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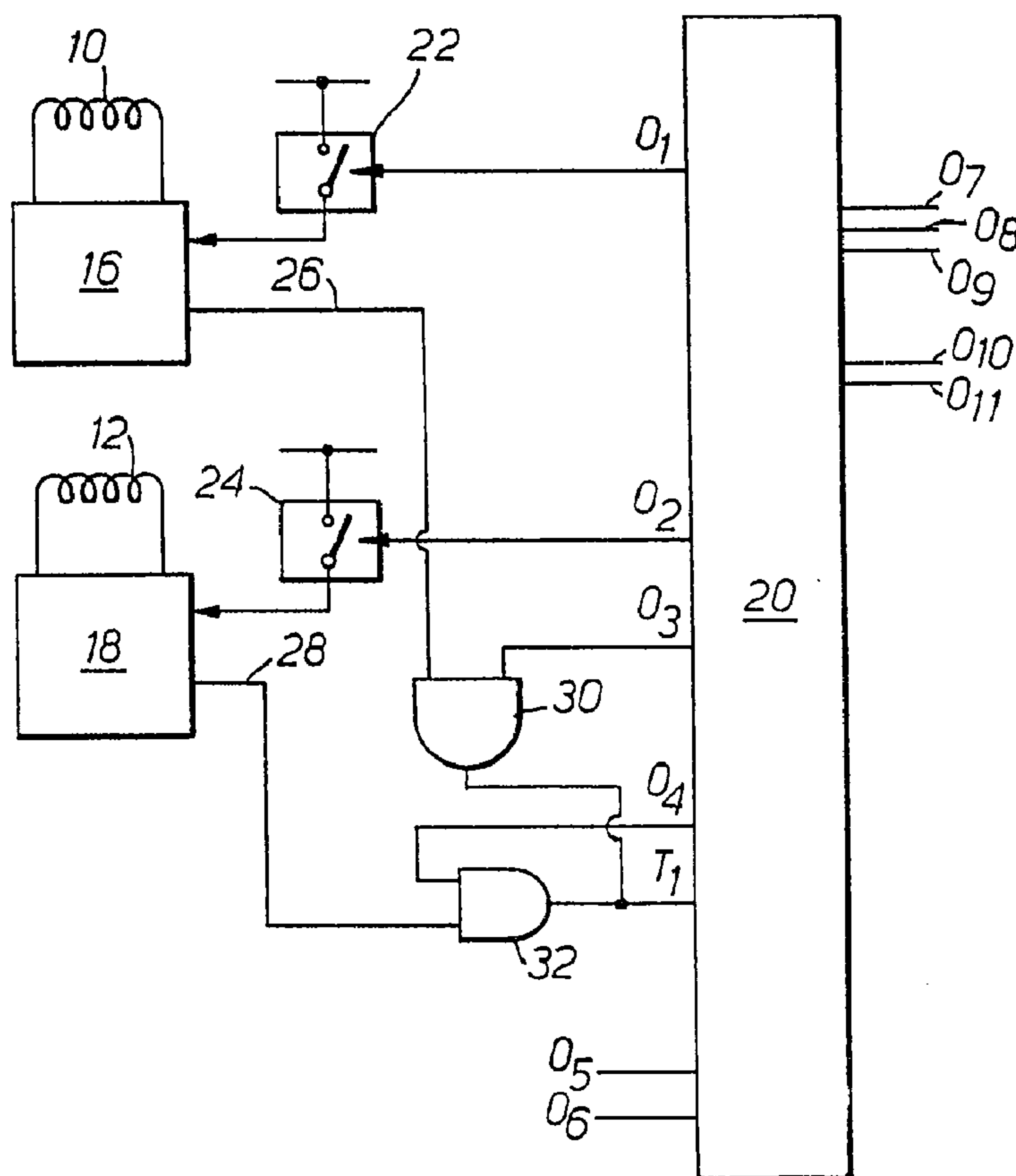
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(54) **DISPOSITIFS DE VALIDATION DE PIECES DE MONNAIE**

(54) COIN VALIDATORS



(57) A coin validator (2) has a thickness sensor formed by two coils (10, 12) positioned one on each side of the coin path. The coil outputs are processed separately using a look-up table (20) to derive values which are linearly related to coin position across the width of the passage, using the same constant of proportionality for both sensors. Accordingly, by combining the processed outputs there is derived a value which is independent of coin position and which can be peak-detected to indicate thickness.



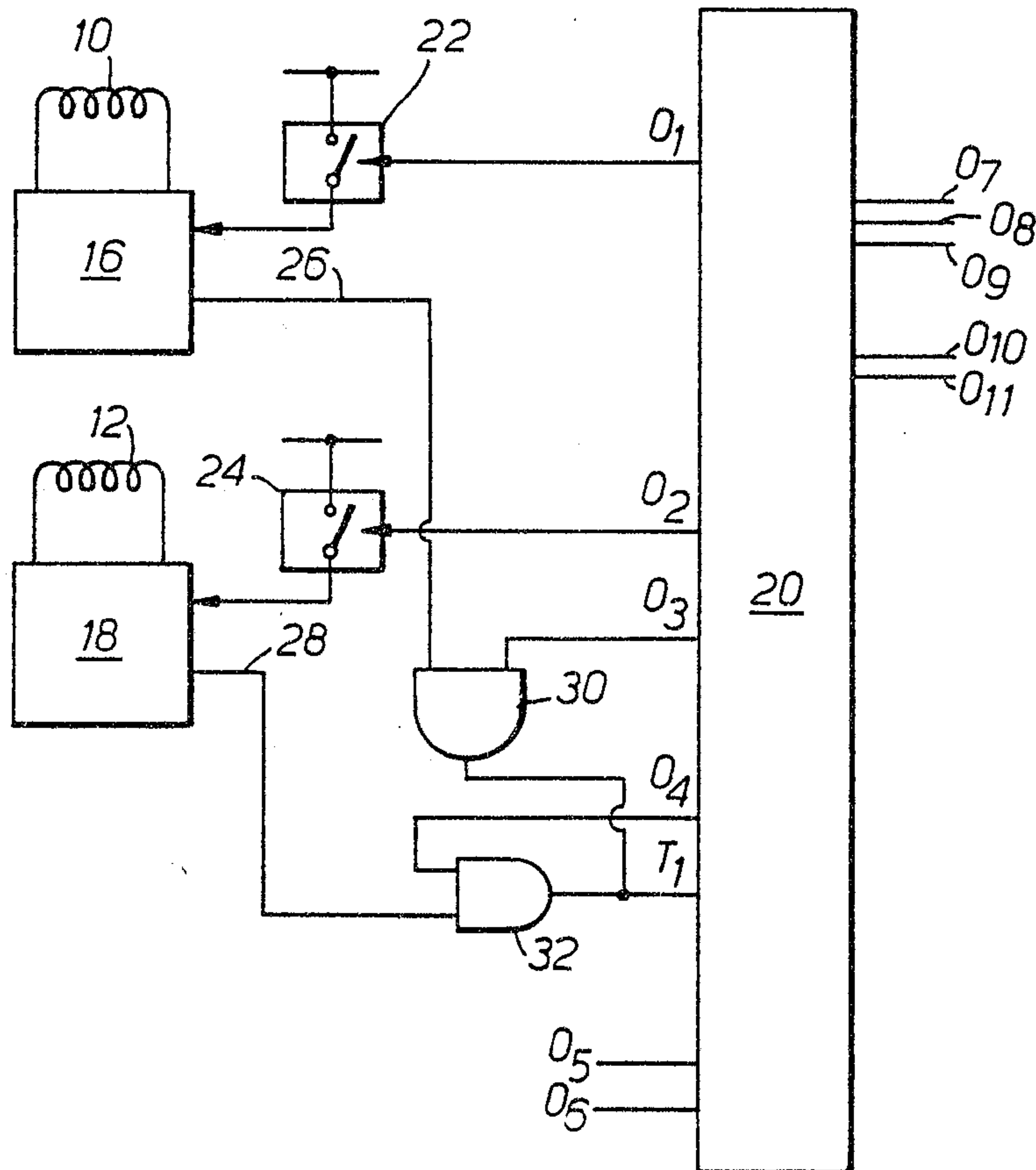
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(21) International Application Number: PCT/GB90/01168 (22) International Filing Date: 27 July 1990 (27.07.90) (30) Priority data: 8917258.9 28 July 1989 (28.07.89) GB (71) Applicant (for all designated States except US): MARS INCORPORATED [US/US]; 6885 Elm Street, McLean, VA 22101-3883 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): WAITE, Timothy, Peter [GB/GB]; 31 Severn Drive, Hinchley Wood, Esher, Surrey KT10 0AJ (GB). ALLAN, Richard, Douglas [GB/GB]; 2 Dartmouth Terrace, Kendrick Road, Reading, Berkshire (GB).		(74) Agent: R.G.C. JENKINS & CO.; 26 Caxton Street, London SW1H 0RJ (GB). (81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), HU, IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), SU, US. Published With international search report.	

(54) Title: COIN VALIDATORS

(57) Abstract

A coin validator (2) has a thickness sensor formed by two coils (10, 12) positioned one on each side of the coin path. The coil outputs are processed separately using a look-up table (20) to derive values which are linearly related to coin position across the width of the passage, using the same constant of proportionality for both sensors. Accordingly, by combining the processed outputs there is derived a value which is independent of coin position and which can be peak-detected to indicate thickness.



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COIN VALIDATORS

This invention relates to coin validators, and is particularly concerned with coin thickness sensors for such validators.

5 It is well known to provide a coin validator which has a coin sensor for testing coins by subjecting them to an electromagnetic field and determining the effect of the coin on the field, for example, by measuring the change in the amplitude
10 and/or frequency of the sensor output. Some sensors are used to produce a result which is predominantly dependent upon the coin thickness. The sensor output will also be influenced by other factors, but this does not affect the ability of the sensor to
15 distinguish between coins of different types and therefore other such influences will be ignored for the purposes of the present specification.

 A thickness sensor may consist of a coin driven at a relatively high frequency and positioned at one
20 side of the coin path. As the coin passes, it travels along a ramp which is so inclined that the coin face tends to lie against a reference plane as the coin passes the sensor. The coil is located on the other side of the passageway, and its field will be

influenced to an extent depending on the location of the coin's closest face with respect to the coil, which in turn will depend on coin thickness. However, in spite of the inclination of the ramp, the coin
5 flight tends to be fairly unstable and therefore errors are encountered due to the possible variations in the coin position with respect to the coil.

In order to mitigate such problems, some thickness sensors are formed with two coils connected
10 together in series or parallel. A first one of the coils is close to the reference plane and the other is at the opposite side of the passageway. For a coin of a particular thickness, any reduction in the effect of the coin on the first coil's field caused by the coin
15 being spaced away from the reference plane is substantially compensated by an increase in the effect of the coin on the other coil's field. However, this is only effective for variations close to a so-called "balance point", and therefore such improvements tend
20 to apply only to a fairly small range of coin thicknesses, and a small range of coin positions with respect to the reference plane.

Attempts have been made to stabilise the coin flight, using for example snubbers for absorbing the
25 coins' kinetic energy, but the problem still remains. Furthermore, it is becoming more desirable to reduce

the size of coin validators, and this tends to increase the coin flight instability in that it reduces the distance in which the coins' flight might be stabilised prior to reaching the sensors.

According to the present invention there is provided a method of testing coins for thickness using a pair of inductances positioned on respective sides of a coin path, the outputs of which are combined to produce a thickness indicating signal, said signal being substantially independent of coin position over at least a limited position range between said inductances for a given coin thickness, comprising the steps of: producing separate inductance output values each indicative of the effect of a coin on an electro-magnetic field as detected by a respective one of the inductances, the gradients of the dependencies of said inductance output values upon the position of a said coin of said given thickness within said position range being different, and; processing at least one of the inductance out-put values and combining the values so as to generate said thickness indicating signal, the processing of said at least one inductance output value being different to that of the other so as to substantially compensate said thickness indicating signal for said gradient difference.

By separating the measurements of the effects detected by the respective inductances, it is possible to take into account the displacement of the coin from each
5 of the respective inductances, and thus provide a measurement which is independent of such displacements.

Preferably, the processing is such that the values which are combined alter substantially in proportion to changes in the position of the coin between the
10 inductances with substantially the same constant of proportionality.

If there is any non-linearity in either of the output values from the inductances or sensors with

respect to coin position, this may be substantially eliminated by the processing. Also, if the ratio between changes in sensor output values and changes in position differs between the sensors, this may be compensated for by appropriate scaling of one or both of the sensor output values. The processing could be achieved by using a look-up table storing predetermined processed values correlated with possible sensor output values. Alternatively, the processing could be achieved by using an appropriate algorithm to operate upon the sensor output values, in which case it may be possible to perform the processing and combining steps simultaneously using a single algorithm.

It is common for a sensor output value to be derived from the signal produced by the sensor when the influence of the coin is at a peak. Such a technique could be used in the present invention for separately deriving each of the sensor output values. However, although this would still permit thickness measurements which are less influenced by coin position than in prior art arrangements, errors may occur due to the position of the coin changing during the time that it passes the sensors, or due to the possibility of the coin travelling in an inclined orientation as it passes the sensors. In either of

these situations, each sensor output value will be indicative of the closest position of the coin in the interval while it is passing the sensor. The combined values will thus produce a thickness measurement which is too high.

A preferred aspect of the invention is intended to eliminate or mitigate the effects of this further source of measurement error. According to this preferred aspect, both sensor output values are indicative of the effect of the coin on the sensors at substantially the same time. This time occurs during a period in which the combined output values are at a peak. For example, successive sensor output values may be processed and combined, and the peak of the successive combined values used as the thickness-indicating measurement. Alternatively, to reduce the amount of processing required, the thickness measurement may be derived from both sensor output values produced when the influence on one of the sensors reaches a peak, or alternatively at a predetermined time after the sensors start to be influenced by the arrival of the coin.

The invention also extends to apparatus for validating coins, the apparatus using a method according to the invention.

An arrangement embodying the invention will now

be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 schematically illustrates a coin passageway of a coin validator in accordance with the invention;

Figure 2 is a schematic diagram of the relevant parts of the circuit of the coin validator;

Figure 3, consisting of graphs (A), (B) and (C), illustrates the advantageous results achieved by the invention in rendering the thickness measurement independent of coin position; and

Figure 4, consisting of graphs (A) to (F), exemplifies the effect of changes in coin position on the thickness measurement, and indicates how this can be mitigated.

With reference to Figure 1, a coin passageway 2 includes a ramp 4 which is inclined in a first plane to the horizontal so that a coin such as that indicated at 6 will slide or roll in the direction of arrow A down the ramp. The ramp is also inclined to the horizontal in a perpendicular plane, so that the coins will tend to move with their faces in contact with one side wall 8 of the passageway, which thus acts as a reference plane.

The validator also has a pair of inductance sensors formed by coils 10 and 12. The coil 10 is

positioned adjacent to and just behind the reference plane formed by side wall 8. The coil is covered by a membrane (not shown) which is flush with the side wall. This separates the coil from the reference plane by a
5 predetermined distance equal to the thickness of the membrane.

The coil 12 is similarly mounted on the other side of the passageway, spaced by a respective membrane from the inner surface of a side wall 14 opposed to the side
10 wall 8. Both coils are thus accurately positioned with respect to the side walls, and therefore with respect to the possible range of positions across the coin passageway which can be adopted by a coin.

This general type of structure is known in itself.
15 An example is disclosed in European Patent Specification No. EP-A-0 146 251, in which the coils are connected in series. In the present embodiment, however, the coils are not interconnected, and have separate outputs.

20 As shown in Figure 2, each of the coils 10 and 12 is connected into a respective oscillator circuit 16 or 18.

The validator has a microprocessor 20 (e.g. selected from the Motorola 6805 family) which has
25 input/output lines 01 to 011, and a timer/counter input terminal T1.

The oscillators 16 and 18 can be turned on and off by switches 22 and 24, respectively, which are controlled by the microprocessor output terminals 01 and 02, respectively. When switched on, each oscillator operates at a relatively high frequency, e.g. 1.0 MHz. The frequencies are preferably high, so that the fields do not substantially penetrate the coins and the effects of the coins therefore are not substantially influenced by their material composition. Outputs carrying signals at the sensor frequencies (or scaled versions thereof) appear on lines 26 and 28, respectively. Pulses on these lines can be delivered to the terminal T1 by closing gates 30 and 32, respectively, which gates are under the control of signals appearing on input/output lines 03 and 04, respectively.

It will be appreciated that the microprocessor can thus turn on either of the oscillators 16 and 18, and close the respective gates 30 or 32 for a predetermined time period during which sensor output pulses appearing at terminal T1 can be counted by an internal counter of the microprocessor to provide a measure of sensor frequency.

In the absence of the coin, the microprocessor repeatedly turns on the oscillator 16 for a brief period and checks the output frequency. If successive

frequency readings change by a certain amount, it is determined that a coin has started to enter the field generated by the coil 10. In this way, coin arrival is detected and used to power up various other parts of the validator circuitry, in a manner which is known per se. From that time, the microprocessor 20 repeatedly enables and disables the oscillators 16 and 18 in an alternating fashion so as to take successive readings from each sensor. Sensor readings may be taken at regular intervals, or in pairs, with a greater interval between successive pairs than between the individual readings of each pair.

After the coin 6 has left the sensors 10 and 12, the microprocessor ceases to power up the oscillator 18, except that one or a few further measurements may be taken from each of the sensors to establish idle values, i.e. frequency measurements in the absence of a coin. The sensor values which are used in the deduction of a thickness measurement are derived from the relationship between the sensed frequencies during the passage of the coin and the idle frequencies (e.g. the difference between or ratio of the frequencies). This technique, which is known per se, reduces the effects of drift of circuit component values, temperature changes, etc. If desired, the idle values can be taken when a further sensor (not shown) detects

the presence of a coin, to ensure that the idle values are measured after the coin has completely left the region of the sensors 10 and 12.

5 In the particular arrangement described, because the idle frequencies are measured after the coin leaves the sensor, the actual thickness detection operation which takes place while the coin is passing may be based on the idle levels detected following passage of the preceding coin. Obviously, this could
10 be avoided by monitoring the idle values before the coin reaches the sensor, e.g. by alternately switching on the oscillators for very brief periods.

By operating the sensors in succession, rather than simultaneously, it is ensured that there is no
15 cross-talk between the sensor outputs, and power consumption is reduced. However, it is not essential to adopt this technique. Cross-talk could be avoided by using coils of high Q, by making the oscillator frequencies substantially different from each other,
20 or by other means. In addition, in some configurations the presence of the coin itself would sufficiently isolate the fields, so that the coils may be driven simultaneously at least while the coin is present.

25 Figure 3(A) illustrates typical sensor outputs

for a coin of given thickness. The horizontal axis represents the positioning of the coin across the width of the passageway. The vertical axis represents on an arbitrary scale the maximum difference between the sensor output frequency and the idle frequency as the coin passes the sensor. Line I represents the output for sensor 10, and line II the output for sensor 12. The broken line represents (on a different scale) the combined outputs which would be obtained if the coils were connected in series or in parallel. It will be observed that the combined output varies substantially depending upon coin position.

Figure 3(B) is similar, but in this case the sensors have been carefully designed so that their responses do not vary substantially from linear responses. Although there is some inaccuracy in the combined measurements due to the slight non-linearity of the responses, there is a greater inaccuracy due to the fact that the gradients of the response curves are different. Although it may be possible by careful designing and positioning of the coils to obtain response curves which are reasonably linear or reasonably symmetrical, achieving both these results for all possible coin positions and thicknesses has not proved possible.

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In the present embodiment, the microprocessor 20 takes each of the frequency shift measurements from each sensor, and processes it so as to avoid such problems. In particular, the microprocessor has a
5 read-only memory (not shown) storing a set of processed values, each of which corresponds to a respective sensor output value. The sensor output value is used to determine the address in the table from which the processed value is to be retrieved.
10 Figure 3(C) illustrates how the processed values I' and II' vary with coin position. It will be observed that the response curves are linear and symmetrical, and therefore when the processed values are combined by the microprocessor 20, the resulting response shown
15 in broken lines in Figure 3(C) is substantially independent of coin position.

The values stored in the look-up table are preferably determined experimentally, and may be deduced individually for each validator so as to take
20 into account possible tolerance variations and thereby effectively to calibrate each mechanism. If both sensor response curves are substantially non-linear, as in Figure 3(A), it is desirable for both sets of sensor output values to be processed to render them
25 linear. However, if the sensor output responses are substantially linear as shown in Figure 3(B), it may

be necessary to process the output of only one sensor in order to scale the output to correspond with that of the other sensor. In any event, the processing should result in substantially linear response curves with substantially the same gradient or constant of proportionality, as shown in Figure 3(C).

In use of the apparatus, the microprocessor 20 converts each sensor output value to a processed value using the look-up table, and combines pairs of output values from the respective sensors to produce a single combined value which is representative of detected thickness. As the coin enters the region between the sensors, this value will increase to a maximum, then stay at this maximum level as the coin passes the sensors, and then decrease to an idling level as the coin leaves the sensors. The maximum value is taken to be the thickness measurement.

Figure 4 illustrates how the present embodiment avoids not merely the problems resulting from an indeterminate position of the coin as it passes the sensor, but also problems caused by variations in that position during the period in which it is passing the sensors. The graphs (A) to (F) of Figure 4 have vertical axes representing sensor outputs on an arbitrary scale, and horizontal axes representing time. The coin enters the region between the sensors

in the period leading up to time t_1 fully overlaps the sensors in the period between t_1 and t_2 , and then after t_2 starts to depart from the sensors.

Figure 4 illustrates the situation where the coin is relatively close to the sensor 12 when it enters the region between the sensors, but is substantially midway between the coils by the time it leaves the region. Thus, in Figure 4A, which represents the output of sensor 10, it will be observed that during the period t_1 to t_2 , the sensor output increases by an amount d . Similarly, in Figure 4B which represents the output of the sensor 12, this output decreases in the period t_1 to t_2 by an amount D . D is greater than d , because of the non-linearity of the response curves which make changes in the position of the coin affect the nearest coil greater than they affect the furthest coil. Accordingly, if these unprocessed values were to be combined, the result would be as shown in Figure 4(C), which is analogous to the result obtained in the prior art arrangements where the coils were connected in series or parallel. In Figure 4(C), it will be observed that the combined output varies between periods t_1 and t_2 by an amount v . Although this is smaller than either D or d , it is still a significant variance. The variance

represents the uncertainty in the measurement due to the uncertainty in the lateral position of the coin.

Figures 4(D) and 4(E) represent the processed outputs of sensors 10 and 12, respectively. Because these processed outputs are linear, the variation d' in the period t_1 to t_2 in the processed output of sensor 10 is equal and opposite to the variation D' in the processed output of sensor 12. Thus, when the outputs are combined, a horizontal peak value as shown in Figure 4(F) providing an accurate measurement of thickness is obtained. This illustrates that the measurement is unaffected either by coin position or variations in the position.

Similar effects occur if the coin is travelling in an inclined orientation along the ramp 4.

As mentioned above, instead of deriving the peak of the combined values as shown in Figure 4(F), it would be possible to perform the processing and combining only at a single time point, which could be determined either by a peak in the unprocessed output of one of the sensors 10 and 12, or at a predetermined time after arrival of the coin has been sensed. It will be appreciated from Figure 4 why it is preferred that the combined processed values represent sensor outputs at a substantially identical time. In particular, if each of the sensors was

individually peak-detected, then the output of sensor 10 at time t_2 would be combined with the output of sensor 12 at time t_1 . The coin would, however, have moved during this interval, and therefore a false reading of thickness would be produced. This situation can, however, be tolerated if the coin flight is sufficiently stabilised that variations in the coin position during this interval are likely to be very small.

10 The embodiment described above derives measurements by detecting shifts in the frequency of an oscillator. However, the measurements may alternatively be based on absolute frequency values, amplitudes, amplitude shifts, phase shifts, etc.

15 The term "coin" has been used herein to cover not only genuine coins but also non-genuine coins, tokens or other items which might be received by a validator.

Claims:

1. A method of testing coins for thickness using a pair of inductances positioned on respective sides of a coin path, the outputs of which are
5 combined to produce a thickness indicating signal, said signal being substantially independent of coin position over at least a limited position range between said inductances for a given coin thickness, characterised by the steps of:
- 10 producing separate inductance output values each indicative of the effect of a coin on an electromagnetic field as detected by a respective one of the inductances, the gradients of the dependencies of said inductance output values upon the position of
15 a said coin of said given thickness within said position range being different, and;
- processing at least one of the inductance output values and combining the values so as to generate said thickness indicating signal, the processing of said at
20 least one inductance output value being different to that of the other so as to substantially compensate said thickness indicating signal for said gradient difference.
2. A method as claimed in claim 1, wherein the
25 values are representative of coin effects detected at substantially the same instant.

3. A method as claimed in claim 2, including the step of successively combining processed values, and peak-detecting the results in order to obtain the thickness-indicating measurement.

5 4. A method as claimed in any preceding claim, wherein the inductances are so arranged that the values produced thereby are non-linearly related to coin position, and wherein the processing of the values is such as to render them linearly related to
10 coin position.

5. A method as claimed in any preceding claim, wherein the processing is achieved using a look-up table which correlates output values with processed values.

15 6. A method as claimed in any preceding claim, including the step of driving the inductances in succession as the coin passes the inductances.

7. A method as claimed in any preceding claim, including the step of using a single one of the
20 inductances to detect arrival of a coin in the validator, and the further step of powering-up selective portions of the validator in response to said detection.

8. A method according to claim 1 further comprising the steps of digitising said inductance output values, and processing said inductance output values using stored data defining processing for
5 balancing the dependence of said inductance output value contributions to said thickness indicating signal for a plurality of positions between said inductances.

9. A coin validator operable to sense coin
10 thickness using a method as claimed in any preceding claim.

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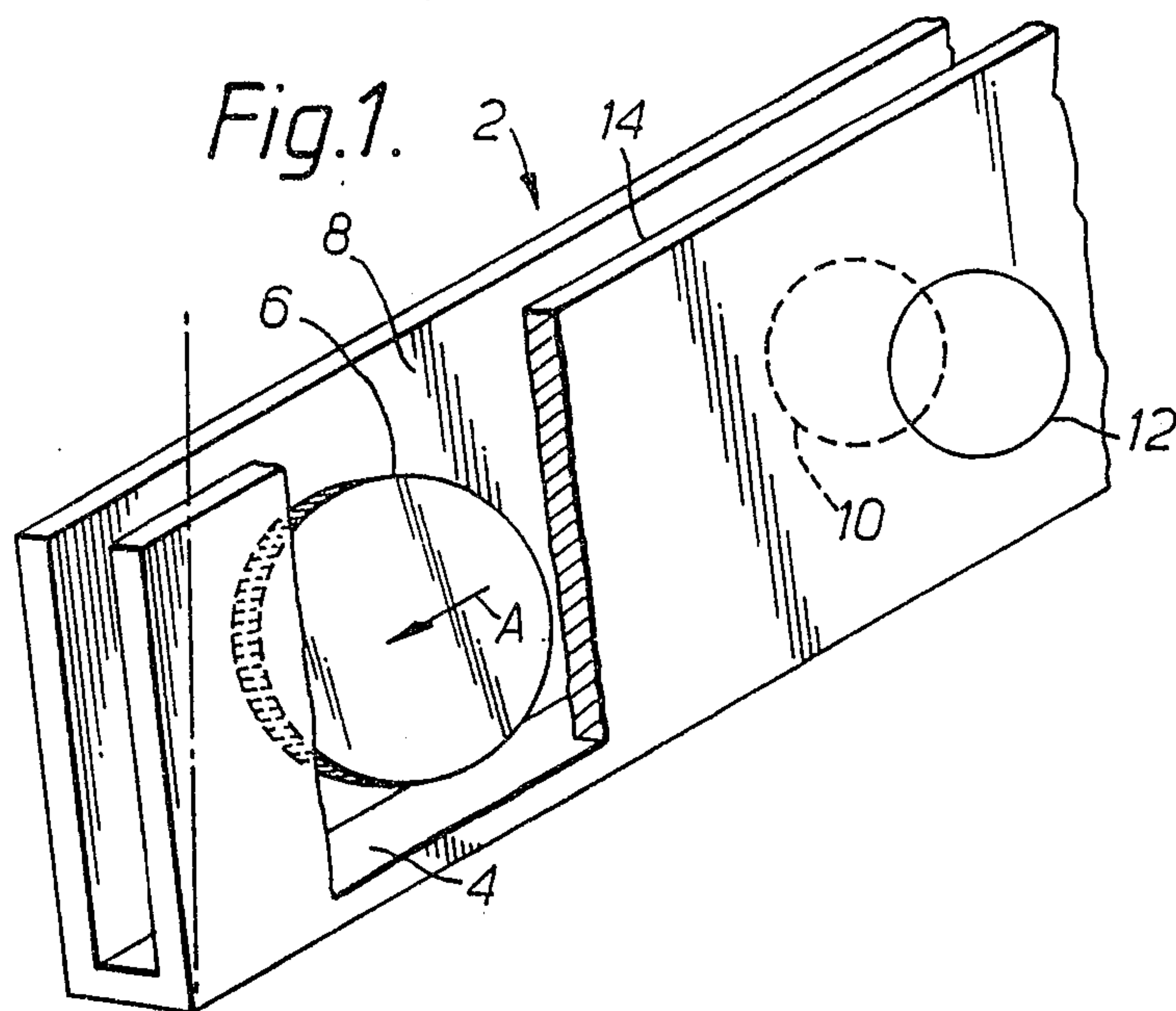
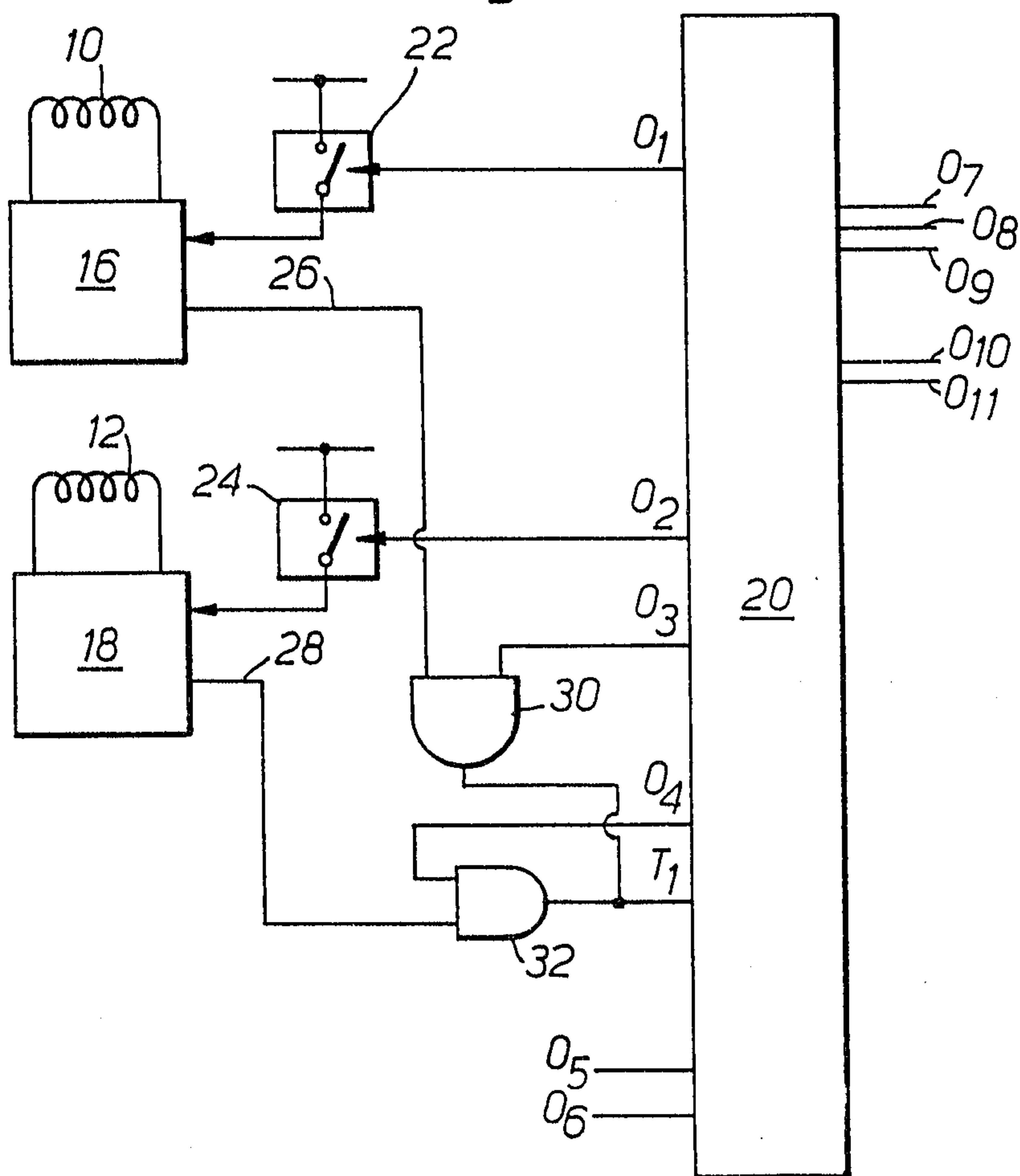


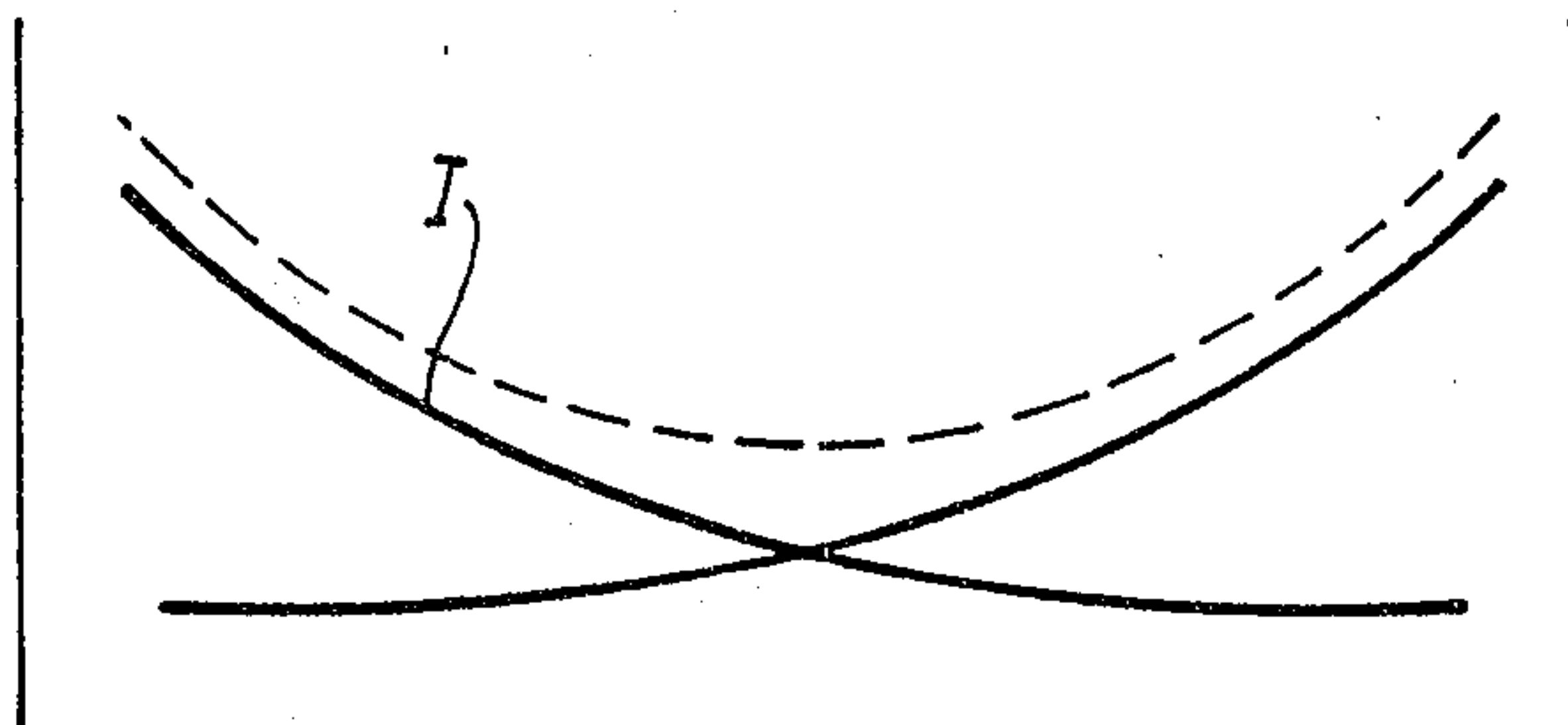
Fig.2.



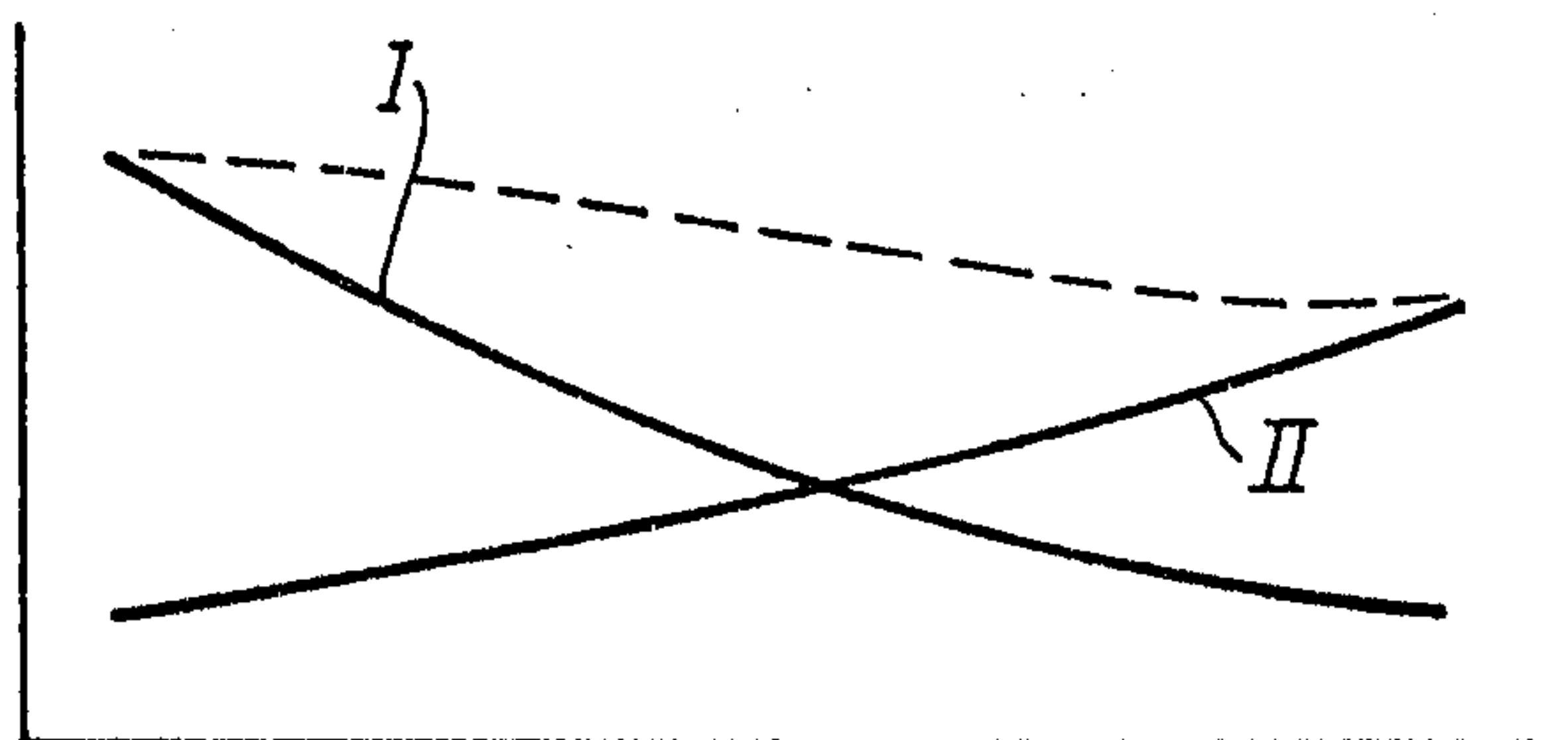
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Fig. 3.

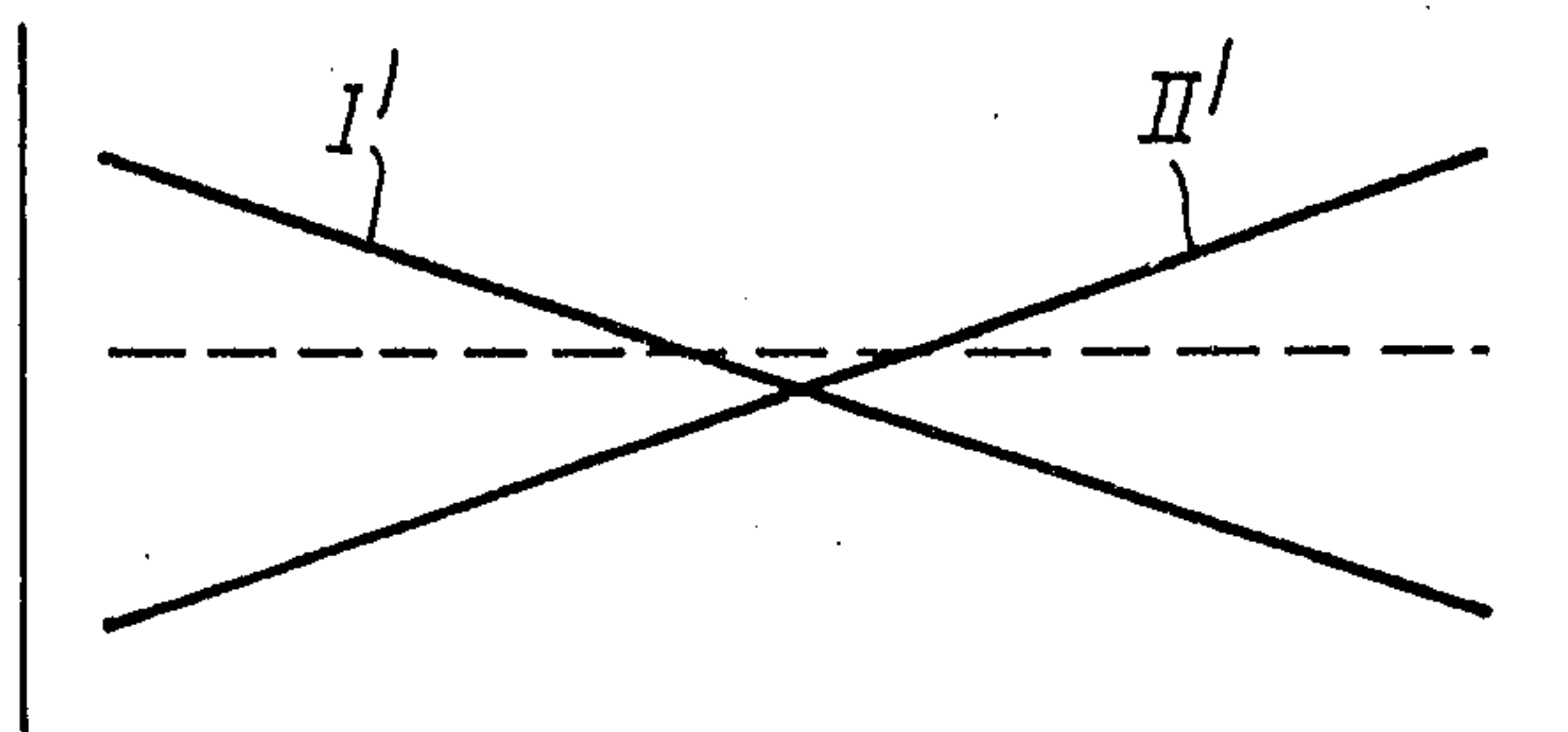
(A)



(B)



(C)



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Fig. 4.

