March 9, 1948. E. L. ROCKWOOD 2,437,558

PRECISION RADIO REMOTE CONTROL SYSTEM

Filed March 12, 1943 2 Sheets-Sheet 1

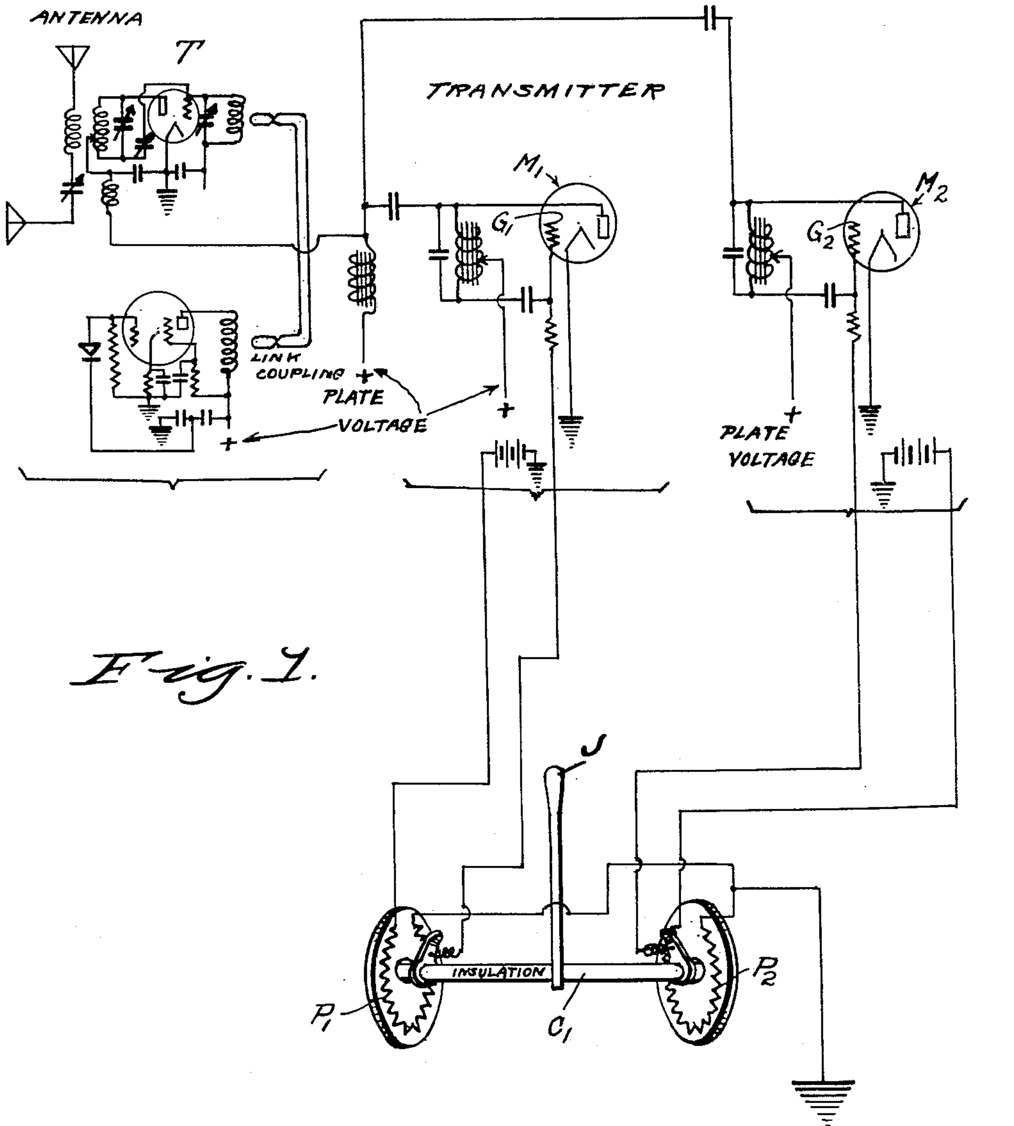

Fig. 1.

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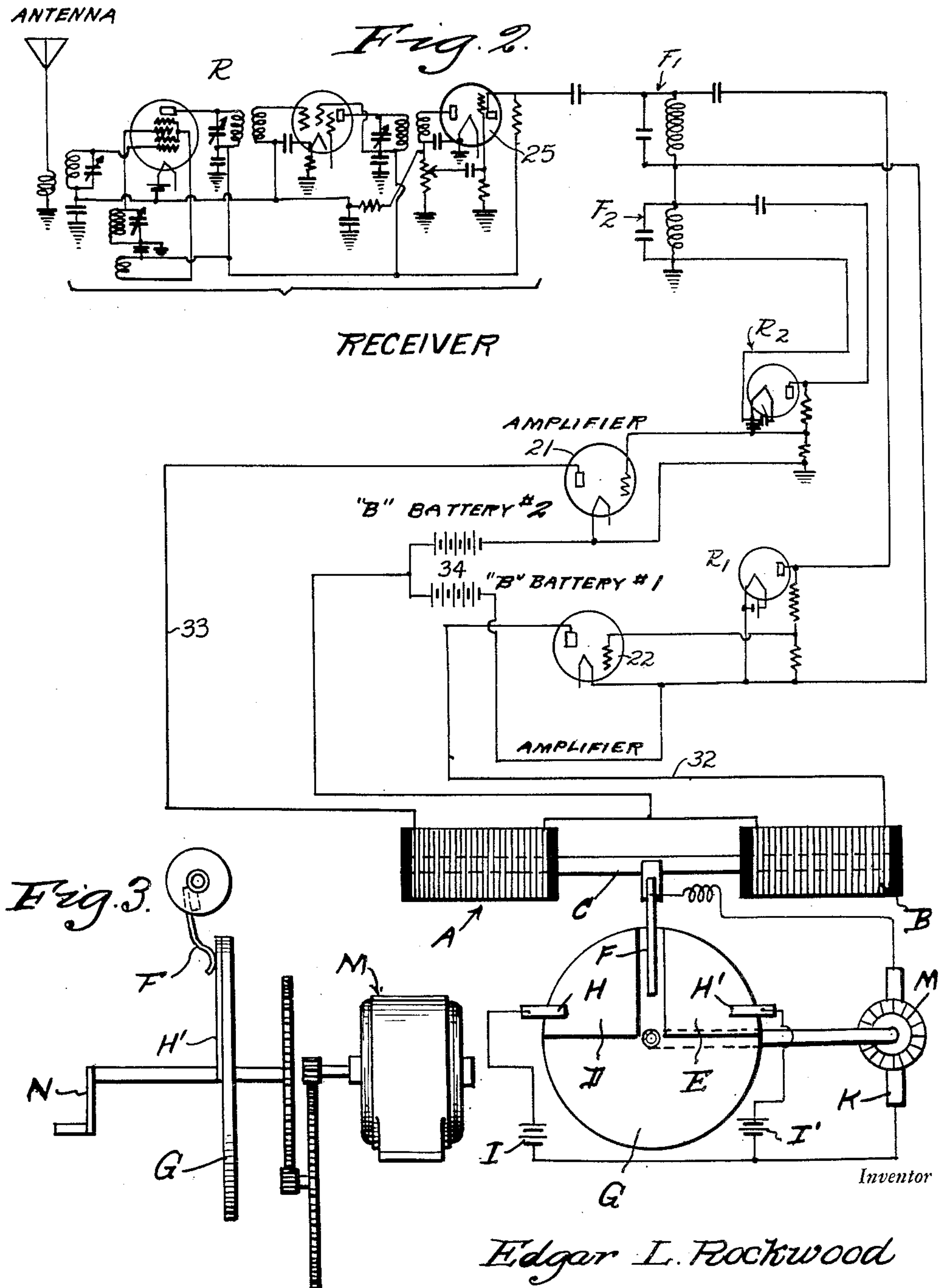

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PRECISION RADIO REMOTE-CONTROL SYSTEM

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2 Claims. (Cl. 318—31)

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This invention relates to remote control systems and it has for its object to provide a system of the character indicated in which the control at the remote point is effected by means of two variable frequencies, transmitted through a communication channel of any type, whose variations are interrelated and always occur in opposite directions. If, for instance, the amplitude of one of the frequencies increases, the amplitude of the other will decrease, the aggregate sum of both being however a constant factor.

With this object in view the invention mainly resides in a system of the type above described with a receiver which is capable of translating the variation imparted to the two frequencies in opposite directions into a mechanical, preferably rotational movement proportional to the value of the difference. The means for effecting such translation may comprise a filter system for separating the frequencies, and a system of coils opposing each other on which the frequencies, after due rectification and amplification, may act. The coils when acting conjointly on a core which is common to them will clearly impart a movement to the core which is proportional to the difference of the amplitudes of the two oscillations which, after transformation and amplification, energize the two coils. Said movement may then be used directly or indirectly to control the movement of a rotating part driven by a local source of power. The latter movement is therefore still proportional to the difference between the variations of the amplitudes of the frequencies.

The invention is illustrated in the accompanying drawings showing one modification thereof. It is however to be understood that this modification is to be regarded as an example illustrating the principle on which the invention is based and the best mode in which this principle is applied. It does not represent the sole modes of application of the invention.

In the drawing:

Figure 1 is a diagrammatic view of a transmitter of some well known type with two different modulation systems, whose control is interrelated.

Figure 2 is a diagrammatic view of a receiver station, embodying remote control means operated by the interrelated variation of two received frequencies.

Figure 3 is a diagrammatic elevational view of the mechanical arrangement reproducing the

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movement transmitted through the transmission channel.

The system according to the invention may be carried into effect with any type of communication system capable of transmitting oscillations. The system used to illustrate an example is a radio communication system the transmitter of which is shown in Figure 1. The transmitter itself may be of any approved type and need not be described. In order to adapt it for the purposes of the present invention it is provided with two modulation tubes M_1 and M_2, for producing the modulation of the carrier wave. The modulating oscillations according to the invention have to be controlled or regulated simultaneously as they are interrelated. In the example shown the amplitude of these oscillations is regulated by means of the control grids G_1, G_2 of the modulation tubes. The interrelation of the variation of the modulating oscillations which is obtained in the tubes M_1 and M_2, is produced by providing each grid circuit with a potentiometer P_1 and P_2, respectively these potentiometers being operated by a common shaft C. When this shaft is rotated in one direction the potentiometers are so operated that the resistances vary or change in opposite directions. This means that if the resistance in the circuit of grid G_2 decreases the resistance in the circuit of grid G_1 increases and vice versa. It is preferable to wind the potentiometers in such a way and to use such fixed resistances that the amplitude of the oscillation in the output or plate circuits of the modulation tubes M_1, M_2 have an aggregate sum which is permanently constant, each increase of the amplitude in one circuit being just compensated by the decrease of the amplitude produced simultaneously in the other circuit.

The shaft C operating the two potentiometers may be provided with a handle J which serves as the remote control handle. Every movement of said handle, as will be clear from the above, produces a variation of the resistance in the grid circuits of the tubes M_1 and M_2 and thereby a variation in the output circuits of said tubes which are interrelated in the manner above indicated.

A carrier wave modulated by the two interrelated modulating frequencies is radiated through the aerial of the transmitter and is received by the antenna 24 of the receiver shown in Figure 2.

The receiver is a standard receiver which is however adapted to separate again the two interrelated frequencies, which have been transmitted. The carrier wave with these two frequencies after being received is amplified and demodulated in the demodulator 25 of the receiver. The resulting oscillation will be a combination of the two frequencies.

In order to separate them the demodulator 25 of the receiver is connected with the two filter circuits F_1 and F_2, which are so tuned that each filter passes merely one of the frequencies contained in the combination. As the filters furnish an A. C. of the desired frequency a rectifier R_1 R_2, respectively, is arranged behind each filter to convert the output into a pulsating D. C. which may be further amplified by the amplifiers 22, 21 arranged in the output circuits of the rectifiers R_1 and R_2.

The rectifier and amplifier arrangements R_1 R_2, 22, 21 are connected with the energizing circuits 32, 33 of solenoid magnets B and A, respectively, which are aligned and are wound in opposite directions. The battery 34 which may also form the B battery of the amplifiers 21 and 22 provides the solenoid circuits 33 and 32 with current, when current is passing through the amplifier. Such a passage occurs, as will be easily understood whenever the filter circuit carries a current and the current passing through the circuits 33, 32 will therefore be proportional to the amplitude of the frequency which has passed the filter and has been rectified in one of the rectifiers R_1 R_2 by virtue of the connection of the plate of the latter with the control grid of the amplifier. It will thus be clear that the energizing current of each solenoid magnet A, B will be proportional to the amplitude of one of the oscillations received.

Both solenoid magnets are encircling a common core piece C, which is axially movable along the common axis of the solenoid magnets. The position occupied by the core is determined by the energization of the solenoid magnets and it will therefore correspond exactly to the difference between the amplitudes of the two oscillations or, when reference is made to Figure 1, to the position of the hand lever J determining the position of the potentiometer arms. The position of the core therefore reproduces exactly the amplitude difference between the frequencies and the position of the lever J in the transmitting station.

For the purpose of exercising a remote control it is, as a rule, necessary to produce an angular or rotational movement which reproduces the movement of the control lever J of the transmitter and which is capable to overcome a notable resistance or to exercise some power so that a local source of power has to be introduced. This translation of the movement and introduction of a local source of power is obtained by means of the mechanism shown in Figures 2 and 3. This mechanism consists in an electric motor M driving a disk G by means of a gear train 27. As a rule a gear train with a high ratio of transmission (for instance about 400:1) is necessary. The disk G is of insulating material and carries two metal plates D and E in the form of a quadrant. These metal quadrants cooperate with brushes H, H' each of which is connected with a circuit containing a special battery I, I' or other source of current respectively. The batteries are capable of driving the motor M and are connected with the brushes with opposite poles. Therefore the negative pole will for instance be connected with brush H' and quadrant E, while the positive pole of battery I is connected, for instance, with brush H and quadrant D. The two other poles of the batteries are connected with each other and with one of the terminals K of the motor M. A further terminal of the motor is connected with brush F which is mounted on the movable core C and which is sliding on the face of the disk.

The motor M is preferably provided with a permanent magnetic field so that it is reversible and changes its direction of rotation when the direction of the current flowing through its armature is reversed. The terminals K in this case are connected with the collector brushes. It will also be clear that the direction of rotation of the motor will depend on the battery I, I', which is connected with the motor by means of brushes H, H' and brush F.

The operation of the arrangement will be readily understood from the foregoing description.

Assuming the handle J to be the control bar to be moved in order to exercise the remote control, it will be clear that its movement will change the amplitude of the two modulating frequencies. The sum of these amplitudes of the two frequencies as has been stated before, is preferably constant. Therefore the carrier wave is modulated with a combined oscillation containing the two interrelated frequencies. The modulated carrier wave is received on the moving or stationary object to be controlled is demodulated and the combined oscillation which is the result of such demodulation is decomposed into its component frequencies by the passage through filters F_1 and F_2. The oscillations coming from said filters are rectified in rectifiers R_1 and R_2 and are amplified and energize the coils A and B respectively. If they happen to be of equal amplitude the core will stay in the center as the magnetic actions of the coils A and B on the core are equal. When the amplitude of one of the frequencies is larger than the other, the core will be moved to one side. Thereby the brush F is moved to one side and closes the circuit of the motor M in a definite direction. The motor M is energized in one direction corresponding to the polarity of the battery I or I' and rotates the disk G until brush F leaves the quadrant. At this point the motor is stopped. With the motor the crank or lever N is moved which effects the remote control on the controlled object.

It will therefore be clear that the movement of the brush F and core C to the left or right in Figure 2 determines the direction of rotation of the motor and the extent of the movement of this brush determines the extent of the angular motion of the disk and of the controlled lever N. On the other hand the extent of the movement of the brush F and core C depends on the difference between the amplitudes of the two frequencies and is therefore dependent on the extent to which the lever J was moved.

It will also be clear that the motor M furnishes the power which is required to move the controlled lever to the angular position which is determined by the cooperation of the disk G and the brush F.

Attention may finally be drawn to the fact that the use of two frequencies for effecting a remote control is by far preferable to the use of a single frequency in most cases and is indispensable in those cases in which a moving object such as an airplane, car, boat or the like is controlled by a remote control system. If merely one frequency is employed the movement of the core, for instance, is controlled by a single coil which in this case has to cooperate with a spring or a similar return means. As this return means exercises a constant influence such as a constant pull or push, the relation of this influence or force with respect to the magnetic force pulling the core is variable with the distance of the controlled object from the controlling station which influences the amplitude of the oscillation received. According to this invention however, the influence due to any change in the amplitude of the receiver is eliminated as merely the difference between the amplitudes of the two modulating oscillations which is solely dependent on the position of the handle, determines the position of the core and thereby the position of the controlled lever.

It will be clear that the specific arrangement described may be subjected to modifications without affecting the essence of the invention. Moreover under special circumstances, for instance, where no local source of power is necessary to move a controlled member the arrangement for introducing the local motoric power may be dispensed with.

I claim:

1. A remote control system in which control is effected by means of two frequencies whose amplitudes are varied jointly in opposite directions with the amplitude of one frequency decreasing while the amplitude of the other increases their sum remaining at a constant value, and which comprises a receiver, demodulating means therein, a filter system, comprising a pair of filter circuits, each circuit tuned to one of the two frequencies received for separating the same, a rectifier arrangement in each filter circuit and a pair of solenoid coils, each coil connected with one of the filter circuits and operated by the rectified filter currents, a common movable core operated by the said solenoid coils, and moved in proportion to the energization of the coils and translation means for transforming said reciprocating movement of the core into proportionate rotational movements.

2. A remote control system in which control is effected by means of two frequencies whose amplitudes are varied jointly in opposite directions with the amplitude of one frequency decreasing while the amplitude of the other increases their sum remaining at a constant value, and which comprises a receiver, demodulating means therein, a filter system, comprising a pair of filter circuits, each circuit tuned to one of the two frequencies received for separating the same, a rectifier arrangement and means for amplifying the rectified circuits in each filter circuit, a pair of aligned solenoid coils opposing each other, each coil connected with one of the filter circuits, a movable core in common to both solenoid coils and adapted to be shifted by the same in proportion to the relative strengths of the amplitudes of the two above mentioned frequencies received, and a translation device for translating the movement of the core into a rotating motion comprising contact arms fixedly mounted on said core, a rotatable disc carrying contact segments in operative connection with said contact arm, a shaft driven by said disc, an electric reversible motor for driving said disc and shaft and operative circuits for said electric motor controlled by the said contactor arm and segments.

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