

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 1

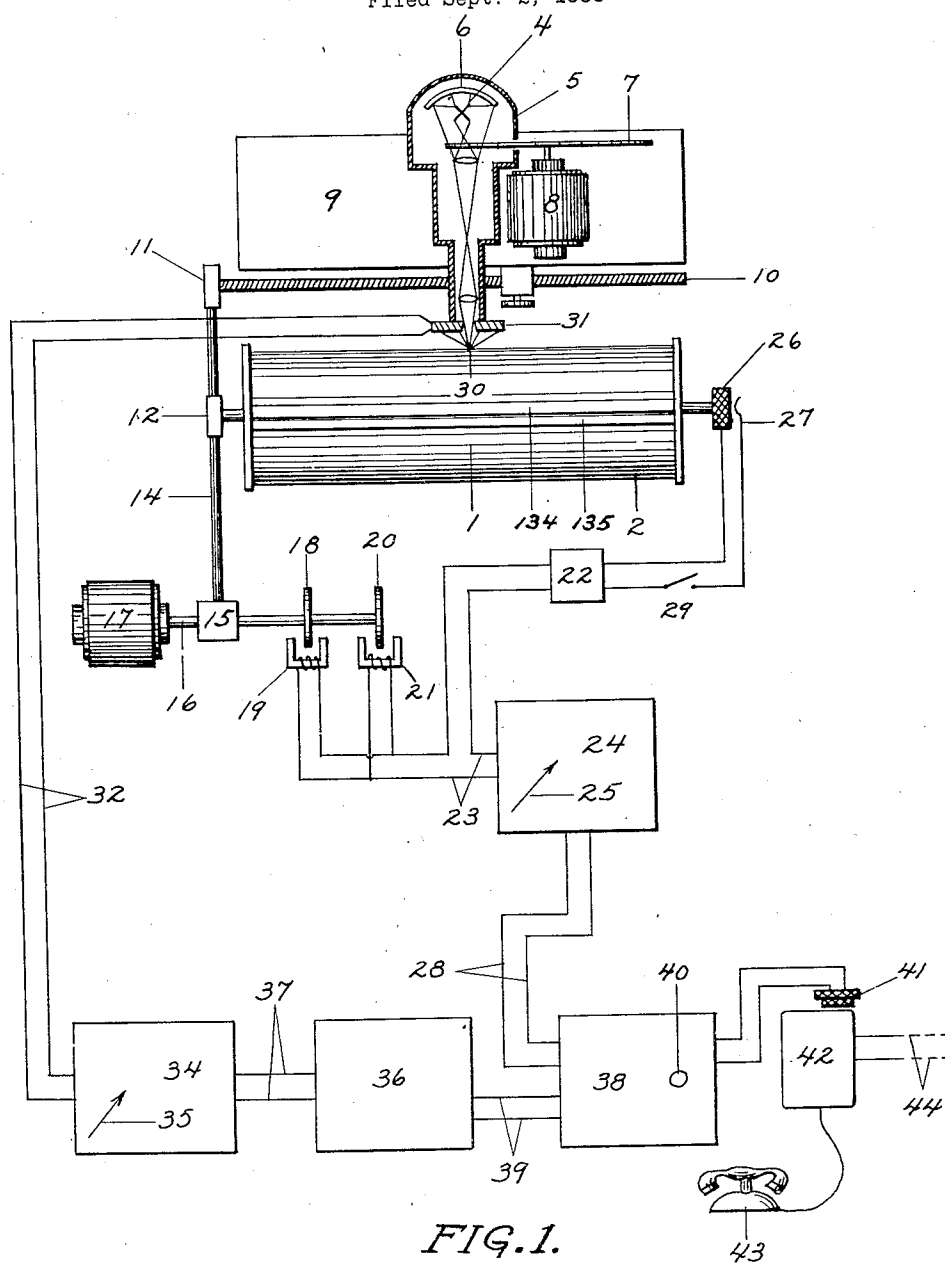


FIG. 1.

INVENTORS.
M. D. McFarlane
E. H. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 2

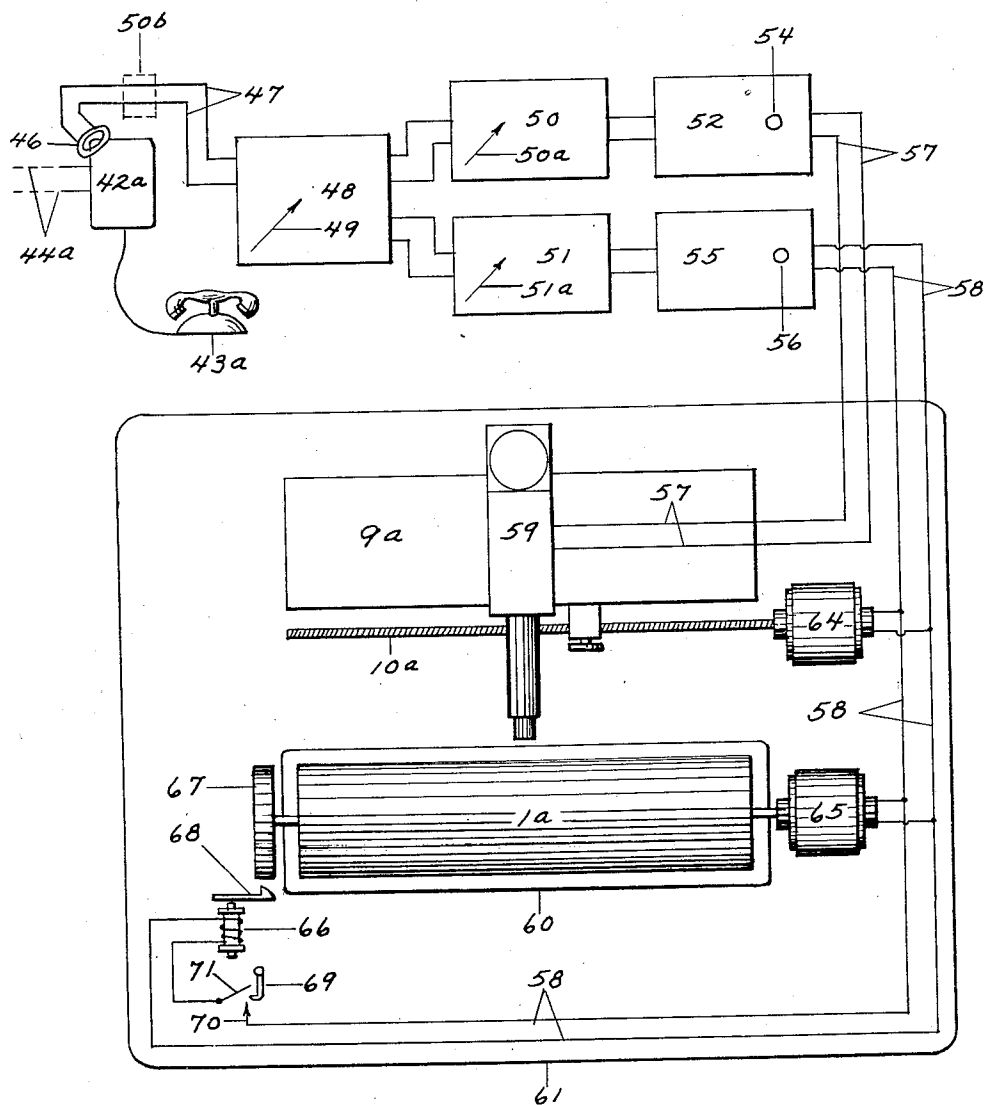


FIG. 2.

INVENTORS.

INVENTORS.
H. M. Garland
E. Hansen

June 27, 1939.

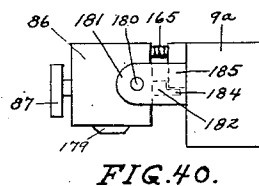
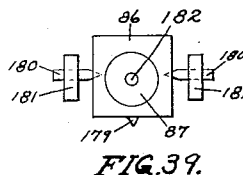
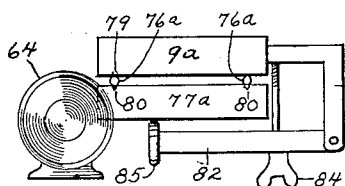
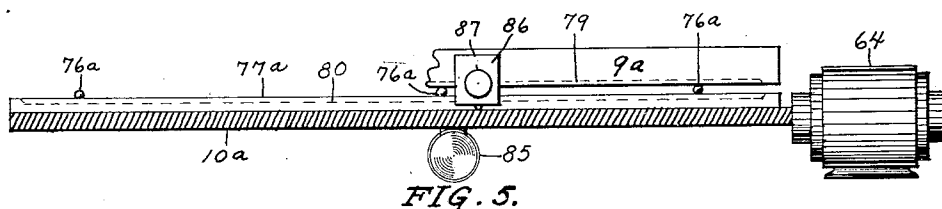
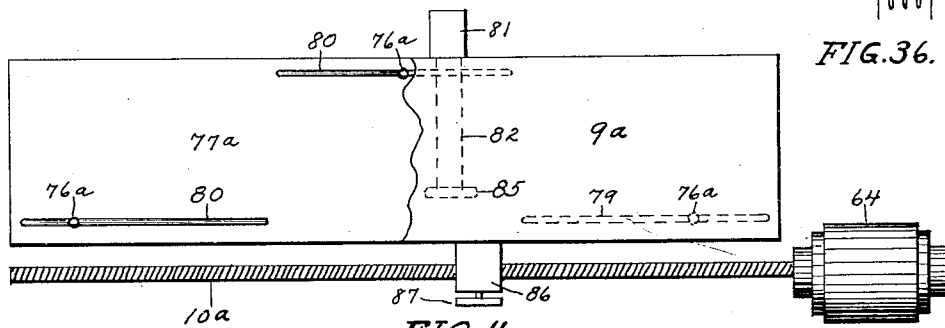
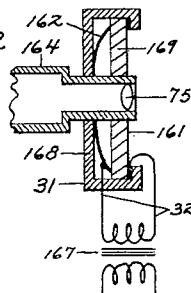
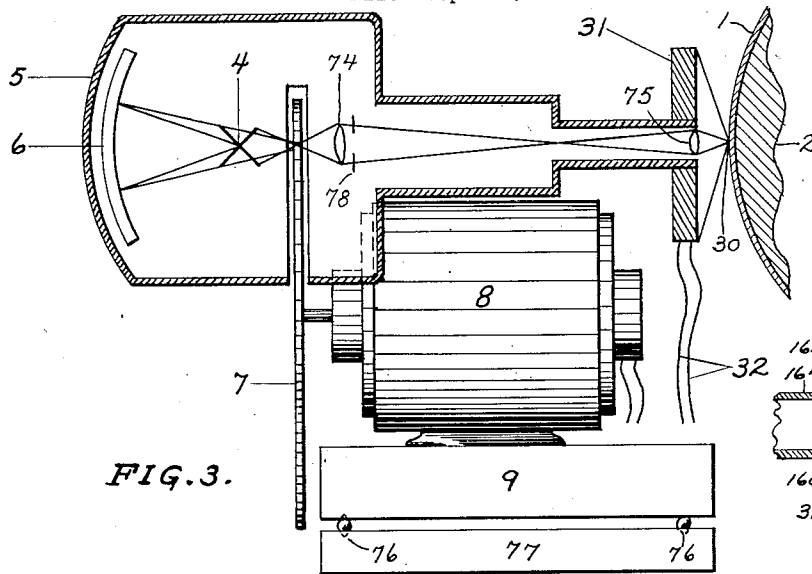
M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 3



INVENTORS.

M. D. McFarlane
E. H. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 4

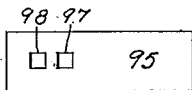
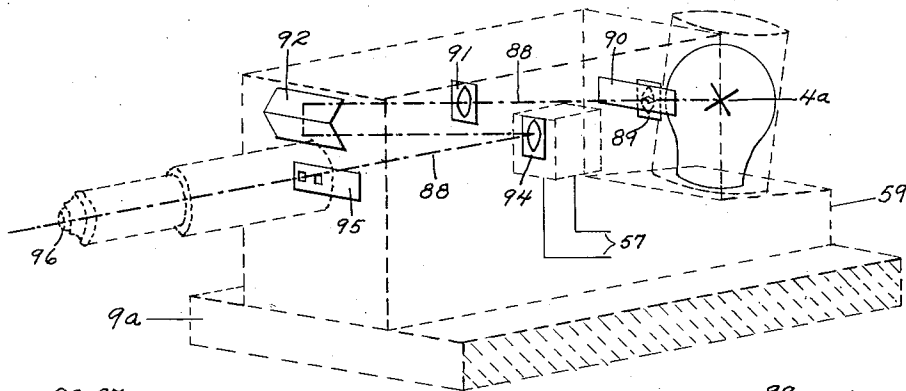


FIG. 9.

FIG. 7.

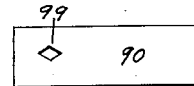


FIG. 8.

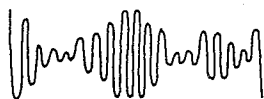


FIG. 10.

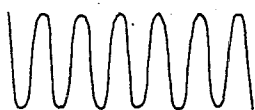


FIG. 11.



FIG. 12.



FIG. 13.

INVENTORS.
M. D. McFarlane
E. H. Hansen

June 27, 1939.

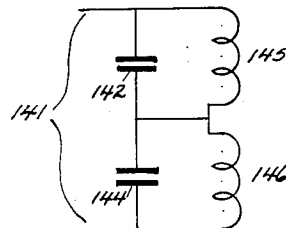
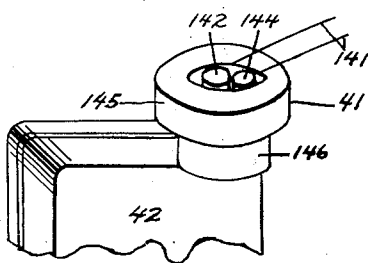
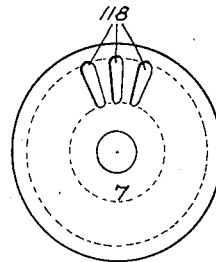
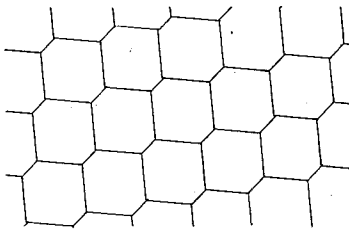
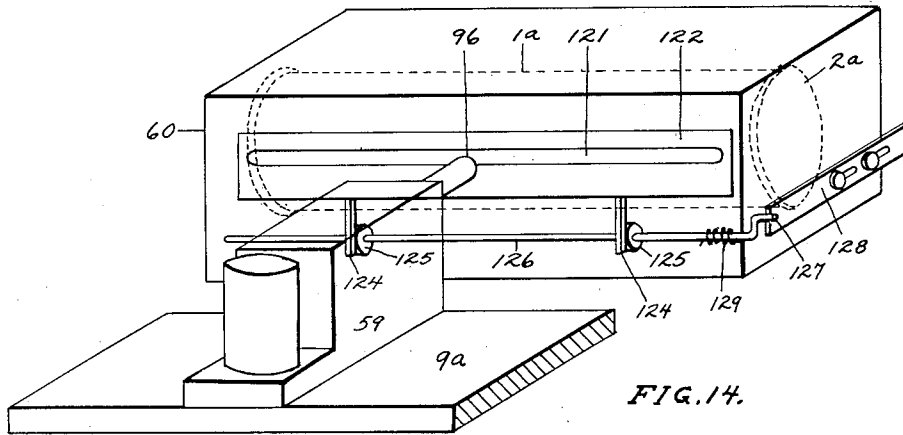
M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 5



INVENTORS.

M. D. McFarlane
E. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 6

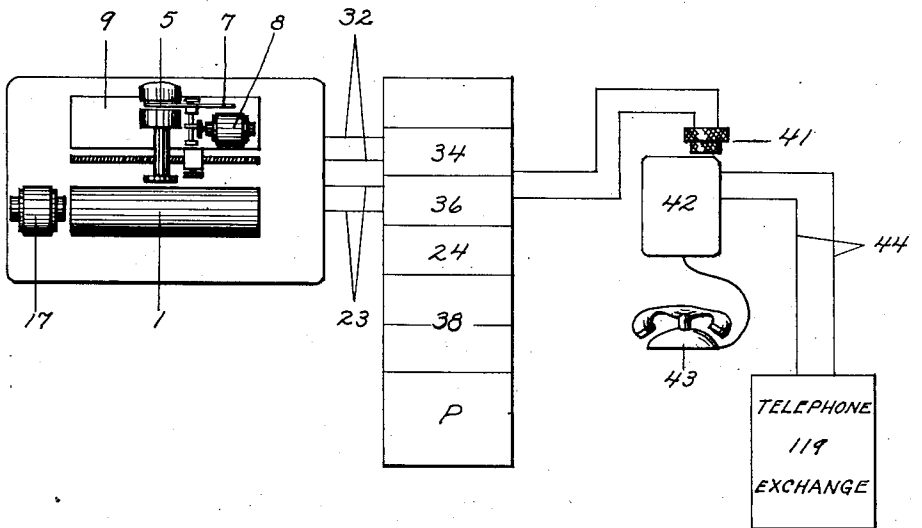
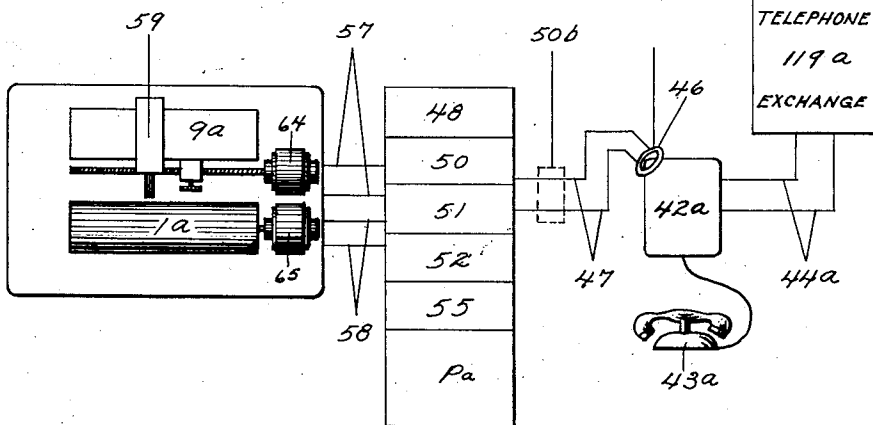


FIG. 19.



INVENTORS.
M. D. McFarlane
E. F. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 7

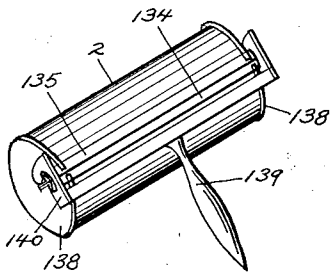


FIG. 22.

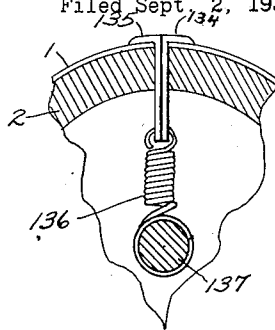


FIG. 20.

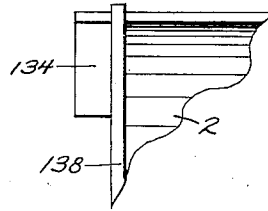


FIG. 21.

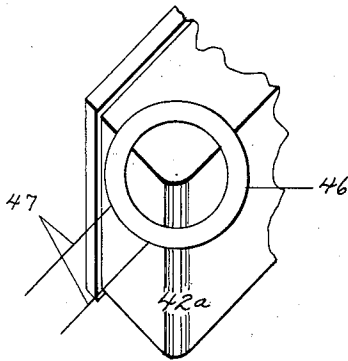


FIG. 23.

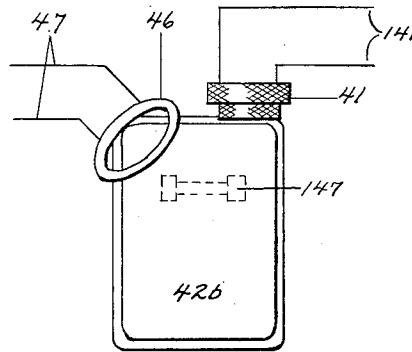


FIG. 24.

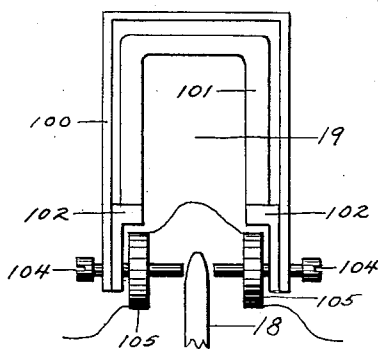


FIG. 25.

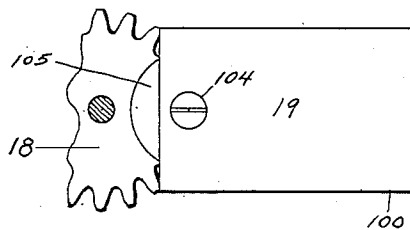


FIG. 26.

INVENTORS.
M. D. McFarlane
E. H. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 8

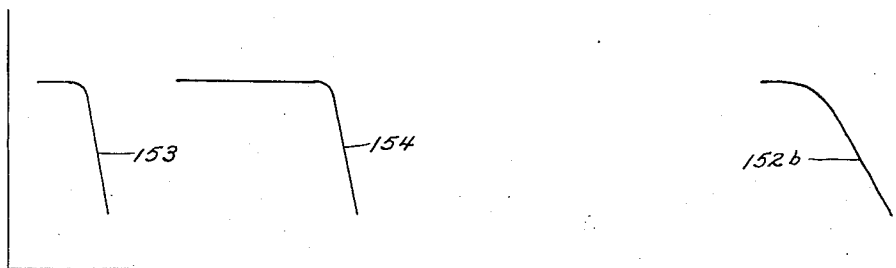


FIG. 30.

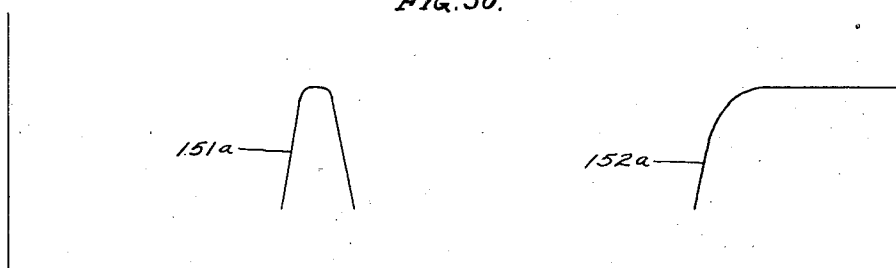


FIG. 29.

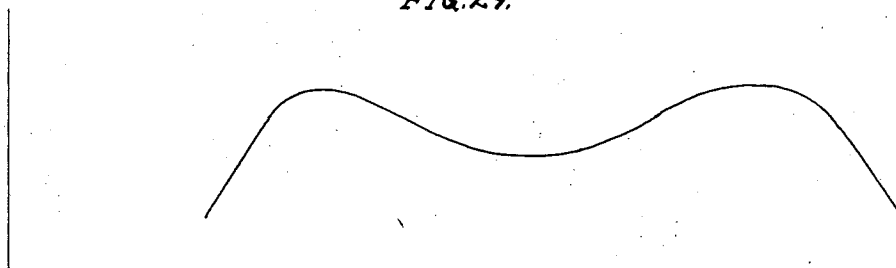


FIG. 28.

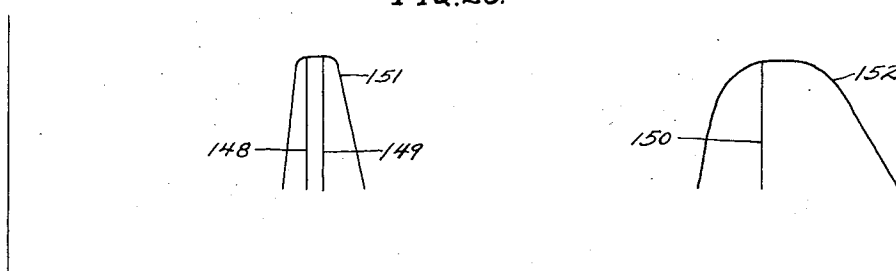


FIG. 27.

INVENTORS.

M. D. McFarlane
E. F. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 9

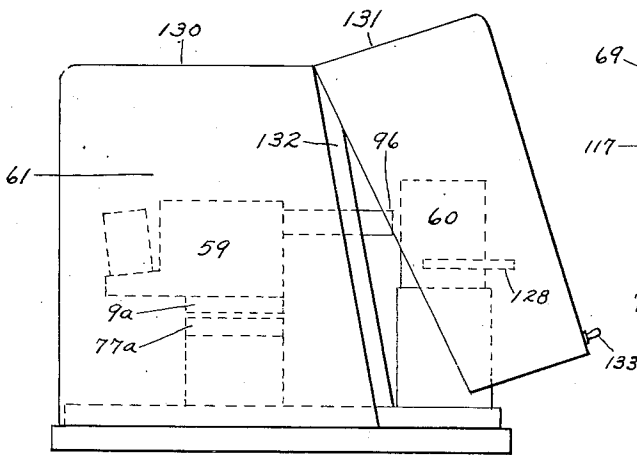


FIG. 33.

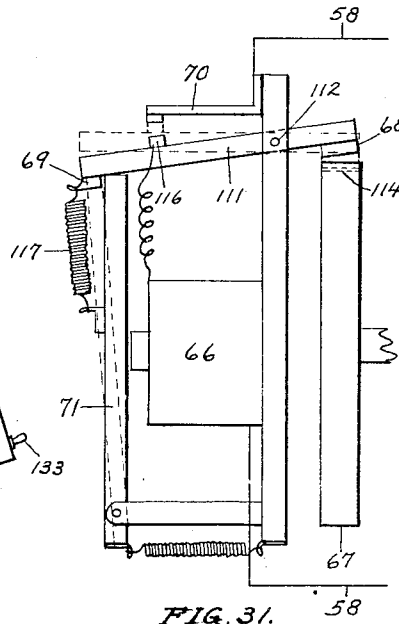


FIG. 31.

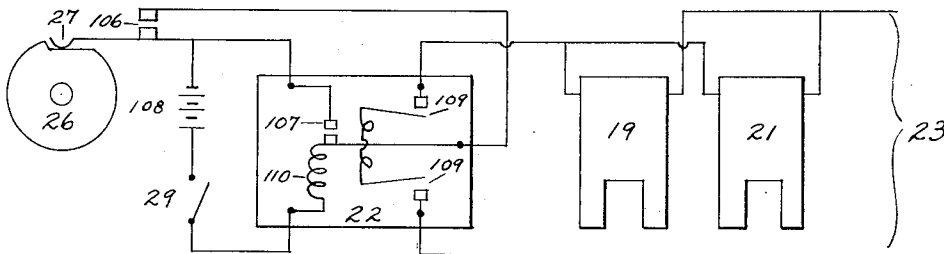


FIG. 32.

INVENTORS.

M. D. McFarlane
E. H. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet 10

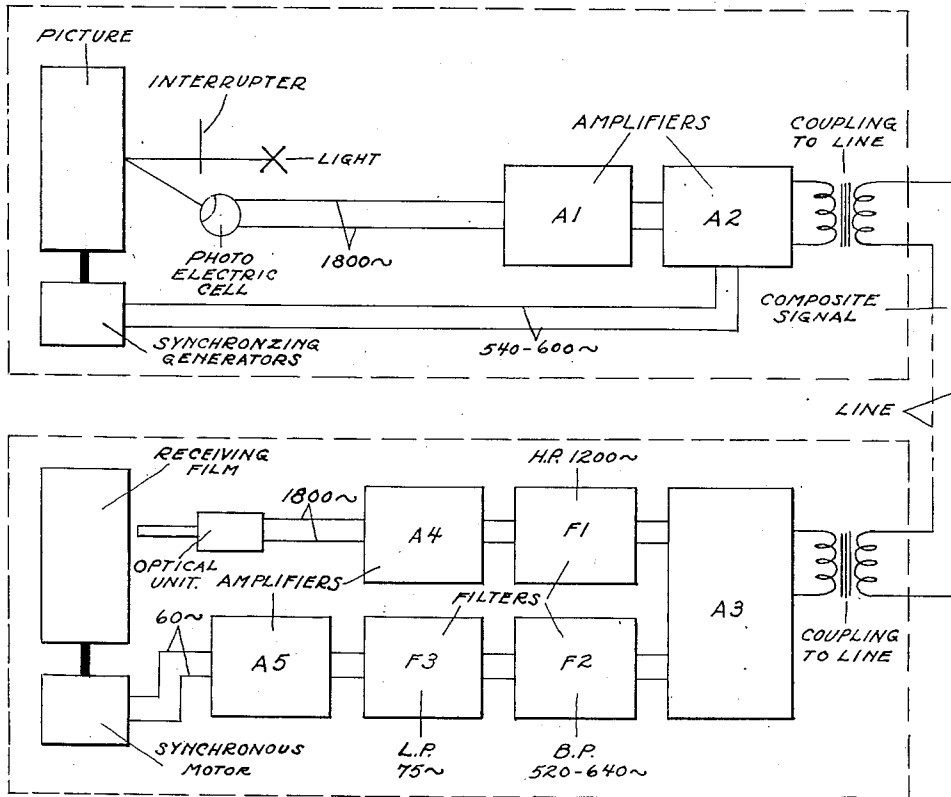


FIG. 35.

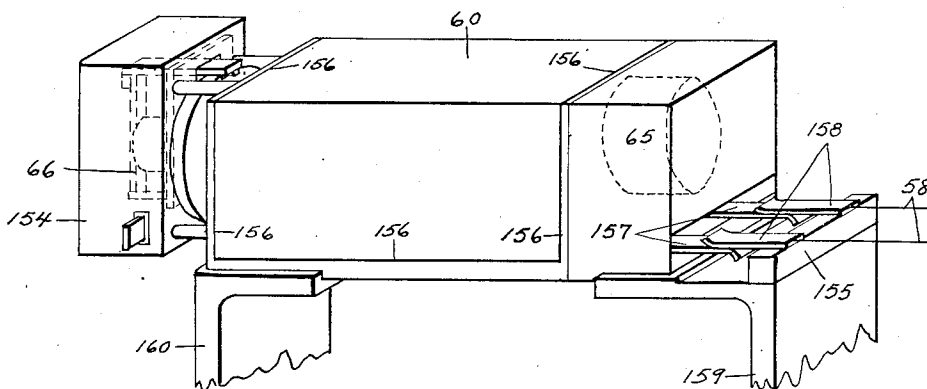


FIG. 34.

INVENTORS.
M. D. McFarlane
E. H. Hansen

June 27, 1939.

M. D. McFARLANE ET AL

2,164,038

FACSIMILE TRANSMISSION AND REPRODUCTION

Filed Sept. 2, 1936

11 Sheets-Sheet.11

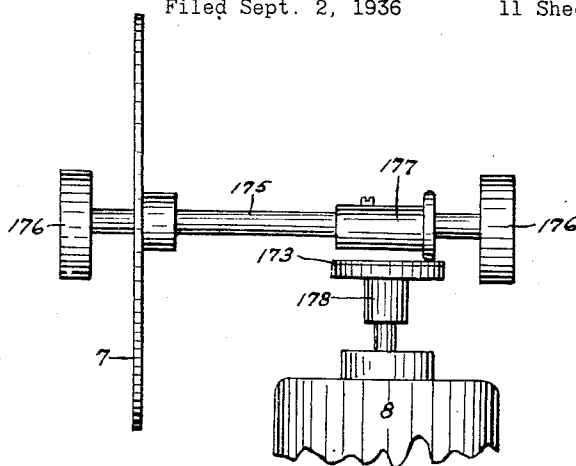


FIG. 38.

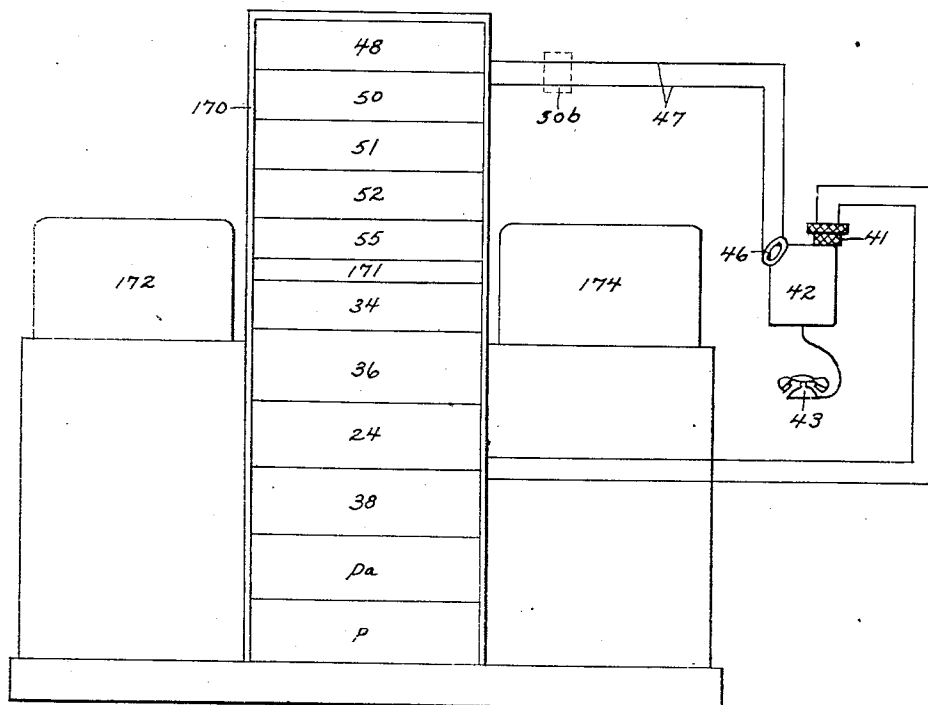


FIG. 37.

INVENTORS.

M. D. McFarlane
E. J. Hansen

UNITED STATES PATENT OFFICE

2,164,038

FACSIMILE TRANSMISSION AND
REPRODUCTIONMaynard D. McFarlane and Edmund H. Hansen,
Hollywood, Calif.

Application September 2, 1936, Serial No. 99,086

18 Claims. (Cl. 178—5.6)

This invention relates to improvements in the art of facsimile transmission and reproduction; that is the reproduction at one or more receiving stations of a facsimile or facsimiles of an original subject at a transmitting station. The disclosure of our invention comprises a complete facsimile system, together with improvements in details and parts thereof. The use of the novel methods and apparatus is not however limited to combination with this particular facsimile system; the various parts herein disclosed may be combined in other ways and with other systems; in addition, many novel features herein disclosed find application in allied arts, and the invention is not limited to their use solely in a facsimile system as herein disclosed.

One of the objects of our invention is to provide a simple and flexible means of transmitting pictures or the like from point to point; and to provide a high efficiency of reproduction in making the facsimile of the original subject.

Another object of our invention is to provide a method for an improved utilization of the transmitted signal; and to utilize a picture frequency for control of unit area reproduction, in contradistinction to the usual envelope frequency utilized for this purpose.

Another object of our invention is to provide a simple and direct method of synchronization; and means to provide a simple and direct method of phasing.

Another object of our invention is to provide a system of facsimile reproduction which may utilize any suitable existing communication circuit; and which is simplified so as to be operable successfully by comparatively untrained personnel.

A still further object of our invention is to provide means for the operation of a facsimile system under the conditions specified by the Federal Communications Commission; and to provide means for facsimile transmission over a voice frequency circuit in such a manner as to be non-interfering to other circuits associated therewith.

Other objects of our invention will be set forth in the appended specification, in which, and in the annexed drawings, certain forms of our invention have been set forth by way of example and for the purpose of explaining the same.

A system of facsimile transmission embodying the principles of our invention is in commercial use. The invention will therefore be described with reference to this system, which consists of

the photographic reproduction of photographs or other similar matter. Our invention resides primarily in the terminal equipment employed, and not in the communication channels involved. Any suitable wire circuit, or any suitable radio circuit may be utilized for the purpose of carrying this invention into effect. In the commercial form referred to above, standard commercial telephone channels are employed for the transmission of photographs.

One feature of our invention is directed to the method of coupling utilized between the facsimile apparatus and the telephone circuit; this coupling is of such a nature as to comply with the rulings of the Federal Communications Commission, and it is to be understood that the use of this coupling is not a limitation on the scope of the invention, as the other parts thereof may readily be utilized with other coupling means than those designated to comply with the regulations aforesaid.

In order to scan the original subject to be transmitted, we may make use of a rotating drum or cylinder; associated with which is a mechanism giving a relative lateral movement between the drum and the scanning apparatus. This relative movement may conveniently be effected by means of a lead screw suitably operated to give the desired helical travel of a scanning spot over the surface of the subject to be transmitted. While various novel devices are described herein with special reference to the sending and receiving mechanisms, it is to be understood that there is no limitation in the invention implied by the use of the drum method of scansion. The same principles may be employed with flat-bed, spiral, side-to-side or any other method of scansion which it may be desired to employ.

According to the form of our invention herein described, the original subject to be transmitted is placed in the transmitting machine and wrapped around the drum. Suitable clips hold this original subject firmly on the surface of the drum. Light from a suitable source is focused to a spot on the surface of this original subject, which may be a picture, photograph or other material to be transmitted. The light is reflected therefrom to a photo-electric cell, and by means of this cell the lights and shades of the original subject are translated into electrical impulses.

For transmission over a telephone line or a similar communication channel, a signal is required which is alternating in character. The

signal may be of a constant frequency varied with respect to amplitude; or a constant amplitude varied with respect to frequency; or a combination of the two. The signal may also be of the timed impulse type wherein the duration of each impulse or train of impulses is a measure of the tone value of the unit area under scansion at any particular instant.

A number of methods well known in the art may be used to secure a pulsating signal from a photo-electric cell system; these include an alternating or undulating potential on the photo-electric cell; or the control by the photo-electric cell and a modulating system of the output of an alternating current generator of suitable frequency. Alternately, the light source may be alternating in character, or the light path may be interrupted by any suitable means at a point between the light source and the photo-electric cell.

Of these, we have illustrated one, in which light is focused by means of a lens system onto the surface of the original subject to be transmitted; this beam of light is interrupted by an interrupter having the requisite number of holes or slots necessary to produce a series of light impulses on the surface of the photo-electric cell of a frequency suitable for use in the system. As the light, after leaving the interrupter strikes the surface of the original subject to be reproduced before reaching the photo-electric cell, the tone value of each unit area of the original subject serves to control the intensity of the unit light impulse striking the photo-electric cell.

The pulsating electric current from the photo-electric cell is translated into alternating current by the action of the first transformer in the circuit, in accordance with well known principles. This alternating current may then be amplified, and the amplification may be carried out by means of conventional thermionic tube amplifiers, or by any other suitable means of amplification. After amplification, the signal from the photo-electric cell may be mixed with a starting and synchronizing signal; and these signals are applied through a coupling device to the telephone line, after further amplification if desired.

At the receiving station, there is provided a similar drum and lead screw arrangement to that at the sending station. The drum or cylinder may be contained in a light-tight housing, and has mounted thereon a film having a photo-graphically sensitized surface. A beam of light is arranged so as to fall on this film, and the relative movements of the said beam and the film surface are so arranged as to be identical, complementary, or proportional to the relative movements of the scanning beam and original subject at the transmitting station.

In order that the individual unit areas of the original shall be correctly located in spatial relationship to each other on the received facsimile, it is necessary with this system for the transmitting and receiving cylinders to run in synchronism. Also, in order that the junction of the original subject on the transmitting cylinder shall correspond with the junction of the photographic surface on the receiving cylinder, it is necessary that the two cylinders shall be in phase with each other.

Our invention provides a method of transmitting phasing and synchronizing signals from the transmitting station to the receiving station in

order to achieve the above results. In the form of the invention illustrated, the phasing is accomplished by the first impulse of the synchronizing signal; this impulse being released to the line automatically at a suitable point to insure the correct phase relationship between the transmitting and receiving cylinders. Our invention is not limited to the use of the particular synchronizing system here shown.

For driving the receiving cylinder and the receiving lead screw, small synchronous motors are used. The power to drive these motors is provided from an amplifier operated by signals received from the transmitting station over the communication channel.

Due to the transmission limitations of an ordinary telephone line, and of many of the communication channels available for the purpose of facsimile transmission, we do not attempt to secure a flat frequency transmission characteristic for the whole band of frequencies involved. Our equipment is peaked to secure the maximum response at the particular frequencies which we utilize. Further, due to the low frequency cut-off of the majority of telephone and other communication channels, we prefer to send a composite synchronizing signal from the transmitting station located in a band of frequencies which is efficiently transmitted by the communication channel to be used, and utilize a component of this composite signal for the driving of the synchronous motors at the receiving end.

For example, where we use 60 cycle synchronous motors, we prefer not to send a 60 cycle signal over the line, as the line characteristics at this frequency are extremely unfavorable. We therefore combine two higher frequencies, both of which will be transmitted satisfactorily over the circuit, in such a manner as to provide a 60 cycle beat at the receiving station. By use of a suitable network, this beat signal is separated from the two component frequencies and used to drive the motors. In practice, we have found the frequencies 540 and 600 cycles to be suitable for transmitting the 60 cycle beat note to the receiver.

Therefore, at the transmitter, we may provide two generators driven in conjunction with the sending cylinder, one generating a frequency of 540 cycles and the other generating a frequency of 600 cycles. A special relay circuit described below may be utilized to keep these synchronizing frequencies off the line until a desired phase relationship exists between the revolving transmitting cylinder and the stationary receiving cylinder. When this condition occurs, the first synchronizing impulse is sent to the receiving station and the receiving cylinder comes up to speed in correct phase relationship with the transmitting cylinder.

The signal is applied to the telephone line at the transmitter by the coupling device. The telephone circuit, being an ordinary commercial circuit and passing through the ordinary repeaters and other apparatus, transmits the said signal to the receiving point or points; here another coupling coil picks up the signal and applies it to the input of a pre-amplifier. After preliminary stages of amplification, networks in the form of electric wave filters separate the picture and synchronizing signals into their respective channels; and after further amplification if required, these two signals are applied to the receiving mechanism to perform their respective functions.

The picture signals, consisting of constant frequency varying amplitude signals as originated in the photo-electric cell at the transmitting station, are applied to a galvanometer unit or light valve by means of which they are caused to control the intensity of a beam of light in such a manner as to regulate the exposure on a photographic surface on the receiving cylinder. In this particular arrangement, shown here by way of example, these picture signals vary the intensity of a beam of light from a source of constant intensity; they may however be utilized to control the intensity of the source, as for example in the case of a gaseous discharge lamp.

The interrupter disc may be driven by a constant speed motor, which may be a motor whose speed is adjusted to be sufficiently constant for the purposes required, or may be a synchronous motor driven from the same source as the motor rotating the cylinder. A definite relationship may be established between the speed of the interrupter disc and the speed of the cylinder, so that the light pulses passing through the interrupter disc fall upon the original subject in such a manner as to divide this surface into a series of unit areas; this implies that there is a fixed relationship between the rotational spacing of the spot hit by each succeeding pulse and the lateral spacing between adjacent turns of the scanning helix. In practice we have found that there are certain wide limitations within which this relationship can best be established.

As the interrupter frequency is also the scanning frequency, the changes which occur in the scansion of a single area have a definite value in the reproduction of the facsimile; and according to our invention, a function of these changes is incorporated in the transmitted signal, and is reproduced by the special arrangement which we may employ of the galvanometer unit or light valve. A full wave galvanometer unit is employed in the reproduction of the facsimile, so that each complete cycle of the alternating current transmitted from the sending station is represented by two exposures on the photographic surface in building up the facsimile reproduction at the receiving station.

It can readily be seen that our invention results in a far higher transmission speed for the same photographic efficiency; in the first place, the conventional relationship between carrier and modulation frequency is eliminated; and in the second place, the full signal wave is recorded on the photographic surface at the receiving station to provide a greater resolution of the received picture.

Apart from the combination of photo-electric cell and high fidelity transformer and filter at the transmitting station, the above result is secured by means of a special mask or aperture in the receiving unit. The preferred form of receiving unit may consist of a galvanometer, responsive to the interrupter frequency. The signal applied to the galvanometer unit is alternating in character, not pulsating as is common practice with other systems; and this alternating signal swings the reflected beam of light to either transparent side of a central opaque portion of a light aperture. The two sides of the aperture may be identical, similar, or of a variant shape.

It is of importance to note that the function performed by the galvanometer unit or light valve when used in accordance with our invention, differs from the function normally performed by such a mechanism in the same way as a Class B

amplifier differs from a Class A amplifier in radio service; and this difference is also borne out by the relative efficiency of the two methods of galvanometer unit or light valve operation—the Class B method of galvanometer unit operation according to our invention being more efficient than the conventional envelope frequency method.

In commercial practice we have used an interrupter giving a frequency of light impulses of approximately 1800 per second; as previously explained, this gives a picture signal of a frequency of 1800 cycles per second. This frequency is sufficiently separated in the frequency spectrum from the other frequencies employed to allow for adequate filtering to segregate the synchronizing frequencies and the picture signal frequency at the receiving station.

The two synchronizing frequencies, after being segregated by a band pass filter or by other suitable means, are passed through a filter or tuned circuit which may have the form of a low pass filter of the constant-k or m-derived type. This filter is arranged to pass the beat frequency, and to reject either of the two component frequencies. The result is that the envelope of these two frequencies, or in other words the beat frequency only, is passed through the low pass filter; and, after amplification, this beat frequency may be utilized as driving power for the motor or motors on the receiver.

In the modification of the apparatus illustrated and described herein, two separate motors are provided in the receiving mechanism. One of these motors drives the receiving drum, and the other motor is geared to the lead screw mechanism for controlling the lateral relative motion of the drum and galvanometer unit. As an alternative to this method of driving both motors under the control of the received signal, we have found that sufficient accuracy of reproduction may be secured by driving the cylinder motor from the received signal, and by driving the lead screw motor from the local power supply.

As an alternative to providing the complete power for driving the receiving motors from the amplified synchronizing signal, this signal may be utilized to control the speed of a motor or motors whose main source of rotational power is provided from some other source of energy; the synchronizing signals then provide only the power necessary to regulate the speed instead of the total power required.

In conjunction with the photo-electric cell and its amplifier in the transmitter, we employ a network which acts as an electric wave filter selective to the scanning frequency. We have found that the use of such a wave filter increases the faithfulness of reproduction of a facsimile due to the elimination from the circuit of spurious signals, of frequencies other than the scanning frequency, introduced by the relative travel of the transmitting cylinder while the original subject thereon is exposed to a light impulse. Intensity changes which occur within the duration of one light impulse are handled by means of the electrical system; other changes which represent a derivative of the picture are suppressed in order to secure faithful reproduction at the receiving station. The effect of this derivative phenomenon is a complex function of the interrupter frequency, the tone difference, the linear speed, and the capacitive effect of the photo-electric cell itself. In order to minimize the effect of spurious frequencies, we have found it advisable to insert a network

whose function is that of a low pass filter, cutting off slightly above the upper of the two generator frequencies, in the circuit of the generators at the transmitting end. This filter network tends to reduce harmonic distortion in the output of the generators themselves, and therefore to reduce distortion in the whole synchronizing system.

The generators described in this application are of a type particularly suited to this work. It is however possible to replace these generators with others of several well known types without departing from the spirit of the invention. The type of generators which we have produced comprise a permanent magnet with adjustable pole pieces, around which pole pieces are located pick-up coils of a suitable impedance. Between the pole pieces passes the toothed edge of an iron disc; the shape of the tooth may be of an involute form. In the mechanical construction of the generators, arrangements are made for the movement of the pole pieces towards and away from the center of the shaft, whereby a suitable spot can be obtained for the production of approximately a pure sine wave. The pole pieces are provided with a screw mechanism whereby they can be drawn towards each other or separated, therefore changing the gap between pole pieces and the generator disc to allow for adjustment of the apparatus to the required output.

As the receiver motors are driven by the amplified signal from the transmitter, it can be seen that their speed is controlled directly by the speed of the transmitter motor; as this latter drives the generators which produce the synchronizing signal. For example, where the transmitter motor is a synchronous motor running at 1800 R. P. M. and by mechanical coupling generating frequencies of 540 and 600 cycles, the beat frequency which drives the receiver motor is 60 cycles giving a normal speed of 1800 R. P. M.; should the speed of the transmitter motor drop to 1770 R. P. M., the 540 cycle frequency will drop to 531 cycles, and the 600 cycle frequency will drop to 590 cycles; the beat between these two frequencies is 59 cycles, which will give a speed of 1770 R. P. M. to the receiving motors. This speed is the same as the speed of the transmitting motor, and therefore transmitter and receiver will continue to run in synchronism; moreover, changes in speed of the transmitter will be compensated by corresponding changes of the receiver motors, due to the above described mathematical relationship of the frequencies and the direct coupling of the generators to the transmitter motor.

The transfer of energy to the telephone line is readily accomplished by making use of the induction coil provided in the telephone box. This induction coil is wired into the circuit of the telephone instrument, and also of the telephone line to the exchange; so that by inducing a current or currents into the induction coil, a transfer of energy takes place which employs the signals from the telephone circuits. In the case of the transmitter, the coupling coil becomes the primary of a transformer whose secondary is the telephone induction coil; in the case of the receiver, the coupling coil is the secondary of a transformer whose primary is the telephone induction coil.

The coupling transfer coil may comprise an air core coil, or it may comprise a coil having a laminated core and a winding thereon. The location of the coil with reference to the telephone bell box depends upon the type of bell box employed; adjustment for this feature is however very readily made by a process of exploration whereby the

optimum coupling is readily determined. As previously mentioned, in a preferred embodiment of our invention the coupling transfer coil is tuned to be responsive to the particular frequencies which we desire to transmit. This tuning is carried out in conjunction with the telephone induction coil which forms the secondary of the transformer so as to secure a peaked response in the telephone line from the signals from the transmitter.

In practice a number of different types of bell boxes are encountered; and the optimum position for coupling has been known to vary with different types of bell boxes. One particular type, which is a standard type used by the American Telephone & Telegraph Company, is herein shown with the coupling coils arranged in a suitable position for inducing signals into the line and for picking up signals from the line. It is not essential that the coupling be through the induction coil in the telephone bell box: we have achieved suitable results by placing a coupling coil in an electromagnetic relationship with the receiver coils of the telephone receiver; and we have carried out experiments showing that there are other arrangements possible.

In the accompanying drawings, certain modifications of the apparatus are illustrated; the particular form or forms of the invention here described do not however form a limitation of the scope of the invention to the particular apparatus herein shown in the drawings, in which:

Fig. 1 shows a diagrammatic layout of a sending station.

Fig. 2 shows a diagrammatic layout of a receiving station.

Fig. 3 shows an arrangement of parts of a sending unit.

Fig. 4 shows a plan view of a lead screw and associated mechanism for lateral travel.

Fig. 5 is an elevation of apparatus shown in Fig. 4.

Fig. 6 is an end view of apparatus shown in Figs. 4 and 5.

Fig. 7 shows a skeletonized view of a galvanometer unit.

Fig. 8 shows one of the masks used in a galvanometer unit.

Fig. 9 shows another of the masks used in a galvanometer unit.

Fig. 10 illustrates a wave form of a picture signal.

Fig. 11 illustrates a wave form of one phonic generator.

Fig. 12 illustrates a wave form of another phonic generator.

Fig. 13 illustrates a wave form of the combination synchronizing signal from two phonic generators.

Fig. 14 shows a skeletonized view of a receiving box.

Fig. 15 shows an elevation of an interrupter disc.

Fig. 16 shows an enlarged portion of a received photographic surface.

Fig. 17 shows one arrangement of coupling coils.

Fig. 18 shows a schematic circuit of coupling coils shown in Fig. 17.

Fig. 19 shows a layout of a complete facsimile system.

Fig. 20 shows a section of cylinder holding mechanism.

Fig. 21 shows an elevation of one end of a cylinder and associated holding mechanism.

Fig. 22 shows a method by which the cylinder holding mechanism may be operated.

Fig. 23 shows an arrangement for a receiving coupling coil.

5 Fig. 24 shows an arrangement for transmitter and receiver coupling coils in relation to a telephone bell box.

Fig. 25 shows a plan view of one of the phonic generators.

10 Fig. 26 shows a side elevation of Fig. 25.

Fig. 27 shows in chart form a suitable arrangement of bands of frequencies which may be employed.

15 Fig. 28 shows a type of overall transmission characteristic for the system.

Fig. 29 shows certain filter network characteristics.

Fig. 30 shows other filter characteristics.

20 Fig. 31 shows an arrangement of a receiver starting mechanism.

Fig. 32 shows a circuit and arrangement of a transmitter starting impulse mechanism.

Fig. 33 shows an arrangement of a light-tight cover on a receiving machine.

25 Fig. 34 shows a portable receiving box and mount.

Fig. 35 shows a schematic circuit of one arrangement of apparatus.

Fig. 36 shows one type of photo-electric cell.

30 Fig. 37 shows an arrangement of transmitting and receiving mechanism at a single station.

Fig. 38 shows a drive for an interrupter.

Fig. 39 shows a hinged block for control of lateral travel.

35 Fig. 40 shows a side elevation of Fig. 39.

In Figure 1, an original subject to be transmitted 1 is wrapped around the sending drum 2, and held in position by suitable clamps 134 and 135. A light source 4 is contained in a lamp housing 5, which may be provided with a spherical mirror 6. An interrupter disc 7 chops the light beam at a predetermined frequency; this interrupter 7 may be driven by a motor 8 and mounted on the plate 9, which is adapted to travel in a lateral direction under the influence of the lead screw 10 which is driven by the gear 11.

40 The cylinder 2 rotates on its axis under the control of the gear 12. Both the gears 11 and 12 are driven by the transverse shaft 14 through the gear 15 on the shaft 16 of the motor 17.

50 The shaft 16 carries, in addition to the gear 15, the phonic wheels 18 and 20. Associated with the phonic wheel 18 is the generator 19, and associated with the phonic wheel 20 is the generator 21. By means of a segmented construction of the wheels 18 and 20, alternating currents of desired frequencies are generated in the coils of the magnetic generators 19 and 21.

60 As has been previously mentioned, other arrangements than that shown for the gears 15, 12, and 11 may be employed. Individual synchronous motors may be used to drive each of the units of the transmitter; or the drives may be combined in any suitable mechanical combination to be driven by one or more motors.

70 One of the leads from the phonic generators is passed to the relay 22, and thence together with the other lead from the generators 19 and 21, to the electric wave filter 24. This electric wave filter may be provided with a volume control 25, and it performs the function of removing spurious harmonics and other undesired characteristics from the output of the phonic wheel generators.

In one form of the apparatus, the motor 17 is 75 a synchronous motor revolving at 1800 R. P. M.

The phonic wheel 18 has eighteen segments, and the phonic wheel 20 has twenty segments. Thus the generator 19 generates a current at a frequency of 540 cycles per second, and the generator 21 produces a frequency of 600 cycles per second. It is to be noted that the beat frequency between these two generator frequencies is 60 cycles per second. The network in the filter 24 may be in the form of a low pass filter, cutting off just above 600 cycles per second.

80 Figures 25 and 26 show a plan and elevation of a generator 19 and segmented wheel 18. The generator 19 may be provided with an outer casing 100 and a permanent magnet 101, which may be provided with pole pieces 102. These pole pieces carry screws 104, and mounted thereon are coils 105. A wheel 18 revolves so that its teeth pass between the ends of screws 104. Due to the segmented nature of the wheel 18, a pulsating electro-magnetic flux is set up by the magnet 101 through pole pieces 102, screws 104, and the teeth of the wheel 18. This pulsating magnetic flux causes the generation of a corresponding current in the coils 105. The wave shape of this current is dependent upon the shape of the teeth of the wheel 18 and the adjustment of screws 104 relative thereto.

90 Figure 12 shows a wave shape of a signal from the generator 19; Figure 11 a shape of a signal from the generator 21. It will be noted by comparison of Figures 11 and 12 that the former is of a slightly higher frequency. After combination of the outputs of the two generators, a resultant wave shape of the type shown in Figure 13 is produced. This is a beat frequency, which is the envelope frequency of Figure 13, and which is the desired synchronizing signal which is in this manner to be transmitted to a receiving station, and in the example here given is 60 cycles per second.

100 The relay 22 is operated through a switch 29 by means of a cam 26 and contact 27. An arrangement of the circuit for this is shown in Figure 32; wherein a cam 26 and associated rider 27 coact to close the contact 106. The relay 22 is provided with a coil 110 and contacts 107 and 109. In conjunction with the battery 108, a switch 29 and contacts 106 and 107 are so arranged that on the closing of the switch 29 the next make of the contact 106 will energize the coil 110 by means of the battery 108. By the consequent movement of the armature of the relay, the contact 107 is closed and short circuits the contact 106; thus the coil 110 is continually energized from the battery 108 until the switch 29 is manually opened. The energizing of the coil 110 also causes the relay armature to close the contacts 109 and thereby completes the circuit from the generators 19 and 21 through the leads 23.

110 Thus the train of synchronizing impulses is sent out through the amplifier to the line after the closing of the switch 29 under the control of the relay 22, at a predetermined position in the cylinder revolution which may conveniently be the moment at which the junction of the original subject passes in front of the light beam; and as previously described this first impulse of the synchronizing signal serves to start the receiving cylinder in its rotation in correct phase relationship with the rotation of the transmitting cylinder. The output of the filter network 24 is passed to the transmitter amplifier by means of the leads 28.

115 The beam of light from the lamp 4 strikes the 7x

surface of the original subject 1 at a point 30. The light is reflected from the surface at this point, and intercepted by the photoelectric cell 31, which may conveniently be in the form of a cell with a hole for the passage of the light beam therethrough. As previously described, the interrupter 7 breaks up the light into impulses, producing a succession of electrical pulses in the circuit of the photo-electric cell 31, each electrical pulse being proportional to the tone value of a corresponding elemental area of the original subject 1 under scansion at the point 30. From the photo-electric cell 31 the leads 32 carry these pulses to the amplifier 34, which may be provided with a volume control 35, which may be used to regulate manually the level of the picture signal. The amplifier 34 converts the pulses from the cell 31 into an alternating current signal, as previously described, and amplifies this signal to the desired level.

A typical wave form of the picture signal as generated in the photo-electric cell 31 and passed through the amplifiers is illustrated in Figure 10. It will be seen that the wave of Figure 10 consists of a single frequency whose amplitude is varied in accordance with the lights and shades of elemental areas of the picture or subject to be transmitted; the heights of the waves in this figure being proportional to the tone values, and each wave corresponding to an individual unit area of the subject under scansion.

The interrupter disc 7 has, in one machine built according to this invention, 60 openings through which the light may pass. The motor 8 may be a synchronous motor revolving at 1800 R. P. M.; therefore the output of the amplifier 34 is a frequency of 1800 cycles per second, varying in amplitude in accordance with the tone values of successive elemental areas of the original subject.

The amplifier 34 is connected by the leads 37 to the filter 36; this filter whose function has been previously described may comprise a high pass network; the cut off point of which may lie below the frequency generated by the interrupter disc. The purpose of the network is to remove from the output circuit the signal components which represent the rate of change of the output of the photo-electric cell due to the rotational relationship between the light beam and the picture 1 mounted on the cylinder.

This filter network 36 may be of the same type as a filter network later referred to in the description of the receiving electrical system. In the particular apparatus we use, the network consists of two T sections in series, having three condensers in series in the upper arm and two inductances in multiple across the two arms.

A power amplifier 38, which may be of any conventional type of power amplifier having the required input and output characteristics, may be provided to further amplify the picture signals and also to amplify the synchronizing signals if desired. This power amplifier 38 is connected to the filter network 36 by the leads 39, and also to the filter network 24 in the synchronizing circuit by the leads 23. A number of methods of mixing these two signals may be employed, but in the practical equipment which we use we have provided a series circuit for the mixing of these two signals.

The power amplifier 38 is, in this illustration, connected to the coil 41 whereby energy is transferred to the induction coil in the telephone box 42, and thence to the line 44. The telephone

instrument is indicated at 43; this instrument performs no useful function in connection with the transfer of energy or the transmission of the picture, except that, if no cut-off switch is provided, it is advisable to cover the mouthpiece of the instrument to prevent the pick-up of extraneous noises which might be superimposed on the telephone circuit. Also, the telephone instrument should be removed from its hook for the purpose of completing the circuit to the exchange. The power amplifier may be provided with a volume indicator 40 whereby the energy applied to the coil 41 may be measured in order to determine that the correct level is being sent out.

In cases in which the regulations requiring that the connection to the telephone line be without physical contact are waived, it is to be understood that the coupling coil 41 may be dispensed with and the output of the amplifier 38 coupled in any other suitable manner to the telephone line 44. For example, should a repeat coil be used for this purpose, the line 44 will be connected to the secondary of this repeat coil and the amplifier 38 to the primary. In this case, the output of the amplifier may be reduced in proportion to the increased efficiency of the repeat coil over that of the transfer coil 41 and the induction coil in the box 42.

Thus the signal, consisting of both picture signal and synchronizing signal, is transferred from the sending machine to the telephone circuits indicated as starting with the telephone line 44. From this point, the signals pass through the regular telephone equipment of exchanges, networks, repeaters, etc., to the receiving station.

A layout of the system, showing both transmitting and receiving stations connected by a line through the telephone exchanges, is illustrated in Figure 19.

Figure 2 illustrates one form of receiving apparatus which may be employed according to our invention. In this figure, the signals are received over the telephone line 44a, associated with which is the telephone box 42a and the telephone instrument 43a. The telephone signals pass through the induction coil within the box 42a, and the pick-up coil 46 is located adjacent to said box in such a manner as to form the secondary of a transformer of which the induction coil is the primary. Thus the signals from the line 44a induce a magnetic field around the induction coil, whose lines of force cut the pick-up coil 46 in such a way as to induce a corresponding current in the coil 46 and the circuits associated therewith.

The coil 46 is connected by the leads 47 to the amplifier 48, which is conveniently provided with a volume control 49 for the purpose of controlling the system. This control may be employed in view of the difference encountered in practice in telephone circuits of different characteristics.

The amplifier 48 is connected to the filter networks 50 and 51. These networks may be provided with volume controls 50a and 51a for the purpose of balancing the level of the two sets of signals. It has been found in practice that different telephone lines sometimes have different frequency characteristics; so that different degrees of attenuation are experienced in the picture and synchronizing signals. This difference is compensated for by the balance achieved by the two volume controls 50a and 51a; although in practice one of these controls may be elimi-

nated and the other may be set at some mid-position for most usual transmissions.

The filter network 50 is of conventional design, and serves to pass the band of frequencies occupied by the picture signal. Since only a single frequency is employed for the transmission of the picture signals, this filter may be one having a narrow range. In practice however, due to variations of the interrupter disc motor 8, and due to frequency changes which occur in the transmission of the signal over a standard telephone circuit, and other causes, we find it desirable to have a network which passes a band of frequencies at this point.

In certain installations, we have found it advantageous to divide up the work performed by this network 50; and under these conditions an additional network 50b is provided in the circuit 47 between the pick-up coil 46 and the amplifier 48. Under these circumstances, the network 50b is arranged as a low pass filter network to cut off signals above the wanted range; and the network 50 is a high pass filter passing signals above the range of the synchronizing signal. This latter arrangement is illustrated in the accompanying drawings.

The network 50b finds its best application under circumstances where the receiver is installed in a location which is electrically noisy. For example, in a number of locations high frequency transients are picked up by the telephone line 44a from local sources, or are picked up at some intermediate point and relayed to the line 44a; and the filter 50b serves to remove the components of these transients which are deleterious to the picture.

One half of the filter 51 may conveniently consist of a band pass filter which passes the frequencies generated by the phonic generators at the transmitter for the synchronizing signal. The second half of the filter 51 may consist of a filter or tuned circuit to pass only the beat frequency of these two generator frequencies.

In this manner, the first section of the filter 51 removes from the incoming signal all frequencies except the comparatively narrow band utilized by the two synchronizing frequencies; and the second half of the filter 51 removes both of these two synchronizing frequencies and passes out only the resultant beat frequency, which is the frequency, which as previously described, it is desired to pass to the motors of the receiver.

It is to be noted that by this arrangement of the generators and the filter networks 51 a frequency suitable for running the receiving motors is passed from the transmitter to the output of the filter 51 without at any time having existed as an individual frequency prior to reaching the output of the filter 51. In other words, the electrical arrangement we have described performs a function which would otherwise be carried out by an elaborate system of modulation and demodulation. Our device as is here described may be replaced by a system of modulation and demodulation, and in practice this has been done; the circuit we have described is however a preferred form as we have found that the results achieved are superior to those of modulation and demodulation.

The output of the filter 50 is connected to the amplifier 52, which may be of any convenient form suitable to raise the level of the signal to the desired operating level. In order to check operation, this amplifier 52 may be provided with a volume indicator 54. The output of the ampli-

fier 52 is carried by the leads 57 to the galvanometer unit or light valve 59. A more detailed description of one form of this galvanometer unit which we have found suitable for operation in accordance with our invention is illustrated in Figure 7 and described below.

The galvanometer unit 59 converts the electrical impulses carried to it from the amplifier 52 through the leads 57 into variations of the intensity of a spot of light. This spot is projected onto the surface of the cylinder 1a, which is adapted to receive a light sensitive photographic material. The cylinder 1a is enclosed in a light-tight box or cover 60, which has an opening to allow the beam of light from the galvanometer unit 59 to strike the surface of the film on the cylinder 1a. An arrangement for effecting this is shown in Figure 14.

The apparatus may also be provided with a second light-tight cover 61. Both these covers may be dispensed with if the machine is operated in a dark room, but when daylight operation is desired, as is frequently the case, light-tight covers are provided. In the commercial form of the apparatus which we employ, the box consisting of the cylinder 1a and light-tight cover 60 is removable from the machine; the cover 61 prevents extraneous light from entering through the opening in the cover 60 when this opening is so arranged as to pass the light from the unit 59. Automatic means for controlling the opening of the shutter in the cover 60 are described in connection with Figure 14, and an arrangement of the outer cover is shown in Figure 33.

The galvanometer unit 59 is mounted on the slide 9a. This slide has a lateral travel similar to that of the slide 9 at the transmitter. Details of the slide mechanism, and the method in which the slide 9a travels under the influence of the lead screw 10a are given in connection with Figures 4, 5, and 6.

The picture signals, originating in the photoelectric cell at the transmitter, are thus passed through the system and filter networks into the galvanometer unit and there control the exposure of the photographic film. The second half of the requirement for successful facsimile transmission lies in the correct placing of the individual unit areas in spatial relationship on the receiving surface. This may be accomplished by means of the synchronizing signals sent out from the transmitter.

These synchronizing signals, as above described, reach the filter 51; and the output of the filter 51 is a signal whose frequency is a function of the speed of rotation of the transmitter. This signal is fed into the amplifier 55, which may conveniently be supplied with a volume indicator 56 as a means of observing operating conditions. The amplifier 55 may be of any suitable type which will supply the requisite output level for the operation of the synchronizing motors. From the amplifier 55, the leads 58 carry the amplified signal to the motors 64 and 65, and also to the coil 66. These motors 64 and 65 may conveniently be synchronous motors adapted to run at the frequency of the beat note of the two generators 19 and 21 of the transmitter. Due to their design, the motors 64 and 65 will run at a synchronous speed which is a function of that of the motor 17 on the transmitter, and will faithfully follow any variations in speed in the motor 17.

The motor 64 is adapted to turn the lead screw 10a, and hence to control the lateral

travel of the slide 5a carrying thereon the galvanometer unit 59. The motor 65 is adapted to rotate the cylinder 1a, and the gearing between the motor 65 and the cylinder 1a bears the same relationship as that between the motor 17 and the cylinder 2 does to their respective synchronous speeds; that is, if both the motors 65 and 17 run at the same speed, the gear ratio between the motor 65 and the cylinder 1a will be identical with that between the motor 17 and the cylinder 2. It is thus seen that the two motors 64 and 65, by controlling the rotation of the cylinder 1a and the lateral travel of the unit 59 in exact corresponding relationship to the rotation of the cylinder 2 and the lateral travel of the light spot 30, fulfil the second half of the above mentioned requirement, in that they produce corresponding spatial relationship of the unit areas of the facsimile as compared to the original subject to be transmitted.

In connection with Figure 1, the contacts 26 and 27 and the relay 22 have been described as a means for sending the synchronizing signals out to the line in such a way as to insure correct phasing relationship of the transmitting and receiving cylinders. We find it advantageous to have a mechanism on the receiving cylinder to coact with that at the transmitting station in order to compensate for the effect produced by certain line conditions encountered in practice. These line conditions may have a tendency to vary the amplitude of the first pulse received from the synchronizing signals, and hence to vary the pull-in time of the motors 64 and 65. A variation of the pull-in time of the motor 64 is not of importance. Under certain circumstances we have found it entirely possible to run the motor 64 from a source of local power without introducing objectionable distortion into the received facsimile. The pull-in time of the motor 65 however, without the additional equipment below referred to, has an effect on the phasing of the two cylinders. To overcome this objection, we have therefore installed the trip device and relay 66.

As above mentioned, the coil of the relay 66 is connected by means of the lead 58 in parallel with the motors 64 and 65 to the output of the amplifier 55. The relay is provided with an armature 71, latch 69, and contact 70. The circuit of the coil 66 is so arranged in conjunction with the contact 70 and armature 71 that when the relay is energized by the first pulse of the incoming synchronizing signal, the armature 71 is drawn away from the contact 70 and the circuit of the coil 66 is thereby opened. The latch 69 prevents the armature 71 from again making contact at 70 until the relay is manually reset. At the same time as the armature 71 is drawn away from the contact 70, the latch 68 is drawn from contact with the flywheel 67 on the shaft of the cylinder 1a; thus allowing the cylinder 1a to rotate under the influence of the motor 65. As shown in Figure 31, the latch 68 and the latch 69 may be mechanically combined into one piece of mechanism.

The coil 66 of this relay is so designed as to operate on a given integrated current, and in this manner the mechanism serves to regulate the starting of the rotation of the cylinder 1a to a definite time value in regard to the starting synchronizing impulse. It will be noted that the circuit through the coil 66 is opened at the contact 70 as soon as the rotation of the cylinder 1a commences; by this arrangement the load of

the relay coil is removed from the synchronizing circuit and the full power output of the amplifier 55 is applied to the motors 64 and 65.

A suitable form of this trip mechanism and relay is shown in Figure 31. In this arrangement, the latch 69 and the latch 68 are arranged at opposite ends of the same movable member 111 which is pivoted at the point 112; and the contact referred to in reference to Figure 2 as between the armature 71 and contact 70 is in this arrangement made between contact 70 and the contact 116 carried on the arm 111. The projection 69 on the arm 111 is arranged to cooperate with the armature 71 in such a way that the armature 71 can only be in its left-hand position when the arm 111 is in its clockwise position. The left-hand position of the armature 71 and clockwise position of the arm 111 are shown dotted. With the arm 111 in this position, the latch 68 engages a slot 114 in the flywheel 67 of the receiving cylinder and the circuit between the contact 70 and the contact 116 is closed.

The operation of the mechanism shown in Figure 31 is as follows. Upon energization of the coil 66, the armature 71 is drawn from its left-hand position; thus from the dotted position to the full line position. When it completes its travel, the end of the armature 71 passes to the right of the latch 69, and, under the influence of the spring 117, the arm 111 is rotated in a counter-clockwise direction around the pin 112 until the arm 111 abuts the end of the armature 71. When this arm 111 reaches the limit of its travel, the contact between 116 and 70 is opened, the latch 68 is disengaged from the slot 114, and the latch 69 abuts the end of the armature 71, so that the mechanism can not return to its preoperated or left-hand position until the arm 111 is manually reset to allow the armature 71 to clear the latch 69. It will be seen that this mechanical locking arrangement keeps the latches in their operated position in spite of the breaking of the current through the coil 66 due to the opening of the contacts 116 and 70.

The slot 114 in the flywheel 67 may be located at a definite angular position with respect to the junction of the film on cylinder 1a, so that when the motor 65 reaches its synchronous speed the said junction on cylinder 1a will pass in front of a beam of light from the galvanometer unit 59 at the same instant as the junction of the original 1 on the cylinder 2 passes before the scanning spot 30. This angle has been determined empirically to be about 105 degrees of clock-wise rotation, and may be found to vary slightly with each installation as it is a function of individual motor performance.

Figure 19 illustrates elements of the apparatus previously described with reference to Figures 1 and 2. In Figure 19 the amplifiers and filters 34, 36, 24, 38 at the transmitter are shown diagrammatically mounted in panel form with a power supply unit P on a standard relay rack. Similarly the receiving amplifiers and filters 48, 50, 51, 52, 55 are shown mounted on a rack with a power supply Pa.

The telephone line 44 is shown connected to the telephone exchange 119, whence the circuits 120 lead to the receiving telephone exchange 119a. The circuit 120 may be of any suitable form, and may comprise repeater stations, carrier and phantom circuits, cable, open wire lines, and radio links, etc. In this circuit may also be included balancing networks, equalizers, and such other apparatus as is required for the correct

transmission of the signals from exchange 119 to exchange 119a. Exchange 119a is connected to the receiving station by the circuit 44a.

Figure 3 illustrates an elevation of the scanning mechanism shown in plan in Figure 1. A light source 4 projects light through the opening of the interrupter disc 7; light is also reflected onto the surface of this disc by the mirror 6. An elevation of one form of the interrupter disc 7 is shown in Figure 15; wherein a plurality of openings 118 are shown arranged towards the outer edge of the disc. These openings are illustrated as slots, because it is preferable that a definite relationship be established between the size of an opening 118 which passes in front of the light beam and the size of the aperture 78. The slotted arrangement of the openings shown in the disc 7 in the Figure 15 allows a control to be exercised of the size of opening passing through the optical beam, by means of a lateral adjustment of the position of the motor 8 on the plate 9 relative to the location of the lamp house 5.

The lateral travel of the plate 9 and scanning mechanism mounted thereon is controlled by means of a lead screw, which is similar to that shown in connection with Figures 4, 5, and 6; except that the lead screw on the transmitter may be driven by gearing 11 from the motor 17 and not by an individual motor as shown in connection with the receiver.

A diaphragm 78 in the path of the light beam adjacent to the lens 74 controls the size of the spot of light 30 on the surface 1. The optical system shown is of a conventional type for this class of work.

An optical system illustrated diagrammatically by the lenses 75 and 74 focus a spot of light at the point 30 on the surface of the original to be transmitted 1 on the drum 2. This light is reflected, and the nonspecular reflection is intercepted by the surface of the photo-electric cell 31. By arranging the photo-electric cell so that it does not pick up specular reflection, glossy as well as mat prints may be used as the original subject matter 1, and thus the arrangement makes it possible to use various kinds of subject matter on the cylinder 2.

Figures 4, 5, and 6 show three views of the slide mechanism. These views relate specifically to the receiving structure, but these are identical with the mechanism used for the transmitting structure with the exception of the method of driving the lead screw as above described, and for the fact that the direction of rotation of the transmitting and receiving lead screws may be reversed with respect to their respective cylinders.

This change in direction of rotation is utilized when a photographic negative of the original subject is being reproduced at the receiving station. If a photographic positive is to be reproduced then the relative directions of rotation of the lead screws with respect to their individual cylinders may be the same. Due to the optical reversal of image on a photographic negative however, the arrangement above mentioned of reversing the direction of relative travel and consequent hand of the scanning spiral is used to secure this optical reversal; and under these circumstances, if both cylinders are rotated in the same direction, and both lead screws have the same hand of thread, the direction of rotation of one lead screw should be opposite to that of the other lead screw.

In Figures 4, 5, and 6, the plate 9a travels in a lateral direction over the base 77a. The slide 9a is provided with grooves 79, and the base 77a with grooves 80. In these grooves, and coacting with them are the balls 76a; these balls provide a means for sliding the plate 9a over the base 77a and for causing its travel to be confined to the desired straight line direction.

In order to prevent the plate 9a from overriding the grooves, we may provide an arm 81, to which is hinged a second arm 82. The two arms are held together by means of a screw 84, and the arm 82 may be provided with a roller 85 which rides on the undersurface of the base 77a. If desired, this roller 85 may be equipped with a rubber bushing to absorb any inequalities in travel; and similarly the screw 84 may be provided with a spring for the same purpose.

The lateral travel of the slide 9a over the base 77a is controlled by means of the lead screw 10a, which is in this illustration driven by the motor 64. The plate 9a may have a hinged block 86 fastened thereto, which bears on its lower surface a knife edge 179 adapted to cooperate with the threads of the lead screw 10a. By means of the knob 87, the block 86 may be raised from 70 contact with the threads of the lead screw 10a to allow the plate 9a to be manually moved into any desired position. By means of this manual movement, the plate 9a may be moved to the correct starting position for the commence-

A suitable type of photo-electric cell which may be used with this equipment is illustrated in Figure 36. This cell is of the type known as a barrier layer cell, and is a self-generating light operated source of electricity. The essential parts of this cell are shown in Figure 36, wherein the light sensitive surface 161 is shown on the plate 169 held in the housing 168 by the spring 162. Leads 32 from the front and back of the cell carry the cell output to the transformer 167 which may be conveniently a part of the amplifier 34, or which may be a repeat coil located at any convenient position. In order to secure the nonspecular reflection above referred to, the cell is mounted over the end of the optical system. In Figure 36, a suitable position of the optical system mounting tube is illustrated at 164.

The interrupter disc 7 is driven at any desired speed by the motor 8; the speed of the disc 7 and the number of openings 118 therein controlling the frequency of the picture signal. A friction drive mechanism which may be used for securing any desired speed of rotation of the interrupter disc 7 is shown in Figure 38, wherein the motor 8 is provided with a friction disc 178 which may be provided with a leather facing 173 if desired, and which, engages a member 177 on the shaft 175 mounted in the bearings 176. The interrupter disc 7 is fastened to the shaft 175, and the speed of the disc is controlled by the relative location of the member 177 with respect to the axis in the motor 8 by adjusting the position of the member 177 on the shaft 175. A set screw may be provided for locking the member 177 in its desired location.

Referring again to Figure 3, the motor 8, and the light housing 5, are mounted upon the base 9. This base 9 is similar in construction to the base 9a described in relation to Figures 4, 5, and 6; the base 9 travels in a direction at right angles to the path of the beam of light on steel

ment of a picture, or the plate 9 can be moved to allow the scansion of any desired spot of the surface 1.

Figures 39 and 40 illustrate a convenient form of mounting which may be used for the block 86 by which the above operations can be carried out. The block 86 may be recessed to take pins 180 mounted in supports 181, said supports being carried upon the plate 9a. The knob 87 may be provided with a shaft 182 passing through the block 86, the end of said shaft 182 being equipped with a flattened portion 184 coacting with the fixed portion 185 fastened to the face of the plate 9a.

The block 86 may be provided with a knife edge projection 179, of such a shape and set at such an angle as to be adapted to engage a lead screw thread when the block is in its lower position. Rotation of the knob 87, and therewith of the shaft 182, causes the portion 184 of the shaft 182 to engage the stop 185 to cause the block 86 to hinge upwardly around the pivots 180; this movement of the block 86 thus withdraws the knife edge 179 from contact with the screw thread of the lead screw, and the plate 9a is free to move in a lateral direction. During the period of engagement of the knife edge 179 with the lead screw, adequate pressure is maintained to secure uniform travel by means of the spring 165, which tends to press the block 86 downwardly, and thus press the knife edge 179 into a groove of the threads of the lead screw 10a.

Figure 7 shows a skeletonized view of the receiving galvanometer unit or light valve 59 mounted upon the plate 9a. In this example, a light source 4a passes a beam of light 88 through the lens 89 and the aperture plate 90. This beam is focused by the lens 91 and the reversing prism 92 onto the surface of the oscillograph mirror 94; and thence through the aperture plate 95 and lens 96 to the surface of the receiving film. The optical system may be so arranged that the aperture plate 95 serves as a diaphragm or stop for the lens 96 and thus serves to control the amount of light passed to this lens; the lens 96, in conjunction with the lens 91, may be adapted to focus the aperture 90 onto the surface of the receiving film.

The mirror 94 may be caused to oscillate in a horizontal plane under the control of the received electric current brought by the leads 57 from the amplifier 52. For each half cycle of the picture signal, this movement of the mirror 94 may cause the beam of light 88 to travel more or less through one or the other of the openings in the aperture plate 95; thus the exposure on the photographic surface takes the form of a succession of images of the opening in the aperture plate 90, the intensity of each exposure being controlled by the angular displacement of the beam 88 under the action of the mirror 94, controlled by the incoming picture signal strength.

As previously described, the aperture plate 95, shown in greater detail in Figure 9, being provided with two apertures 97 and 98, passes illumination through one or the other of these openings for each half cycle of the incoming signal wave. For example, with no signal applied to the oscillograph element, the mirror 94 is stationary and the beam of light is intercepted by the opaque portion between the openings 97 and 98, so that there is no exposure on the photographic film. A positive signal applied to the oscillograph element causes the mirror to pass light through, say, the aperture 97, the amount

of lateral displacement of the beam 88 and therefore the amount of light passed through the opening 97 being governed by the strength of the signal applied to the oscillograph element. Conversely, under similar circumstances, the strength of a negative impulse to the oscillograph element regulates the amount of light passed through the opening 98. Thus with an alternating current signal applied to the oscillograph element, the mirror 94 will oscillate in both directions from its central position, and light will be passed alternately through each of the openings 97 and 98 in the aperture plate 95; and each half cycle of these alternations will be represented on the photographic surface by an exposure corresponding in shape to that of the aperture 90 and corresponding in intensity to the amount of lateral displacement of the beam 88 under the action of the mirror 94, controlled by the signal.

As an alternative to the above arrangement where the beam of light 88 from the mirror 94 is completely obstructed by the opaque portion of the aperture plate 95 between the openings 97 and 98, it may be advisable under certain circumstances to so adjust the system that the spot of light striking this opaque portion is slightly larger than this opaque portion of the aperture plate, so that a very small amount of light is permitted to pass through each of the apertures 97 and 98 under conditions of no signal on the oscillograph element. This may be done to overcome the photographic inertia inherent in all types of photographic film, so that slight variations of signal intensity from the no signal level will be registered on the photographic film after development as variations of intensity.

The opening 99 in the aperture plate 90 may be of any desired shape. This opening 99 controls the size and shape of the unit area exposed on the photographic surface; and due to the movement of this photographic surface during exposure, the shape of the area exposed will be an elongated form of the shape of the opening 99. In Figure 16 is shown an enlarged view of a section of a photographic film which may be produced by an opening in the form of a rhombus. It will be noted that each section of the mosaic of Figure 16 is represented by a hexagonal figure; the length of the two extra sides of the figure being proportional to the relationship between time of exposure and speed of travel of the photographic surface. While Figure 16 represents one form of mosaic pattern, it is to be understood that there are many forms suitable for the reproduction of the facsimile, and that these are controlled in part by the shape of the opening 99 in the aperture plate 90. Each of the areas in the mosaic of Figure 16 will have a tone value corresponding to the tone value of the elemental area under scansion at the transmitter in corresponding spatial relationship.

While we have used and described metallic plates for the aperture plates 90 and 95 provided with openings therein 97, 98, and 99, it is to be understood that these plates may be replaced by any other arrangement which will perform the same function. For example, they may be made of glass with opaque portions painted on the surface thereof, or they may be photographically prepared. Also, in these alternatives, the opaque portions may be of varying density if desired, as for example for softening the edges of the opening 99 and thus rendering the mosaic of Figure 16 less apparent. The term opening as applied in this connection therefore refers to a portion of

the aperture plate which is wholly or partially open to the passage of light.

Figure 14 shows a skeleton view of an arrangement of the galvanometer unit or light valve 59 with respect to the receiving cylinder 1a and its light-tight cover 60. This light-tight cover 60 may be provided with an opening 121 which is normally closed by a shutter 122. This shutter is provided with a rack mechanism 124 adapted to be operated by pinions 125 on the shaft 126. This shaft 126 is partially rotated by the crank 127 by means of the slidable member 128. This slidable member 128 may project from the front of the box 60 and thus be adapted to be operated by the main light-tight cover of the receiving machine. The closing of the main light-tight cover slides the member 128 and operates the crank 127 to lower the shutter 122 and open the slot 121. The opening of the slot 121 allows light from the lens 96 of the optical unit 59 to impinge upon the surface 1a, and the lateral travel of the unit 59 and plate 9a exposes the area of the rotating surface 1a in the form of a helical path. Fogging of the sensitive surface is prevented by the closing of the shutter 122, obstructing the slot 121, automatically on the opening of the main cover and release of the member 128, allowing the shaft 126 to rotate and close the shutter under the influence of the spring 129.

The main cover may be of any suitable form which will render the mechanism light-tight for purpose of daylight operation, when such operation is required. One such form of cover is illustrated in Figure 33, which is an end view of the apparatus showing the location of the plate 9a, the base 77a, the light-tight box 60 and slide 128. In this illustration, the cover 61 is provided with a fixed portion 130 and a hinged portion 131 which closes down over a flange 132 to render the whole mechanism light-tight. The front of the hinged portion 131 may be adapted to strike the slide 128 after the side of part 131 of the cover has passed the flange 132, so that a light seal of the internal mechanism is already in existence when the shutter 122 opens the slot 121 under the action of the slide 128. A handle 133 may be arranged for the convenient opening of the part 131.

The receiving box may be entirely removed from the machine for the purpose of carrying into a dark room for loading and unloading the photographic film. A suitable arrangement of apparatus which allows for this to be effected is illustrated in Figure 34, which shows the complete film box mechanism mounted on supports 159 and 160. On other facsimile machines, which have removable film boxes, difficulty has been experienced in securing a good mechanical joint between the gear drive mechanism and the cylinder; as this mechanical joint is prone to wear with constant usage. For this reason, the mechanism shown in Figure 34 is so arranged that the motor driving the receiving cylinder is an integral part of the removable box. This construction is facilitated by the use of the two separate motors 64 and 65 for performing the two rotational movements required for the receiving mechanism. The necessary electrical connections for driving the motor 65, which motor is shown dotted in Figure 34, may be made by means of the spring contacts 157 and 158; the latter may be fastened to the insulating block 155 and connected to the leads 58.

In this figure, the light-tight cover 60 is illustrated with light trap grooves 156, and the relay

starting mechanism 66 is shown under its cover 154. The whole unit is lifted off the supports 159 and 160 for removal of the portable box; said supports 159 and 160 being provided with locating flanges for the correct location of the portable box with respect to the galvanometer unit 59 and the slide 9a when the box is in its place in the receiving machine.

The receiving photographic film and the original subject to be transmitted, may be held on their respective cylinders by similar mechanisms. Figure 20 shows a section of a transmitting cylinder wherein a print 1 is held on a cylinder 2 by means of clamps 134 and 135, each of these two clamps cooperating with an edge of the print 1 to hold it firmly in place. The clamps 134 and 135 may be held tightly down clamping the edge of print 1 onto the surface of cylinder 2, by means of springs 136 which may be located on shaft 137. The ends of clamps 134 and 135 may project beyond the ends of the cylinder 2, and may be arranged to overhang the cylinder boss 138 as shown on Figure 21. By means of this arrangement, a loading tool 139 may be arranged for raising the clamps 134 and 135 alternately to allow the insertion of print 1 on cylinder 2. This is shown diagrammatically in Figure 22, wherein clamp 135 is being raised by a loading tool 139. The end member 140 of the loading tool may be so shaped that, while the clamp 135 is being raised, the loading tool 139 may be resting upon clamp 134 and using the point of contact as a fulcrum for the raising of clamp 135. This additional pressure on clamp 134 while clamp 135 is being raised prevents the opposite end of the print 1 from sliding out from under clamp 134 while the print 1 is being drawn taut around the cylinder 2. In a similar manner, by reversing the loading tool 139, clamp 135 may be pressed down while clamp 134 is raised.

The method of loading a film on the receiving cylinder may be similar to the above. In the dark room cover 60 may be raised and a loading tool 139 inserted so as to raise one of the cylinder clamps. One end of the film may be inserted under the clamp, and the film may then be wrapped around the cylinder. The loading member 139 may be reversed so as to raise the other clamp, and the free end of the film slipped under the second clamp. Removal of the loading handle then leaves the film tightly wrapped around the cylinder and held by the clamps at each end.

Where it may be desired to couple the facsimile apparatus to a telephone line without physical connection thereto, coupling coils 41 and 46 may be employed. Figure 17 illustrates a preferred form for coupling of a transmitter to a telephone circuit by means of a coil 41 and a subscriber's bell box 42. Coil 41 is shown mounted above box 42, in such a manner that the magnetic lines of force of the coil interact with the telephone induction coil within the box in order to induce corresponding currents into the induction coil and thereby into the telephone line. In other words, the coil 41 forms the primary of a transformer whose secondary is the induction coil within the telephone box 42.

As shown in Figure 18, a preferred form of the coil 41 comprises two sections of inductance, 145 and 146, across which are two condensers 142 and 144. The coil may be coupled to the remainder of the apparatus by means of the leads 141; and as shown in Figure 17, for convenience in mechanical mounting these condensers 142 and 144 may be placed within the coil. Also for con-

venience in manufacture, the coils 145 and 146 may be wound separately and mounted together with the condensers 142 and 144 to form the unit 41. This arrangement of two coils and two condensers is purely a manufacturing design, and our coupling arrangement is not limited to the particular construction shown. Also, while the position shown for the coil 41 with reference to the box 42 is one which we normally employ, our coupling arrangement is not limited to this particular location. It has been found that the optimum coupling position for the coil 41 varies with the type of telephone subscriber's bell box used—the position shown is one suitable for use with box Type 684-A supplied as standard equipment on circuits of the American Telephone and Telegraph Company.

A similar coil to that shown in Figure 17 may be used for picking up the signals from the telephone line, or the pick-up coil may be of any other suitable type, such as a single untuned coil. The function performed is similar to that at the transmitting station, except that the telephone induction coil becomes the primary of a transformer of which the pick-up coil is the secondary. Figure 23 shows a pick-up coil 46, of the single untuned type which has been found satisfactory for this service, coacting with a telephone subscriber's bell box 42a for the purpose of picking signals from the telephone line and transferring them by the leads 47 to the receiving amplifiers. In a similar manner to the arrangement of the transmitting coil, the receiving coil may be placed in any suitable position in relation to the box 42a; Figure 23 illustrates a suitable position for use with the above mentioned Type 684-A telephone box.

Where transmitting and receiving machines are installed in the same location, it is convenient to have both transmitting and receiving transfer coils arranged in permanent location ready for use as and when desired. Figure 24 shows such an arrangement, where coils 41 and 46 are arranged in juxtaposition to a telephone box 42b, whose induction coil is shown dotted at 147. This arrangement allows a single telephone line to be used for either transmission or reception of facsimiles; and it also provides a convenient coupling means for testing facsimile terminal equipment. Under the circumstances of such a test, coil 41 acts as the primary of a transformer whose core is that of induction coil 147, and pick-up coil 46 acts as the secondary of this transformer. As above described, many alternative positions for coils 41 and 46 may be employed than the positions shown in this Figure 24; the sole requirements being that at the transmitting station sufficient current shall be induced into the line for the correct working of the system, and at the receiving station a sufficiently high level signal shall be picked up to enable the receiving amplifiers to amplify this signal without detrimental effects due to a poor signal-to-noise ratio.

A suitable arrangement of transmitting and receiving mechanisms where both are installed at one station is illustrated in Figure 37. In addition to the transfer coils coacting with the telephone box 42 above mentioned, this figure illustrates a transmitting machine 172 and a receiving machine 174 which may be mounted on either side of a frame 170, which frame 170 may conveniently be adapted to carry the amplifying and filter units 48, 50, 51, 52, 55, 34, 36, 24, and 38, in addition to the power supply units Pa and P. An additional panel 171 on this frame 170 may

provide a suitable location for a switching mechanism whereby either transmitter 172 or receiver 174 or both may be energized for the purpose of transmitting, receiving, or testing. When only one coil is used in cooperation with box 42, the switching mechanism on panel 171 may be arranged to switch this coil to transmitter or receiver as may be required, and this may be performed by the same switching operation as that which controls the energization of the equipment, so that one operation both energizes the apparatus and sets up the correct coupling conditions.

Figures 27, 28, 29, and 30 illustrate, by means of curves, the electrical functions of the various parts of the equipment. The over-all transmission characteristic is governed by the tuning of the coil 41 as previously described; and this transmission characteristic is therefore illustrated by the curve of Figure 28. It will be noted that this curve is not a flat curve, but may be peaked at appropriate points to concentrate the energy transfer to those portions of the frequency spectrum in which the various frequencies which may be utilized are located.

In Figure 27, the vertical lines 148 and 149 may represent two synchronizing frequencies, say 540 and 600 cycles per second. Vertical line 150 may represent a picture frequency, say 1800 cycles per second. The curve 151 may represent a transmission band utilized for transmission of synchronizing signals, and curve 152 may represent a transmission band utilized for picture signals.

In Figure 29 curve 151a may represent a characteristic of a band pass section of the filter 51, and curve 152a may represent a high pass characteristic of filter 50 and also of filter 36. A low pass section of filter 51 for abstracting a beat frequency from its components may be shown by curve 153 in Figure 30; and in the same figure curve 152b may show a characteristic of filter 50b. The curve 154 may show the characteristics of filter 24 in a synchronizing circuit.

Figures 27, 28, 29, and 30 are arranged one above the other with their frequency axes in vertical coordination in order that the various curves illustrated may be compared and their performance in the system readily understood.

Figure 35 shows a simplified schematic arrangement of one form of the facsimile system according to our invention. The individual parts of apparatus and electrical circuits have been appropriately designated on the figure; and also the frequencies which may be utilized in the individual parts of the circuit are indicated in the figure. It is to be understood however that this particular arrangement of parts, and the particular choice of frequencies specified, is herein given by way of example only and as a means of clearly illustrating the working of the system.

Without in any manner circumscribing the above disclosure, our invention may be summarized for purposes of clarification as follows:

This invention has been described in relation to a method of facsimile transmission and reproduction; wherein a scanning system passes light impulses of varying intensity from a succession of unit areas of an original subject to be reproduced to a photo-electric cell; and said light impulses are thus caused to control electric currents in such a manner as to produce signals capable of transmission in voice frequency bands by existing communication channels, either by wire or by radio. Methods are described for the

adequate transmission of picture signals and synchronizing and starting signals to be handled in the same voice frequency band, and means are described for separating the individual signals and causing each to perform its individual function at a receiving station, and for the reproduction of a facsimile of the original subject at said receiving station. A method is further described of eliminating the necessity for modulating a carrier wave; and also for obtaining and utilizing a full wave signal for the transmission and reproduction of a facsimile, and a method is disclosed of obtaining a synchronizing signal from the separate frequencies sent from transmitter to receiver. In cases where such connection may be necessary, suitable equipment is disclosed for coupling inductively to standard telephone circuits, and for producing an overall transmission characteristic which has suitable parameters for the purposes of this invention. Novel features of many parts of a facsimile system are disclosed.

Apparatus for carrying the above methods into effect is described in detail so that the invention may be carried out; the apparatus so described illustrates one form of the invention and is not limitative thereof.

While we have described and illustrated one example of our invention, many changes in form may be made without departing from the broad basis of the invention. For example, the phonic synchronizing generators may be replaced by many other forms of generators, as for instance by a photo-electric cell or photo-electric cells adapted to be exposed to light impulses of the required frequency, and if desired this may be performed in conjunction with the interrupter 1 and the photo-electric cell 31, or by a separate optical system and photo-electric arrangement. Therefore the appended claims are not in any manner limited to the exact forms of apparatus shown, but are directed to the novel features of the invention in their broadest sense.

The Federal Communications Commission has issued certain rulings relating to the transmission of pictures and facsimiles over telephone circuits; and, as has been previously stated, the apparatus herein disclosed complies with the orders of the Commission. These orders state that the coupling between the picture apparatus and the telephone line shall be accomplished "without physical connection"; this has been interpreted to mean that the signal transfer between the picture apparatus and the telephone line shall take place without any conductive connection, such as would be occasioned by the use of a repeat coil or ordinary transformer. Satisfactory forms of coupling may be, according to the Commission, acoustic, inductive, or any other type of coupling not involving physical connection of any circuit of the picture apparatus with any circuit of the telephone apparatus. The type of coupling herein described meets these requirements in all respects, and in the appended claims we have referred to this type of coupling (which consists of a separate inductive member forming part of the picture transmission apparatus and cooperating with another inductive member which itself forms part of the telephone apparatus normally supplied in a subscriber's station) as an "indirect" coupling; and the facsimile apparatus is, in this manner, "indirectly" coupled to the telephone.

Since the method of signal transfer from the picture apparatus to the telephone line embodies

the use of a separate coupling unit, it is obvious that the portable features of the apparatus are enhanced by the possibility of using the apparatus from any telephone station, such station being known in the art as a "subscriber's station". All that is required, according to this invention, for placing the facsimile or picture signal on the telephone line, is to place the coupling unit in juxtaposition with the appropriate part of the terminal apparatus at the subscriber's station, and thereby provide a path for energy transfer which will cause signals to be induced in the telephone line corresponding to the signals in the coupling unit.

Therefore, where in the specification and appended claims we have referred to "terminal telephone apparatus" it is to be understood that we refer to the telephone apparatus normally employed or installed in a subscriber's station; that is to say, the transmitter, receiver, hand-set, bell-box, desk-stand, wall-mounting, or other apparatus normally or usually installed on a subscriber's premises for telephonic communication. The term does not apply to the equipment utilized in telephone exchanges, carrier systems, repeater stations, or other points remote from the subscriber's premises, except where such apparatus is the same or similar to that installed at the subscriber's premises.

Having now described our invention, we claim:

1. The method of picture transmission characterized by: scanning a succession of elemental areas of a picture or the like which is to be reproduced and thereby producing a succession of impulses each of which corresponds to one of said elemental areas, producing a constant frequency picture signal therefrom, simultaneously producing signals of two other synchronizing frequencies, and transmitting these three signals over one channel to a receiving station for the reproduction of a facsimile of the original subject, under control of the picture signal and a composite signal produced by the beat between the two said synchronizing frequencies.

2. Apparatus pertaining to a picture transmission system comprising: a source of light, an interrupter, a photo-electric cell, means to cause said light and said photo-electric cell to scan the surface of an original subject to be transmitted, an amplifier, an alternating current generator operated by said scanning means producing an electric current of a frequency distinct from that produced by said interrupter, a second alternating current generator similarly operated producing an electric current of another distinct frequency, means to transmit signals to a receiving station, an amplifier, means to segregate picture and synchronizing signals, means to extract a frequency which is the difference of the said distinct synchronizing frequencies, and means under control of the picture frequency and the beat note thus produced to reproduce a replica of the original subject.

3. In an electrical system, means for segregating a beat note from two components of a composite signal having at least three components comprising: an electric wave filter selective to the two said components, a second wave filter selective to the beat note, and means for passing a signal therethrough.

4. In a picture transmission system, means to create a facsimile of an original subject being transmitted by exposing a sequence of like areas of uniform size on a light sensitive surface comprising: a source of light, an aperture, a gal-

vanometer unit, a second aperture having two openings therein, and an optical system whereby the uniform dimensions of each area exposed are related to the dimensions of the single aperture, and the intensity of the exposure of each area is proportional to the angular displacement of the light beam with respect to one of the openings in the double aperture.

5. In a picture transmission system, means to control the phasing of a sending and receiving cylinder comprising: relay means operated under control of the transmitting cylinder to close a circuit at the transmitter, thereby starting the transmission of a continuous synchronizing wave, and means at the receiver for starting the receiving motor adapted to be driven under control of said continuous synchronous wave and starting said mechanism in accordance with the action of said relay at the transmitter, and continuing to drive said receiving motor under control of said continuous synchronizing wave transmitted from the transmitting to the receiving station.

6. The method of transmitting a picture or facsimile over an audio-frequency channel characterized by the production of a succession of impulses at a predetermined frequency, each impulse corresponding in amplitude to the tonal value of an elemental area of the original subject to be transmitted; simultaneously producing two audio-frequency synchronizing signals, both of a distinct frequency and separate from the picture signal frequency; transmitting said signals and synthesizing a replica of the original subject under control of said first signal for tonal intensity and of the combination of said synchronizing frequencies for the control of location of picture signals with respect to one another and with respect to the borders of the picture or facsimile being reproduced.

7. A picture transmission system comprising: a picture to be transmitted, a drum carrying said picture, means for rotating said drum; a source of light, an optical system, an interrupter, a photo cell, means to scan the picture in a helical path with a spot of light from said optical system which is adapted to be reflected to said photo cell; a plurality of phonic wheel generators; means to amplify the electrical output of said photo cell and to remove therefrom spurious unwanted signals; means to apply a combined signal of the picture frequency and the two phonic wheel frequencies to a communication channel; means to receive said complex signal and segregate it into its component frequencies; means to apply the received picture signals to control a recording upon said surface; a drum carrying said surface, and means controlled by the signals from said phonic generators for starting and rotating said drum and for causing the recording means to trace a corresponding helical path over said receiving surface.

8. In an electro-optical system for the recording of a succession of tone values on a photographic surface corresponding to the instantaneous intensities of an electric current, the method of recording which comprises controlling the size of each of the recorded areas by one aperture and the intensity of exposure of alternate areas in succession by the angular displacement of light alternately with respect to each of two openings in a second aperture.

9. In a picture transmission system, a coupling unit for transferring picture and synchronizing signals to a telephone line through indirect inductive coupling to the apparatus on said line com-

prising: an inductance in a plurality of sections, and capacitative means to tune at least one of said sections.

10. In a picture transmission system having a sending station and a receiving station, and a telephonic communication channel provided with terminal apparatus connecting said sending station to said receiving station, the method of transmitting a picture which comprises: producing a train of picture signals at a predetermined frequency, the intensity of which corresponds to the tone value of an original subject, amplifying said signals, applying said amplified signals to a coupling unit tuned to respond to the frequency band occupied by said signals, and applying said signals to said telephone apparatus indirectly through the agency of said coupling unit and an inductive winding of said apparatus cooperating as a tuned transformer.

11. In combination, a communication channel, terminal telephone apparatus thereon including an inductive member, means to use said terminal apparatus for normal voice communication, a facsimile transmitter, an inductive member connected thereto, means to establish a common path of inductive flux between said members, and means to utilize said terminal apparatus for indirectly imposing a facsimile signal on said communication channel.

12. In a system for transmitting picture signals over a telephone line having terminal telephone apparatus thereon including a member susceptible of influence by external fields, an original subject, means to scan said subject, means to produce picture signals corresponding individually to the pictorial tone values of unit areas of said subject, means to produce synchronizing signals, a coupling device tuned for maximum energy transfer in the frequency bands occupied by said signals, an electro-magnetic field external to said device, means to cause this field to control the susceptible member of said telephone apparatus for indirectly producing corresponding signals in said telephone line, and means for receiving said signals and producing a facsimile therefrom.

13. In a facsimile system having a sending station and a receiving station connected by a telephonic communication channel, the method of producing a replica of an original subject at the transmitting station which comprises: producing signals at the transmitting station corresponding to the shadings of individual unit areas of said original subject and synchronizing signals corresponding to the speed of scansion of said subject, amplifying said signals, and applying both amplified signals together to an inductive unit disposed to interact indirectly with an inductive unit forming part of the terminal equipment provided on said channel; at the receiving station receiving said signals from said channel and synthesizing a replica of the original subject in accordance with said signals.

14. In a system for the transmission of facsimiles by telephone, the method of transferring signals representing the tone values of individual unit areas of a subject being scanned to a telephone line by indirect inductive coupling which comprises: producing a succession of such tone signals at a predetermined rate of succession, amplifying said signals, and inductively applying them to terminal telephonic equipment on said telephone line through the agency of an inductive relationship between a coupling unit tuned selectively for maximum energy transfer over the fre-

quency band of the signals and an inductive winding of said terminal telephonic equipment.

15. In a facsimile receiver adapted to be operated by incoming signals of three frequencies, a wave-selective system comprising: means to select one of said frequencies, means to select the other two frequencies in combination, means to select the beat frequency of the latter two frequencies, and means to apply the incoming signals to the first two means in parallel, and to the third means through the second means.

16. In loading a sheet on a cylinder in a picture machine, the method of securing a taut mounting which comprises inserting one end of the sheet under a holding edge, and exerting greater pressure than normal on this edge to prevent slippage while tensioning the sheet and securing the other end under another holding edge.

17. In a picture receiver for the reproduction of a facsimile on a light-sensitive surface, a plurality of light-tight covers, means for opening one cover when a second is closed, and means for closing the first when the second is opened, so that the light-sensitive surface is protected from stray illumination in the operation of the device.

18. In a facsimile receiver for the reproduction of a picture on a light-sensitive surface, an internal cover over said light-sensitive surface having a normally closed recording slot therein, an external cover over said internal cover, and means for opening said recording slot in the internal cover when the external cover is closed, and for closing said slot when the external cover is opened.

MAYNARD D. MCFARLANE.
EDMUND H. HANSEN.