

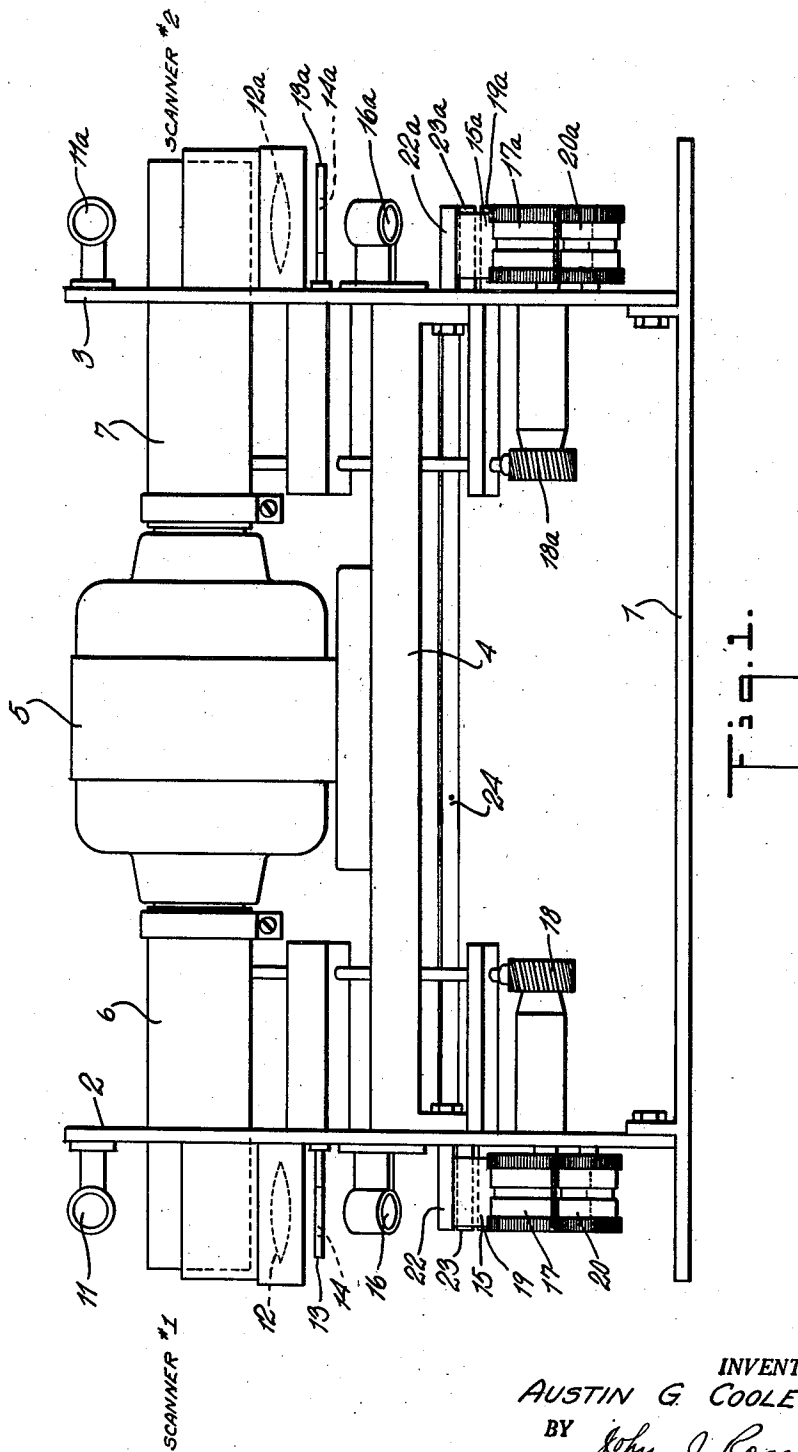
Aug. 10, 1948.

A. G. COOLEY
METHOD OF COMPENSATING FOR FADING
EFFECTS IN A FACSIMILE SYSTEM

2,446,635

Filed Oct. 20, 1945

4 Sheets-Sheet 1



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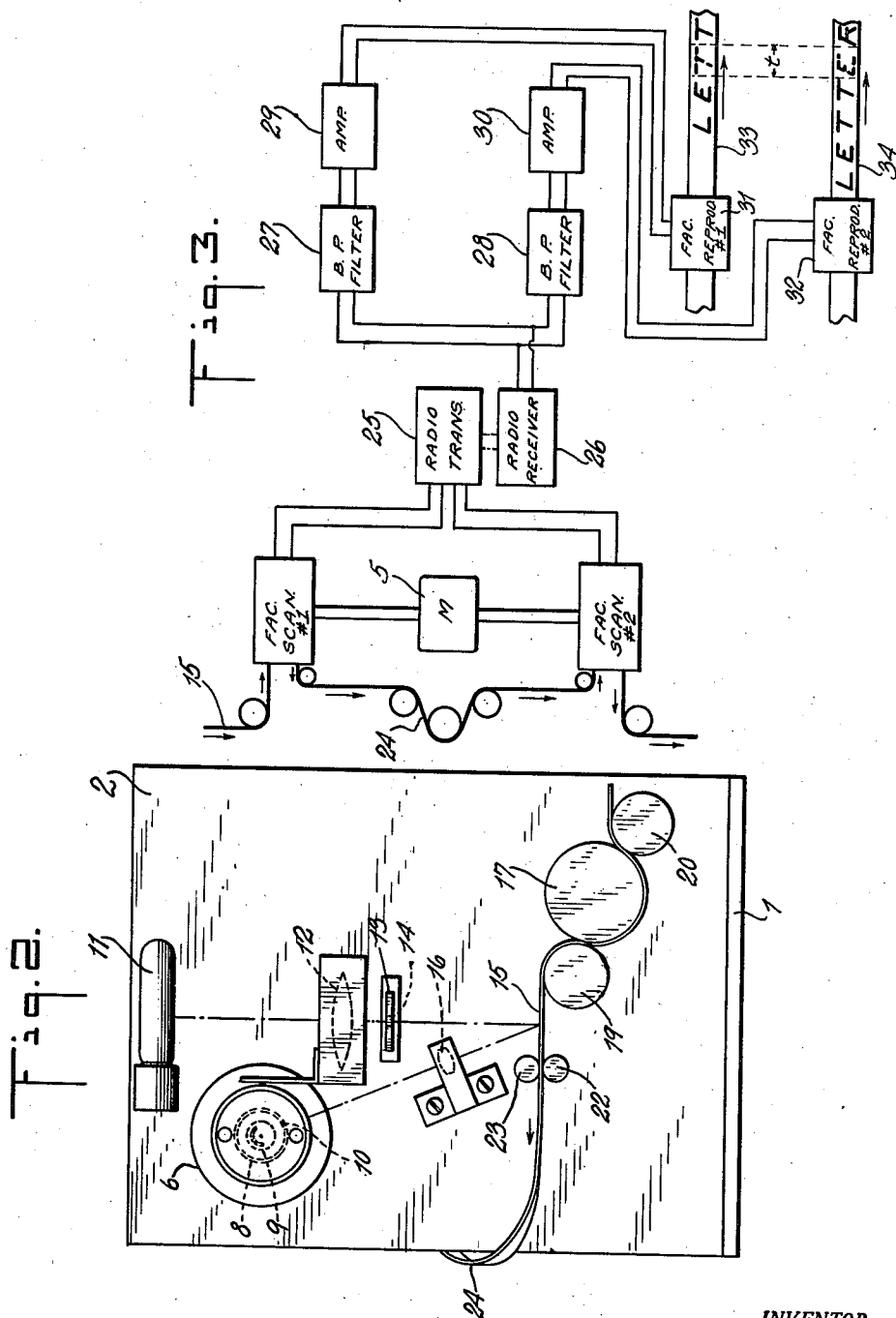
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4 Sheets-Sheet 2



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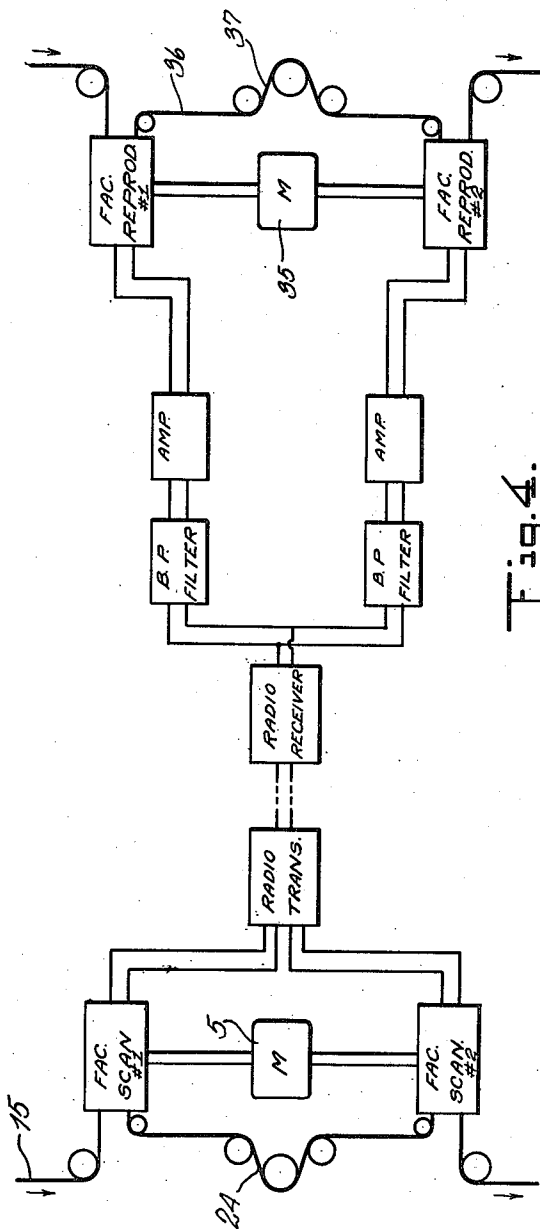
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4 Sheets-Sheet 3



36
ONE LETTER IS MISSING ON THIS PA
ONE LETTER IS MISSING ON THIS PA

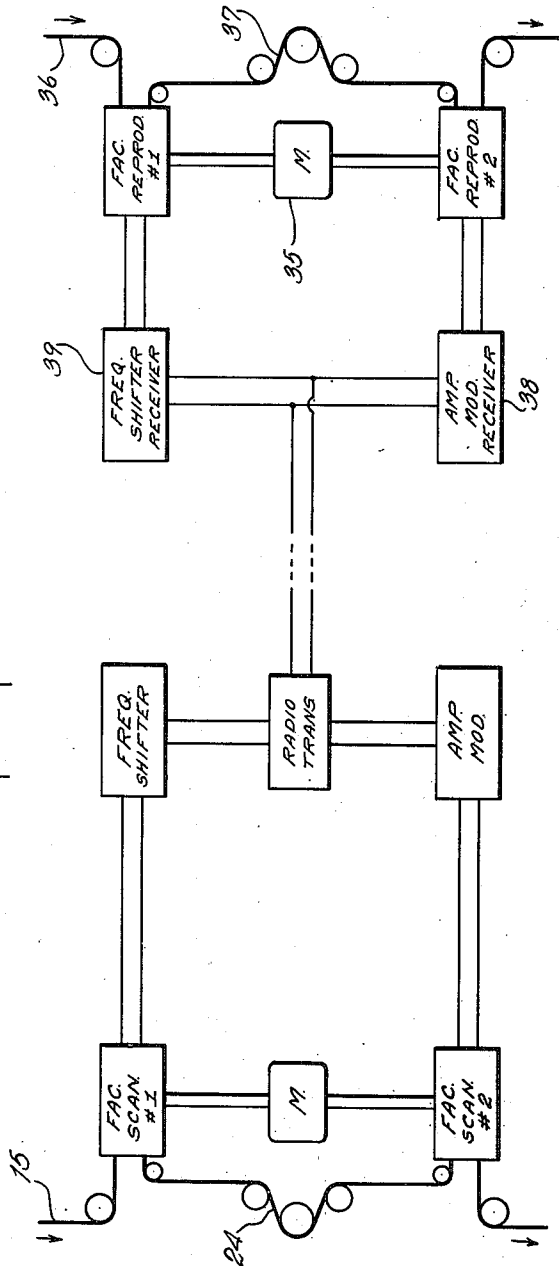
Fig. 5.

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4. Sheets-Sheet 4

4. Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,446,635

METHOD OF COMPENSATING FOR FADING
EFFECTS IN A FACSIMILE SYSTEMAustin G. Cooley, New York, N. Y., assignor to
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Application October 20, 1945, Serial No. 623,588

5 Claims. (Cl. 173-6)

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This invention relates to facsimile systems and more especially to improved methods and apparatus for radio transmission of facsimile subject matter.

A principal object of the invention is to provide a novel method and apparatus for transmitting facsimile signals via radio, and whereby the disturbing effects of signal fading in the transmission channel are substantially reduced in so far as readability or accuracy of the recorded signals is concerned.

Another object is to provide an improved method and apparatus for telegraph signalling whereby the accuracy of the reproduced message is materially increased notwithstanding the effects of fading in the communication channel.

A feature of the invention relates to a unitary facsimile machine for transmitting intelligence by facsimile scanning, whereby the same message can be scanned in time displaced duplicate, with the displacement coordinated with the fading conditions encountered in the communication channel e. g., a radio channel, over which the facsimile signals are being transmitted.

A further feature relates to the novel organization, arrangement and relative interconnection of parts which cooperate to provide an improved tape telegraph transmission system.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing,

Fig. 1 is a front elevation of a unitary duplex facsimile scanning machine according to the invention.

Fig. 2 is a left-hand end view of Fig. 1.

Fig. 3 is a schematic diagram in block form, of a system embodying features of the invention.

Fig. 4 is a modification of Fig. 3.

Fig. 5 illustrates a portion of a recording tape on which the facsimile subject matter is reproduced according to the invention.

Fig. 6 is a modification of Fig. 4.

In the transmission of intelligence via radio, the phenomenon referred to as fading is usually encountered. In the case of voice transmissions, the seriousness of the fading effect may not be as great as in the case of telegraph signals which must be reproduced in recorded form. In many cases, the fading occurs in cycles which are spaced apart at various intervals from a few seconds to several minutes in duration. This interval ordinarily does not vary in duration abruptly, so that for a given telegraphic message the duration of

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the fading periods can be estimated within certain limits. In accordance with the present invention, the difficulties arising from fading in the communication channels are greatly reduced, in so far as readability or accuracy of the recorded facsimile signals is concerned, by transmitting the original intelligence through the intermediary of duplicate facsimile scanners. One scanner is arranged to scan the original message in time displaced relation to the other scanner, and this time displaced duplicate scanning is correlated with the duration of the prevailing fading intervals. At the receiving end, the duplicate transmissions are both recorded in displaced relation on a pair of tapes or on the same tape. By comparing the messages recorded on the two tapes, any deletions on one tape caused by fading are supplied by the other tape. Such an arrangement will, under many fading conditions, reduce the necessity of "repeats" by 80 or 90 percent. Heretofore, in order to overcome the effects of fading in such systems, it has been proposed to transmit each word twice. In some cases each complete word has been required to be transmitted three times, while under other conditions each letter is transmitted twice. The transmission time consumed in such repeats is in some cases prohibitive. In accordance with the present invention, not only is the percentage of repeats reduced but there is at all times at the receiver a duplicate record by means of which the lack of completeness of one record can be immediately compared with, and supplemented by the other record.

In order to achieve the objects of the invention, there is provided a special unitary duplex facsimile tape facsimile machine which is shown in Figs. 1 and 2. The machine comprises a base plate 1, on which is fastened a pair of end plates 2, 3, and between which the shelf 4 extends. Fastened to shelf 4 is a suitable driving motor 5 which has oppositely extending shaft ends to which are fastened the respective scanning heads 6, 7. Each head includes a cylindrical scanning drum 8 which encloses a photoelectric cell 9, the drum 8 being rotated by the motor shaft. Each member 8 has a series of rows of scanning holes 10 disposed in plural helical arrangement around the periphery of the cylindrical housing 8. For a detailed description of the scanning heads 6, 7, and the rotatable scanning drums 8, reference may be had to my U. S. Patent No. 2,363,398.

Mounted on plate 2 is an electric lamp 11, a condenser lens system 12, and an aperture plate 13, having a light slit 14 therein by means of which the message tape 15 is illuminated by a trans-

verse narrow line of light. Also fastened to plate 2 is an objective lens system 16 for imaging the illuminated transverse strip of tape 15 on the perforated scanning drum 8. The tape 15 is adapted to be fed at a constant rate of speed in the direction of the arrow (Fig. 2) by means of a roller 17 which is driven through suitable gearing 18 from the motor 5. Suitable pressure rolls 19, 20, hold the tape 15 in contact with the knurled or serrated peripheral edges 21 of the feed wheel 17. As a result of the continuous linear movement of the tape 15 and the rotation of the scanning drum 8, the tape 15 is scanned in successive elemental areas extending across the width of the tape. Consequently, the subject matter on the tape 15 is translated by means of the photoelectric cell 9 into corresponding facsimile signal current. The tape 15 after passing the scanning point proceeds through guide rollers 22, 23, and thence is looped around the machine as indicated by the numeral 24, and passes through a pair of guide rollers 22a, 23a, and thence between rollers 17a, 19a and 20a, which are identical with the corresponding rollers 17, 19 and 20, on the left-hand side of the machine. Also mounted on the plate 3 is an electric lamp 11a which cooperates with the scanning head 7, the condenser lens system 12a, light slit member 13a, objective lens system 14a, so as to scan the tape 15 as it is fed by roller 17a. The elements 11a, 12a, 13a, 14a, 16a, are identical with the corresponding elements 11, 12, 13, 14 and 16, which are mounted on the left-hand side of the machine. Likewise, the feed wheel 17a is driven through gearing 18a from the motor 5.

The scanning drum 8a within the head 7 is substantially the same as the scanning drum 8 at the left-hand side of the machine except that in accordance with one feature of the invention, it has a greater number of scanning rows of perforations than the number of rows of perforations in the scanning drum 8. For example, if there are 60 scanning perforations in drum 8, there may be 80 scanning perforations in the corresponding scanning drum 8a within the head 7. Thus, the perforations in drum 8 may be arranged in three helical rows of 20 perforations each, whereas the scanning drum 8a within head 7 may have four helical rows with 20 perforations in each row. It will be understood, of course, that the invention is not limited to a scanning drum with the scanning perforations arranged in plural rows, for example the drum 8 may be provided with a single helically arranged row of 60 perforations, and the corresponding scanning drum in head 7 may have a single helical row of 80 scanning perforations. In any event, the facsimile signals from the head 6 have a regular audio frequency component determined by the rate of rotation of the scanning drum 8, and the number of scanning perforations per rotation of the drum. Likewise, the facsimile signals from head 7 will have a fixed audio frequency rate which will be different from the rate of the signals from head 6. If the motor 5 drives both scanning drums at the rate of 1800 R. P. M., the frequency of the signals from head 6 will be 1800 C. P. S., and the frequency of the signals from head 7 will be 2400 C. P. S. It will be observed therefore, that the tape 15 is subjected to two separate and time displaced facsimile scanning operations, and as a result of the loop 24, these two scanings occur at different portions of the tape. The net result is therefore that each elemental area of the tape

is scanned twice but at time displaced phase, the duration of which displacement is determined by the length of the loop 24.

At any given instant of scanning, there are produced two separate audio frequency signals e. g., 1800 C. P. S. and 2400 C. P. S. These two signals can be applied to modulate any well-known radio transmitter 25, as indicated schematically in Fig. 3, wherein parts corresponding to those of Figs. 1 and 2 are designated by the same numerals. The two audio frequency signals are received in any suitable radio receiver 26 and the detected signals are passed through respective band-pass filters 27, 28. For example, the filter 27 may have a pass-band of 1500 to 1900 cycles, and the filter 28 may have a pass-band of 2000 to 2500 cycles. The signals from the filters are amplified in respective audio frequency amplifiers 29 and 30, the outputs of which are applied to respective facsimile reproducers 31, 32, of any well-known construction. Preferably, reproducers 31 and 32 are of the type which employ recording tapes 33, 34, and such as are described for example in said Patent No. 2,363,398. It will be understood of course, that in the manner well-known in facsimile transmission systems, the scanning mechanism and the tape feed mechanism of the reproducers 31 and 32 are synchronized with the scanning mechanism and the tape feed mechanism of the transmitter (Figs. 1 and 2). The result of this arrangement is that the original subject matter on the tape 15 is reproduced on two separate tapes 33 and 34, but as a result of the time delay between the two sets of facsimile signals controlling the respective reproducers 31 and 32, the subject matter on tape 34 for example is delayed with respect to the subject matter on tape 33. If for example, a fade period should occur in the radio transmission channel represented by the interval "t," no reproduction will occur on either of the tapes 33 and 34. However, because of the delayed recording on tape 34, this deleted subject matter will appear on a subsequent portion of the said tape 34. The receiving operator therefore, by lining up the two tapes, can supplement the deleted recorded subject matter on one tape by the actual recorded subject matter on the other tape so as to complete the message.

Instead of using two entirely independent facsimile reproducers, a duplex facsimile reproducer may be employed similar to the duplex transmitter already described. Such an arrangement is schematically illustrated in Fig. 4, wherein the parts corresponding to those of Figs. 1 to 3, bear the same designation numerals. In the embodiment of Fig. 4, the facsimile reproducer #1 and the facsimile reproducer #2 are identical and are driven by the same motor 35. However, in this embodiment, instead of employing two separate recording tapes, a single recording tape 36 is employed which is fed through the reproducer #1 in the direction of the arrow and thence is looped as indicated by the numeral 37, and is then fed through the facsimile reproducer #2. The loop 37 then corresponds to the delay loop 24 at the transmitter. With this arrangement therefore, the two separate scanning transmissions are recorded on the same tape as indicated in Fig. 5, wherein the spaces between the dotted lines represent fading intervals in the radio transmission channel. Here again, by supplementing the missing recordings on one section of the tape by the recordings on the other section, a complete mes-

sage can be determined. It will be understood that in the arrangement of Fig. 4, the tape 36 is sufficiently wide to enable the two recordings to be made thereon and the scanning mechanism of reproducer 1 is proportioned so that it scans the section A along the length of the tape while the reproducer 2 scans the section B along the length of the tape.

Instead of using a single radio transmitter which is modulated by two separate audio frequencies derived from scanner #1 and scanner #2, if desired two separate radio transmitters may be employed. In that event, facsimile scanner #1 would modulate one radio transmitter operating at one radio transmission frequency, and the facsimile scanner #2 would modulate the second radio transmitter operating at a different transmission frequency. With this arrangement the scanners #1 and #2 may be of identical construction, since the segregation of the two transmissions is determined by the different operating frequencies of these two transmitters. With this arrangement therefore, two separate radio receivers are required, the detected output of one radio receiver being applied to control one facsimile reproducer, and the detected output of the other radio receiver being applied to control the other facsimile reproducer.

As an alternative method of transmission where a single radio transmitter is employed, the signals from facsimile scanner #1 (Fig. 3), may amplitude-modulate the radio carrier, while the signals from facsimile scanner #2 may shift the carrier frequency over a limited range which does not interfere with the amplitude modulations from the first facsimile scanner. Such an arrangement is schematically illustrated in Fig. 6 of the drawing. At the receiving end of the embodiment of Fig. 6, the signals representing the outputs of the two facsimile scanners are separated into respective channels by any well-known type of amplitude modulation receiver 38 and by any well-known type of receiver 39 used in carrier frequency-shift reception. These two separate signals are then applied to separate facsimile reproducers in the manner already described so as to produce two separate but displaced records of the original subject matter.

What is claimed is:

1. The method of transmitting intelligence by facsimile to overcome the effects of fading periods in the transmission medium which comprises, scanning the same subject matter to produce two series of currents displaced in phase in correlation with the average duration of the fading periods the said series having individual distinguishing characteristics, simultaneously receiving and separating said currents into separate channels under control of said characteristics, and reproducing the subject matter in duplicate under control of the currents in each of said channels, whereby two similar records are produced of the intelligence but with the effects of the fading apparent in different portions of the recorded intelligence of the two records.

2. The method of transmitting electric intelligence signals to overcome the effects of fading periods in the signal transmission medium which comprises, subjecting the successive elemental areas of the subject matter to a first continuous

scanning to derive a corresponding first series of electric signals, subjecting the said successive elemental areas of said subject matter to another continuous scanning to derive a similar series of electric signals but delayed in phase with respect to the first series, simultaneously transmitting both said series to a receiving point, and adjusting said phase delay in accordance with the average duration of the said fading periods.

3. The method of transmitting intelligence by facsimile signals to overcome the effects of fading periods in the transmission medium which comprises, subjecting the successive elemental areas of the subject matter to a first continuous scanning to derive a first series of electric signals, subjecting the said successive elemental areas of said subject matter to another continuous scanning to derive a similar series of electric signals but delayed in phase with respect to the first series, simultaneously transmitting both said series to a receiving point, and simultaneously applying the two received series of electric signals to produce corresponding records wherein the fading is effective only on different portions of the recorded intelligence of the two records.

4. The method of transmitting intelligence by facsimile to overcome the effects of cyclically recurrent fading periods in the transmission medium, which comprises scanning the same subject matter to produce two series of current signals displaced in phase to correspond with the cyclical periodicity of said fading periods, each series having an individual distinguishing frequency characteristic, simultaneously receiving and separating said currents into separate channels under control of said frequency characteristic, and reproducing the subject matter in duplicate under control of the currents in each of said channels to produce two similar records of the intelligence but with the effects of the fading apparent in different portions of the recorded intelligence in the two records.

5. The method of transmitting electric intelligence signals to overcome the effects of cyclically recurring fading periods in the signal transmission medium, which comprises subjecting the successive elemental areas of the subject matter to a first continuous scanning to derive a corresponding first series of electric signals having a distinguishing frequency characteristic, subjecting the said successive elemental areas of said subject matter to another continuous scanning to derive a similar series of electric signals having a different distinguishing electric characteristic and delayed in phase with respect to the first series, simultaneously transmitting both said series to a receiving point, and adjusting said phase delay in accordance with the average periodicity of said fading periods.

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