Be it known that we, William F. Friedman, and Joseph O. Mauborgne, both residents of Washington, in the District of Columbia, have invented new and useful improvements in signaling systems, of which the following, taken in connection with the accompanying drawings, is a full, clear, and exact description.

This invention relates to the transmission of signaling or other waves, and deals particularly with the obtaining of secrecy in such transmission.

It is an object of this invention to transmit with secrecy signals or other waves used in the transmission of intelligence by any of the now well-known methods of transmitting photographs by electrical means.

In what follows, it will be convenient to refer to the material that constitutes the elements or data of the transmission in terms corresponding to those employed in cryptography. Thus, in cryptography the original or intelligible matter to be communicated to the correspondent is called the clear text; the final, unintelligible, or secret matter transmitted to the correspondent is called the cryptographic text, or cipher text, or often simply, the cryptograph; and in certain cases where the method of enciphering involves the use of an independent text the letters of which are employed as successive key letters in the enciphering or deciphering process, and are known only to the correspondents, this intermediate text is referred to as the key text. Since this invention deals with secrecy in the art of space or wire radio~~telegraphy~~ photography, the original or intelligible photograph to be communicated to the correspondent will be called the "clear photograph", the adjective "clear", of course, here having no reference to the quality of the photograph, but simply indicating that it corresponds ~~to~~ in its meaning ~~in~~ to the equivalent phrase in cryptography, "clear text". The clear photograph may be a "positive" or a "negative", celluloid or thin-paper transparency; ~~or thin paper transparency~~; it may be a photograph of any description whatsoever - a house, a person, a scene, and so on. It may be, for purposes of this description, a photograph of a hand-drawn sketch, a drawing, a map, and so on; it may be a sheet of translucent paper upon which words have been typewritten or printed, for example, a bank draft. In short, any material that can now be transmitted by space or wire radio~~telegraphy~~ photography falls within the class of things for which our invention provides a method and means of transmitting with secrecy.

Equivalent to the term cryptograph as employed in cryptography, the term cryptophotograph will here be used in referring to the enciphered or secret form of the clear photograph. The cryptophotograph is "unintelligible" in the sense that it conveys on its face no idea of what is intended to be communicated, nor does it correspond directly to the intelligence to be transmitted. For example, a clear photograph consisting of a representation of a bank draft may, in its enciphered or cryptophotographic form, as produced by the invention, consist of an absolutely unsymmetrical, very much disordered hodge podge of lines, points, or spots, conveying no idea whatsoever, least of all, that it represents a bank draft.

Equivalent to the phrase "key text" as employed in cryptography, the phrase "key photograph" will here be used in referring to the photograph of printed, hand-drawn, or typewritten material that is employed as the key in enciphering the clear photograph. And just as it is essential that both correspondents in the ordinary methods of cryptographic communication possess identical keys, so it is necessary, in accordance with the requirements of this invention, that the correspondents possess identical copies of the key photograph. And just as in any scientifically constructed system of cryptography the essence of the secrecy achieved by the system is inherent not in the method (which may be known to all persons) but in the specific key that is employed (which is known only to the correspondents and is readily variable), so in the system contemplated herein, the secrecy features are inherent in the use of a key photograph which is known only to the correspondents and which is readily changed, perhaps with each clear photograph to be enciphered.

The various objects and features of the invention will be clear from the following detailed description, and accompanying drawings, Figure 1 to 6.

Figure 1 shows a portion of a circuit at a transmitting station, this portion containing the fundamental elements of our invention.

Figure 2 shows a portion of a circuit at the receiving station for interpreting the signals transmitted by the sending station.

Figure 5 shows a specific embodiment of our invention in a transmitting station.

Figure 6 shows a corresponding specific embodiment in a receiving station.

move down to * on next page

Figure 3 shows a very much enlarged scale minute portions of three lines, the first occurring in a clear photograph to be transmitted; the second, a line occurring in a key photograph, and the third representing the resultant effect of the combination of the electrical equivalents of the first and second lines, and constitutes the resultant line of the cryptophotograph.

Figure 4 shows in a form corresponding to Figure 2, a set of lines, the first being the line in the cryptophotograph as actually received; the second, the line in the key-photograph identical with the homologous line at the transmitting station; and the third, the line resulting from the combination of the electrical equivalents of the first and second lines, yielding a negative copy of the line in the original or clear photograph.

Insert matter * on p.4

In these drawings only those parts which are essential to the exposition of our invention are shown. It will be understood that the invention is readily applicable to any of the present methods and systems of space or wire radiophotography. The essential features of all systems are that the picture or material to be transmitted is analyzed into a single sequence of very small light and dark points; means is provided for translating, transmitting, and receiving these light and dark points into and by some characteristic of an electric current; and at the receiving end means is provided for reversing the process, that is, for translating the received electric signals into light and dark points corresponding in relative values and positions with those of the original picture. In nearly all practicable systems of today the analysis referred to involves the use of a photoelectric cell which is rapid in its response to changes in intensity of light acting upon it. The exact form which the process of photo-analysis takes in the praticular system of radiophotography used, that is, the mechanical arrangement for producing the sequence of changes in the properties of an electric current corresponding to the light and dark points of the picture, is of no direct concern in the present invention. We shall first merely begin with the photoelectric cell and its associated electrical circuits, and treat of the electric currents controlled by the cell, leaving it to be understood that such other mechanical and electrical arrangements as are essential to the complete analysis of the picture at the transmitting end, and its synchronous synthesis at the receiving end, really do not fall properly within the scope of the invention and are immaterial to its exposition. However, at a later stage, for purposes of illustration, our invention is shown embodied in one of the most successful of the present day systems of radiophotography.

Reference will now be made to Figure 1. In this figure are shown within broken lines the four principal sections of apparatus and circuits comprising the essence of our invention. Using the terminology set forth above, A represents the apparatus and circuits involved in producing the sequence of signals corresponding to the light and dark point analysis of the clear photograph. A comprises B, a photoelectric cell of the well known two electrode type; C, a three electrode vacuum tube amplifier of well known form; D, a two or three electrode vacuum tube rectifier, also of well known form. The polarities of the currents issuing from D are as indicated in the figure. In the same figure, A^1 represents the apparatus and circuits involved in producing the sequence of signals corresponding to the light and dark point analysis of the key photograph. A^1 comprises B^1, C^1, and D^1, all essentially identical in form and operation with the corresponding parts, B, C, and D of A. The polarities of the currents issuing from D^1 are as indicated in the figure.

For purposes of ease in reference, that section of Figure 1 which is indicated by the letter E will hereafter be designated as the "interaction circuit", wherein the electrical signals emanating from D and D^1 interact or combine to produce a single signal as the effect of two conditions existing simultaneously in A and A^1. Interaction circuit E consists of two equal sections, F and F^1, having one side, H-H^1, in common. I is a winding situate at the midpoint of H-H^1. I^1 is a winding in which currents are induced by the passage of current through I. J and J^1 are adjustable resistances, the purpose of which is to permit of the establishment of a state of complete electrical equilibrium between sections F and F^1 of E, so that if impulses of equal potential come from D and D^1 simultaneously they exactly cancel each other and therefore no current will flow through winding I as a result of the interaction of the two signals. Results of other conditions existant momentarily in interaction circuit E will be discussed later.

The signals induced in I^1 are led to K, hereafter designated as the "resultant circuit". K comprises L, a multistage amplifier of well known form, M, a modulator of N, a source of carrier oscillations preferably of the power tube type. The electrical oscillations coming from K are then led to line or to a transmitting antenna.

It is to be understood that the analysis of the clear photograph and the key photograph occurs simultaneously. This may be effected by having appropriate mechanical arrangements. In the case where the photograph is mounted upon a rotating cylinder which is horizontally displaced past the analyzer photoelectric cell, the cylinders bearing the clear photograph and the key photograph can be made to rotate synchronously by gearing to the same drive shaft, and similarly the horizontal displacements of both can be made cynchronous by a common driving member. In the case where the analysis of the photograph is effected by keeping the photograph in a fixed position and causing the analyzer to make the necessary excursions over the surface of the photograph, the excursions of the clear photograph and the key photograph analyzers can be made synchronous by appropriate mechanical arrangements. It is only necessary that when the analyzer is at a specific point in one photograph it should be at a homologous specific point in the other.

Let us now consider the operation of the circuits described, and for the present we will consider that both the clear photograph and the key photograph consist of pure black line "positive" transparencies, all their lines being of equal intensity or blackness. There can be but one of four and only four possible cases of conditions existing at a given moment in two homologous points in the clear and the key photographs simultaneously. The four cases are as follows:

1. (A black point in the clear photograph occurs simultaneously with
(A black point in the key photograph

2. (A black point in the clear photograph " " "
(A white point in the key photograph

3. (A white point in the clear photograph " " "
(A black point in the key photograph

4. (A white point in the clear photograph " " "
(A white point in the key photograph

It will be assumed that a black point in either photograph prevents or cuts off the light playing upon the photoelectric cell so that no current flows through the cell; only when the light falls upon it does current flow through it, in proportion to the intensity of the light. Having assumed that we are dealing now with pure black line material, it is obvious that a black point represents a period of no current, a white point, one of current flow; in short, the signals in this case partake of the nature of "spacing" and "marking" impulses in printing telegraphy.

Hence, taking case (1), where two black points occur simultaneously, no current will flow through either D or D^1, and hence interaction circuit E will remain unaffected; no signal will be produced in the resultant circuit K. Taking case (2), where a black point in the clear photograph and a white point in the key photograph occur simultaneously, let us see what happens. The black point in the clear photograph allows no light to reach photoelectric cell B, and hence will cause no change in A, and no signal will issue from D; the white point in the key photograph will, however, allow light to reach photoelectric cell B^1, and hence cause current to flow through B^1; thence it is amplified at C^1, and rectified at D^1. A positive impulse starts at O^1, flows along P^1 to point H. Photoelectric cell B being in the nature of a key which opens and closes a circuit, and the circuit through A being at this moment in the open condition, the current at H cannot flow along Q, but can along H-H^1, passing through winding I, thence along Q^1 back to negative terminal R^1 of D^1. A circuit has been completed and the flow of current through I causes a current to be induced in I^1, which is then amplified in L, and causes the modulator M to send out a modulated signal along S,S^1. The result, then, of the interaction of the electrical conditions representing a blank point in the clear photograph and a white point in the key photograph is that a signal is produced in the resultant circuit K, and transmitted at S,S^1.

Case (3) is merely the interchange of the separate conditions set forth under case (2), and will likewise result in the production of a signal at S,S^1.

In case (4) we have the condition where a signal is set up at D and D^1 simultaneously. A positive impulse starting at O in A flows along P reaching H^1; a positive impulse of equal potential starting at O^1 flows along P^1 reaching H; the two equipotential currents arriving at the terminals of $H-H^1$ simultaneously, but going in opposite directions exactly oppose each other; or, looked at in another way, H and H^1 will be points of equal potential and hence no current will flow through the conductor connecting them. Thus, no current can flow through I, hence none is induced in I^1, and no signal is produced in K.

It is clear, therefore, that the four cases set forth above result in only two ultimate conditions: a signal is either produced or not produced at S,S^1. These signals may be transmitted along conductors according to the principles of wire radio, or may be emitted from an antenna, according to the principles of space radio. The transmitted signals represent or rather correspond to the cryptophotograph transmitted.

In Figure 2 there are illustrated examples and the results of all four cases specified above, in the form of theoretical photomicrographic diagrams. Here A represents a section along a portion of the "positive" clear photograph, with the black and white portions represented as indicated by a to m. A^1 represents a section along a honologous portion of the "positive" key photograph, and it is to be understood that superimposed parts of A and A^1, a to m and a^1 to m^1, represent points subject simultaneously to the scrutiny of the analyzing photoelectric cell. K represents the sequence of resultants in the form of a succession of "0"s and "+"s, where "0" represents "no signal" and "+" represents "signal". If these resultants were received and recorded directly on a film, and if it were possible to transmit any kind of a signal without some losses, causing the rounding off of the signal, the received and recorded cryptophotograph would appear as shown at S, Figure 2. The rounding off of the signals, however, is of no direct concern in the present invention and will be disregarded.

The superimposition of a of A and a^1 of A^1 represents case (1), a condition where no signal is produced because no currents flow through the clear photograph and key photograph currents of Figure 1. The resultand, a^{11} of K, is therefore a blank, and if such a cryptophotograph were being recorded as such, at the receiving end, no light would be directed on the recording sensitized surfact. In case the sensitized surface were a film negative, on development the particular point under discussion would be blank, that is, transparent. In case it were a sensitized paper, on development, the point would be white, as shown in a^{111} of S. The superimposition of e of A and e^1 of A^1 represents case (2), a condition where a signal is produced at K of Figure 1. The resultant, e^{11} of K, in Figure 2 is therefore a "+" and represented by a black point in e^{111} of S. The superimposition of b of A and b^1 of A^1 in Figure 2 represents case (3), a condition where a signal is produced at K of Figure 1. The resultant, b^{11} of K, is therefore a "+", represented by an "exposed" or black point, b^{111}. Finally, the superimposition of g of A and g^1 of A^1 represents Case (4), a condition where no signal is produced at K of Figure 1 because the currents established at D and D^1 of Figure 1 exactly neutralize each other in the interaction circuit E, and hence b^{11} is an "O" and is represented by b^{111}, a transparent or white point.

It may be pointed out that the cryptophotograph produced by the invention is totally different from the photograph produced by exposing a single sheet of sensitive photographic paper to two different negatives. In the latter case there is merely a sort of arithmetical additive effect, while the resulting print may be confused, yet it is always possible for the eye to separate the constituent parts of each picture, and thus see either or both of them. In the case of the cryptophotograph produced by this invention it is altogether different, and there is no mere arithmetical additive effect. It is a sort of algebraic additive and subtractive effect so that the resultant bears no resemblance to either the clear or the key photograph.

In Figure 2 are shown the arrangements of parts and circuits at the receiving station, suitable for receiving and simultaneously deciphering the cryptophotograph. It is to be understood that synchronization of the transmitting with the receiving station is necessary to the practical operation of the present invention just as it is in the ordinary systems of radiophotography, and the methods well known in the art are applicable. In the more successful systems the receiving station is under the complete control of the transmitting station, which exercises the primary control. In Figure 2, A^1, with its parts B^1, C^1, and D^1, is exactly the same as the corresponding parts of Figure 1, and it is of course essential that the key photograph employed to decipher the received cryptophotograph must be identical with that employed at the transmitting station to encipher the clear photograph. A^{11} represents the received cryptophotograph circuit, where S, S^1 represent the terminals of the incoming signals, C^{11} is the amplifier and D^{11} the rectifier, all of well known form, suitable for the reception of the signals corresponding to the transmitted cryptophotograph. E of Figure 2 is the same and functions for the same purpose as E of Figure 1; its coils I and I^1 are similar to the corresponding coils of Figure 1. K^1

is the resultant circuit, where the electrical resultants of the interaction circuit E are amplified by L^1 and then caused to retranslate the electrical signals into light values by the light value M^1 which controls the source of light, N^1. M^1 may be of the magnetic type or of any other form suitable for translating the electrical signals back into their corresponding light values and making a record of the same on sensitized paper of film moving synchronously with that at the transmitting station.

The interaction circuit E^1 of Figure 2 functions exactly as does E of Figure 1, so that further description is necessary toward an understanding of the principles. In the resultant circuit K^1, Figure 2, the light value M^1 takes the place of the modulator M of Figure 1, and causes a record to be made of the resultants of the interaction between signals arriving from the distant station, led into the interaction circuit E from D^{11} of A^{11}, and local deciphering signals led into the interaction circuit E from D^1 of A^1.

The four cases detailed in connection with the sets of conditions in the interaction circuit of the transmitting station, Figure 1, are identical in form with those at the receiving station, Figure 2, but the resultant effects in the resultant circuit are exactly opposite. Whereas at the transmitting station the simultaneous occurrence of a white point on both the clear photograph and the key photograph represents a period of current flow to the interaction circuit, but a period of no current flow in the resultant circuit, at the receiving station the simultaneous occurrence of a period of no current flow in the receiving half of the interaction circuit and a similar period of current flow in the local or deciphering half of the interaction circuit causes current to flow through I of the interaction circuit, thence through I^1 of the resultant circuit, and hence causes light to fall on the recording or sensitized surface of the deciphering cylinder. If this recording surface is a negative film, the particular point under discussion would be exposed to light; on development the point would be black. By contact printing on sensitized paper, however, the black point would be reversed to a white point, and thus made to correspond exactly with the point on the clear photograph.

In Figure 4 there are illustrated examples and the results of all four cases of interaction, in a form similar to that shown in Figure 3. S^1 represents the received cryptophotograph, if recorded. K^1 shows the sequence of incoming signals representing the received cryptophotograph, corresponding in its sequence of "0"s and "+"s with that of K of Figure 3. A^1 represents a section along that portion of the key photograph which is necessary properly to decipher the particular section of the cryptophotograph under discussion: A^1 of Figures 3 and 4 are, as stated before, identical in whole and in part, and the synchronizing mechanism must, of course, bring homologous parts of both key photographs into the correct positions in order to maintain the proper enciphering-deciphering relationship between the transmitting and the receiving stations. A^{11} of Figure 4 represents a section along the resultant or deciphered cryptophotogram, which, if correctly done, is a negative image of A of Figure 3, the original or clear photograph. A of Figure 4 is the positive print of A^{11}, and corresponds exactly with A of Figure 3.

In Figure 4 the interaction of a^{111} of K and a^{11} of A^{1} represents case (1), a condition where no signal is produced. The resultant in this case is shown by a of A^{11}, Figure 4, a blank or white spot. It is thought unnecessary to detail examples of the other three cases, because they are exactly analogous to those already explained in connection with Figure 3. It is only to be pointed out that the deciphering process results in the production of A^{11}, which is an exact duplicate of A of Figure 3, the original or clear photograph, except that it is a negative of A. By contact printing or by enlargement from the developed film, A, the exact clear photograph is reproduced.

In Figure 5 there is shown in digrammatic form a specific embodiment of the invention in a practical wired radiophotograph transmitting station. Here a motor, 10, is the driving mechanism of the single shaft 1, the rotation of which causes the cylinders 2 and 2^{1} to revolve, through the agency of gear wheels $3, 3^1$ and $4, 4^1$, and secondary shafts $5, 5^1$. A synchronous horizontal displacement of the cylinders 2 and 2^1 is accomplished by means of the movement of identical carriages 6 and 6^1, and identical screw portions $7, 7^1$ of the shaft 1. Thus, all portions of the photographic transparencies mounted upon 2 and 2^1 are brought under the scrutiny of the light coming from light sources 8 and 8^1, through lenses 9 and 9^1; this light is either passed or stopped by portions of the photographic transparencies, depending upon whether a light or a dark portion, respectively, appears under the focal point of the lenses 9 and 9^1. B and B^1 are the photoelectric cells affected by the light passing through the photographic transparencies. No further explanation of the apparatus comprised with in the dotted sections A, A^1, E and K is necessary inasmuch as they correspond exactly with similarly labeled parts in Figure 1.

The motor 10 in an impulse motor of well known form, controlled by an electrically operated tuning fork, 11. The motor 10 drives the shaft 1 through a clutch mechanism, 12, which is controlled by a local switch and which at the moment of engagement sends an impulse along conductors $13, 13^1$ to the amplifier L, whereupon a signal is sent to the receiving station, and the starting clutch at the distant end is operated to start the shaft which drives the homologous receiving cylinders there to revolve at the same instant that the drive shaft 1 starts to revolve at the transmitting station, Figure 5.

Impulses from the control or synchronizing carrier wave oscillator 14 are controlled by modulation by the master fork 11, and the synchronizing impulses are sent to line S,S^1 through a control channel filter, 15^1, and a terminal amplifier, 16. The frequency of the control carrier oscillations in order to permit of the transmission of both oscillations over one channel, and hence the filter circuits 15 and 15^1 are inserted, in order that the two modulated currents may be kept separated from each other.

The terminal amplifier 16 is necessary in order that signals of sufficient strength may be sent to line or to the transmitting antenna.

The operation of the clear photograph circuit A, the key photograph circuit A^1, the interaction circuit E, and the resultant circuit K is exactly the same as has been described in connection with Figure 1, and nothing further need be said concerning it in connection with Figure 5.

In Figure 6 there is shown in diagrammation form the arrangements at the receiving station. They are self-explanatory when considered in connection with Figures 1 and 5. The incoming signals on the line S,S^1 are first amplified in 16. The electrical filters 15 and 15^1 serve to separate the two modulated carrier frequencies from each other, that appropriate to the picture system being separated out by the picture channel filter 15, that appropriate to the synchronizing or control system, by 15^1.

The isolated modulated picture carrier is then amplified in C^{11}, and rectified in D^{11}. The isolated modulated control carrier is amplified in L^1, and rectified in M^1. The rectified picture currents are then led into the interaction circuit E; the rectified control currents are led to the secondary fork 11^1, which controls the motor 10^1 and keeps it in exact synchronism with the corresponding motor at the transmitting station. Thus the master or primary fork, 11, at the transmitting station not only controls the motor 10 but also the motor 10^1 at the receiving station through its dependent fork 11^1.

The starting mechanism 12^1 is operated by the amplified starting signal coming from the line S,S^1 through Amplifier C^{11}, and this signal starts the drive shaft 1^1 to rotating exactly at the same instant that draft shaft 1 at the transmitting station starts.

It is to be understood, naturally, that the mechanical arrangements as regards the rotation and horizontal displacement of the cylinders 2 and 2^1 at the receiving station are identical with those at the transmitting station, and that the cylinders are of exactly the same dimensions throughout. It is also clear that the key photograph mounted upon cylinder

2^1 must not only be an exact duplicate of that at the transmitting station but also it must be mounted upon the cylinder in exactly the same relative position as its mate at the transmitting station. The requirement in this respect is no different from that in ordinary cryptographic processes involving the use of continually shifting key letters; for not only must the enciphering and deciphering sequences be identical but also they must be applied at exactly homologous parts of the text.

The interaction in E of currents coming through A^1 with those coming through A^{11} is exactly in accordance with the four cases detailed before in connection with Figure 1. The resultant effects are impressed upon winding I^1 and thence they go to resultant circuit K^1 where the light valve M^1 is controlled by them. Light valve M^1 serves either to open and close a shutter of the optical system N^1 or to vary the intensity of the light, and thus cause the electrical variations of I^1 to be translated into light variations. The ray of light passes through lens 9 and impinges upon a sensitized film mounted upon 2. The result is that the received cryptophotograph is deciphered and corresponds to the original or clear photograph at the transmitting station, as a negative of the latter.

In the description thus far the photographs used as matter to be transmitted or as keys have been considered to be of pure black line composition against a pure white background. This condition is not a necessary element to the successful functioning of the invention, which is applicable to the encipherment of photographs of varying density as regards the lines of which they are composed.

Referring again to Figure 1, let us suppose that in the clear photograph circuit, A, the analyzer photoelectric cell B is scrutinizing a point, X, and in the key photograph circuit A^1, the analyzer B^1 is scrutinizing a homologous point X^1. Further, let us arbitrarily draw up a scale of intensity of shade, calling pure white or perfect transparency +1, and pure black or perfect opacity 0, with the gradations between the two extremes in ten equal steps. Let point X be of opacity .9, and X^1 of opacity .1. X would then be almost pure white or almost perfectly transparent; X^1 would be almost pure black or almost perfectly opaque. Now in an alkali metal photoelectric cell the illumination-current relationship is rectilinear, that is, as the illumination of the cell is changed the current permitted to pass through it changes in direct proportion. Hence, the current passing through D of A will be proportional to the illumination of B, and likewise the current passing through D^1 of A^1 will be proportional to the illumination of B^1. Now since point X is of density .9 it will allow almost the entire available amount of light to fall on B; and since point X^1 is of density .1, it will allow very little light to fall on B^1. The currents produced being proportional to the illumination, the current through B, and thence through D, will be approximately nine times as much as that through B^1, and thence through D^1. Therefore, there will be a difference in potential between H^1 and H, the former being 9 units, the latter only 1 unit. Hence there will be a flow of current from H^1 to H through I, equivalent to 8 units, and the amount of flow will be in proportion to the difference in illumination of B and B^1, that is, to the difference in intensity of blackness of X and X^1. The modulation of the carrier will then be in proportion to the current flowing through I, and thus the difference in light value between X and X^1 is transmitted over line S, S^1, in the form of a carrier wave modulated in amplitude in accordance with the sequence of resultant effects in I. The case in this respect is exactly analogous to that which exists in radio telephony.

At the receiving station, Figure 2, there will flow through I^1 currents representing the rectified signals received, and these will vary in potential with the modulations impressed upon the carrier wave emitted from the transmitting station. The currents induced in I will then affect the interaction circuit E^1 in the same manner as before described. In the case under discussion the flow of current through I of Figure 2 is equivalent to 8 units. This current will interact with the one originating locally in A^1, which as was noted above, is equal to that caused by a point X^1 in the key photograph, the density value of which is .1. The result of the interaction of the two currents, that from the incoming signal, .8, and that from the local deciphering signal, .1, is an additive effect, viz., .9, which is exactly equal to that of point X at the transmitting station.

We claim:

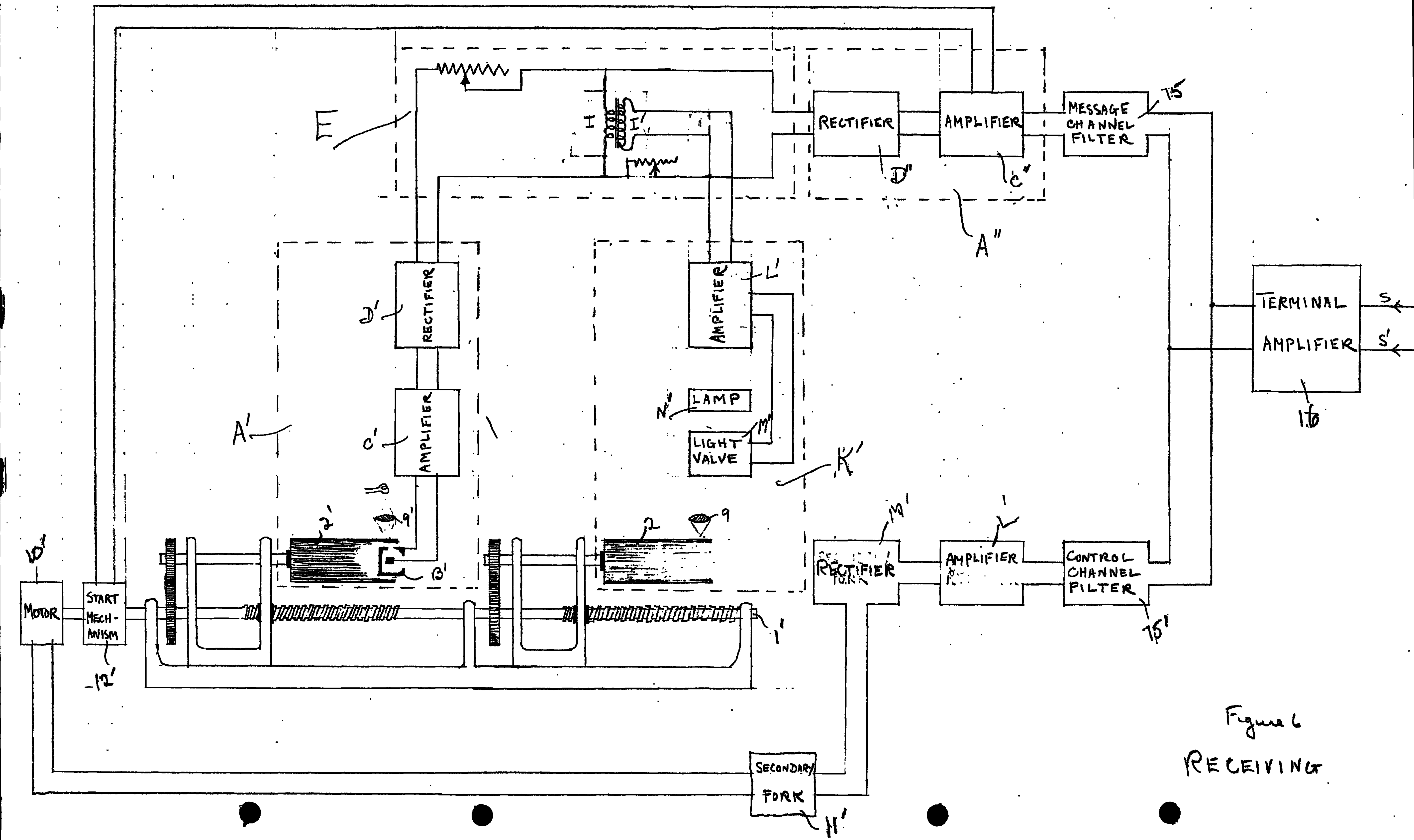


Figure 6

RECEIVING

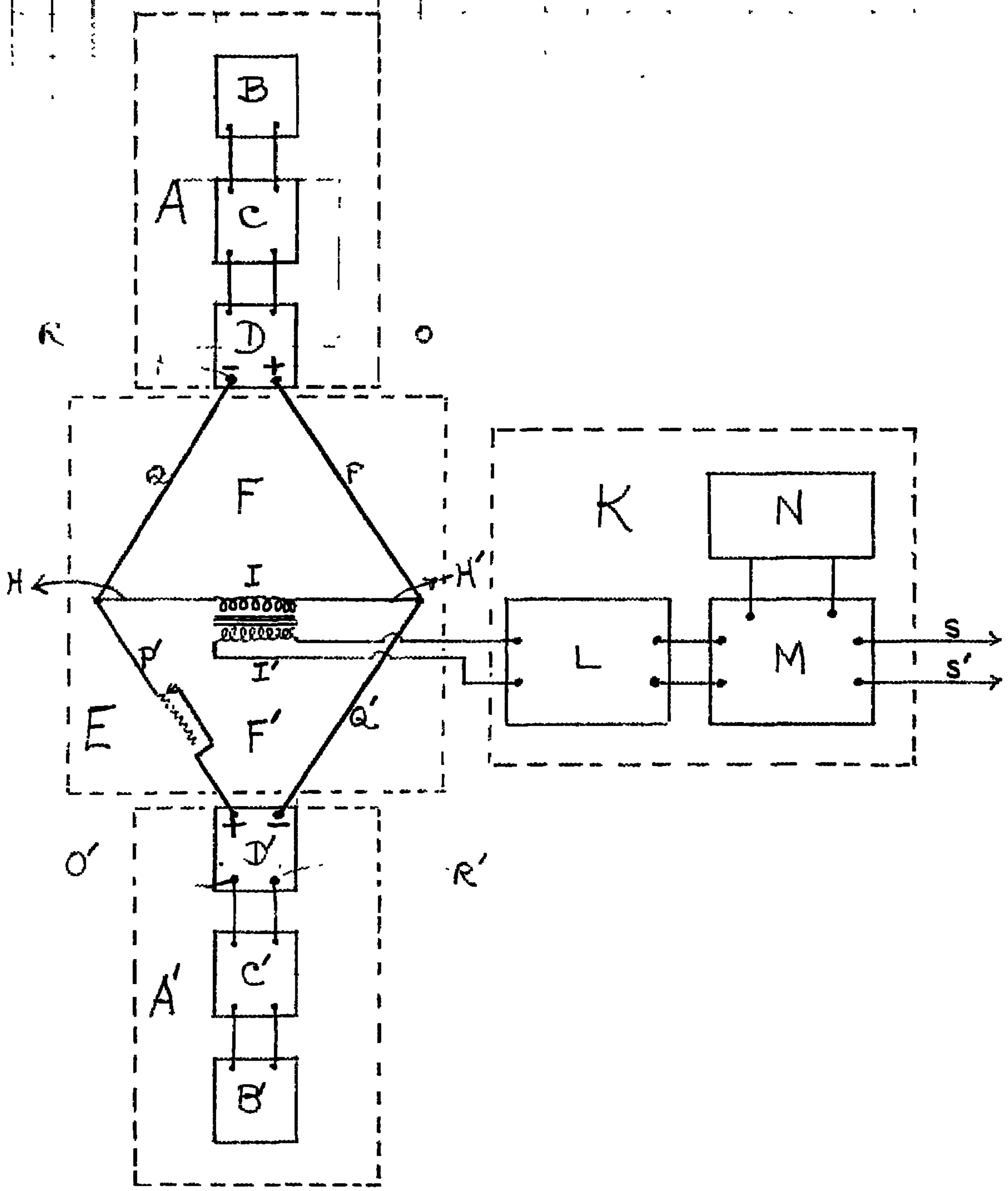


Fig 1 TRANSMIT

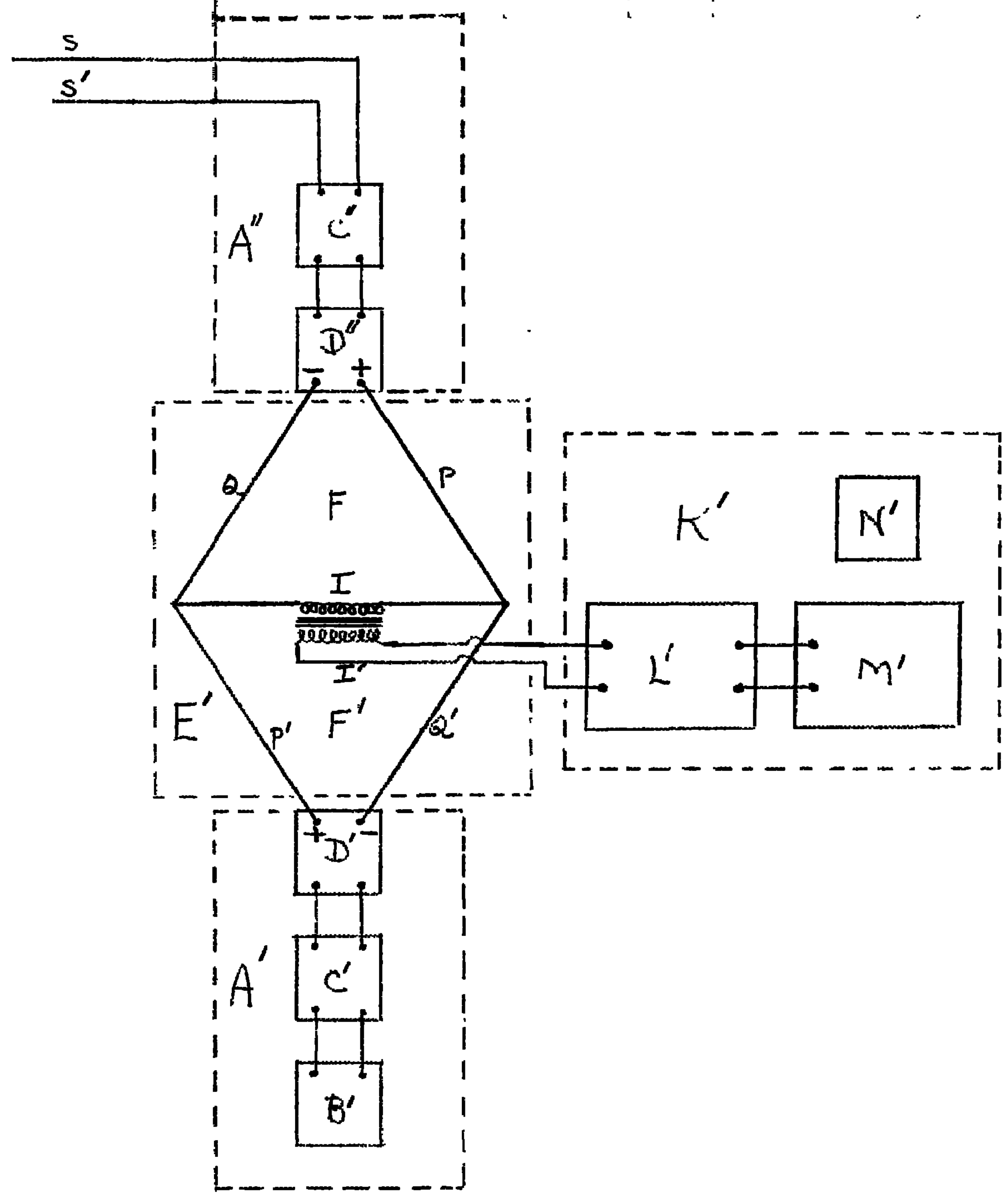


Fig 2 RECEIVE

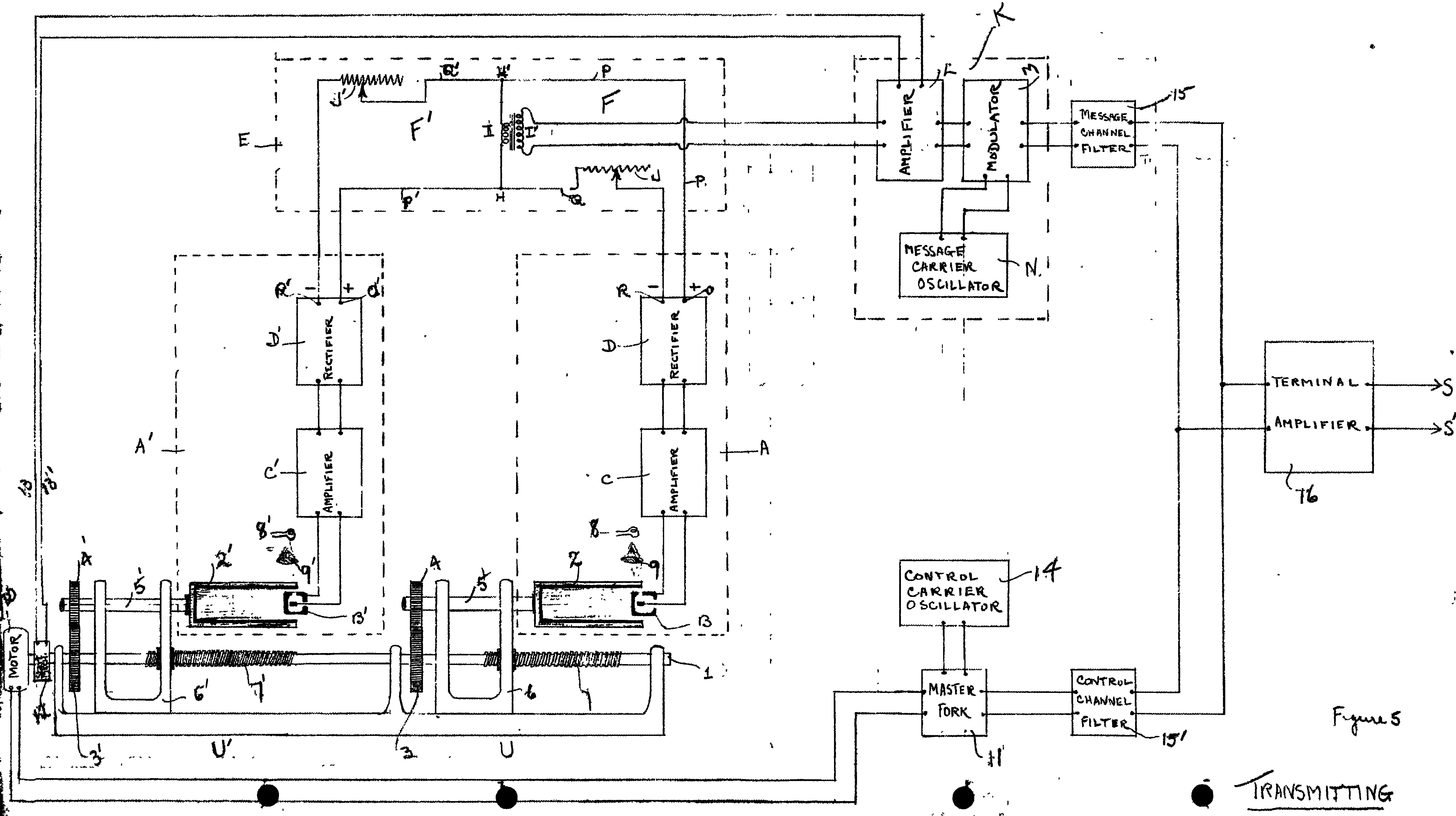


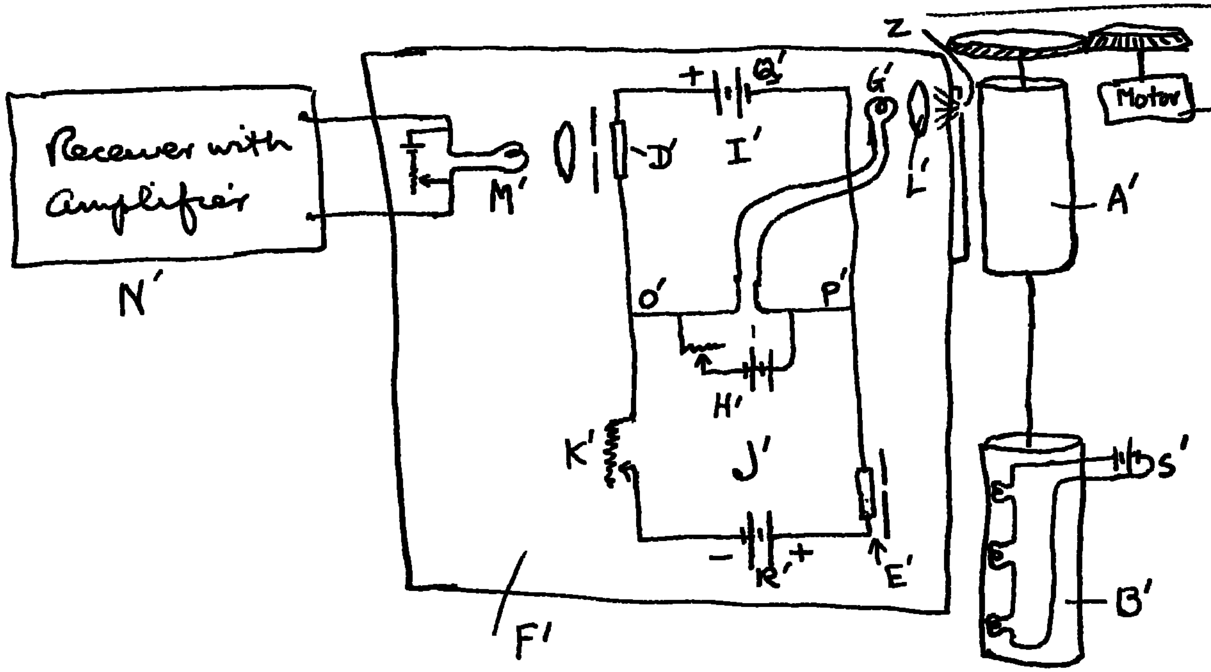
Figure 5

TRANSMITTING

REF ID:A105153

Method for Secret Transmission and Reception of Photographs by Electric means.

RECEPTION



Action as follows:

Case 1- { Signal in receiving circuit / No signal in local decoding circuit } Increased glow in lamp G'

Case 2- { No signal in receiving circuit / Signal in local decoding circuit } same result as in Case 1

Case 3- { Signal in receiving circuit / Signal in local decoding circuit } Equal and opposite potentials established along O'-P' No effect on G'

Case 4- { No signal in receiving circuit / No signal in local decoding circuit } No effect on lamp G'.

A'- cylinder upon which light sensitive paper or film is mounted, shielded from light except at Z.

B'- cylinder upon which an exact duplicate of camouflage picture at transmitting station is mounted.

A' + B' keyed to same shaft + rotate at same speed.

C'- Driving motor synchronized with C at transmitting end.

D'- light sens. cell acted upon by receiving circuit

E'- " " " " " light from camouflage picture on B'.

F'- Carriage upon which D', E', etc. as shown are mounted. F' moved ~~longitudinally~~ along parallel to axis of A' and B' at same rate F at transmitting station.

G'- Lamp kept just below glow point by local source H'.

I' + J' form arms of an electric bridge circuit balanced at K'.

L'- lens

M'- lamp responsive to incoming signals

N'- Receiver with amplifier to detect, amplify signals transmitted from trans. station

O'- P'- side of bridge common to both I' and J' circuits.

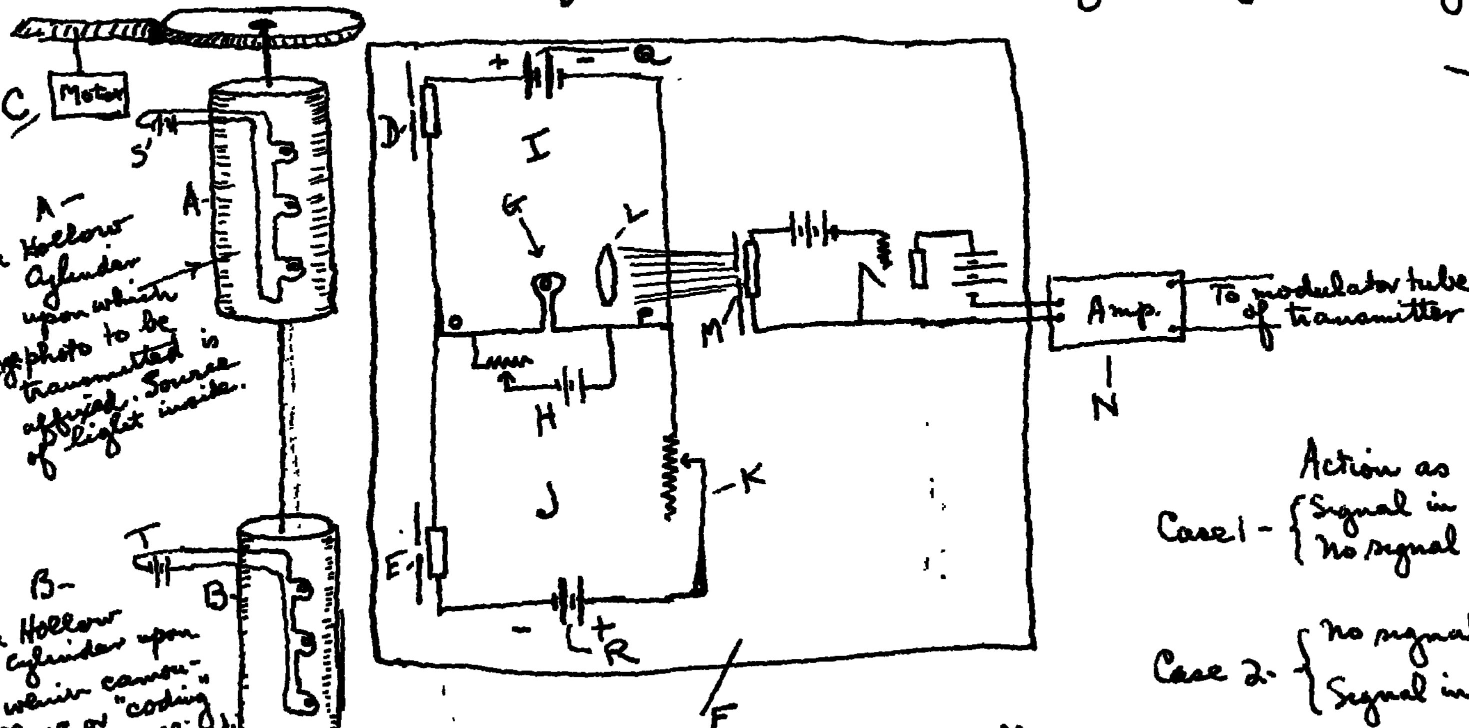
Q' and R'- equal potential sources of direct current connected to circuits according to polarities shown.

Inventors {

Disclosed to ... at Washington, D.C.

Method for Secret Transmission and Reception of Photographs by Electric Means,

TRANSMISSION



A – a Hollow cylinder upon which photo to be transmitted is affixed. Source of light inside.

B – a Hollow cylinder upon which camouflage or "coding" picture is affixed. Light source inside.

A+B keyed to same shaft driven by motor C

S+T equal in power, + lamps in A and B of same C.P.

F – Carriage for photoelectric cells D and E, and circuit pertaining. F is moved ~~transversely~~ longitudinally along parallel to axis of A and B so that D and E, photoelectric cells, sweep across photos on A and B at exactly same rate. ~~and~~

G – a lamp kept just below glow point by local source, H.

I and J form two parts of an electric bridge circuit, balanced at K.

L – lens

M – photoelectric cell in vacuum tube circuit to N, amplifier.

O-P – side of bridge common to both I and J circuits

Q+R – equal potential sources of direct current connected to circuits according to polarities shown above.

Action as follows:

Case 1 – { Signal in message photo circuit / No signal in camouflage circuit } Increase in potential through lamp G across O-P. Increased glow in lamp G

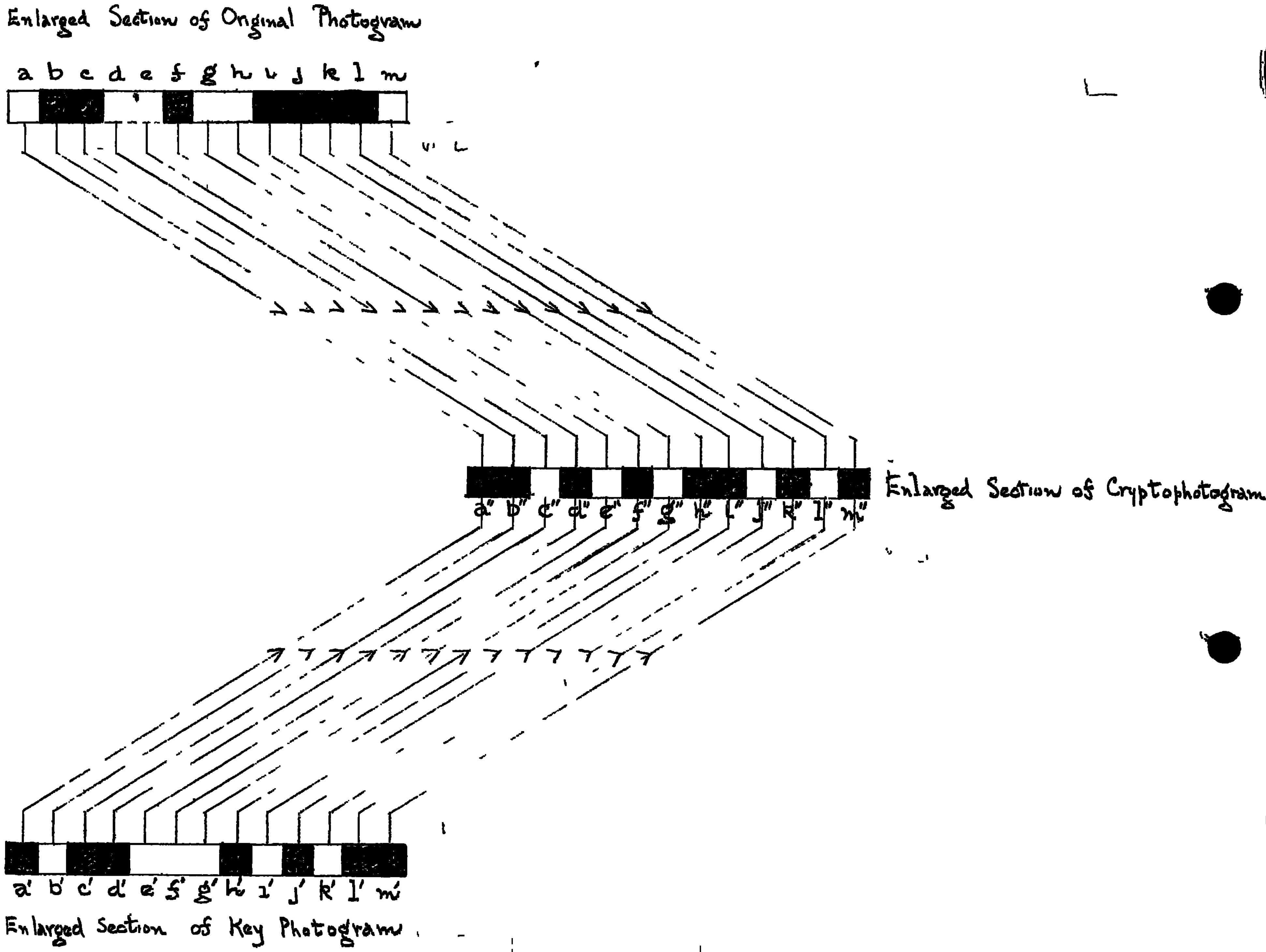
Case 2 – { No signal in message photo circuit / Signal in camouflage circuit } same result as in Case 1

Case 3 – { Signal in message photo circuit / Signal in camouflage circuit } Equal and opposite potentials established along O-P. No effect on lamp G

Case 4 – { No signal in message photo circuit / No signal in camouflage circuit } ~~[illegible]~~ no effect on lamp G

Inventors: {

Disclosed to us at Washington, D.C., {


Enlarged Section of Original Photogram
a b c d e f g h i j k l m
Enlarged Section of Cryptophotogram
a" b" c" d" e" f" g" h" i" j" k" l" m"
a' b' c' d' e' f' g' h' i' j' k' l' m'
Enlarged Section of Key Photogram

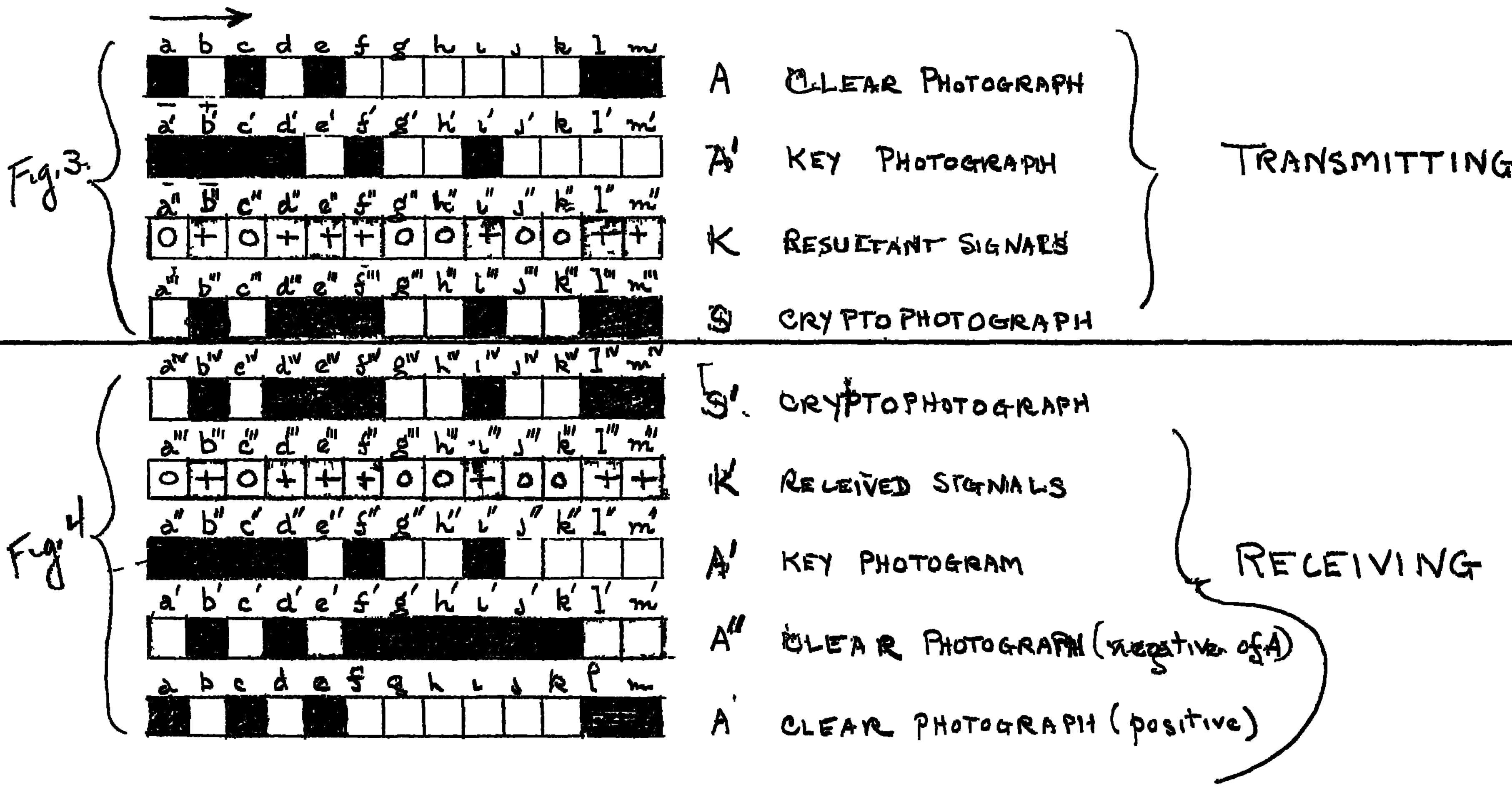


Fig. 3.
a b c d e f g h i j k l m
A CLEAR PHOTOGRAPH
A' KEY PHOTOGRAPH
K RESULTANT SIGNALS
S CRYPTOPHOTOGRAPH
TRANSMITTING
Fig. 4
S' CRYPTOPHOTOGRAPH
K RECEIVED SIGNALS
A' KEY PHOTOGRAM
A'' CLEAR PHOTOGRAPH (negative of A)
A CLEAR PHOTOGRAPH (positive)
RECEIVING