(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 103 629
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 02.08.89

(51) Int. Cl.[4]: G 08 B 13/24

(21) Application number: 83901292.9

(22) Date of filing: 10.03.83

(86) International application number:
PCT/US83/00316

(87) International publication number:
WO 83/03203 29.09.83 Gazette 83/23

(54) **METHOD AND APPARATUS FOR THEFT DETECTION SYSTEMS.**

(30) Priority: 15.03.82 US 358299
15.03.82 US 358383
01.04.82 US 364264

(43) Date of publication of application:
28.03.84 Bulletin 84/13

(45) Publication of the grant of the patent:
02.08.89 Bulletin 89/31

(84) Designated Contracting States:
AT BE CH DE FR GB LI LU NL SE

(56) References cited:
FR-A- 763 681
US-A-3 665 449
US-A-3 740 742
US-A-3 747 086
US-A-3 838 409
US-A-3 983 552
US-A-4 168 496
US-A-4 300 183
US-A-4 309 697
US-A-4 321 586

(73) Proprietor: PROGRESSIVE DYNAMICS INC.
507 Industrial Road
Marshall MI 49068 (US)

(72) Inventor: ECCLESTON, Larry
3293 Albion Road
Concord, MI 49237 (US)

(74) Representative: Robinson, Anthony John
Metcalf et al
Kilburn & Strode 30 John Street
London, WC1N 2DD (GB)

EP 0 103 629 B1

Courier Press, Leamington Spa, England.

Description

Technical Field

This invention relates in a broad sense to detection systems and apparatus, and more particularly to detection systems principally used in "anti-pilfering", i.e., theft-prevention, systems; more particularly still, the invention relates to that type of detection system in which an alternating electromagnetic field is monitored to unobtrusively and invisibly detect the presence within the field of a small strip of permalloy or like highly-magnetizable (ultra-low coercivity) metal foil which is hidden upon or in articles such as consumer merchandise whose theft or otherwise-impermissible taking is to be detected and prevented.

Background of the Invention

Many prior efforts have been made toward deterring or preventing thefts in the nature of shoplifting, or other undesired removal of "contraband" articles or goods, for example, unchecked library books or the like, and such prior efforts have given rise to a variety of different systems and approaches, based upon different technological phenomena including, for example, detection of permanent magnet pieces, a variety of electromagnetic field applications, microwave systems, infrared or ultraviolet, etc. These rather extensive prior efforts have, quite understandably, advanced the general state of the art in these different fields, and have in general enhanced the degree of success available; however, the desired end is exceedingly difficult from a technological point of view, since the areas to be monitored (in general, doorways or like points of egress) are large in a physical sense, whereas the articles under surveillance are usually relatively small, requiring a proportionally tiny detection element or "marker". Generally speaking, this requires exceedingly high system sensitivity, but it is not only important to detect the illicit passage of contraband material; it is almost equally as important to avoid "false alarms", in which bona fide customers or other innocent persons are wrongly pointed out as carrying stolen or contraband goods through the portal, since this not only leads to immediate wrongful embarrassment of the individual involved, but also is likely to cost the merchant or other proprietor the loss of substantial goodwill and, potentially, possible litigation by those claiming to be damaged by such incidents.

Accordingly, real progress satisfying both of the aforementioned requirements of high sensitivity attended by great selectivity has been difficult to achieve and slow in coming. This conclusion is evidenced by the issuance of various patents over a long period of years, each asserting the achievement of improvements, but each followed in time by another patent directed to still a further improvement in a seemingly continuous sequence. By way of example, perhaps the most frequently-employed, and probably the most successful system concept, relates back to the often-noted French Patent of P. A. Picard, No. 763,681, issued in 1934, in wwhich the technological phenomenon is described as involving electromagnetic field perturbations resulting from the insertion or presence within the field of a piece of magnetic material. In particular, Picard noted the field effects created by the presence of highly-magnetic (high permeability) material such as permalloy, which creates the presence of a number of the higher-order odd harmonics of the fundamental frequency of the applied field (e.g., Picard referred to the presence of the ninth and eleventh harmonic). While a period of almost 50 years has elapsed since the appearance of this patent to Picard, various patents continue to issue from time to time asserting advances in Picard's theories and findings in the area of "pilferage detection" systems of the type noted hereinabove; for example, reference is made to a number of patents issued to Edward Fearon (including U.S. Nos. 3,631,442, 3,754,226, 3,790,945, 3,820,103, 3,820,104) and to Peterson U.S. No. 3,747,086), Elder et al. (U.S. Nos. 3,665,449 and 3,765,007) as well as U.S. Patent No. 3,983,552 to Bakeman. Indeed, a very recent such patent is that issued to Robert Richardson, U.S. No. 4,300,183, which is directed to and describes various attributes of the underlying concept relating back to Picard.

As stated above, the seemingly continuous advance in the general state of the art, as evidenced by the aforementioned patents, has undoubtedly provided new insights and improvements in the general level of the art, the requirements of truly satisfactory detection systems are very severe and demanding, and the need therefore continues to exist, and in some ways becomes even more pronounced, for truly reliable systems which will unerringly detect relatively small "marker" elements or indicia, while at the same time being essentially immune to a practically endless number of widely-varying metal devices, objects, articles, and components, all of which cause perturbations in the magnetic interrogation field, with resulting detection-actuating results being inevitably present.

Brief Summary of the Invention

The present invention as defined in claims 1 and 26 provides new and highly significant improvements in electromagnetic field-type detection systems of the type noted above, which improvements substantially enhance both the sensitivity and the selectivity of such a system, pursuant to which previously-unappreciated detrimental effects such as field-perturbing metal structural components in the environment of the egress portal (e.g., field-perturbing ceiling grids overhead and/or field-perturbing reinforcing rods or mesh in structural concrete nearby, etc.) are substantially eliminated as error sources. The improved system provided hereby thus makes it possible to accurately, consistently, and reliably detect the presence of tiny markers or tags of magnetic material and reject, or not detect, the presence of other field-disrupting metal elements or components as, for example, keys, pocketknives, wristwatches, metal containers such as beverage cans or the like, baby strollers and shopping carts, and a host of other widely-differing apparatus and objects.

Accordingly, a detection system and method is provided with greatly enhanced processing of the marker-detection signals, incorporating a summing and differencing procedure for substantially improved signal-to-noise ratios, in accordance with which a comparatively low frequency component band and a comparatively high frequency component band are separately determined, and utilized in a multiple-step comparative manner to dymamically control the detection alarm threshold. In this manner, a balancing of the frequency components or bands is utilized, to produce alarms only when the ratio of frequency bands is in the appropriate order, representative of the actual marker indicia, thereby avoiding false alarms produced by prior systems in response to metal articles whose field-perturbation effects happen to be very similar to those of the authentic marker, even including those articles which produce similar frequency components but which are distinguishable by the relative amounts of different frequency bands, i.e., the ratio of the signal strength representative of different frequency component bands.

Further the method and apparatus provided operates to additively, or constructively, sum representations of detection signals indicative of marker presence within the field, regardless of and continuously consistent with, field alternation phase changes and differences; additionally, the method and apparatus provided differences or subtracts signals representative of non-marker presence (i.e., noise) in order to accurately portray non-marker effects. In this manner, the marker-characterizing signals are comparatively analyzed by reference to the non-marker signals, thus substantially enhancing selectivity.

Somewhat more particularly, detection logic and processing methods and apparatus are provided for examining representations of electrical signals which are produced initially by receiver means that monitor an alternating electromagnetic interrogation field in which a predetermined marker may be present, so as to accurately and reliably determine the presence, and/or the non-presence, of such a marker in such a field. In accordance herewith, such signal-examining is carried out in a manner having the effect of determining, and using, a first and second composite analysis signal, the first being used to set a first value of a comparison operation and the second such signal being used to set a second such comparison value, such two comparison values being effectively compared in such comparison operation. Preferably, this is accomplished by developing an integrated ambient-representative signal and using the latter to vary a preset threshold in comparison stages whose primary comparison inputs are signals representative of marker presence and marker absence, with the results of such comparisons being summed against each other, and the resultant summation level used to trigger an alarm or indicator showing the verified presence of the marker within the interrogation field. In particular, the inventor provides preferred methods and apparatus for selective preamplification and processing of the signals produced initially by the receiver means, prior to the operation of the preferred detection logic and processing methods and apparatus, both of which are further disclosed in the following description of particular preferred embodiments.

A number of additional improvements and advantages are provided in accordance herewith, as described in more detail hereinafter in conjunction with certain preferred embodiments of the invention as depicted in the attached drawings and specifically noted in conjunction therewith for a more meaningful disclosure.

Brief Description of the Drawings

Fig. 1 is a simplified, schematic-form block diagram of the overall detection system in accordance with the invention;

Fig. 2 is an enlarged and schematic circuit diagram of the preamplifier portion of the system shown in Fig. 1;

Fig. 3 is an enlarged schematic circuit diagram of the inhibit amplifier portion of the system shown in Fig. 1;

Fig. 4 is an enlarged, simplified system block diagram illustrating the preferred detection logic and processing circuitry;

Fig. 5 is a schematic circuit diagram showing a first portion of the detection logic and processing circuitry of Fig. 4; and

Fig. 6 is a schematic circuit diagram showing the second portion of the detection logic and processing circuitry of Fig. 4.

Detailed Description of Preferred Embodiments

The general nature of the overall system is illustrated in Fig. 1, in which a typical two-portal system is depicted. Generally speaking, such "portals" should be understood as being egress passages, e.g., doorways, on the opposite sides of each of which are maintained electromagnetic interrogation field sources (e.g., induction coils constituting part of an oscillating L—C tank circuit) together with a receiving antenna which monitors the electromagnetic field from that particular side of the portal. As will be understood, many of the prior patents referred to hereinabove depict and discuss systems using such interrogation coils and antennae; for example, Richardson U.S. No. 4,300,183) depicts a system and components whose general nature may be taken as more-or-less standard, dating back to the work of E. Fearon whose prior patents are also noted above. As illustrated in the aforementioned Richardson patent, wherein the "portals" are designated "doorways", and wherein one of a number of different possible coil shapes and orientations are illustrated, the field-inducing coils are physically large, such that the interrogation field which they produce occupies a physical area which is more than sufficient for a human being to readily pass through. Inasmuch as the general characteristics, attributes, and parameters of such systems, including their field-inducing coils and receiving antennae, have long been known and have, in effect, resulted from the work of a number of individuals working at various points in time, the aforementioned prior patents of Fearon, Elder, Richardson, et al. should be considered as portraying the known state of the art and describing both general system characteristics and circuitry, componentry, and the like; consequently, these patents should, to the extent deemed necessary or desirable for environmental disclosure or otherwise, be considered as incorporated herein by reference.

Referring further to Fig. 1 herein for a very general illustration of the overall system, it will be noted that "portal 1" has a pair of oppositely-spaced sides, designated "side 1" and "side 2", and the same is true with respect to portal 2, which may be considered a substantial duplicate of portal 1. Each side 1 of each portal preferably receives the same type of drive, i.e., interrogation coil-excitation or drive current and each side 2 coil is also driven like its counterparts, although as explained hereinafter the side 2 excitation preferably changes in phase periodically whereas the side 1 excitation does not.

With continued reference to Fig. 1, it will be seen that the signal path from each side of each portal is individually coupled (via channels or paths. A and A', and B and B') to a preamp 1, from which two outputs are separately processed, one being directed to an amplifier/filter 2 and the other to an inhibit amplifier 3, whose respective outputs are coupled on paths E and F to a detection logic and processing module 9, which also receives control signals on path G from a timing generator 4. Generally speaking, the detection logic module 9 functions to provide indicator and/or alarm signals indicative of the presence, within the alternating interrogation field maintained between the respective sides of a given portal, of the desired field-affecting marker member, such indicator or alarm outputs being depicted in Fig. 1 as coupled along a path H to an alarm module which is so marked. Power supply paths are indicated in Fig. 1 as being directed from an outside "power in" source and along a common bus 11 to a power supply 8. The latter provides various power levels and types to the preamp 1, the detection logic module 9, the amp/filter 2, the inhibit amplifier 3, the timing generator 4, the phase driver control 5, and the phase driver 6. The outputs of the phase driver 6 are coupled along the aforementioned paths C and D to portals 1 and 2, to drive the oscillating interrogation coils located there. While state of the art circuits and components which are generally usable as the foregoing functional units are certainly known and available at the present point in time, and are referred to in the aforementioned prior patents, for example, certain preferred new versions or improvements of such are disclosed hereinafter.

It should be understood that in accordance with the present invention the interrogation coils at the portals are preferably driven at a nominal oscillation frequency of 10 kHz, and that in order to maximize detection capabilities in a broad sense, it is desirable to drive the two interrogation coils on opposite sides of the same portal in an alternating in-phase and out-of-phase sequence, in "bursts" which continue over a desired number of cycles. Thus, for a first such period both sides of portal 1 and portal 2 will be driven in phase, whereas for the next ensuing such period side 1 of each will be driven with the same phase as before but side 2 of each will be driven with directly out-of-phase excitation, the effect of which will be to re-direct the resulant direction of the interrogation field by 90°, thus affording detection capabilities for particular marker orientations within the field which might possibly be missed or produce very weak detection signals if by chance oriented essentially orthogonal with respect to the direction of flux within the interrogation field. A particular example of a preferred phase-reversal sequencing comprises alternating bursts of 160 cycles (i.e., 16 msec) of the nominal 10 kHz fundamental alternation, separated by a "dead time" or "inter burst gap" of 4 msec, with the first such 160 cycle burst applied with the same phase condition (e.g., "phase A") on both sides 1 and 2 of each portal (i.e., "A—A" phasing), and the second such burst applied with "phase A" on side 1 and the opposite ("phase B") applied to side 2 of each portal (i.e., "A—B" phasing). Accordingly, the antenna at each portal side (constituting the initial "receiving means" herewith) will return in-phase signal components for marker-present conditions within the portal during the first such in-phase drive condition, and out-of-phase marker-present signals during the next such drive condition.

As indicated in conjunction with Fig. 1, the detection signals from the antennae at the various portal sides are coupled along signal paths A, A' and B, B' to the preamplifier 1, a detailed illustration of a preferred embodiment of which is set forth in Fig. 2, to which reference is now made. In the preamp 1, signal paths A and A' from the receivers, or antennae, which monitor side 1 of both portals 1 and 2, are coupled respectively to preamp inputs P—1 and P—2. Conversely, signal paths B and B' from side 2 of both portal 1 and portal 2 are coupled, respectively, to preamp inputs P—3 and P—4. As may be observed, each such preamp input feeds into an identically-configured amplifying and filtering network branch, located generally within the circuit portion on the left, designated 1—A, and each of the four such preamplifier/filter network portions feeds into a summation circuit portion on the right, designated 1—B.

Generally speaking, the interrogation field-generating coils are driven, in the alternating-phase sequence noted above, with current pulses on the order of magnitude of approximately 50 amps, preferably once every several cycles of tank circuit oscillation (e.g., every fourth cycle of oscillation), resulting in an oscillation of approximately three hundred volts (peak to peak) in amplitude. Each receiving antenna, therefore, would nominally detect a very strong 10 kHz signal, and for this reason the antennae are preferably figure-eighted in winding configuration, so as to null out as much as possible of the 10 kHz component. The field perturbations caused by the presence within one of the portals of the permalloy strip or other such marker element are miniscule in comparison to the tank drive level, thus presenting very substantial signal-processing difficulties in order to achieve high sensitivity, to avoid missing contraband-carried markers, while at the same time achieving a high degree of selectivity, to avoid erroneous contraband or theft-indicative alarms brought about by any of a variety of metallic objects or articles which also cause perturbations in the interrogation field.

Toward the foregoing end, certain characteristics of marker detection have become known which greatly facilitate the sensitivity-selectivity requirements; for example, the drive excitation pulses applied to the field-inducing coils are highly disruptive in and of themselves, and it is thus desirable to blank out all or part of the receiving circuitry during the time such drive pulses are being applied to the interrogation coil. Furthermore, the actual permalloy or other such low-coercivity markers create field perturbations by switching their magnetic domain orientation each half-cycle of alternation of the interrogation field, i.e., on each positive-going half-cycle as well as upon each negative-going half-cycle, with magnetic domain switching occurring during the first 90° of current flow in the coils for each such half-cycle. Accordingly, if the antenna ("receiver means") signals are examined to determine the presence of a marker within the field only during the current-rise portion of the cycle (i.e., the first 90°), other non-marker perturbations may be screened out. Furthermore, if a sample of the antenna/receiver means signals is examined during other portions of the cycles of interrogation field alternation, i.e., when marker perturbations are not anticipated (i.e., during the current falling portion of each half-cycle), a representative ambient field condition may be established for comparison with the receiver means signals obtained or examined during those periods when marker signals are to be anticipated if indeed a marker is present within the portal, i.e., within the interrogation field.

In addition to the foregoing, the treatment afforded the receiver means signals prior to actual analysis efforts, whose purpose is to determine whether or not a marker is present, becomes very important to successful processing. That is, while it has heretofore been recognized that the interrogation field fundamental frequency (here, 10 kHz) must be eliminated to the fullest extent possible, the countervailing consideration is to maintain the integrity (fidelity) of the actual signal from the antenna to the greatest extent possible. This desired result is greatly facilitated by the circuit configuration shown in Fig. 2 for the preferred form of preamp 1, in which each separate preamp circuit path proceeding from the different antenna inputs P—1, P—2, etc., is identical, thus making a description of only one such path necessary. Referring to path P—1, it may be seen that the signals first encounter a Pi-type RC filter 40, which applies an initial attenuation of 6 DB centered upon the 10 kHz drive frequency, but does not introduce any appreciable noise content as other filtering might. Next, the receiver signals encounter an amplifying stage 42, which is preferably a low-noise voltage amplifier having a gain on the order of about ten, designated U100. In a particular preferred embodiment, the latter is implemented by use of an integrated circuit operational amplifier such as that designated as IC5534 coupled into the circuit in the manner indicated, with resistive feedback. Accordingly, the receiver signals from the antennae essentially encounter strong low-noise amplification prior to operational filtering. Such filtering occurs after the first stage of amplification 42, in the twin-T notch filter 44 comprised of resistors R107, R108, R109, and capacitors C104, C105, and C106, in which it will be observed that resistors R108 and R109 are variable in nature, to provide for precise setting of the notch characteristics. Notch filter 44 is centered upon the 10 kHz interrogation field frequency, and supplies at least 40 DB of rejection for such frequency.

Following the notch filter 44 in the preamp circuit paths is a buffer stage of amplification 46, which may be implemented by another integrated circuit No. 5534 operational amplifier, configured to provide unity gain. It is to be noted that both amplifiers 42 and 46 should be wide band amplifiers, so as to accommodate all of the frequencies within the range extending from the fundamental of the interrogation field out to at least the fifteenth harmonic thereof. While set forth more fully hereinafter, it is to be noted that the high-order and low-order harmonic content of these antennae signals are utilized as important determinative factors in accordance herewith by observing the ratio or relative amounts of these bands of frequencies. The lower-frequency band comprises primarily the third and fifth harmonic range, and to some extent the seventh, since this range is highly representative of interrogation field perturbations brought about by non-marker metal objects of many and different particular natures. That is, the actual permalloy or like marker produces a significantly different ratio of the higher-order harmonic band with respect to the lower-order harmonic band, even though both the authentic marker and other non-marker objects may produce varying amounts of both frequency bands in the responses detected from the field perturbations which they cause. Indeed, some particular and relatively unusual metal objects (such as certain plated keys and certain loop-form or mesh-type metal objects) may to a considerable degree "mimic" (that is, resemble) the response of an authentic permalloy or like marker, although in essentially every instance the actual ratio of the high order harmonic band to the low order band (as defined above) will be at least somewhat different than those brought about by the authentic marker element.

Each of the preamp circuit paths commencing at the inputs P—1, P—2, etc., thus produces a relatively noise-free and significantly amplified version of the antennae/receiver means signals, with the fundamental 10 kHz signal substantially reduced but with harmonics of this signal present. Each such circuit path has a pair of output resistors R111/R112, R211/R212, etc., which are coupled into the summing portion of the preamp 1-B in the following manner. First, it will be noted that the R111-R211 outputs are ganged together and fed to the inverting side of a differential amplifier U102. This same circuit path is coupled to the output side of an upper switch portion S_1 in a four-stage CMOS analog switch S100, through which signals from preamp path P—3 output resistors R311 and R411 may also be coupled, upon appropriate actuation (excitation) of switch control terminal $SC_{1/4}$, which also controls switch stage S_4 of the CMOS switch S100.

Output resistors R112 and R212 in preamp paths P—1 and P—2 are ganged together and coupled to the inverting input of a second differential amplifier U202, and that signal path is also coupled to the output side of a third switch stage S_3 of switch S100. Similarly, output resistors R312 and R412 of preamp paths P—3 and P—4 are ganged together and coupled to the input side of switch stage S_3 in switch S100. These same two output resistors, R312 and R412, are also coupled to the input of the fourth switch stage, S_4, of the CMOS switch S100, just as output resistors R311 and R411 are additionally commonly-coupled to the input side of the second switch stage, S_2, of switch S100.

From the foregoing, it may be seen that the output of commonly coupled, preamp paths P—1 and P—2, which represent side 1 of both portals 1 and 2 (Fig. 1), are coupled to the inverting (i.e., "−") side of both differential amplifiers U102 and U202, and that signals from preamp paths P—3 and P—4, representing side 2 of both portals 1 and 2, will also be applied to this same side of differential amplifiers U102 and U202 (as outputs from resistors R311 and R411) when either the first stage (S_1) or the third stage (S_3) of switch S100 are actuated, through energization of their respective different control terminals (i.e., $SC_{1/4}$ or $SC_{2/3}$). At the same time, the non-inverting (i.e., "+") side of differential amplifier U102 is coupled to receive the outputs from side 2 of portals 1 and 2 (preamp paths P—3 and P—4, from resistors R311 and R411) whenever the second switch stage (S_2) of switch S100 is triggered by a signal on switch control terminal $SC_{2/3}$, and the analogous (non-inverting) side of differential amplifier U202 will receive the side 2 (paths P—3 and P—4) output signals (from resistors R312 and R412) upon actuation of the fourth stage (S_4) of switch S100, by an appropriate signal on switch terminal $SC_{1/4}$. For purposes of this specification, these control signals applied to switch terminals $SC_{1/4}$ and $SC_{2/3}$ may merely be considered as comprising appropriately-timed gating signals produced by the timing generator 4 of Fig. 1 which are closely synchronized to the frequency and phase of the oscillations actually present at the interrogation field.

Accordingly, by supplying the aforementioned gating signals to the switch terminals of CMOS switch S100, the antenna signals from the opposite sides of the two portals will be constructively summed (magnitudes instantaneously added) in one path and conversely, "destructively summed" or differenced in another path, to provide two quite different but nonetheless related signal outputs on preamp output terminals P—5 and P—6, leading from differential amplifiers U102 and U202, respectively. More particularly, when both sides of each portal are being driven in-phase with one another, the outputs from their respectively-associated antennae are in phase and are directly added (summed) by operation of the first switch stage S_1 of switch S100, an appropriate control signal being supplied at that time to control terminal $SC_{1/4}$. Under these conditions, differential amplifier U102 has all four such amplified, in-phase antenna signals applied to its inverting input, and none applied to its non-inverting input. The control signal applied to terminal $SC_{1/4}$ also actuates the fourth switch stage, S_4, thus applying the very same output signal from paths P—3 and P—4 to the second differential amplifier, U202, but in the reverse manner, i.e., applying such signals to the non-inverting inputs, whereas the other two antenna signals are applied to the inverting inputs, so that these two sets of signals are differenced, or subtracted, at differential amplifier U202.

When the opposite phase relationship occurs at the interrogation fields (i.e., side 2 of both portals driven out-of-phase with side 1 thereof), a similar end result is obtained through opposite switching of the analog switch S100. That is, additive summation occurs at differential amplifier U102 and subtractive summation at amplifier U202, i.e., signals from side 2 of both portals are arithmetically added together at amplifier U102 (directly out-of-phase signals applied to opposite inputs of the differential amplifier) while the same signals are arithmetically subtracted at amplifier U202 (i.e., directly out-of-phase signals resistively combined and applied to the inverting input, and no signal applied to the non-inverting input). Accordingly, the output appearing at preamp ouput terminal P—5 represents the algebraic difference but arithmetic sum of the antenna signals from sides 1 and 2 of the two portals, whereas the output at preamp terminal P—6 represents the algebraic summation but arithmetic difference of the antenna signals from opposite portal sides, taking into effect the alternating phase conditions present within the interrogation field. In this connection, it is to be noted that the control signals applied to terminals $SC_{1/4}$ and $SC_{2/3}$ and the CMOS switch S100 are preferably of sufficient duration to maintain switch actuation throughout the entire time interval from the initiation of one phase condition (for example A—A) to the initiation of the next succeeding phase condition (continuing the example, A—B). That is, the "on" time for the switch should preferably continue through the aforementioned dead space or interburst gap, rather than ending at the immediate conclusion of the ongoing phase condition, since by continuing the summing and differencing operation on into the "dead space", additional signal information will be obtained with respect to interrogation field perturbations which will contribute meaningfully to system sensitivity and selectivity.

Quite clearly, the two signals appearing on preamp output terminals P—5 and P—6 will have substantially different characteristics, the first such output representing combined antenna outputs providing the highest possible signal-to-noise characteristics, for maximum sensitivity, whereas the output on the second such terminal has had eliminated from it "common-mode" noise and other such undesired frequency components. The first aspect is particularly important with respect to the weakest likely marker-present conditions, i.e., a marker whose particular metallurgy and/or physical characteristics produce very weak perturbations of the interrogation field, and which is located in the middle of the portal, midway between the two sides where the receiver means antennae are located, a set of conditions likely to be missed in prior systems. Of course, by use of a separate preamp circuit or path for each portal side receiver, i.e., antenna, sensitivity is optimized in any event, and even this basic factor has been lost upon certain of the prior systems; this is all the more true when the particular preamp circuit path configuration, as described above, is taken into consideration, since this optimizes the desired signal (i.e., harmonic frequency bands with the least introduction of noise). Of course, the summing (additive and subtractive) described above is a further and very substantial enhancement for systems such as those in use or proposed heretofore.

Some of the reasons underlying the above-described differencing of the common-mode noise signals from the two different sides of a single portal result from the fact that, in contrast to the true or real (e.g., permalloy) marker, most other objects or materials which would have a low enough coercivity to generate harmonics of interest (i.e., tending to mimic or mask a true marker) also have low permeability and only cause a perturbation in the interrogation field when in close proximity to the portal sides, i.e., to an interrogation field-generating coil or to an antenna or receiver. Thus, a non-marker object carried through a portal causes a perturbation in the field as the object passes near the interrogation coil. At the same time, there are many objects or structures which may be present beneath the floor, for example, wire mesh, concrete reinforcing rods, etc..., or in the ceiling (e.g., ceiling grids) which cause receiver signals in the 30 to 50 kHz region, i.e. the third and fifth harmonic of the 10 kHz drive frequency fundamental. Additionally, even distortion in the capacitor geometry and the coil geometry of the L—C field drive circuit are likely, due to the high magnetic flux densities, to produce receiver signals in the 30 to 50 kHz region. It is desirable to lower this background or ambient noise level, so that field perturbations caused by non-marker items passing through the portals very near the interrogation field coil at one side would have the greatest detectable effect, i.e., would be more easily and more reliably detected, and thus discriminated out of alarm-causing effect.

To this end, the receiver (antennae) signals from opposite sides of the same portal are "summed" (i.e., combined) in accordance herewith such that during each particular interrogation field phase condition such signals are arithmetically subtracted from one another, or differenced, that is, they will (at least partially) cancel out one another. The signals coming from the two antennae are much alike, and if the two signals, properly phased, are summed together so that one cancels with the other, the result will be to lower the signal portion attributable to "background" or environmental noise, thereby enhancing, or highlighting, perturbation effects from objects located near one portal side. On the other hand, a true marker causes a significant perturbation even as it passes down the center of a portal, and it is desirable to enhance those perturbation effects. To accomplish such enhancement, the antenna signals from opposite sides of the same portal are constructively (algebraically) added in the preamp and processor to produce a differently-constituted second composite or resultant signal for subsequently processing, containing all of the perturbation effects present at either antenna and therefore maximizing the result produced by a real marker.

Thus, the present invention provides an appreciation and realization that the only time a non-marker object is likely to produce perturbations with a harmonic response fairly closely mimicing that caused by an actual marker is when the object is close to one of the portal sides. That is, because of the comparatively low permeability of most non-marker objects, they do not have as large an affect on the interrogation field as the permalloy strip of a true marker does, and so only generate significant harmonics when interrogated with a very strong field. When so interrogated, a non-marker may actually generate some of the same harmonics as a marker, but not to the same extent, and not in the same ratio of harmonic orders, and non-marker objects will thus be detected to a greater extent when the object is close to one portal side. It is important to realize, moreover, that perturbations caused by non-markers do not have the same distribution or ratio of harmonics, and that is why it is desirable to produce, and compare, the two different preamp output signals, as done in accordance herewith. Furthermore, while a non-marker will theoretically produce the same distribution of harmonics, or the same harmonic content, whether it is in the middle of a portal or close to one side, the permeability of such an object is likely to be such that its magnetic domains do not even undergo switching by the interrogation field if the object is near the center of the field, whereas a true marker will still undergo substantial saturation and domain-switching under such circumstances. That is, the strength of the interrogation field does differ across its width, but the perturbation effect of any object is really a function of two factors: first, coercivity, which for non-markers is most likely not as low as that of the real marker, requiring a stronger field to cause domain-switching; second, non-marker objects do not have as high a permeability as real markers, and non-marker objects do not disrupt the field as much when they do undergo switching. Thus, there is a double effect as an object moves away from a side of the portal, and the effects caused by non-markers fade away very quickly.

The above-described separate outputs from preamp terminals P—5 and P—6 are separately and respectively applied to the inhibit amplifier 3 and the amplifier/filter 2 noted above in connection with Fig. 1, where each such output is separately processed (basically, amplified and frequency-shaped), and the resulting outputs are then separately supplied to the detection logic and processing unit 9.

More particularly, the output signal from preamp terminal P—6 is applied to input terminal A—1 of the inhibit amplifier 3, a preferred embodiment of which is illustrated for convenience in Fig. 3. Basically, inhibit amplifier 3 is preferably a two-stage band pass amplifier whose pass band encompasses primarily the third and fifth harmonic, and preferably the seventh as well, of the alternating interrogation field frequency (in the preferred embodiment already noted, 30 to 50, and up to about 70 kHz), which generally characterizes the lower frequency spectrum in the ratio used to critically identify the particular marker element within the interrogation field, as explained more fully hereinafter. It will be noted that both the input terminal A—1 and the output terminal A—2 are subject to switching by being coupled through the complementary halves of a CMOS analog switch S300, which may advantageously be implemented by a single four-stage such switch, the two complementary halves of which are shown for purposes of illustration at different positions in Fig. 3 (i.e., one at the input and one at the output). Additionally, the input terminal A—1, after being switched through switch portion S_5 of CMOS switch S300(a), is coupled to a twin-T notch filter 310 preferably having a variable resistance in both its series-connected and parallel-connected branches. Like the twin-T notch filter 44 noted above in connection with the preamp 1, notch filter 310 is used for the purpose of further removing, i.e., diminishing, the 10 kHz fundamental frequency of the interrogation field, since the effects of the latter are very strongly present in the receiver signals picked up by the various antennae, and require substantial effort to properly filter out for optimum sensitivity and selectivity in marker detection. By the variable-resistance twin-T filtering concept noted, another 40 DB of rejection in the residual level of the 10 kHz signal may be accomplished, with desirable results.

As noted, the input to the inhibit amplifier 3, and the output from such amplifier and circuit, are both subject to switching by the analog switch S300. This switching is provided for blanking purposes, during which the inhibit amplifier may be effectively removed from operation at certain critical points in the operation of the system, i.e., when the interrogation field-generating coils are receiving their drive pulses. Such blanking is accomplished by appropriately timed inputs on CMOS switch control terminals SC—10 and SC—12, the first of which blanks the input and the second of which blanks the output. Signals for these two control terminals are provided from the timing generator 4 noted in connection with Fig. 1, and may generally be considered as pulse-type blanking signals whose pulse-width determines the time of circuit shutdown, the timing of the blanking signals being synchronized to the application of the aforementioned excitation or drive to the field-producing coils. In a more particular sense, the blanking signal applied to control terminal SC—12, at the output of the inhibit amplifier, is preferably about 50% longer in duration than the signal applied to switch control terminal SC—10, which blanks the input of this amplifier. In a particular sense, where the interrogation field fundamental frequency is 10 kHz and one quarter-cycle (during which time the drive pulse is actually applied) has a duration of 25 microseconds, a preferred input blanking period is on the order of 100 microseconds, and a preferred output blanking period is 150 microseconds, both signals synchronized to the drive pulse. By so doing, transients produced in the amplifier as a result of switching will have been avoided, and both the amplifier and the LC oscillating circuit will have undergone substantially complete settling, thus avoiding distortion effects which can be very significant.

The output from the inhibit amplifier 3 comprises carefully timed bursts of the frequency range representing primarily the third, fifth and seventh harmonic of the interrogation field fundamental, as noted above, and this output from terminal A2 of the inhibit amplifier is applied to input terminal DL—4 of the detector logic circuit 9

(Figs. 4, 5 and 6), to be described further hereinafter.

The second output from the preamp 1, namely that appearing on its output terminal P—6, is applied to the amplifier/filter 2, noted previously in connection with Fig. 1. Although not illustrated specifically in the drawings, it should be understood that the amp/filter 2 has an input terminal to which the preamp signal (from output terminal P—6) is applied. Preferably, the amp/filter 2 is a three-stage band-pass device, having a single-ended output which is coupled to the detector logic circuit 9. With respect to the preferred characteristics of the amp/filter 2, the three stages of amplification may all be implemented by use of an LM—318 integrated circuit operational amplifier, connected in a multiple-pole amplifying configuration with appropriate frequency-shaping capacitance, centered upon the desired pass band comprising the fifteenth harmonic of the fundamental frequency at which the interrogation field is driven, in the embodiment contemplated here approximately 140 kHz. In a preferred configuration, the first stage is a high pass stage, the second stage is a band-pass stage, and the third stage is essentially a gain stage with both high and low cuts. Where integrated circuit amplifier stages are used, each succeeding stage is preferably coupled in complementary conductance configuration, with appropriate positive-negative-positive reference or biasing voltages. As already indicated, the output from the amplifier/filter unit 2 is coupled to the detector logic network 9, where it is inputted on terminal DL—1.

Referring now to the detection logic network 9, and initially to Fig. 4 which illustrates the general nature of a preferred form thereof, it will be observed that this system has five discernible branches, designated by the numerals 900, 910, 920, 930, and 940, which are set apart from one another in this figure by dashed lines, for purposes of illustration. Of these, branches or sectors 900 and 930 are essentially the same as one another from the standpoint of componentry, although having very definite operational differences to be noted subsequently. That is, both branches 900 and 930 embody a control switch 10, 12, respectively, a reference control and threshold comparator set 14, 18 and 16, 22, respectively, and a driver, timer, and indicator unit or circuit portion 22 and 24, respectively, each of the latter having respective output terminals 21 and 25 as well as LED signal elements ("LED 2" and "LED 3", respectively). As further seen in Fig. 4, the respective outputs from the threshold comparators 18 and 22 are also directed to an integrator 34, and thus are seen to be summed with respect to one another; however, the particular manner in which such summing is carried out is an important aspect and is described in much greater detail hereinafter.

With continuing reference to the block diagram of Fig. 4, and to the general attributes of detector logic unit 9, the center circuit portion 920 includes an amplifying and integrating, or integrating detector, circuit portion 30, which receives an input from terminal DL—4 and has an output directed to a comparator and alarm 32 having an LED indicator ("LED 1") as one of its outputs. The output from this alarm is also fed as an input to the lower circuit branch 940, more particularly, to a driver, timer and alarm unit 38, which as indicated provides an "Alarm Output No. 2". This same input terminal of the alarm unit 38 receives control signals on an input lead 39 connecting to the "signal gate" and "noise gate" inputs fed to control switches 10 and 12 from circuit input terminals DL—2 and DL—5. The second (upper) input terminal of the driver, timer and alarm unit 38 is coupled back to the input side of a discharge clamp 26 in path 910, whose primary input is from circuit terminal DL—3. The output of the discharge clamp 26 is coupled to, and directly affects, the integrator 34, and the integrator is coupled to, and actuates, a comparator, timer and alarm 28 having a primary alarm output directed to a lamp driver 29, which also provides a switched alarm output, labeled Alarm Output #1. Also, timer and alarm 28 controls an indicator LED ("LED 4") coupled to its output.

Referring now in more detail to the detector logic circuitry as depicted in Figs. 5 and 6, it will first be noted that the upper and lower portions of the circuit, comprising channels 900, 910, 930 and 940 in Fig. 4, are depicted in Fig. 5, whereas the central portion of the circuit, comprising the path designated by the numeral 920 in Fig. 4, is depicted separately in Fig. 6. In the preferred embodiment shown in these Figures, the elements identified as "control switch 1" and "control switch 2" in Fig. 4, and designated by the numerals 10 and 12 therein, are shown to comprise input switching transistors Q1 and Q2, whose bases receive control inputs through resistors R8 and R9, respectively, from circuit input terminals DL—2 and DL—5. Also, the bases of switching transistors Q, and Q2 are coupled together through resistors R4 and R10, and the junction of the latter two resistors is coupled to the low voltage side of a pull-up resistor R21, and then through conductor 39 to the positive or non-inverting side of an amplifier U11 in path 940. The primary signal inputs to be switched by transistors Q1 and Q2 are received on circuit input terminal DL—1, which is coupled to the collector of each such transistor through resistors R6 and R5, respectively.

The "reference control" components or units 14 and 16 of Fig. 4 are seen in Fig. 5 to comprise switches, e.g. transistors, Q4 and Q3, respectively, which are connected in emitter-follower configuration, and whose bases are coupled together by a lead 49 so as to receive a common input, to be described subsequently. The respective outputs from transistors Q4 and Q3 are coupled as reference inputs to threshold comparators U—1a and U—14a, and it is to be noted that the circuit arrangement of paths 900 and 930 is of an inverted configuration, i.e., the output from transistor Q4 in path 900 is applied as an inverting input to comparator U—1a, whereas the output from transistor Q3 in path 930 is applied to the non-inverting input of comparator U—14a. Each such comparator input also receives a particularly-set reference voltage obtained from the junction of voltage-divider resistors R14 and R1, and applied through input resistances R16 and R3, respectively. The respective opposite input terminals of threshold comparators U—1a and U—14a receive inputs from the collectors of switching transistors Q1 and Q2, respectively. These inputs are also supplied to comparators U—1b and U—14b (which may be half of the same double integrated circuit amplifier comprising comparators U—1a and U—14a, respectively, for example, an integrated circuit comparator No. 339). In essence, the second comparators U—1b and U—14b are used as drivers for ensuing timers and indicators U—2a and U—2b, whose primary function is merely to time out or an indicator drive signal of desired duration on respective signal lamps LED 2 and LED 3, as described hereinafter. As indicated, the two timers U—2a and U—2b are interconnected to one another, and they may in fact be implemented as the complementary halves of an IC556 timer, which is a double unit.

The lowermost circuit portion 940 of the detector logic network 9 comprises in effect a comparator, a current source which drives a ganged double-timer, and an amplified lamp-driver output for alarm signal purposes. More particularly, the initial comparator comprises the aforementioned comparator unit U—11, which may be implemented by use of a 339 integrated circuit component. The comparator output is diode coupled to a transistor Q5 disposed in grounded-collector configuration to act as a timed current source whose timing cycle is determined by the charge rate on capacitor C14. This current source drives the double timer U—12a and U—12b, which may advantageously be the two halves of a No. 556 integrated circuit timer whose terminals are ganged in the manner illustrated. The first half of the timer, U—12a, is diode-coupled (D7) to a final amplifier or driver U—13 and lamp driver Q6, driver U—13 being a further comparator component which may be implemented by use of a 339 IC whose non-inverting input is supplied by the same signal which is applied to the inverting side of the first-stage amplifier U—11. Further, the first timer stage U—12a is connected to (diode OR'd with) the second timer stage U—12b such that the first stage, upon its initial excitation, immediately commences a continuous lamp-driving operation of amplifier U—13 and switch Q6, as a "power on" indicator; however, whenever the current source comprising transistor Q5 and its timing capacitor C14 reaches full charge, the second timer (U—12b) is gated in and assumes control of the output signal, causing a blinking of the signal lamp driven by driver Q6, for purposes noted subsequently.

Generally speaking, the operation of that portion of the detector logic circuitry described above is as follows. Input terminal DL—1 receives the above-described output from the amp/filter 2, which as already pointed out comprises the arithmetically-summed antenna signals from both sides of a given portal, or group of portals, after band-pass amplification centered upon the fifteenth harmonic of the interrogation field fundamental frequency. This signal is supplied equally to the control switches Q1 and Q2, whose switching operation determines whether or not any portion of the supplied signal is gated through the switching transistors to either path 900 or path 930. The latter two channels are gated into and out of operation by timing signals applied to inputs DL—2 and DL—5, as supplied from the timing generator 4. The first such input, to transistor Q1, is representative of the "signal gate" or "marker signal window", i.e., those particular increments of time representing an increasing-current condition (both positive-going and negative-going) in the interrogation field drive coils; consequently, these gate signals represent times when a marker-present signal is likely to be present in the signals from the portal antennae, if a marker is in fact present within the interrogation field. Conversely, the gating signals applied to terminal DL—5 and transistor Q2 represent the opposite portion of the interrogation field alternations, i.e., when marker-present signals are not likely to occur in the antennae signals even if a marker is present in the portal. Consequently, the gate signals applied to terminal DL—5 define a "noise gate", i.e., a period of time during which the signals received by the portal antennae, on an instantaneous basis, represent an actual measure of the existing noise level in the antennae signals.

It should be noted that, in accordance with this invention, the duration of the aforementioned "noise gate" is shorter than the duration of the "signal gate", and that there is a gap or interval between the two. More particularly, assuming the interrogation field fundamental frequency to be 10 kHz, so that the duration of each quarter-cycle is 25 microseconds, the marker-present signals are likely to occur during the quarter-cycles when the current is increasing, either positively or negatively, whereas the current-decreasing quarter-cycles represent the condition when marker-present signals are not likely to occur in the antennae signals. By maintaining the "signal gate" for a full 25 microseconds but maintaining the "noise gate" for only approximately half that time, thus providing a gap of approximately 12 microseconds between each noise gate and ensuing signal gate, distortion and transients which otherwise would "ring through" the circuit will be eliminated, thus further enhancing sensitivity and reliability. Of course, the particular timing and synchronization of such signals are also highly important. While the general state of the art includes circuits and components well able to provide representative gating or blanking signals of this type, a preferred form of timing generator is a digital clock and divider, synchronized to the actual oscillation conditions of the interrogation field.

Since the inputs to terminals DL—2 and DL—5 occur at different points in time, and in effect represent an alternating sequence, circuit paths 900 and 930 of the detector logic 9 in effect alternate in operation, and during the period each is in operation it applies an input to the aforementioned threshold comparators U—1a (and U—1b) (in channel 900) and U—14a (and U—14b) (in channel 930). In so doing, each such circuit path functions to alter the charge state of an integrating capacitor C9, and it is important to note that the two circuit paths act oppositely from one another in that regard. That is, the switched input from transistor Q1 to comparator U—1a in path 900 is applied to the noninverting (i.e., positive) input, whereas the opposite is true in path 930, where the signals gated through by switch Q2 are applied to the inverting side of comparator U—14a. Consequently, the two such circuit paths act to rapidly and sequentially apply increments of charge to, and draw increments of charge from, integrating capacitor C9, on an alternating, increment-by-increment or pulse-by-pulse basis. As will be seen hereinafter, these added and subtracted increments of charge are not necessarily equal in magnitude, and the resultant charge state on the integrating capacitor is thus cumulative with respect to time during each "burst" of pulses, so long as they are of the same phase, as described more fully hereinafter.

It is very important to note, in conjunction with the alternating operation of circuit paths 900 and 930 noted just above, that the signals gated through by transistors Q1 and Q2 to comparators U-1a and U—14a work against variable reference levels, and that these variable reference levels are applied to the opposite-polarity input terminal of each such comparator. That is, in circuit path 900 the inverting input of comparator U-1a receives the variable reference level, whereas in circuit path 930 it is the non-inverting input of comparator U—14a which receives the other such variable reference level. As already indicated above, these variable reference levels both operate from the same nominal or steady-state reference level, obtained from the junction of voltage-divider resistors R14 and R1, through identical series resistors R16 and R3. This steady-state reference level is subject to variation, however, by the operation of transistors Q4 and Q3, which constitute the "reference controls" 14 and 16 noted in connection with Fig. 4. That is, in channel 900 the base of transistor Q4 is controlled, in a manner described more particularly hereinafter, so as to vary the resulting reference level applied to the inverting terminal of differential amplifier U—1a. In channel 930, the steady-state reference level is applied to the non-inverting input of comparator U—14a, and this nominal reference level is made subject to variation by reference control 16, i.e., transistor switch Q3, which receives the same varying input as transistor Q4, i.e., the base of each of these transistors is commonly coupled to receive the same control input signal (from the output of the amplifier, peak-detector and integrator 30 in path 920, shown in Fig. 5). In the case of both circuit paths 900 and 930, the second-stage comparators U—1b and U—14b, respectively, may be considered as in essence duplicative of the first such stage, insofar as inputs are concerned, except that instead of applying and subtracting charge from integrating capacitor C9, they are utilized to drive indicators LED 2 and LED 3, which are pulsed by timer units U—2a and U—2b, to indicate the operational status of each such circuit path.

The second portion or channel 910 of the detector logic network 9 is also illustrated in detail in Fig. 5, and will be seen to include a pair of inputs, a first one of which is provided by circuit input terminal DL—3 which is coupled to the inverting input of a comparator U—3, comprising the "discharge clamp" —26 noted in connection with Fig. 4. The output of this comparator connects to the conductors 21 and 23 by which charge is applied to and removed from integrating capacitor C9. Therefore, when an appropriate gating signal is applied to the inverting side of comparator U—3, under general system conditions to be noted subsequently, this comparator/amplifier will clamp integrating capacitor C9 to ground, thus fully discharging the integrator. This in effect terminates, and dissipates, the incrementally-accumulated charge effect carried on for the duration of each different phase condition present in the interrogation field, as noted above. Therefore, each time the interrogation field-inducing coils are to be switched from one phase condition to another (for example, from an in-phase or phase A—A condition to an out-of-phase, or phase A—B condition), an appropriate pulse supplied from the timing generator 4 is applied to input terminal DL—3, to fully discharge the integrating capacitor C9. During the time each opposite phase condition exists (described previously as preferably on the order of 16 msec, representing 160 cycles of alternation) the charge state existing on integrating capacitor C9 is continuously subject to pulse-by-pulse change, depending upon the operational levels of circuit paths 900 and 930, described above.

An important function of the detection logic and processor 9, involving that portion thereof designated generally as channel 910, and particularly of that portion of the circuitry disposed to the right of portal point 911, is the production of a desired alarm or signal upon the detected presence of the particular marker within the interrogation field. More particularly, it will be noted that the node or junction 911 where comparator U—3 interconnects with conductors 21 and 23, which lead to the integration capacitor C9, comprises the signal input to a comparator U—4, which receives a predetermined bias or steady-state reference on its positive (non-inverting) input terminal from voltage-divider resistors R13 and R15. Therefore, at any time the charge level on integrating capacitor C9, representing the relative proportions of higher-order harmonic content in the antenna signals versus lower-order harmonic content therein, caused by an object producing perturbation of the interrogation field, rises to a predetermined level, established by the reference applied to comparator U—4, this comparator triggers and applies an alarm-causing output signal to the timer U—5 (which may be an IC No. 555). One output of timer U—5 actuates an alarm signal (LED 4) and is also coupled to an output driver Q7, which may be used to drive a signal lamp, sound an audible alarm, or the like, utilizing an output taken at terminal 912 connected to the collector of transistor Q7. Further, a switched output signal of timer U—5 which is representative of the control signal applied to the base of transistor Q7 is available on the output terminal designated 914.

Perhaps the most important of the many important functions of the detection logic and processing network or unit 9, is carried out on circuit path 910, shown in more detail in Fig. 6. As shown there, this circuit path receives an input on terminal DL—4, which input comprises the amplified, frequency-selective output from the inhibit amplifier 3, noted generally in connection with Fig. 1 and more particularly described in connection with Fig. 3. This signal from the inhibit amplifier 3 comprises sequential, time-gated, synchronized bursts of the subtracted (differenced) signals from the portal antennae, after low-pass selective amplification thereof in the inhibit amplifier. Consequently, this input to the detection logic circuit is representative of the low frequency component band (in the range of the third, fifth, and up to the seventh harmonic of the interrogation field, here on the order of 30 to 50, and approaching 70, kHz), which signal is attributable to an object within the interrogation field. Whether that object is an actual marker, or merely some non-marker element causing perturbations in the interrogation field, remains to be determined, but as already indicated, the true or actual markers will have a relatively unique ratio or balance of the high frequency component band with respect to the low frequency band. This low frequency band is used in the detection logic and processing unit 9 as a determinant which must be satisfied by the magnitude of the high frequency band produced by the same object within the interrogation field before a marker-present signal or alarm is sounded; i.e., the amount (magnitude) of the low frequency band actually encountered, as represented by the magnitude of the input applied to terminal DL—4, is used to determine the required level which the high frequency band produced by the same object in the field must equal or exceed if it is indeed an actual marker; the ratio or balance of these frequency components for true markers being relatively unique.

To achieve the above result, the aforementioned input on terminal DL—4 is coupled to one end of a variable resistance or potentiometer R2, whose movable contact is coupled through a series resistor R56 to the inverting input of a differential amplifier U—6 coupled into the circuit as an inverting amplifier, whose gain is thus set by potentiometer R2. Inverting amplifier U—6 (which is preferably implemented by use of a 3240 integrated circuit operational amplifier) forms part of the amplifier, detector and integrator unit 30 noted briefly above in connection with Fig. 4; thus, the output of inverting amplifier U—6 is diode-coupled through a series resistor R48 to the parallel combination of a second inverting amplifier U—7 and an R—C integrating network consisting of resistor R50 and capacitor C28. This overall network in effect comprises a combination amplifier, peak-detector and integrator, or in effect an integrating detector. That is, the charging time-constant for capacitor C28 is a function of the voltage drop across series resistor R48. Thus, the charge on capacitor C28 will build during the continuation of each burst of input signals applied to terminal DL—4 and passed by inverting amplifier U—6, with capacitor C28 integrating only the peaks of the negative excursions of the incoming signals (i.e., that portion of a cycle which exceeds the preset reference level).

The peak-integration or integrating detector effect just noted is preferably accomplished by maintaining the integration time constant or capacitor C28 of very short duration, for example by utilizing a .1 microfarad capacitor for C28 and a 4.6 K-ohm resistor for R48. This will produce a very fast-acting integrator which will operate in the manner of a current source, i.e., integrating for only the first few excursions and tracking the applied signal very accurately and closely, yet reducing the effects of narrow, high-amplitude spikes due to switching transients from the blanking (gate-generating) and other related circuitry. This type of detector is preferred since the band-pass stages preceding it allow some of the higher order components (for example in the range of 140 kHz) to pass through, usually in the form of spikes. Additionally, spikes may be created by the blanking circuitry, as just indicated. If a more conventional peak-detector was used, such spikes would result in a high level of detected signal, whereas the preferred integrating detector responds more to the average value above the diode (D—10) voltage drop. The level of the signal so integrated appears on conductor 48, on the output side of inverting amplifier U—7, and this signal level is not only coupled forward to a comparator U—8, but is also reflected back (on conductors 50, 47 and 49) as a threshold-changing signal to transistors Q3 and Q4, (i.e., "reference controls" 14 and 16) noted above in connection with Figs. 4 and 5.

The forwardly-coupled signal from inverting amplifier U—7 is applied to comparator U—8 and, when this signal rises to a predetermined level constituting a system override condition, comparator U—8 switches, thereby energizing an indicator labeled "LED 1", through a series resistance R52 and a level-setting resistor R53. This provides a visual indication that the charge level on integrating capacitor C28 has reached the override threshold voltage determined by comparator U—8. Furthermore, the output of comparator U—8 is coupled to the inverting input of differential amplifier U—9, to whose output is also coupled the anode side of LED 1, and the resulting output from amplifier U—9 is coupled to one input of a second inverting amplifier U—10. The output of amplifier U—10 is coupled back, on conductor 901, to the non-inverting input of the aforementioned amplifier U—11 in path 940 (Fig. 5), whose function has been described previously, and also coupled back (on conductor 39) to the bases of switching transistors Q1 and Q2, to bring about system override, or lockout, as will be noted subsequently.

Accordingly, it will be seen that the input to terminal DL—4 of channel 920, representing the lower-frequency spectrum produced by the interrogation field-monitoring antennae, is utilized, with appropriate processing, to accomplish two distinct purposes. First, the peak-detected and integrated reflection of this input is coupled back to the bases of threshold reference-setting transistors Q3 and Q4, to change the threshold level of comparators U—1a and U—14a as a direct function of the instantaneous level of the low frequency spectrum produced by an object detected in the portals. Of course, the effect of this is to change in a very significant way the amounts of charge applied to and accumulated on integrating capacitor C9. This directly changes the relative conditions under which a logical decision is made to either produce or not produce a marker-detection alarm, through that portion of circuit path 910 coupled to node 911 and including comparator U—4, timer U—5, and output driver Q7. That is, in the manner already described in a qualitative sense above, the determination that an object within the interrogation field is a genuine marker is made to be directly dependent upon the relative proportion of the high frequency spectrum (in the neighborhood of the fifteenth harmonic) with respect to the low frequency spectrum (primarily third and fifth harmonic) which that object is producing in the interrogation field. In this manner, by using the ratio of the detected frequency component bands as the requisite detection criteria, substantial and accurate discrimination is accomplished between actual markers and the myriad of other objects which produce more-or-less analogous interrogation field perturbations and which, if detected and indicated as being real markers, would provide a false and erroneous output indicating theft, pilfering, or the like where none was in fact taking place.

In accordance with the foregoing, it will now be appreciated that the present detection system provides a multiple-step or multilayered approach for highly sensitive and yet highly selective detection of the low-coercivity permalloy or other such marker within the interrogation field, based upon the inevitably characteristic and relatively unique balance or ratio of low-order harmonics versus high-order harmonics caused by the magnetic domain-switching of the marker in response to each ensuing half-cycle of alternation of the interrogation field. Whereas many or even most metal objects will have some of the low-order harmonic band, and may even have an appreciable quantity of the highorder band, few if any non-marker objects will have the same characteristic ratio of high-order to low order harmonic bands or component groupings; generally speaking, the higher-frequency harmonic band will be deficient in objects and articles which are not true markers, even through in a general sense substantial quantities of the higher-order harmonics may indeed be present, particularly in objects and articles which provide multiple magnetic paths or loops and which include at least some arcing points, i.e., gaps in the magnetic circuits.

Thus, the invention provides a method and means to determine the low-frequency components or band and the high-frequency components or band of an object within the interrogation field, and these low frequency components are used to dynamically control the detection threshold of the high-frequency components which produce an alarm signal. In so doing, the signals from the antennae monitoring the interrogation field are carefully processed to produce two different types of signal output: one which represents the summation of the signals from the antennae, for maximum sensitivity, and the other of which represents the differencing of the signals from opposite sides of the interrogation field, for maximum selectivity. These two signals are separately processed to emphasize their respective high- and low-order harmonic content, and the signal with the high-order harmonic band is time-sampled in a manner such that the resulting samples are likely to accurately portray marker-presence signals on the one hand and marker-absence or ambient-level (noise-level) signals on the other hand. The resulting samples are then separately compared to a varying threshold reference which is provided by a peak-integrated signal representative of the detected object's low-order harmonic band, such that the higher the level of the latter signal, the higher the level which the marker-present signal must have in order to bring about a threshold-crossing in either of the two marker-present or marker-absent signal channels.

Whatever threshold crossings do result from the foregoing process are then in effect differenced and the result integrated cumulatively over the repeated cycles of the interrogation frequency during each successive phase-related burst thereof. Should the resulting integrated level exceed that indicative of the presence of a genuine marker within the interrogation field, an alarm is sounded. Conversely, if the peak-integrated signal representative of the low-order harmonic band becomes sufficiently large to exceed a predetermined threshold, indicating that the variable reference to which the high-order frequency samples are compared has become prohibitively large and is, in effect, blocking the detection channels, an indication of that status is given. Initially, this indication results from energizing an indicator light and, should the condition exist for a time period exceeding that attributable to some unusual but nonetheless expectable occurrence, a flashing alarm is enabled (via detector logic channel 940).

The condition just described, indicative of an unusual and undesirable situation prevalent within the interrogation field which is causing a substantial overbalancing of the detection circuitry by way of excessive levels of the low-frequency harmonic band, is a severe aberration in the detection circuit parameters, and thus indicates the advisability of fully inhibiting the detection circuitry, in addition to the flashing lamp indication just noted which shows the existence of the condition. Thus, the signal indicative of the low-frequency overbalance which is coupled back to channel 940 for the purpose of enabling and driving the flashing lamp indicator is also coupled back, on conductor 39, to each of the control switches 10 and 12 (transistors Q1 and Q2) such that they latch out and block the input from terminal DL—1, thereby preventing any build-up on integrator 34 (capacitor C9) which might otherwise result in an erroneous detection alarm.

In connection with the function and operation of detector logic channels 900 and 930, it is to be noted that the level of the instantaneously-variable detection threshold or reference on comparators U—1a and U—14a, set initially by voltage divider R14 and R1, and varied by proportional or relative conduction of transistors Q3 and Q4, is in effect stored for a short time interval on capacitors C7 and C8, coupled to the emitters of transistors Q4 and Q3, respectively, through a time constant-setting resistor R16 and R3, respectively. That is, the peak levels of threshold variation due to conductance of transistors Q3 and Q4 in response to elevated inhibit signals from integrating capacitor C28, are stored on capacitors C7 and C8 between phases; thus, these threshold peaks will be held briefly when the interrogation field switches its resultant flux direction in response to reversal in the phase of the drive excitation applied to one of the interrogation field-inducing coils. Thus, the system will not be susceptible to error as a result of detection harmonic content levels which vary substantially from one phase condition to the next. What is desired is to have enough storage in the system so that relatively high inhibit levels built up during one phase condition, which have effectively raised the threshold at the comparators to a substantial degree, will be maintained after the change in phase condition for at least the first half-cycle of the next interrogation field alternation and resulting detection signal, representative of a change in phase condition. For example, assuming the interrogation field fundamental frequency to be the aforementioned 10 kHz, utilizing a bleed-off time constant on the order of about 100 msec for capacitors C7 and C8 (the combined resistance of resistors R16 and R1 for C7 and R3 and R1 for C8), storage will be provided for an interval reasonably representative of the aforementioned period.

Claims

1. A method of detecting the presence of a particular marker member within an alternating electromagnetic interrogation field established between the sides of a portal, wherein said electromagnetic field is monitored by at least first and second receiver means each disposed to access the field from a different position with respect to the sides of said portal to detect the presence of signal indicia caused by such a marker in response to the alternations of the field and said receivers each provide an electrical signal representative of the frequency content of the alternating field at least in the area nearer to that receiver, characterised by: producing a first composite electrical signal for marker-presence analysis by using at least selected portions of said electrical signals produced by said first and second receivers, to increase detection sensitivity; producing a second composite electrical signal for use in marker-presence analysis by subtracting at least portions of said electrical signals produced by said first receiver from signals produced by said second receiver, to reduce common-mode noise or other undesired signal characteristics in that composite electrical signal; comparatively examining representations of said first and second composite marker-presence signals with respect to one another to determine differences therebetween; and using such differences in subsequent marker-presence determination.

2. A method according to claim 1, including the step of producing said first composite electrical signal by summing at least portions of said signals produced by said first and second receivers.

3. A method according to claim 1, including the steps of sampling said first composite marker presence signal at at least two different points during its cyclic alternations, comparatively examining representations of each such signal sample with signals representative of said second composite marker-presence signal to produce mutuallyrepresentative resultant signals, and using said mutually-representative resultant signals as marker-presence signals in determining the presence of a marker within the interrogation field.

4. A method according to claim 2, including the steps of comparatively examining representations of said samples of said first composite signal by using said samples to set the value of a first comparison condition, using representations of the second such composite signal to vary a nominal value for a second comparison condition, and comparing the varied value of said second comparison condition with said value of said first comparison condition.

5. A method according to claim 4, including the

steps of periodically changing at least certain of the alternation characteristics of said interrogation field, and maintaining a representation of the varied value of said second comparison condition signal for at least a brief interval bridging such periodic changes of alternation characteristics of the interrogation field, whereby a representation of said varied value is present at the commencement of the changed field alternation characteristics.

6. A method according to claim 1, including the step of selectively treating said second composite marker-presence signal to emphasize the presence therein of a predetermined frequency spectrum prior to said step of comparatively examining representations of said signal samples with representations of said second composite signals.

7. A method according to claim 6, including the steps of dynamically varying a detection threshold in accordance with the relative amount of said predetermined frequency spectrum present in said second composite marker-presence signal, comparing other frequency-content criteria represented in said first composite marker-presence signal to said varying threshold, and determining marker presence as a result of said other frequency-content criteria exceeding the instantaneous value of said dynamically-varying threshold.

8. A method according to claim 7, including the steps of using as said other frequency-content criteria a representation of the amount of higher-order harmonics of the fundamental frequency of alternation of the interrogation field, in the range of about the thirteenth to fifteenth harmonic thereof.

9. A method according to claim 7, including the steps of using as said predetermined frequency content primarily the third and fifth harmonics of the fundamental alternation frequency of said interrogation field.

10. A method according to claim 7, including the steps of sequentially sampling signals which are representative of said first composite marker-presence signal at different points during its cyclic alternations, and using the resulting signal samplings in said step of comparing criteria representative of such first composite signal to said varying threshold by conducting a series of sequential comparisons of the samplings with the instantaneously varying threshold.

11. A method according to claim 10, including the steps of separately comparing at least certain of said signal samplings with the varying threshold values to produce separate comparison values, and summing at least certain of the said separate comparison values over certain increments of time to produce composite comparison values.

12. A method according to claim 11, including the steps of periodically changing the resultant direction of at least portions of the magnetic flux in said interrogation field, and maintaining a representation of the varied value of said varying reference which was present prior to such a periodic change for at least a predetermined interval bridging such periodic changes of resultant flux direction, whereby a representation of the varied value is carried forward to the beginning of the period of changed flux direction.

13. A method according to claim 12, including the steps of carrying out a repeating sequence of said steps of sampling, separately comparing and summing over a plurality of successive cycles of alternation of the interrogation field and resulting cycles of the receiver-produced signals, and cumulatively summing the successive sequential composite comparison values.

14. A method according to claim 13, wherein said interrogation field is established by alternating electrical excitation currents and said periodic changes in the resultant direction of the flux in said field are representative of a plurality of cycles of alternation of said excitation currents in a first phase condition followed by another plurality of cycles of current alternation in a second phase condition, and wherein said steps of sampling, separately comparing, summing and cumulative summing are carried out synchronously with the said cycles of the alternating excitation current in each of said phase conditions, and said new repeating sequences are commenced synchronously with the said changes in phase condition of said excitation currents.

15. A method according to claim 1, comprising the steps of producing a first electrical signal for marker-presence analysis by sampling representations of the receiver-produced signals at a particular time during a cycle of the interrogation field alternations when marker-caused signal indicia would be likely to occur if a marker were within the field; producing a second electrical signal for marker-presence analysis by sampling representations of the receiver-produced signals at a different particular time during a cycle of the interrogation field alternations, when marker-caused signal indicia would not be likely to occur if a marker were within the field; processing said first and second electrical signals produced for marker-presence analysis by repeated differential summations of representations of the first such signal with respect to representations of the second such signal, and by cumulatively summing the results of said repeated differential summations over at least several cycles of the receiver-produced signals, to thereby produce a varying marker-presence signal value; and comparing the said varying marker-presence signal value to a reference in order to determine the presence of a marker member within said field.

16. A method according to claim 15, including the steps of comparing at least one of said first and second electrical signals produced for marker-presence analysis with a threshold value and using the resultant signal value from such comparing as the said representation of said one of said first and second electrical signals in said repeated differential summations whose results are cumulatively summed to produce said varying marker-presence signal value.

17. A method according to claim 16, including the steps of varying said threshold value from time to time between the instances of said comparing therewith of said at least one of said first and second electrical signals, said threshold being varied as a function of the frequency content of at least certain of said receiver-produced signals.

18. A method according to claim 17, including the steps of comparing both of said first and second electrical signals produced for marker-presence analysis with thresholds whose values are variably set as a function of the frequency content of representations of at least certain of said receiver-produced signals, and using the result of said comparing as the said representations of said first and second electrical signals in said repeated differential summations whose results are cumulatively summed to produce the said varying marker-presence signal value.

19. A method according to claim 16, wherein the said sampling of representations of the receiver-produced signals at a time during a cycle of the interrogation field when marker-induced signal indicia would not be likely to occur is carried out for an interval shorter than a quarter-cycle of the alternations of the interrogation field nominal frequency.

20. A method according to claim 17, wherein the said sampling of representations of the receiver-produced signals at a time during a cycle of the interrogation field when marker-induced signal indicia would be likely to occur is carried out for an interval which is on the order of the same length of time as a quarter-cycle of the alternations of the interrogation field nominal frequency.

21. A method according to claim 1, wherein said step of subtracting signals produced by said first and second receiver means comprises subtracting at least portions of the signals produced by a receiver means relatively further from a marker within the interrogation field from the signals produced by a receiver means which is relatively closer to that marker, thereby at least partially cancelling out ambient noise and/or other undesired effects from the receiver means signals prior to further processing thereof.

22. A method according to claim 21, wherein said subtraction step comprises subtracting from the signals produced by at least one of said receiver means certain of the low-order harmonics of the fundamental alternation frequency of the interrogation field prior to said step of comparatively examining representations of signals.

23. A method according to claim 22, further comprising the step of maintaining the presence in said signals produced by said one receiver means of low-order harmonics of the fundamental field frequency resulting from marker-caused field perturbations while subtracting out low-order harmonics produced by non-marker causation.

24. A method according to claim 1, including the steps of producing an alarm-inhibit signal at least in part by subjecting representations of at least certain of said second composite signal to frequency-content-representative integration, and conditionally comparing the resulting integration signal with other representations of the receiver-produced signals in a manner such that the greater the magnitude of the said alarm-inhibit integration signal the greater the magnitude of the said other representations of receiver-produced signals must be to cause indication of marker-presence within the interrogation field.

25. A method according to claim 24, including the steps of performing frequency-selective amplification of the signals used to produce said alarm-inhibit signal and performing peak-integration of the resulting frequency-selective amplified signals.

26. Apparatus for detecting the presence of a particular marker member within an alternating electromagnetic interrogation field established between the spaced sides of a portal, wherein first and second receiver means access the field from different positions at said portal and each such receiver produces an electrical signal which is representative of the frequency content of the alternating field at least in the area accessed by that respective receiver, characterised by: means (1A, 1B) for producing a first composite electrical signal for marker-presence analysis by use of at least selected portions of the said electrical signals produced by said first and second receivers, and for producing a second composite electrical signal for use in marker-presence analysis by differencing the said electrical signals produced by said first and second receivers; and means (2, 3, 9) for comparatively examining representations of said first and second composite marker-presence signals with respect to one another to determine difference characteristics therebetween, and for using such characteristics to determine the presence of such marker within said field.

27. Apparatus according to claim 26, wherein said means for comparatively examining said first and second composite signals includes electronic comparator apparatus (18, 22), and means (10, 12, 14, 16) for applying a representation of the first such signal to said comparator apparatus to set a first value for comparison and for applying a representation of the second such composite signal to said comparator apparatus to set the other value for said comparison, said comparator apparatus adapted to compare the said first value with the said other value.

28. Apparatus according to claim 27, including means (10, 12) for sampling said first composite marker-presence signal at at least two different points during its cyclic alternations, means (U—1, U—14) for comparatively examining representations of each such signal sample with signals representative of said second composite marker-presence signal to produce mutually-representative resulting signals, and means (30, 34, 28,

32) for determining the presence of a marker within the interrogation field as a function of said mutually-representative resultant signals.

29. Apparatus according to claim 26, comprising means (2, 3, 9) for combining selected characteristics of said two receiver-produced electrical signals to produce a pair of differently-constituted analysis signals, a first such analysis signal primarily including the higher-order frequencies caused by the presence of a marker within said field, and a second such analysis signal primarily including the lower-order such frequencies; means (30, 34) for using said second analysis signal to dynamically vary a reference value; means (28, 32) for comparing said first analysis signal to said dynamically-varying reference value; and means (28, 29) for actuating an indicator at least partially in response to the result of said comparing.

30. Apparatus according to claim 29, including means (14, 16) for sampling signals which are representative of said first analysis signal at different points during the cyclic alternations of said first analysis signal, and means (U—1, U—14) for comparing such signal samplings to said varying reference value by conducting sequential comparisons of the samplings with said varying reference value.

31. Apparatus according to claim 30, including means for separately comparing at least certain of said signal samplings with the varying reference value to produce separate comparison values, and means for summing at least certain of the said separate comparison values over certain increments of time to produce composite comparison values.

32. Apparatus according to claim 31, wherein at least certain of the alternation characteristics of said interrogation field are periodically changed, and including means for maintaining a representation of the varied value of said varying reference present just prior to such a periodic interrogation field change for at least a predetermined interval bridging such periodic changes of alternation characteristics of the interrogation field, whereby a representation of the varied value is carried forward to the beginning of the period of changed alternation characteristics.

33. Apparatus according to claim 31, including means for repeatingly and sequentially sampling, separately comparing and summing said separate comparison values over a plurality of successive cycles of alternation of the interrogation field and corresponding cycles of the receiver-produced signals, and for cumulatively summing the successive sequential composite comparison values.

34. Apparatus according to claim 33, wherein the resultant direction of the flux in said electromagnetic interrogation field is periodically changed, and including means for periodically commencing new repeating sequences of said sampling,. separately comparing, summing, and cumulative summing of successive sequential composite comparison values synchronously with said periodic changes of interrogation field flux direction.

35. Apparatus according to claim 26 comprising means for producing a first electrical signal for marker-presence analysis by sampling representations of the receiver-produced signals at a particular time during a cycle of the interrogation field alternations when marker-caused signal indicia would be likely to be present if a marker were within the field; means for producing a second electrical signal for marker-presence analysis by sampling representations of the receiver-produced signals at a different particular time during a cycle of the interrogation field alternations, when marker-caused signal indicia would not be likely to occur if a marker were within the field; means for processing said first and second electrical signals produced for marker-presence analysis by repeated differential summations of representations of the first such signal with respect to representations of the second such signal, and by cumulatively summing the results of said repeated differential summations over at least several cycles of the receiver-produced signals, to thereby produce a varying marker-presence signal value; and means for comparing the said varying marker-presence signal value to a reference in order to determine the presence of a marker member within said field.

36. Apparatus according to claim 26 comprising means for producing an alarm-inhibit signal at least in part by subjecting representations of at least certain of said receiver-produced signals to frequency-content-representative integration and differentially summing the resulting integration signal with other representations of the receiver-produced signals in a manner such that the greater the magnitude of the said alarm-inhibit integration signal the greater the magnitude of said other representations of receiver-produced signals must be to cause indication of marker-presence within the interrogation field.

37. Apparatus according to claim 36 including means for peak-integration of the frequency-content-representative signals.

Patentansprüche

1. Verfahren zum Aufspüren des Vorhandenseins einer einzelnen Markierungseinheit innerhalb eines elektromagnetischen Abfragewechselfeldes, das zwischen den Seiten eines Eingangs angeordnet ist, wobei genanntes elektromagnetisches Feld überwacht wird mit mindestens einem ersten und einem zweiten Empfangsmittel und diese so angeordnet sind, dass sie in das Feld von einer unterschiedlichen Position aus in bezug auf die Seiten des genannten Eingangs eintreten können, um das Vorhandensein eines Kennsignals aufzuspüren, das durch eine Markierung infolge der periodischen Wechsel im Feld ausgelöst wird, jeder der genannten Empfänger ein elektrisches Signal abgibt, kennzeichnend für die Periodenzahl des Wechselfeldes zumindest im

näheren Bereich zum Empfänger, dadurch gekennzeichnet, daß, um die Aufspürempfindlichkeit zu erhöhen, ein erstes zusammengesetzes elektrisches Signal erzeugt wird für die Bestimmung des Vorhandenseins einer Markierung, durch Verwendung von zumindest selektierten Teilen der genannten elektrischen Signale, die durch den ersten und den zweiten Empfänger erzeugt werden, und daß ein zweites zusammengesetztes elektrisches Signal erzeugt und verwendet wird für die Bestimmung des Vorhandenseins einer Markierung durch Subtraktion zumindest von Teilen der elektrischen Signale, die durch den ersten Empfänger hergestellt wurden, von Signalen, die durch den zweiten Empfänger erzeugt werden, um Gleichtaktstörungen oder sonstige unerwünschte Signaleigenschaften in dem zusammengesetzten elektrischen Signal zu reduzieren, und daß Darstellungen des genannten ersten und zweiten zusammengesetzten Signals des Vorhandenseins einer Markierung in bezug zueinander durch Vergleich überprüft werden, um Unterschiede zwischen diesen festzustellen, und daß solche Unterschiede bei einer darauffolgenden Bestimmung des Vorhandenseins einer Markierung berücksichtigt werden.

2. Verfahren nach Anspruch 1, wonach das genannte erste zusammengesetzte elektrische Signal erzeugt wird durch Summieren zumindest von Teilen der durch den ersten und den zweiten Empfänger erzeugten Signale.

3. Verfahren nach Anspruch 1, wonach erstes zusammengesetztes Signal des Vorhandenseins einer Markierung auf mindestens zwei verschiedenen Punkten während der periodischen Wechsel abgefragt wird und Darstellungen einer jeden Signalabfrage durch Vergleich überprüft werden mit Signalen, die für das zweite zusammengesetzte Signal des Vorhandenseins einer Markierung kennzeichnend sind, um daraus gegenseitig repräsentative Signale zu erzeugen, und wobei die sich ergebenden gegenseitig repräsentativen Signale bei der Bestimmung des Vorhandenseins einer Markierung im Abfragefeld als Signale des Vorhandenseins einer Markierung verwendet werden.

4. Verfahren nach Anspruch 2, wonach Darstellungen von Abfragungen des genannten ersten zusammengesetzten Signals vergleichsweise überprüft werden, wobei genannte Abfragungen dazu dienen, um den Wert einer ersten Vergleichsbedingung festzulegen, unter Verwendung von Darstellungen des zweiten zusammengesetzten Signals zum Ändern eines Sollwertes für eine zweite Vergleichsbedingung, und wobei der geänderte Wert der zweiten Vergleichsbedingung mit dem Wert der ersten Vergleichsbedingung verglichen wird.

5. Verfahren nach Anspruch 4, wonach zumindest ein bestimmter Teil der Wechseleigenschaften des genannten Abfragefeldes periodisch verändert wird, und wobei man eine Darstellung des geänderten Wertes des Signals der zweiten Vergleichsbedingung erhält, zumindest für eine kurze Zeitdauer, in der solche periodischen Veränderungen der Wechseleigenschaften des Abfragefeldes überbrückt werden, wodurch eine Darstellung des abgeänderten Wertes beim Übergang auf die Wechseleigenschaften des geänderten Feldes vorhanden ist.

6. Verfahren nach Anspruch 1, wonach das zweite zusammengesetzte Signal des Vorhandenseins einer Markierung selektiv verarbeitet wird, um darin das Vorhandensein eines vorbestimmten Frequenzspektrums vor dem vergleichsweisen Überprüfen von Darstellungen der Signalabfragen mit Darstellungen von zweiten zusammengesetzten Signalen hervorzuheben.

7. Verfahren nach Anspruch 6, wonach ein Aufspürschwellenwert dynamisch verändert wird, in Übereinstimmung mit der relativen Größe des vorbestimmten Frequenzspektrums im zweiten zusammengesetzten Signal des Vorhandenseins einer Markierung, andere Periodenzahl-Kriterien verglichen werden, die im ersten zusammengesetzten Signal des Vorhandenseins einer Markierung an genannte sich ändernde Schwelle dargestellt sind, und wobei das Vorhandensein einer Markierung bestimmt wird als Ergebnis der anderen Periodenzahl-Kriterien, die den momentanen Wert der sich dynamisch ändernden Schwelle übersteigen.

8. Verfahren nach Anspruch 7, wonach wie bei anderen Periodenzahl-Kriterien eine Darstellung der Größe von Oberschwingungen höherer Ordnung der Grundfrequenz eines Wechsels des Abfragefeldes verwendet wird, ungefähr im Bereich zwischen der dreizehnten und fünfzehnten Oberschwingung.

9. Verfahren nach Anspruch 7, wonach wie bei der vorbestimmten Periodenzahl in erster Linie die dritte und die fünfte Oberschwingung der Grundwechselfrequenz des Abfragefeldes verwendet wird.

10. Verfahren nach Anspruch 7, wonach Signale, die für das erste zusammengesetzte Signal des Vorhandenseins einer Markierung kennzeichnend sind, an verschiedenen Stellen während der zyklischen Wechsel sequentiell abgefragt werden und die sich ergebenden Signalabfragungen verwendet werden beim Vergleichen von Kriterien, die für das erste zusammengesetzte Signal an die sich ändernde Schwelle kennzeichnend sind, durch die Durchführung einer Reihe von sequentiellen Vergleichen der Abfragungen mit der sich gerade ändernden Schwelle.

11. Verfahren nach Anspruch 10, wonach zumindest gewisse Signalabfragungen mit den sich ändernden Schwellenwerten getrennt verglichen werden, um getrennte Vergleichswerte zu erhalten, und zumindest gewisse getrennte Vergleichswerte über gewisse Intervallstufen zu summieren, um zusammengesetzte Vergleichswerte zu erhalten.

12. Verfahren nach Anspruch 11, wonach die sich ergebende Richtung zumindest von Teilen des magnetischen Flusses im Abfragefeld periodisch verändert wird und man eine Darstellung erhält des geänderten Wertes des sich ändernden

Bezugspunktes und der vor einem solchen periodischen Wechsel zumindest über einen vorbestimmten Zeitraum vorhanden war und welcher periodische Wechsel der Richtung des sich ergebenden Flusses überbrückt, wodurch eine Darstellung des geänderten Wertes an den Beginn der periode der geänderten Flußrichtung weitergeleitet wird.

13. Verfahren nach Anspruch 12, wonach eine Wiederholung des Abfragens, getrennten Vergleichens und Summierens über eine Vielzahl von aufeinanderfolgenden Zyklen von Wechseln des Abfragefeldes und sich ergebenden Zyklen der vom Empfänger erzeugten Signale durchgeführt wird und die aufeinanderfolgenden, sequentiellen, zusammengesetzten Vergleichswerte kumulativ summiert werden.

14. Verfahren nach Anspruch 13, wonach das Abfragefeld durch wechselnden elektrischen Erregerstrom bestimmt wird und die periodischen Veränderungen der sich ergebenden Richtung des Flusses im Feld kennzeichnend sind für eine Vielzahl von Wechselzyklen beim Erregerstrom in einem Zustand der ersten Phase, auf die eine weitere Vielzahl von Stromwechselzyklen in einem Zustand der zweiten Phase folgt, und wonach das Abfragen, getrennte Vergleichen, Summieren und kumulative Summieren synchron mit den Zyklen des wechselnden Erregerstroms in einem jeden Zustand der Phasen durchgeführt wird und die neue sich wiederholende Ablauffolge synchron mit den Veränderungen im Zustand einer Phase beim Erregerstrom beginnt.

15. Verfahren nach Anspruch 1, wonach ein erstes elektrisches Signal für die Bestimmung des Vorhandenseins einer Markierung erzeugt wird durch Abfragen von Darstellungen der vom Empfänger erzeugten Signale zu einem bestimmten Zeitpunkt während eines Zyklusses der Wechsel im Abfragefeld, wenn die Wahrscheinlichkeit gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal auftritt, wenn sich eine Markierung im Feld befände, und ein zweites elektrisches Signal für die Bestimmung des Vorhandenseins einer Markierung erzeugt wird durch Abfragen von Darstellungen der vom Empfänger erzeugten Signale zu einem anderen bestimmten Zeitpunkt während eines Zyklusses der Wechsel im Abfragefeld, wenn nicht die Wahrscheinlichkeit gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal auftritt, wenn sich eine Markierung im Feld befände, und das erste und das zweite elektrische Signal für die Bestimmung des Vorhandenseins einer Markierung verarbeitet wird, durch wiederholte Ausgleichsummierung von Darstellungen des ersten Signals unter Bezugnahme auf Darstellungen des zweiten Signals, und durch kumulatives Summieren der Ergebnisse der wiederholten Ausgleichsummierungen über mindestens mehrere Zyklen der durch den Empfänger erzeugten Signale, um dadurch einen unterschiedlichen Signalwert des Vorhandenseins einer Markierung zu erhalten, und wobei dieser unterschiedliche Signalwert des Vorhandenseins einer Markierung mit einem Bezugspunkt verglichen wird, um das Vorhandensein einer Markierungseinheit innerhalb des Feldes zu bestimmen.

16. Verfahren nach Anspruch 15, wonach mindestens eines der ersten und zweiten, für die Bestimmung des Vorhandenseins einer Markierung erzeugten elektrischen Signale mit einem Schwellenwert verglichen werden, der sich aus einem solchen Vergleich ergebende Signalwert verwendet wird als Darstellung eines des ersten und des zweiten elektrischen Signals in den genannten wiederholten Ausgleichsummierungen, deren Ergebnisse kumulativ summiert werden, um genannten unterschiedlichen Signalwert des Vorhandenseins einer Markierung zu erhalten.

17. Verfahren nach Anspruch 16, wonach genannter Schwellenwert von Zeit zu Zeit zwischen den Fällen des Vergleichens von mindestens einem der ersten und zweiten elektrischen Signale verändert wird, wobei der Sclhwellenwert abgeändert wird als eine Funktion der Periodenzahl zumindest gewisser durch einen Empfänger erzeugten Signale.

18. Verfahren nach Anspruch 17, wonach sowohl das erste als auch das zweite, für die Bestimmung des Vorhandenseins einer Markierung erzeugte elektrische Signal mit Schwellen verglichen wird, deren Werte unterschiedlich festgelegt werden als eine Funktion der Periodenzahl von Darstellungen von zumindest gewisser durch einen Empfänger erzeugten Signale, das Ergebnis des Vergleichs verwendet wird als Darstellungen des ersten und des zweiten elektrischen Signals in den wiederholten Ausgleichsummierungen, deren Ergebnisse kumulativ summiert werden. um genannten unterschiedlichen Signalwert des Vorhandenseins einer Markierung zu erhalten.

19. Verfahren nach Anspruch 16, wonach das Abfragen von Darstellungen der durch einen Empfänger erzeugten Signale zu einem Zeitpunkt während eines Zyklusses des Abfragefeldes, wenn die Wahrscheinlichkeit nicht gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal auftritt, über einen Zeitraum durchgeführt wird, der kleiner ist als ein Viertel des Zyklusses der Wechsel der Sollfrequenz des Abfragefeldes.

20. Verfahren nach Anspruch 17, wonach das Abfragen von Darstellungen der durch einen Empfänger erzeugten Signale zu einem Zeitpunkt während eines Zyklusses des Abfragefeldes, wenn die Wahrscheinlichkeit gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal auftritt, über einen Zeitraum durchgeführt wird, der genauso lang ist wie ein Viertel des Zyklusses der Wechsel der Sollfrequenz des Abfragefeldes.

21. Verfahren nach Anspruch 1, wonach das Subtrahieren von Signalen, die durch das erste und das zweite Empfangsmittel erzeugt werden, das Abziehen von zumindest Teilen der Signale, die durch ein Empfangsmittel verhältnismäßig weiter entfernt von einer Markierung innerhalb des Abfragefeldes erzeugt werden, von jenen Signalen umfaßt, die durch ein Empfangsmittel

verhältnismäßig näher bei einer Markierung erzeugt werden, wodurch zumindest teilweise Störgeräusche und/oder sonstige unerwünschte Effekte von den Empfangsmittelsignalen vor dem weiteren Verarbeiten aufgehoben werden.

22. Verfahren nach Anspruch 21, wonach das Abziehen das Subtrahieren von jenen Signalen umfaßt, die durch mindestens eines der Empfangsmittel erzeugt werden, wo mit Sicherheit Oberschwingungen niedrigerer Ordnung der Grundwechselfrequenz des Abfragefeldes gegeben sind, bevor Darstellungen von Signalen durch Vergleich überprüft werden.

23. Verfahren nach Anspruch 22, wonach weiters das Vorhandensein in den Signalen festgestellt wird, die erzeugt werden durch das genannte eine Empfangsmittel mit Oberschwingungen niedrigerer Ordnung der Grundfeldfrequenz, die sich während der Subtraktion von durch Nichtmarkierung erzeugten Oberschwingungen niedrigerer Ordnung durch von Markierungen ausgelösten Feldstörungen ergeben.

24. Verfahren nach Anspruch 1, wonach ein Alarmblockiersignal erzeugt wird, zumindest teilweise dadurch, daß Darstellungen mindestens gewisser Teiler des zweiten zusammengesetzten Signals einer für die Periodenzahl kennzeichnenden Integration unterworfen werden, das resultierende Integrationssignal mit anderen Darstellungen der durch einen Empfänger erzeugten Signale auf solche Weise eingeschränkt verglichen wird, daß je größer das Alarmblockiersignal ist, umso größer die anderen Darstellungen der durch einen Empfänger erzeugten Signale sein müssen, um die Anzeige des Vorhandenseins einer Markierung innerhalb des Abfragefeldes zu bewirken.

25. Verfahren nach Anspruch 24, wonach eine frequenzselektive Verstärkung jener Signale erfolgt, die für die Erzeugung des Alarmblockiersignals verwendet werden, und eine Spitzenintegration der resultierenden frequenzselektiven, verstärkten Signale ausgeführt wird.

26. Vorrichtung zum Aufspüren des Vorhandenseins einer einzelnen Markierungseinheit innerhalb eines elektromagnetischen Abfragewechselfeldes, das zwischen den in einem Abstand stehenden Seiten eines Eingangs angeordnet ist, wobei ein erstes und ein zweites Empfangsmittel von verschiedenen Positionen am Eingang in das Feld eintreten und jeder dieser Empfänger ein elektrisches Signal erzeugt, kennzeichnend für die Periodenzahl des Wechselfeldes zumindest in dem Bereich, wo der jeweilige Empfänger eintritt, dadurch gekennzeichnet, daß sie aus Mitteln 1A,1B besteht, zum Erzeugen eines ersten zusammengesetzten elektrischen Signals für die Bestimmung des Vorhandenseins einer Markierung, durch Verwendung von mindestens selektierten Teilen der durch ersten und zweiten Empfänger erzeugten elektrischen Signale, und zum Erzeugen eines zweiten zusammengesetzten elektrischen Signals für die Verwendung bei der Bestimmung des Vorhandenseins einer Markierung, indem bei den durch ersten und zweiten Empfänger erzeugten elektrischen Signalen unterschieden wird, weiters bestehend aus Mitteln 2,3,9, um Darstellungen des ersten und des zweiten zusammengesetzten Signals des Vorhandenseins einer Markierung in bezug zueinander durch Vergleich zu überprüfen, für die Bestimmung unterschiedlicher Eigenschaften zwischen diesen, und um diese Eigenschaften für die Bestimmung des Vorhandenseins einer Markierung innerhalb des Feldes zu verwenden.

27. Vorrichtung nach Anspruch 26, wonach genannte Mittel für die vergleichsweise Überprüfung des ersten und des zweiten zusammengesetzten Signals Komparatoreinrichtungen 18,22 umfassen, sowie Mittel 10, 12, 14, 16 zum Anpassen einer Darstellung des ersten Signals an die Komparatoreinrichtungen, um für den Vergleich einen ersten Wert festzulegen, und zum Anpassen einer Darstellung des zweiten zusammengesetzten Signals an die Komparatoreinrichtungen, um den anderen Wert für den Vergleich festzulegen, und wobei die Komparatoreinrichtungen derart arbeiten, daß sie den ersten Wert mit dem anderen Wert vergleichen.

28. Vorrichtung nach Anspruch 27, bestehend aus Mitteln 10,12 zum Abfragen des ersten zusammengesetzten Signals des Vorhandenseins einer Markierung an mindestens zwei verschiedenen Punkten während der zyklischen Wechsel, weiters aus Mitteln U-1, U—14 zum vergleichsweisen Überprüfen von Darstellungen einer jeden Signalabfrage mit Signalen, kennzeichnend für das zweite zusammengesetzte Signal des Vorhandenseins einer Markierung, um sich ergebende gegenseitig repräsentative Signale zu erzeugen, und aus Mitteln 30, 34, 28, 32 zum Bestimmen des Vorhandenseins einer Markierung innerhalb des Abfragefeldes als eine Funktion der sich ergebenden gegenseitig repräsentativen Signale.

29. Vorrichtung nach Anspruch 26, bestehend aus Mitteln 2, 3, 9 zum Verbinden von selektierten Eigenschaften der zwei durch einen Empfänger erzeugten elektrischen Signale, um ein Paar unterschiedlich aufgebauter Bestimmungssignale zu erzeugen, wobei ein erstes Bestimmungssignal in erster Linie die durch das Vorhandensein einer Markierung innerhalb des Feldes ausgelösten Frequenzen höherer Ordnung beinhaltet, und ein zweites Bestimmungssignal in erster Linie die Frequenzen niedrigerer Ordnung beinhaltet, aus Mitteln 30, 34 für die Verwendung des zweiten Bestimmungssignals zur dynamischen Abänderung eines Bezugswertes, aus Mitteln 28, 32 für das Vergleichen des ersten Bestimmungssignals mit dem dynamisch abgeänderten Bezugswert, und aus Mitteln 28, 29 für das Auslösen eines Indikators zumindest teilweise als Reaktion auf das Ergebnis des Vergleichs.

30. Vorrichtung nach Anspruch 29, bestehend aus Mitteln 14, 16 zum Abfragen von Signalen, die kennzeichnend sind für das erste Bestimmungssignal an verschiedenen Stellen während der zyklischen Wechsel des ersten Bestimmungssignals, und Mittel U-1, U—14 für das Vergleichen dieser Signalabfragen an den sich ändernden Bezugs-

wert durch das Ausführen von sequentiellen Vergleichen der Abfragungen mit dem sich ändernden Bezugswert.

31. Vorrichtung nach Anspruch 30, bestehend aus Mitteln für das getrennte Vergleichen von zumindest gewissen Signalabfragungen mit dem sich ändernden Bezugswert, um getrennte Vergleichswerte zu erhalten, und aus Mitteln für das Summieren von zumindest gewissen getrennten Vergleichswerten über bestimmte Zeitstufen, um zusammengesetzte Vergleichswerte zu erhalten.

32. Vorrichtung nach Anspruch 31, wobei zumindest gewisse Wechseleigenschaften des Abfragefeldes periodisch geändert werden, und bestehend aus Mitteln für das Erhalten einer Darstellung des abgeänderten Wertes des sich ändernden Bezugspunktes, der unmittelbar vor einem periodischen Wechsel im Abfragefeld gegeben ist, mindestens über einen vorbestimmten Zeitraum, in dem derartige periodische Veränderungen der Wechseleigenschaften des Abfragefeldes überbrückt werden, wodurch eine Darstellung des abgeänderten Wertes an den Beginn der Periode der veränderten Wechseleigenschaften geleitet wird.

33. Vorrichtung nach Anspruch 31. bestehend aus Mitteln zum wiederholten und sequentiellen Abfragen, getrennten Vergleichen und Summieren der getrennten Vergleichswerte über eine Vielzahl von aufeinanderfolgenden Zyklen von Wechseln des Abfragefeldes und entsprechenden Zyklen der durch einen Empfänger erzeugten Signale, und zum kumulativen Summieren der aufeinanderfolgenden, sequentiellen, zusammengesetzten Vergleichswerte.

34. Vorrichtung nach Anspruch 33, wobei die sich ergebende Richtung des Flusses im elektromagnetischen Abfragefeld periodisch verändert wird, und bestehend aus Mitteln für den periodischen Beginn von neuen sich wiederholenden Abläufen des Abfragens, getrennten Vergleichens, Summierens und kumulativen Summierens aufeinanderfolgender, sequentieller, zusammengesetzter Vergleichswerte, synchron mit den periodischen Veränderungen der Flußrichtung des Abfragefeldes.

35. Vorrichtung nach Anspruch 26, bestehend aus Mitteln zum Erzeugen eines ersten elektrischen Signals für die Bestimmung des Vorhandenseins einer Markierung durch Abfragen von Darstellungen der durch einen Empfänger erzeugten Signale zu einem bestimmten Zeitpunkt während eines Zyklusses der Wechsel des Abfragefeldes, wenn die Wahrscheinlichkeit gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal vorhanden ist, wenn eine Markierung sich innerhalb des Feldes befände, weiters bestehend aus Mitteln zum Erzeugen eines zweiten elektrischen Signals für die Bestimmung des Vorhandenseins einer Markierung durch Abfragen von Darstellungen der durch einen Empfänger erzeugten Signale zu einem anderen bestimmten Zeitpunkt während eines Zyklusses der Wechsel des Abfragefeldes, wenn nicht die Wahrscheinlichkeit gegeben wäre, daß ein durch eine Markierung ausgelöstes Kennsignal auftritt, wenn eine Markierung sich innerhalb des Feldes befände, weiters bestehend aus Mitteln zum Verarbeiten des ersten und des zweiten für die Bestimmung des Vorhandenseins einer Markierung erzeugten elektrischen Signals durch wiederholte Ausgleichsummierungen von Darstellungen des ersten Signals in bezug auf Darstellungen des zweiten Signals, sowie durch kumulatives Summieren der Ergebnisse der wiederholten Ausgleichsummierungen, über mindestens mehrere Zyklen der durch einen Empfänger erzeugten Signale, um dadurch einen sich ändernden Signalwert des Vorhandenseins einer Markierung zu erhalten, und bestehend aus Mitteln zum Vergleichen des wechselnden Signalwertes des Vorhandenseins einer Markierung mit einem Bezugspunkt, um das Vorhandensein einer Markierungseinheit innerhalb des Feldes zu bestimmen.

36. Vorrichtung nach Anspruch 26, bestehend aus Mitteln zum Erzeugen eines Alarmblockiersignals zumindest teilweise dadurch, daß Darstellungen zumindest gewisser durch einen Empfänger erzeugten Signale einer Periodenzahl-repräsentativen Integration unterworfen werden, und das resultierende Integrationssignal mit anderen Darstellungen der durch einen Empfänger erzeugten Signale derart ausgleichend summiert wird, daß je größer das Alarmblockierintegrationssignal ist, umso größer die anderen Darstellungen der durch einen Empfänger erzeugten Signale sein müssen, um eine Anzeige des Vorhandenseins einer Markierung innerhalb des Abfragefeldes zu bewirken.

37. Vorrichtung nach Anspruch 36, bestehend aus Mitteln für die Spitzenintegration der periodenzahlrepräsentativen Signale.

Revendications

1. Procédé pour détecter la présence d'un élément marqueur particulier à l'intérieur d'un champ électromagnétique alterné d'interrogation établi entre les côtés d'un portique, ledit champ électromagnétique étant surveillé par au moins un premier et un second moyen récepteur disposés chacun pour accéder au champ à partir d'une position différente par rapport aux côtés du portique précité afin de détecter la présence d'indices d'un signal provoqué par un tel marqueur en réponse aux alternances du champ et lesdits récepteurs fournissant chacun un signal électrique représentatif du contenu en fréquence du champ alterné, au moins dans la zone plus proche de ce récepteur, caractérisé: par la production d'un premier signal électrique composite pour une analyse de la présence d'un marqueur en utilisant au moins des portions choisies desdits signaux électriques produits par le premier et le second récepteur susdits pour augmenter la sensibilité de la détection; par la production d'un second signal électrique composite pour une utilisation dans une analyse de la présence d'un marqueur en soustrayant au moins des portions desdits signaux électriques, produits par le pre-

mier récepteur précité, des signaux produits par le second récepteur précité pour réduire le bruit de mode commun ou d'autres caractéristiques inopportunes de signal dans ce signal électrique composite; par l'examen comparatif des représentations du premier et du second signal composites susdits de présence d'un marqueur, l'un par rapport à l'autre, pour déterminer des différences entre eux; et par l'utilisation de telles différences dans la détermination subséquente de la présence d'un marqueur;

2. Procédé suivant la revendication 1, caractérisé en ce qu'il comporte la production dudit premier signal électrique composite en additionnant au moins des portions des signaux précités produits par le premier et le second récepteur précités.

3. Procédé suivant la revendication 1, caractérisé en ce qu'il comporte un échantillonnage du premier signal composite susdit de la présence d'un marqueur en au moins deux points différents pendant ses alternances cycliques, un examen comparatif des représentations de chaque échantillon de signal avec les signaux représentatifs dudit second signal composite de la présence d'un marqueur pour produire des signaux résultants réciproquement représentatifs, et l'utilisation desdits signaux résultants réciproquement représentatifs comme signaux de la présence d'un marqueur pour déterminer la présence d'un marqueur à l'intérieur du champ d'interrogation.

4. Procédé suivant la revendication 2, caractérisé en ce qu'il comporte un examen comparatif des représentations des échantillons précités du premier signal composite susdit en utilisant lesdits échantillons pour régler la valeur d'une première condition de comparaison, l'utilisation de représentations du second signal composite pour changer une valeur nominale pour une seconde condition de comparaison, et la comparaison de la valeur changée de ladite seconde condition de comparaison avec la valeur susdite de la première condition de comparaison précitée.

5. Procédé suivant la revendication 4, caractérisé en ce qu'il comporte le changement périodique d'au moins certaines des caractéristiques d'alternance du champ d'interrogation précité, et la conservation d' une représentation de la valeur changée du signal susdit de la seconde condition de comparaison pour au moins un court intervalle faisant la soudure entre de tels changements périodiques des caractéristiques d'alternance du champ d'interrogation, une représentation de ladite valeur changée étant présente au début des caractéristiques changées de l'alternance du champ.

6. Procédé suivant la revendication 1, caractérisé en ce qu'il comporte le traitement sélectif du second signal composite susdit de la présence d'un marqueur pour y amplifier la présence d'un spectre prédéterminé de fréquence avant l'étape susdite de l'examen comparatif des représentations desdits échantillons de signal avec des représentations des seconds signaux composites susdits.

7. Procédé suivant la revendication 6, caractérisé en ce qu'il comporte la variation dynamique d'un seuil de détection conformément à la valeur relative dudit spectre prédéterminé de fréquence présent dans le second signal composite susdit de la présence d'un marqueur, la comparaison d'autres critères de contenu en fréquence représentés dans ledit premier signal composite de la présence d'un marqueur avec le seuil variable précité, et la détermination de la présence d'un marqueur par suite desdits autres critères de contenu en fréquence dépassant la valeur instantannée du seuil susdit dynamiquement variable.

8. Procédé suivant la revendication 7, caractérisé en ce qu'il comporte l'utilisation, comme autres critères susdits de contenu en fréquence, d'une représentation de la valeur d'harmoniques d'ordre supérieur de la fréquence fondamentale de l'alternance pour le champ d'interrogation, dans la gamme d'environ leur treizième à leur quinzième harmonique.

9. Procédé suivant la revendication 7, caractérisé en ce qu'il comporte l'utilisation, comme contenu prédéterminé précité de fréquence, principalement de la troisième et la cinquième harmonique de la fréquence fondamentale d'alternance pour le champ précité d'interrogation.

10. Procédé suivant la revendication 7, caractérisé en ce qu'il comporte l'échantillonnage séquentiel de signaux qui sont représentatifs du premier signal composite susdit de la présence d'un marqueur en différents points pendant ses alternances cycliques et l' utilisation des échantillonnages résultants du signal dans l'étape précitée de la comparaison des critères représentatifs d' un tel premier signal composite avec le seuil variable précité en effectuantune série de comparaisons séquentielles des échantillonnages avec le seuil variant instantannément.

11. Procédé suivant la revendication 10, caractérisé en ce qu'il comporte la comparaison séparée d'au moins certains desdits échantillonnages de signal avec les valeurs variables de seuil pour produire des valeurs séparées de comparaison, et l'addition d'au moins certaines desdites valeurs séparées de comparaison sur certains incréments de temps pour produire des valeurs composites de comparaison.

12. Procédé suivant la revendication 11, caractérisé en ce qu'il comporte le changement périodique de la direction résultante d'au moins des portions du flux magnétique dans le champ d'interrogation précité, et la conservation d'une représentation de la valeur variée de la référence variable susdite qui était présente avant un tel changement périodique pour au moins un intervalle prédéterminé faisant la soudure entre de tels changements périodiques de direction du flux résultante, une représentation de la valeur variée étant reportée au début de la période d'une direction de flux changée.

13. Procédé suivant la revendication 12, caractérisé en ce qu'il comporte l'exécution d'une séquence à répétition desdites étapes d'échantil-

lonnage, de comparaison séparée et d'addition sur une multitude de cycles successifs d'alternance du champ d'interrogation et de cycles résultant des signaux produits par un récepteur, et l'addition cumulative des successives valeurs séquentielles et composites de la comparaison.

14. Procédé suivant la revendication 13, caractérisé en ce que le champ d'interrogation susdit est établi par des courants électriques alternés d'excitation et lesdits changements périodiques dans la direction résultante du flux dans le champ précité sont représentatifs d'une multitude de cycles d'alternance des courants d'excitation précités dans une première condition de phase suivie par une autre multitude de cycles d'alternance de courant dans une seconde condition de phase et en ce que les étapes susdites d'échantillonnage, de comparaison séparée, d'addition et d'addition cumulative sont exécutées en synchronisme avec les cycles susdits du courant alterné d'excitation dans chacune des conditions de phase susdites, et les nouvelles séquences à répétition susdites sont commencées en synchronisme avec lesdits changements dans une condition de phase des courants d'excitation précités.

15. Procédé suivant la revendication 1, caractérisé en ce qu'il comprend la production d'un premier signal électrique pour une analyse de la présence d'un marqueur par un échantillonnage de représentations des signaux produits par le récepteur à un moment particulier pendant un cycle des alternances du champ d'interrogation lorsque des indices d'un signal provoqué par un marqueur devraient vraisemblablement apparaître si un marqueur était à l'intérieur du champ; la production d'un second signal électrique pour une analyse de la présence d'un marqueur par un échantillonnage de représentations des signaux produits par le récepteur à un moment particulier différent pendant un cycle des alternances du champ d'interrogation, lorsque des indices d'un signal provoqué par un marqueur ne devraient vraisemblablement pas apparaître si un marqueur était à l'intérieur du champ; le traitement du premier et du second signal électrique susdits produits pour une analyse de la présence d'un marqueur par des sommations différentielles répétées de représentations du premier signal de ce genre par rapport à des représentations du second signal de ce genre, et en additionnant de manière cumulative les résultats desdites sommations différentielles répétées sur au moins quelques cycles des signaux produits par le récepteur, pour produire par ce moyen une valeur variable de signal de la présence d'un marqueur; et la comparaison de ladite valeur variable du signal de la présence d'un marqueur avec une référence afin de déterminer la présence d'un élément marqueur à l'intérieur du champ précité.

16. Procédé suivant la revendication 15, caractérisé en ce qu'il comprend la comparaison d'au moins un parmi le premier et le second signal électrique précités, produits pour une analyse de la présence d'un marqueur, avec une valeur de seuil et l'utilisation de la valeur de signal résultante de la comparaison comme étant ladite représentation de celui susdit parmi le premier et le second signal électrique dans les sommations différentielles répétées susdites dont les résultats sont additionnés de manière cumulative pour produire la valeur variable précitée d'un signal de la présence d'un marqueur.

17. Procédé suivant la revendication 16, caractérisé en ce qu'il comprend la variation de temps à autre de la valeur de seuil précitée, entre les cas de ladite comparaison avec cela d'au moins celui susdit parmi le premier et le second signal électrique susdits, ledit seuil étant changé en fonction du contenu en fréquence d'au moins certains des signaux produits par le récepteur.

18. Procédé suivant la revendication 17, caractérisé en ce qu'il comprend la comparaison des deux, le premier et le second, signaux électriques, produits pour une analyse de la présence d'un marqueur, avec des seuils dont les valeurs sont variablement réglées en fonction du contenu en fréquence des représentations d'au moins certains desdits signaux produits par un récepteur et l'utilisation du résultat de ladite comparaison comme étant les représentations précitées du premier et du second signal électrique susdits dans les sommations différentielles répétées précitées dont les résultats sont additionnés de manière cumulative pour produire la valeur variable susdite d'un signal de la présence d'un marqueur.

19. Procédé suivant la revendication 16, caractérisé en ce que l'échantillonnage susdit de représentations des signaux produits par un récepteur, à un moment pendant un cycle du champ d'interrogation lorsque des indices de signal induit par un marqueur ne devraient vraisemblablement pas apparaître, est effectué pour un intervalle plus court qu'un quart de cycle des alternances de la fréquence nominale du champ d'interrogation.

20. Procédé suivant la revendication 17, caractérisé en ce que l'échantillonnage susdit de représentations des signaux produits par un récepteur, à un moment pendant un cycle du champ d'interrogation lorsque des indices de signal induits par un marquer devraient vraisemblablement apparaître, est effectué pour un intervalle qui est de l'ordre de la même durée de temps qu'un quart de cycle des alternances de la fréquence nominale du champ d'interrogation.

21. Procédé suivant la revendication 1, caractérisé en ce que la soustraction de signaux produits par le premier et le second moyen récepteur précités comporte la soustraction d'au moins des portions des signaux, produits par un moyen récepteur relativement plus éloigné d'un marqueur à l'intérieur du champ d'interrogation, des signaux produits par un moyen récepteur qui est relativement plus près de ce marqueur, le bruit ambiant et/ou d'autres effets non souhaités s'éliminant, au moins partiellement par ce moyen, des signaux du moyen récepteur avant un traitement ultérieur de ceux-ci.

22. Procédé suivant la revendication 21,

caractérisé en ce que ladite soustraction comporte l'opération de soustraire des signaux produits par au moins un des moyens récepteurs susdits, certaines des harmoniques d'ordre inférieur de la fréquence fondamentale de l'alternance du champ d'interrogation avant l'étape précitée de l'examen comparatif des représentations de signaux.

23. Procédé suivant la revendication 22, caractérisé en ce qu'il comprend en outre la conservation de la présence dans lesdits signaux, produits par le moyen récepteur susdit, d'harmoniques d'ordre inférieur de la fréquence fondamentale du champ résultant de parasites du champ provoqués par un marqueur, en soustrayant des harmoniques d'ordre inférieur produits par une causation de marqueur absent.

24. Procédé suivant la revendication 1, caractérisé en ce qu'il comporte la production d'un signal pour le blocage d'une alarme, au moins en partie, en soumettant des représentations d'au moins un certain signal dudit second signal composite à une intégration représentative du contenu en fréquence, et la comparaison conditionnelle du signal résultant de l'intégration avec d'autres représentations des signaux produits par le récepteur d'une manière telle que, plus grande est la valeur du signal d'interrogation précité pour le blocage d'une alarme, plus grande doit être la valeur des autres représentations précitées des signaux produits par le récepteur pour provoquer une indication de la présence d'un marqueur à l'intérieur du champ d'interrogation.

25. Procédé suivant la revendication 24, caractérisé en ce qu'il comporte l'exécution d'une amplification sélective en fréquence des signaux utilisés pour produire ledit signal de blocage d'une alarme, et l'exécution d'une intégration de crête des signaux résultants amplifiés et sélectifs en fréquence.

26. Dispositif pour détecter la présence d'un élément marqueur particulier à l'intérieur d'un champ électromagnétique alterné d'interrogation établi entre les côtés espacés d'un portique, le premier et le second moyen récepteur accédant au champ depuis différentes positions sur ledit portique et chaque récepteur semblable produisant un signal électrique qui est représentatif du contenu en fréquence du champ alterné au moins dans la zone accédée par ce récepteur respectif, caractérisé par: des moyens (1A, IB) pour produire un premier signal électrique composite, pour une analyse de la présence d'un marqueur par une utilisation d'au moins des portions choisies desdits signaux électriques produits par le premier et le second récepteur susdits, et pour produire un second signal électrique composite pour une utilisation dans une analyse de la présence d'un marqueur en différenciant lesdits signaux électriques produits par le premier et le second récepteur susdits; et des moyens (2, 3, 9) pour examiner comparativement des représentations du premier et du second signal composite précités de la présence d'un marqueur l'un par rapport à l'autre afin de déterminer des caractéristiques de différence entre eux, et pour utiliser de telles caractéristiques afin de déterminer la présence d'un marqueur semblable à l'intérieur du champ précité.

27. Dispositif suivant la revendication 26, caractérisé en ce que lesdits moyens pour examiner comparativement le premier et le second signal composite susdits comportent un dispositif comparateur électronique (18, 22) et des moyens (10, 12, 14, 16) pour appliquer une représentation du premier signal audit dispositif comparateur afin de régler une première valeur pour une comparaison et pour appliquer une repésentation du second signal composite audit dispositif comparateur afin de régler l'autre valeur pour ladite comparaison, ledit dispositif comparateur étant adapté pour comparer la première valeur susdite à l'autre valeur précitée.

28. Dispositif suivant la revendication 27, caractérisé en ce qu'il comporte des moyens (10, 12) pour échantillonner ledit premier signal composite de la présence d'un marqueur à au moins deux différents points pendant ses alternances cycliques, des moyens (U-1, U—14) pour examiner comparativement des représentations de chaque échantillon semblable de signal avec des signaux représentatifs du second signal composite susdit de la présence d'un marqueur afin de produire des signaux résultants réciproquement représentatifs, et des moyens (30, 34, 28, 32) pour déterminer la présence d'un marqueur à l'intérieur du champ d'interrogation en fonction desdits signaux résultants réciproquement représentatifs.

29. Dispositif suivant la revendication 26, caractérisé en ce qu'il comprend des moyens (2, 3, 9) pour combiner des caractéristiques choisies des deux signaux électriques précités produits par le récepteur afin de produire deux signaux d'analyse constitués différemment, un premier signal d'analyse comportant principalement les fréquences d'ordre supérieur provoquées par la présence d'un marqueur à l'intérieur dudit champ et un second signal d'analyse comportant principalement les fréquences d'ordre inférieur; des moyens (30, 34) pour utiliser le second signal d'analyse susdit afin de varier dynamiquement une valeur de référence, des moyens (28, 32) pour comparer ledit premier signal d'analyse à ladite valeur de référence dynamiquement variable; et des moyens (28, 29) pour commander un indicateur, au moins partiellement en réponse au résultat de la comparaison susdite.

30. Dispositif suivant la revendication 29, caractérisé en ce qu'il comprend des moyens (14, 16) pour échantilloner des signaux qui sont représentatifs dudit premier signal d'analyse, en différents points, pendant les alternances cycliques dudit premier signal d'analyse et des moyens (U-1, U—14) pour comparer de tels échantillonnages de signal à ladite valeur variable de référence en effectuant des comparaisons séquentielles des échantillonnages avec ladite valeur variable de référence.

31. Dispositif suivant la revendication 30,

caractérisé en ce qu'il comporte des moyens pour comparer séparément au moins certains desdits échantillonnages de signal à la valeur variable de référence pour produire des valeurs séparées de comparaison, et des moyens pour additionner au moins certaines desdites valeurs séparées de comparaison sur certains incréments de temps pour produire des valeurs composites de comparaison.

32. Dispositif suivant la revendication 31, caractérisé en ce qu'au moins certaines des caractéristiques d'alternance dudit champ d'interrogation sont changées périodiquement, et en ce qu'il comporte des moyens pour conserver une représentation de la valeur variée de ladite référence variable présente juste avant un tel changement périodique du champ d'interrogation pour au moins un intervalle prédéterminé faisant la soudure entre ces changements périodioues des caractéristiques d'alternance pour le champ d'interrogation, une représentation de la valeur variée étant reportée au début de la période des caractéristiques changées de l'alternance.

33. Dispositif suivant la revendication 31, caractérisé en ce qu'il comporte des moyens pour échantillonner de manière répétitive et séquentiellement, pour comparer séparément et pour additionner lesdites valeurs séparées de comparaison sur une multitude de cycles successifs d'alternance du champ d'interrogation et sur des cycles correspondants des signaux produits par le récepteur, et pour additionner de manière cumulative les successives valeurs séquentielles et composites de comparaison.

34. Dispositif suivant la revendication 33, caractérisé en ce que la direction résultante du flux dans ledit champ électromagnétique d'interrogation est changé périodiquement et en ce qu'il comprend des moyens pour commencer périodiquement de nouvelles séquences à répétition desdits échantillonnage, comparaison séparée, addition et addition cumulative de successives valeurs séquentielles et composites de comparaison, en synchronisme avec les changements périodiques précités de la direction du flux dans le champ d'interrogation.

35. Dispositif suivant la revendication 26, caractérisé en ce qu'il comprend des moyens pour produire un premier signal électrique pour une analyse de la présence d'un marqueur en échantillonnant des représentations des signaux produit par un récepteur à un moment particulier pendant un cycle des alternances du champ d'interrogation lorsque les indices de signal provoqués par un marqueur devraient vraisemblablement être présents si un marqueur était à l'intérieur du champ; des moyens pour produire un second signal électrique pour une analyse de la présence d'un marqueur en échantillonnant des représentations des signaux produits par le récepteur à un moment particulier différent pendant un cycle des alternances du champ d'interrogation, lorsque des indices de signal provoqué par un marqueur ne devraient vraisemblablement pas apparaître si un marqueur était à l'intérieur du champ; des moyens pour traiter le premier et le second signal électrique susdits produits pour une analyse de la présence d'un marqueur par des additions différentielles répétées de représentations du premier signal par rapport aux représentations du second signal et en additionnant de manière cumulative les résultats desdites additions différentielles répétées, sur au moins quelques cycles des signaux produits par le récepteur ,pour produire de cette façon une valeur variable du signal de la présence d'un marqueur, et des moyens pour comparer ladite valeur variable du signal de la présence d'un marqueur à une référence afin de déterminer la présence d'un élément marqueur à l'intérieur dudit champ.

36. Dispositif suivant la revendication 26, caractérisé en ce qu'il comprend des moyens pour produire un signal de blocage d'une alarme au moins en partie en soumettant des représentations d'au moins certains des signaux produits par un récepteur à une intégration représentative du contenu en fréquence et en additionnant différentiellement le signal d'intégration résultant avec d'autres représentations des signaux produits par le récepteur d'une telle manière que plus grande est la valeur dudit signal d'intégration pour le blocage d'une alarme, plus grande doit être la valeur des autres représentations susdites de signaux produits par le récepteur pour provoquer une indication de la présence d'un marqueur à l'intérieur du champ d'interrogation.

37. Dispositif suivant la revendication 36, caractérisé en ce qu'il comprend des moyens pour une intégration de crête des signaux représentatifs du contenu en fréquence.

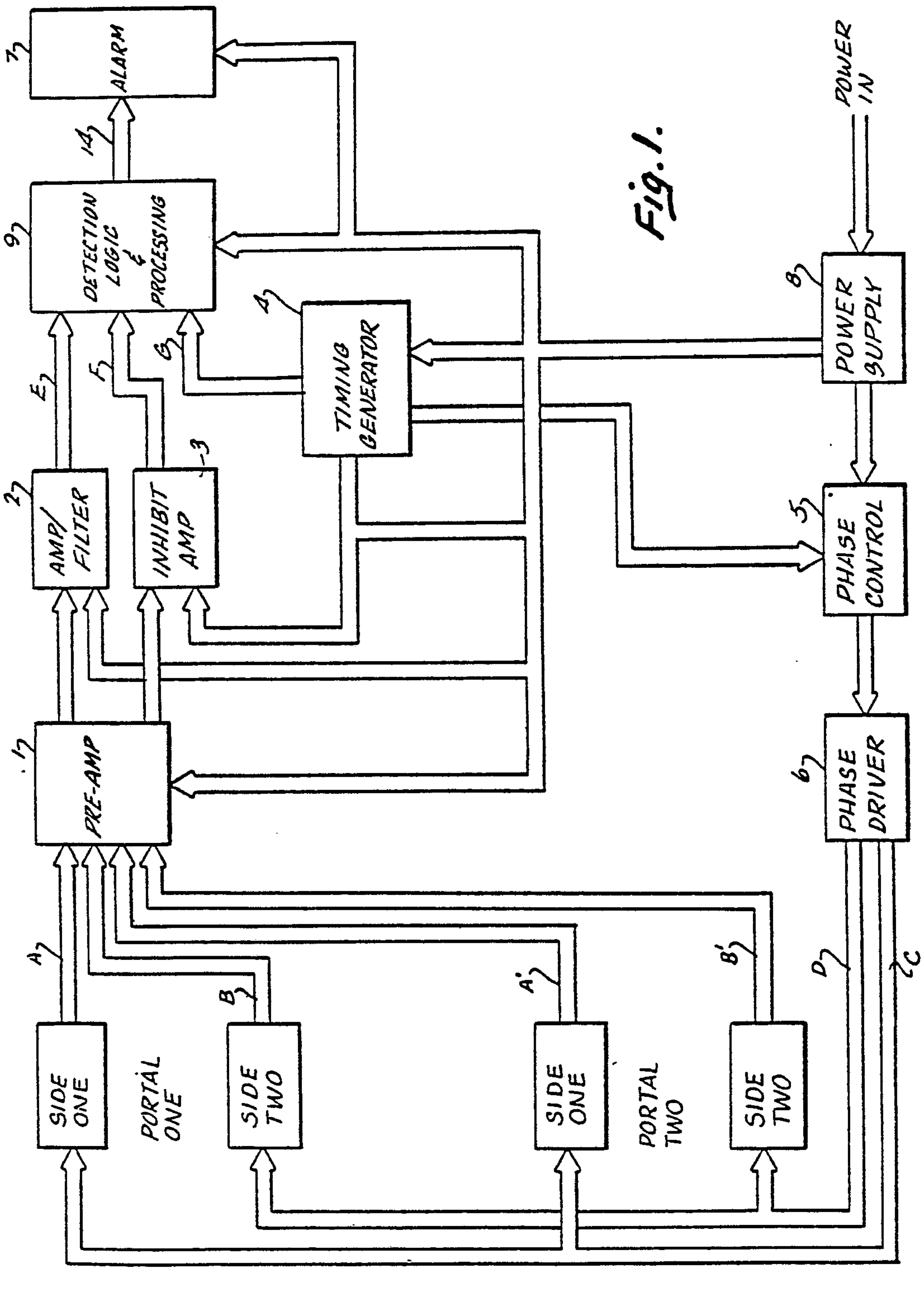

ALARM
DETECTION LOGIC & PROCESSING
TIMING GENERATOR
POWER SUPPLY
POWER IN
AMP/ FILTER
INHIBIT AMP
PRE-AMP
PHASE CONTROL
PHASE DRIVER
SIDE ONE
SIDE TWO
PORTAL ONE
SIDE ONE
SIDE TWO
PORTAL TWO

Fig. 1.

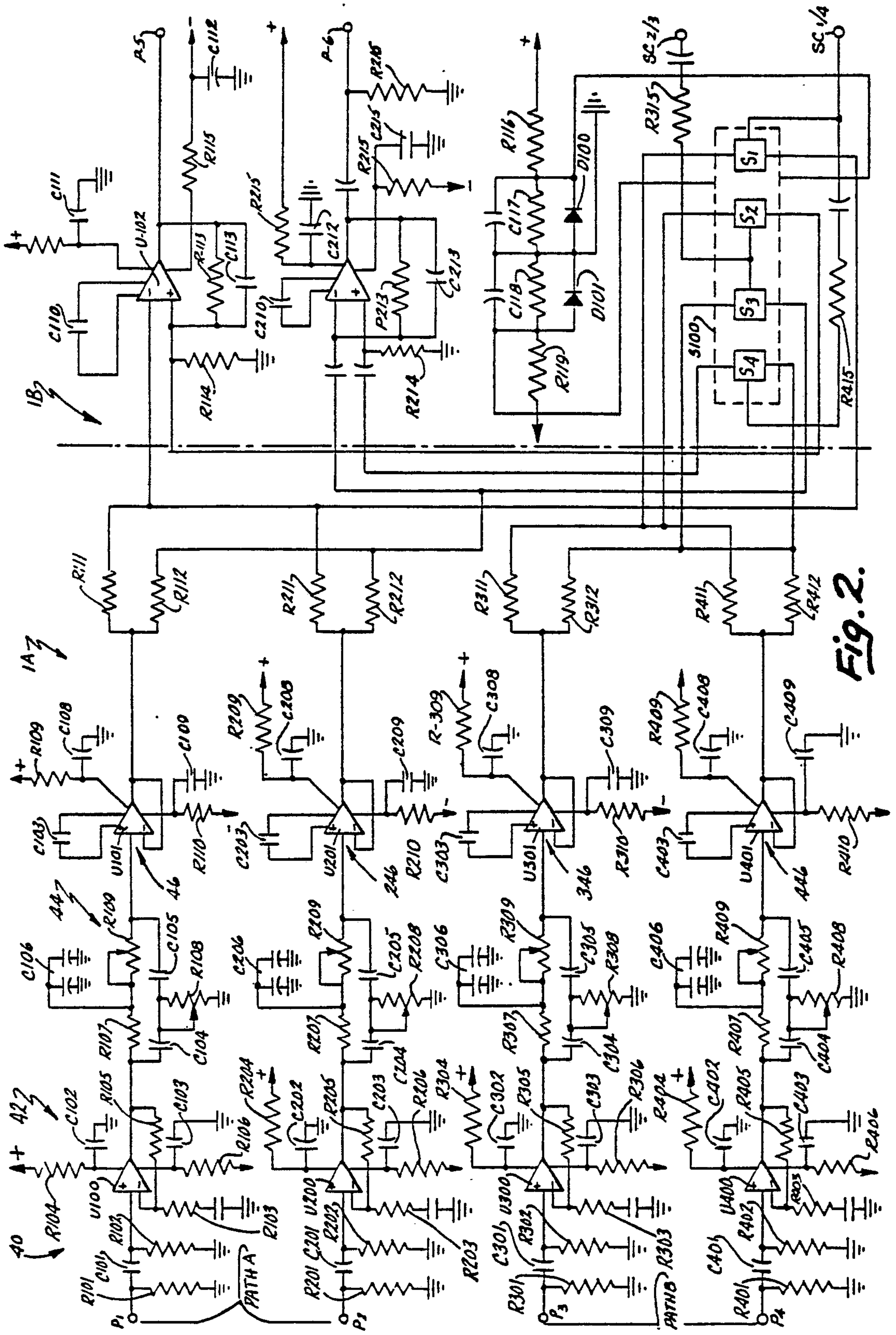
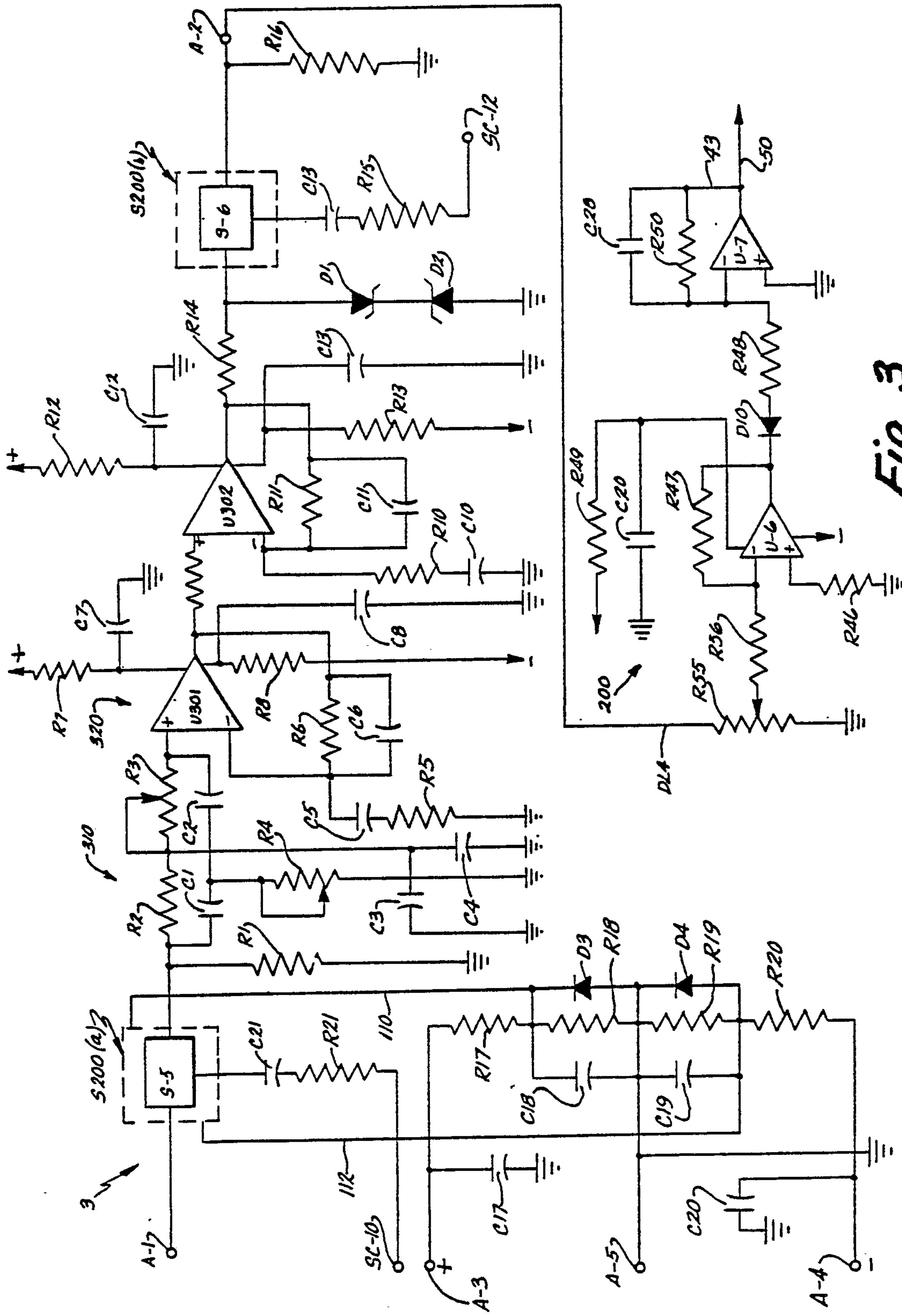

1A
1B
40
42
44
46
P1
P2
P3
P4
PATH A
PATH B
P-5
P-6
U100
U101
U-102
U200
U201
U300
U301
U400
U401
S1
S2
S3
S4
S100
SC 2/3
SC 1/4
D100
D101
R111
R112
R211
R212
R311
R312
R411
R412
R315
R415

Fig. 2.



A-1
A-2
A-3
A-4
A-5
SC-10
SC-12
S200(a)
S200(b)
S-5
S-6
U301
U302
U-6
U-7
310
320
200
110
112
DL4
43
50

Fig. 3.

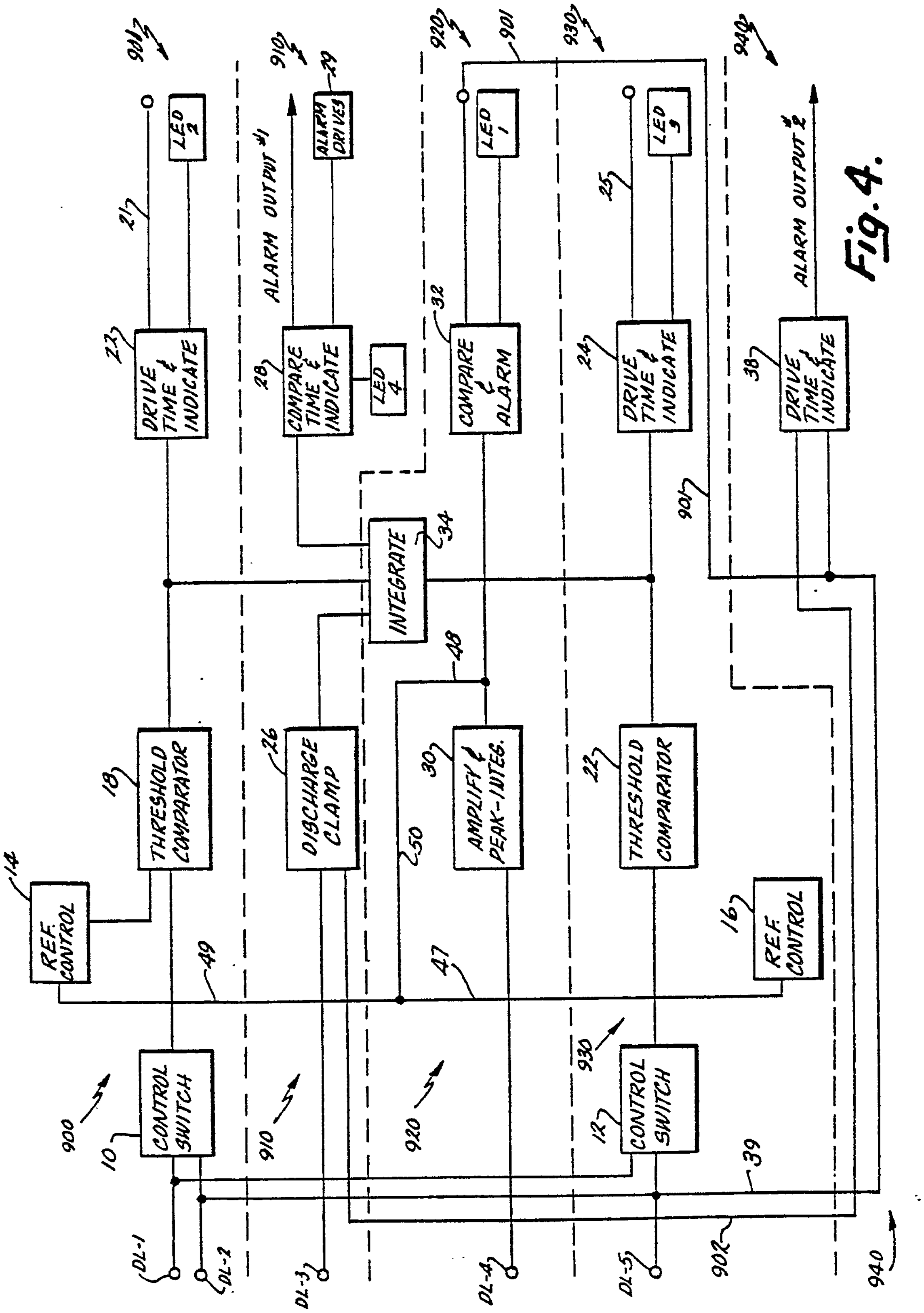

CONTROL SWITCH
REF. CONTROL
THRESHOLD COMPARATOR
DRIVE TIME & INDICATE
LED 2
DISCHARGE CLAMP
INTEGRATE
COMPARE TIME & INDICATE
LED 4
ALARM DRIVES
ALARM OUTPUT #1
AMPLIFY & PEAK-INTEG.
COMPARE & ALARM
LED 1
THRESHOLD COMPARATOR
DRIVE TIME & INDICATE
LED 3
CONTROL SWITCH
REF. CONTROL
DRIVE TIME & INDICATE
ALARM OUTPUT #2
DL-1
DL-2
DL-3
DL-4
DL-5

Fig. 4.

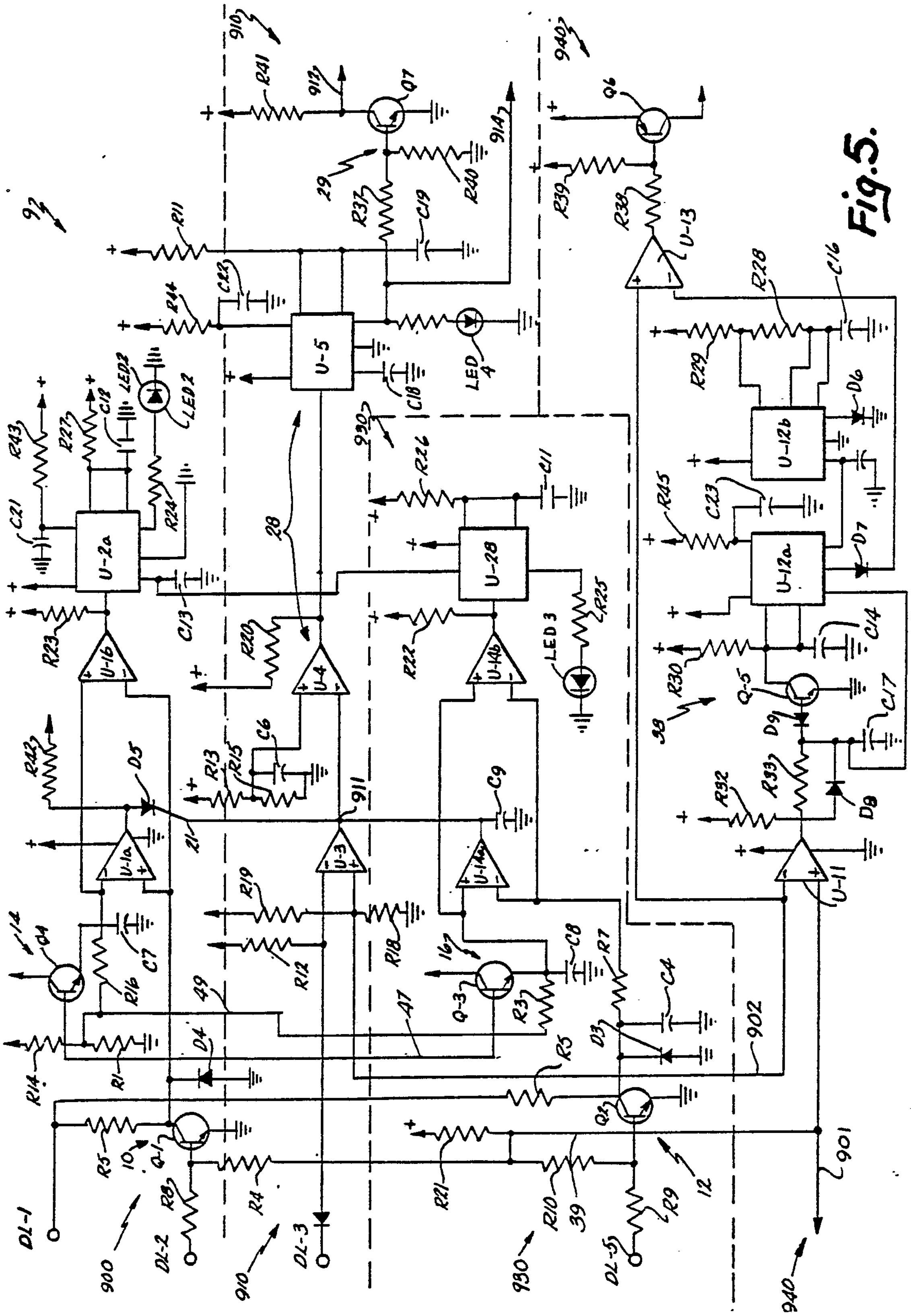

DL-1
DL-2
DL-3
DL-5
900
910
930
940
U-2a
U-5
U-4
U-3
U-1a
U-1b
U-28
U-14a
U-14b
U-11
U-12a
U-12b
U-13
Q7
Q6
Q4
Q-3
Q-5
LED 2
LED 3
LED 4
911
901
902

Fig.5.

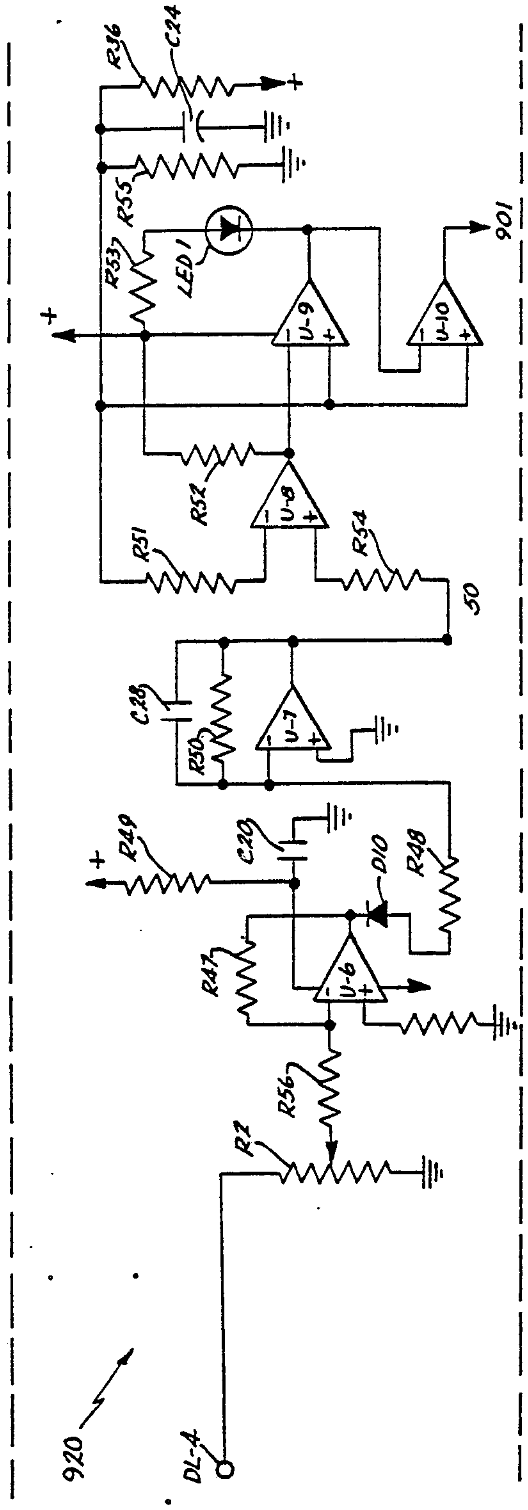

R36
C24
R55
R53
LED1
901
U-9
U-10
R52
U-8
R51
R54
50
C28
R50
U-7
R49
C20
D10
R48
R47
U-6
R56
920
DL-4

Fig. 6.