PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : G01V 3/10, 3/12, 3/38

A1

(11) International Publication Number: WO 90/00748

(43) International Publication Date: 25 January 1990 (25.01.90)

(21) International Application Number: PCT/AU89/00281

(22) International Filing Date: 28 June 1989 (28.06.89)

(30) Priority data:
PI 9234 11 July 1988 (11.07.88) AU

(71) Applicant *(for all designated States except US):* BAYLISS ELECTRONIC INDUSTRIES PTY. LTD. [AU/AU]; 16 Cottage Street, Blackburn, VIC 3130 (AU).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : THOMPSON, Brian, Kenneth [GB/AU]; 70 Narr Maen Drive, Croydon, VIC 3136 (AU).

(74) Agent: WATERMARK; 50 Queen Street, Melbourne, VIC 3000 (AU).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

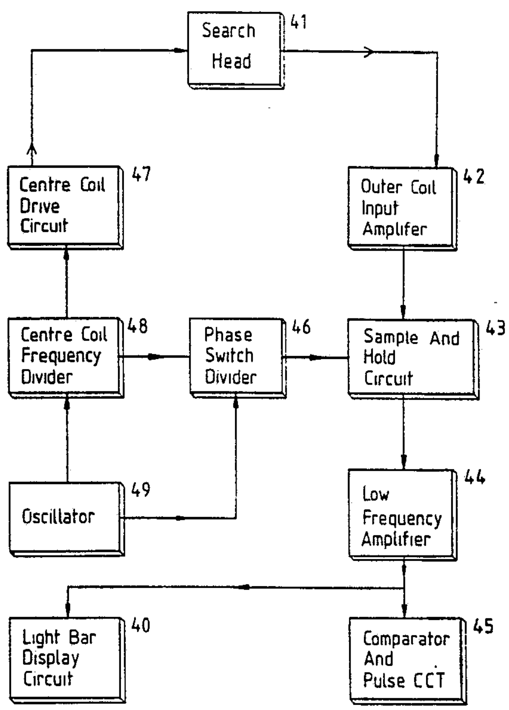
Published
With international search report.

(54) Title: METAL/MINERAL DETECTOR WITH RECEIVED SIGNAL SAMPLING

(57) Abstract

A detector for the detection of metal or mineral values having means (47, 48, 49, 41) for generating and transmitting a first signal, receiving means (41, 42) for receiving said first signal and detection means (44, 45) for analysing the received first signal to determine when said first signal has been influenced by a mineral in proximity to said detector; further comprising a sampling means (46, 43) adapted to present a portion only of said received first signal to said detection means (44, 45).

DETECTOR BLOCK DIAGRAM



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Fasso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	HU	Hungary	NO	Norway
BJ	Benin	IT	Italy	RO	Romania
BR	Brazil	JP	Japan	SD	Sudan
CA	Canada	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic			SN	Senegal
CG	Congo	KR	Republic of Korea	SU	Soviet Union
CH	Switzerland	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany, Federal Republic of	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		

METAL/MINERAL DETECTOR WITH RECEIVED SIGNAL SAMPLING

Field of Invention

The present invention relates to the field of detectors for use in detecting metal and/or other mineral values. Specifically, the present invention relates to metal detectors. More specifically, the present invention relates to metal detectors with coiled search heads or sensor means.

Prior Art

Metal detectors heretobefore comprise coiled search heads for sensing or detecting the presence of metals of a particular type. Typically, a quadrature phase detector circuit and an auto balance circuit, in combination, are used to analyse the heads RF output to reduce noise levels. The quadrature phase circuit "looks" at half the RF output waveform, a full 180 degree cycle of the coil waveform. If noise is present in this 180 degree cycle, it is passed on through the detectors circuitry. The reference source or clock means for the phase detector invariably comprises a standard R-C oscillator circuit means.

Terms used throughout this document

Herein 'sample & hold' is referred to as 'S/H', and refers to the type or function of circuitry.

Object of the Invention

An object of the present invention is to provide a metal detector in which noise present on the coil(s) signal is reduced or alleviated.

A further object of the present invention is to eliminate the need for an auto-balance circuit in a metal detector.

Still a further object of the present invention is to alleviate at least one of the disadvantages of prior art metal detectors.

Summary of Invention

The present invention provides a detector for the detection of metal or mineral values having transmission means for generating a signal, receiving means for receiving a returned signal and detection means for analysing the returned signal to determine whether said returned signal has been influenced by a mineral or metal in proximity to said detector, the improvement comprising a sampling means adapted to present a portion only of said returned signal to said detection means.

The present invention also provides a detector including the above improvement.

The metal or mineral value detector of the present invention includes a sampling means to reduce noise detected by the detector of the present invention. The sampling means is preferably a S/H means, switch means or a clock means, or a S/H and clock means in combination. The sampling means samples the coil voltage for a short portion of its cycle. Preferably, the coil voltage is sampled for 5 to 10% of its cycle, however this may vary dependent on the detectors application.

The sensor means is preferably adapted to be adjustable for the detection of various minerals or metals to the exclusion of others. However, multiple detections and analysis is hereby contemplated.

The present invention may also provide one or more low pass filter networks to improve noise reduction.

The present invention may reduce noise levels by keeping the residual "out of balance" voltage low.

The detector of the present invention may provide a further feature of adjustability of the clock means so that interference by another detector is alleviated. The detector, when operated in close proximity with another detector, may include adjustable clock means which can be locked and remain relatively fixed, e.g. digitally, to avoid or alleviate interference. A crystal oscillator may provide a stable oscillator for the clock means.

A preferred invention embodiment of the present invention will now be described with reference to the accompanying drawings, wherein:

Figure 1 shows a detector including a sample & hold means for sampling the signal provided by the sensor, and presently the sampled single (a portion of the sensor signal) for analysis and output.

Figure 2 shows a detector including a sample & hold means and clock means.

Figure 3 shows a detector including a clock means.

Figure 4 shows a preferred metal detector in accordance with the present invention in block diagram form.

Figure 5 shows a preferred S/H circuit for use with the present invention.

With reference to the figures, the metal or mineral detector includes a sensor means, which comprises a coiled search aperture, having at least two, preferably three coils therein. A single coil search head can be constructed using the present invention. The coil can be switched between a signal transmit mode and signal receive mode, after which the received signal can be analysed in accordance with the present invention. However, hereinafter, the description of the preferred embodiment will be made in relation to a metal detector comprising a three coiled search head or aperature (one transmitter coil and two receiver coils coupled in differential relationship), without limiting the scope of the present invention.

With reference to figures 1, 2 and 3, the first coil or centre coil thereof is driven by a first frequency, preferably a high frequency sine wave, and the other two outer coils of the preferred three coil aperture, are wound and connected so as to produce a net zero output voltage when no metal or other element is juxtaposed to or within the aperture.

When a metal or other element is positioned juxtaposed or within the aperture, the field generated by the first coil is disturbed and thereby alters the signal induced to the other outer coil. An induced output will appear across the other coil which is approximately sinusoidal, proportionate to the first coil signal, and at substantially the same frequency as the first coil signal or drive signal. Dependent upon the nature or type of metal or element within or juxtaposed the aperture, the phase relationship between the drive signal and the other coil(s) output may vary by about +/- 90 degrees.

The sampling means preferably in the form of a S/H means of the present invention as shown in figures 1 and 5, provides a means of converting the first frequency, preferably full cycle frequency, into a second or lower sampled potential by means of sampling the first frequency. As the second frequency is produced as a result of a relatively small or reduced sample of the first frequency, the probability or amount of noise possible in the second frequency is greatly reduced. The sampling means can take many different forms, as would be known to a skilled person. Basically, the sampling means samples the first frequency (signal produced by the search head). The sample is taken on the basis of a one or more "looks" or an instantaneous sample of the first frequency per cycle. This sample is then further processed by the detector of the present invention in order to indicate the presence (or absence) of a desired mineral or metal. In a preferred form, the S/H circuit samples 5 to 10 per cent of the search head signal. More or less of a sample can be taken dependent on the application of detection, and the desired (or tolerable) output noise level. The second frequency potential represents the substantially instantaneous voltage at any one or a series of point(s) in time with reference to the first coil drive or centre coil frequency. The second frequency may then be substantially amplified, and/or analysed and via a comparator, produce an output, preferably digital, that provides an indication of a detected state (e.g. the required type of mineral).

With reference to figure 4, in particular, the residual or disturbed signal from the search head 41 is amplified by amplifier 42. As a mineral is introduced into or juxtaposed the aperture in head 41, the amplitude and phase of the signal generated will depend on the nature of the mineral. The detector is capable of distinguishing between various effects so that an output is given should the phase of the signal be within certain limits but not given if it lies within other limits.

To achieve this, the signal may be first passed through a low pass filter (not shown) to remove frequency components higher than the primary drive frequency, then passed through a high pass filter (not shown) to remove power line associated interference.

The resultant signal is now ready for the sampling means in the form of a sample & hold circuit 43. Figure 5 shows a preferred form of S/H circuit which include a sampling switch means 50, and a hold capacitor 51 and (optionally) a buffer amplifier 52 and may further include resistive means 54, high frequency reduction means (not shown), low pass filter means (not shown) and/or other conventionally affilliated circuitry. The sampling means can also take the form of a simple switching means (above). In that case, an analogue switch or FET can "pass" (sample) a small portion of the first frequency for analysis by the retaining circuitry to indicate a desired mineral or metal. Many forms of apparatus and methods are known to the skilled person for sampling a signal. The present disclosure incorporates these alternatives. The switch means may take the form of an analogue switch which is normally in a high impedance state and switches to its' low impedance condition for a short period when an enabling signal is applied to the gate 55 [substantially somewhere between 20 to 40 degrees of the fundamental operating frequency] to sample the first frequency. The instantaneous or sampled voltage level present at the output of the sample switch of the S/H means is the applied (maybe via R3) to the hold capacitor 51. The voltage across capacitor 51 becomes equal to the instantaneous voltage at the input when the sample switch is enabled. Thus, a quiescent voltage is achieved which is representative of a metal free condition in or about the search aperture.

When mineral or metal is introduced into or juxtaposed the aperture, a signal is generated in the coil which is then impressed on the input of the sample & hold circuit 43. The voltage across the hold capacitor 51 will change accordingly giving an output proportional to the amount of the required mineral present in or about the aperture.

Should a mineral be passed through the search head that is considered "normal" and is not to be detected, no output will result. However, the mineral will produce a signal across the coil which will then appear at the input of the sample & hold circuit 43. To counter an output being given for a "normal" mineral, adjustment of the input requirement for the S/H may now be contemplated such that a trigger or level is registered, or flagged for a wanted or required metal or mineral.

A point in the cycle will exist that shows zero or almost zero change when the mineral or metal is passed through the aperture. A sample pulse when position at this point will allow the output to have almost no change when the material passes through the head. However, when a mineral passes through the aperture, a signal of different phase will be generated which produces an output into the buffer amplifier 52.

With reference to figure 5, a crystal oscillator 49 may provide timing reference so that any change or variation of timing will be alleviated, thereby avoiding a reduction in the performance of the detector.

A hybrid 50 MHz crystal oscillator may provide the stable reference frequency. Dividers 48 and 46 may be used to divide the reference frequency allowing separate bands of operation. The centre coil drive signal may be produced by dividing the reference frequency. A first divider may have its preset inputs switched and a second divider may have its inputs fixed or preset.

The counter counts up from the preset input to its maximum count at which time the output gates may load the counters with preset inputs. The cycle may repeat at twice the coil drive frequency. The counter output may be buffered.

A sample & hold drive may be generated in a similar manner but with counter's inputs being switchable. (A switch may be labelled the phase switch).

The preset inputs may be loaded by a signal which may be the output described previously, after it has been divided by 2. This may allow the counter to count up only during the positive half cycles of the coil drive. The output of the two counters is conventionally a substantially square wave of equal mark-space ratio which may be taken to a dual monostable vibrator. The resultant pulse may be used to co-operate with the sample & hold circuit 43.

The centre or first coil drive signal may be derived via an output from a counter and inputted to a dual monostable vibrator. One section thereof may produce a pulse time from the positive going transition of the input, the other section thereof may produce a pulse timed from the negative going transition of the input. The resultant pulse(s), spaced 180 degrees apart, may be used to drive bases of a transistor push-pull output stage 47. An output transformer may be tuned to the coil drive frequency thereby producing a sinusoidal waveform to be fed to the sensor coil(s).

The other or outer coil signal may be derived via the output of the coil taken to the primary of a transformer. Common mode signals may thereby be greatly reduced and the difference signal may be increased by the turns ratio of the transformer. The secondary of the transformer may be tuned to the coil drive frequency to reduce spurious signals at other frequencies. A differential wideband amplifier 42 may amplify the difference signal and this signal may then be filtered by a low pass filter (not shown) and may be capacitively coupled or otherwise into the sample & hold circuit 43 by a capacitive and/or resistive network.

The sample & hold circuit 43 may comprise a CMOS analogue switch as the sampling switch 50 and a hold capacitor 51. A resistor 54 may reduce the high frequency response of the system alleviating most of the switch transients. The sample & hold drive enabling signal can be applied to gate 55.

The output of the sample & hold circuit may then be buffered 52 and amplified 44. The amplifier stage(s) may be AC coupled, with or without feedback, to reduce the bandwidth. The output may be capacitively or otherwise coupled into a comparator and pulse circuit 45.

A comparator and pulse output circuit 45 may comprise the following. Attenuation by an auxiliary sensitivity switch and/or a sensitivity switch may provide control over the signal level into the comparator 45. The comparator may be connected so that one section has a positive reference voltage and the other section has a negative reference voltage. The input may be taken to the output of the sensitivity switch and the output(s) may be ORED. The comparator may give a negative output whenever the input signal exceeds either a given positive or negative value. The pulse output may then be processeed by either a manually reset bi-stable multivibrator or a monostable multivibrator, the output of which may drive either a relay, timer or other system.

A light bar display circuit 40 may be coupled to the amplifier 44 and comprise the following. The analogue input to the comparator circuit may be capacitively or otherwise coupled and full wave rectified to provide a unipolar signal into the input of a display driver, e.g. LED. Signals from within the individual rectifier loops may operate to either enable one side or the other of the light bar display. The indications provided by the light bar display may greatly facilitate setting up the detector by showing the level of the analogue signal with virtually no delay or time constant.

It is also contemplated within the scope of the present invention to provide a detector adapted to provide a device able to detect a spectrum of minerals or metals. Multi-coiled or multiple search heads can be provided on a detector, each of which is adjustable or tuned to detect minerals or metals of a particular type; so, two coils or search heads can detect two minerals. Each coil or search head can provide a signal which is indicative of a disturbed or interrupted field, and the detector can sample the signals (via the sampling means) and the further process of the signals. The display indication of minerals or metals detected can be formulated to show a spectrum of detections, somewhat similar to a conventional spectrum analyser output.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. In a detector for the detection of metal or mineral values having transmission means for generating a signal for transmission, receiving means for receiving a returned signal and detection means for analysing the returned signal to determine whether the return signal has been influenced by a mineral or metal in proximity to said detector, the improvement comprising a sampling means adapted to present a portion only of said returned signal to said detection means.

2. An improvement as claimed in claim 1, wherein the sampling means samples less than 40% of the returned signal.

3. An improvement as claimed in claim 1 or 2, wherein the sampling means comprises a switch.

4. An improvement as claimed in claim 1, 2 or 3, wherein the sampling means further comprises capacitive means coupled to the switch to form a sample and hold means.

5. An improvement as claimed in any one of claims 1 to 4, wherein the sampling means samples less than 10% of the returned signal.

6. A detector including the improvement as claimed in any one of claims 1 to 5.

7. A detector for detecting metal or mineral values comprising:

transmission means for generating a signal for transmission,

receiving means for receiving a returned signal,

detection means for analysing whether the returned signal has been influenced by a mineral or metal value in proximity to the detector, and

sampling means for sampling a portion only of the returned signal, the portion being for analysis by said detection means.

Fig .1.

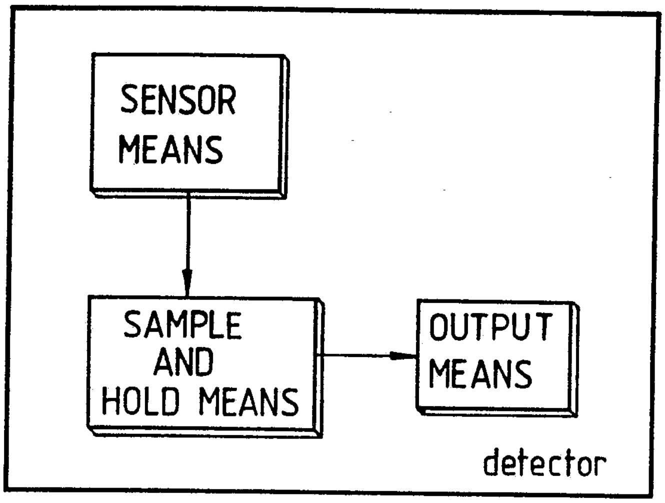


Fig .2.

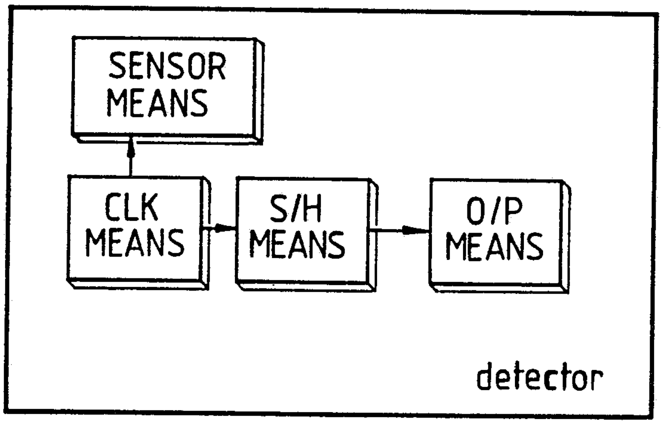


Fig .3.

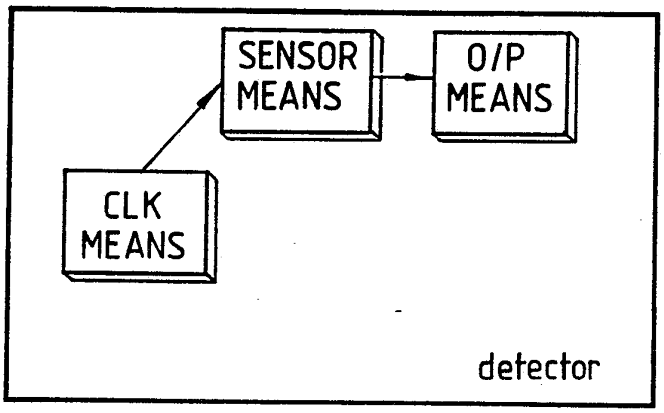
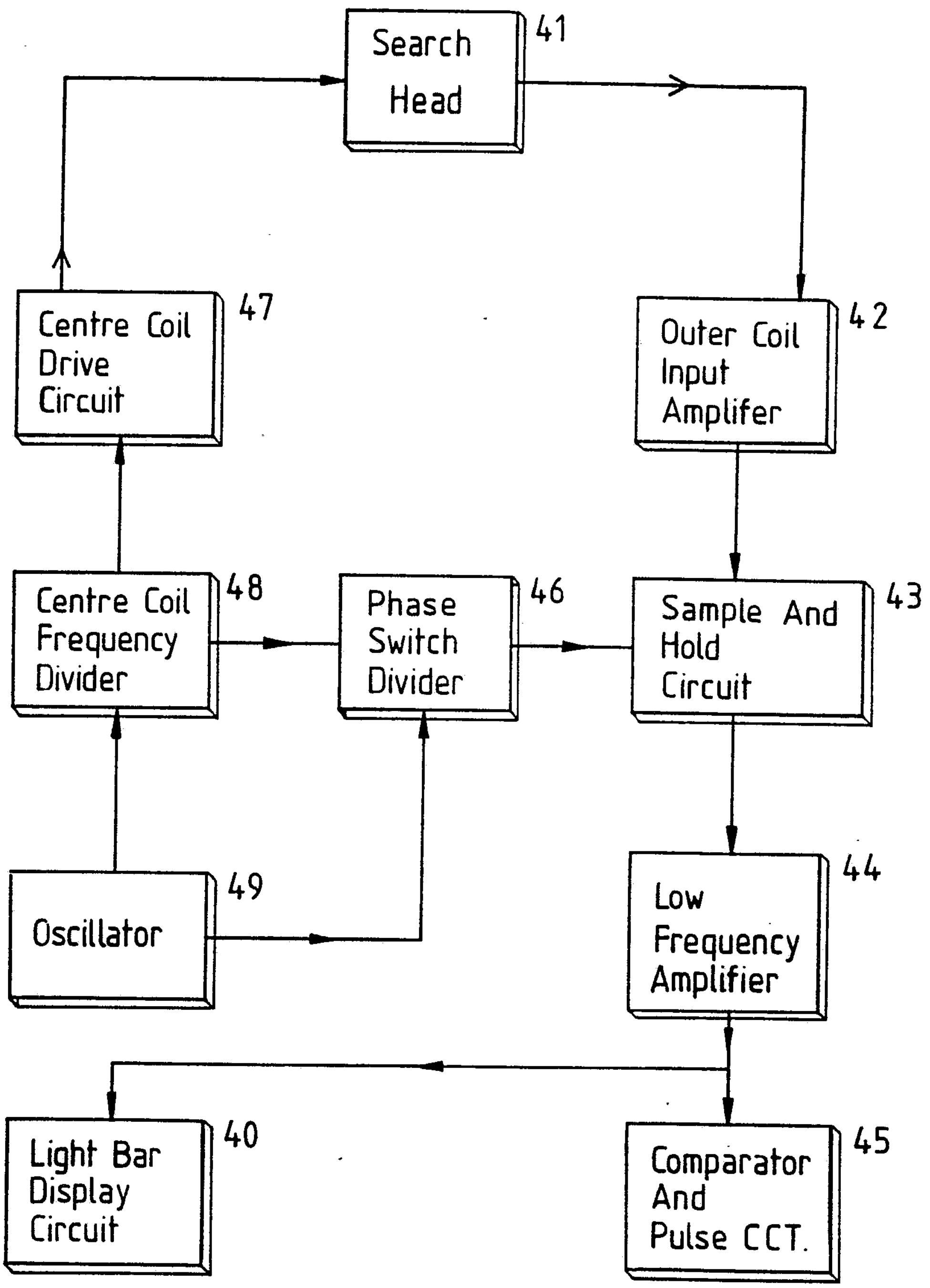


Fig.4.

DETECTOR BLOCK DIAGRAM



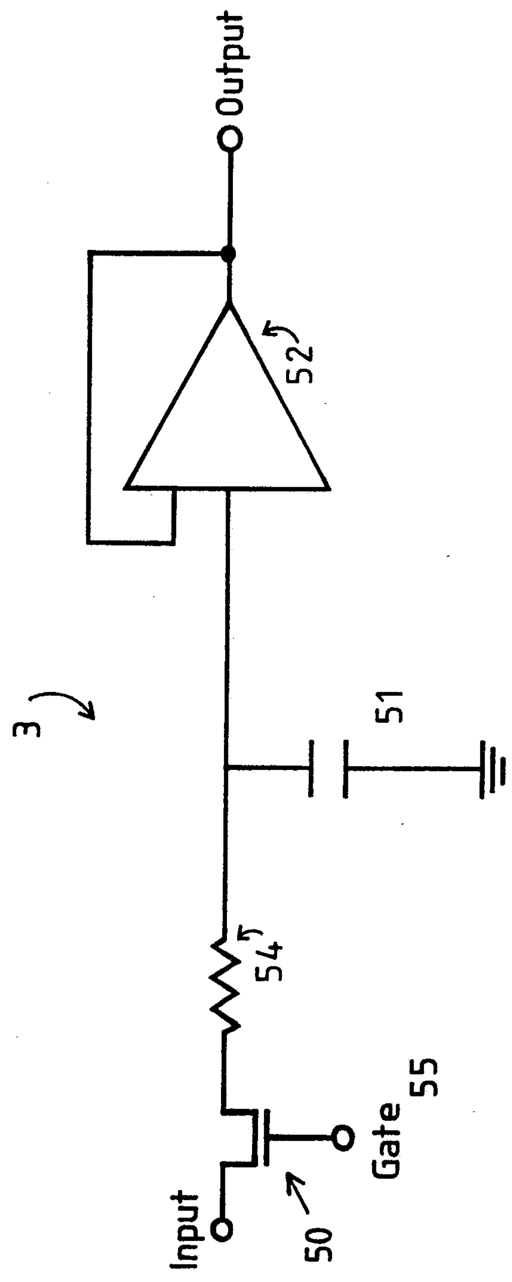


Fig .5.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 89/00281

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[4] G01V 3/10 3/12 3/38

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	G01V 3/10 3/12 3/38

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU: IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	US,A,4030026 (PAYNE) 14 June 1977 (14.6.77)	1-7
X,P	GB,A,2200216 (KOELECTRIC LIMITED) 27 July 1988 (27.7.88)	1-7
X	US,A,4325027 (DYKSTRA) 13 April 1982 (13.4.82)	1-7
X	US,A,4110679 (PAYNE) 29 August 1978 (29.8.78)	1-7
X	GB,B,1534039 (LAWRENCE) 29 November 1978 (29.11.78)	1-7
X	GB,A,2041532 (PLESSEY CO) 10 September 1980 (10.9.80)	1-7
X	GB,A,2174203 (PLESSEY CO) 29 October 1986 (29.10.86)	1-7

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25 August 1989 (25.08.89)	(20.09.89) 20 September 1989
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	S. CLARK S. Clark

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 89/00281

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members			
GB 2174203	EP 218669	WO 8606501		
US 4110679	US 4030026			
US 4030026	US 4110679			
GB 2200216	EP 274450			

END OF ANNEX