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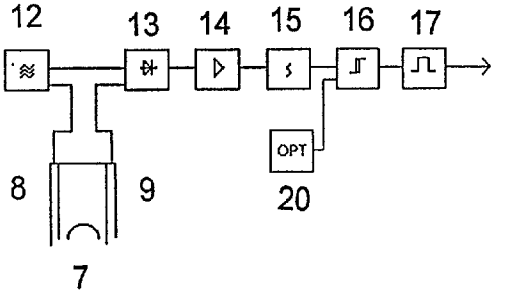
(54) **PROCEDE ET DISPOSITIFS PERMETTANT DE VERIFIER DES DOCUMENTS DE SECURITE**

(54) **METHOD AND APPARATUS FOR CHECKING SECURITY DOCUMENTS**



(57) L'invention concerne un procédé et des dispositifs permettant de vérifier des documents de sécurité. Selon le procédé de vérification de documents de sécurité, qui fait appel au couplage capacitif connu en soi, il est prévu que des signaux électriques émanant d'antennes émettrices soient transmis à des antennes réceptrices par le biais de caractéristiques de sécurité électroconductrices, et amplifiés. Ces signaux sont ensuite évalués d'après leur réponse d'amplitude et leur réponse en temps, et comparés à des courbes de signaux existantes, par conversion en courbes de signaux présentant des paramètres facilement comparables. Afin de parvenir à une sélectivité spécifique du dispositif de vérification, un amplificateur sélectif est en outre couplé à l'unité électronique d'évaluation. On parvient à une définition propre à la monnaie à l'aide de l'unité électronique d'évaluation, du fait qu'une limite de temps de l'amplitude du signal de vérification différant de la durée de la réponse d'amplitude de toutes les autres monnaies, peut être déterminée par exemple à l'aide de contrôleurs.

(57) The invention concerns a method and devices for checking security documents. According to this process which uses known capacitive coupling, electrical signals are transmitted by transmitting antennae via electrically conductive security features to receiving antennae and amplified. The amplitude responses and time characteristics of the electrical signals are then evaluated and compared with existing signal responses, by being converted into signal responses having easily comparable parameters. In order to enable the testing arrangement to be specifically selective, a selective amplifier is additionally coupled to the evaluation electronics. Currency-specific definition by means of the evaluation electronics according to the invention is attained in that, for a given currency, a time limit of the test signal amplitude can be determined by means of controllers, for example, this time limit differing from the duration of the amplitude response of all the other currencies.

Attorney Docket 970224

Abstract

The invention relates to a method and to apparatus for checking security documents. The method of checking of security documents provides, on the basis of conventional capacitive coupling, for the transmission and amplification of electrical signals from transmitting antennae to receiving antennae by way of electrically conductive security elements, which signals, by conversion into signal patterns with easily comparable parameters, are then evaluated in accordance with amplitude and time response and compared to existing signal patterns. In order to provide for a specific selectivity of the checking apparatus a selective amplifier is additionally connected to the electronic evaluation circuit. A definition regarding specific currencies by means of the electronic evaluation circuit in accordance with the invention is obtained that for a given currency a time limit of the test signal amplitude which differs from the interval or the amplitude response of any other currencies, may be defined, e.g. by a controller.

Attorney Docket 970224

Method and Apparatus for Checking Security Documents

The invention relates to a method and apparatus for checking or examining security documents in accordance with the preamble of claim 1.

Many processes, apparatus, methods and examining systems are known for determining the authenticity of security documents, for monitoring the usability, for defining the location in processing machines as well as for defining and counting currency. German Patent 1,223,594 describes an apparatus for capacitively sensing image materials in which the sensing capacitors consist of sensor electrodes arranges on both sides of a path along which the image material is moving. There is no assurance that this apparatus will sense embedded, impressed or applied electrically conductive strips, ribbons or other particles.

German Patent 1,774,290 describes a measuring arrangement for the automatic evaluation of a characteristic element of a bank note in an apparatus for examining the authenticity of currency bills by means of capacitive coupling of electrodes arranged in a grid-like pattern. This known measuring arrangement does not permit an exact determination of the respective characteristic element at processing speeds required under present day conditions, and even at a slow checking operation only the presence of such an element is detected and is thus unsatisfactory as regards currently known forgeries using electrically conductive components in bank notes, for example.

In German Laid-open Specification 2,619,457, magnetic properties of a testing strip provided in a bank note are measured.

German Patent 2,834,287 describes examining the authenticity of ferro-magnetic security strips in printed securities by application of a magnetic field. These examining methods are too slow and always require exact positioning of the object or strip to be checked.

German Patent 2,760,165 describes a technically complex examining

apparatus by which the authenticity of bank notes is determined in a second testing section in particular, by measuring differences in thickness and fluorscent properties. Examining only these properties, no longer corresponds to the state of currently circulating forgeries. Counterfeit money including water marks and fluorescent paper or dye can no longer be recognized as false by this apparatus.

Even the read heads among others of the processing machines described in German Laid-open Specifications 3,236,373 and 3,236,374, which, together with indicia on security documents, form an electrical capacitor and which affect a defined change in the capacitance value by introducing the ferry-electric material between the capacitive electrodes of the read element, are unsuitable for high-speed processing machines and for examining currently circulating European bank notes.

Verifying the presence of an electrically conductive security strip by untuning oscillators and resonant circuits in accordance with German Patent 2,912,712 has not found acceptance because of the low reliability of the evaluations and its great technical complexity and complicated structure.

U.S. Patent 5,308,992 describes a measuring arrangement of optical and capacitive sensors, which requires precise positioning of the testing strip, however. To improve its rate of error-free operation and to distinguish between different test objects (e.g. different currencies), the use of an additional magnetic sensor is proposed, which makes the measurement structure even more complicated and dear. Following resorting of bank notes, the capacitive sensor can only detect the presence of an electrically conductive security strip.

In accordance with German Patent 4,103,832, there is also known an examining arrangement in which capacitive and/or elector-optical and/or millimeter wave sensors are arranged for checking along a check path. The subject matter of the disclosure relates to examining the dielectric properties of bank notes, among others.

German Patent 4,325,027 describes a method and an arrangement for

examining the authenticity of bank notes in which the change in the field strength arising from bridging a high frequency field by a metallic security strip is evaluated. Because of its limited sensitivity and low suppression of interference energy it is suitable for use at low velocities only. Moreover, surface conductive and moist test objects are also recognized as genuine. Breaks in the metal strips of genuine bank notes are not recognized leading to erroneous stopping of the machine. Because of the low sensitivity of the arrangement, the distance between the electrodes and the metallic security strip of the bank note is very small which prevents its use in fast running bank note processing machines. A sequential arrangement of several such sensors is possible only at a relatively large spacing between them so that the sensors do not influence each other.

In WO 94/22114 there is described an apparatus for detecting metallic conductive security threads. Here, too, surface conductive and moist test objects are detected as genuine, as its is performed for measuring the electrical charge of the sensor electrodes. No provision is made for classification of differently dimensioned security threads.

European Patent specification 0,204,574 describes a method of detecting a magnetic print design by means of electromagnetic induction. Sine even conventional copying machines may be loaded with electrically conductive ink, this type of checking is very limited in its reliability in view of the quality of present day forgeries.

The disadvantages of these known examining methods and arrangements primarily are their high technical complexity and their insufficient reliability in detecting forgeries among bank notes rapidly fed through a money processing machine. In the known measuring arrangements for examining capacitive properties, the disadvantage is that a sufficiently low capacitive resistance can be established only within the provided low frequency ranges from 10 to 220 kHz and only at very small spacings between the electrodes and the metal strip. Moreover, in this frequency range, the effect of the dielectric change is still very significant, i.e., a material

of high relative permittivity leads to an increased capacitance and, hence, to a reduction in the capacitive resistance between the antennae. Thus, moist counterfeit, for instance, would be recognized as authentic. *In praxi*, these arrangements, particularly in respect of mechanized authenticity checking have up to the present time not proven themselves.

European Patent 589,195 A2 describes a method in which for determining the authenticity of test objects an allocation code is derived by means of a device having an excitation coil and a sensor coil, from a detection signal obtained by sensing a sensing area provided with highly permeable magnetic elements, and in which the authenticity is affirmed if the detection signal and the allocation code coincide. This checking method may be used to a limited extent only in connection with plastic cards, paper documents and only few non-European bank notes provided with magnetic or magnetizable particles. Other checking methods such as those described in European Patents 204,574 A2, 553,402A1 and 560,023 A1 in which geometric and/or physical properties of testing objects are classified by a method of comparison, may be used with one type of test object only, they are very complex, and because of the required high speeds they have not been accepted as the only single operation authenticity checking method.

It is a task of the invention to eliminate the existing disadvantages of the known examining arrangements and methods and to provide a method, by means of which it is possible reliably to detect a characteristic testing element, which may be used in connection with many kinds of bank notes and currencies, including, for instance, moist or deliberately moistened and/or soiled test objects, which can distinguish them from each other, which is of low technical complexity, which is useful for being practiced in retro-fitted processing machines, and which satisfies the rapid through-put in processing machines. An electrically conductive security thread or ribbon or a two-dimensionally formed security element in bank notes or securities is used as the characteristic test element. Furthermore, it is a task to structure a testing unit for practicing the method such that an authenticity check may be

performed ahead of sorting on the basis of currencies and kinds.

It is still another task of the invention to develop an apparatus for examining security documents which as a security element contain an electrically conductive ribbon or thread-like strip for examining uninterruptedly electrically conductive strips as well as those which are provided with a plurality of electrically conductive areas which are electrically insulated from each other.

An example of such a security document are current U.S. bank notes provided with a security thread supporting electrically conductive characteristics insulated from each other. Modern practice demands that such examining systems may without difficulties be incorporated in processing machines which not only recognize high-quality forgeries but also genuine documents of poor quality which in practice occur frequently and which would lead to faulty releases which would interfere considerably with the operation of the processing machines.

Utilizing capacitive coupling of the kind known *per se*, the method in accordance with the invention for examining security documents provides for the transmission and amplification of electrical signals from transmitting antennae to receiving antennae by way of electrically conductive security elements, which are evaluated after an amplitude response over a predetermined time and which are converted into signal patterns with easily comparable parameters and which are compared with existing signal patterns. To practice the method with its steps to be described, an examining apparatus utilizing capacitive coupling is proposed in respect of bank notes, documents, securities and the like provided with security strips or threads or two-dimensional security elements, which may be used in a bank note processing machine, preferably, a counting machine. An arrangement of sensors is placed in a housing assembly in the vicinity of optical and/or magnetic and/or format sensors. The machine passes the bank notes and/or securities by the examining apparatus. The sensor arrangement comprises a plurality of antennae and/or electrodes. The longitudinal extent of the surface

area of the antennae and/or electrodes in the direction normal to the feed path is such that the security strip or thread sweeps sufficiently across the antennae and/or electrodes, even at a defined lateral play of the test objects and regardless of whether a test object is moving through the examining apparatus with its face or reverse pointing upwardly. The antennae and/or electrodes correspond to slide apparatus, pressure rollers and/or feed belts of the kind known *per se* so that the documents to be checked may be spaced from the antennae a predetermined distance and/or pressed against the electrodes during their rapid passage. By the inventive arrangement of the examining apparatus in the vicinity of optical and/or magnetic and/or format sensors which conventionally function to recognize geometry, disposition, dye and the like, actuation of the sensor arrangement is accomplished at the same time.

One or more antennae and/or electrodes are energized with high and/or low frequency energy and/or with direct current, and, by way of a security strip or thread, one or more antennae and/or electrodes receive a portion of the transmitted energy. The voltage applied at one or more receiving antennae and/or receiving electrodes is changing.

In order to make comparable statements, for instance in respect of the authenticity and usability of documents or the currency of bank notes constant conditions of movement such as, for example, the running speed, are necessary for test objects to be compared. The antennae and/or electrodes supply a voltage to an electronic evaluation circuit. The electronic evaluation circuit furnishes an easily comparable voltage in proportion to the signal pattern of the received voltage. In order to suppress interfering and extraneous energies and to prevent the basic conductivities of test objects from affecting the test result, special filters and/or phase comparators may be utilized.

The output pulse of the electronic evaluation circuit is independent of the feed speed. In order to allow for a specific selectivity of the check apparatus, a selective amplifier is additionally coupled to the electronic

evaluation circuit. The selective amplifier converts the voltage coming from the sensor arrangement into an easily comparable voltage which is dependent upon the response of the amplitude. In defining the electronic evaluation circuit of the category under consideration (electrically conductive security strips or security threads or conductive markings of any kind) additional limits of amplitude are preset the response of which is so closely adjacent the amplitude excursion of a test signal, that a definition of authenticity is obtained on the basis of the difference between the defined preset amplitude limits and the largest possible amplitude excursion of any objects to be checked. This means that even the latest forgeries in circulation which generate a signal which under normal circumstances would be detected as an evaluation signal, would be detected as a forgery by the evaluation electronics in accordance with the invention.

In accordance with the invention, defining specific currencies, for instance all bank notes of individual countries having similar security strips, by means of the evaluation electronics of the invention is accomplished by a definable time limit of the test signal amplitude, for instance by a controller, for a given currency which differs from the interval of the amplitude response of all other currencies.

Currencies of like intervals of test signal amplitude will be subjected to an additional test, e.g., by a method of color recognition and/or color distinction and/or magnet and/or format checking. Recognition signals derived from light barriers, for instance, are combined with the signal of the sensor arrangement in accordance with the invention and converted into a machine-specific output pulse.

A variation of the method consists of examining security documents by energizing one or more pairs of transmission antennae in a phase-shifted manner. As a result of the capacitive coupling between a transmission antenna, an electrically conductive indicia on the security strip and the receiving antenna positioned opposite the transmission antenna an authenticity determining signal is generated at the input of an amplifier.

Because of the absence of an electrically conductive strip in its effective range, no capacitive signal coupling occurs between the second transmission antenna which is energized out of phase relative to the first transmission antenna and its receiving antenna. Thus, this arrangement makes it possible to check a continuous electrically conductive strip. Displaced from these pairs of antennae, there are further pairs of transmitting and receiving antennae which in their dimensions and distances from each other are calibrated to electrically conductive indicia of the security strip. By moving the object to be checked at a defined distance relative to the test sensor arrangement, characteristic amplitude and time signals which may be evaluated are fed from the receiving antennae to the evaluation electronics. Thus, an examination is carried out which is capable of recognizing and evaluating a plurality of electrically conductive indicia insulated from each other. In this context, it does not matter if the insulation between electrically conductive indicia is deliberate, as is the case in a U.S. bank note, or if the insulation is the result of fractures in indicia produced as continuous electrically conductive strips as is the case in German bank notes, for instance. A micro controller can compare the number of interruptions with stored values. By arranging several pairs of transmitting and receiving antennae and associated evaluation electronics it is possible to obtain a reliable indication as regards the authenticity of a document, since the examining apparatus operates reliably even though the object to be checked may have shifted relative to the checking apparatus when feeding it into it. If, in accordance with the invention, the transmitting and receiving antennae are arranged across the entire operational width of the processing machine, an authenticity check may be performed regardless of the position of the test object. Hence, it does not matter if a document is fed with its front or rear surface facing upwardly and/or if its security strips are arranged at its right or left side and/or if it is fed in a laterally displaced position relative to its direction of movement. In this manner it is possible to check documents differing in terms of format as well as the disposition of their security strip

relative to the direction of movement. In addition, not only do the different kinds of security strips permit a classification in terms of authenticity, but also a specific arrangement of different documents, such as different currencies.

In the direction of movement of the bank notes, further testing sensors may be arranged ahead of or behind the testing sensor arrangement in accordance with the invention. In such a case the output signal of such a testing sensor arrangement is combined with the output signal of the testing sensor arrangement in accordance with the invention (double check), without necessitating changes in the software of the processing machine, as, for instance, when retrofitting with a checking apparatus of the method in accordance with the invention.

Aside from the claims, advantageous embodiments of the invention may also be gleaned from the specification and drawings, wherein individual characteristics may severally or jointly in sub-combination represent protectable embodiments for which protection is herein claimed. Embodiments of the invention are depicted in the drawings. In the drawings:

Fig. 1: is a block circuit diagram of the evaluation circuit;

Fig. 2: are the detection curves of a bank note moving at different speeds;

Fig. 3: are currency-specific detection curves;

Fig. 4: are detection curves of several bank notes and counterfeit;

Fig. 5: is a block circuit diagram of the evaluation circuit incorporating double checking;

Fig. 6: is a section the a schematic presentation of a checking apparatus;

Fig. 7: is a test sensor arrangement;

Fig. 8: is a block circuit diagram of a checking apparatus;

Fig. 9: is the arrangement of a test sensor arrangement in a processing machine.

The method to be described in detail with reference to different apparatus and arrangements is essentially based upon practicing the process

steps of capacitive coupling of electrical signals from transmitting antennae to receiving antennae through electrically conductive security materials; amplification and conversion of the received signals which differ in their amplitude and time response into easily comparable signals and comparing the same with existing signal patterns to indicate and evaluate the authenticity of the documents to be checked in an appropriate form. A machine coupled with the checking apparatus transport the bank notes or security documents into the range of the checking apparatus. The light barriers will thereupon activate the testing sensor arrangement.

The transmitting antenna is energized by high-frequency energy. In the present embodiment the frequency is 6 MHZ. As the security strip or thread passes the test field, the receiving antenna absorbs a portion of the transmitted energy. The HF voltage present at the receiving antenna changes. The reason for this, as is well known, is the capacitive coupling between transmitting and receiving antennae because of the electrical conductivity of the security strip or thread. The HF conductivity differs with different currencies. In order to be able to give currency-specific indications with the aid of an evaluation circuit, it is necessary to provide uniform feed conditions in respect of all objects to be checked a single operation.

An electronic evaluation circuit essentially comprising an analog to digital converter and controller or integrator 15, trigger 16, controller mono-flop 17 as well as, if desired, an AND gate 18 is functionally integrated with the checking unit and its test sensor arrangement by shielded connectors. An example of an electronic evaluation circuit is depicted in Fig. 1.

Reference character 12 is a HF transmitter, 13 is a HF receiver which receives the energy transmitted by the receiving antenna 9 and amplifies it as currency-specific and/or authenticity utilization signal, 15 is an integrator, 16 is a trigger which in addition to the present signals receives the evaluation circuit activating signals from the light barriers 20 and delivers them as time-coordinated pulses by way of the mono-flop 17 as output signal for test objects determined to be authentic. As may be seen by the curves a and b in

Fig. 4 representing the passage of bank notes, forgeries 26 do not generate output signals comparable to those of bank notes determined to be genuine.

The defined shielding of the test sensor arrangement of the electronic evaluation circuit from electrical and electro-magnetic fields, as well as the arrangement of the test sensors in the area of the light barriers ensure a high ratio of useful and interfering signals, and in combination with the positive feeding by conveyor belts at a defined bank note feeding speed they guarantee a currency-specific selectivity of the checking apparatus. A further advantage of this method in accordance with the invention is that the moisture content and/or degree of soiling of test objects and/or bank notes and/or security documents no longer appear as primary sources of interference.

Fig. 6 is a sectional schematic representation of a checking apparatus which is used in accordance with the method set forth *supra* in a bank note processing machine, preferably a counting machine. At a housing assembly 1, there is provided a machine support 2 which receives a test sensor arrangement on a horizontal arm 3. The sensor arrangement is provided in the range of light barriers 4, 5 on a non-conductive support material 6 of the arm 3. The support material 6 is provided with apertures and/or perforations 7 for the passage of light of the light barriers 4, 5. If the support material 6 used is transparent, there is no need for the apertures and/or perforations 7.

The test sensor arrangement consists of a plurality of strip sensors 8. In the embodiment shown, there are two sensors, namely a strip sensor 8 functioning as a transmitting antenna and a strip sensor 9 functioning as a receiving antenna. The longitudinal extent of the surfaces of the strip sensors 8, 9 in a direction normal to the direction of movement of bank notes 11 is such that even at a defined lateral play of the bank note 11 and regardless of whether a bank note 11 is passing through the checking apparatus with its front or rear surface facing upwardly, the security strip or thread will still sweep over the strip sensors 8,9 sufficiently and will be guided under them through the checking apparatus. Feed belts 10 are extending below the arm

3 and parallel therewith, at a distance from the strip sensors 8, 9 that during their rapid movement the bank notes are pressed against the strip sensors 8, 9. Light barriers 4, 5 are arranged between the feed belts 11 and vertically relative to the direction of movement of the bank notes.

The electronic evaluation circuit is also arranged in a shielded section of the processing machine. In the embodiment shown, it is for practical purposes positioned in that area of the housing where the paper thickness adjustment apparatus is provided.

The defined shielding of the test sensor arrangement and of the electronic evaluation circuit from electrical and electromagnetic fields as well as the arrangement of the test sensor arrangement in the area of the light barriers guarantees a high ratio of useful and interfering signal and, in combination with the positive guidance by the feed belts 10 together with a defined bank note feeding speed, a currency-specific selectivity of the checking apparatus. A further advantage of the checking apparatus in accordance with the invention is that moisture content and/or degree of soiling, for instance, of the test objects no longer appear as primary sources of interference.

As seen in the direction of bank note movement - not shown in this example - a further test sensor arrangement, for instance magnetic checking as shown in the block diagram of Fig. 5, may be arranged ahead of or behind the testing sensor arrangement in accordance with the invention.

In that case the output signal of this sensor arrangement is combined with the output signal of the test sensor arrangement in accordance with the invention, without necessitating a change of the software of the relevant processing machine, for instance when retrofitted with a sensor arrangement in accordance with the invention.

As shown in Fig. 2 and Fig. 3, the evaluation circuit connected with the test sensor arrangement and the light barriers delivers a direct current dependent upon the amplitude response of the received HF voltage. This is exemplified in the mentioned figures by the transmitted signals, depicted as

curves a.

Fig. 2 depicts curves of detecting a bank note fed at a different feed velocity. Curve a depicts the transmitted signal and curve b depicts the output signal of the electronic evaluation circuit. v_1 corresponds to a feeding velocity of 500 bank notes per minute, and v_2 corresponds to a feeding velocity of 1,800 bank notes per minute. Curve b additionally exemplifies how a bank note recognition signal supplied by the light barriers is combined with the signal from the test sensor arrangement and is converted to a machine-specific output pulse. This output pulse is independent of the feeding velocity as may be seen by comparing curves b in Fig. 2.

Fig. 3 depicts currency-specific detection curves of feeding bank notes of different currencies. Curve a again depicts the transmitted signal from the test sensor arrangement, whereas curve b depicts the evaluation signal of a selective amplifier which was additionally connected to the electronic evaluation circuit in order to make possible a currency-specific selectivity of the checking apparatus without additional sensors. In Fig. 3, DE stands for German currency, CH stands for Swiss currency, EG stands for Egyptian currency and CH stands for Chinese Yuan beginning with the 1990 series.

The amplitude response of the received HF energy differing in accordance with the different kinds of security strips is clearly visible with the bank notes of different currencies and is thus detectable by the electronic evaluation circuit. If it is necessary to process the currency-specific signal, an additional signal processed by the electronic evaluation circuit is possible for the currency-specific classification by means of a controller, for instance. In the same manner in which different currencies may be distinguished by different security strips or threads, forgeries will be detected as long as they are provided with imitation security strips or threads or at least fractions thereof. Fig. 4 depicts detection curves of eleven bank notes in a money counting machine. The bank notes numbered 21 to 25 and 27 to 31 have been recognized as genuine. The test object numbered 26 is a forgery which for checking purposes was deliberately inserted. Because of the lack of a

security strip or because of an imitated security strip, no signal was furnished by the test sensor arrangement. In practice, the bank note processing machine will be stopped if there is no signal or if the signal does not relate to a bank note, and the forgery or the unusable note is removed or mechanically deposited separately.

If the checking apparatus is additionally connected to a test sensor arrangement, the machine-specific output pulse indicates the detection of a given security strip of thread and is combined with the output signal of that additional check by the processing machine, by the AND gate. If one of the authenticity signals is absent, the machine is stopped, and an operator removes the defective or counterfeit bank note.

With the electronic evaluation circuit being appropriately defined, a further possibility of use results from the evaluation signals of the selective amplifier, as shown in Fig. 3. If, for instance, in large processing machines of the kind used for sorting different currencies, the amplitude limit A marked in Fig. 3, is exceeded for all currencies to be checked, those with a genuine security strip responding to the test sensor arrangement at velocity v_2 will be detected. A specific time t_k is associated with each currency. To distinguish individual currencies, times $t_k = t_1 ... t_4$ though t_n are to be defined as t_f in terms of specific currencies. Thus, for instance, t_f for German currency is to be selected to be larger than t_2 of Swiss franks, or t_f of Swiss francs is to be selected larger than t_3 of Egyptian currency. Since t_f of German currency may possibly have to be selected to be equal to t_f of a currency not shown in Fig. 3, it is necessary to provide in the processing machine a further currency specific check by conventional color recognition and/or format and/or magnetic check. Individual currencies thus sorted are deposited in compartments or stacking boxes in a well-known manner.

For checking non-continuous electrically conductive security strips of documents, processing machines are equipped with a test sensor arrangement 54 of the kind shown in Fig. 7 and consisting of a plurality of transmitting and receiving antennae all of which are disposed parallel to each

other and orthogonally to the direction of movement. For checking, bank notes are placed on a feed device for feeding through a processing machine such that the longest dimension of the security strip or thread in the bank note is aligned substantially parallel to the direction of movement. That is to say, a German bank not would be placed with its longest dimension aligned substantially normal to the direction of movement. The transmitting antennae A2, A3 and the receiving antennae A are disposed opposite each other. Displaced therefrom, several transmitting antennae B2.1 (I=1...n) and several receiving antennae B1.I form pairs of antennae. These pairs are arranged displaced from each other to suppress double coupling of a signal from one transmitting antenna B1.I to an adjacent but not associated receiving antenna B1.k (k=1...n, I<>k). Adjacent transmitting antennae (B2.I, B.2.i+1) and associated receiving antennae (B1.I, B1.I+1) are displaced by a predetermined distance, preferably by the distance between a transmitting antenna B2.I) and its associated receiving antenna (B1.I). To reduce interferences, the pairs of antennae which are displaced diagonally from each other are preferably arranged between the transmitting antennae A2, A3 and the receiving antenna A1.

Fig. 8 depicts a block circuit diagram of a checking apparatus in accordance with the invention in which the test sensor arrangement is energized as shown in Fig. 7. If a document is fed to a processing machine equipped with the checking apparatus in accordance with the invention, it will be activated by light barriers or similar position defining sensors. A frequency generator 41 energizes the transmitting antenna A2 and, by way of a phase shifter 42, the transmitting antenna A3. The phase shifted energization prevents the influences of interferences from extraneous energies and detects forgeries which do not display any difference in electrical conductivity. This is also true of bank notes the properties of which have changed, for instance, as a result of aging and/or mechanical damage and/or moisture. At the same time, a number n of transmitting antennae B.2i (I=1..n) are energized by a second frequency generator 43 and a second phase shifter

44. Any transmitting antennae B2.I positioned transversely of the direction of movement and not in line are energized in a phase shifted manner in order to reduce the effects of disturbances from extraneous energies and to prevent a capacitive double coupling from one transmitting antenna B2.I to a non-corresponding receiving antenna B1.k (k=1..n, I<>k). In order to prevent signal distortions at the receiving antennae, the frequencies of the signals from the two generators are selected such that no frequency is a multiple of another frequency or a multiple of the difference between the two frequencies.

During checking, capacitive coupling of the signal of the transmitting antenna A2 to the receiving antenna A1 is taking place through an continuous electrically conductive security strip, whereas the signal of the transmitting antenna A3 is not capacitively coupled to the receiving antenna A1. The shortest distance between the transmitting antenna A2 and the receiving antenna A1 is less than the greatest length of the electrically conductive security strip in the smallest document to be checked. If at no time during checking the security strip is present in the operational range of the transmitting antenna A2 and the receiving antenna A1, the security strip will be located in the operating range of the transmitting antenna A3 and the receiving antenna A1 and further functions are satisfied analogously to the case described *supra*. In that case, a signal will be present at the receiving antenna A1, which by way of a rectifier 45 and selective amplifier 46 will in turn feed a signal to the micro controller 47. The micro controller 47 will perform the authenticity check by comparing the signal from the selectivity amplifier 46 with a signal, for instance a specific threshold value, stored in the micro controller 47. If the threshold value is exceeded, the micro controller 47 classifies the object to be checked as an object with a continuous electrically conductive security thread, i.e. as genuine in the case of German bank notes. If there are electrically conductive indicia in the security strip which because of their extent are not noticed by the transmitting antenna A2 and the receiving antenna A1, it is possible to detect them by the arrangement of the

transmitting antenna B2.I and associated receiving antenna B1.I since their distances are noticeably smaller than the distance between the transmitting antenna A2 and the receiving antenna A1. If, for instance, the dimension of an electrically conductive mark disposed parallel to the document direction of movement is 1.5 mm, the distance between the transmitting antenna B2.I and the receiving antenna B1.I is to be selected at 1.3 mm in order to ensure capacitive coupling. During checking, the security document to be checked is moved at a defined speed in the effective range of the test sensor arrangement in accordance with the invention. The displaced arrangement of transmitting antenna B2.I and receiving antenna, there will be a balancing of the margins in case of an orthogonal shift of the bank note relative to the direction of movement. Signals arising at the receiving antennae B1.I are fed to the micro controller 47 by way of rectifiers 48..50 and selective amplifiers 51..53. Depending upon structure and location of the security thread within the document, the signals from the selective amplifiers 46, 51...53 received at the micro controller 47 are distinguished in their frequency and amplitude response. In that manner, a classification of the document is possible by the micro controller 47 on the basis of comparing frequency and/or threshold value with predetermined values stored in the micro controller 47. These values are determined by manual input, programming and/or comparison with values parametricized on the basis of a comparison document which has already been classified. The micro controller 47 generates a machine-specific signal which is characteristic of the authenticity of the bank note to be checked. This classification signal of the micro controller 47 is fed to appropriate indicators and/or to the appropriate interface of the processing machine, for further processing. In the same manner as different currencies are distinguishable by different security strips or threads, forgeries will also be detected, provided they have imitation security strips or threads, or simply fractions thereof. The compact structure of the entire checking apparatus, more particularly the sensors and electronic evaluation circuit integrated into a single unit, as well as additional shielding measures result in further

possibilities of reducing interferences which are becoming ever more significant. The arrangement within a processing machine is such that the usual feeding of currency bills is not interfered with by the test sensor arrangement.

The manner of an exemplary integration of an inventive checking apparatus into a conventional processing machine is shown in Fig. 9. To this end, the test sensor arrangement 54 made up of the transmitting antennae A2, A3, B2.I and the receiving antennae A1, B1.I is integrated into an existing guidance device 56. The test sensor arrangement 54 is positioned tangentially relative to the guidance device 56, or it is positioned tangentially displaced relative to the feed roll 55 in such a manner that it additionally assumes its guiding function in the area of the test sensor arrangement 54. For that reason, a bank note to be checked is fed into the operating range of the sensors without additional pressure means. The test sensor arrangement is tangentially placed with respect to a present guidance device 56 such that a security document to be checked and fed by the feed rollers 55 is guided by the test sensor arrangement 54 at a defined spacing and at a defined velocity. By appropriate fasteners at the guidance device 56, in particular wobble screws, a defined spacing may be set between the feed roller 55 and the guidance device 56 or the test sensor arrangement. Setting of the threshold values and of the classification values is accomplished by switches not shown in the figure, or by appropriate software of the micro controller 47. In this manner, an operator may by simple switching easily change the classification values in order to check different currencies. In practice, the machine will be stopped when no signal appears or at a signal not related to a bank note, and the forgery or unusable bill is removed.

The influence of paper quality, age, moisture and so forth on the authenticity classification is reduced by the lateral extension of the antenna arrangement over the entire width of the document. This also includes the possibility of a classification into forgeries, authentic bank notes and badly worn bank notes. This kind of classification is carried out by an appropriate

evaluation of the amplitude and time responses of the signals generated by the selective amplifiers 46, 51..53 and by a corresponding threshold value setting by the evaluating micro controller 47. The micro controller 47 is calibrated manually, software-controlled or by checking specific calibration documents the authenticity classification of which is known. In the latter method, a calibration document is checked by the checking apparatus in the manner described above. Instead of comparing the signals at the outputs of the selective amplifiers 46, 51..53 with signals stored in the micro controller 47, they are stored in the micro controller 47 as reference values.

Another location for mounting the test sensor arrangement 54 has been disclosed in (German) Patent application 195 18 229.4. In accordance with that invention the test sensor arrangement 54 may for instance be mounted at the end of the circularly arcuate guidance device 56 as shown in Fig. 10. Here, too, necessary pressure devices for a defined spacing and/or contact feeding of test objects by the test apparatus are dispensed with. This possibility may be used if it is not possible to mount the test sensor arrangement 54 tangentially offset in the arcuate area of the guidance device 56. Since in accordance with the invention, pressure means such as springs, pressure rollers are dispensed with the test object itself is subjected to less mechanical stress.

The method in accordance with the invention has been described with reference to concrete embodiments of the test sensor arrangement and the electronic evaluation circuit in the context of a money counting machine. It is, however, to be mentioned that the present invention is not limited to the details of the embodiments in the description, as changes and alterations are claimed within the scope of the claims. Thus many different embodiments of the electronic evaluation circuit adapted to the specific operation of the selective amplifier are possible.

Attorney Docket 970224

Patent Claims

1. Method of examining security documents by utilizing capacitive coupling between transmitter and receiver and transmission of energy between transmitter and receiver by bridging an electromagnetic field by electrically conductive security strips, tapes, threads or two-dimensionally structured security materials as well as following evaluation electronics, **characterized by the fact** that several antennae arranged in one or more planes and functioning as transmission and receiving sensors form test fields in the range of conventional optical sensors present in processing machines and spatially corresponding with a capacitive test sensor circuit in a processing machine and activating the test sensor circuit, and that in connecting the antennae electromagnetic energy is transmitted over the test object in dependence of its geometry and/or its conductivity, and that several antennae are energized at least in different phase positions and feed the transmitted energy to a succeeding selective amplifier (14), that for preventing interfering energies as well as for suppressing basic conductivities of test objects, e.g. bank notes, a phase comparator at the output of the selective amplifier as well as special filters for suppressing interfering and extraneous energies and an evaluation unit are arranged such that it is possible to classify electrically conductive security strips, tapes, threads or two-dimensionally structured security materials, whereby the test object is force-guidedly moved through the test field in an undefined lateral disposition during a checking operation.

2. Method according to claim 1, **characterized by the fact** that the electronic evaluation circuitry substantially consisting of an analog to digital converter and controller or integrator (15), trigger (16), controller, mono-flop (17) and/or AND gate (18) defines amplitude limit excesses (A) and/or the currency-specific time t_k on the basis of the signal characteristic at the output

of the selective amplifier (14).

3. Method according to claim 1 or 2, **characterized by the fact** that an authenticity classification is performed by an electronic evaluation circuitry by setting an amplitude limit (A) for the authenticity of currencies to be checked.

4. Method according to claim 1 or 2, **characterized by the fact** that the classification of different bank notes and/or security documents is performed by an electronic evaluation circuitry by setting, preferably by a controller, a currency-specific time (t_k) and that the test objects having a time $t_1..t_{k-1}$, $t_{k+1}..t_n$ are sorted out.

5. Method according to claim 4, **characterized by the fact** that with currencies having identical times (t_k) an additional examination is performed following the authenticity

6. Method according to claim 1 or 2, **characterized by the fact** that the evaluation electronics, preferably one or more controllers, by time comparison and/or voltage comparison delivers a machine-specific signal for depositing individually classifies objects in special slots or stacking containers.

7. Method according to claim 1 or 2, **characterized by the fact** that in a direction intersecting the direction of movement of the test objects the antennae and/or electrodes are of such two-dimensional longitudinal extent that even at a defined lateral play of the test objects and regardless of whether a test object passes through the test apparatus with its front or rear surface facing upwardly, the security strip or thread will in any case sweep over the antennae and/or electrodes contacting them at a defined spacing.

8. Method according to claim 1 or 2, **characterized by the fact** that an additional examination is performed the result of which is combined by an

AND gate with the signal of the evaluation electronics without necessitating changing the software of the given processing machine.

9. Apparatus for examining security documents having elements for capacitive coupling, transmission of energy between transmitter and receiver by bridging an electromagnetic field by electrically conductive security strips, tapes, threads or two-dimensionally structured security materials and evaluation electronics, for practicing the method according to claim 1, **characterized by**

- conventional optical sensors present in a processing machine for activating a capacitive test sensor arrangement;
- test fields formed by several sensors arranged in one or more planes and functioning as transmitting and receiving antennae;
- a selective amplifier (14) and
- a phase camparator connected to the output thereof;
- special filters for suppressing interfering and extraneous energies; as well as
- an electronic evaluation circuit essentially comprising an analog to digital converter and a controller or integrator (15), trigger (16), controller, mono-flop (17) and, if desired, an AND-gate, and that during the checking operation the test object is arranged for moving by the sensors in defined contact therewith at an undefined lateral disposition by means of hold-down devices and/or feed belts (10), rollers arranged in this area.

10. Apparatus according to claim 9, **characterized by the fact** that the sensors functioning as transmitting or receiving antennae are structured as strip sensors (8;9) in one plane or in two planes positioned opposite each other and/or mirror-symmetrically.

11. Apparatus according to claim 9 or 10, **characterized by the fact** that the strip sensors (8;9) are provided with recesses and/or apertures and/or

windows (7) or that such are arranged in the immediate vicinity of the strip sensors (8;9).

12. Apparatus according to one or more of preceding claims 9 to 11, **characterized by the fact** that sensors in test units are arranged mirror-symmetrically relative to the test zones and/or security strips, threads and/or tapes of objects to be checked, preferably bank notes, security documents and packing materials.

13. Apparatus for examining security documents having elements for capacitive coupling, transmission of energy between transmitter and receiver by bridging an electromagnetic field by electrically conductive security strips, tapes, threads or two-dimensionally structured security materials and evaluation electronics, for practicing the method according to claim 1, **characterized by the fact** that a plurality of transmitting antennae (A2, A3, B2.1..B2.n) and a plurality of receiving antennae (A1, B1.1..B1.n) forming a test sensor arrangement (54) are arranged such that security strips which are uninterruptedly electrically conductive as well as those provided with a plurality of electrically conductive sections insulated from each other in a security strip may be checked, whereby the test sensor arrangement (54) is arranged displaced tangentially parallel to an arcuate conductor (56) or tangentially parallel relative to a feed roller (55) and that there are arranged, orthogonally relative to the direction of the longest dimension of a security strip and orthogonally to the direction of movement of a document to be checked, two transmitting antennae (A2, A3) energized at opposite phases with low or high frequency energy, and one or more oppositely placed receiving antennae (A1) and, between them, several transmitting antennae (B2.1..B2.n) disposed parallel relative to the transmitting antennae (A2, A3) and several receiving antennae (B1.1..B1.n) parallel relative to the transmitting antennae (B2.1..B2.n), whereby adjacent transmitting antennae B2.I..B2.I+1) and associated receiving antennae (B1.I, B1.I+1) are displaced

by a defined distance, preferably the distance between a transmitting antenna (B2.I) and associated receiving antennae (B1.I) and that the shortest distance of a transmitting antenna (B2.I) from its associated Receiving antenna (B1.I) is less than the shortest distance between one of the transmitting antennae (A2, A3) and the receiving antennae (A1).

14. Apparatus according to claim 13, **characterized by the fact** that several transmitting antennae (A2, A3, B2.1..B2.n) and several Receiving antennae (A1, B1.1..B1.n) are arranged over the entire width of the document feed path.

15. Apparatus according to claim 13 or 14, **characterized by the fact** that the transmitting antennae (A2, A3, B2.1..B2.n) and the receiving antennae (A1, B1.1..B1.n) are arranged in a plane adjacent to each other, in parallel and displaced such that an authenticity check of the documents is performed independently of sides and independently of edges relative to two parallel document edges.

16. Apparatus according to claim 13, **characterized by the fact** that receiving antennae (B1.1..B1.n) and transmitting antenna (B2.1..B2.n) displaced parallel and/or in a line transversely of the direction of are arranged in spaced apart relationship such that each security element to be checked sweeps over a receiving antenna (B1.1..B1.n) and an associated transmitting antenna (B2.1..B2.n) regardless of its disposition within the document.

17. Apparatus according to claim 13, **characterized by the fact** that the longest side of a transmitting antenna (B2.I) and the longest side of the associated receiving antenna (B1.I) corresponds to the width of the conductive marking of the security strip.

18. Apparatus according to claim 13, **characterized by the fact** that

following rectifiers (45, 48..50) and selective amplifiers (46, 51..53) there are arranged manipulatable or software-controlled switching and setting elements, in particular micro-controllers (47) such that the output signals of the selective amplifiers (46, 51..53) may be combined or logically connected.

19. Apparatus according to claim 13, **characterized by the fact** that following rectifiers (45, 48..50) and selective amplifiers (46, 51..53) there are arranged manipulatable or software-controlled switching and setting elements, in particular micro-controller (47) such that a change-over between different types and kinds of documents and degrees of wear is performed without a change in the arrangement of the sensors.

20. Apparatus according to claim 13, **characterized by the fact** that the shortest distance between two transmitting antennae (B2.I) arranged in a row is greater than the shortest distance between two electrically conductive and insulated markings of the security strip and that change-over elements are arranged such that the antennae (A3) are used either as transmitting or as receiving antennae, depending upon the feeding of the document to be checked.

21. Apparatus according to claim 13, **characterized by the fact** that software or manually controlled switching elements are arranged such that one or more transmitting antennae (B2.I) and the corresponding receiving antennae (B1.I) may be selectively activated or deactivated.

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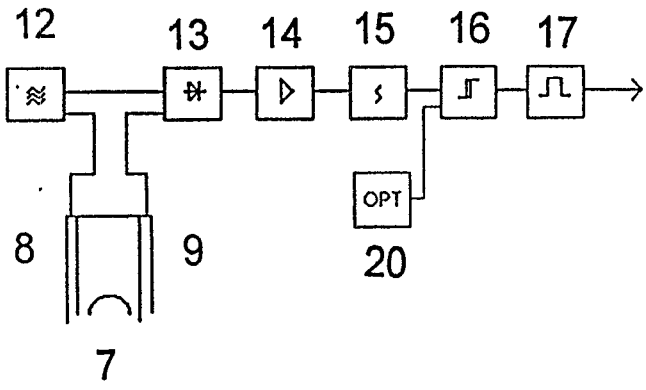

Fig. 1

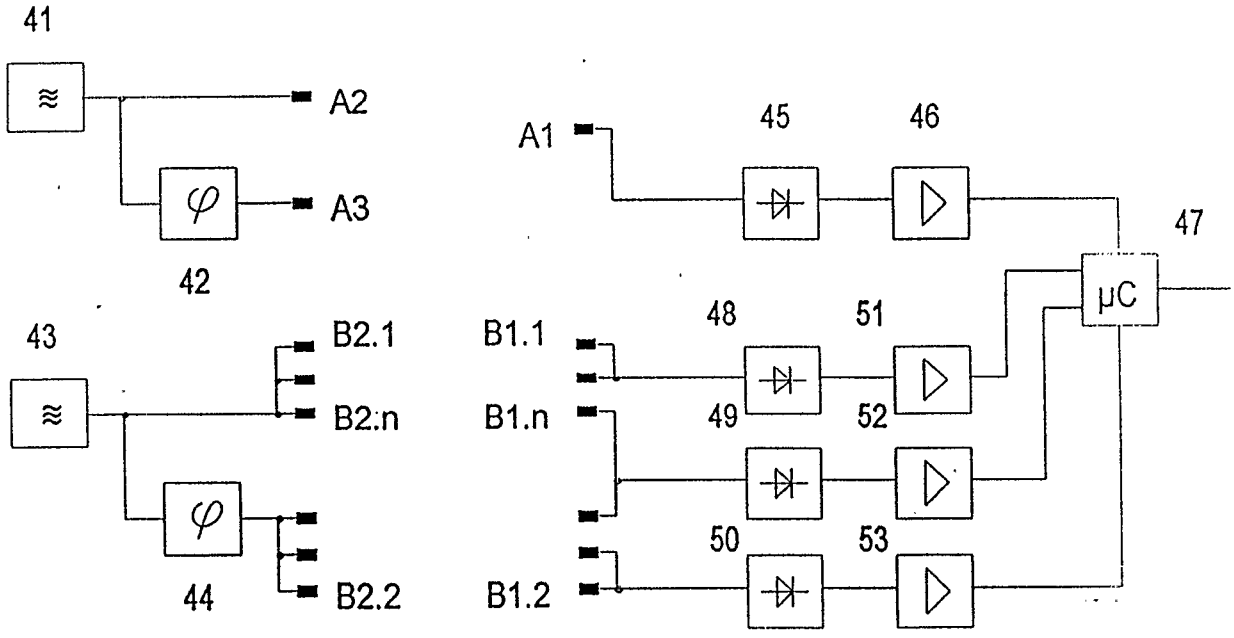

Fig. 8

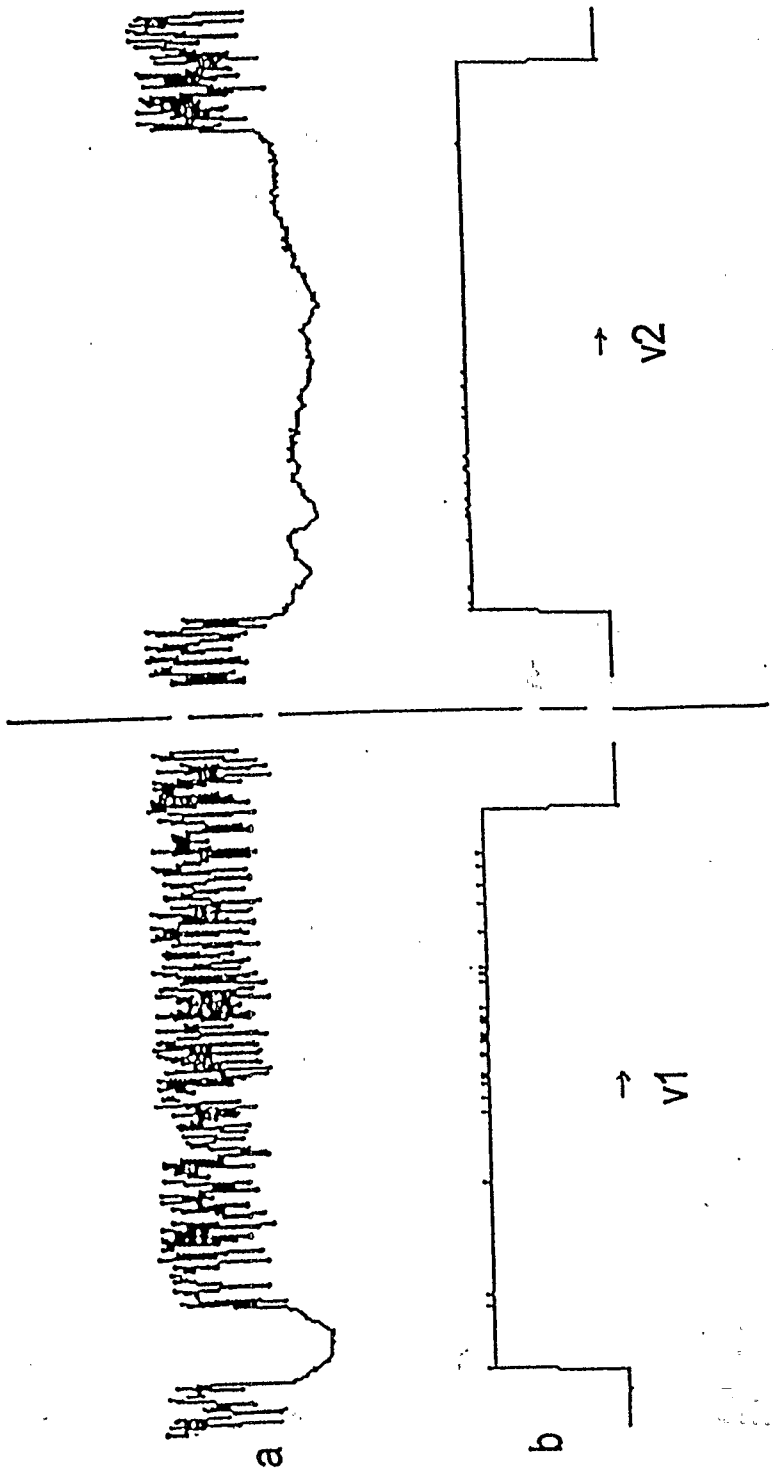

Fig. 2

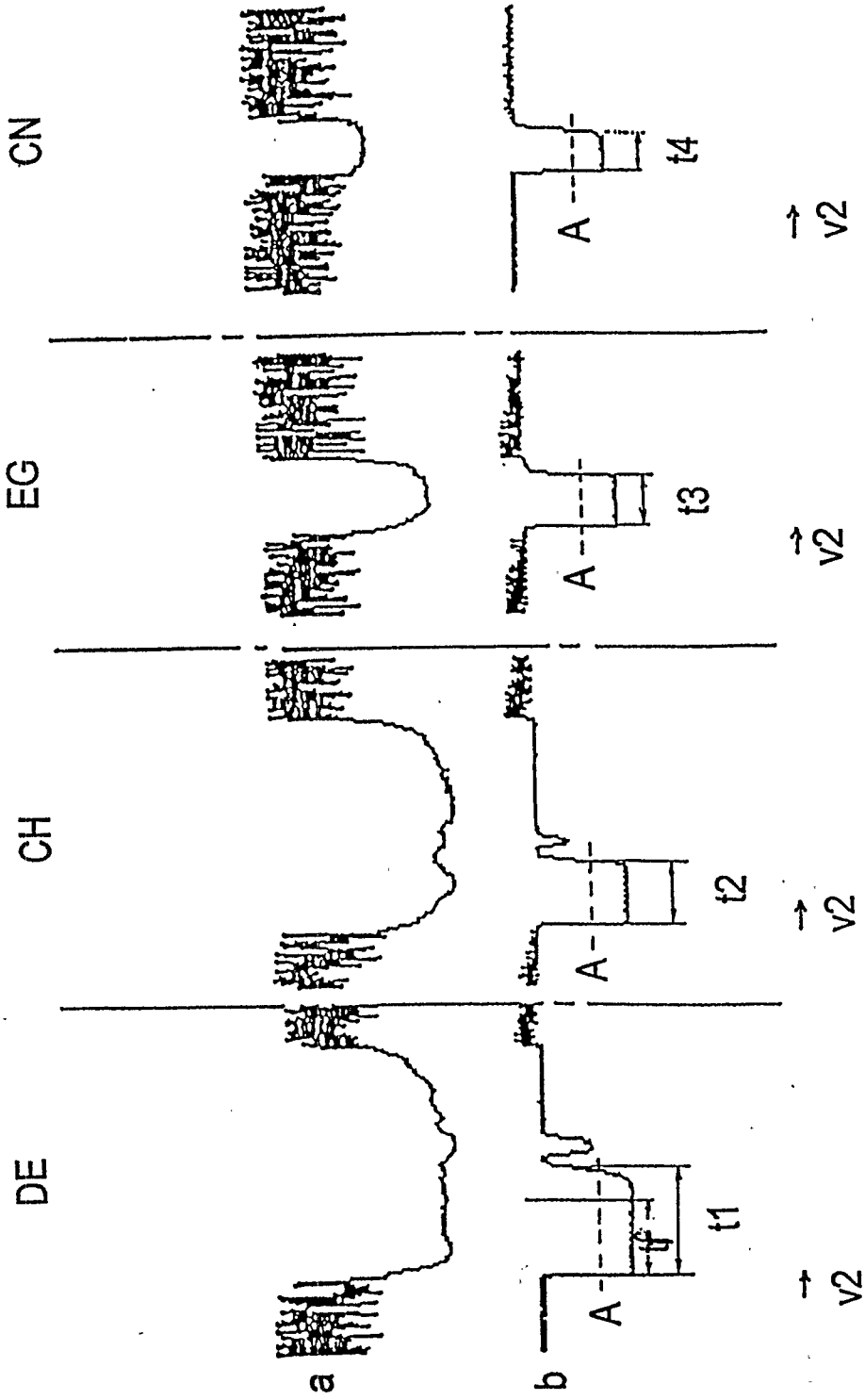

Fig. 3

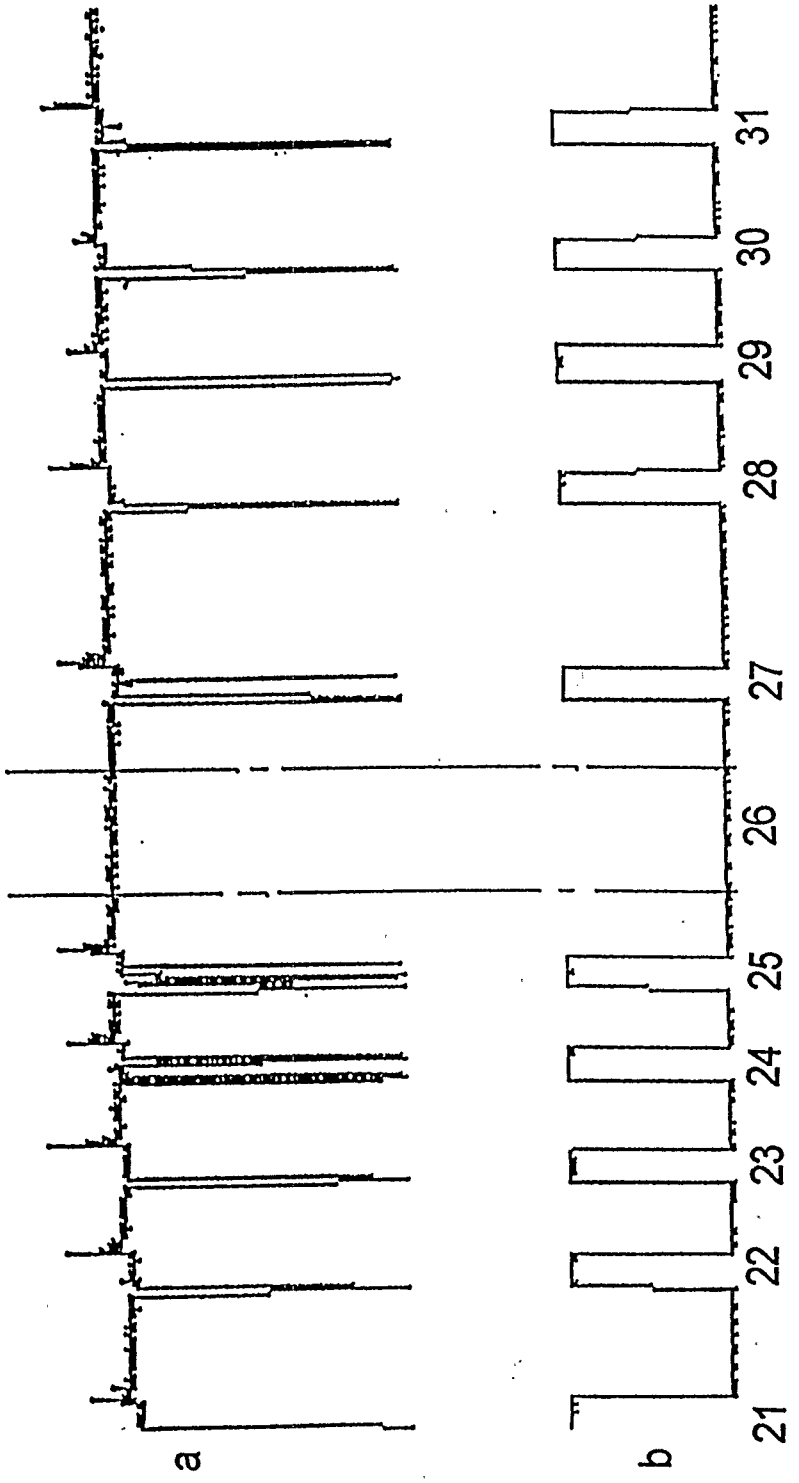

Fig. 4

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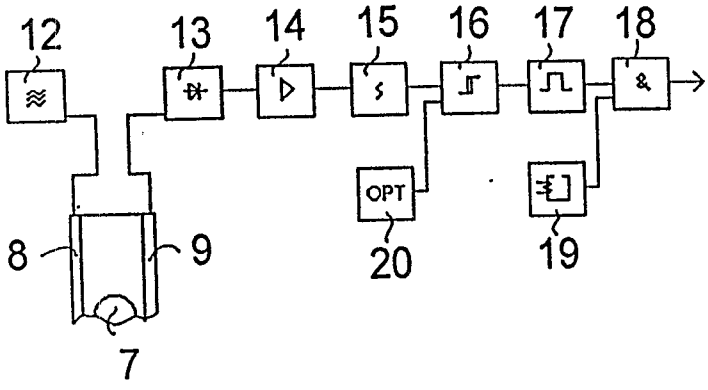

Fig. 5

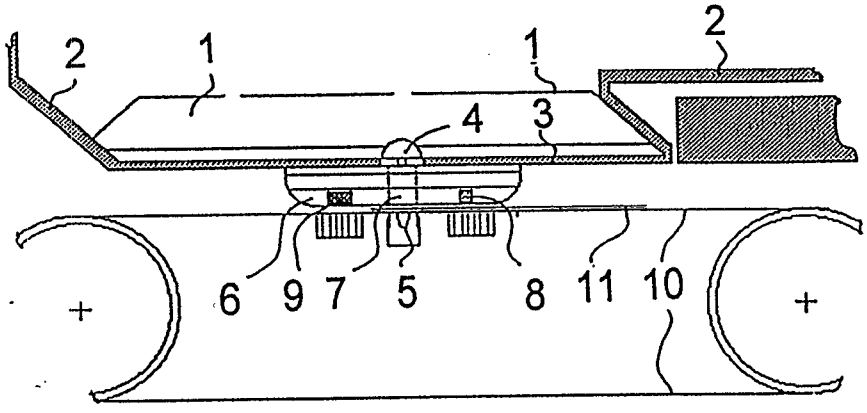

Fig. 6

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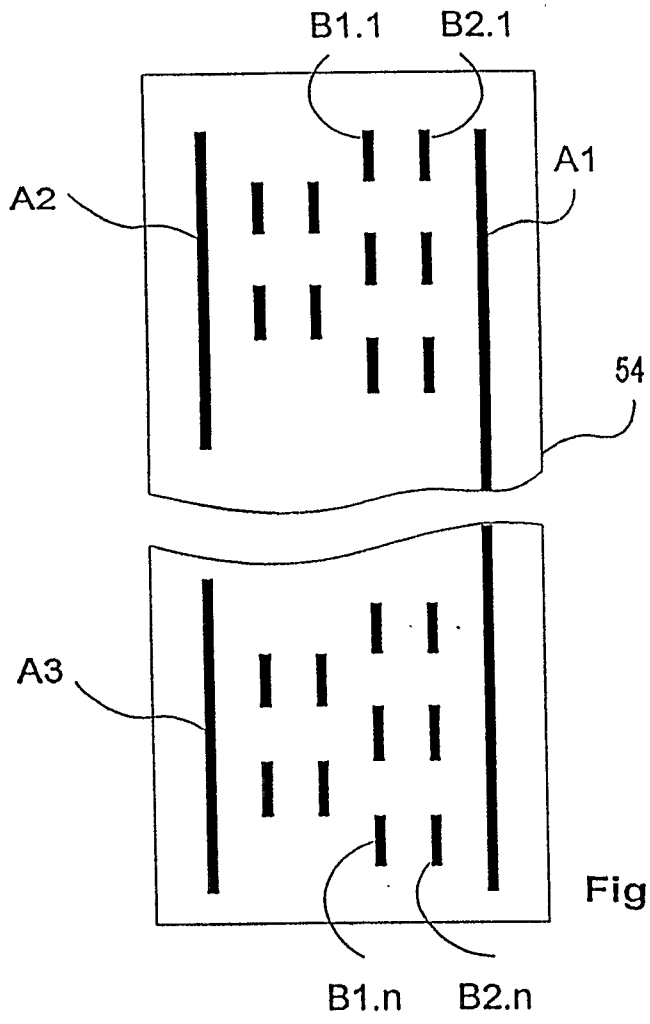


Fig. 7

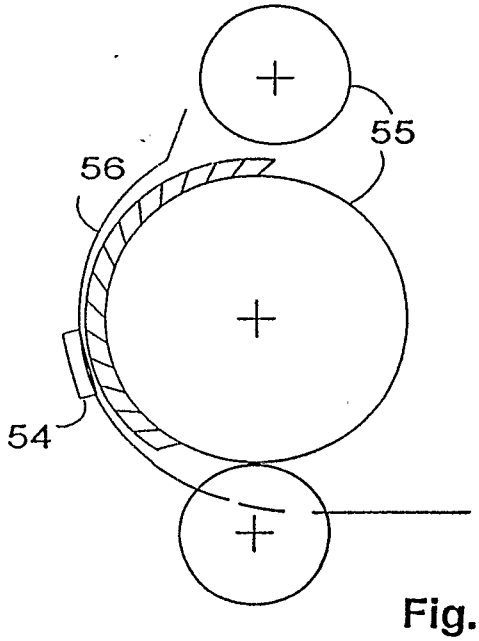


Fig. 9

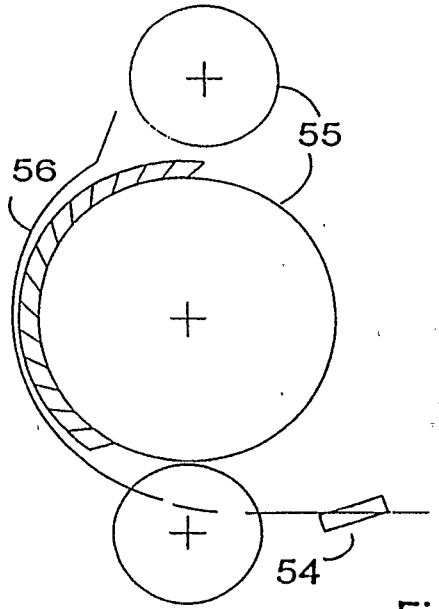
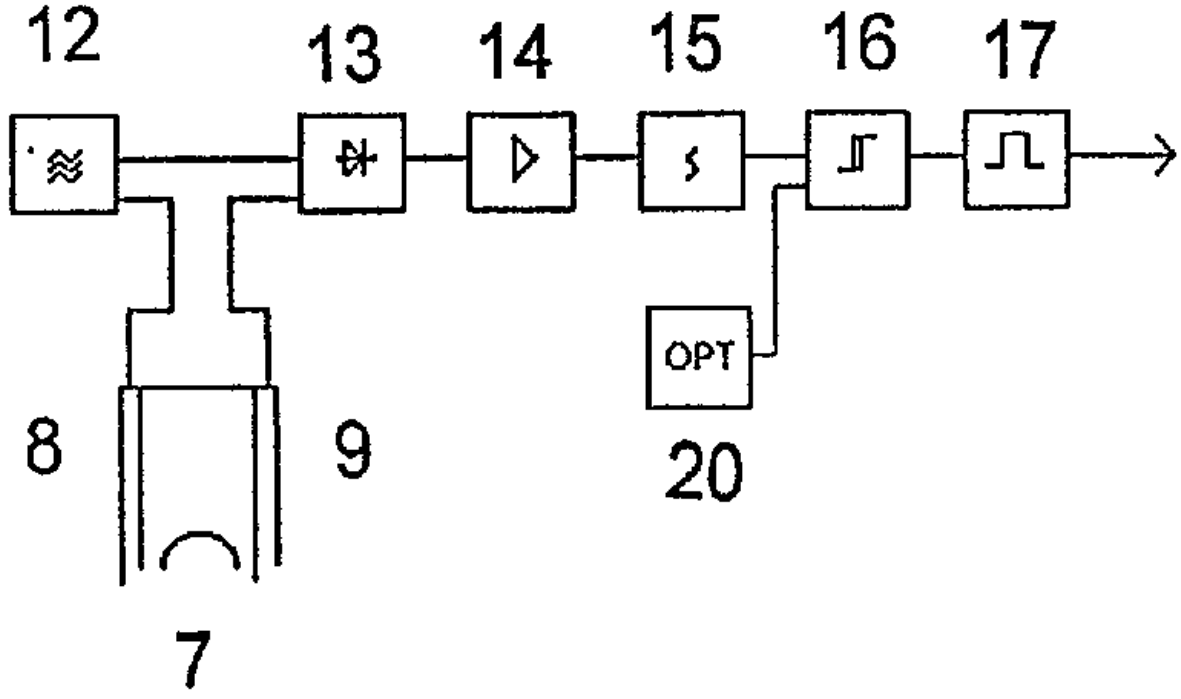


Fig. 10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