LV 11505

(19) LATVIJAS REPUBLIKAS
PATENTU VALDE

(11) **LV 11505 B**

(51) Int.Cl. 6 **G07F3/02**
G07D5/02
G07D5/08

Latvijas patents uz izgudrojumu
1995.g. 30.marta Latvijas Republikas likums

(12) # Īsziņas

(21) **Pieteikuma numurs:** P-95-290

(22) **Pieteikuma datums:** 21.09.1995

(41) **Pieteikuma publikācijas datums:** 20.08.1996

(45) **Patenta publikācijas datums:** 20.12.1996

(30) **Prioritāte:**

94810544.0	21.09.1994	EP
00350/95-3	08.02.1995	CH
95810150.3	08.03.1995	EP

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(54) **Virsraksts:** **Monētu, žetonu vai citu plakanu metāla priekšmetu autentiskuma pārbaudes ierīce**

(57) **Kopsavilkums:** Monētu (M), žetonu vai citu plakanu metāla priekšmetu autentiskuma pārbaudes ierīce (fig.1) satur monētas kanālu (1), kuram ir apakšējā (4) un augšējā (5) sānu sienas. Monēta (M) virzās pa monētas kanālu (1), kontaktējot ar apkšējo (4) sānu sienu, garām pirmajam un otrajam induktīvajam sensoriem (9,10). Induktīvie sensori ir izveidoti vai nu spoļu (9,10), vai spoļu un metāla plākšņu (9,11; 10,12) veidā, pie kam pirmā spole (9) ir uzstādīta pie apakšējās sānu sienas (4), bet otrā spole (10) - pie augšējās sānu sienas (5). Abas spoles darbojas elektriski neatkarīgi. Spoles (9,10) ir elektriski izdevīgi sakārtot kā svārstību kontūru (RCL) virkni. Monētai virzoties gar spolēm, tiek mērītas un analizētas katrā spolē (9,10) inducētās strāvas pretestības izmaiņas. Tādā veidā tiek noteikti monētas (M) sakausējuma sastāvs un monētas biezums d.

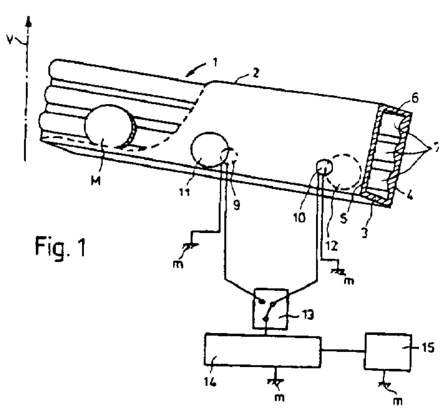


Fig. 1

IZGUDROJUMA FORMULA

1. Monētu (M), žetonu vai citu plakanu metāla priekšmetu autentiskuma pārbaudes ierīce, kas satur:

monētas kanālu (1) ar apakšējo (4) un augšējo (5) sānu sienām, pie kam monētas kanāls (1) novietots noteiktā slīpumā attiecībā pret vertikāli (V), un monēta (M) ideālā gadījumā virzās gar apakšējās sānu malas sienu (4), saskaroties ar to,

divus induktīvos sensorus, iestiprinātus monētas kanālā (1),

elektronisko shēmu (14) un vadības un novērtēšanas bloku (15),

atšķiras ar to, ka:

pirmais induktīvais sensors ir spole (9), kas uzstādīta pie apakšējās sānu sienas (4),

otrais induktīvais sensors ir spole (10), kas uzstādīta pie augšējās sānu sienas (5),

bloki (13, 14) paredzēti tādi, lai strādātu ar abām spolēm (9, 10) elektriski neatkarīgi,

elektroniskā shēma (14) ir izveidota tā, lai izmērītu abu spoļu (9, 10) omisko pretestību $R_9(t)$ un $R_{10}(t)$ izmaiņas monētas (M) virzīšanās laikā,

vadības un novērtēšanas bloks (15) nosaka pirmās spoles (9) izejas pretestības $R_9(t)$ lielāko vērtību K_1,

vadības un novērtēšanas bloks (15) nosaka otrās spoles (10) izejas pretestības $R_{10}(t)$ maksimumus (m1, m2) un nosaka šo maksimumu (m1, m2) lielāko vērtību (v1, v2), ko apzīmē ar K_2,

vērtības K_1 un K_2 vai K_1 un $H_2=K_1+K_2$ tiek izmantotas, lai pieņemtu lēmumu par monētas (M) atzīšanu par derīgu vai noraidīšanu.

2. Monētu (M), žetonu vai citu plakanu metāla priekšmetu autentiskuma pārbaudes ierīce, kas satur:

monētas kanālu (1) ar apakšējo (4) un augšējo (5) sānu sienām, pie kam monētas kanāls (1) novietots noteiktā slīpumā attiecībā pret vertikāli (V), un monēta (M) ideālā gadījumā virzās gar apakšējās sānu malas sienu (4), saskaroties ar to,

divus induktīvos sensorus, iestiprinātus monētas kanālā (1),

elektronisko shēmu (14) un vadības un novērtēšanas bloku (15),

atšķiras ar to, ka:

pirmais induktīvais sensors ir spole (9), kas uzstādīta pie apakšējās sānu sienas (4),

otrais induktīvais sensors ir spole (10), kas uzstādīta pie augšējās sānu sienas (5),

bloki (13, 14) paredzēti tādi, lai strādātu ar abām spolēm (9, 10) elektriski neatkarīgi,

elektroniskā shēma (14) izveidota tā, lai izmērītu abu spoļu (9,10) omisko pretestību $R_9(t)$ un $R_{10}(t)$ izmaiņas monētas (M) virzīšanās laikā,

vadības un novērtēšanas bloks (15) nosaka pirmās spoles (9) pretestības $R_9(t)$ lielāko vērtību K_1,

vadības un novērtēšanas bloks (15) nosaka otrās spoles (10) pretestības $R_{10}(t)$ maksimumus (m1, m2) un šo maksimumu (m1, m2) lielāko vērtību (v1, v2), ko apzīmē ar K_2,

vadības un novērtēšanas bloks (15) nosaka pirmās spoles (9) iekšējo pretestību r_1 un otrās spoles (10) iekšējo pretestību r_2 tieši pirms vai pēc monētas (M) virzīšanās garām spolēm,

vērtības $P_1=r_1/K_1$ un $P_2=r_2/K_2$ vai P_1 un $I_2=P_1+P_2$ tiek izmantotas, lai pieņemtu lēmumu par monētas (M) atzīšanu par derīgu vai noraidīšanu.

3. Ierīce saskaņā ar 1. vai 2. punktu, kas **atšķiras ar to,** ka spoles (9, 10) pielāgotas virknes rezonanses kontūra (RLC) pretestības mērīšanai.

4. Ierīce saskaņā ar 3. punktu, kas **atšķiras ar to,** ka elektroniskā shēma (14) satur diferenciālo pastiprinātāju (18) un pastiprinātāja shēmu (22), pie kam no diferenciālā pastiprinātāja (18) izejas barošanas spriegums caur rezistoru (21) tiek padots uz inverso ieeju (19) un caur pastiprinātāja shēmu (22) uz neinverso ieeju (20), pie kam pastiprinātāja shēma (22) pie ieslēgtas elektroniskās shēmas (14), pirmkārt, iesvārsta virknes rezonanses kontūru (RLC), otrkārt, veido stabilas amplitūdas spriegumu (U3(t)) virknes rezonanses kontūra (RLC) ierosināšanai.

5. Ierīce saskaņā ar 4. punktu, kas **atšķiras ar to,** ka pastiprinātāja shēma (22) satur divus invertorus (24, 25), kas ir virknē saslēgti vai nu NAND, vai NOR elementi.

6. Ierīce saskaņā ar vienu no 3.- 5. punktiem, kas **atšķiras ar to,** ka ir paredzēti līdzekļi svārstību frekvences ($\omega_0(L_S)$ izmaiņu noteikšanai pirmajā spolē (9) monētas (M) virzīšanās laikā un ka šīs izmaiņas tiek izmantotas kā kritērijs lēmuma pieņemšanai par monētas (M) atzīšanu par derīgu vai noraidīšanu.

7. Ierīce saskaņā ar vienu no 1.- 6. punktiem, kas **atšķiras ar to**, ka katrā gadījumā metāla plāksnīte (11, 12) ir piestiprināta spolēm (9, 10) pretējai sānu sienai (5, 4).

8. Monētu (M), žetonu un citu plakanu metāla priekšmetu autentiskuma pārbaudes ierīce, kam ir monētas kanāls (1) ar apakšējo (4) un augšējo (5) sānu sienām, pie kam apakšējā (4) sānu siena ir apgādāta ar ribām (7) monētas kustības virzienā, monētas kanāls (1) ir novietots noteiktā leņķī attiecībā pret vertikāli (V), un monēta (M) ideālā gadījumā virzās gar apakšējās sānu sienas (4) ribām (7), saskaroties ar tām,
atšķiras ar to, ka ribu (7) izliekuma rādiuss (R) ir vismaz puse no attāluma (a) starp blakus izvietotajām ribām (7).

9. Ierīce saskaņā ar 8. punktu, kas **atšķiras ar to**, ka ribu (7) izliekuma rādiuss (R) ir aptuveni salīdzināms ar attālumu (a) starp blakus izvietotajām ribām (7).

Device for testing the authenticity of coins, tokens or other flat metallic objects

The invention relates to a device for testing the authenticity of coins, tokens or other flat metallic objects of the type mentioned in the precharacterizing clause of Claim 1.

Such devices are suitable, for example, as collection stations in public telephone stations, vending machines, meters for measuring electricity, etc.

A device for testing the authenticity of coins of the type mentioned in the precharacterizing clause of Claim 1 is known from EP 304 535 B1. The device has three inductive sensors, operating independently of one another, for determining the thickness, the alloy composition and the diameter of the coin to be tested. These inductive sensors are constructed as double coils which are arranged on both sides of the coin channel and are connected electrically in parallel or in series, so that measurement scatter as a result of bouncing or jumping of the coin in the coin channel can be partially compensated for, bouncing and springing meaning a lifting off from the bottom of the coin channel or a change in the position with respect to the side walls of the coin channel. The use of double coils, however, is associated with the disadvantage that the alloy composition and the thickness of the coin cannot be determined independently of each other. Each of the inductive sensors are part of a parallel resonant circuit in which the shift of the resonant frequency, brought about by the coin, and the changed quality are measured. The measured changes in these parameters serve as decision criteria for the acceptance or rejection of the coin. It is also envisaged to construct an inductive sensor serving for the determination of the alloy composition as a simple coil which is fitted to only one side of the coin channel.

A coin detector with inductive sensors, which is operated at frequencies from 3 kHz to 1 MHz, is known from GB 1 397 083. The inductive sensors are arranged in resonant circuits and in bridge circuits. The resonant frequency in the presence of the coin serves to characterise the coin.

The use of energy-absorbing elements, in order to achieve rolling of the coin without bouncing or jumping in the region of the sensors, is known from GB 2 266 804 and also from German Utility Model G 90 13 836.8. Such energy-absorbing elements are preferably platelets made of ceramic which are arranged in the coin channel in such a way that each coin inserted into the coin inlet opening impacts thereon.

It is known from DE 30 07 484 to construct the lower side wall of a coin channel which is inclined by a predetermined angle with respect to the vertical with ribs designated as guide rails along the running direction of the coin.

The invention is based on the object of providing a device for testing the authenticity of coins in which the alloy composition and the thickness of the coin may be determined independently of each other, in which bouncing or jumping of the coin is firstly excluded as far as possible and secondly any remaining bouncing or jumping leads to a measurement scatter which is as small as possible.

The said object is achieved according to the invention by means of the features of Claims 1, 2 and 8.

Exemplary embodiments of the invention are explained in more detail below using the drawing, the reference to the coin M in the following also being understood to refer to tokens or other flat metallic objects.

Fig. 1 shows a coin channel of a testing device,

Fig. 2 shows the coin channel in cross-section,

Figs. 3, 4 show measured value diagrams,

Fig. 5 shows a sensor signal and

Fig. 6 shows an electronic circuit.

Fig. 1 shows a device for testing the authenticity of coins, tokens or other metallic objects, having a coin channel 1 which is preferably constructed as a recess in a body 2 consisting of two plastic parts. The coin channel 1 is confined by the bottom 3, a lower and an upper side wall 4 and 5 and a cover 6. The lower side wall 4 is provided with integrally moulded ribs 7 which are running parallel to the bottom 3 in the travel direction of the coin M. The coin channel 1 is inclined in the running direction of a coin M to be tested and the two side walls 4 and 5 are inclined by an acute angle of typically 10° with respect to the vertical V, so that the coin M to be tested rolls or slides on the bottom 3 down along the coin channel 1 and, while one face of the coin M is laying flat on the ribs 7 of the lower side wall 4, ideally. Both side walls 4 and 5 have, on their side facing away from the coin channel 1, recesses to accommodate coils 9 and 10 which are arranged in an off-axis displacement and, optionally, metallic platelets 11, 12. The coil 9 and the platelet 12 are located on the lower side wall 4, for which reason they are shown by dashed lines. The recesses are shown only in Fig. 2 on grounds of clarity. The platelets 11 and 12 are fitted opposite the coils 9 and 10, respectively. They are preferably round or rectangular but can also have any other desired geometric form. In each case one coil 9 or 10 and, if appropriate, the metallic platelet 11 or 12 arranged in the opposite side wall 5 or 4 form an inductive sensor. The two coils 9 and 10 have two connections, one each of which is led to a common electric ground connection m, the other to a switch 13, so that they can be connected to an electronic circuit 14 for electrical operation independent of one another. The device further contains a control and evaluation unit 15, for example in the form of a microprocessor, for evaluating the output signal supplied by the electronic circuit 14 and for controlling the device. The circuit 14 and the microprocessor 15 are constructed to the effect that they derive, from the signals measured with the coils 9 and 10, discrete values which are a measure of the alloy and the thickness d of the coin M. The coin M is only considered to be authentic and is accepted by the testing device if these values agree with predetermined values within prescribed limits, otherwise the coin M is rejected.

Fig. 2 shows the coin channel 1 in cross-section at the level of the coil 10. The ribs 7 are arranged at a mutual distance a which is preferably a = 7.25 mm. The shape of their surface facing the coin channel 1 is cylindrical, their radius of curvature R is of comparable size to the spacing a: R ≡ a. A somewhat larger value of R = 8 mm is preferred. The ribs 7 are naturally separated by depressions 16 whose depth is about 0.5 mm. The depressions 16 have a flat area 17 in the region of the greatest depth between the ribs 7, so that the side wall 4 has a minimum wall thickness in the region of the recesses 8, the wall thickness is chosen based only on the material properties of the body 2 and on the mechanical stresses to be expected as a result of the coins M, but irrespective of the radius of curvature R and the spacing a. Preferably, a minimum wall thickness of 0.6 mm is provided, so that the coil 9 fitted in the recess 8 in the lower side wall 4 has a fixed spacing of 1.1 mm from a coin M rolling past in an ideal manner. The ribs 7 are also there in order to prevent undesired sticking or even jamming of a wet coin.

The construction of the ribs 7 having a cylindrical surface with a comparatively large radius of curvature R results in a greater contact area between the lower side wall 4 and the coin M than is the case in ribs according to the prior art. This leads to the fact that an impact, directed against the lower side wall 4, of a coin M which does not rest in an ideally flat manner, is connected with a relatively high damping, so that bouncing and jumping of the coin M in the region of the coils 9 and 10 rarely will occur, even if the coin has damages such as scratches or indentations. The extent to which the bouncing and jumping of the coin M can also be suppressed with ribs 7 whose radius of curvature R is smaller than the spacing a and, for example, is only a/2, is easy to determine by means of trials. Also, the shape of the ribs 7 does not have to be exactly that of a cylinder.

The high damping of the coin M impacting against the lower side wall 4 also results in significantly lower noise emissions compared to a conventional construction of the ribs 7.

Another embodiment of the invention comprises instead of the ribs 7 in the lower side wall 4 in the region of the coils 9 and 10, a thin plate which is loosely fastened parallel to the side wall 4. The plate has a comparatively low mass, compared with the masses of the coins M to be tested, and consists, for example, of metal or of ceramic. It serves for the purpose of absorbing the energy of the jumping coin M, if necessary in the event of an impact of the coin M on the plate, and as a result to damp the jumping of the coin M.

According to a further embodiment of the invention, apart from the mechanical precautions to prevent the bouncing and/or jumping of the coin M, improvements in terms of measurement are also provided which further reduce the influence of any possible remaining bouncing or jumping on the measurement of the important characteristics of alloy composition and thickness of the coin M.

Insofar as the considerations apply to both, the coil 9 and the coil 10, the reference symbol S is used below on grounds of simplicity instead of the reference number 9 or 10. Thus, a coil S means one of the coils 9 or 10. The coil S is electrically characterised by its inductance L_S and its ohmic internal resistance R_S. It represents an inductive sensor. The above mentioned combination of the coil S with one of the platelets 11 or 12 represents another inductive sensor. During the passage of the coin M past the coil S, the values L_S and R_S change briefly because of physical interactions between the coil S and the coin M. The internal resistance R_S comprises a static component $R_{S,DC}$ and a dynamic component $R_{S,AC}(\omega)$ which is a function of the angular frequency ω of the current flowing through the coil S, of the physical properties of the coin M, of the geometry of the coil S and, in particular, of the spacing between the coil S and the coin M. As soon as the coin M, while rolling along the coin channel 1, passes into the measurement region of the coil S, its internal resistance R_S increases. The typical variation with time of the internal resistance R_S is shown in Fig. 5. In order to avoid any influence of the diameter of the coin M on the measurements of the thickness d and of the alloy composition, the diameter of the coil S is selected to be smaller than the diameter of the smallest coin M to be measured and the coil S is arranged on the side wall 4 or 5 of the coin channel 1 at a corresponding level, so that the smallest coin M to be tested completely covers the coil S during the passage for a short time. The diameter of the coil S is, for example, 14 mm. The resistance of the feed wires is comparatively small. Wire-wound coils with a ferrite core are particularly suitable as coils 9 and 10. The implementation of the coils 9 and 10 as single coils arranged in each case on only one side of the coin channel 1, and their complete electrical separation, avoids the loss of sensitivity associated with double coils.

The electronic circuit 14 operates the coil S in a series resonant circuit and supplies at its output an analogue signal which is proportional to the internal resistance R_S of the coil S. During the passage of a coin M through the measurement region of the coil S, the variation with time of this output signal is acquired by the microprocessor 15 by means of an analogue/digital converter as a series f1 of digital values which are stored. Subsequently, the microprocessor 15 carries out a detailed analysis which is explained below, whose result are two values, for example the values K_1 and K_2 described below, which are used to decide about the acceptance or rejection of the coin M.

The coil 9 is located on the lower side wall 4 along which the coin M moves in contact, so that the spacing between the coil 9 and the nearest face of the coin M is fixed, for example, at 1.1 mm. The coin M is made either from a single alloy or from a composition of a plurality of alloys. The internal resistance R_9 of the coil 9, measured in the presence of the coin M, is a approximate function of the material of the coin M, exclusively, if the frequency ω of the current flowing through the coil 9 is selected property. Fig. 3 shows the internal resistance R_9 as a function of the thickness d of the coin M for coins produced from various alloys L1, L2 and L3, the coin M being located during the measurement in a symmetrical position resting in front of the coil 9. It can be seen from this that the internal resistance R_9 is practically independent of the thickness d. Hence, using the coil 9, an important first characteristic variable of the coin M, which is almost exclusively a function of its alloy or its alloy composition, can be determined in a simple way.

The spacing between the coil 10 and the coin M is a function of its thickness d. In the case of the coil 10, the internal resistance R_{10} is thus a function not only of the material of the coin M but also of its thickness d. As Fig. 4 shows, the dependence on the thickness d in the range of interest is approximately linear for all the alloys L1, L2 and L3 shown. If the alloy of the coin M is known, the thickness d of the coin M can be determined unambiguously.

In contrast to the use of so-called double coils which are arranged on both sides of the coin channel 1 and are connected electrically in parallel or in series, the use of the two single coils 9 and 10 with or without platelets 11 and 12, which are arranged on only one side wall 4 and 5, respectively, allows the mutually completely independent determination of the two parameters of the coin M which characterise the coin M on the basis of its alloy or alloy composition and thickness.

Fig. 5 shows the variation with time of the output signal of the electronic circuit 14 for three coins of the same type. The coins come into the measurement region of the first coil 9 at time t_1, and leave it again approximately at time t_2. At time t_3 they come into the measurement region of the second coil 10, which they leave again approximately at time t_4. The output signal from the coil 9 has two maxima M1 and M2 having values U1 and U2, the output signal from the coil 10 two maxima m1 and m2 having values v1 and v2. The continuous line represents the output signal of a coin M which rolls down the coin channel 1 (Fig. 1) without bouncing or jumping and, in so doing, lies flat on the ribs 7. In this case, the measured values U1 and U2 and also the values v1 and v2 are equal: U1=U2, v1=v2. The dash-dotted line shows the output signal of a coin M which bounced or jumped in the measurement region of the first coil 9: the values U1 and U2 are different. The dashed line shows the output signal from a coin M which bounced or jumped in the measurement range of the second coil 10: the values v1 and v2 are different. Trials have shown that at least one of the values U1 or U2 and v1 or v2 is relatively stable, that is to say it has a low scatter, whereas the minimum lying between the corresponding maxima is subject to a greater scattering. In the case of the first coil 9, the value of the greater of the two maxima corresponds to the smallest spacing between the coil 9 and the coin M, since then the damping of the coil 9 is at its strongest. In the case of the example shown in Fig. 5, this is for both lines the second maximum M2 having the value U2, which is also the more stable of the two maxima. The microprocessor 15 is therefore programmed to the effect that it determines the greatest value of the output signal in the first coil 9 and stores it as the value K_1. The damping of the second coil 10 is smaller, the larger the spacing is between the coil 10 and the coin M. The microprocessor 15 is therefore programmed to the effect that it determines the values v1 and v2 of the two maxima m1 and m2 in the second coil 10 and stores the smaller of the two values v1 and v2 as the value K_2: K_2=min(v1, v2). In the example in Fig. 5, the maximum m2 corresponds to this case.

In a manner known per se the microprocessor 15 carries out this described analysis of the output signals. In order to balance out noise effects and to reduce the scatter of the values K_1 and K_2 to be determined, it is advantageous to convert the sequence f1 into a sequence f2, each value of the sequence f2 being the running average determined over, for example, ten successive values of the sequence f1. The determination of the greatest value of the output signal from the first coil 9 can be carried out by means of numeric comparisons, the determination of the maxima m1 and m2 can be carried out by calculating the first and second derivatives of the sequence f2.

In order to exclude the influences of other physical factors such as temperature, humidity, etc. on the measured results to the greatest extent possible, it is advantageous for the microprocessor 15 to form relative values $P_1 = r_1/K_1$ and $P_2 = r_2/K_2$, the variables r_1 and r_2 representing reference resistances which are equal to the internal resistance R_9 of coil 9 and R_{10} of coil 10 in the absence of the coin M. The reference resistances r_1 and r_2 are advantageously determined each time directly before or after the passage of the coin M.

As is known, each coin M has two faces which are embossed differently and which, in common English usage, are designated "head" and "tail". This asymmetrical embossing of the coin M leads to the fact that the characteristic variables K_1 and K_2 determined in the case of the coin M depend on which side of the coin M rests on the side wall 4. The scatter in the variables K_1 and K_2 which is present in the case of a specific type of coin is additionally increased by this effect. However, the range of scatter of the variable K_1 remains sufficiently small in order to be able to determine the alloy of the coin M unambiguously. On the other hand, the measurement of the thickness d is disturbed by this effect to such an extent that the assessment of the authenticity of the coin M and/or the determination of its value is made more difficult since coins of different value produced from the same alloys often differ very little in their thickness. Using a further measure, which will now be described, the influence of this effect on the determination of the thickness d can be reduced. In the case of a coin M without embossing, the measurements from the coils 9 and 10 yield, for example, a value K_1 and a value K_2. If the coin M has an asymmetrical embossing, and if the head side faces the coil 9, the measurements yield slightly changed values $K_1 + \delta r_1$ and $K_2 - \delta r_2$. An increase in the variable K_1 leads to a decrease in the variable K_2, since a reduction in the spacing between the coil 9 and the coin M leads to a consequent increase in the spacing between the coin M and the coil 10. Because of the linearity of the variables K_1 and K_2 as a function of the spacing of the coin M from the corresponding coil, it is true in the case of using identical coils 9 and 10 and using the same frequency ω to excite the coils 9 and 10 that: $\delta r_1 = \delta r_2 = \delta r$. In the case of the same coin M, if the tail side faces the coil 10, the measurements yield values $K_1 - \delta r$ and $K_2 + \delta r$ instead. Hence, the sum $H_2 = K_1 + K_2$ or the sum $I_2 = P_1 + P_2$ thus advantageously serves as a measure of the thickness d of the coin M and thus as a decision criterion for the acceptance or rejection of the coin M. The sums H_2 and I_2 are independent of how the coin M faces the side wall 4, since the values $-\delta r$ and $+\delta r$ cancel each other out.

Fig. 3 shows that the measurement values K_1 are distinctly different for different alloys. The alloy of the coin M can thus be determined comparatively easily, that is to say the tolerance limits which specify whether the coin M is accepted or rejected on the basis of its measured alloy can be set to be relatively wide. The closer the tolerance limits for the variables K_2 or P_2 or H_2 or I_2 are set, the more coins M can be reliably distinguished on the basis of their thickness d. The prevention of the bouncing or jumping of the coins in the region of the inductive sensors by means of the newly constructed ribs 7 in combination with the detailed signal analysis described now makes possible the setting of very close tolerance values for the variables K_2 or P_2 or H_2 or I_2.

Fig. 6 shows an advantageous electronic circuit 14 having a series resonant circuit RLC for the separate acquisition of the change of the ohmic resistance R_S and the inductance L_S of a coil S. The starting point is the knowledge that the series resonant circuit RLC formed from the coil S and a capacitive element C represents in the case of resonance a purely ohmic impedance Z_S which is equal to the resistance R_S of the coil S. In contrast to this, in the case of resonance, a parallel resonant circuit in which the coil S and the capacitive element C are connected in parallel behaves like an impedance

$$Z_p = j \times \frac{C \times R_S}{L_S}$$

which is a function of the ratio of the resistance R_S to the inductance L_S of the coil S (j designates the imaginary unit). The resonant frequency $\omega_0(L_S)$ of the series resonant circuit RLC is given by

$$\omega_0(L_S) = \frac{1}{\sqrt{L_S \times C}}.$$

The electronic circuit 14 has a differential amplifier 18 with an inverting input 19 and a non-inverting input 20, a resistor 21, a two-stage amplifier circuit 22 and an amplitude detector 23. The series resonant circuit RLC consists of the coil S and a capacitive element C which are connected in series, and is connected to ground m with one connection and to the inverting input 19 of the differential amplifier 18 with the other connection. The output of the differential amplifier 18 is fed back via the resistor 21 to the inverting input 19 and via the amplifier circuit 22 to the non-inverting input 20.

The amplifier circuit 22 has the objects, firstly, of bringing the series resonant circuit RLC into oscillation when the circuit 14 is switched on and, secondly, to make available an amplitude-stabilised voltage $U_3(t)$ for exciting the series resonant circuit RLC. This object is realised by means of two inverters 24 and 25, connected in series, and a downstream-connected voltage divider 26. A capacitor 27 and 28 is in each connected upstream of the input of the inverters 24 and 25, and the output of the inverters 24 and 25 is fed back to the input in each case via a resistor 29 and 30. The capacitors 27 and 28 serve for direct current DC decoupling. The resistors 29 and 30 determine the DC operating point of the inverters 24 and 25. On switching on the circuit 14, the amplifier circuit 22 behaves like a linear AC amplifier so that, because of the positive feedback of the output voltage $U_1(t)$ of the differential amplifier 18 to its input 20, the series resonant circuit RLC begins to oscillate. The amplification of the input signal $U_1(t)$ is selected to be so high that the second inverter 25 is then always brought into saturation, so that a square wave voltage $U_2(t)$ is present on its output, the two voltage levels of said voltage corresponding to the positive and the negative voltage level with which the entire electronic circuit 14 is fed in a bipolar fashion with reference to ground m in a manner known per se. With the aid of the ohmic voltage divider 26 connected to ground m, the level of the voltage $U_2(t)$ is reduced. A square wave voltage $U_3(t)$ is thus present at the output of the amplifier circuit 22 and hence at the input 20 of the differential amplifier 18, said voltage being in phase with the voltage $U_1(t)$, but its amplitude being independent of the amplitude of the voltage $U_1(t)$. The voltage divider 26 has two resistors 31 and 32, the resistor 31 being of the order of magnitude of the resistance R_S of the coil S. The resistor 32 is to be dimensioned such that the level of the voltage $U_3(t)$ is a few tens to one hundred millivolt. The amplitude detector 23 serves to measure the amplitude of the voltage $U_1(t)$ and to transmit it to the microprocessor 15 in a suitable form.

During the passage of the coin M past the coil S, the resonant frequency $\omega_0(L_S)$ changes, as appropriate with the change of the inductance L_S. The circuit 14 described operates such that the series resonant circuit RLC oscillates at a frequency ω which is always equal to the resonant frequency $\omega_0(L_S)$. During the passage of the coin M past the coil S, the resistance R_S of the latter also changes. Since the series resonant circuit RLC has the ohmic impedance $Z_S = R_S$ at resonance, and since the voltage $U_3(t)$ which serves to excite the series resonant circuit RLC is a periodic voltage of constant amplitude, the current i(t) flowing through the series resonant circuit RLC and hence the amplitude of the voltage $U_1(t)$ at the output of the differential amplifier 18 is directly a measure for the resistance R_S of the coil S. The evaluation of the signal $U_1(t)$ is now carried out by means of the microprocessor 15 as previously described.

The frequency ω of the rectangular voltage $U_2(t)$ present at the output of the second inverter 25 can be determined in a simple manner, not shown, for example using a counter module which is enabled to count by the microprocessor 15 in accordance with the variation with time of the amplitude of the voltage $U_1(t)$, while the coin M covers the coil S. The frequencies ω_1 and ω_2 determined in this manner in the coil 9 or in the coil 10 correspond to the resonant frequencies during the passage of the coin M and represent a third and fourth characteristic variable K_3 and K_4, which can serve as further decision criteria for the acceptance or rejection of the coin M.

Using the device described, the variables K_1 and K_2 and hence the alloy composition and the thickness d of the coin M can be determined with an accuracy which is sufficient to be able to distinguish a multiplicity of coins M. In order to exclude the possibility of deceit, whereby a coin M2 of a specific alloy and greater thickness d can be faked by using a coin M1 of smaller thickness d or with a thin metallic platelet, in that the spacing of the coin M1 or of the metallic platelet from the coil 9 is intentionally increased, for example by inserting a non-metallic layer between the coin M1 and the coil 9, it is sufficient to establish whether the resonant frequency $\omega_0(L_S)$ of the coil 9 during the passage of the coin M is greater or smaller than in the absence of a coin. The sign of the change in resonant frequency $\omega_0(L_S)$ of the coil 9 thus advantageously serves as a further decision criterion for the acceptance or rejection of the coin M. An exact determination of the resonant frequency $\omega_0(L_S)$ in the presence of the coin M is not necessary.

The arrangement of the coil 9 or 10 in the series resonant circuit RLC offers the advantage that a variable characterising the alloy composition or a variable characterising the thickness d may be determined with a circuit which is of simple construction and which measures the damping of the series resonant circuit RLC in the presence of the coin M. The series resonant circuit RLC consequently represents a particularly suitable means for measuring the resistance change induced in the coil S. Hence, coins can also be detected which yield no signal change or an insufficient signal change when using a parallel resonant circuit, if the changes in the inductance L_S and in the resistance R_S mutually compensate each other.

The inductance L_S of the coil S and the value of the capacitive element C are selected such that the resonant frequency $\omega_0(L_S)$ of the tuned circuit RLC is located in the range from 50 to 200 kHz, a typical value being 90 kHz. At these frequencies, the penetration depth of the magnetic field generated by the coil S into the coin M is sufficiently large, with the result that the composition in terms of materials of the coin M may be detected sufficiently selectively.

Fluctuations in the level of the voltage $U_3(t)$ exciting the resonant circuit RLC, which are brought about, for example, by fluctuations in the operating voltage which serves as the power supply of the circuit 14, have no influence on the variables P_1 and P_2, since these represent a ratio of two directly successive resistance measurements.

The inverters 24 and 25 can, for example, be inverters of the known type 4007. In a special embodiment of the circuit 14, at least one of the inverters 24 or 25 is substituted by a NAND or a NOR component with an additional input, the additional input being connected to an output of the microprocessor 15. The circuit 14 can be switched on and off in a simple manner via the logic potential at this output of the microprocessor 15. The circuit 14 can thus be switched on briefly as required, only just for the testing of a coin M. The substitution of both inverters 24 and 25 by a NAND or a NOR component offers the advantage that the circuit 14 needs exceptionally little power in the switched-off condition.

Fig. 6 shows only one example of an electronic circuit 14 which is suitable to detect the change in resistance R_S of the coil S by means of a series resonant circuit RLC. Numerous further examples of electric circuitry of the series resonant circuit RLC, which excite the series resonant circuit RLC with a voltage or a current, can be found in the technical literature.

PATENT CLAIMS

1. Device for testing the authenticity of coins (M), tokens or other flat metallic objects, having a coin channel (1) with a lower (4) and an upper (5) side wall, the coin channel (1) being inclined by a predetermined angle with respect to the vertical (V) and the coin (M), in the ideal case, moving along the lower side wall (4) in contact, having two inductive sensors arranged along the coin channel (1), an electronic circuit (14) and having a control and evaluation unit (15), characterised in that the first inductive sensor is a coil (9) fitted to the lower side wall (4), in that the second inductive sensor is a coil (10) fitted to the upper side wall (5) in that means (13, 14) are provided to operate the two coils (9, 10) electrically independently, in that the electronic circuit (14) is equipped to measure the variation with time of the ohmic resistance $R_9(t)$ and $R_{10}(t)$ of the two coils (9, 10) during the passage of a coin (M), in that the control and evaluation unit (15) determines the greatest value of the resistance $R_9(t)$ of the first coil (9) as the value K_1, in that the control and evaluation unit (15) determines the local maxima (m1, m2) of the resistance $R_{10}(t)$ assumed by the second coil (10) and determines the greater of the two values (v1, v2) of the two maxima (m1, m2) as the value K_2, and in that the values K_1 and K_2 or the values K_1 and $H_2 = K_1 + K_2$ serve to decide about the acceptance or rejection of the coin (M).

2. Device for testing the authenticity of coins (M), tokens or other flat metallic objects, having a coin channel (1) with a lower (4) and an upper (5) side wall, the coin channel (1) being inclined by a predetermined angle with respect to the vertical (V) and the coin (M), in the ideal case, moving along the lower side wall (4) in contact, having two inductive sensors arranged along the coin channel (1), an electronic circuit (14) and having a control and evaluation unit (15), characterised in that the first inductive sensor is a coil (9) fitted to the lower side wall (4), in that the second inductive sensor is a coil (10) fitted to the upper side wall (5) in that means (13, 14) are provided to operate the two coils (9, 10) electrically independently, in that the electronic circuit (14) is equipped to measure the variation with time of the ohmic resistance $R_9(t)$ and $R_{10}(t)$ of the two coils (9, 10) during the passage of a coin (M), in that the control and evaluation unit (15) determines the greatest value of the resistance $R_9(t)$ of the first coil (9) as the value K_1, in that the control and evaluation unit (15) determines the local maxima (m1, m2) of the resistance $R_{10}(t)$ assumed by the second coil (10) and determines the greater of the two values (v1, v2) of the two maxima (m1, m2) as the value K_2, in that the control and evaluation unit (15) determines the internal resistance r_1 of the first coil (9) and the internal resistance r_2 of the second coil (10) directly before or after the passage of the coin (M), and in that the values $P_1 = r_1/K_1$ and $P_2 = r_2/K_2$ or the values P_1 and $I_2 = P_1+P_2$ serve to decide about the acceptance or rejection of the coin (M).

3. Device according to Claim 1 or 2, characterised in that the coils (9, 10) are arranged to measure the resistance in a series resonant circuit (RLC).

4. Device according to Claim 3, characterised in that the electronic circuit (14) comprises a differential amplifier (18) and an amplifier circuit (22), the output of the differential amplifier (18) being fed back via a resistor (21) to the inverting input (19) and via the amplifier circuit (22) to the non-inverting input (20), and the amplifier circuit (22), firstly, on switching on the electronic circuit (14), brings the series resonant circuit (RLC) into oscillation and, secondly, makes available an amplitude-stabilised voltage ($U_3(t)$) for exciting the series resonant circuit (RLC).

5. Device according to Claim 4, characterised in that the amplifier circuit (22) has two inverters (24, 25) connected in series or NAND or NOR components.

6. Device according to one of Claims 3 to 5, characterised in that means are provided in order, during the passage of the coin (M), to determine the sign of the change in the resonant frequency ($\omega_0(L_S)$) in the first coil (9), and in that this sign serves as a further decision criterion for the acceptance or rejection of the coin (M).

7. Device according to one of Claims 1 to 6, characterised in that a metallic platelet (11, 12) is fitted in each case on that side wall (5, 4) lying opposite the coils (9, 10).

8. Device for testing the authenticity of coins (M), tokens or other flat metallic objects, having a coin channel (1) with a lower (4) and an upper (5) side wall, the lower side wall (4) being provided with ribs (7) in the running direction of the coin, the coin channel (1) being inclined by a predetermined angle with respect to the vertical (V) and the coin (M), in the ideal case, moving along the ribs (7) of the lower side wall (4) in contact, characterised in that the radius of curvature (R) of the ribs (7) is at least half as large as the spacing (a) of adjacent ribs (7).

9. Device according to Claim 8, characterised in that the radius of curvature (R) of the ribs (7) is approximately comparable to the spacing (a) of adjacent ribs (7).

ABSTRACT

A device for testing the authenticity of coins (M), tokens or other flat metallic objects contains a coin channel (1) having a lower (4) and an upper (5) side wall. A coin (M) moves along the coin channel (1) on the lower side wall (4) in contact, past a first and a second inductive sensor (9, 10). The two inductive sensors are either a coil (9, 10) or a coil and a metallic platelet (9, 11; 10, 12), the first coil (9) being fitted to the lower side wall (4) and the second coil (10) to the upper side wall (5). The two coils (9, 10) can be operated electrically independently. The coils (9, 10) are advantageously arranged electrically in a series resonant circuit (RLC). During the passage of the coin (M), the variation of the resistance change induced in each coil (9, 10) is measured and analysed and the alloy composition and the thickness d of the coin (M) are determined therefrom.

(Fig. 1)

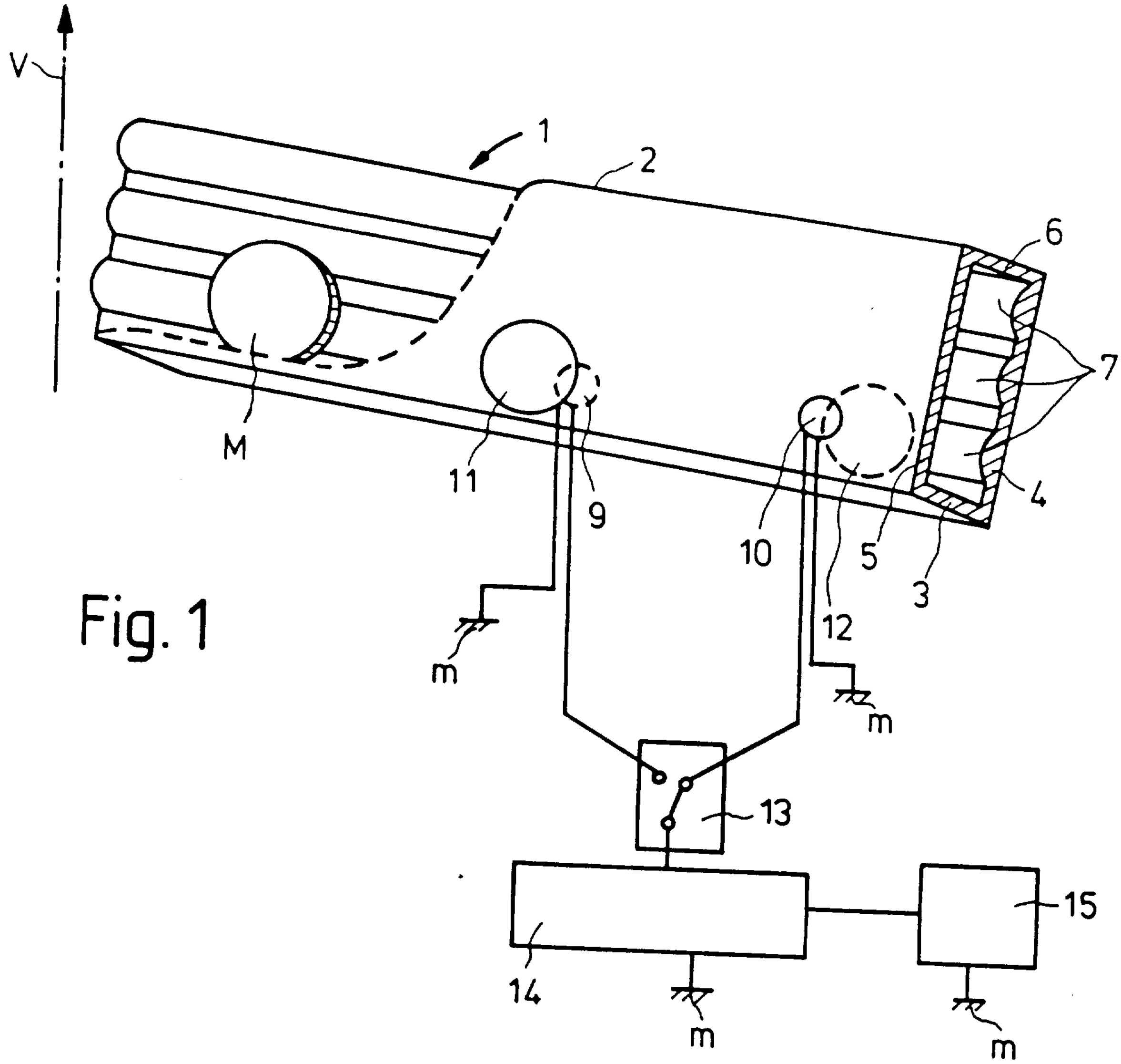


Fig. 1

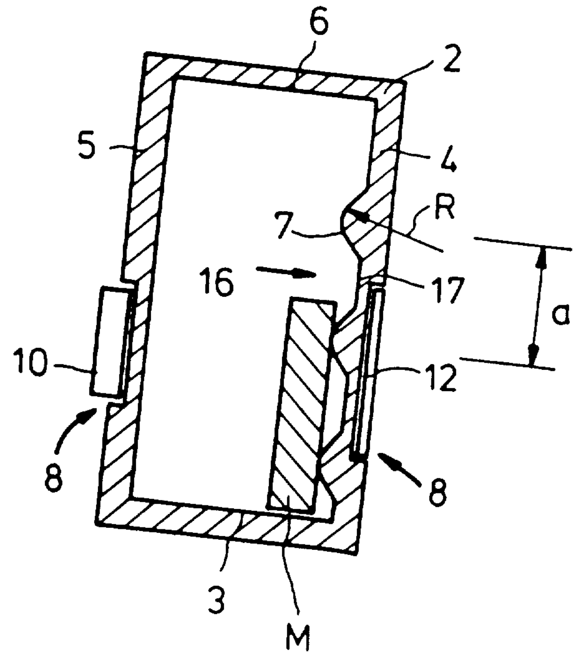


Fig.2

Fig. 4

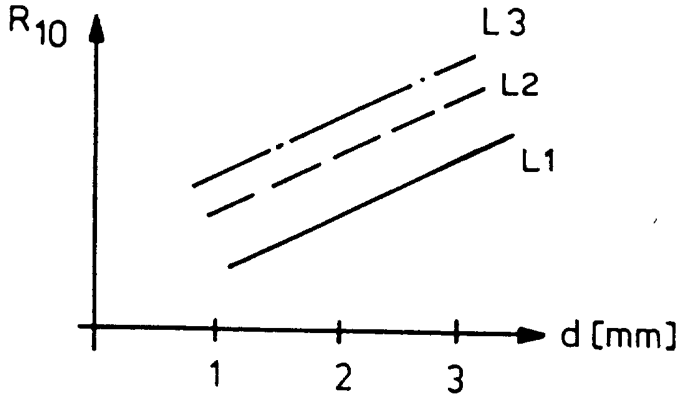


Fig. 3

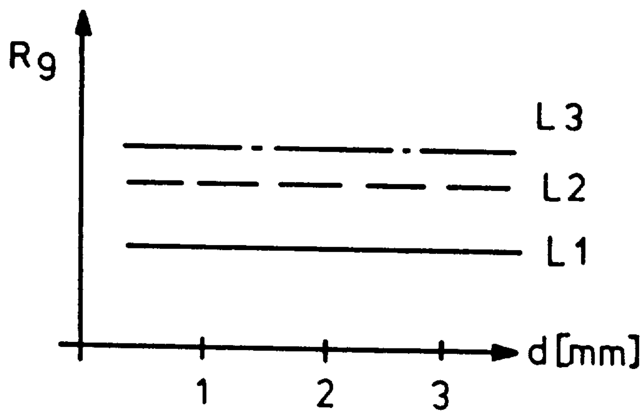
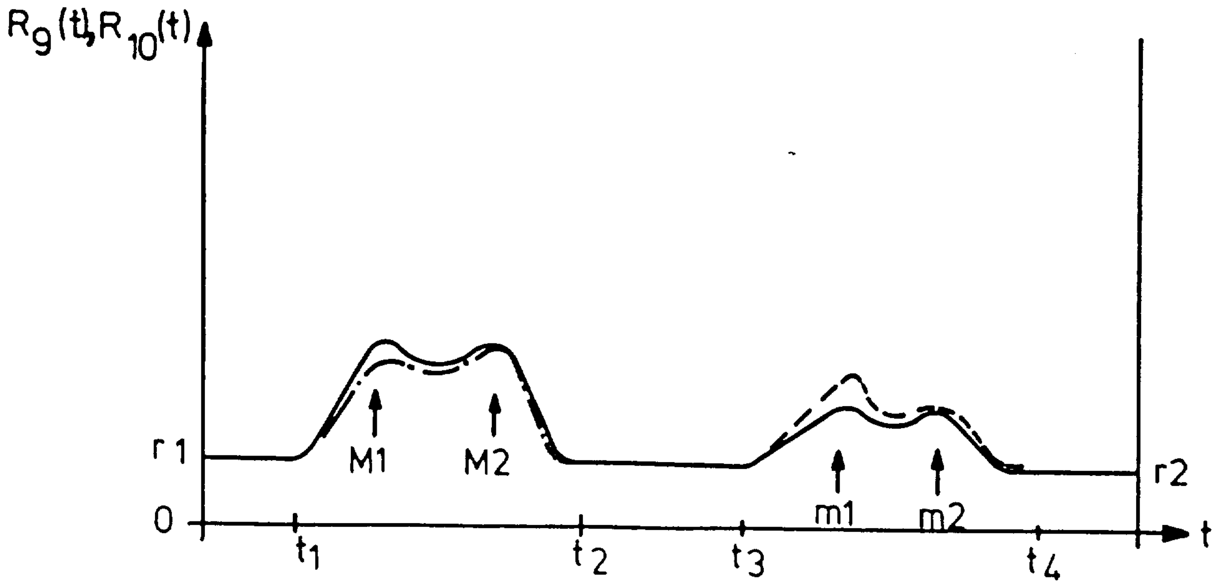
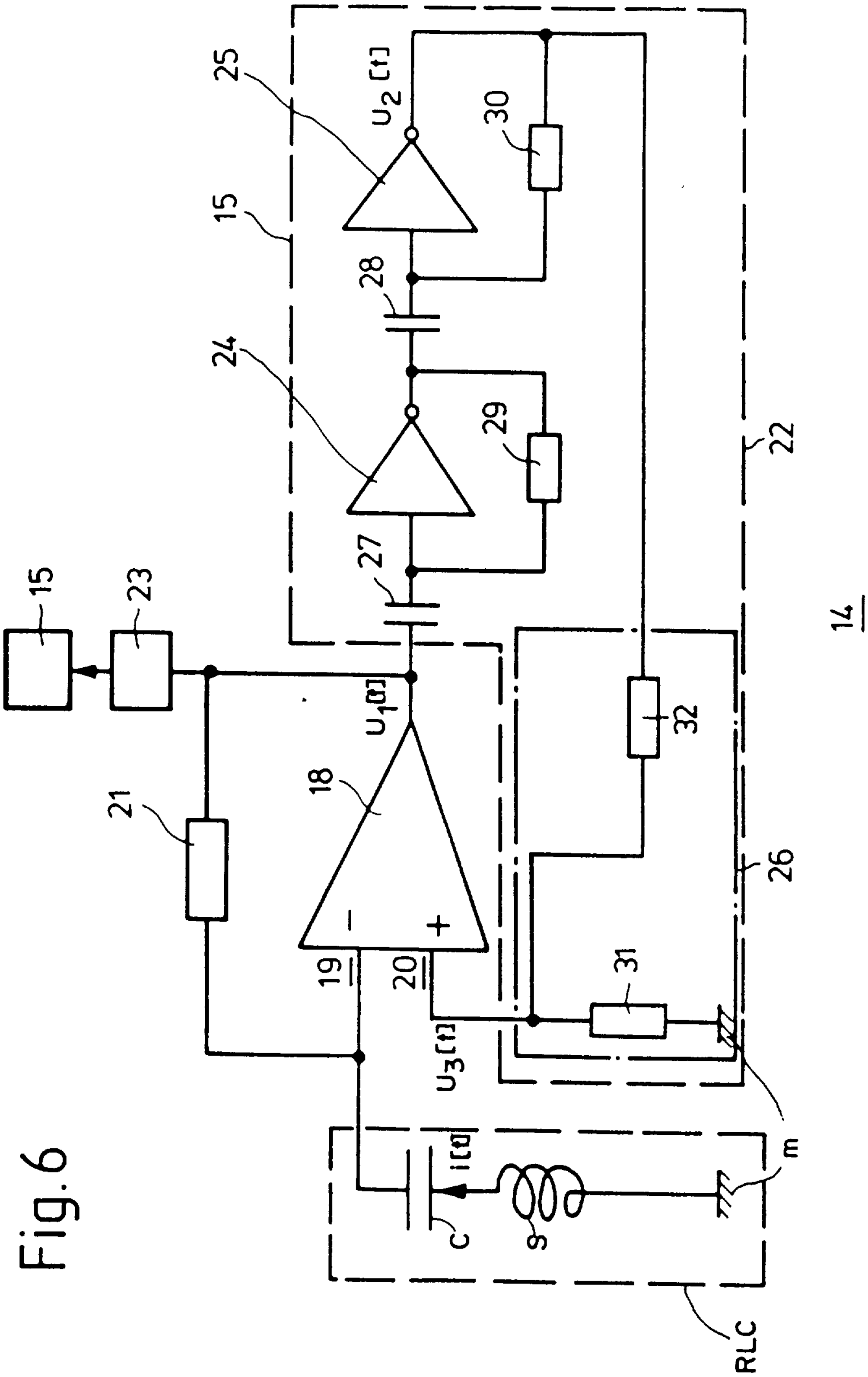


Fig. 5




15
23
21
18
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25
24
27
28
29
30
22
14
32
31
26
m
RLC
C
S
$U_1(t)$
$U_2(t)$
$U_3(t)$
$I(t)$

Fig.6