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(54) **A digital electronic remote control system.**

(57) A transmitter and receiver suitable for use in a digital electronic remote control system for operating remote equipment. The system uses radio control and digital frequency techniques. In the transmitter, information regarding the desired function of the remote equipment is digitally encoded and transmitted serially. A receiver at the remote equipment decodes the received information and is adapted to enable respective functions of the equipment in response to the decoded information. Fail-safe features may be incorporated into the system.

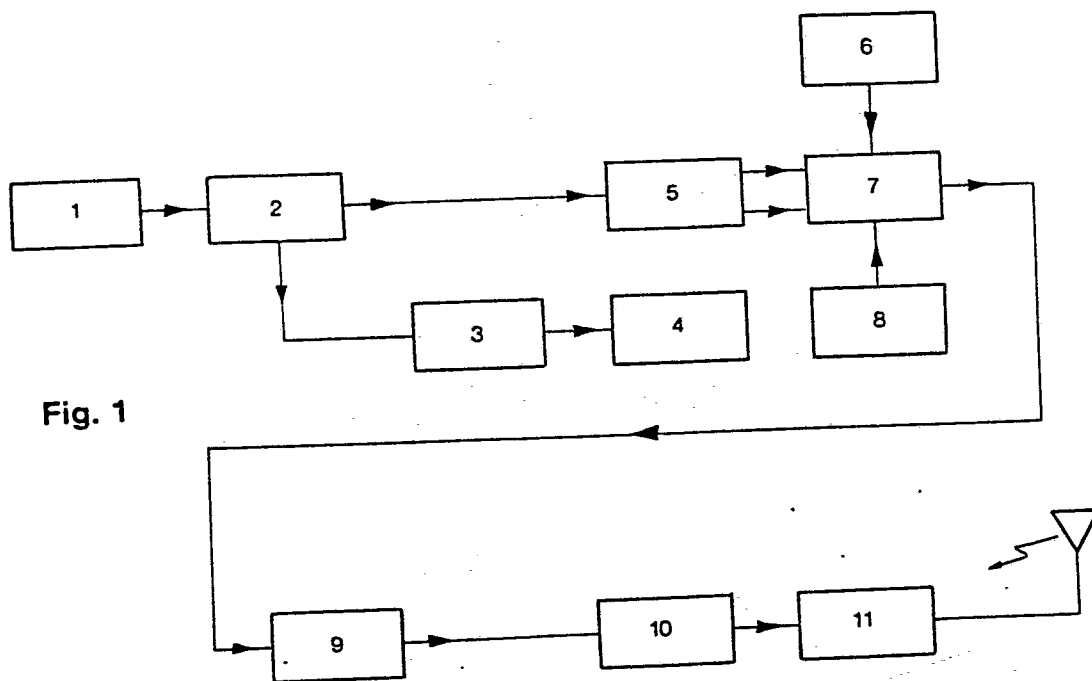


Fig. 1

"A DIGITAL ELECTRONIC REMOTE CONTROL SYSTEM"

The present invention relates to a transmitter and a receiver suitable for use in a digital electronic remote control system which can be used for the remote operation of industrial equipment. In particular, the present invention
5 uses radio control and digital frequency techniques.

In most instances throughout the world, industrial installations and electrical equipment show an application for remote control of mechanical equipment. Historically
10 this remote control has been by means of multicore cabling to pendants or control stations, or by manual signalling.

The use of radio control for such applications has many advantages over traditional techniques. In particular, it allows the use of remote controlled equipment in
15 industrial environments which are not suitable for man. Also, the remote controlled equipment has greater manoeuvrability due to the absence of control wires and cabling.

It is an object of the present invention to provide
20 an improved digital electronic remote control system, including a transmitter and receiver suitable for use therewith.

ADVANTAGES OF THE PRESENT INVENTION(a) Labour Saving

25 With a small lightweight control transmitter the operator is not confined in movement or position as with cable connected controllers. The operator can position himself to the best advantage when operating thus removing the problems of restricted vision and the consequent delays
30 and errors that occur with manual signalling. Where cranes are involved the operator, being fully mobile, may sling and steer his own loads enabling smoother and quicker operations.

(b) Safety

Where the equipment being controlled moves into a
35 hazardous area caused by heat, gases, radioactivity or unstable structures or formations the operator may remain safely outside the danger zone whilst retaining full control of the machinery involved.

(c) Flexibility & Economy

Different applications of the present invention can be based on identical circuitry and the various control options can be organised to suit specific customer requirements. The control unit can be virtually any size and layout above the smallest unit, the hand held radio control model, which is carried by the operator. Where the control point is fixed with respect to the machinery, command transfer can be by means of a single pair of conductors over a long distance instead of by radio transmission. This saves on cost and radio spectrum usage and will often be cheaper than equivalent runs of multicore cables.

Installation costs are low as the receiver can be configured to emulate conventional controllers and pushbuttons where required.

Operating costs essentially comprise radio licence fees (where applicable) and battery charging costs which are negligible compared to potential cost savings.

According to one aspect of the present invention, there is provided a transmitter for use in a digital electronic remote control system for operating remote equipment, said transmitter comprising

control means having a plurality of selector means adapted to be enabled, each selector means corresponding to a particular function of said remote equipment,

a plurality of control channels connected to said selector means, whereby enabling said selector means generates signals on respective predetermined control channels to thereby determine their status, each enabled selector means determining a unique control channel status code,

encoder means for digitally encoding information including the status of said control channels, and

output means connected to said encoder means for modulating and transmitting said digitally encoded information serially.

According to another aspect of the present invention, there is provided a receiver for use with the abovementioned transmitter, said receiver comprising reception means for receiving and demodulating the modulated serial

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digitally-encoded information transmitted from said transmitter, decoding means connected to an output of said reception means for decoding the demodulated encoded information, and actuator means operable in response to the
5 decoded information for enabling the operation of predetermined functions of said remote equipment.

According to a further aspect of the present invention, there is provided a digital electronic remote control system comprising the abovedefined transmitter and
10 receiver.

Preferred embodiments of the invention will now be described with reference to the drawings in which:

Fig. 1 is a schematic diagram of a transmitter of an embodiment of the present invention,

15 Figs. 2a and 2b are schematic diagrams of a receiver suitable for use with the transmitter of Fig. 1; Fig. 2b being a continuation of Fig. 2a,

Fig. 3 is an allocation chart depicting a particular function/control channel allocation.

20 Turning to Fig. 1, the description of the transmitter can be broken down into functional blocks for ease of explanation. The power source comprises a battery 1 which is preferably a 150MAH 12 volt rechargeable Battery Pack which will give 8 hours of normal operation before requiring
25 recharging. Recharging time is nominally 12 hours from flat. The transmitter can also operate with non-rechargeable batteries if required.

Controls 2 comprise selector means by which the desired functions of the remote equipment can be chosen. The
30 construction and configuration of the selector means can be varied to suit particular customer requirements, but the means are usually engraved pushbuttons for motions, crane power, horn etc., and preferably always include a key switch (not shown) to allow the transmitter to be activated and a
35 "deadman" pushbutton (not shown) to prevent accidental operation.

A plurality of parallel control channels originate in the controls 2 where they are connected to the selector means. When the selector means are enabled, enabling signals

are generated on respective predetermined control channels. The presence or absence of a signal on a control channel determines its status. Thus, using digital notation, the status of a control channel is "high" if a signal is present, and "low" if no signal is present thereon. Consequently, the status of 24 control channels can be represented by a 24 bit code word, "1" bits and "0" bits signifying the presence or absence, respectively, of a signal on the respective control channel.

10 Although the preferred embodiment operates with 24 independent channels of control, the invention will work with any suitable number of control channels. The number of required control channels will depend on the number of functions which the remote equipment is required to perform. 15 There should be a sufficient number of control channels to provide a unique channel status arrangement for each function; that is, no two functions should result in the same channel status code.

 A power sense and control unit 3 monitors the state of charge of the battery whilst the transmitter is turned on, and for example, a low voltage situation can cause a red "low battery" light (not shown) to flash. Where further decrease in voltage occurs, at a given point, the power control circuitry 3 shuts power off to the rest of the circuitry. 20 The time of operation from warning to shutdown is preferably approximately 5 to 10 minutes continuous use. The circuitry can be designed so that the transmitter will not start up whilst the battery is in a low state. Further, the power is routed through a key switch and the deadman switch and 25 opening either will cause shutdown. 30

 A power indicator 4 is enabled when sufficient battery charge exists for operation. For example, the power indicator can comprise an orange "Battery OK" light (not shown) which comes on when the power key switch is closed and the deadman button is pressed. 35

 A parity generator 5 is connected to the control channels, and generates a parity bit from the incoming signals on the control channels to maintain an odd parity of scan information. Any other suitable parity code may be

used. The parity information is used for verification at the receiver.

An identification code device 6 generates a predetermined code unique to each transmitter, which is also scanned for transmission and is used for verification at the receiver. Preferably the code consists of four bits but this may be varied in accordance with the number of similar remote control systems operating in the vicinity.

A parallel-to-serial convertor 7 is arranged to repetitively scan parallel information presented thereto which comprises the control channel status information, the parity information and the identification code. The parallel-to-serial convertor 7 converts the parallel information into a predetermined serial format at a rate which is set by a rate generator 8. Preferably, the serial information is in the form of 32 bit words comprising:

1 start bit	(always high)
4 ident bits	(preset and unique)
24 control bits	(determined by control channels)
1 parity bit	(determined by control channels)
2 stop bits	(always low)

However, the word length and format can be varied to suit customer requirements and different applications of the present invention.

The scanning by the parallel-to-serial convertor 7 is done continuously creating a repeating, constant stream of digital data.

A rate generator and sequence logic 8 connected to the parallel-to-serial convertor 7 sets the rate of scan and the sequence of scanning, and is preferably fixed by a crystal oscillator, or other constant frequency source. A scanning rate of 1 baud is preferred.

An AFSK generator 9 (Audio Frequency Shift Keying Generator) is connected to the output of the parallel-to-serial convertor 7 and converts the serial digital data therefrom into a frequency-shifted keyed signal, for example, 850Hz AFSK. In the preferred embodiment, the two tones used are 2125Hz and 2975Hz, but the frequencies can be altered to avoid interference from neighbouring audio

noise sources for example.

An audio processing unit 10 connected to the AFSK generator 9 processes the audio generated to ensure the optimum level and wave shape for the transmitter.

5 The output of the audio processing unit 10 is connected to a transmitting device which can be a UHF (Ultra High Frequency) transmitter 11 adapted to transmit approximately 100 milliwatts of RF at UHF frequency, frequency-modulated with the processed audio from the unit
10 10. A short aerial can be attached to the transmitter for directing the radio transmission.

The status of the control channels, the parity bit(s) generated therefrom, and the identification code are scanned at the fixed rate and, together with start and stop bits, are
15 formed into a precise digital code which is transmitted from the transmitting device. Any deviation from this fixed format in either makeup or speed (within tolerance) will not be accepted by a corresponding receiver as a valid transmission.

20 The transmitter of Fig. 1 can be incorporated in a hand held control unit which weighs about 2.6 Kg, has an internal, removable, rechargeable ni-cad battery, is constructed of tough stainless steel to withstand rough treatment, has a flexible "rubber" aerial only about 16 cm
25 long and a shoulder strap to leave both hands free when the unit is not in use.

The 24 independent control channels which can be configured, as exemplified in the function/channel allocation chart of Fig. 3, to provide many functions. Other
30 function/channel allocations can be used.

Preferably, all configurations have the "deadman" facility which prevents operation unless pressed, and the battery sensing system 3 which warns of a low battery charge condition and eventually prevents operation until the battery
35 is charged.

A preferred embodiment of a receiver for use with the abovedescribed transmitter is shown in Fig.2. The receiver comprises a power supply (not shown) which is common to all sections of the receiver. The receiver is powered by four

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separate voltage supply lines.

(i) Relays - 24 to 33 volt semi regulated DC.

(ii) Electronics A side - 24 volts to 33 volts semi regulated DC.

5 (iii) Electronics B side - 24 volts to 33 volts semi regulated DC.

(iv) Receiver Unit - 12 volt fully regulated DC.

These supplies are preferably separately protected from over-current and over-voltage conditions and should
10 withstand a 1.5 second failure to incoming supply without effect. Each supply line is separately indicated but a main switch (not shown) isolates all supplies. Input to the power supply is the standard 240 volt AC 50Hz supply unless customer requirements dictate special input voltages.

15 The receiver comprises reception means having a UHF-FM receiver unit 12 adapted to receive the signal transmitted by the transmitter (Fig. 1) and detect the audio information therein. Preferably, it also provides an output indicating whether a signal is present or not.

20 The output of the receiving unit is connected to an audio buffer 13 which buffers the audio signal from the receiver unit 12 and ensures a sufficient level and correct wave shape for the following demodulator section.

A mute buffer 14 is also connected to the output of
25 the receiver unit 12 and senses the signal/no signal output from the receiver unit 12 and provides a control voltage for the safety relays 25.

A mute indicator 15 connected to the mute buffer 14 provides an indication of signal/no signal condition.

30 The components of the receiver described hereafter are duplicated for failsafing reasons. Only one half (A side) is shown in Fig. 2a and Fig. 2b, the other half (B side) being identical. Although the receiver operates satisfactorily without circuit duplication, the circuit
35 duplication is preferred for the higher degree of reliability and safety which it provides.

The output of the audio buffer 13 is connected to an AFSK Demodulator 16 which demodulates the AFSK audio signal from the audio buffer and provides serial digital information

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for the serial-to-parallel convertor 17 to which it is connected.

The serial-to-parallel convertor 17 converts the serial information to parallel information which is the
5 mirror of the digital information provided from the controls of the transmitter.

The control channel status information and parity bits in the parallel information are passed to a parity checker 18 which compares the parity bits with the parity of
10 the received control channel status information for validity checking. Also, a identification comparator 19 compares the received and converted identification code of the transmitter with the receiver identification code from a receiver identification code generator 27.

15 A validity decoder 20 samples all information including parity checker 18 output, identification comparator 19 output and speed of reception. If all conditions are correct the validity decoder enables ON/OFF counters 22.

20 A rate generator and sequence logic 21 is connected to the serial-to-parallel convertor 17, and the validity decoder 20, and controls the rate of decoding and the sequence of decoding of the received information and detects the synchronising start bits of each scan from the
25 transmitter.

There is an ON/OFF counter 22 for each of the 24 control outputs from the serial to parallel convertor corresponding to the control channels. These ON/OFF counters, for example, can be configured to have the
30 following effect: Three "ON" condition outputs must be counted before an output is passed on, but only one "OFF" condition output is required for an "OFF" output to be passed. Again, this provides a safety check before the remote equipment is enabled.

35 Relay drivers 23 which, for example, can be open collector driver transistors, apply energising power to respective output relays 26 whenever the "ON" output is presented to them from respective ON/OFF counters 22.

A safety driver 24 connected to the mute buffer 14

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provides energising power to a safety relay 25 whenever a "signal" condition output is presented to it. The safety relay 25 provides return power to the output relays 26 for each side of the receiver system respectively. That is, when
 5 either safety relay de-energises, ALL output relays de-energise.

It is the output relays 26 which provide the actual output from the receiver to the equipment it is controlling in the form of normally open interlocks. Preferably, for a
 10 higher safety margin, the respective output relays from each side of the receiver must be energised for output to occur, i.e. the output circuit is wired in series through both output relays per function.

A receiver constructed in accordance with the above
 15 provided the following test results:

Receiver Unit Specification

	Usable Sensitivity	- 0.4 Micro Volt
	Mute Sensitivity	- 0.25 Micro Volt
	Adjacent Channel Selectivity	- -90 dB or better
20	Spurious Response	
	Attenuation	- -80 dB or better
	Bandwidth	- $\pm$ 0.25 of mean operating frequency
	Frequency Stability	- $\pm$ 5 ppm
25	Channel spacing in	
	Frequency Bands	- 25/30 KHz
	Ambient Temperature Range	- -10°C to +60°C

The system is immune to heavy levels of natural and man made interference. However, excessive interferences will
 30 not cause random operation but will cause the system to shut down, as illustrated by the following test results

Receiver Corruption Test Results

	Remote Control Transmitter	Interference Signal Level to Shutdown System
35	(Signal Levels at Receiver Aerial)	
	1 uV	.3 uV
	10 uV	1.5 uV
	100 uV	20 uV
	1 mV	200 uV
40	10 mV	2 mV

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Expected signal level at the receiver is on the average 10mV or better.

These tests indicate that mobile transmitter of 10 watts radiated power, 280 yds. from the receiver, and with 5 the remote control transmitter 20 yds. situated from the receiver, will shutdown the system.

However, the above statement is only true as long as the mobile transmitter is on the same frequency as the remote control transmitter of the present invention and this would 10 probably only be the case if the mobile transmitter was malfunctioning or operating illegally. When the mobile is not on the same frequency, no corruptive interference will occur. These results are the worst case and would normally 15 be far exceeded.

The foregoing describes some embodiments of the present invention and modifications, obvious to those skilled in the art, may be made thereto without departing from the scope of the present invention as defined in the following 20 claims. For example, the number of control channels may be increased or decreased with a corresponding increase or decrease in the number of bits per scan. Further, the function/control channel relationships shown in Fig. 3 may be reallocated in accordance with the guidelines defined herein.

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CLAIMS

1. A transmitter for use in a digital electronic remote control system for operating remote equipment, said transmitter comprising

control means having a plurality of selector means adapted to be enabled, each selector means corresponding to a particular function of said remote equipment,

a plurality of control channels connected to said selector means, whereby enabling said selector means generates signals on respective predetermined control channels to thereby determine their status, each enabled selector means determining a unique control channel status code,

encoder means for digitally encoding information including the status of said control channels, and

output means connected to said encoder means for modulating and transmitting said digitally encoded information serially.

2. A transmitter as claimed in claim 1 wherein said information is presented in parallel form to said encoder means, and said encoder means comprises a parallel-to-serial convertor for repetitively scanning said parallel information at a predetermined rate and providing a serial output of the digitally encoded information.

3. A transmitter as claimed in claim 2 wherein said output means comprises an audio frequency shift keying generator connected to the serial output of said parallel-to-serial convertor, and having an audio frequency output dependent on the bit status of said digitally encoded information.

4. A transmitter as claimed in claim 3 wherein said output means further comprises transmitting means connected to said audio frequency shift keying generator, and adapted to transmit a carrier frequency, modulated by said audio output.

5. A transmitter as claimed in claim 4 wherein said carrier frequency is in the UHF range, and said carrier frequency is frequency modulated by said audio output.

6. A transmitter as claimed in any preceding claim,

further comprising identification code means for generating an identification code unique to said transmitter, and parity code means connected to said control channels for generating a parity code determined by the status of said control channels, wherein said information comprises said identification code and said parity code.

7. A transmitter as claimed in any preceding claim wherein said control means comprises a key switch and a deadman switch, whereby said key switch and deadman switch must be enabled before said selector means can be enabled.

8. A transmitter as claimed in any preceding claim wherein said transmitter is incorporated in a portable, hand-held unit.

9. A receiver for use with the transmitter of any one of claims 1 to 8, said receiver comprising reception means for receiving and demodulating the modulated serial digitally-encoded information transmitted from said transmitter, decoding means connected to an output of said reception means for decoding the demodulated encoded information, and actuator means operable in response to the decoded information for enabling the operation of predetermined functions of said remote equipment.

10. A receiver as claimed in claim 9 wherein said decoding means comprises serial-to-parallel convertor means and a plurality of controlling channels connected to the output thereof, said serial-to-parallel convertor means being adapted to convert the serial digitally-encoded information to parallel form, derive enabling and disabling signals therefrom, and present said enabling and disabling signals to respective ones of said plurality of controlling channels.

11. A receiver as claimed in claim 10 wherein said actuator means comprises a plurality of relay means for enabling predetermined functions of equipment, said relay means being energisable and de-energisable in response to said enabling and disabling signals, respectively, on respective controlling channels.

12. A receiver as claimed in claim 11 further comprising a plurality of ON/OFF counters each connected between respective ones of said controlling channels and said

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relay means, each ON/OFF counter being adapted to provide an energising output to its respective relay means only after receiving a predetermined number of consecutive enabling signals from its respective controlling channel.

13. A receiver as claimed in any one of claims 10 to 12 comprising identification code generating means for generating an identification code corresponding to the identification code of said transmitter, and identification comparator means connected to said identification code generating means and said serial-to-parallel convertor means for comparing said generated identification code with an identification code derived from said parallel information, further comprising validity decoder means connected to said identification comparator means and adapted to enable said actuator means only in the event of a valid comparison of said identification codes.

14. A receiver as claimed in claim 13 further comprising parity code generating means connected to said controlling channels for generating a parity code therefrom, and parity comparator means connected to said parity code generating means and said serial-to-parallel convertor means for comparing the generated parity code with a parity code derived from said parallel information, wherein said validity decoder means is connected to said parity comparator means and is adapted to enable said actuator means only in the event of a valid comparison of said parity codes.

15. A receiver as claimed in any one of claims 9 to 14, further comprising sensing means connected to said reception means for sensing the reception of a transmission from said transmitter, and means connected to said sensing means and responsive thereto for enabling said actuator means only during reception of said transmission from said transmitter.

16. A receiver as claimed in any one of claims 11 to 15 wherein said decoder means and said actuator means are duplicated, whereby the functions of said equipment are operable only when both sets of the respective relay means are energized.

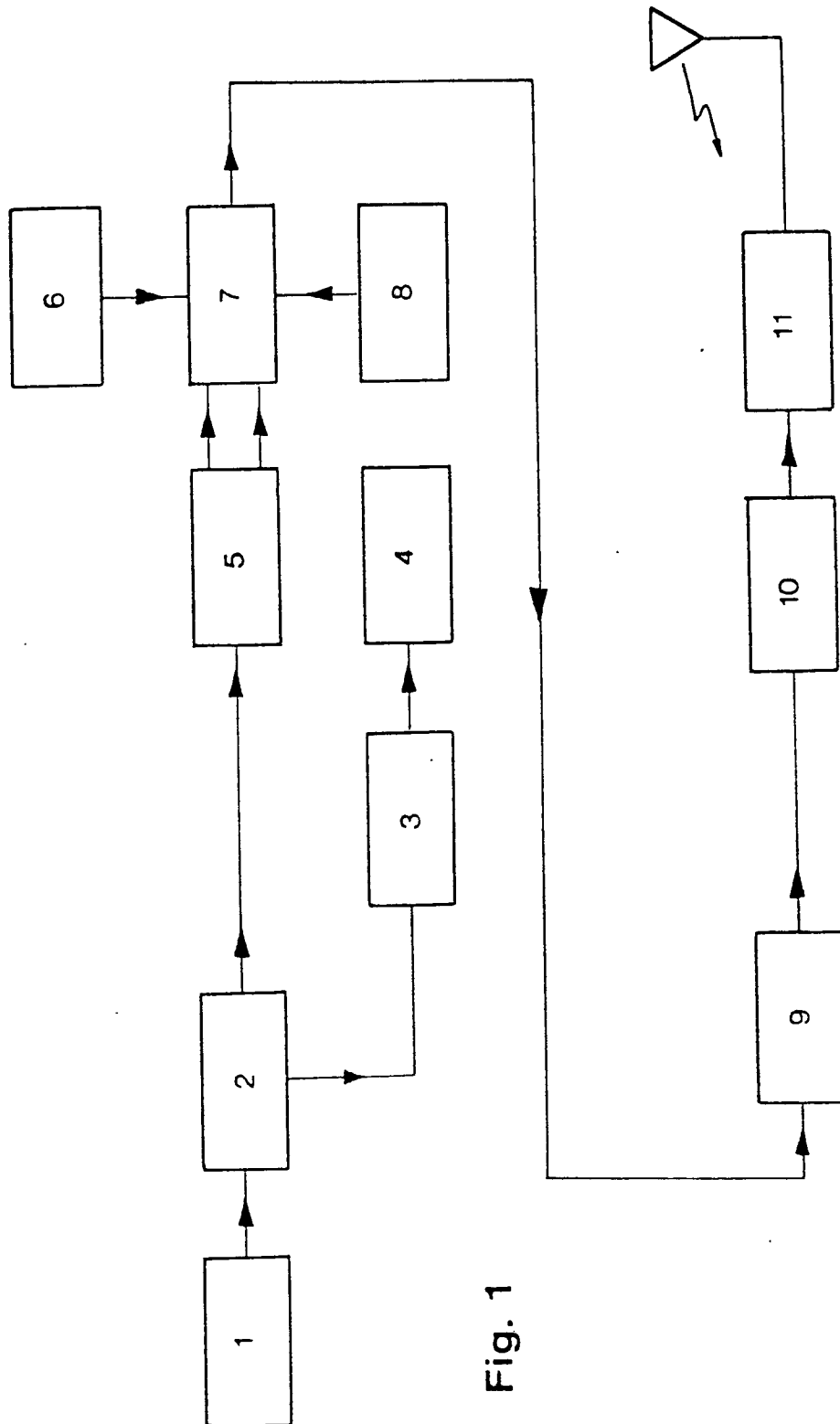


Fig. 1

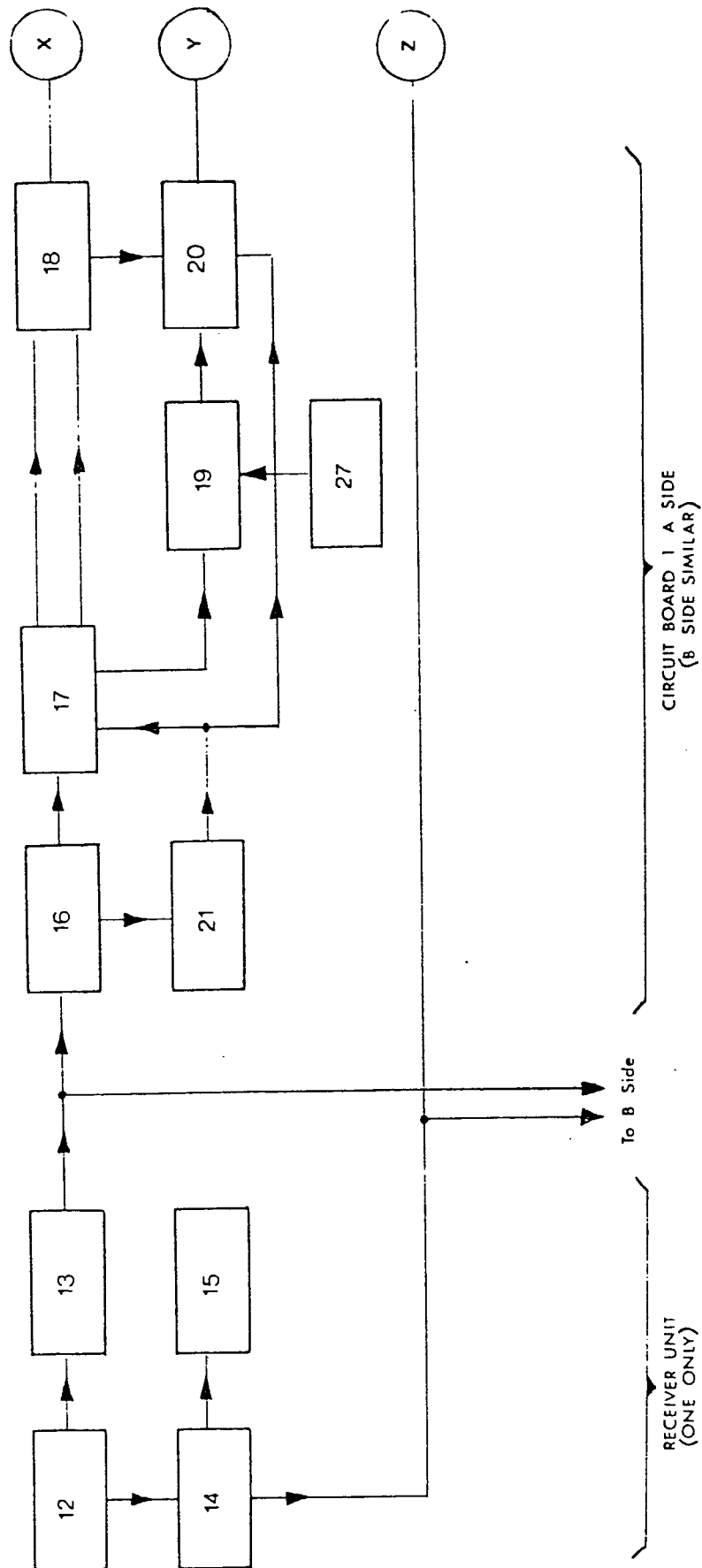


Fig. 2a

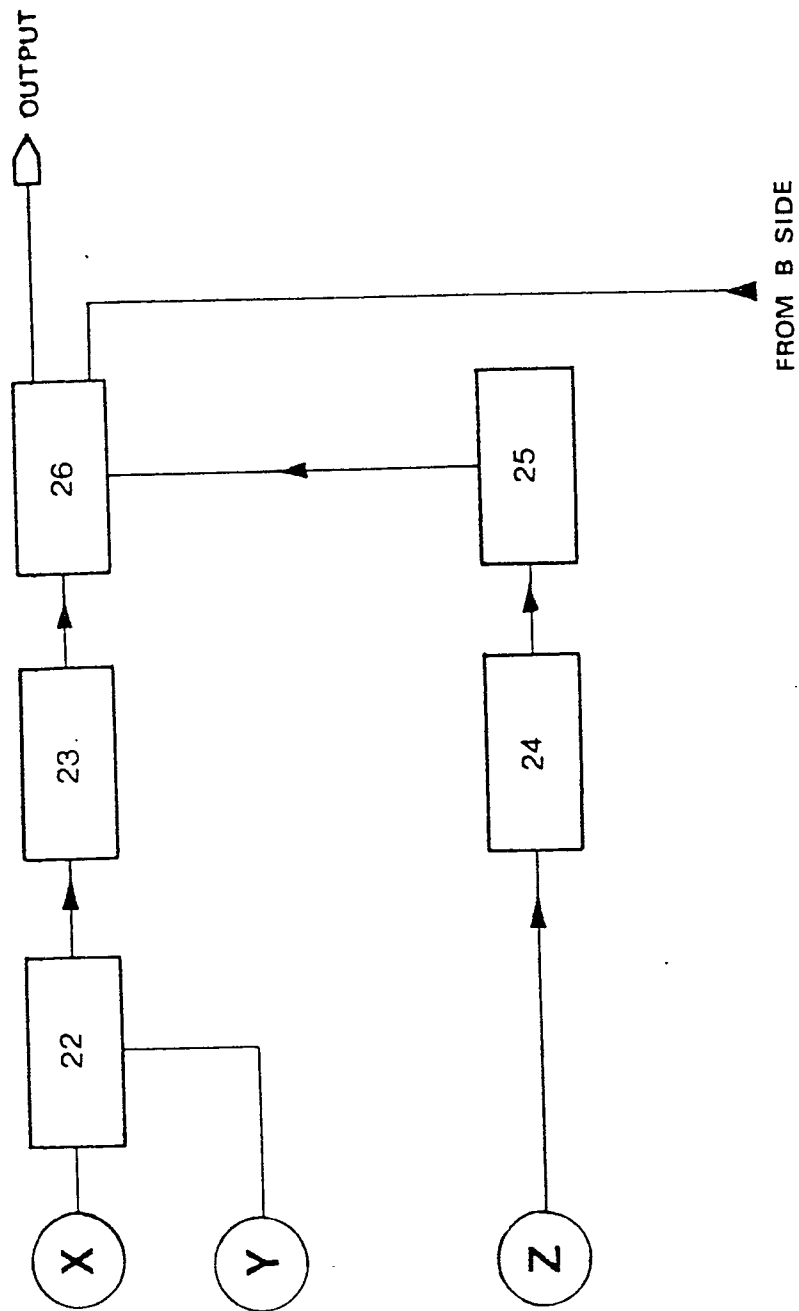


Fig. 2b

Fig. 3

CHANNELS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
FUNCTION																									
EAST FAST	1	X		X		X																			
EAST 3	2	X		X	X																				
EAST 2	3	X		X																					
EAST SLOW	4	X																							
WEST SLOW	5		X																						
WEST 2	6		X	X																					
WEST 3	7		X	X	X																				
WEST FAST	8		X	X	X	X																			
NORTP FAST	9						X		X	X	X	X													
NORTH 4	10						X		X	X	X														
NORTH 3	11						X		X	X															
NORTH 2	12						X		X																
NORTH SLOW	13						X																		
SOUTH SLOW	14							X																	
SOUTH 2	15							X	X																
SOUTH 3	16							X	X	X															
SOUTH 4	17							X	X	X	X														
SOUTH FAST	18							X	X	X	X	X													
RAISE 1 FAST	19												X		X	X	X								
RAISE 1 3	20												X		X	X									
RAISE 1 2	21												X		X										
RAISE 1 SLOW	22												X												
LOWER 1 SLOW	23													X											
LOWER 1 2	24													X	X										
LOWER 1 3	25													X	X	X									
LOWER 1 FAST	26													X	X	X	X								
RAISE 2 FAST	27																	X		X	X				
RAISE 2 MED	28																	X		X					
RAISE 2 SLOW	29																	X							
LOWER 2 SLOW	30																		X						
LCWER 3 MED	31																		X	X					
LOWER 2 FAST	32																		X	X	X				
CRANE ON	33																					X			
LIGHTS ON	34																						X		
LIGHTS OFF	35																							X	
SIREN	36																								X



European Patent
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EUROPEAN SEARCH REPORT

0037238

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	<u>GB - A - 1 418 652</u> (MOOG INC.) + Fig. 1-3,10; page 2, line 88 - page 3, line 94 + -- <u>DE - B - 2 354 221</u> (METZ APPARATEWERKE) + Fig; claim 1 + -- FUNKTECHNIK, vol. 32, no. 13, July 1977, Heidelberg PAUL J. MUENZER "Störunterdrückungsschaltungen für UKW Autoradios" pages 215-220 + Fig. 8 + -- <u>US - A - 3 378 817</u> (VITT) + Fig. 1,2; columns 2-5 + -- <u>GB - A - 1 116 712</u> (RADARGUARD SECURITY) + Totality + --	1-6,9,10,13,14 12 15	H 04 Q 9/00 H 04 B 1/10
			TECHNICAL FIELDS SEARCHED (Int. Cl.)
			H 04 B 1/00 H 04 L 27/00 H 04 Q 9/00 H 03 J 1/00 G 08 C 15/00
X	<u>US - A - 3 323 107</u> (DU VALL) + Column 2 + -- <u>US - A - 4 190 800</u> (KELLY, ROBINSON) + Fig. 2; columns 2-4 + --	1 2-4,9-13	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document
Place of search VIENNA		Date of completion of the search 23-06-1981	Examiner HÜTTNER



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EUROPEAN SEARCH REPORT

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Application number

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>DE - A - 2 222 707</u> (HERTLE) + Fig. 8; pages 1-7 + -- <u>DE - A - 2 504 102</u> (KRONE GMBH) + Fig. 1,2; page 11 - page 26, line 8 + ----	1-5, 9-12 1,2,9, 10	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)