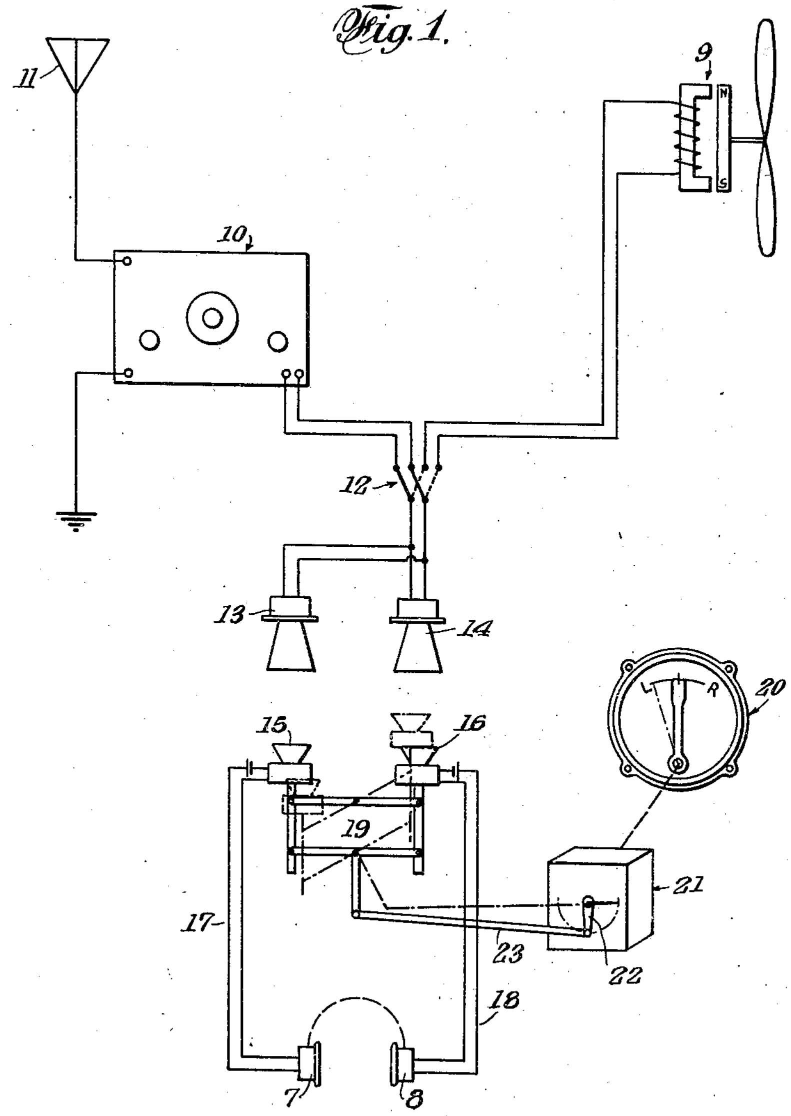
Fig. 1.



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BINAURAL FLYING

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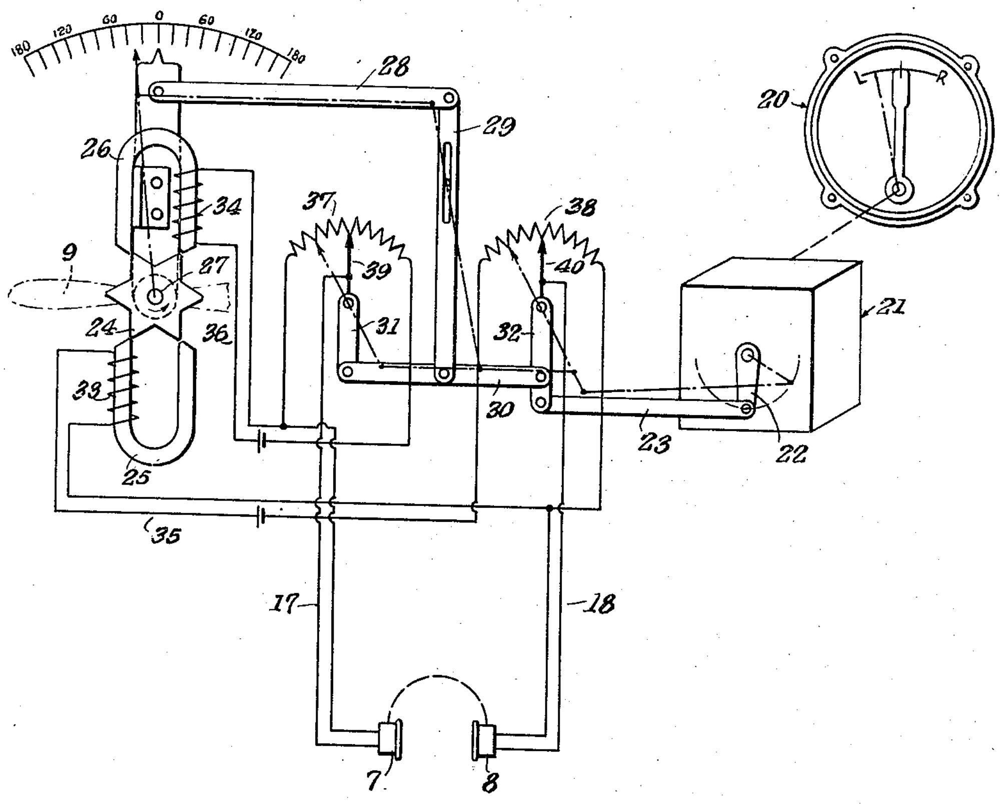
Fig. 2.



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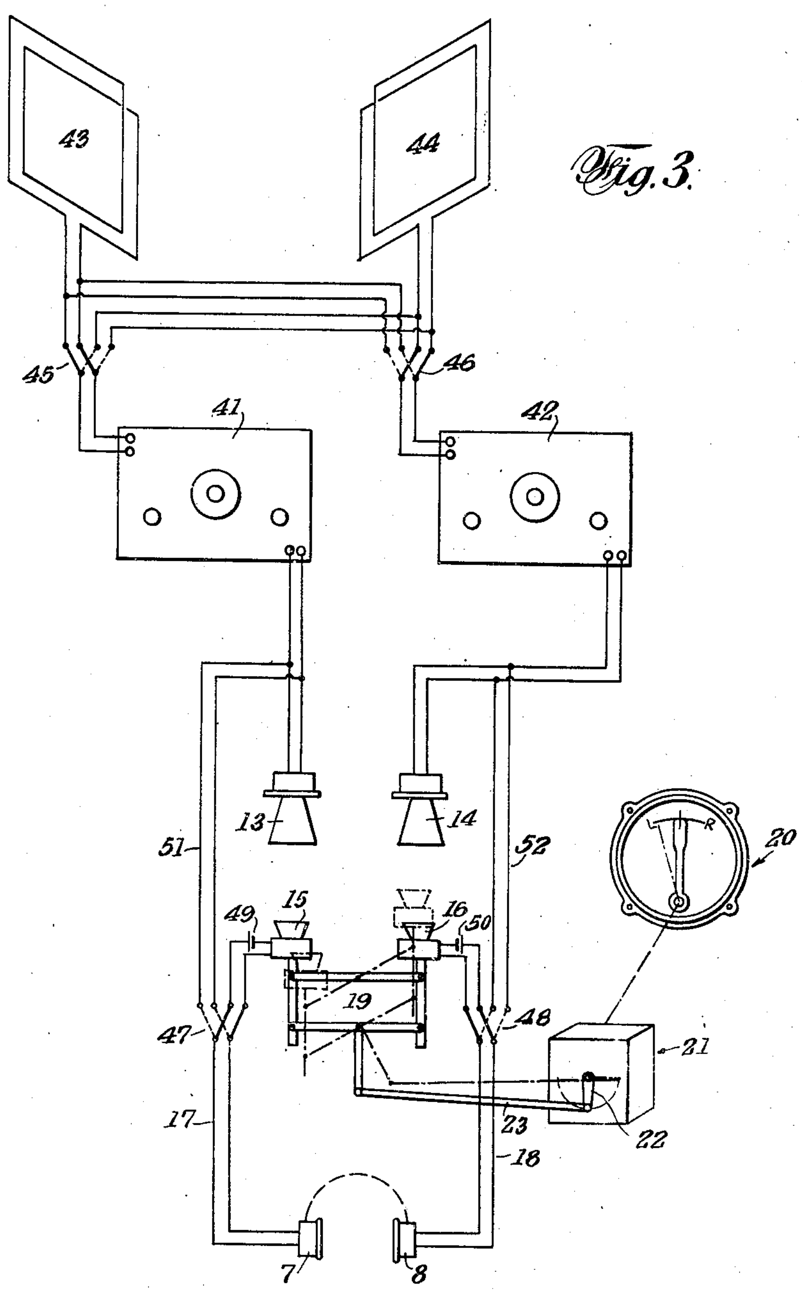

Fig. 3.

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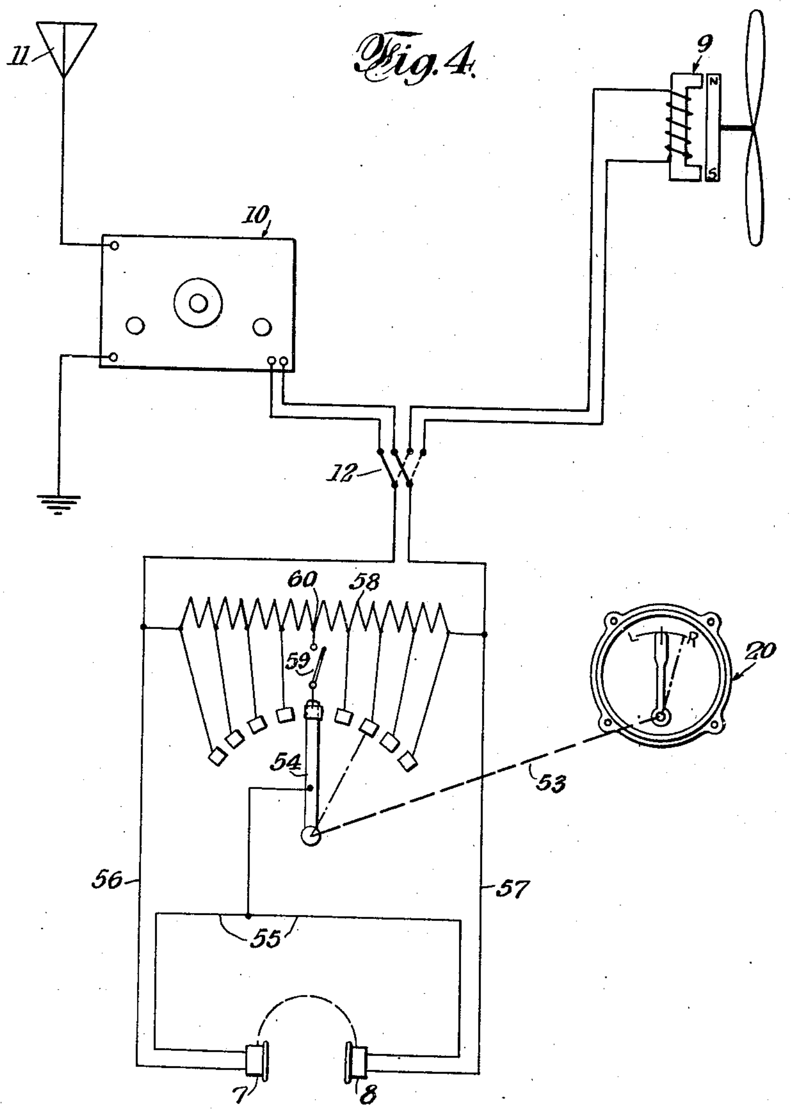
Fig. 4.



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2,103,248

BINAURAL FLYING

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14 Claims. (Cl. 177—311)

This invention is related to the fact that the direction from which a sound reaches the ears is sensed binaurally and that through binaural faculty, a course can be set in respect to such sound. Sound can thus serve as a reference for direction or attitude.

It is known that flight can not be maintained without some reference point or plane. Thus a pilot in a fog, without instruments, can not consciously maintain flight. This need for some reference applies even to bird flight as demonstrated by tests with hooded birds.

Heretofore, the needed reference for blind flying has been provided by visual observation of certain instruments, such as turn and bank indicators, artificial horizons and the like. An objection to instrument flying is that it requires the almost complete visual attention of the pilot and requires that the pilot immediately and correctly translate the meaning of the instrument readings into necessary corrective measures in the handling of the craft.

Special objects of this invention are to avoid these difficulties and objections, to utilize sound as a reference point and to make use of the binaural faculty in such a way as to render the act of flying as nearly natural and instinctive as possible.

Other objects are to provide efficient, reliable and practical apparatus for conveying the directional information to the pilot in a manner that can be sensed in this binaural fashion.

Additionl objects and the novel features of the invention will appear or are set forth in the following specification.

The drawings accompanying and forming part of the specification illustrate a number of different embodiments of the invention, but it will be appreciated, as the invention is understood, that the practical form of apparatus used may vary within wide limits, all within the broad scope of the claims.

Fig. 1 is a representation largely diagrammatic of one form the invention may take.

Fig. 2 is a similar view of another embodiment.

Figs. 3 and 4, like the preceding, are generally diagrammatic illustrations of other possible forms of the invention.

In the several views, binaural signal receivers are indicated at 7, 8. These may be the two telephones of an ordinary headset or other usual or special binaural receptive devices.

The signal, which in the end reaches the ears of the pilot as sound, may be generated locally or at some distant point.

Both possibilities are illustrated in Fig. 1, where there is shown a wind driven generator 9, to be mounted in some favorable position on the craft and a radio receiver 10, having a suitable antennae system 11, for picking up broadcast, beam, radio telegraph or other radio signals.

A changeover switch is indicated at 12, to enable utilization of either local or remote signal energy.

Suitably connected in the signal circuit are indicated the speakers or sound reproducers 13, 14, in spaced relation and of equal output.

Opposed to the speakers are indicated individual microphones or pickup devices 15, 16, individually in circuit at 17, 18, with the binaural signal receivers 7, 8.

The speakers 13, 14 and associated microphones 15, 16, are variably related, acoustically, electrically or mechanically, or in a combination of these ways, and in such manner as to create the desired binaural effect. In this particular illustration, the transmitters 15, 16, for the individual ear phones 7, 8, are mounted on parallel linkage 19, constructed to hold them in an intermediate position, opposite and equally distant from the sound reproducers 13, 14, and to shift either one toward one reproducer, while retracting the other from the other reproducer.

These adjustments have the effect of creating both phase differences and intensity variations, a lead in phase being established by the approach of one microphone and recession of the other, with attendant increase in intensity at the approaching microphone and loss of intensity at the receding microphone.

These combined effects of phase difference and intensity variations are strikingly evident in the head phones, providing binaural signals of marked characteristics. It is recognized that phase difference becomes less of a factor as the pitch of a sound increases, due to the reduction in the time between vibrations and that at the higher pitches the directional effect is determined largely by difference in intensity. The human mind is accustomed to the phase differences for the lower pitch sounds and to the intensity effect for the higher pitch sounds and for purposes of orientation, the mind expects and relies on phase difference for the lower pitch sounds and does not expect it or rely so much on it for the relatively high pitches. The gradation in effect of these changes in phase, with pitch, seems entirely natural and produces no unusual effect in sensing direction.

The phase and intensity variations are automatically effected in the illustration by means of a turn sensitive instrument, such as a turn and bank indicator 20, gyro compass or the like, acting through a servo-motor 21, or equivalent, to operate a crank 22 and link 23, for shifting the microphone linkage.

With the changeover switch 12 in the position indicated in full lines in Fig. 1, the speakers 13, 14, will be connected to the output of the radio receiver 10. This receiver may be tuned to a selected radio transmitting station, such as a station known to be in the desired direction of flight. Properly paired, the output of the speakers 13 and 14 will be equal. Therefore with the ship held on a course pointed at the transmitting station and the turn sensitive device maintaining the microphones 15, 16, in the intermediate full line position, equidistant from speakers 13, 14, the sounds picked up at 15, 16, will be of equal intensity and in phase and the pilot through the binaural faculty, will sense the source of sound as directly in front and steer accordingly. If the ship veers to the left, in the example, the turn sensitive instrument, through the connections indicated, will effect a shifting of the right hand pickup 16, toward speaker 14, and recession of the left hand pickup 15 from speaker 13, as indicated in the broken lines to effect an increase in intensity and an advance in phase of signal in the right hand receiver as compared with the signal in the left hand receiver. Consequently, the pilot, through his binaural sensibilities, is given the impression that the sound is toward the right and by a simple natural reaction, will swing the ship toward the right, back to the true course indicated by the equality of signal in both ears.

With appropriate controlling connections from the turn sensitive mechanism, phase and intensity variations may be amplified or even exaggerated, as desired. While experience has indicated that combined phase and intensity variations are the most readily recognized, as in line with the normal hearing functions of the ears, it is possible that either one or the other of these variations only may be utilized for course directing purposes.

In blind flight, it has been found that probably the most important control under ordinary circumstances, is the turn of the ship. This has lead to the development of the generally accepted "one-two-three system" in which turning movement of the ship is first stopped before other conditions are corrected. Many ships are so inherently stable that if turning is properly controlled, it is possible to operate, even in rough air with turn control alone. Therefore, the binaural reference to turn, alone, in a ship of proper stability enables flying to be safely accomplished.

With the switch 12 thrown to the right in Fig. 1, the local wind driven generator 9, can be utilized as the source of signal energy, the operation otherwise being then as before described. Additional indication is derived in this case however, in that changes in air speed as effected by diving or climbing, will occasion changes in frequency and hence vary the pitch of the sound heard by the pilot to notify him accordingly of such changes in the attitude of the airplane or other craft.

Fig. 2 illustrates a construction by which changes in phase and intensity are effected electrically. In this view the wind driven generator 9 includes a star wheel form of rotor 24, cooperating with generator poles 25, 26. The latter polar member 26 is shiftable about the axis 27, through the medium of link 28, lever 29, link 30 and levers 31, 32, the latter being connected with link 23, operated by the servo-motor 21.

The polar members 25, 26, carrying windings 33, 34, are connected by wiring 35, 36, across the non-inductive potentiometer resistances 37, 38. One head receiver 7 is connected by its wiring 17, with one end of resistance 27 and with movable potentiometer contact 39, and the other head receiver 8, is connected by its wiring 18, in the reverse order to potentiometer resistance 38, and to the adjustable potentiometer contact 40. These two variable contacts being carried by levers 31, 32, which are connected by link 30, it follows that with movement of the crank 22 of the servo-motor, potentiometer resistance will be cut into circuit of one phone, while being removed from the circuit of the other phone.

With the parts in the centralized intermediate position indicated in full lines, Fig. 2, the signal strength in both head phones will be equal, giving indication of straight, on the course, flight. With a turn to the left however, as indicated in the broken lines, the turn sensitive instrument, through the servo-motor, will effect a shifting of both potentiometer arms and the movable pole pieces 26, toward the left to reduce the voltage drop on the potentiometer at 37, across the left hand head phone 7, increase the potentiometer voltage drop at 38, across the right hand head phone and introduce a lag in phase into the winding 34, serving the left head phone 7. Consequently, there will be both an apparent lead in phase and an increase in intensity in the right hand ear phone, simulating the effect of turning leftward away from a sound source. The pilot to fly toward the sound source naturally will then swing his ship back to the right to bring it again in the line of projected flight. A swing to the right will effect the reverse operations.

The structure illustrated in Fig. 3, involves the general features of that shown in Fig. 1, but with the substitution of an independent directional receiving set for each of the speakers 13, 14. The two radio receivers are designated 41, 42, having their outputs directly connected to speakers 13, 14, and equipped with directional vertical loops 43, 44, in planes equi-angular counter-clockwise and clockwise respectively to longitudinal axis of the ship.

By means of double-throw cross connecting switches 45, 46, each receiver may be connected with either antennae.

In use, the receivers 41 and 42 may be first tuned to a source of radio signal in the direction of proposed flight and adjusted to the same gain by connecting first one and then the other with the same antenna and adjusting until the intensity is brought to the same in both ears. This ability of separate adjustment also enables the receivers being set to give the same sound in both ears in case the intended line of flight is not directly toward a remote station. Then with the switches 45, 46, in the solid line positions and flight held in the intended direction, the intensity and phase will be the same in both ears. Deflection from the intended line of flight however will effect, as before, displacement in phase and variations in intensity, giving the pilot immediate indication that he is swerving off the course and guidance binaurally by which he can bring his ship immediately back on the course.

Double throw changeover switches are indicated in Fig. 3, at 47, 48, by which the outputs of the two receivers 41, 42, may be sent directly into the binaural receivers 7, 8, instead of through the medium of the phase displacement and intensity changing couplings between speakers 13, 14, and the sound pickups 15, 16. It will be noted that with switches 47, 48, turned to the dotted line positions, the microphones or pickups 15, 16, with their energy sources 49, 50, will be cut out of circuit and the binaural receivers 7, 8, cut in on the receiver outputs through the branch leads 51, 52. If desired, in this latter use, the speakers 13, 14, may be cut out of action. Under the last described conditions, the separate receivers with directional loop antennae will give intensity variations in the binaural receivers, notifying the pilot instantly of any turning off the course and enabling the pilot to naturally and more or less instinctively swing the ship back into the line of desired flight.

The Fig. 4 construction is generally similar to that first illustrated, except that the signal output from the non-directional receiving set or wind driven generator is applied to the binaural receivers through a potentiometer controlled directly or indirectly from the turn sensitive instrument 20. In this illustration, the turn sensitive device is indicated as connected at 53, with the movable arm 54, of the potentiometer, which arm has common connections 55, with both binaural receivers, the latter having individual connections 56, 57, with opposite ends of the potentiometer resistance 58, so that with change in direction, intensity of signal will be increased in one ear, while being reduced in the opposite ear.

Thus in the illustration, with turn to the right, the potentiometer arm will be displaced to the right as indicated in the broken lines, to increase the signal in the left ear and reduce signal strength in the right ear, giving the pilot the sense of turning right-handedly away from the signal source and urging him to swing left, back onto the course.

Fig. 4 illustrates further the special feature of a quiet or silent zone for indicating on the course position. This is shown simply as a switch 59, by which a central section 60, of the resistance may be cut out of circuit, so that with the potentiometer arm in a generally central position, no signal will be heard in either ear phone. Upon deviation from the intended direction however, the signal will be cut in on the ear phones as before described. This construction or equivalent, enables the pilot to pick up the direction signal and after setting his course, cut out the signal and keep it out, so long as proper direction is maintained. The instance of signal reception in addition, then becomes a notice or warning of deviation from the course. Checking of the signal may be effected at any time by simply closing switch 59.

With the possibility of signal reception from two different sources as in Figs. 1 and 4, there is always the opportunity of checking one against the other. This same feature may be incorporated in the systems illustrated in Figs. 2 and 3.

While it may be the more natural way to pick up a sound source and then fly toward that source, it is contemplated that the reverse procedure may be followed, that is, to use the signal as a warning notice, as in a construction on the order of Fig. 4, where a signal is heard only when the pilot turns off the course to one side or the other.

The use of a radio receiver or receivers as the signal source has special advantages but subjects the pilot to conditions at the transmitting station and the intervening distance. The wind driven or local signal generating hook-up makes the entire system a self-sufficient unit. A combination of the two signal sources such as indicated in Figs. 1 and 4, may usually be desirable, as enabling the pilot to figure on a ground station of fixed location and if a particular station be off the air or difficult to hear, then to shift over to the local signal source. The apparatus is relatively simple and may be quite compact. Any ordinary receiving set already present on the plane may be used as the signal source. The phase displacement and intensity variations may be directly proportional to the extent of turn or deviation from direction, so that the pilot will have a proportional or quantitative sense of the change and can apply corrective measures accordingly. Many changes in structure are possible, so the terms employed herein should be considered in a descriptive rather than in a limiting sense, except possibly as limitations may be imposed by state of the prior art. Thus the variable connection with the binaural receivers may be effected in various ways, as for example by absolute connection and disconnection or merely modification of resistance in the two phone circuits. The directional loops indicated at 43 and 44 in Fig. 3, may be of the flat type, instead of upright as shown.

In all the various forms of the invention, the piloting, steering or flying of the craft is made quite natural and instinctive through the creation of a sound reference and the utilization of the binaural faculties to locate or sense the direction of that reference. The ears are thus made use of in their normal and natural capacity of sensing direction without taking the attention of the pilot away from other duties. While the turn indication is the main requirement, particularly for safety in blind flying, the invention contemplates other indications, such as the angle or pitch indication provided by the local wind driven form of signal source illustrated in Figs. 1 and 2, where with change in angle, as in diving, the frequency and hence the pitch of the signal will increase, while in climbing the frequency and correspondingly the pitch will drop. In blind flying, this change in signal tone, regardless of whether the ship is in a turn or on the straight course, will indicate to the pilot if the ship is nosing up or down.

What is claimed is:

1. Apparatus for the piloting of aircraft or the like, comprising in combination, binaural receivers, a turn indicator and means controlled by said turn indicator for impressing on said receivers signals varying in phase and in intensity in accordance with direction of turn.

2. Apparatus for the piloting of aircraft or the like, comprising in combination, binaural receivers, a turn indicator, means controlled by said turn indicator for impressing on said receivers signals varying in phase and in intensity in accordance with direction of turn, said means including variable resistance and signal phase displacement mechanism actuated by said turn indicator.

3. Apparatus for the piloting of aircraft or the like, comprising in combination, binaural receivers, a turn indicator, means controlled by said turn indicator for impressing on said receivers signals varying in phase and in intensity in ac-

cordance with direction of turn, said means including variable resistance and signal phase displacement mechanism actuated by said turn indicator, said phase displacement means operating at audio frequency and said signal means including a receiver of radio frequency.

4. Binaural piloting apparatus, comprising in combination with aircraft, a radio receiver on said aircraft, binaural receivers on said aircraft, a turn indicator on said aircraft and means operated by said turn indicator for variably impressing the output of said radio receiver on said binaural receivers in accordance with direction of turn.

5. In apparatus of the character disclosed, a turn sensitive instrument, a servo-motor controlled thereby, binaural receivers, a source of signal energy for said receivers and means operable by said servo-motor for variably impressing signal energy from said source on said binaural receivers in accordance with direction of turn.

6. In apparatus of the character disclosed, a dual circuit signal generator, binaural receivers connected respectively in the circuits of said signal generator, turn sensitive means for effecting difference in phase in said binaural signal circuits and associated means for simultaneously increasing intensity with advance in phase.

7. In combination, a non-directional radio receiver, a turn sensitive instrument, binaural receivers and means operable by said turn sensitive instrument for selectively connecting the output of said non-directional radio receiver with said binaural receivers in accordance with deviation from direction.

8. In apparatus as disclosed, the combination of binaural receivers, a signal source, a turn sensitive instrument and connections between said signal source and the respective binaural receivers, including means operable by said turn sensitive instrument for introducing phase displacement in said binaural receivers in accordance with deviation from direction.

9. In combination, radio receivers having directional antennae in spaced relation, binaural receivers connected respectively with said radio receivers, and turn sensitive means for introducing differences in phase in the binaural receivers in accordance with deviation from direction.

10. In combination, a signal source, speakers energized thereby, pickup devices movably related to said speakers, binaural receivers connected with said pickup devices and turn sensitive means for effecting the shifting of said pickup devices reversely toward and away from said speakers.

11. Binaural flying apparatus, comprising in combination with aircraft, binaural receivers on said aircraft, a radio receiver on said aircraft coupled to said binaural receivers and means on said aircraft including an instrument shiftable in accordance with change of direction of flight of said aircraft for introducing varying binaural effects in the output of said radio receiver in accordance with deviation from direction.

12. In the flying of aircraft, an instrument sensitive to change in attitude, binaural receivers, signal means for said receivers and means operable by said instrument for varying the phase and intensity of the signals from said signal means in said binaural receivers in accordance with deviation from predetermined attitude and for simultaneously increasing intensity with advance in phase of signal in one binaural receiver while simultaneously reducing intensity with retardation of phase in the other binaural receiver.

13. Apparatus for the piloting of aircraft, comprising in combination binaural receivers, a signal generator of variable frequency in accordance with air speed and means for selectively impressing signal energy from said generator on said binaural receivers in accordance with deviations from predetermined flight attitude and including mechanism for also shifting the phase of the signals in the binaural receivers in accordance with deviation from predetermined flight attitude.

14. In apparatus for maintaining aircraft flight, the combination of mechanism sensitive to deviation from predetermined flight attitude, a servo-motor controlled thereby, binaural receivers, a source of signal energy for said receivers and means operable by said servo-motor for selectively directing energy from said signal source to said binaural receivers in accordance with deviation from said predetermined flight attitude.

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