

[54] **CORRELATION MEASUREMENT APPARATUS**

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[51] Int. Cl. **G06g 7/19**

[58] Field of Search..... **235/181, 194, 61.7 R, 235/61.7 B, 61.11 E; 340/149 R, 149 A, 146.3 Q, 146.3 SY; 250/219 CR, 219 QA, 219 DQ; 356/71**

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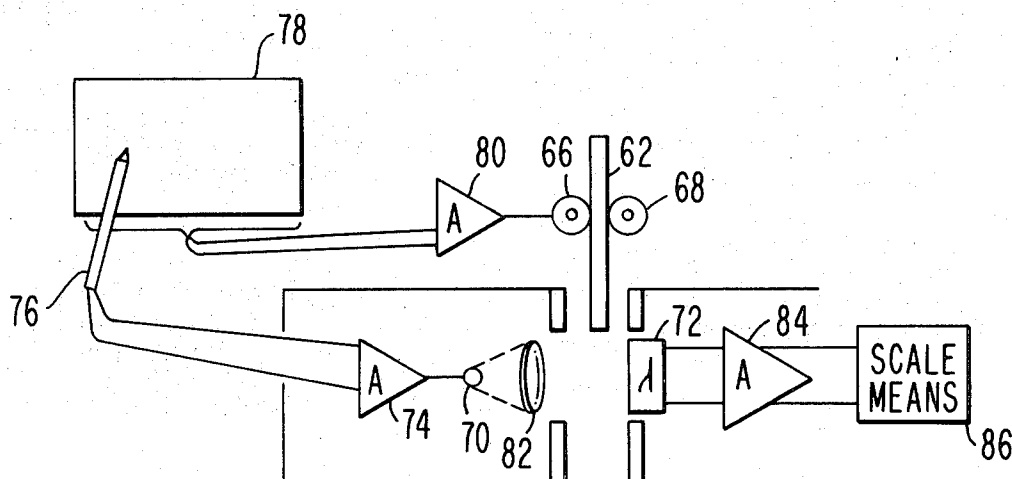
Primary Examiner—Felix D. Gruber

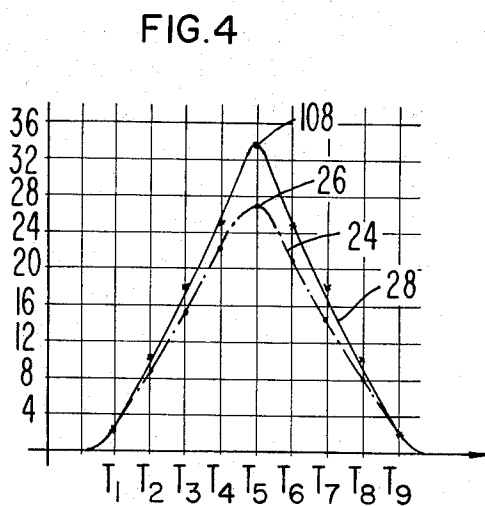
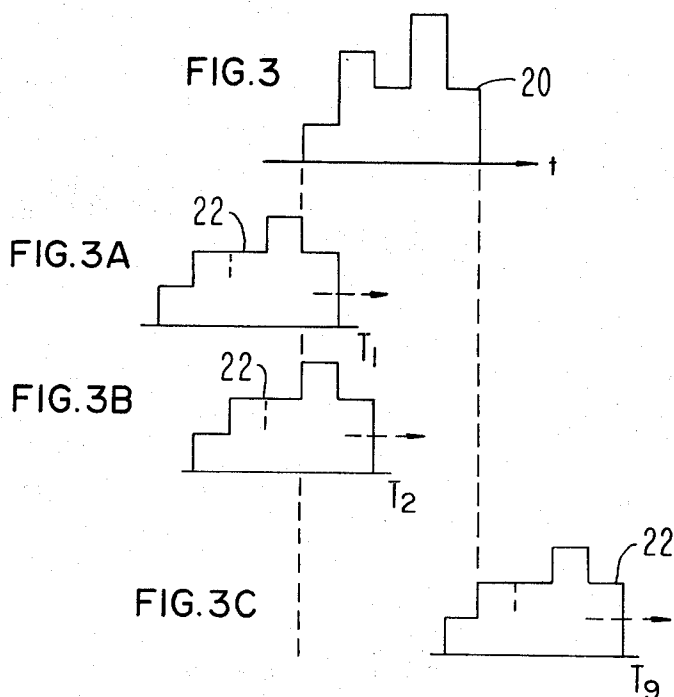
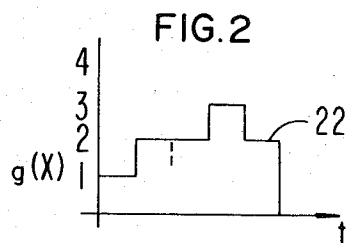
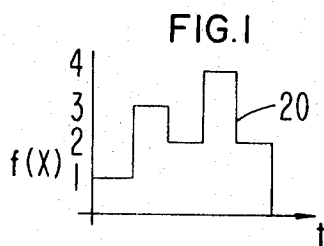
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[57] **ABSTRACT**

An analog correlation measurement apparatus provides a relative correlation figure of merit between an unknown and a known signal. The known signal is photographically stored on a film strip having a plurality of contiguous areas of varying image density. An optical system having a light emitting gallium arsenide diode interrogates the film strip synchronously with the tracing or generation of the unknown signal. As a result of the interrogation, an accumulated voltage value is generated that is equivalent to the mathematical process of summation of a plurality of products. This value is used with a similar value derived from an autocorrelation of the known signal to provide a relative correlation number representing the correlation coefficient.

13 Claims, 12 Drawing Figures





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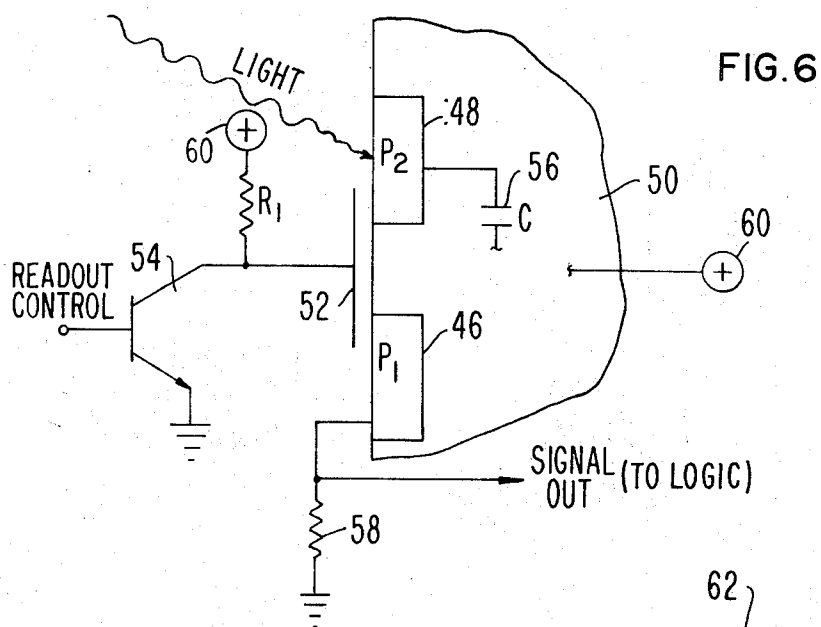
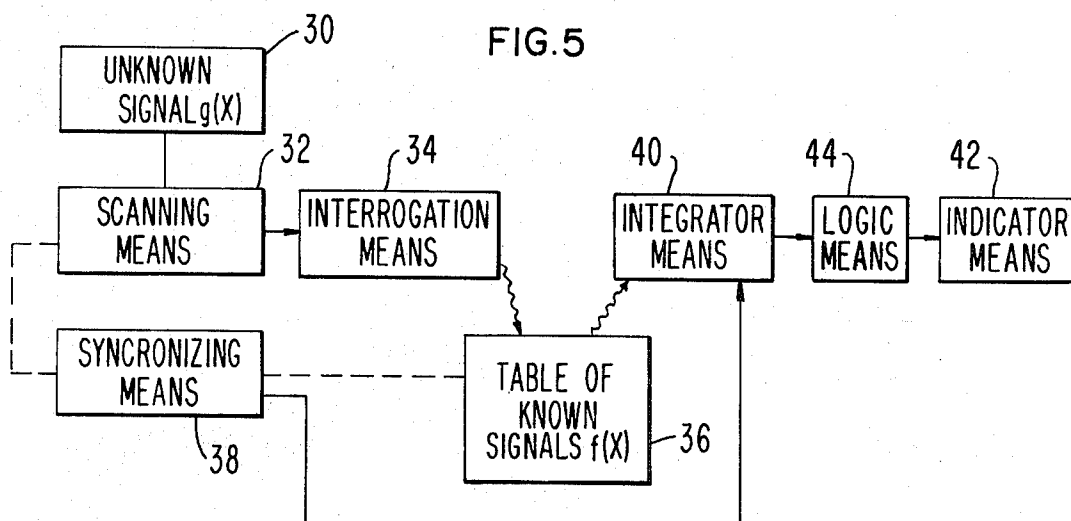
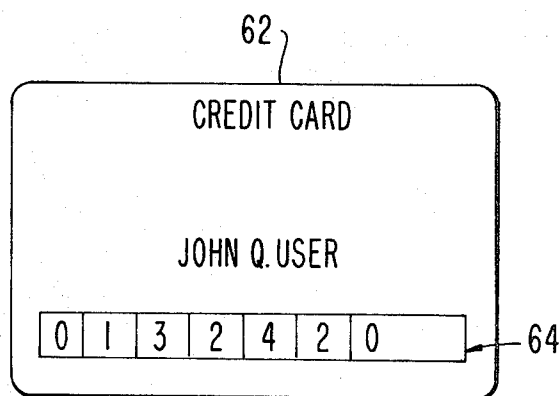
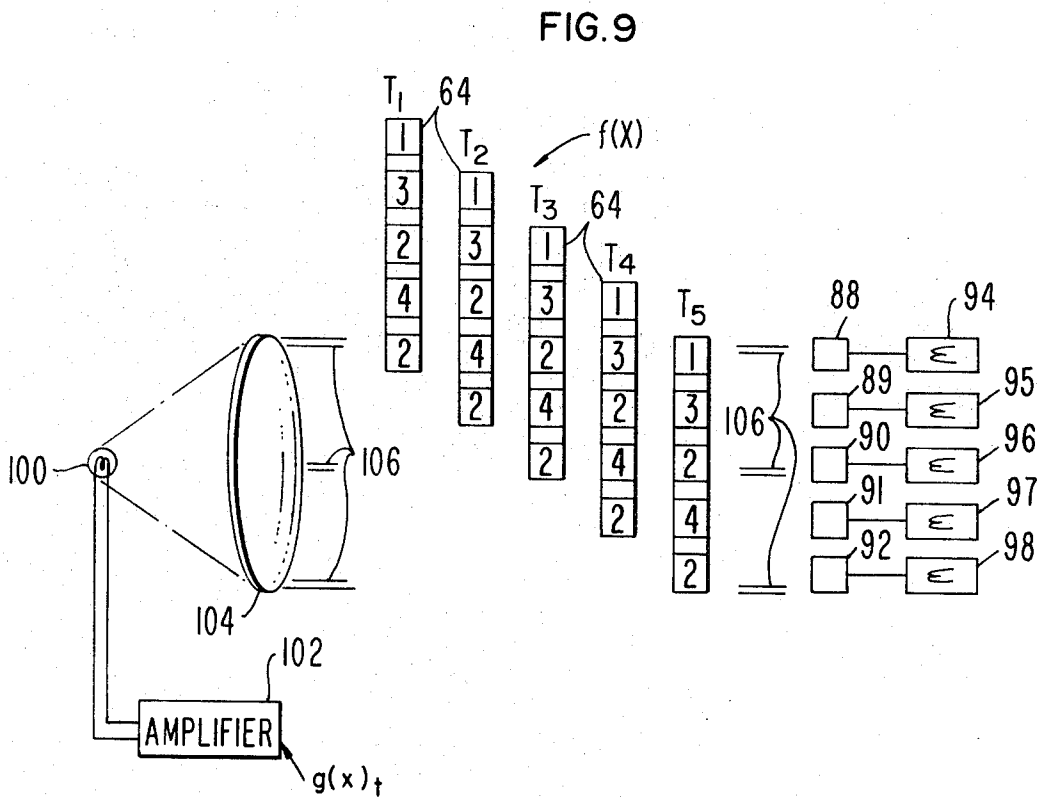
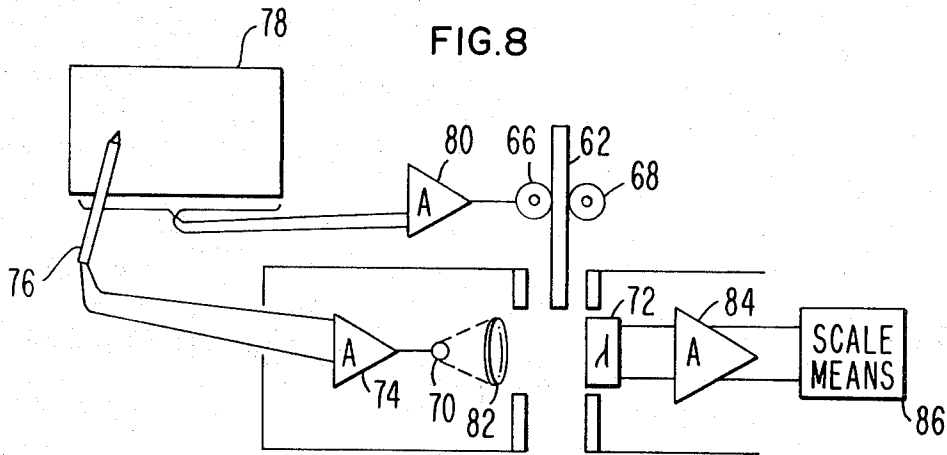


FIG. 7





CORRELATION MEASUREMENT APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

The correlation measurement apparatus of the present invention is useful in the patent entitled Personal Identification Method and Apparatus, U. S. Pat. No. 3,579,186 by R. R. Johnson et al. issued on May 18, 1971. Also, the patent entitled Stylus With Pressure Responsive Transducer, U. S. Pat. No. 3,528,295 by R. R. Johnson et al is incorporated herein by reference. Both of the above are assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a correlation apparatus for correlating two electrical signals and in particular to an analog photographic apparatus for correlating a known and an unknown signature.

2. Prior Art

As disclosed in the above-identified patent application P.N. 3,579,186 prior art correlations are basically digital in character. This often involves a correlator of extreme complexity and size to provide the necessary digital multiplication and integrations between a large number of corresponding points along each signal.

Prior art analog correlators have also treated each signal by subjecting each signal to a burst of sampling pulses from a master oscillator. Ultimately, the results of this operation are stored and sampled from an integrator for interpretation by a recording millimeter or an oscilloscope.

Optical correlation of two functions is shown in U. S. Pat. No. 3,283,133 wherein one of the functions is reproduced on a strip of photograph film and is fixedly attached to an elongated light source. The second function is also reproduced on a second strip of photographic film and is moved lengthwise along the first strip. The light intensity of the light source is fixed and is beamed through both film strips. The light intensity output from both film strips is measured by a plurality of photocells and the amplitude summation from all of the photocells is recorded. Each high amplitude peak on the recorder indicates correlation between both signals.

Such prior art devices are by their very nature large and complex, and therefore not adaptable for use in the commercial world. As indicated in the Personal Identification Method and Apparatus patent application, the need of a more positive identification system in the field of credit purchases is becoming increasingly more apparent. One embodiment of the correlation measurement apparatus provides for the relatively instantaneous verification between a credit card holder and the rightful owner of the credit card. This embodiment is relatively simple and compact and is therefore not only commercially feasible to use at a commercial location but will provide a degree of accuracy which is acceptable to the merchant and more importantly to the credit card holder.

In another embodiment of the correlation measurement apparatus, the apparatus described herein can be adapted to compare an unknown signal or character which has been transformed into an electrical signal with a table of known acceptable signals or characters.

Such an application may be found in document sorting equipment.

In both of the above embodiments, the correlation is performed by analog techniques wherein the summation of the products of the standard correlation equation is performed by electro-optical means and not by digital processes.

It is therefore a principal object of this invention to provide an analog correlation measurement apparatus.

It is a further object of this invention to provide an analog correlation measurement apparatus for correlating an unknown signal with a table containing a plurality of known acceptable signals to identify which one of known signals most closely correlates, including the degree of correlating with the unknown signal.

SUMMARY OF THE INVENTION

In accordance with the above enumerated objects and with other objects which will hereinafter become apparent, there is described and defined an analog signal correlation apparatus for generating a relative correlation value between an unknown and a known signal according to the equation:

$$C(X_0) = \int_0^{X_0} f(X) \cdot g(X - X_0) dX$$

While this equation is expressed as a function of space and not time, it should be noted that the relationship between space and time is constant and is treated as such for the purpose of this equation.

The apparatus comprises means for scanning the unknown signal or character and generating an analog signal representing the unknown signal or character. This signal is applied to a variable intensity radiant energy source to cause the source intensity to vary according to the amplitude of the signal.

The known signal has been previously transferred to a strip of developed photographic film having a plurality of contiguous areas of varying image densities representing the known signal or character. The film strip is interrogated by the radiant energy source and the analog result of this interrogation is stored in an integrator amplifier. The integrator, using the inter-region capacitance of a semi-conductor device, stores the result of the summation of the products of the above equation. An indicator means responsive to the integrator provides an indication of the relative value of correlation between the unknown and the known signals.

DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a graphic representation of a known function $f(X)$;

FIG. 2 is a graphic representation of an unknown function $g(X)$;

FIGS. 3-3C is a graphic illustration of the mathematical process of correlation;

FIG. 4 is a graphic illustration of the relative correlation between FIG. 1 and FIG. 2 according to the invention herein;

FIG. 5 is a block diagram of one embodiment of the correlation measurement apparatus;

FIG. 6 is a schematic of the integrator means of the correlation measurement apparatus;

FIG. 7 is a diagram of a credit card having a photographic strip affixed thereon;

FIG. 8 is a diagram illustration of another embodiment of the correlation measurement apparatus using the credit card of FIG. 7; and

FIG. 9 is an illustration of modification of the correlation measurement apparatus and in particular the interrogation and integrator means of FIG. 5.

DETAILED DESCRIPTION

The correlation measurement apparatus to be described herein is used to approximate the correlation equation

$$C(X_0) = \int_0^{X_0} f(X) \cdot g(X - X_0) dX$$

when functions $f(X)$ and $g(X)$ are not single linear functions. The system to be described herein and in particular the correlation measurement apparatus will be used to generate information relative to the correlation coefficient.

Referring to FIGS. 1 and 2, there is illustrated in graphic form, a plot 20 of the function $f(X)$ with respect to time in FIG. 1 and in FIG. 2 a plot 22 of the function $g(X)$ with respect to time. Each function is shown as a rectangular shaped graph. The multiplication operation required for the solution of the correlation function of equation No. 1 is achieved mathematically by "sliding" one function across the other. The positions during the sliding operation correspond to the displacement variable X in the basic equation. FIG. 3 is a graphic representation of this mathematical operation and the following Table 1 is a chart showing the summation of the products of the functions at each value of X .

TABLE 1

(1×2) = 2
(1×3)+(3×2) = 9
(1×2)+(3×3)+(2×2) = 15
(1×2)+(3×2)+(2×3)+(4×2) = 22
(1×1)+(3×2)+(2×2)+(4×3)+(2×2) = 27
(3×1)+(2×2)+(4×2)+(2×3) = 21
(2×1)+(4×2)+(2×2) = 14
(4×1)+(2×2) = 8
(2×1) = 2

In particular, the horizontal scale represents time. In FIG. 3 the standard or reference function is $f(X)$ and the function $g(X)$ which is the new function is moved across $f(X)$. FIG. 3A shows or illustrates the initial movement of the plots of function $g(X)$ 22 across $f(X)$ 20 and corresponds to the product illustrated in the first line of Table 1. At time T_1 , the value of $f(X)$ equals one, and the value of $g(X)$ equals two, providing a product of two as shown in line one of Table 1.

FIG. 3B illustrates the further moving of the plots $g(X)$ 22 across $f(X)$ 20 at time T_2 . A mathematical derivation from this illustration is shown on the second line of Table 1 wherein the value of $f(X)$ equals one, the value of $g(X)$ equals three and that product is in turn added to the product of $f(X)$ equalling three and $g(X)$ equalling two resulting in a summation of three and six equal to nine. This summation is shown on the second line of Table 1.

This operation is continued until the plot of the whole function $g(X)$ 22 has moved past the function $f(X)$ 20 as illustrated in FIG. 3C at time T_3 . The summation of the products of FIG. 3C is illustrated on the

last line of Table 1 wherein the product of $f(X)$ and $g(X)$ is equal to two.

Plotting the values obtained in Table 1 on a graph, there is illustrated in FIG. 4 a distribution curve 24.

This curve is a plot of the correlation function of the two curves of the functions $f(X)$ and $g(X)$. The middle or high point 26 of FIG. 4 is equivalent to the complete overlap of the two equations and in the particular example is the fifth time period. The amplitude or value of this midpoint 26 will lead to a correlation coefficient of the two functions by the mathematical process of normalization.

For the purposes of the present invention, only one point in this curve, namely the midpoint 26 which is the maximum value, is of interest. However, the adjacent points to either side of the midpoint could be used in a similar manner, as will hereinafter be described, to further reach a determination as to the degree of correlation between the two functions.

If the functions $f(X)$ and $g(X)$ are equal, then the correlation becomes an autocorrelation. In such a situation the second curve 28 in FIG. 4 is the correlation curve for autocorrelation and corresponds to the results obtained in Table 2. These values were obtained by sliding the plot 20 across itself.

TABLE 2

(1×2) = 2
(3×2)+(1×4) = 10
(2×2)+(3×4)+(1×2) = 18
(4×2)+(2×4)+(3×2)+(1×3) = 25
(2×2)+(4×4)+(2×2)+(3×3)+(1×1) = 34
(2×4)+(4×2)+(2×3)+(3×1) = 25
(2×2)+(4×3)+(2×1) = 18
(2×3)+(4×1) = 10
(2×1) = 2

The coefficient of correlation measures the "goodness of fit" of the standard function to that of the assumed or new function. The coefficient of correlation is a number between minus one and plus one and the greater the coefficient of correlation, the better the fit of the two functions. For example, in autocorrelation, where one equation is compared or correlated with itself, the coefficient of correlation is equal to plus one.

FIG. 5 illustrates in block diagrammatic form the organization of a correlation measurement apparatus according to the present invention. The unknown signal 30, $g(X)$ which may be an electrical signal, a plot of a curve, a letter or character of a given front, or a signal being instantly generated such as signature wave form, is scanned by a scanning means 32 to generate an electrical wave form. If the unknown signal is a letter or character such as used in magnetic ink character recognition, the scanning means 32 may be an electromagnetic transducer. If the unknown is a letter or character or the like which is optically recognizable, then the scanning means may be an electro-optical transducer. As will be shown, if the unknown is to be a signature, the scanning means may be the stylus shown and described in U.S. Pat. No. 3,528,295.

In whatever form the scanning means 32 assumes, the output of the scanning means 32 is an electrical signal derived from and representative of the object pattern. This signal is electrically supplied to an interrogation means 34 where it is converted into light energy in the preferred embodiment. In particular, the interrogation means 34 may be a source of radiant energy such as a lamp or light-emitting semiconductor whose output ra-

diant intensity is varied according to the amplitude of electrical signal from the scanning means 32.

A table 36 of known signals to which the unknown signal is to be correlated is interrogated by the radiant energy of the interrogation means 34. In the preferred embodiment, the table comprises a plurality of strips of photographic film upon each of which one of the known signals is represented by an image of variable density. The image on the film strips is generated by previously scanning a known signal at the same or proportional rate as the unknown signal is now being scanned. The light output of the interrogation means 34 is captured on undeveloped film which is moving past the interrogation means 34 at the same rate or synchronously under control of the synchronizing means 38 as the character is being scanned. The synchronizing means 38 correlates the movement of the scanning means 32 with the movement of the film by means of a synchronizing signal from the scanning means 32 to the synchronizing means 38. When the film is developed, the image density, along the strip, represents the known signal.

In place of a variable density film, a two density film, essentially clear or opaque, may be employed. When using such film, variable width strips of clear and opaque film form the object pattern. The principles of pulse width modulation are employed to record this object pattern on two density film.

Since there are a plurality of known signals, one of which is equivalent to the unknown signal, the interrogation of each of these known signals can be accomplished more efficiently by interrogating each of the known signals simultaneously. This is accomplished, in the preferred embodiment, by providing a plurality of integrator means. Associated with each known signal strip and responsive to the radiant intensity passing through the strip is an integrator means 40. The function of each integrator means 40 is to electrically integrate the summation of the products of the radiant intensity of each area on the signal strip according to the correlation equation.

At the conclusion of the scanning of the unknown signal 30, the integrator means 40 have a voltage values stored therein which provide a means for indicating which of the known signals most closely correlates to the unknown signal. In particular, the largest voltage signal magnitude would represent this correlation. An indicator means 42 is responsive under control of logic means 44 to this maximum signal amplitude to provide an operative indication identifying the unknown signal. Such indicator means 42 may be a visible indication such as a light or print out or may be a mechanical indication such as a pocket deflection on a document sorting machine.

An example of an integrator amplifier which may be used is illustrated in FIG. 6. The integrator means 40 is a MOS device formed of two P regions P₁ 46 and P₂ 48 in an N substrate 50 having a superimposed insulated gate 52. At the beginning of the operation a switch means, the transistor 54 is turned on by the application of a readout control signal, from the synchronizing means 38, to the base of the transistor to form a channel under the gate electrode 52. The forming of the channel connects the P₂ region 48 to the P₁ region 46 and charges the capacitance 56 between the P₂ region 48 and the substrate 50 to ground potential through the resistor 58. When

the transistor 54 is turned off, the P₂ region 48 is isolated and reverse biased relative to the substrate 50 which is connected to a positive potential 60.

During the interrogation of a translucent photographic strip on a credit card 62 as will hereinafter be more fully described, the light from the interrogation means 34 as passed through the developed film representing the known signal falls on the P₂ region 48 and causes current to flow between the P₂ region 48 and the substrate 50. This current flow discharges the capacitance 56, of the P₂ region. The voltage of the capacitance 56 will change according to the following equation:

$$V = \frac{1}{C} \int_0^{t_x} I(t) dt,$$

where C = the capacitance of the P₂ region; I(t) = the current which is proportional to the amount of light falling on the P₂ region as a function of time. As a result, the voltage of the capacitance 56 is a function of the amount of light falling on the P₂ region.

At the end of the interrogation the switch means, the transistor 54 is turned on by the synchronizing means 38 and the instantaneous current flowing through the resistor 58 is monitored. This current, which is indicative of the voltage of the capacitance 56, is applied to the logic network 44 to determine the degree of correlation between the known signal f(X) from the table 36 and the unknown signal g(X) 30. As the transistor 54 continues to conduct, the capacitance 56 recharges for the next operation.

In one embodiment of the correlation measurement system, the identity of the holder of a credit card 62 is verified through his dynamic signature with the information stored on the credit card. When the credit card 62 is first issued to an individual, he is requested to sign his name on a standard form. The purpose of this standard form is to generate a function f(X), from a series of sampling points representing his signature. The sampling points utilized to represent the signature are in accordance with the manner described in U. S. Pat. No. 3,579,186 and U. S. Pat. No. 3,528,295 referenced earlier herein. These sampling points may represent the letter amplitudes with respect to a horizontal time dimension and once these sampling points are determined, a strip 64 of photographic film is made according to the information from the signature. The image density on the film varies according to the numerical value of the sampling points of the signature. For example, at a given time where there is no signature signal, the film may be completely black and the transmittance will be equal to zero. Conversely, the higher the amplitude of the sampling point the more transparent the film becomes. This is illustrated by the strip 64 in FIG. 7 where the numbers show the relative intensities of the film.

When the film strip 64 is completed, the image has the appearance of an elongated strip having a plurality of different shaded areas transverse to the length of the strip. The length of each area will correspond to the time distance between the adjacent points which collectively represent the signature. This strip 64 is then affixed to a credit card 62 as illustrated in FIG. 7, in such a manner that at the proper time, the strip is inter-

rogated by the radiant energy source. The strip 64 carries the encoded standard signature of the credit card owner which will be correlated with a dynamic signature of the credit card holder any time the credit card is used for purchase.

Referring to FIG. 8, there is illustrated means for carrying out the correlation measurement system of this embodiment. A credit card 62, FIG. 7 having a standard photographic strip bearing the reference function $f(X)$, attached thereto is driven by a pair of drive rollers 66 and 68 past the radiant energy source 70 and the integrator or responder 72. In this embodiment, the radiant energy source is a light emitting semiconductor, typically a gallium arsenide diode, which is controlled by an amplifier 74. The function of the amplifier 74 is to vary the current applied to the diode thereby varying its output light intensity. The amplifier 74 responds to the movements of an electronic pencil or pen 76 across a special tablet or indexing table 78 as generally shown in U.S. Pat. No. 3,579,186 and more clearly in U.S. Pat. No. 3,563,097 which is also assigned to the assignee of the subject application. As previously indicated, the strip 64 contains information concerning the amplitude time relationship of the several sampling points within the signature. In order to synchronize the movement of the card 62 with the motion of the pen 76 across the special tablet 78, the horizontal or time measurement of the tablet is electrically supplied to an amplifier 80 which controls the drive roller 66. As the pen 76 moves to the right on the tablet, the credit card 62 is driven down between the light source 70 and the responder 72.

The light from the light source 70 is directed through a lens 82 wherein the light energy rays are directed in parallel to the responder or solar cell 72. As the pen 76 moves across the tablet 78 during the writing of the dynamic signature, the amplifier 74 output varies in potential according to the signature sampling points causing the lamp source 70 to vary its output intensity. The output of the solar cell is electrically connected to an integrating-amplifier 84 which forms a summing function in a manner previously described. The multiplication of the two functions, namely the function of the dynamic signature which is $g(X)$ and the function of the credit card signature which is $f(X)$, is achieved by the lamp 70 having a brightness proportional to $g(X)$ and the film strip 64 having light transmission proportional to $f(X)$. The output of the amplifier 84 may be interpreted and applied to a scale means 86 along with a value representing the autocorrelation of the $f(X)$ curve thereby indicating the relative correlation between the two curves.

In another embodiment and using apparatus similar to that as illustrated in FIG. 8 but working from the pressure characteristic of signatures, a relative coefficient of correlation can be determined. When an individual signs his name, he applies a varying amount of pressure to the pen 76 as he writes his signature. In this embodiment, the pen 76 is responsive to the pressure applied by the individual at the time of signing his name on the tablet 78. The photographic strip 64 on the credit card 62 is the standard or fixed signature pressure pattern to which these pressure points are compared. The actual pressure that one applied to his signature as he signs it at different times may vary, but the pattern or the ratios between the pressure points along the signature typically remain constant.

Referring to FIG. 9, there is illustrated in graphic form the photograph strip 64 as it is moved between the light source 70 and a plurality of responders 88-92. Attached to each responder is an amplifier 94-98 which integrates the product of the function $g(X)$ which is supplied to the lamp 100 and the function $f(X)$ which is indicated by the photographic strip 64. Here again, the standard is denoted by values on the strip 64 of the function $f(X)$ and the new function or character is supplied to the amplifier 102 by the equation $g(X)$. The light intensity from the lamp 100 is directed by the lens 104 into a plurality of parallel rays 106 to be received by the responders 88-92. Illustrated are five different times T_1, T_2, T_3, T_4 , and T_5 and it is noted that the first responder 88 sees each and every area of the function $f(X)$. The output of its amplifier 94 will be the greatest and will be used as a measure of coefficient of correlation.

In FIG. 8, the responder 72 essentially sees each and every area of the equation $f(X)$ as a new signature is being written. Since theoretically we are comparing the standard signature and newly written signature which are identical, the correlation coefficient should be plus one. The sum of the products of $f(X)$ and $f(X)$ in the autocorrelation equals 34 which is the high point 108 on curve 28 of FIG. 4 which is found by squaring each value of $f(X)$ at the several time periods and then adding each product together. This value 34 is placed on the credit card 62 and is obtained therefrom either by the operator or automatically and entered into the card reader. This value will then be used as one input to the logic circuitry 86, the scale means, as the value to which the product of $f(X)$ and $g(X)$ will be compared. As the credit card 62 is fed past the responder 72, the summation of the products of the two functions $f(X)$ and $g(X)$ are electrically generated within the integrating-amplifier 84. As illustrated in Table 1 in the middle line of that table, the summation of the products equals twenty-seven. The logic circuitry 86 determines the ratio between the standard amplitude which is 34 and the amplitude that is determined from the card reader which is 27 and indicates the relative correlation as 0.795. This relative correlation is similar to but is not mathematically the same as that which is known as the coefficient of correlation.

Making use of this value a decision can be made whether or not the signature on the tablet 78 representing the credit card holder is close enough or equivalent to the standard signature on the credit card 62 representing the credit card owner. As previously mentioned, the several side points of the correlation function as measured by sensors 88-92 could be used in the decision-making operation. If the side points for five time decisions were to be used, then an apparatus such as shown in the FIG. 9 having five responders 88-92 will be used. In such a case, the summation of the products will be as illustrated in Table 1 wherein responder 92 represents line one of Table 1, and responder 90 represents line three of Table 1.

In summary, there is illustrated a system for the measurement of correlation between a known and unknown signal by the use of a photocell optical system. The unknown signal is applied to a light energy source varying its output intensity synchronously with the movement of a known signal which is represented by a strip of film having variable degrees of transmittance according to the known signal. This strip of film is

moved between the light source and the photocell for the purpose of multiplying the two functions together at predetermined intervals and in summing the instantaneous value of each product. At the end of the correlation, the magnitude of the voltage in the summing amplifier is determined and compared to the standard to determine a figure relating to the coefficient of correlation.

What is claimed is:

1. An analog signal correlation apparatus for determining correlation between an unknown signal and a known signal according to the equation

$$C(X_0) = \int_0^{X_0} f(X) \cdot g(X - X_0) dX$$

where $C(X)$ is a correlation value, $f(X)$ is said known signal and $g(X)$ is said unknown signal, said apparatus comprising:

scanning means for scanning said unknown signal, generating an electrical equivalent of said unknown signal and for generating a synchronizing signal;

radiant energy means responsive to the output of said scanning means for producing a radiant energy output of varying intensity, said intensity varying according to the output of said scanning means;

a strip of variable transparency material comprising a plurality of in-line adjacent translucent areas representative of said known signal;

synchronizing means responsive to said synchronizing signal from said scanning means for moving said adjacent translucent areas of said strip past the varying radiant energy output of said radiant energy means to generate a second varying radiant energy output representing the product of the known signal and said unknown signal; and

integrator means responsive to said second varying radiant energy output for integrating the product of the known signal and said unknown signal and for storing an electrical signal representative thereof, said electrical signal being representative of the correlation value of said equation.

2. The analog signal correlation apparatus according to claim 1 wherein said scanning means is an electro-optical transducer.

3. The analog signal correlation apparatus according to claim 1 wherein said radiant energy means is a light emitting diode.

4. The analog signal correlation apparatus according to claim 1 wherein the strip of variable translucent material is a strip of photographic film.

5. The analog signal correlation apparatus according to claim 1 wherein said integrator means is an MOS device having two P regions formed in an N substrate with a superimposed insulated gate electrode extending between said P regions and at least one of said P regions being responsive to radiant energy.

6. The analog signal correlation apparatus according to claim 5 further including switch means electrically connected to said gate electrode and operable to electrically connect said P regions to a source of potential to charge the capacitance between said radiant energy responsive P region and said substrate.

7. The analog signal correlation apparatus according to claim 1 wherein said scanning means is an electromagnetic transducer.

8. An analog signal correlation apparatus for indicating correlation between an unknown signal and a plurality of known signals, said apparatus comprising:

scanning means for scanning said unknown signal, generating an electrical equivalent of said unknown signal and for generating a synchronizing signal;

radiant energy means responsive to the output of said scanning means for producing a radiant energy output of varying intensity, said intensity varying according to the output of said scanning means;

a plurality of strips of variable transparency material with each of said strips comprising a plurality of in-line adjacent translucent areas representative of one of said plurality of known signal;

synchronizing means responsive to said synchronizing signal from said scanning means for moving said adjacent translucent areas of said plurality of strips past the varying radiant energy output of said radiant energy means to generate a plurality of second varying radiant energy outputs, each second varying radiant energy output representing the product of one of said plurality of known signals and said unknown signal;

integrator means responsive to said plurality of second varying radiant energy outputs for integrating the products of each of said plurality of known signals and said unknown signal and for storing electrical signals representative thereof, said electrical signals being representative of the correlation values of said unknown signal and said plurality of known signals.

9. The analog signal correlation apparatus according to claim 8 wherein said plurality of strips of variable transparency material comprises a plurality of photographic film strips each representing a different known signal.

10. The analog signal correlation apparatus according to claim 9 wherein said photographic film strips have contiguous areas of varying image densities each area representing a portion of the total signal.

11. The analog signal correlation apparatus according to claim 10 wherein said radiant energy means is a light emitting semiconductor.

12. The analog signal correlation apparatus according to claim 11 wherein said integrator means is an MOS device having at least one light responsive region formed in the substrate.

13. A signature identification system for determining the relative correlation between a standard signature and a new signature and utilizing a credit card having a photographic strip of varying image density thereon, said image density being a representation of the standard signature, said system comprising:

a guideway along which said credit card is moved, writing means including a pressure responsive stylus and an indexing table or writing the new signature, said indexing table generating a first electrical signal indicating the horizontal position of the stylus with respect to one end of said table and said pressure responsive stylus generating a second electrical signal indicating the pressure applied thereto, first amplifier means responsive to the electrical signal generated by said indexing table for moving

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said credit card along said guideway in synchronism with the transverse movement of said stylus along said table during the writing of the new signature,
a variable light source positioned along and to one side of said guideway for interrogating said photographic strip of said credit card,
second amplifier means responsive to said second electrical signal for varying the current applied to said light source to vary the light intensity thereof

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on said photographic strip as said strip is moved along said guideway, and
a light energy responsive circuit responsive to the light emitting from said light source passing through said photographic strip for generating a voltage value as a result of the electro-optical multiplication of said light intensity and said image density at predetermined intervals.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,767,907 Dated 10/23/73

Inventor(s) Arthur J. Radcliffe, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 3, line 20, change "meansurement" to --measurements--.
Col. 4, line 49, change "front" to --font--.
Col. 8, line 54, change "decisions" to --positions--.
Col. 10, line 61, change "or writing" to --for writing--.

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents