

4. A rail flaw detector mechanism as specified in claim 2, in which said first inductive means comprises a plurality of coils positioned with their axes substantially normal to the outer edges of the rail head, and said second inductive means comprises a plurality of coils positioned substantially across the rail head between the outer edges.

5. A rail flaw detector mechanism as specified in claim 2, in which said first inductive means comprises a plurality of coils positioned across the rail head between the outer edges thereof, and said second inductive means comprises a plurality of coils positioned outside the outer edges of the rail head and having their axes vertical.

6. A rail flaw detector mechanism comprising means for energizing the rail with flux and a plurality of inductive means spaced from the rail and movable relative thereto so as to respond to variations in flux and generate signal voltages, said inductive means generating signal voltages in response to internal rail flaws and to surface defects, a certain set of said inductive means being spaced from the rail differently than a certain other set of said inductive means so that the ratio of response between them is relatively low for internal rail defects and relatively high for surface defects, means for combining the responses of said first and second sets of inductive means in opposed relation whereby a ratio of response is obtained, indicating means, means for actuating said indicating means, and means for rendering said actuating means effective only in response to said relatively low ratios.

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