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(54) Systems for locating mobile objects by inductive radio.

(57) The invention relates to a position locating system for detecting a mobile object on a predetermined route. This system includes a twisted-pair type inductive radio-frequency lines (1) which are arranged along the route of the object. The inductive lines (1) comprise a plurality of crossings (3, 4) and intervals of specific two different lengths p1 and p2 within an area necessary for detecting the absolute position of the object with value of p2 being larger than the value of p1. The position locating system according to the invention is available even for the place where it is difficult to install multi-pairs of the inductive lines and it is inexpensive for the production and simple for the installation.

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SYSTEMS FOR LOCATING MOBILE OBJECTS BY INDUCTIVE RADIO

FIELD OF THE INVENTION

Position detecting and control of a mobile object.

BACKGROUND OF THE INVENTION

The present invention relates to systems by inductive radio, particularly to a position locating systems by inductive radio. It enables to detect and control mobile objects, such as a train, travelling crane on running tracks. In container yards of wharf, for instance, the installation of conventional multi-wire type lines for radio-frequency will not be allowed since it requires under-ground construction. In such case a relative position locating system may be used which counts the number of crossings in the twisted-pair type inductive radio-frequency lines.

As shown in Fig. 1, the twisted-pair type inductive lines 1 are installed along the track of the mobile object and a radio-frequency power supply is connected to the lines 2. A pair of antennas 5, and 6 are attached to the mobile object keeping a fixed interval lengthwise of the lines. In the antennas, magnetic flux which is exemplified by the dotted lines in Fig. 1, will generate induced currents flowing in the directions corresponding to those (phase) of the currents in the twisted-pair lines 1, the lines 1 having crossings 3, 4, ----, spaced at fixed intervals whereby the phase of current flowing in the lines 1, as shown by the arrow in the Fig. 1, alternates at an interval equal to that between the crossings.

Now, assuming that the phases of the induced currents in the antennas 5, 6 and the current in the lines 1 have a relation shown by the lines in Fig. 1, the currents in the antennas 5, and 6 are in an opposite phase to each other.

When the phase-relation between the antennas 5, 6 and the lines 1 has been varied as shown by the one-dot-and-dash lines in Fig. 1, as the mobile object travels rightwardly in the figure, the current in the antennas 5 and 6 are in the same phase.

Such phase relation between the antennas 5, 6 alters with the every passage of the antennas, i.e., the mobile object, through crossing. Hence, the number of the phase alternation is counted to thereby obtain the number of crossings through which the mobile object has passed, thus indicating the relative position thereof.

In the above case, however, the mobile object is determined merely of its relative location of the travelling route, whereby an absolute position sensing method is required in addition. A typical way of the absolute position detecting of a mobile object is to install a plurality of twisted-pair type inductive lines for radio-frequency with different intervals between crossings and with different frequencies allocated so that the combinations of the phases of the induced currents in the antennas and sensing for each lines indicative of the absolute location of the mobile object.

In the above case, however, position of the mobile object can be determined in its relative location on the travelling route and another lines for sensing the absolute location of the object are to be installed.

A typical example of the method for detecting the absolute position of a mobile object on the pre-determined travelling route is carried out by installing a plurarity of a twisted-pair type inductive lines in parallel to the travelling line of the moving object and by detecting the combination of the phases of the induced currents in the antennas for each signal line installed.

A typical means for detecting the absolute position of a mobile object on a travelling route is to combine the phase relations of the induced currents in a antenna by each of the twisted-pair type inductive lines. In this case some specific signal frequency will be allocated to each of the line.

Another absolute position detecting method for the mobile object is illustrated in Fig. 1. In this case some signal sources are located on the specific position on the travelling route of the object with abovementioned detecting lines for the relative position of the object. The presence of the object is simply determined when antenna(s) detects the specific signal from the source on the pre-determined zone on the travelling route.

Such method, however, requests signal sources to be installed along the inductive frequency lines and moreover needs frequency discriminators which will increase the installation costs and will cause difficulties for maintenance, especially a large number of detecting zones may exist.

DISCLOSURE OF THE INVENTION

An object of the invention is to provide an absolute position locating system which is available even for the place where it is difficult to install the multi-pairs of the twisted inductive radio-frequency lines and which is inexpensive to produce and simple to install.

This invention will be described in detail according to the drawings. Referring to Fig. 2, the positional relation between signal sensing antennas and the twisted-pair type inductive radio-frequency lines 1 is shown, in which reference numeral 7 designates a reference antenna, 8 designates an auxiliary antenna, 9 designates a comparison antenna, 2 desigantes a radio-frequency power supply, and 3 and 4 designate the crossings of the line 1, the reference antenna 7 and the comparison antenna 9 being attached to a mobile object (not shown in the Figure) keeping a distance ℓ along the lines 1. The crossings in lines 1 are spaced at the predetermined interval L or 2L: two times the interval L, the distance ℓ being set in a range to meet the relation of $L \leqq \ell < 2L$.

Fig. 3 shows a block diagram of a sensor 10 attached together with antennas 7, 8 and 9 in Fig. 2 to a mobile object and given outputs from the above three antennas, input terminals 7', 8' and 9' of sensor 10 being given outputs of antennas 7, 8 and 9 in Fig. 2. Reference numeral 13 designates a phase comparator which compares the signal phases on input terminals 7' and 8' and outputs a digital value "1" or "0" corresponding to the comparison results of whether the signals are in the opposite phase or in the same phase. 14 designates a phase comparator which compares the signal phases on input terminals 7' and 9' and outputs digital value "1" or "0" corresponding to the comparison results of whether the signals are in the opposite phase or in the same phase. These phase comparators also serve as an analog/digital converter generating digital signals corresponding to the comparison results of analog amount. Reference numeral 15 designates an AND gate, 16 designates a shift register of five stages given an output of AND gate 15 and a shift pulse S from phase comparator 13, and 17 disignates an AND gate for decoding the contents of the shift register 16.

Assuming that the antennas 7, 8 and 9 are positioned as shown in Fig. 2 following the movement of the mobile object, since antennas 7 and 8 are positioned at both sides of the crossing point 3, induced current in each antenna is in a opposite phase so that the phase comparator 13 in Fig. 3 feeds digital signal "1" to one input terminal of AND gate 15 and a shift pulse S to the shift register 16.

The antennas 7 and 9 are similarly positioned at both side of the crossing 4 so that the induced current in each antenna is in a opposite phase whereby the phase comparator 14 in Fig. 3 outputs digital signal "1". The AND gate 15, which is given "1" signal from the both antennas, outputs "1" to the shift register 16 so that one additional "1" signal is read on the shift register readings.

On the other hand, when the interval between the crossings 3 and 4 in Fig. 2 is 2L, and when the antennas 7 and 8 are located between the two crossings, the phase comparator 13 outputs signal "1". As there is no crossing between the antennas 7 and 9, the currents therein are in the same phase and the phase comparator 14 outputs "0".

Fig. 4 shows an example of an arrangement of the crossings a, b, c, and d. A pattern of combination of intervals between crossings in the twisted-pair type inductive radio-frequency lines 1 and variations in an arrangement of antennas 7, 8, and 9 are illustrated.

When the antennas 7, 8 and 9 more rightwardly through the above lines 1, positioning of them vs the crossings are shown downwardly in the figure. The figure also indicates that relative space between the antennas are kept unchanged during their movement on the route. When the antennas 7 and 8 are located between crossings, the reading of the shift register is "1", and when they are placed in the both sides of the crossing b, i.e., the crossing b is positioned between them, the currents induced in the antennas 7 and 8 are in the same phase. The phase comparator 14, then, outputs "0" signal so that the reading on the shift register will become "0". Similarly in the case when the antennas 7 and 8 are located between the crossings c, d and e, the readings of the shift register 16 will become "0", "1" and "1" respectively.

Thus, each time when the reference antenna 7 passes the crossing, the shift register 16 shows readings of "1" or "0" depending on whether the antenna 7 and 9 are positioned between crossings or not. In Fig. 4, the respective columns 16-1, 16-2, ..., 16-5 of the shift register 16 show "1", "1", "0", "0" and "1" respectively.

Hence, when the antannas 7 and 8 are presently positioned across the crossing e, i.e., the antenna 7 passes the crossing e, the AND gate 17 outputs a digital signal "1" to an output terminal 18. The present location of the antennas and also that of the mobile object will be displayed on the shift register by combination of the digital codes which imply the absolute address of the object on the travelling route.

The intervals between crossings, outside the absolute position detecting area on the route of the object is set in a constant length larger than the interval, i.e., the distance between the antennas 7 and 9, whereby the phase comparator 14 always outputs "0" signal and the readings on the shift register 16 will become always "0". On the contrary, each time when the reference antenna 7 passes a crossing, the phase comparator 13 outputs "1" signal to the terminal 19 thereby provides location detecting signal with the moving object.

In Fig. 3, the AND gate 15 can be eliminated and the output terminal of the phase comparator 14 is connected directly to the shift register 16 and thus enables the output from the phase comparator 13 to be used as a drive signal for the phase comparator 14. The phase comparison of the induced currents in the antennas 7 and 9 will result in digital signals "1" or "0", only when the reference antenna 7 passes a crossing as shown in Figs. 2 and 4.

When the alignment of the antennas 7 and 8 are altered in Fig. 2, the comparison of the phases of the induced currents in the antennas 7 and 9 is carried out just before the reference antenna 7 has reached an crossing, instead of doing the same just after the reference antenna has passed a crossing.

In this case, the phase comparison circuit 14 is designed so as to output the digital signal "1" or "0", depending on whether the phases of the induced currents in the antennas and 9 are in the same phase or not, i.e., depending on the presence of the crossing 4 between the antennas 7 and 9, respectively.

In this way the address information about the mobile object is stored as "11001" in the shift register in Fig. 3 and thus enables the AND gate 17 to output signal "1" to the terminal 18.

Another example of the preferred embodiment of this invention is shown in Fig. 5. In the blockdiagram 17-1, 17-2, 17-3, ... 17-5 are AND gates, the other elements with numerals as equivalent to those in Fig. 3 are illustrated.

In Fig. 6 is exemplary of an arrangement of crossing within the absolute location, i.e., the address of an area in the twisted-pair type inductive radio-frequency lines 1. This illustrates the functions of the circuit in Fig. 5. In case that the interval between the crossings in the relative location detecting zone is designed to be larger than the interval between the aforementioned antennas 7 and 8, the shift register 16 maintains the reading of "0" in the relative location detecting area and therefore the address is kept unchanged as (00000) until the reference antenna 7 passes the crossing a in Fig. 6.

Thereafter, the first column of the shift register 16-1 shows "1" when the reference antenna 7 passes the crossing a and consequently the terminal 18-1 at the AND gate 17-1 outputs the signal "1". Similarly operation take place when the antenna 7 passes the crossings b, c, and so on and the AND gates 17-2, 17-3, 17-4, ... in Fig. 5 output "1" to the corresponding terminals 18-2, 18-3, 18-4 .... respectively. Hence, the address of the mobile object is determined at every crossing a, b, c, ... on the travelling route of the object.

Another preferred embodiment of the invention is shown in Fig. 7, in which numeral 20 designates a reference antenna, 21 designates an auxiliary antenna, 22 designates a comparison antenna. 1 designates a twisted-pair type radio-frequency lines, and 3 and 4 are crossings on the route of the travelling object. Reference antanna 20, as shown in Fig. 7-A, is located perpendicularly to the lines 1, and the auxiliary antenna 21 and the comparison antenna 22 in a parallel position to the same.

Fig. 7-B shows a relative value a of the power level received by the reference antenna 20 and in the vicinity of the crossing 3 an power level of the induced currents on

the antenna 21 and 22. The reference antenna 20 is vertically positioned and is being given the maximum power on the crossing and is also diminishing the power level up to zero as it leaves the crossing point. The antenna 21 and 22 being given almost zero power on the crossing and gradually the power level goes back to a constant value as it leaves the crossing.

On the other hand, the phases of the induced currents in the reference antenna 7 and 9 are either in the same phase or in the altered phase, depending on whether the crossing 4 is present between them or not.

The reference antenna 20, the auxiliary antenna 21 and the comparison antenna 22 are connected to the input terminals 7', 8' and 9' in Fig. 3 respectively, where the phase comparator 13 therein is to be replaced by a level comparator which is equivalent thereto in its function. The level comparator outputs "1" to one of the two input terminals of the AND gate 15, shift pulse terminal of the shift register 16, and output terminal 19. The other components in Fig. 3 function in the same manner as the mentioned examples.

In Fig. 7, the antennas 20 and 21 may be set with an interval equal to the minimum interval of L in the lines 1, so that the levels of the induced currents in both the antennas 20 and 22 be compared only when the antenna 20 is positioned in the vicinity of the crossing. The results of the comparison in such configuration are shown in Fig. 7-C. The levels at the antennas 7 and 9 are about equal so that the comparison results are "0"s and in Fig. 7-D, where the antenna 9 is positioned at the crossing 4, is almost zero in power level and the comparison results in always.

As described above, the spaces between the neighbouring two crossings in the inductive lines may be expressed by the two values, namely p1 and p2, where p2 is larger than p1. In a preferred embodiment of the present invention, the only one requisit for p1 and p2 is to satisfy with the following equations:

(1) $\ell/2<p1\leqq$ and $p2>\ell$

or

(2) $p1\leqq\ell<p2$ and $\ell<2p1$

These conditions imply that p1 is larger than $\ell/2$ so that the number of crossings which are present between the two antennas of 7 and 9 are kept unchanged along the lines. For instance one crossing may exist in the case of Fig. 2, and two crossings always exist when the antenna 7 and 8 are exchanged in position along the inductive lines. The another implication of the above equation is that p1 is less than ℓ in order to detect the absolute position of the mobile object. The another implications of the above equations are that p1 is less than ℓ when the absolute address of the mobile object on the inductive lines with short distance between the neighbouring two crossings. On the contrary it is required that p2 is larger than ℓ when detection of the absolute position of the object is necessary along the inductive lines with long distance of the neighbouring two crossings.

There have been shown various modification of the comparing circuitry. There have been shown various modifications of the circuitries for comparing the phasers or levels of the currents induced in the reference antenna 20 and in the auxiliary antenna 21. In brief, they are enough to operate as a proper detecting means for the position of the reference antenna in the vicinity of the crossing and actuates the comparator or its output which compares the phases or the levels of the current induced.

As described in details, the purpose of the present invention is to provide simple and economical means for detecting an absolute position of a mobile object on its travelling lines. The combination of large and small intervals between crossings of the radio-frequency inductive lines and the reference and comparison antennas are utilized. It should be emphasized that many modifications can be done within the scope of the present invention.

WHAT IS CLAIMED IS:

A system for detecting mobile object on the predetermined route utilizing twisted-pair type inductive radio lines, which are installed along said travelling route of the object,

1. said system being characterized in that said inductive lines comprising a plurality of crossings and intervals of the specific two different length p1 and p2 within an area necessary for detecting the absolute position of the mobile object and p2 is larger than p1.

2. the mobile object is equipped with a reference antenna and a comparison antenna and the space between said antennas ℓ meets with the following equations:

$$p1 \leqq \ell < p2 \text{ and } \ell < 2p1$$

3. the currents induced in the antennas of Claim 2 are compared in terms of phases and power levels and output signal of "1" or "0" depending on the coincidence or non-coincidence of the comparison results.

4. detection means for the presence of the reference antenna in the vicinity of a crossing in said inductive radio lines to thereby actuate said comparison means or an output thereof.

5. discrimination means for storing an output of said comparison means to discriminate said stored contents.

FIG. 1

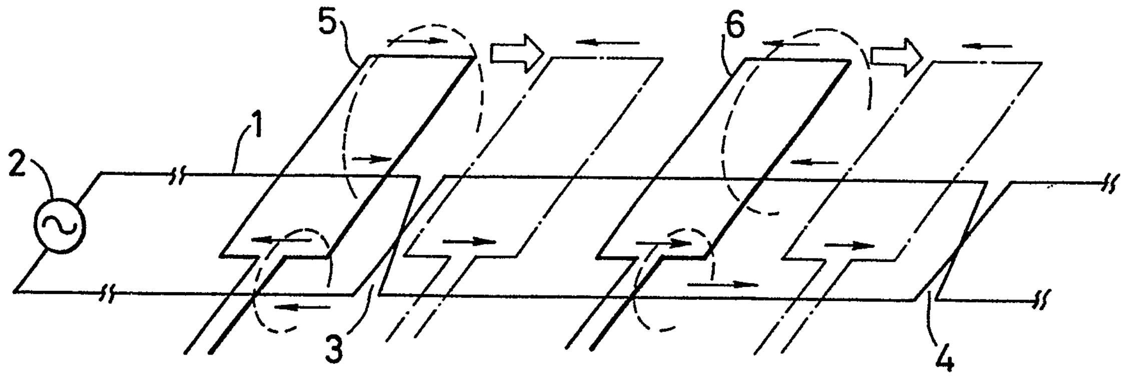


FIG. 2

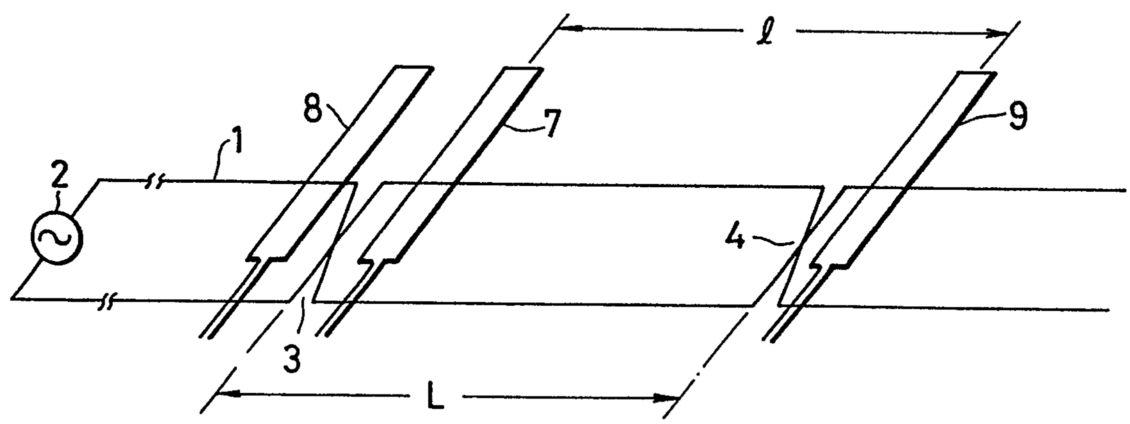
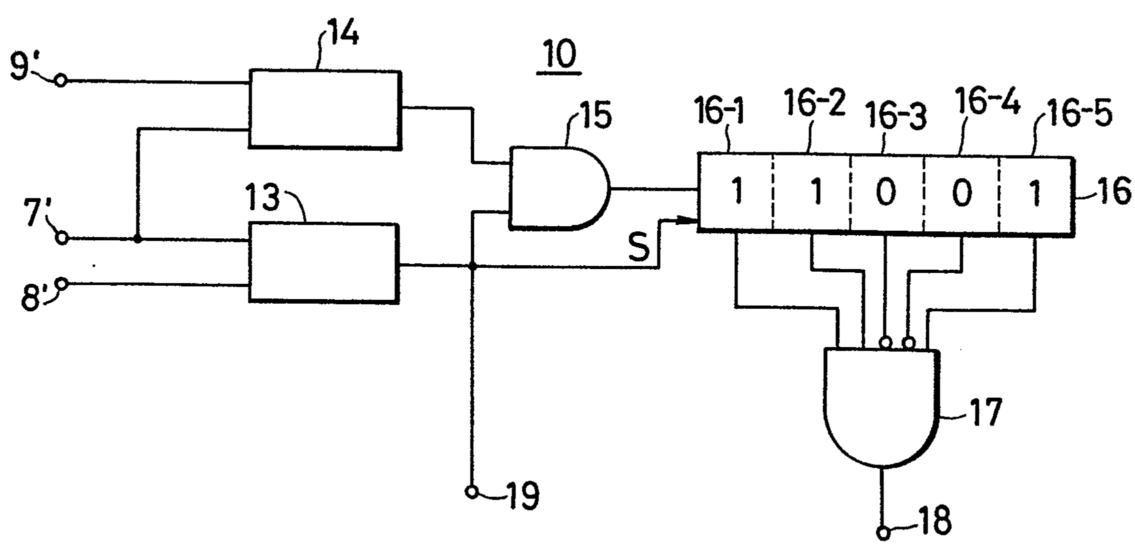


FIG. 3



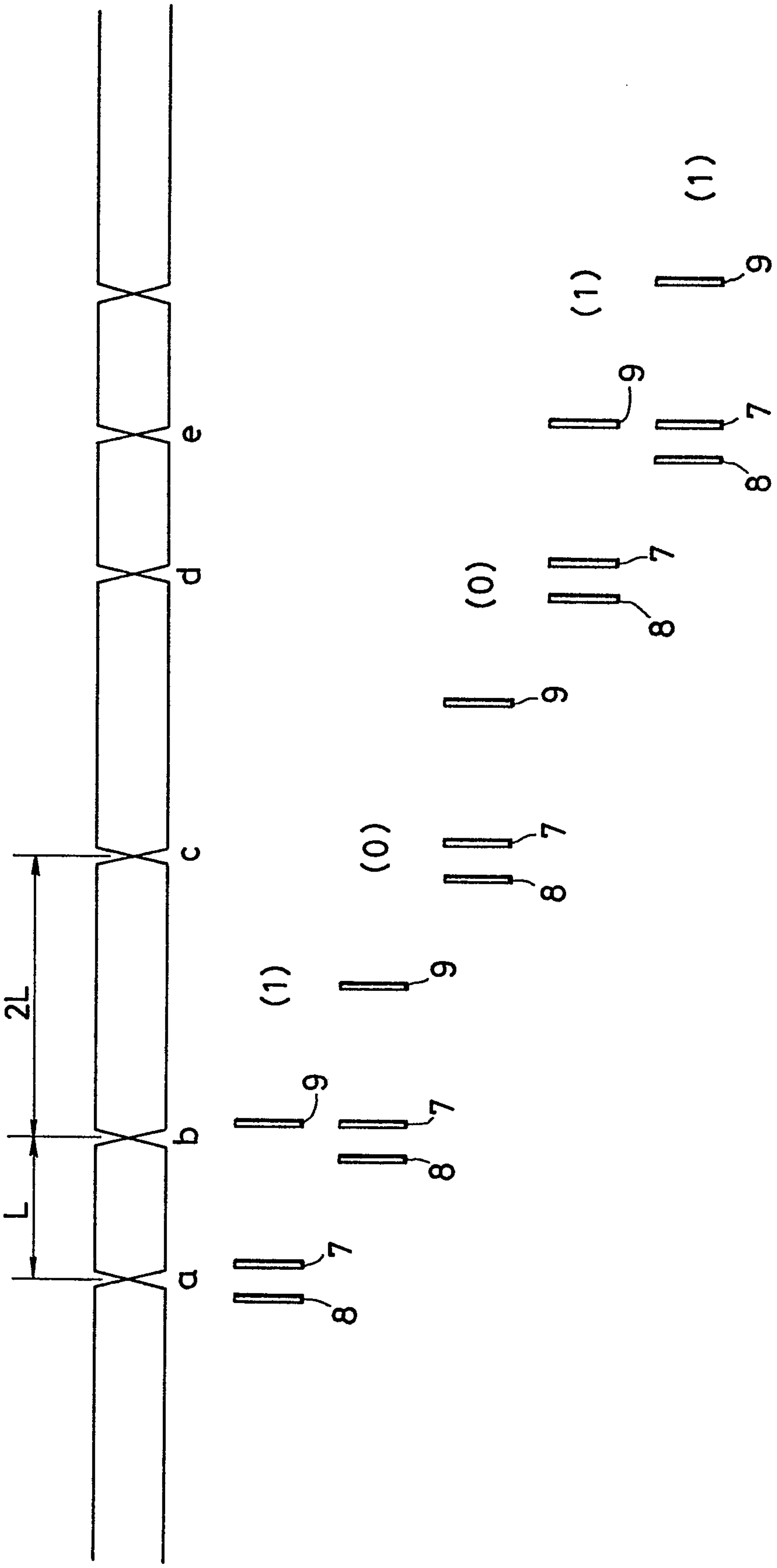


FIG. 4

FIG. 5

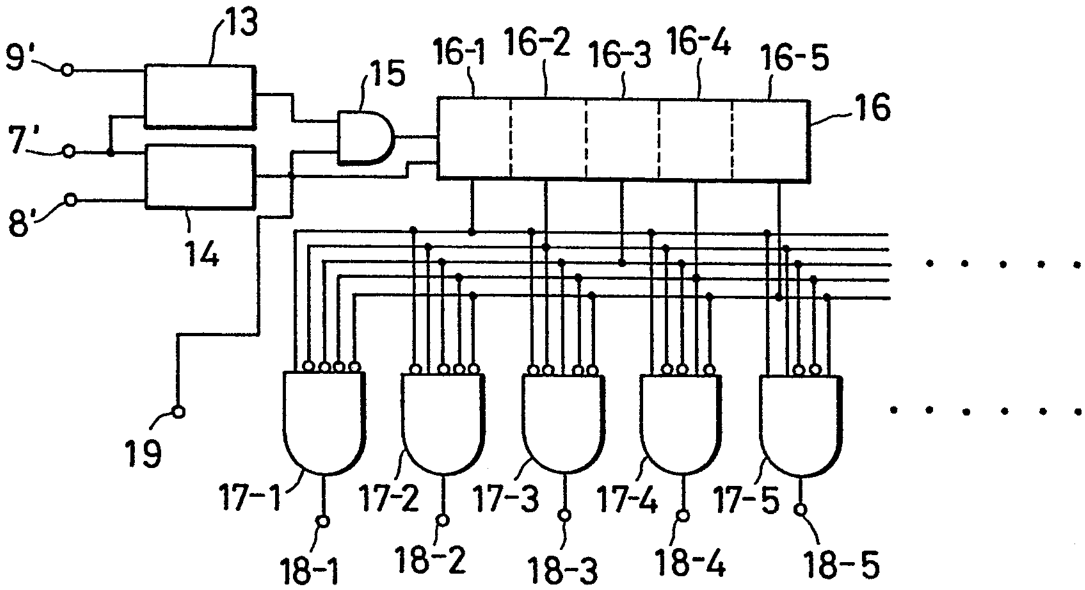

9'
7'
8'
13
14
15
16-1
16-2
16-3
16-4
16-5
16
19
17-1
17-2
17-3
17-4
17-5
18-1
18-2
18-3
18-4
18-5

FIG. 6

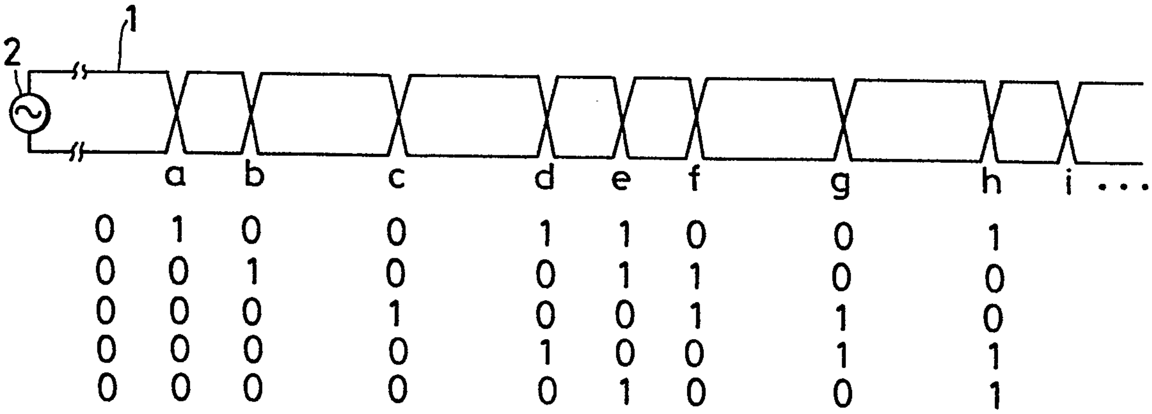

1
2
a b c d e f g h i ...
0 1 0 0 1 1 0 0 1
0 0 1 0 0 1 1 0 0
0 0 0 1 0 0 1 1 0
0 0 0 0 1 0 0 1 1
0 0 0 0 0 1 0 0 1

FIG. 7A

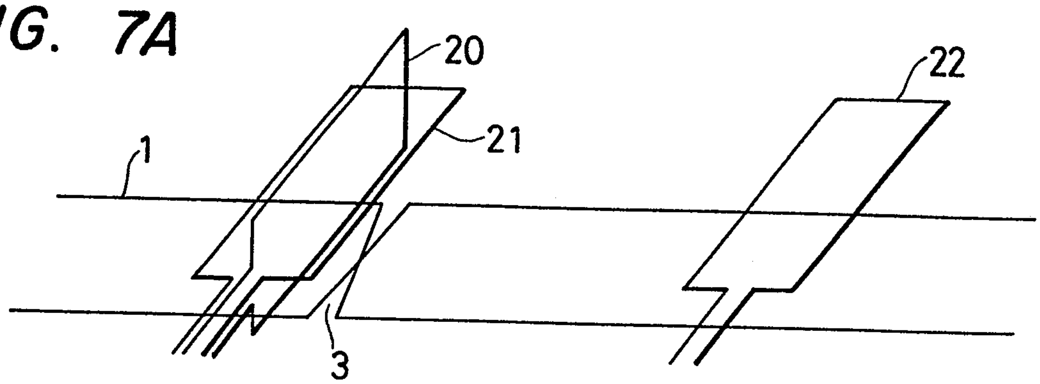


FIG. 7B

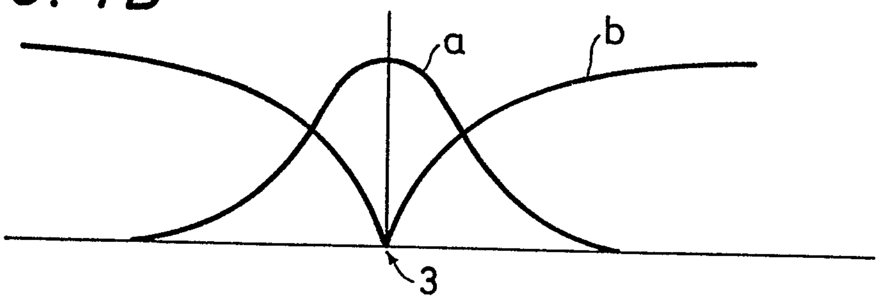


FIG. 7C

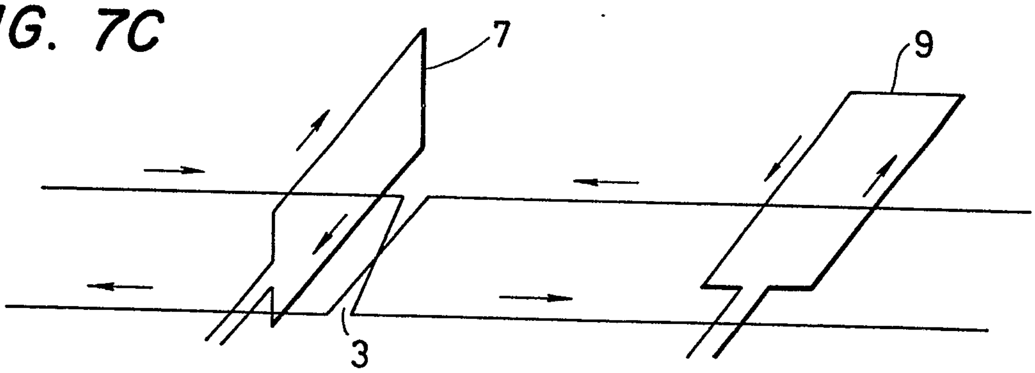
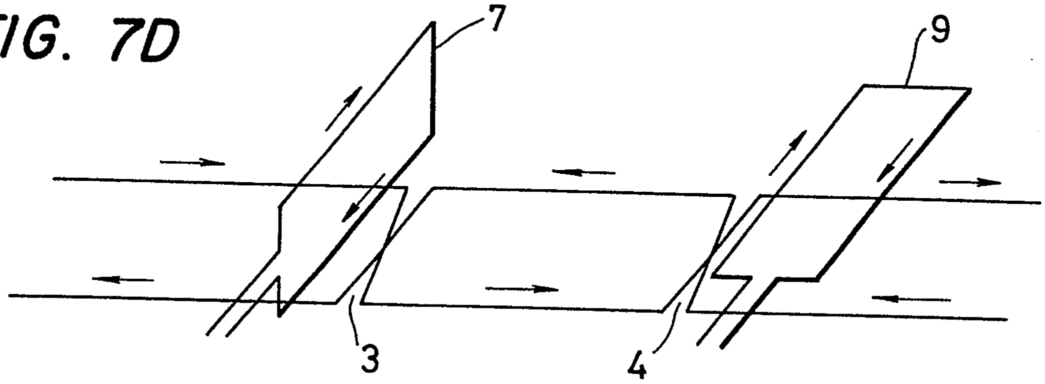


FIG. 7D



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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 82 10 6432

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	US-A-3 588 494 (MERTENS) *The whole document* ---	1	B 61 L 25/02
A	DE-A-2 819 430 (LICENTIA) *Page 5, line 8 to page 6, line 18* ---	1	
A	FR-A-2 369 136 (INT. STANDARD ELECTRIC) *The whole document* -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 61 L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-03-1983	SGURA S.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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