July 14, 1936. A. BAILEY 2,047,817

PICTURE TRANSMITTING SYSTEM

Filed Dec. 24, 1924 2 Sheets-Sheet 1

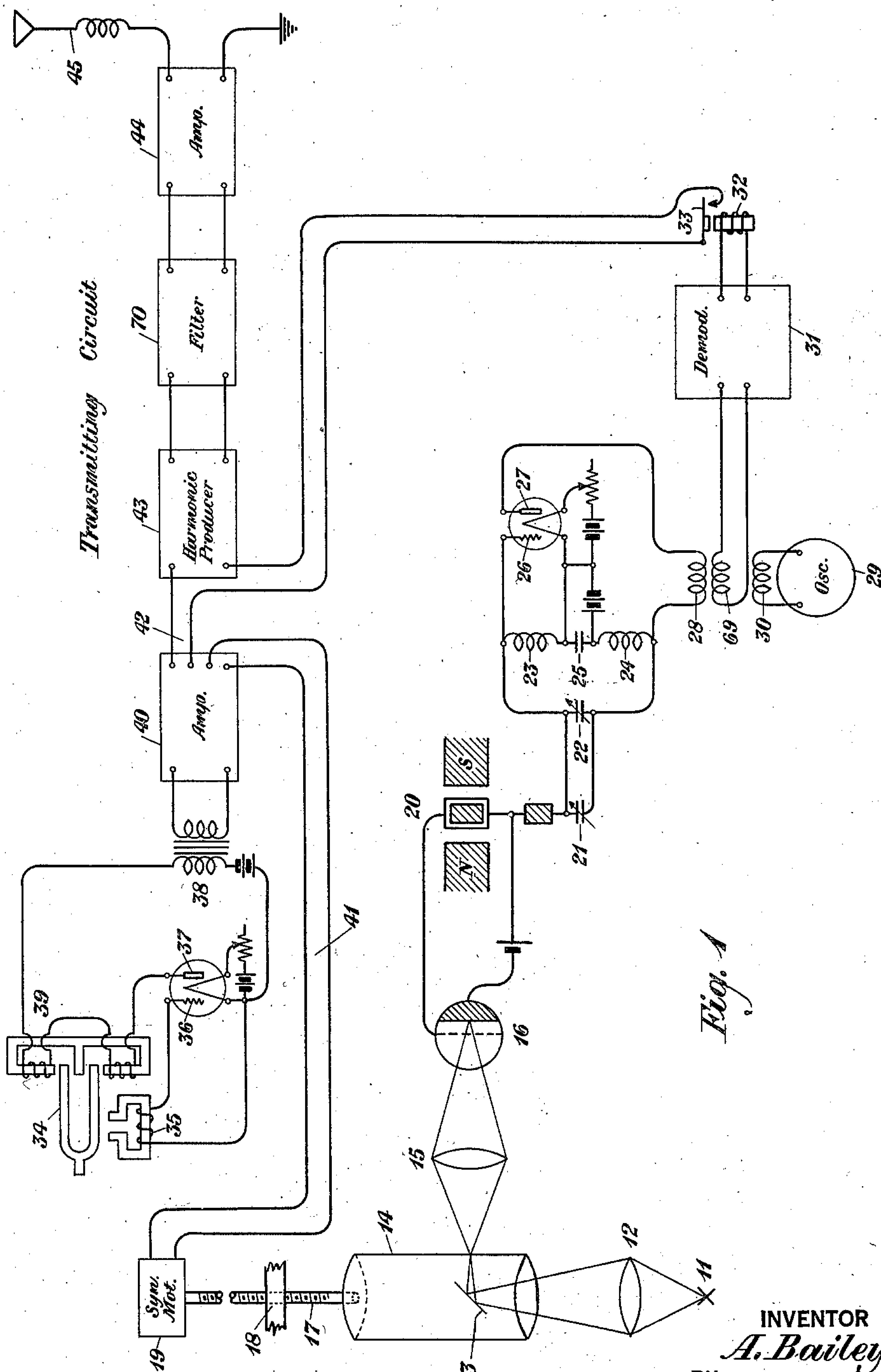

Fig. 1

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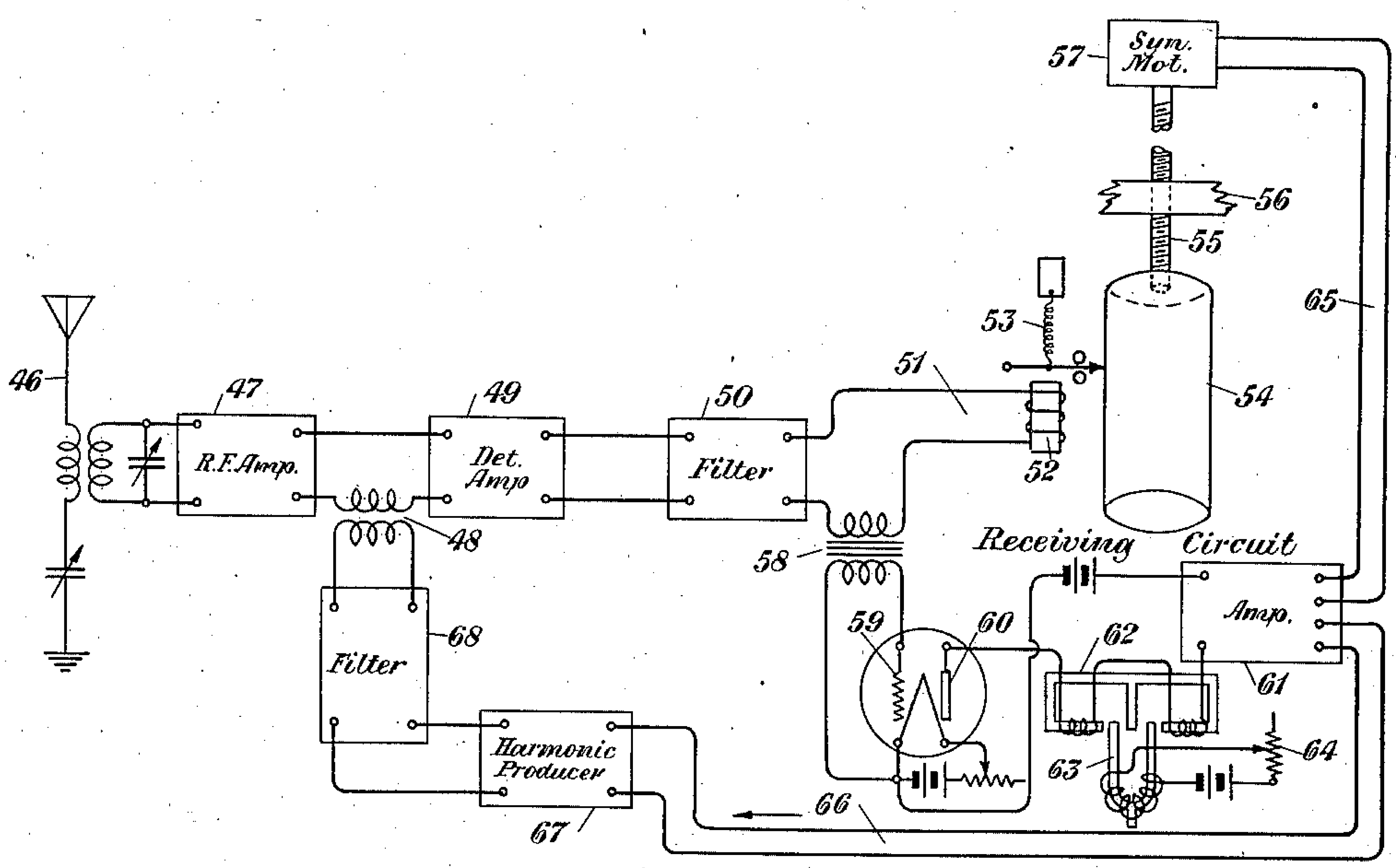

Fig. 2

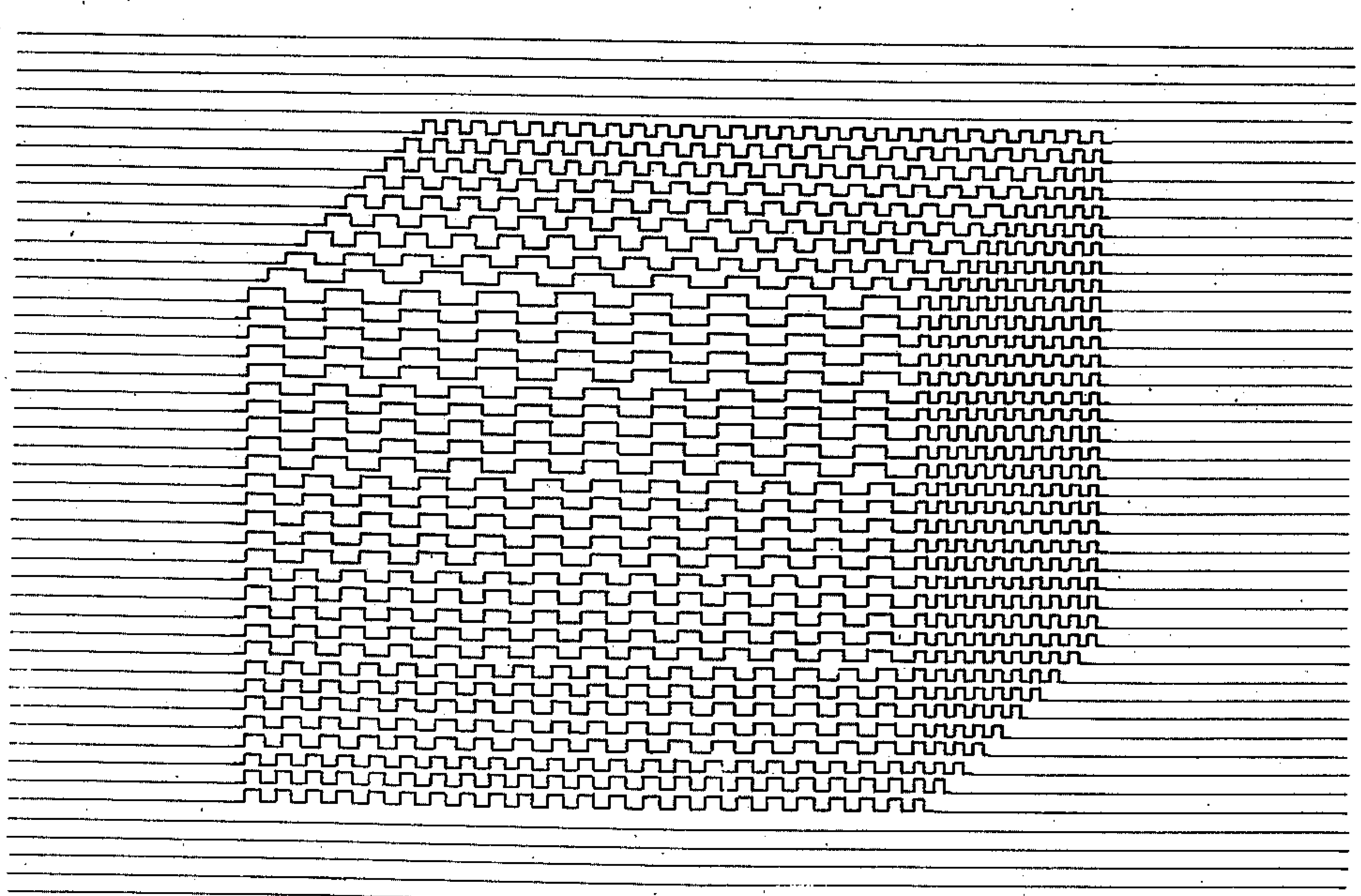

Fig. 3

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Patented July 14, 1936

2,047,817

UNITED STATES PATENT OFFICE

2,047,817

PICTURE TRANSMITTING SYSTEM

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Application December 24, 1924, Serial No. 757,871

14 Claims. (Cl. 178—6)

My invention relates to carrier current transmission and an object is to provide an improved method and system of carrier current transmission especially adapted for picture and image transmission and for radio sending and receiving. Another object of my invention is to provide for transmitting a picture or other image by modulation of a current in such a way that the operation will not be unfavorably affected by variable transmission losses. In accordance with the preferred form of my invention provision is made for sending a picture or other image by interrupting a current at a varying frequency corresponding to the shade of successive picture elements, operating a receiving means in accordance with this variable frequency and limiting the amplitude of response of the receiving means so that variations in the amplitude of the current will give no unfavorable effect. These and various other objects of my invention will become apparent on consideration of an example of practice in accordance therewith which I have illustrated in the accompanying drawings and will now proceed to describe in the following specification. It will be understood that this specification relates to this particular example of the invention and that the invention will be defined in the appended claims.

Referring to the drawings, Figure 1 is a diagram of a radio picture sending station embodying my invention; Fig. 2 is a diagram of the corresponding receiving station; and Fig. 3 is a diagram showing the nature of the picture record at the receiving station.

Light from the source 11 passing through the lens 12 is reflected by the mirror 13 within the open-ended glass drum 14 supported on the shaft 17. The light from the mirror 13 is focused near the surface of the drum 14, round which the picture to be transmitted is wrapped in the form of a semi-transparent film. The light passing through the spot of the film across its path goes through the lens 15 and is focused in the photoelectric cell 16.

The drum 14 is rotated by the synchronous motor 19, and the supporting shaft 17 has screw-threaded engagement with the frame 18 so that as the drum 14 rotates it is also advanced slowly, and the elemental area of the film lying in the path of the beam of light traces a helical course on the film. Accordingly the light to the photoelectric cell 16 varies according to the shade of successive elementary areas of the film in helical order.

The current in the circuit of the photoelectric cell 16 varies according to the quantity of light and actuates the galvanometer 20 whose moving member carries one plate of the adjustable condenser 21. Thus the capacity of the condenser 21 is adjusted to correspond to the degree of shade in the successive elements of the picture.

The condenser 21 forms part of an oscillatory circuit which also comprises the condensers 22 and 25 and the coils 23 and 24. Condenser 22 is made adjustable so that when no light falls on the cell 16 the beat frequency between the two oscillators 29 and that including tube 26—27 can be made zero and no signal (or a long dash) will be transmitted. The oscillation frequency of the oscillatory circuit just referred to will vary according to the adjustment of the condenser 21, and an electromotive force of this frequency will be impressed on the grid 26 of the audion whose plate is 27. Accordingly there will be a corresponding oscillatory current developed in the plate circuit and applied through the transformer primary winding 28.

An oscillation generator 29 sends current of constant frequency through the primary winding 30, and both primaries 28 and 30 cooperate with the same secondary 69 so that both frequencies are put into the demodulator 31. The direct current in the plate circuit of the demodulator 31 is a current varying in intensity at a frequency corresponding with the variation of the capacity of the condenser 21, that is, in correspondence with the degree of shade in the successive elements of the picture on the drum 14. Accordingly for one extreme shade the relay 32 will operate rapidly to open and close its contact 33, and for a shade of opposite extreme the relay 32 will operate slowly to open and close its contact 33.

The tuning fork 34 when set in vibration induces a correspondingly varying electromotive force in the winding 35, which, applied to the grid 36 of the audion whose plate is 37, generates a plate circuit current of corresponding frequency that goes to the transformer primary winding 38 and to the electromagnet 39 to sustain the vibration of the tuning fork 34.

The secondary current induced by the current in the primary 38 goes to the amplifier 40 from which lead two output circuits 41 and 42. The output over the circuit 41 goes to drive the synchronous motor 19 which drives the drum 14, as already described. The circuit 42 comprises the contact 33 of the relay 32, already described, and when this contact is closed at 33 the output from the amplifier 40 in the circuit 42 goes to the harmonic producer **43** which generates a harmonic and delivers this harmonic through the filter **70** to the amplifier **44** whose output then goes to energize the sending antenna **45**.

It will be seen that the sending antenna **45** radiates wave trains of the wave frequency determined by the harmonic producer **43**, and that these wave trains are of a variable length and have a variable frequency determined by the opening and closing of the contact **33** of the relay **32**, and that the rate of opening and closing of this contact varies in accordance with the change in the shade of the elements of the picture passing across the path of the beam of light from the mirror **13** to the photoelectric cell **16**.

At the receiving station the radio waves are received by the antenna **46**, and the corresponding currents go through the amplifier **47** to the detector-amplifier **49**. The input circuit for the detector-amplifier **49** comprises the secondary winding of a transformer **48** through which the locally generated current of standard frequency is applied for detection according to the heterodyne method.

As will be explained presently, the output from the detector-amplifier **49** will be a current of the same frequency as that determined by the sending fork **34** at the sending station. This output goes through the filter **50** and thence through the circuit **51** comprising the relay magnet **52** and the primary winding of the transformer **58**. The relay **52** operates whenever the wave trains start or stop and shifts the recording stylus **53** accordingly. This is in engagement with a receiving surface wrapped on the drum **54**. This drum **54** is driven by a synchronous motor **57** and traversed axially by the screw-threaded engagement of its shaft **55** with the frame **56**. As will be pointed out presently, the speed of the synchronous motor **57** is such that the drum **54** is rotated and traversed in correspondence with the drum **14** at the sending end.

The same current that operates the relay **52** is applied through the transformer **58** to establish a correspondingly varying electromotive force on the grid **59** of the audion whose plate is **60**. Accordingly the output current from this audion will vary at the same frequency, and it is applied through the magnet **62** to vibrate the tuning fork **63**, and, as will be pointed out presently, the rate of vibration of the tuning fork **63** will be the same as of the fork **34** at the sending station.

The output current from the plate **60** also goes through the amplifier **61** to two circuits **65** and **66**. The circuit **65** supplies the current to the synchronous motor **57** already mentioned, and thus this motor is driven in synchronism with the motor **19** at the sending station.

The other output circuit **66** from the amplifier **61** goes to the harmonic producer **67** which generates a certain harmonic of the fundamental frequency and applies it through the filter **68** and the transformer **48** to the detector-amplifier **49** already mentioned.

By adjustment at **64** the rate of the tuning fork **63** is made very nearly the same as that of the tuning fork **34**. Suppose the rate of the tuning fork **34** is 1,500 cycles per second and that the harmonic producer **43** gives the thirty-eighth harmonic, which would be a current of frequency 57,000 cycles per second. Assume that the frequency that is getting through to the amplifier **61** is 1,500 cycles per second, and accordingly this is the frequency of the input to the harmonic producer **67** at the receiving station. Let the harmonic here generated be the thirty-seventh harmonic, a current of frequency 55,500 cycles per second. This frequency applied through the transformer **48** in the detector-amplifier **49** will give an output thereat of 1,500 cycles per second. Now suppose that the frequency of the receiving tuning fork **63** varies slightly from 1,500 and becomes $1{,}500\pm n$. The thirty-seventh harmonic of this frequency from the output of the harmonic producer **67** will be $55{,}500\pm 37n$, and the corresponding output frequency from the detector-amplifier **49** will be

$$57{,}000-(55{,}500\pm 37n)=1{,}500\pm 37n$$

Therefore, it is evident that when the frequency of the fork **63** varies slightly from that of the fork **34**, the variation in the frequency impressed upon the fork **63** will be in the opposite sense, thus establishing a tendency to hold the fork **63** at the standard frequency determined by the fork **34**.

In Fig. 3 an enlargement is shown for a received picture of a cube. This shows how the dark shades are obtained by rapid vibration of the recording stylus **53** and how light shades are obtained by slow vibration of this stylus. If the received record is too coarse-grained to be satisfactory, it can easily be photographed down to a smaller size, so that the observer will get only the impression of the varying shades without the details of the "half tone" structure.

It will be observed that the recording stylus always operates with the same amplitude, and it is this which prevents an unfavorable effect in the reproduction due to variable transmission losses, fading, etc. which cause changes in amplitude, or level, of the received current. By utilizing variations in frequency to represent the shades of the picture, the response of the receiving device, or device for controlling the reproduction, need not vary in amplitude. By maintaining the amplitude constant the effect of change of amplitude or level of the incoming current upon the reproduction is eliminated.

I claim:

1. In a system for the transmission of images by radio, a source of constant frequency alternating current, image scanning means, means responsive to areas of the scanned image to produce variations in the frequency of the constant frequency source, a source of carrier waves of radio frequency, means energized by alternating current from said source of alternating current and having no control over said source for interrupting the waves of carrier frequency and means responsive to these interruptions for producing a record the density of which varies in accordance with the frequency variations.

2. In a system for the transmission of images by radio, light responsive means for testing the shades of the elemental areas of a picture, an alternating current generator, means responsive to variations in said light responsive means for causing a corresponding variation in the frequency of the current produced by the generator, means for generating a carrier current, means energized by, but having no control over, said alternating current to interrupt the carrier current in accordance with the frequency variations of said alternating current, and means responsive to the interrupted carrier current for reproducing said picture.

3. In combination, means for testing the

shades of the elemental areas of a picture or field of view, an alternating current generator, means operable in accordance with the degrees of shade determined by said test for causing a corresponding variation in the frequency of the current produced by said generator, a second alternating current generator, means for beating the current produced by said second generator with the current of varying frequency produced by said first generator to produce a beat frequency current, means for generating a carrier current, means to interrupt the carrier current by said beat frequency current, and means for transmitting the interrupted carrier current.

4. In an image transmission system, a rotatable sending member, a synchronizing device vibrating at a given frequency for controlling the speed of said member, means to test the shades of a picture, a generator for generating an alternating current of a normal constant frequency, means to vary the frequency of said current in correspondence with the change in the shades of said image, a harmonic generator for producing a given harmonic of the frequency of said device, means for altering the harmonic current in accordance with the frequency variations of said variable frequency current, and means for transmitting the altered current.

5. In combination, a tuned electric circuit including variable reactive means, means for producing an alternating current in said circuit, a light sensitive electric device, and means for connecting said light sensitive device to said variable reactive means for controlling in accordance with the light activation of said device the reactance of said variable reactive means to control the tuning of said tuned circuit and thereby correspondingly modifying the alternating current in said tuned circuit.

6. In combination, a tuned electric circuit including variable capacitative means, means for producing an alternating current in said circuit the frequency of which is determined by the tuning of said circuit, a light sensitive electric device, and means for connecting said light sensitive device to said variable capacitative means for controlling the setting of said variable capacitative means to control the tuning of said tuned circuit in accordance with light activation of said light sensitive device.

7. The method of carrier current image transmission which comprises generating and transmitting groups of waves of changing group periodicity corresponding to tone values of elemental areas of an object an image of which is desired, both the duration of the wave group and the intervals between successive wave groups varying in the same direction in accordance with tone value variations, and operating a receiving device at a frequency dependent upon the wave train period.

8. The method of carrier wave signaling which comprises transmitting waves the amplitude of which is similarly changed at intervals of changing length to represent component parts of a signal, the duration of both the maximum and minimum amplitude portions of said wave varying in the same direction in accordance with signal variations, and operating a signal receiving device in accordance with said change in amplitude.

9. The method of producing an image at a receiving station of an object or field at a transmitting station which comprises producing a carrier wave separated into groups and having wave group frequencies corresponding to the tone values of elemental areas of the object or field, both the duration of the wave group and the intervals between successive wave groups varying in the same direction in accordance with tone value variations, and causing an image producing action at the receiver at both the beginning and end of each received wave group.

10. The method of carrier current image transmission which comprises generating and transmitting a carrier current for predetermined periods and interrupting the transmission for predetermined periods between successive transmission periods to represent a predetermined tone value of the image, and varying both the transmission periods and the interruption periods in the same direction to represent a tone value different than said predetermined tone value.

11. The method of producing an image at a receiving station of an object or field at a transmitting station which comprises transmitting at intervals a carrier wave of constant amplitude to represent a certain tone value, increasing both the transmission periods and the periods of interruption when the tone value changes in a predetermined direction and decreasing both the transmission periods and the periods of interruption when the tone value changes in the opposite direction.

12. The method of producing an image at a receiving station of an object or field at a transmitting station which comprises transmitting at intervals a carrier wave of constant amplitude to represent a certain tone value, increasing both the transmission periods and the periods of interruption when the tone value changes in a predetermined direction and operating a receiving device at a frequency dependent upon the rate of recurrence of said transmission periods.

13. The method of carrier wave image transmission which comprises transmitting for predetermined periods carrier waves of a predetermined amplitude and alternately reducing the amplitude of the carrier waves for predetermined periods between said transmission periods to represent a predetermined image tone value, increasing both said periods for a change in tone value in one direction and decreasing both said periods for a change in tone value in the opposite direction.

14. A system for producing images electro-optically which comprises means for scanning the object an image of which is desired, a source of carrier waves of substantially constant amplitude, means for causing waves from said source to be transmitted and suppressed alternately for predetermined periods, and means under control of said scanning means for varying both said periods in the same direction simultaneously in accordance with changes in tone value of the portions of the object being scanned.

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