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(11) **EP 1 146 160 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.10.2001 Bulletin 2001/42

(51) Int Cl.7: **D06F 37/20**

(21) Application number: **01102353.8**

(22) Date of filing: **02.02.2001**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**
Designated Extension States:
AL LT LV MK RO SI

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(30) Priority: **27.03.2000 IT PN200017**

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(54) **Clothes washing machine with oscillating assembly displacement transducer**

(57) The oscillating assembly (3) of the washing machine is arranged at a distance (L) from an ultrasonic receiver (8) mounted on the outer casing (1) of the machine in a position on a side of an emitter (7). The ultra-

sounds are reflected by the oscillating assembly (3) and are intercepted, ie. picked up by the receiver (8) with a phase angle whose variations are indicative of the displacements of the oscillating assembly (3).

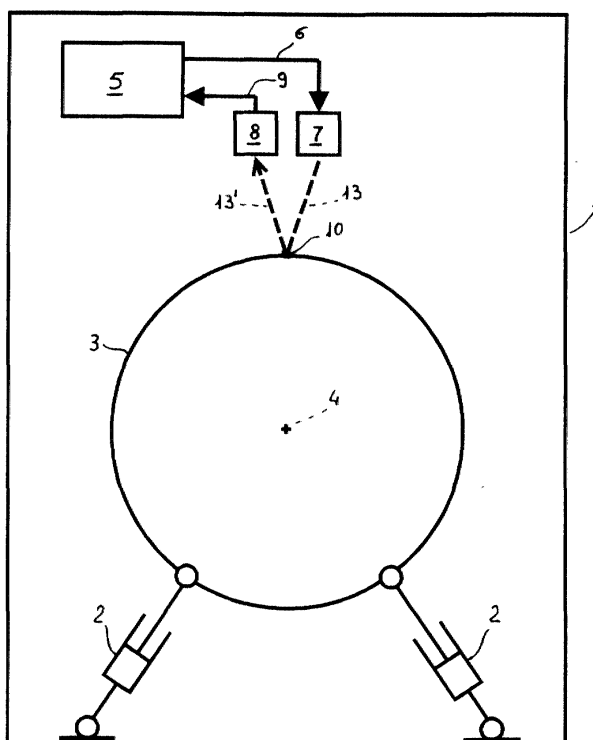


Fig. 1

Description

[0001] The present invention refers to a washing machine, such as a clothes washing machine, a combined clothes washing and drying machine and the like, provided with an improved kind of arrangement acting as a transducer of the displacement of the oscillating assembly of said machine.

[0002] Such an oscillating assembly of a clothes washing machine is generally known to include a drum adapted to rotate inside a washing tub, and to be connected to the outer casing of the machine through an arrangement of vibration-damping and shock-absorbing means that generally enable it to displace in a just moderate, ie. appropriately dampened manner with respect to a resting position thereof. The extent of such displacement under static conditions, ie. when the clothes are loaded in the rotating drum, enables the weight of the same clothes, ie. the washload, to be calculated and, as a result, the washing process parameters, such as for instance the most adequate amount of detergent to be used, to be adjusted and adapted accordingly.

[0003] A measurement of the displacement of the oscillating assembly under dynamic conditions, particularly when the drum is rotating at high spin-extraction speeds, enables the possibility for the same oscillating assembly to be thrown or move off its balance to be minimized, so as to automatically ensure a correct dynamic trim thereof, for instance as this is described in EP-A-0 878 574.

[0004] Various types of transducers are known in the art to be adapted to detect the static and/or dynamic displacement of the oscillating assembly of a washing machine. In particular, they may include dynamic pressure-responsive metering devices, such as described for instance in EP-A-0 885 993, or differential-inductance systems.

[0005] All these kinds of transducers require some of their parts to be physically connected to both the stationary outer casing of the washing machine and the suspended oscillating assembly, so that their installation turns out to be undesirably arduous and critical on a mass-production scale.

[0006] In any case, since relative distances and displacements between the component parts being controlled are quite small, ie. of a rather limited extent, especially under static conditions, it actually is very difficult for the displacements of the oscillating assembly to be measured in a satisfactory manner as far as sensitivity and accuracy are concerned, unless particularly sophisticated and expensive devices are used, which are however practically out of question in, ie. clearly beyond the scope of household appliance applications.

[0007] On the other hand, even a sophisticated sonar system would prove scarcely adapted to measure the displacements of the oscillating assembly of a washing machine, which are in the order of a few centimetres under dynamic conditions, and just a few millimetres un-

der static conditions. In fact, sonar systems, which are usually based on the measurement of the travelling time of reflected waves, are not capable of working to any satisfactory extent in the rather narrow space available inside a household appliance, which allows for just extremely reduced travelling times of said waves.

[0008] It therefore is a purpose of the present invention to provide a washing machine equipped with a transducer adapted to pick up and measure the displacement of the oscillating assembly thereof, which not only is particularly simple and low-cost from both a construction and assembly viewpoint, but also proves advantageously sensitive and accurate.

[0009] In particular, it is a purpose of the present invention to provide a washing machine equipped with a displacement transducer of the above cited kind, which is capable of satisfactorily measuring the displacements of the oscillating assembly also under static conditions thereof, so as to enable the weight of the washload, ie. the clothes loaded in the drum, to be effectively calculated.

[0010] According to the present invention, these and further aims are reached in a washing machine provided with an oscillating-assembly displacement transducer having the characteristics as recited in the appended claims.

[0011] Anyway, features and advantages of the present invention will be more readily understood from the description that is given below by way of nonlimiting example with reference to the accompanying drawings, in which:

- Figure 1 is a schematical view of a washing machine according to the present invention;
- Figure 2 is a basic schematical view of a preferred embodiment of the washing machine illustrated in Figure 1; and
- Figure 3 is a schematical view of some signals as processed in the arrangement illustrated schematically in Figure 2.

[0012] With particular reference to Figure 1, the washing machine mainly comprises a stationary outer casing 1 which supports, through an arrangement of vibration-damping and shock-absorbing means 2, an oscillating assembly 3 comprising a washing tub inside which there is adapted to rotate, preferably about a substantially horizontal axis 4, a drum holding the washload.

[0013] The main operating parts and arrangements of the machine are controlled by a programme sequence control unit 5, preferably of the electronic microprocessor-based type, that has an output 6 driving an emitter 7 of ultrasounds 13, as well as an input 9 driven by an ultrasound receiver 8. For example, the emitter-receiver unit 7, 8 may comprise respective piezo-electric ultrasonic sensors Murata MA40S4, which are low-cost, do

not take up any significant space, and are suitable to the particular purpose.

[0014] With reference also to Figure 2, the ultrasound emitter 7 and/or the ultrasound receiver 8 are preferably mounted in a fixed position on the casing 1 of the washing machine, at a pre-determined distance L from a reference zone of the oscillating assembly, as generally indicated at 10 in the Figures. In particular, the receiver 8 is adapted to pick up the ultrasonic waves 13' which, upon having being transmitted by the emitter 7, are reflected by the above mentioned reference zone 10.

[0015] Preferably, the emitter 7 and the receiver 8 are arranged on a side of each other, ie. on a side-by-side arrangement, at the same distance L from the oscillating assembly 3, along a preferably vertical axis 11 passing through said reference zone 10.

[0016] With reference also to Figure 3, the above cited output 6 corresponds to the output of a generator 12 of a square wave having for instance a frequency of 40 kHz. This square wave triggers the emitter 7 to transmit towards the oscillating assembly 3 a beam of ultrasonic waves 13, at a corresponding frequency (Figure 3a), wherein said beam is reflected towards the receiver 8. This receiver 8 generates a corresponding square-wave signal at its output 9.

[0017] As this has been demonstrated also experimentally, the ultrasonic waves 13' that are picked up by the receiver 8 (Figure 3b) upon having been reflected by the oscillating assembly 3 have the same frequency as the transmitted ones 13, but show a phase difference, or phase angle, that depends on the distance L. When the rotating drum of the washing machine is empty and under static conditions, the distance L will have a known reference value and also a possible phase angle between the transmitted ultrasonic waves 13 and the reflected ones 13' will have a known reference value.

[0018] As a result, a possible displacement of the oscillating assembly 3 in the direction 11 with respect to said static reference position will determine a corresponding variation in the phase angle between the transmitted ultrasounds 13 and the ultrasounds 13' that are picked up by the receiver 8. In other words, a possible variation in the distance L can be calculated on the basis of the variation in the phase angle between the ultrasounds 13 transmitted by the emitter 7 and the ultrasounds 13' picked up by the receiver 8.

[0019] In the preferred embodiment that is described by way of example, the possible displacement of the oscillating assembly 3 is detected by comparing, in a phase comparator 14, the square-wave signals that are present at the output 6 of the generator 12 (triggering signals shown in Figure 3a) with the square-wave signals that are on the contrary present at the output 9 of the receiver 8 (reflected signals shown in Figure 3b). The variations in the error signal generated by the phase comparator 14, as possibly filtered, levelled and/or amplified, are representative of corresponding displacements of the oscillating assembly 3 and can be used by

the programme sequence control unit 5 in an appropriate manner.

[0020] In particular, when the washing machine is under static conditions and the clothes to be washed are loaded into the drum, the corresponding variation in the error signal is indicative of the resulting downward displacement of the drum and, therefore, the weight of the clothes loaded thereinto.

[0021] When on the contrary the drum is rotating, for instance at any high spinning speed, the variation in the afore mentioned error signal is indicative of the dynamic unbalance condition of the oscillating assembly 3, which therefore will in this way be able to be corrected automatically as described for instance in the afore cited publication EP-A-0 878 574.

[0022] In principle, the wave lengths corresponding to the typical frequencies of the ultrasounds are adequate in view of a sufficiently accurate measurement of a distance L, which is in the order of 5 to 10 cm. In the practical example being described here, however, in order to be able to correctly measure the variations in the distance L that are typical of a washing machine it may be preferable for the frequency of the signals driving the phase comparator 14 (ie. the frequency of the transmitted signal 13 and the reflected signal 13') to be divided by a constant factor N. This factor N will have such a value (4, for instance) as to allow for the extent of resolution which is required by the application within a controlled range containing the possible displacements with the necessary margin for compensating construction tolerances and the system's inherent zero error. As far as the assessment of the unbalance is concerned, owing to a smaller resolution being required due to greater displacements being actually involved, said value N may be greater.

[0023] To this purpose, the signals available at the outputs 6 and 9 are sent to the phase comparator 14 via respective frequency dividers 15, 16, one of which (the divider 15, shown in Figure 2) is preferably adapted to also shift by 90° at the output the phase of the signal received at its own input. As a result, the phase comparator 14 turns out to be driven by the square-wave signals shown in Figures 3c and 3d, respectively, and is adapted to generate at its output an error signal that is shaped as shown in Figure 3e and contains the information concerning the variations in the distance L, ie. the displacement of the oscillating assembly 3 along the direction 11. It should be noticed that the above mentioned 90° phase shift between the two signals driving the comparator 14 most advantageously enables a clear and significant error signal to be obtained regardless of the actual direction in which the oscillating assembly 3 moves along the axis 11 when displacing.

[0024] It will be appreciated that the above described washing machine may be the subject of a number of modifications without departing from the scope of the present invention.

[0025] For example, anyone skilled in the art will be

capable of concluding that the displacement of the oscillating assembly 3 can be also determined by comparing the instantaneous phase of the signal 13' picked up by the receiver 8 with a reference value, ie. with the phase of the same signal 13' when the washing machine is at rest under static conditions. This reference value can be quite easily stored and compared with said instantaneous phase of the signal 13' so as to obtain a signal that is substantially equivalent to the afore cited error signal.

[0026] The possibility is also given, without any functional modification being actually required, for the emitter 7 and/or the receiver 8 to be mounted on the oscillating assembly 3, in which case the afore cited reference zone 10 would be situated in a fixed position on the outer casing 1 of the washing machine.

[0027] It will furthermore be appreciated that the displacement of the oscillating assembly may be measured similarly to the above described concept by aligning the emitter-receiver array 7, 8 and the reference zone 10 along an axis 11 that differs from the vertical one. In this case, all those skilled in the art are capable of appreciating that the weight of the washload and/or the dynamic unbalance of the oscillating assembly can be calculated by the programme sequence control unit 5 by processing the signal generated at the output 17 of the comparator 14 according to a correspondingly different algorithm that is not a part of the present invention.

[0028] In any case, the washing machine according to the present invention enables the displacements of the oscillating assembly 3 to be controlled with a high degree of sensitivity and accuracy through the utilization of simple, low-cost and reliable means that can be most conveniently and quickly mounted solely on the outer casing 1 or the oscillating assembly 3.

Claims

1. Washing machine provided with a displacement transducer for the displacement of an oscillating assembly connected through vibration-damping and shock-absorbing means to a stationary outer casing of the machine, **characterized in that** said transducer comprises ultrasound emitter means (7) and ultrasound receiver means (8) arranged at a variable distance (L) from a reference zone (10) situated on said oscillating assembly (3) or said stationary outer casing (1), in which said emitter means (7) are adapted to emit ultrasounds (13) having a pre-determined frequency and phase, and said receiver means (8) are adapted to pick up ultrasounds (13') that are reflected by said reference zone (10) and have a phase difference, ie. phase angle, with respect to said emitted ultrasounds (13), which is indicative of said distance (L), and in which comparator means (14) are provided to detect the variations in said phase angle and drive with a corre-

sponding error signal appropriate user means (5) adapted to calculate the corresponding static and/or dynamic displacements of said oscillating assembly (3) with respect to the outer casing (1).

2. Washing machine according to claim 1, **characterized in that** said ultrasound emitter and receiver means (7, 8) are attached to the outer casing (1) of the machine, whereas said reference zone (10) is situated on the oscillating assembly (3).
3. Washing machine according to claim 1, **characterized in that** said ultrasound emitter and receiver means (7, 8) are attached to the oscillating assembly (3), whereas said reference zone (10) is situated on the outer casing (1) of the machine.
4. Washing machine according to claim 1, **characterized in that** said ultrasound emitter and receiver means are provided in a substantially side-by-side arrangement, at the same distance (L) from said reference zone (10).
5. Washing machine according to claim 1, **characterized in that** said ultrasound emitter and receiver means (7, 8) are arranged at said distance (L) from the reference zone (10) along a substantially vertical axis (11).
6. Washing machine according to claim 1, **characterized in that** said comparator means (14) are driven by a first signal that is representative of the ultrasounds (13) emitted by said emitter means (7), and a second signal that is representative of the ultrasounds (13') picked up by said receiver means (8).
7. Washing machine according to claim 6, **characterized in that** said first and said second signals drive said phase comparator (14) via frequency divider means (15, 16).
8. Washing machine according to claim 7, **characterized in that** said frequency dividers (15, 16) are adapted to shift by substantially 90° the phase of said first signal with respect to the phase of said second signal, or vice-versa.

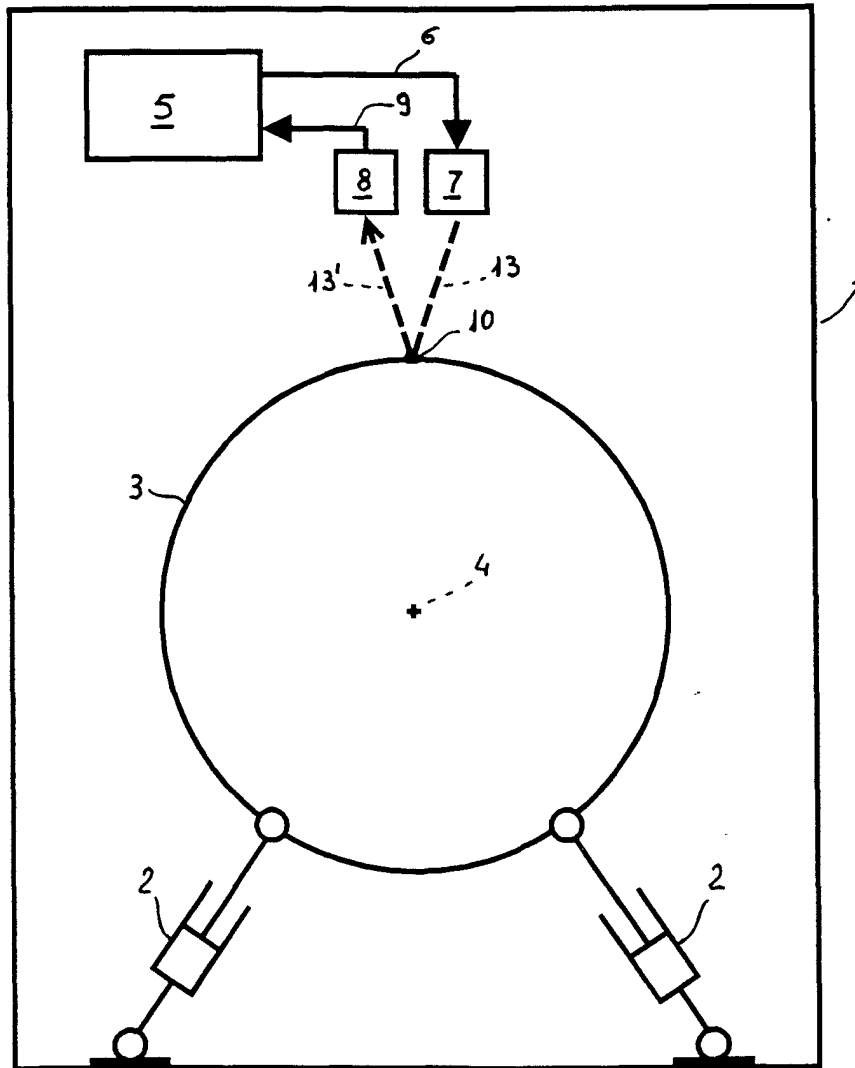
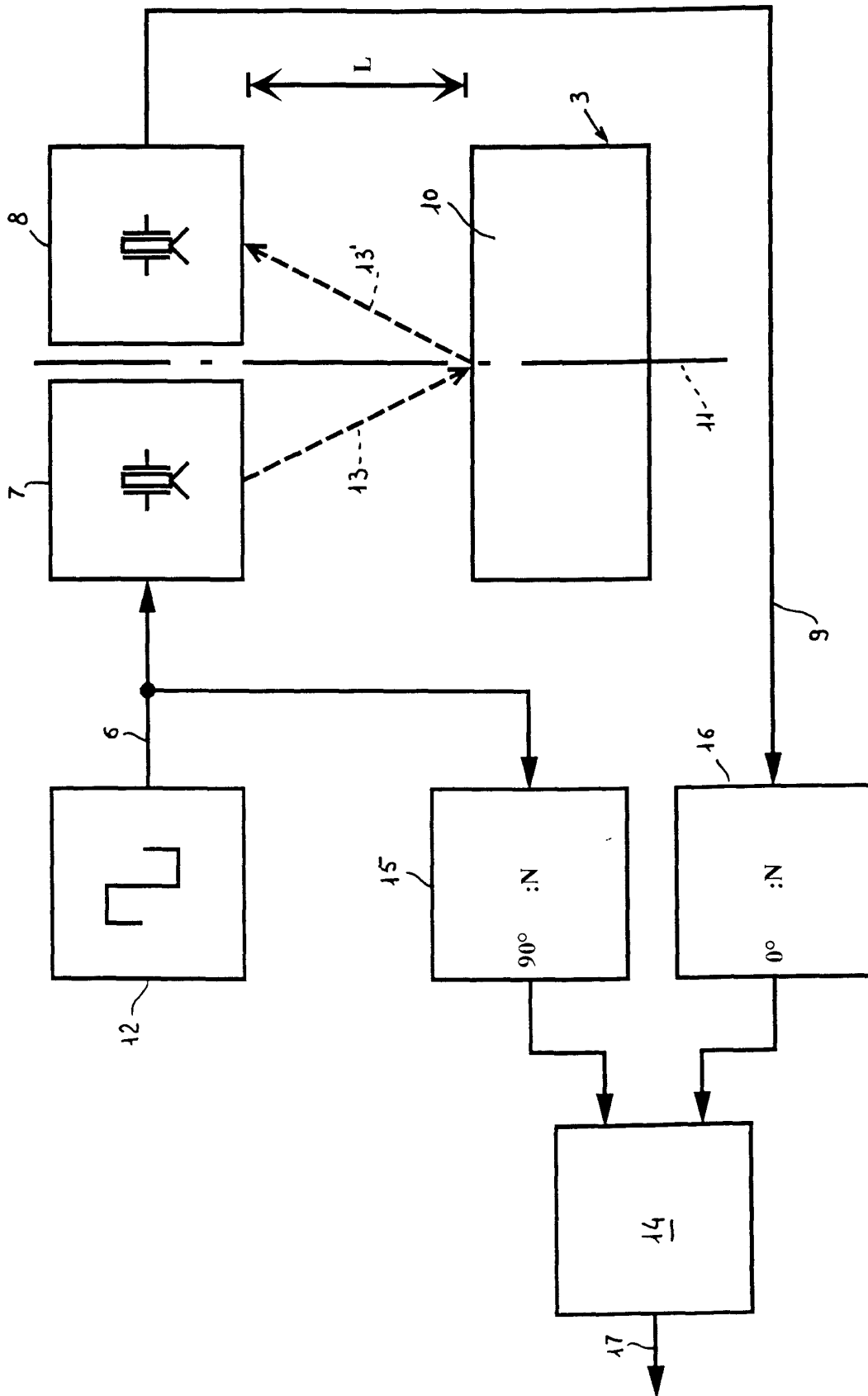


Fig. 1



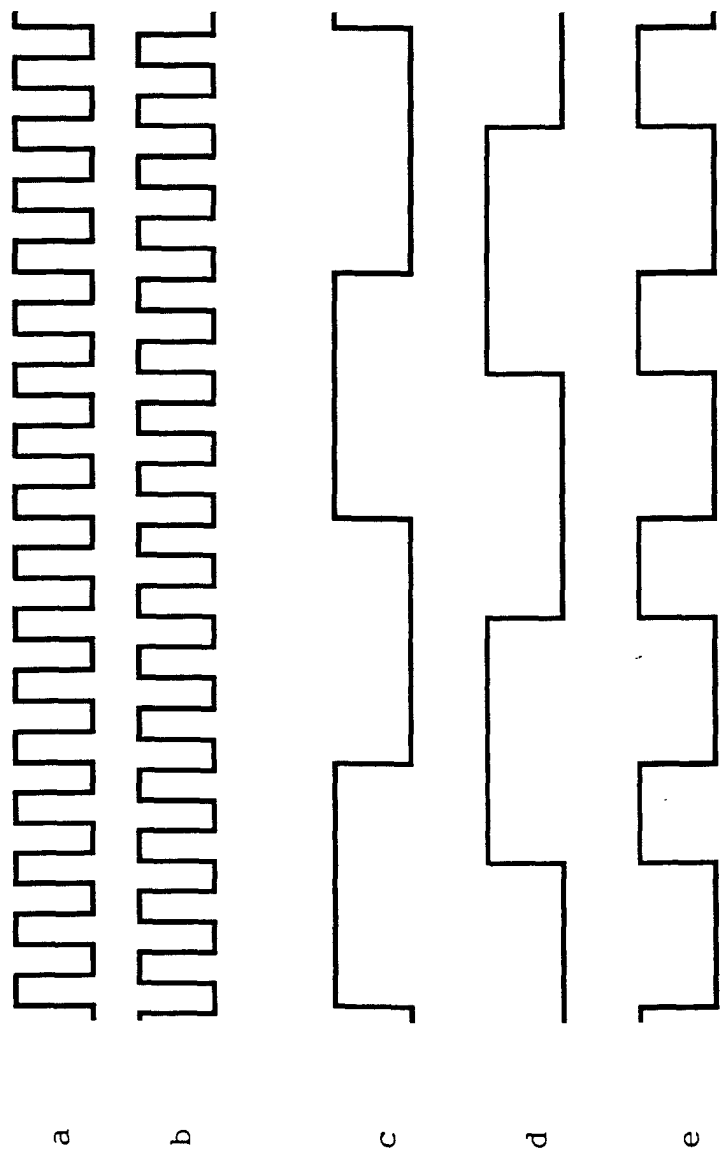


Fig. 3