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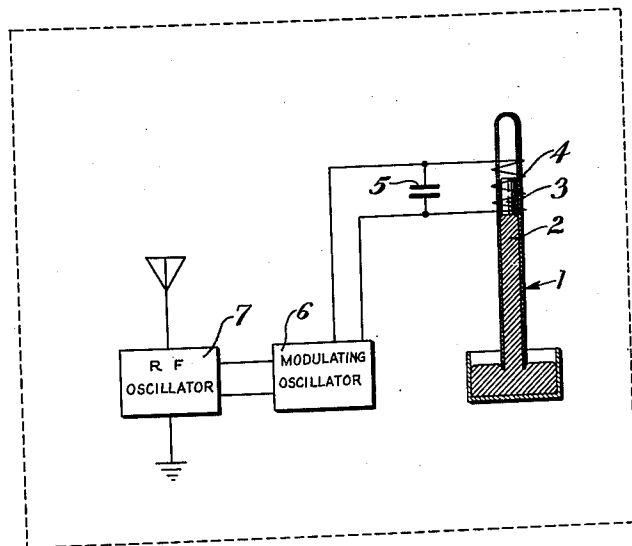
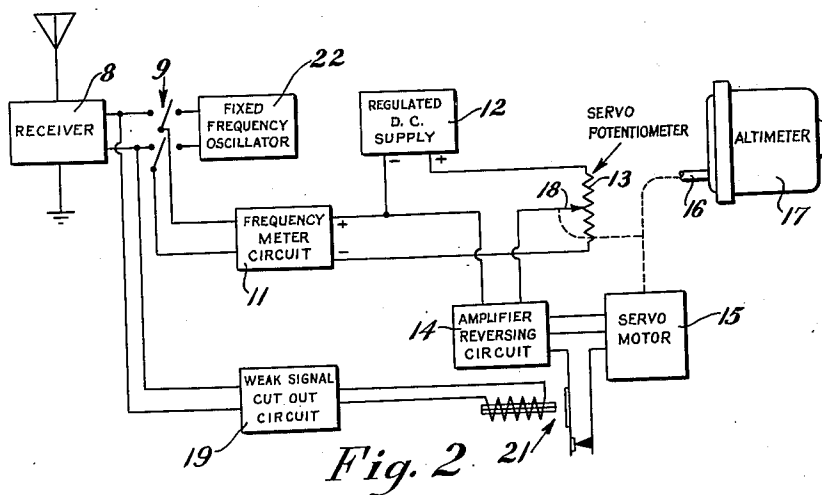
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2,618,976

TELEMETERING SYSTEM AND AUTOMATIC ALTIMETER SETTING

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2 SHEETS—SHEET 1



GROUND STATION

Fig. 1

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2 SHEETS—SHEET 2

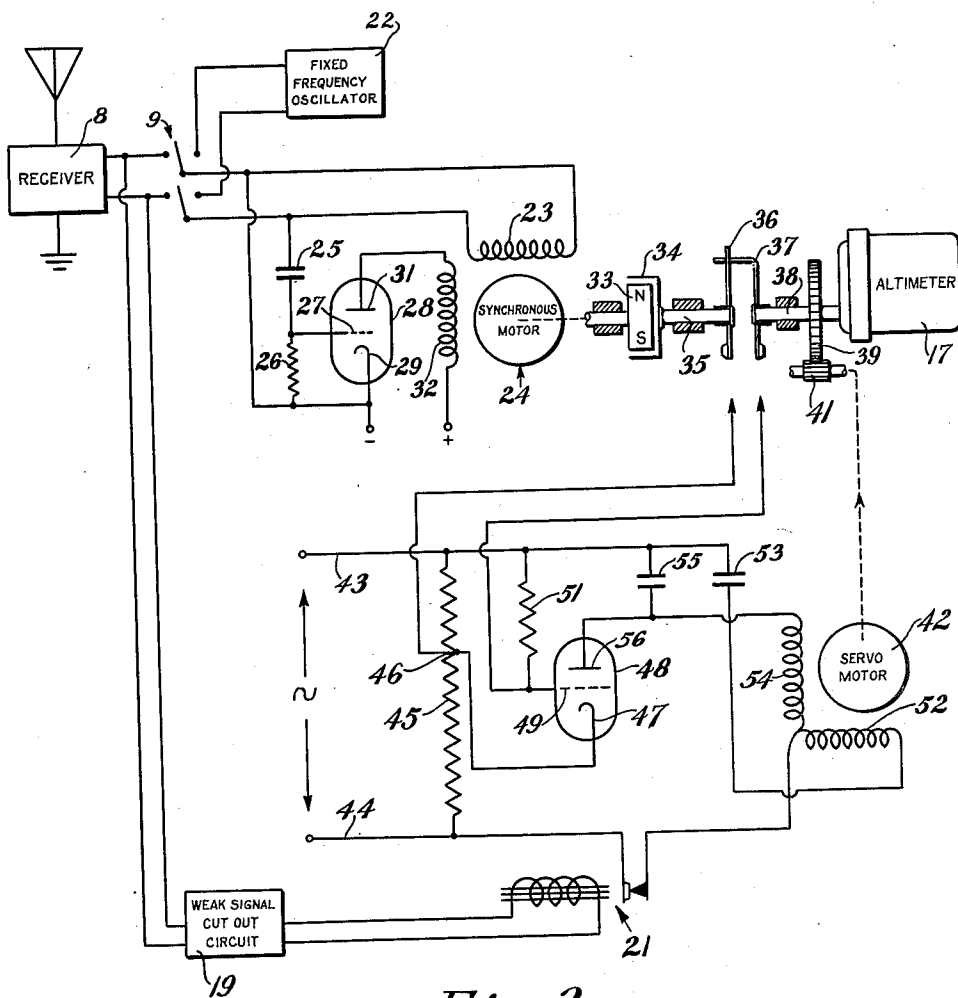


Fig. 3

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TELEMETERING SYSTEM AND AUTOMATIC
ALTIMETER SETTING

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8 Claims. (Cl. 73—387)

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This invention relates to a system for automatically telemetering values of a variable condition on a constant radio or carrier frequency modulated in amplitude by variations in audio frequency determined by variations in said condition. It is particularly adapted to the telemetering of data from a ground broadcast station to aircraft in flight or from a flight instrument to a ground station.

The system has been specifically illustrated in connection with the transmittal of the barometric pressure at a ground station and the automatic setting of this ground barometric pressure into a barometric altimeter indicating the aircraft height.

Under presently operating conditions, it is necessary for an aircraft pilot to depend on audible radio contact with ground operators so that he may reset the altimeter as barometric pressure changes occur. The pilot must not only correctly hear the number given to him by the ground operator, but he must also remember it long enough to manually adjust his altimeter to obtain the correct setting. This not only gives rise to the possibility of dangerous human error, but also increases the pilot's duties. With the telemetering system according to the present invention, the altimeter correction for ground barometric pressure is automatically set in the instrument in accordance with values of audio frequency determined by the barometric pressure at the ground broadcast station.

Systems have been disclosed in the past attempting to secure automatic altimeter setting by variation in radio frequency determined by variation in the barometric pressure at a ground broadcast station, but these have not proven desirable in view of the wide broadcast band required and conflict with other radio communication. According to the present invention, the information to be transmitted, and specifically the ground barometric pressure values, is broadcast by audio frequency modulation of a constant radio or carrier frequency and the variation in audio frequency is utilized to automatically set the aircraft altimeter to the proper ground barometric pressure without pilot manipulation.

An object of the invention is the provision of a telemetering system in which the value of a variable condition determines an audio frequency signal broadcast at constant radio or carrier frequency in which the audio frequency received at a remote point is utilized through a frequency

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meter to effect the operation of a servomotor to effect a setting in accordance with the variable condition.

Another object of the invention is a telemetering system in accordance with the preceding objects in which the audio frequency signal effects the automatic setting of the barometric pressure of a ground station in a barometric altimeter.

Another object of the invention is a telemetering system in accordance with the preceding objects in which a weak signal cutout is provided to cut off the operation of the servomotor as the signal strength fades out with increased distance of the receiver from the broadcast station.

Another object of the invention is a telemetering system in accordance with the preceding objects in which there is provided a test circuit supplying a predetermined audio frequency to test proper operation of the system by its response thereto.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a schematic representation of a ground station or broadcast unit of a telemetering system according to the method and apparatus of this invention.

Figure 2 is a schematic representation of one form of receiver for the telemetering system indicating the automatic altimeter setting.

Figure 3 is a schematic representation of a modified form of receiver unit for effecting automatic altimeter setting.

In the schematic representation of the ground broadcast station, there is shown a mercury barometer 1 having a column of mercury 2 whose height depends upon the barometric pressure at the ground station. Upon the column 2 there floats a magnetic core 3 within a coil 4 having a condenser 5 in parallel therewith. The inductance of the coil 4 will vary with the position of the core 3 and hence the resonant frequency of the circuit formed by the coil 4 and condenser 5 will vary in accordance with changes in the height of the column 2 occasioned by changes in barometric pressure. This resonant circuit is connected to the modulating oscillator 6 which generates an audio frequency signal in accordance with the frequency of the resonant circuit. This audio frequency signal is transmitted to the radio frequency oscillator 7 which broadcasts it at a constant carrier frequency. Thus, an audio

signal is broadcast from the ground station at radio carrier frequency with the frequency of the signal varying in accordance with changes in barometric pressure at the ground station.

The receiving unit mounted in the aircraft comprises a receiver 8 tuned to the fixed radio or carrier frequency of the oscillator 7. The output of the receiver 8 leads to a two pole double throw switch generally indicated by the numeral 9. With the switch 9 in the neutral position shown in the drawing, the system is disconnected. When thrown into its left hand position, the output of receiver 8 is fed to a frequency meter circuit 11 whose output is a direct current voltage varying in value with the frequency of the audio frequency signal fed thereto. There is provided a D. C. supply 12 with the outputs of the frequency meter 11 and of the D. C. supply 12 feeding the two legs of a potentiometer 13 which forms therewith a bridge circuit. When the bridge is unbalanced, its output is fed to an amplifier-reversing circuit 14 which controls the direction of rotation of a servomotor 15 which moves both the setting shaft 16 of the altimeter 17 and the mid-connection 18 of the potentiometer 13 to return the bridge into its balanced condition.

When the aircraft is distant from the ground station, the signal fades sufficiently so that the input to the frequency meter is insufficient for reliable operation. When this happens, it is desired to leave the altimeter at its last setting and for this purpose there is provided a weak signal cutout circuit 19 which operates a relay indicated generally at 21 to disconnect the servomotor.

In setting up the specifically illustrated system, there will be provided a plurality of ground stations, for example, at airports and at elevated hazards in the plane's path such as mountain peaks. In the operation of the system, the pilot will normally fly with the switch 9 in its left hand position as viewed in Figure 2. As the plane approaches a ground station and the signal strength becomes sufficiently strong to operate the bridge, the weak signal cutout circuit 19 permits the relay 21 to close to energize the servomotor. Thereafter, any unbalance in the bridge circuit formed by the output of the frequency meter circuit 11, regulated D. C. supply 12, and legs of potentiometer 13 effects an input into the amplifier-reversing circuit 14 which operates the servomotor 15 to both set the ground barometric pressure in the altimeter 17 and also to move the tap 18 to restore balance to the bridge at which point the servomotor is de-energized and the ground barometric pressure has been automatically set in the aircraft altimeter. If the barometric pressure at the ground station should thereafter change, the frequency of the audio frequency signal will be changed as will also the output of the frequency meter 11. This will again unbalance the bridge and cause an input to the amplifier-reversing circuit 14 to again supply the servomotor to reset the altimeter and restore the bridge balance.

As the plane travels away from the ground station and the signal strength fades, the weak signal cutout circuit 19 will operate as previously described to open the relay 21 and disconnect the servomotor 15 so that the setting of the altimeter 17 will remain at the last value received from the ground station and the servomotor will remain de-energized until another ground station signal of appropriate strength is received.

There is provided means for the pilot to check the operation of the automatic setting system. When the switch 9 is moved to the right hand pole position as viewed in Figure 2, a fixed frequency oscillator 22 is connected to the frequency meter circuit 11. This fixed frequency oscillator may be set at any desired frequency, for example, a value corresponding to standard barometric pressure. With the switch 9 in this test position, the circuit should then operate for the servomotor to move the altimeter setting to this standard number. If the system thus functions, the pilot is assured of its operation and upon return of the switch to the left hand position of Figure 2 the setting placed upon the altimeter 17 will be known to be the proper ground barometric pressure, if a ground station is within range.

The receiving system of Figure 3 utilizes a different frequency responsive unit and a follow-up system therefor for operating the setting shaft of the altimeter. The frequency oscillator and the weak signal cutout remain the same as previously described. In the system of Figure 3, the audio frequency output of the receiver 8 directly feeds one phase 23 of a synchronous motor 24. Across the output of receiver 8 there is connected a condenser 25 and resistance 26 in series. The capacity of the condenser 25 is high with respect to the resistance 26 at low frequency so that a substantially 90° phase shift is secured over a wide range of frequency at the point of connection between the condenser and the resistance. This point is connected to the grid 27 of an amplifier tube 28 having a cathode 29 and an anode 31 connected to feed the second phase 32 of the synchronous motor 24. The motor 24 will, therefore, rotate at a speed determined by the frequency of the audio frequency output of the receiver 8.

The synchronous motor 24 drives a drag cup tachometer indicated by a permanent magnet 33 connected to the motor and inducing a torque in a drag cup 34 tending to rotate the drag cup against a biasing spring, not shown, in conventional manner. Upon the shaft 35 of the drag cup 34 is mounted a contact arm 36. Cooperating with the contact arm 36 is a second contact arm 37 mounted on the setting shaft 38 of the altimeter 17, the shaft 38 having keyed thereto a driving gear 39 meshing with a pinion 41 driven by a reversing servomotor 42.

To operate the servomotor 42, there is shown a motor control circuit described and claimed in applicant's co-pending application Serial No. 644,136, filed January 29, 1946, entitled Motor Control. In this circuit an alternating current source is indicated by the lines 43 and 44 across which is connected a voltage dividing resistor 45 having a point 46 thereon adjacent the line 43 connected to the cathode 47 of an electronic tube 48 and also connected to the contact arm 36. The grid 49 of the tube 48 is connected through a grid bias resistor 51 to the line 43 and is also connected to the contact arm 37. Winding 52 of the two phase winding of the motor 42 is fed directly from line 43 through a condenser 53 and the winding 54 of the motor 42 is fed through a condenser 55 which is by-passed by the connection of winding 54 to the anode 56 of tube 48. Condenser 53 has a greater capacity than condenser 55 so that when tube 48 is not firing the current in the winding 54 leads the current in the winding 52 to rotate the servomotor 42 in one direction. When the tube 48 is firing, it provides a substantially resistive circuit feeding the winding 54 so that the current in winding 54 will

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follow that in winding 52 to reverse the direction of rotation of the motor 42. This motor reversal enables the contact arm 37 to follow the movement of contact arm 36 since tube 43 fires while the contact arms are engaged and is cut off while they are separated.

In the operation of the system of Figure 3, the audio frequency output of the receiver 8 drives the synchronous motor 24 at a rotational speed determined by the frequency of the signal. This exerts a torque on the drag cup 34 of the magnetic tachometer driven by motor 24 to position contact arm 36 at a point determined by the speed of rotation of the motor and hence by the frequency of the signal. Contact arm 37 follows movement of contact arm 36 though the operation of the reversing circuit for the servomotor 42 which drives pinion 41 to rotate the gear 39 to rotate the shaft 38 so that contact arm 37 follows the position of contact arm 36. As shaft 38 is also the setting shaft for the altimeter 17, this follow-up movement of the contact arm 37 will also effect automatic setting of the altimeter at the ground barometric pressure determined by the frequency of the audio signal.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a signal whose frequency varies in accordance with variation in the barometric pressure at the station comprising a receiver in the aircraft receiving said signal, means in said aircraft responsive to said signal frequency for effecting automatic barometric pressure setting of the aircraft altimeter, and means responsive to the strength of the signal received at the aircraft for rendering said setting means inoperative as the signal strength fades below a predetermined value.

2. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in the aircraft tuned to said fixed broadcast frequency, a frequency meter circuit fed by the audio frequency output of said receiver, said frequency meter circuit having a direct current output whose voltage varies in accordance with the variation of the input frequency, a fixed direct current source, a bridge circuit including the output of said frequency meter circuit and said direct current source, a servomotor for effecting setting of the aircraft altimeter and for varying the legs of said bridge circuit, means responsive to unbalance of the bridge circuit for operating said servomotor to change the altimeter setting and return the bridge circuit to balance, and a weak signal cut-out circuit for disconnecting said servomotor when the signal strength fades to a point where the output of the frequency meter circuit is insufficient to operate the bridge.

3. A system for automatically setting the ground barometric pressure in a barometric al-

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timeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in the aircraft tuned to said fixed broadcast frequency, a frequency meter circuit fed by the audio frequency output of said receiver, said frequency meter circuit having a direct current output whose voltage varies in accordance with the variation of the input frequency, a fixed direct current source, a bridge circuit including the output of said frequency meter circuit and said direct current source, a servomotor for effecting setting of the aircraft altimeter and for varying the legs of said bridge circuit, means responsive to unbalance of the bridge circuit for operating said servomotor to change the altimeter setting and return the bridge circuit to balance, a known frequency source in said aircraft, and means for optionally feeding said known frequency to said frequency meter circuit to determine by the altimeter setting corresponding to the known frequency and the operation upon removal of the known frequency source, the proper functioning of the system.

4. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in said aircraft tuned to said fixed broadcast frequency, a synchronous motor driven by the audio frequency output of said receiver, a drag cup tachometer driven by said synchronous motor and controlling the position of a first contact in accordance with the motor speed, a servomotor connected to effect barometric pressure setting of the aircraft altimeter, and a second contact driven by said servomotor to follow the position of said first contact.

5. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in said aircraft tuned to said fixed broadcast frequency, a synchronous motor driven by the audio frequency output of said receiver, a drag cup tachometer driven by said synchronous motor, a contact movable by said tachometer in accordance with variations in speed of rotation of said synchronous motor, a servomotor for effecting the barometric pressure setting of the aircraft altimeter, a second contact movable by said servomotor, and a control circuit for said servomotor including said contacts for effecting operation of the servomotor so that said second contact follows the position of said first contact with corresponding automatic setting of the ground barometric pressure in the altimeter in accordance with the signal frequency.

6. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station com-

prising a radio receiver in said aircraft tuned to said fixed broadcast frequency, a synchronous motor driven by the audio frequency output of said receiver, a drag cup tachometer driven by said synchronous motor and controlling the position of a first contact in accordance with the motor speed, a servomotor connected to effect barometric pressure setting of the aircraft altimeter, a second contact driven by said servomotor to follow the position of said first contact, and a weak signal cutout circuit for rendering said servomotor inoperative when the output of said receiver is insufficient to operate the synchronous motor at synchronous speed.

7. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in said aircraft tuned to said fixed broadcast frequency, a synchronous motor driven by the audio frequency output of said receiver, a drag cup tachometer driven by said synchronous motor, a contact movable by said tachometer in accordance with variations in speed of rotation of said synchronous motor, a servomotor for effecting the barometric pressure setting of the aircraft altimeter, a second contact movable by said servomotor, a control circuit for said motor including said contacts for effecting operation of the servomotor so that said second contact follows the position of said first contact with corresponding automatic setting of the ground barometric pressure in the altimeter in accordance with the signal frequency, a source of known frequency in said aircraft, and means for optionally driving said synchronous motor by said known frequency source to deter-

mine by the resulting altimeter setting and the operation upon removal of the known frequency source, the proper operation of the system.

8. A system for automatically setting the ground barometric pressure in a barometric altimeter for aircraft from a ground station broadcasting a fixed radio frequency carrier wave modulated in amplitude by an audio frequency signal varying in frequency in accordance with variation in barometric pressure at the station comprising a radio receiver in the aircraft tuned to said fixed broadcast frequency, a servomotor for effecting setting of the aircraft altimeter, means responsive to the audio frequency output of said receiver for operating said servomotor in accordance with variation in the audio frequency to set the altimeter to the barometric pressure of the ground station, a source of known frequency in said aircraft, means for temporarily feeding said known frequency to said responsive means to determine the proper functioning thereof, and means responsive to the strength of the signal received by said receiver for rendering said servomotor inoperative as the signal strength fades below a predetermined value.

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