PUBLISHED
MAY 18, 1943.
BY A. P. C.

R. WELLENSTEIN

MICRO CHRONOMETER, IN PARTICULAR FOR LANDING ALTIMETERS ON AIRCRAFT FOR MEASURING THE ALTITUDE BY MEANS OF SOUND WAVES BY THE ECHO SOUNDING METHOD

Filed June 12, 1939

Serial No. 278,776

FIG. 1.

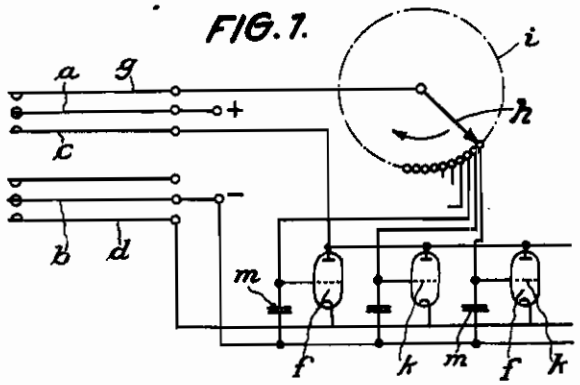


FIG. 2.

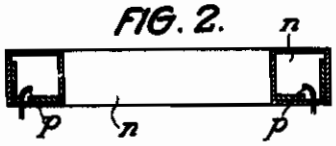


FIG. 3.

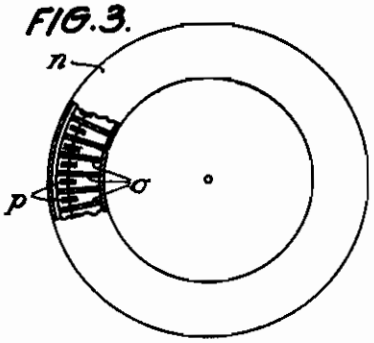


FIG. 4.

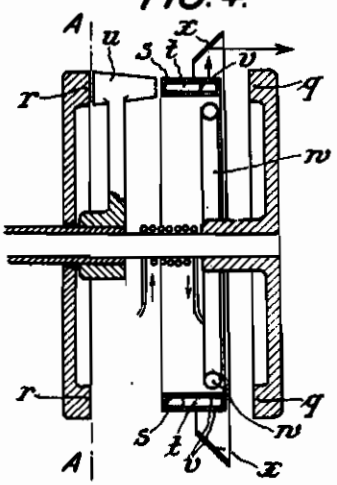


FIG. 5.

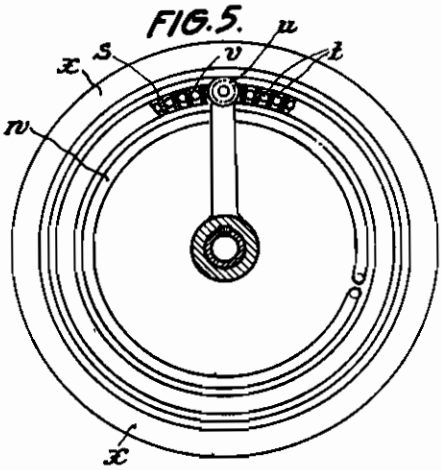


FIG. 6.

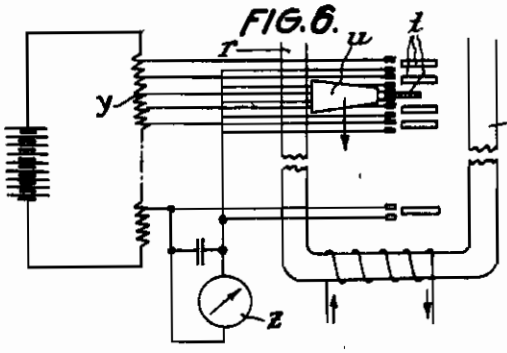
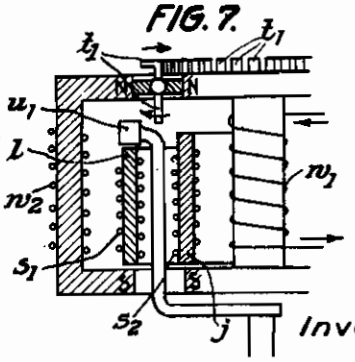


FIG. 7.



Inventor,
R. Wellenstein
By:
Glascock Downing & Seebold
Attorneys.

Published May 18, 1943 Serial No. 278,776

ALIEN PROPERTY CUSTODIAN

MICRO-CHRONOMETER, IN PARTICULAR FOR LANDING ALTIMETERS ON AIRCRAFT FOR MEASURING THE ALTITUDE BY MEANS OF SOUND WAVES BY THE ECHO SOUNDING METHOD

Robert Wellenstein, Bremen, Germany; vested in the Alien Property Custodian

Application filed June 12, 1939

The invention relates to micro-chronometers, in particular for landing altimeters on aircraft for measuring the altitude by means of sound waves by the echo sounding method, having a time-giving member which moves to and fro or rotates at a definite speed and the position of which with respect to the initial or zero position is shown at the end of the time to be measured by the echo or other phenomenon, by a visible indication on a scale calibrated in time or distance units.

With the known micro-chronometers of this nature, the indication is always only visible for a very short time determined by the duration of the echo impulse or other phenomenon. This makes the observation very difficult.

In measuring by the echo sounding method, attempts have already been made to create the impression of a continuous indication by increasing the rate of the sounding sequence. This process can only be used, however, with advantage when the time of transit of the sound is short.

It has also been already suggested to attain a permanent indication by retaining the indication caused by the echo during the period up to the next echo impulse. This retention was obtained by a condenser which was brought by the echo to a potential corresponding to the time of transit of the sound, this potential being taken from a condenser discharging from the instant of the emission of the sound. This solution is not, however, advantageous, as a sufficient accuracy cannot be thereby attained, since the ratio of magnitude of the condenser giving the potential and of that taking the potential cannot in practice be so increased that the potential of the large condenser is not markedly varied by what is taken from it by the small condenser. Furthermore, the small condenser cannot be made as small as desired, since with a slow sounding sequence the potential of the small condenser, even when using a voltmeter (tube voltmeter) of very high ohmic resistance, is reduced by the current discharge.

A process for echo sounding is also known in which a stop-watch is used which is stopped by the echo, and remains stopped up to the instant of the next sound emission, when it moves again during the period of transit of the sound so that even though there is a more or less long stoppage of the indication, no permanent indication is attained.

All these drawbacks are obviated according to the invention in that, using a mechanical, e. g. reciprocating or circularly moved time-giving member, the visible indication is maintained throughout the duration of the echo impulse and is only extinguished by a device actuated by the following echo. In this way, a permanent indication is attained without, however, the indication suffering a loss in accuracy such as occurs with the known permanent indication with condenser discharge. A relatively large number of mechanical or optical indicating members are preferably arranged distributed over the scale of the indicating appliance, and are so connected with a relay arrangement actuated by the echo impulse that, on the arrival of the echo impulse, only the indicating member allocated to the position then reached of the time-giving member is displaced by the controlling time-giving member into the indicating position or indicating condition, all the other indicating members being meanwhile brought into the position of rest or retained therein. The indicating members may consist of gas-filled luminous tubes or luminous tube elements with auxiliary electrodes arranged in a common vessel, which tubes or tube elements on the arrival of the echo are all at first temporarily switched off by the closed-circuit current potential, whilst that luminous tube or luminous tube element, which is allocated to the position occupied by the time-giving member on the arrival of the echo, is set with its auxiliary electrode at an illumination potential.

When using a relay which after a brief deflection returns into its initial position, the illumination potential can be retained on the auxiliary electrode by a condenser until the closed-circuit current potential is again applied. It is naturally also possible by different change-over times of two relay contacts to keep the ignition potential on the auxiliary electrode until the closed-circuit current potential is again applied to the tube.

A relay can also be used with advantage which is provided with a number of actuating members, corresponding to the number of the indicating elements, which are so influenced by the time-giving member that on the arrival of the echo impulse only that actuating member corresponding to the position then existing of the time-giving member is brought or held in the indicating position, whilst the other actuating members are brought or held in the position of rest. A suitable embodiment of such a relay can be attained by the actuating members being so movably carried as armatures between the two poles of an electromagnet, that in both terminal posi-

tions they are closer to one pole of the magnet than to the other, and that constantly a piece of soft iron carried by the time-giving member circulates between the actuating members and the remoter magnet pole, in such manner that on the excitation of the magnet by an echo impulse, only that actuating member which is opposite the piece of soft iron is drawn towards the remoter magnet pole, all the others being drawn, on the contrary, to the nearer magnet pole. The actuating members of the relay can be held in the fresh position produced by the echo, by their own gravity, by frictional forces or by other breaking devices even after the expiration of the echo impulse, and in this way be specially used as indicating members, preferably in the form of light baffles. In this way, any electric switching operation either by the time-giving member or by the individual relay members is entirely avoided.

Various ways of carrying out the invention are illustrated diagrammatically in the acompanying drawings, in which:

Fig. 1 shows a circuit arrangement with gas discharge tubes as indicating members,

Figs. 2 and 3 show an indicating device with indicating elements arranged in a common vessel, in cross-section and plan respectively,

Fig. 4 is an axial section of a third embodiment of the indicating apparatus,

Fig. 5 is a cross-section on the lines A—A of Fig. 4,

Fig. 6 shows a fourth embodiment with the time-giving arrangement and relay developed; and

Fig. 7 shows a fifth embodiment partly in section.

The devices shown may, for example, be used for determining the altitude of flight on aircraft by the echo sounding method. In the echo-method, the time between the emission of the sound impulse and the return of the echo is determined. The arriving echo in this case releases an electric relay arrangement whereby a visible sign is produced on the scale of the indicating appliance.

There is used as the relay in the first embodiment shown in Fig. 1, a micro-chronometer with two sets of contacts. The two moving contact arms *a* and *b* of the relay are connected with the two terminals of a source of potential. In the position of rest, this potential is applied across the contacts c and *d* connected respectively to the anode and cathode of a number of gas-filled luminous tubes *f* which are connected in parallel and are arranged distributed over a circular or rectilinear scale. On the arrival of an echo, all the tubes *f* are, as will easily be seen, simultaneously disconnected from the source of potential and the relay arm *a* connected with the positive pole strikes against a contact *g* which, through a contact arm *h* rotating with uniform speed and a collector *i*, is connected with the grid *k* of a tube *f*. The contact arm rotates in synchronism with the sounding sequence. It produces on the emission of the sound the connection with that tube *f* which is in the zero position of the scale. The grids *k* of the tubes *f* are connected not only with the collector *i* but also each through a condenser *m* with the negative pole. Thus, on the arrival of an echo, the condenser *m* of that tube which is just at this instant connected through the collector *i* with the rotating contact arm *h* is charged. On the return of the contact levers *a* and *b* of the relay into the initial position (c, *d*) a potential is again applied to the anode and cathode of all the tubes. This potential is, however, so slight that it does not normally cause the tubes to light up. Only that tube the grid condenser *m* of which has obtained potential through the collector *i* and the rotating contact arm *h* is now illuminated. Immediately after the illumination of the tube, the potential on the grid condenser *m* again collapses as this potential can no longer be maintained on the flowing of the closed-circuit current. As soon, therefore, as a fresh echo arrives and the relay responds, the previously illuminated tube is also extinguished and, on the return of the relay into its position of rest, only that tube can again be ignited the condenser of which is again brought to illumination potential through the collector *i* and the revolving contact arm *h*.

It is advantageous to use the negative blue glow for the indication, since only a comparatively small potential is necessary for its production. Instead of a large number of separate luminous tubes, there may be provided individual luminous tube elements which, as shown by Figs. 2 and 3, are arranged in a common vessel *n*. This vessel is subdivided by partitions o into separate compartments. By means of separate auxiliary electrodes *p* introduced into the chambers and to which an illuminating potential can be applied in the same way as to the grids of the circuit arrangement of Fig. 1, the negative blue glow can be produced separately in the individual chambers.

Figs. 4 and 5 show an arrangement in which the relay has a large number of actuating members, which themselves act as indicating members. These actuating members consist of separate small rods *t* movable in brass tubes *s* or similar guides, between the two poles *q* and *r* of an electromagnet. Here, the travel of the rods *t* is so limited by the ends of the guides *s* that the rods are, in both terminal positions, closer to the one pole *q* of the electromagnet. If, consequently, the electromagnet is energised on the arrival of the echo, the rods *t* which consist of ferromagnetic material are always more strongly attracted by the pole *q* than by the pole *r*. This holds good for all the rods *t* arranged in the circumference of the magnet with only one exception. Between the rod guides *s* and the further magnet pole *r*, there rotates continuously with uniform velocity a piece of soft iron (pole piece *u* for *r*), corresponding approximately to the size of one of the rods *t*. By means of this piece of soft iron, the distance of the rod *t*, which is at the position in question, from the magnet pole *r* is, contrary to all the other rods, smaller than the magnet pole *q*, so that this one rod is attracted to the opposite side to all the other rods. In the guides *s* are formed radially extending apertures *v* behind which is a source of light *w* extending round and continuously illuminating the whole circumference. As can easily be seen, the luminous opening *v* is always only left free by that rod *t* which at the instant of the arrival of the echo is opposite the revolving piece of soft iron *u*, vide rod *t* in Fig. 4 at the top.

To strengthen the action, there could if necessary be allocated to the revolving pole piece *u* a further ring-shaped pole piece revolving in front of the other magnet pole *q* and having a gap at the position of the pole piece *u*.

The rods *t*, since they are all carried hori-

zontally, remain by their own weight in the fresh position produced by the echo impulse until the next echo arrives. If necessary, further separate braking devices could be provided in order to ensure the terminal position at any time reached by the rods *t*. There is also provided for observing the luminous beams which are radially directed outward through the openings *v*, an annular mirror *x* inclined at 45°, which deflects the rays of light from the radial direction through 90° into the axial direction.

It is furthermore also possible to use the rods *t* of the arrangement according to the Figures 4 and 5, not as light baffles but as actuating members which switch on and off the current circuit releasing the indication. Fig. 6 shows an example of this where the relay, for the sake of clearness, is shown developed. In this case a suitable potential is applied to each rod or actuating member *t*, for example through a potentiometer *y*, and in such manner that the lowest potential is applied to the actuating member or rod in the zero position, and to each subsequent one a regularly increasing potential. Instead of rods, levers can be used which can be drawn through an unstable central position towards one or other terminal position. There is here used as the indicating member a voltmeter *z* which is preferably strongly damped, and has a small natural oscillation period but which need not be of great ohmic resistance. If this voltmeter, as in the example illustrated, is made in the form of a pointer instrument, it is advisable for steadying purposes to arrange a condenser in parallel with the voltmeter.

The improved appliance is particularly suitable for use as a landing altimeter for aircraft since it is distinguished by an especially simple and easy construction and ensures the continuous indication specially desired by aircraft. But the improved process and the device can also be used with advantage in combination with other echo sounding installations. The circuits according to Figs. 1, 2, 3 and 6 have the further important advantage that they permit the separation of the time-giving mechanism and the actual indicating appliance, so that only the actual indicating appliance need be fitted at the observation post, whilst the time-giver can be mounted at any other position more favourable for operation and space utilisation.

Fig. 7 shows a modified form of the relays used in the arrangements according to Figs. 4 to 6. In this embodiment a supplementary winding *w1* and *w2* is provided through which a continuous current flows and a polarisation is attained in order to ensure a secure holding of the actuating members in their terminal positions. Furthermore, with this embodiment, there are provided two separate magnetic circuits. The relay consists of an inner circular magnet of double-T-shaped cross-section and an outer magnet of U-shaped cross-section annularly surrounding the former. The windings *w1* and *w2* have a magnetising action in such sense that like poles of the two magnets are opposite each other. The actuating members *t1* are oscillatably carried between the two North poles in such manner that they lie in one terminal position in the circuit of the inner magnet, and in the other terminal position in the circuit of the outer magnet. In order to attain a good magnetic closed circuit and a powerful attractive action on the oscillatable armatures *t1* there are provided between the poles of the inner and outer magnets ring-shaped magnetic closure members *l* and *j* respectively. These members are of different length, so that in the range of oscillation of the armatures *t1* there are air gaps of different length. There are provided on the two magnetic closing members, windings *s1* and *s2* which are excited by the echo impulse to the same extent and in such manner that they assist the windings *w1* and *w2* of the corresponding magnetic circuit. In front of the magnetic closure member *l* of the outer magnet there revolves with uniform velocity a piece of soft iron.

The armatures *t1*, as is clearly seen, can only be held in the two terminal positions, since in the central position shown on the drawing they assume an unstable equilibrium and by the magnetic attraction of the two magnets are either attracted inward or outward. Let it be assumed that all the armatures are located in the circuit of the inner magnet. On the arrival of an echo impulse, all the armatures will remain in their inner position. Only the one armature which is just opposite the revolving piece of soft iron *u1* will be drawn out of its inner position into the circuit of the outer magnet. It also remains in this position, since the polarisation of the outer magnet suffices to retain the armature in its position. On the next echo impulse, however, the attractive force of the inner magnet suddenly preponderates in such manner that the armature is again drawn back into the circuit of the inner magnet, assuming that the rotating piece of soft iron is this time in some other position.

The polarisation could alternatively be obtained by the use of permanent magnets instead of by supplementary windings *w1* and *w2*. It would also be possible to combine the two ring-shaped closure members *l* and *j* into a single closure member and to cause the piece of soft iron of the time-giving member to rotate between the poles of the two magnets as with the embodiments according to Figs. 4, 5 and 6. Furthermore, instead of oscillatable armatures, displaceable armatures could be used. The arrangement of oscillatable armatures has, however, the advantage that with the arrangement of a weight-equalising counterpoise arm, the influence of gravity on the position of equilibrium can be entirely excluded, so that the arrangement works properly in any desired position (arrangement in the centre of gravity). The counterpoise arms can, as shown in the embodiment illustrated, be provided with vane-like bent parts which can be used directly as indicating members and can co-operate with a suitable circular scale. If it is desired not to mount the relay with the time-giving member and its drive at the observation position, the relay, on account of the contact pressure attainable, is nevertheless also suitable to a special extent for the remote control of the actual indicating device, the armatures *t1* being used as switching members for electric current circuits in a manner similar to that shown in Fig. 6.

The difference of the magnetic forces acting on the relay members, instead of being attained by different widths of the air gaps, can also be attained by correspondingly different construction of the magnet windings *w1* and *w2* or, if a preponderance of the magnetic force in one or other direction is only desired for the instant of the echo impulse, by different construction of the windings *s1*, *s2* traversed by the echo impulse. The necessary difference in the ampere turns can obviously also be attained by a different current

distribution instead of by a corresponding number of turns.

In particular with aircraft echo sounding double echoes which interfere with the indication frequently occur as a result of multiple reflection between the wings and the surface of the earth. To prevent such double or other interfering echoes following the first useful echo from suppressing the true indication and being themselves indicated, a device is provided which is actuated by the first echo arriving after the emission of the sound and makes the indication of the subsequent echoes impossible until a fresh sound emission. This may be obtained, for example, by a relay actuated by the first echo which switches out the amplifier of the echo sounding device. This relay must only be reconnected on the next emission of sound. In this way, the result is attained that an indication of the first echo is not affected by further double or interfering echoes, which is naturally of special importance in connection with the present continuous indication method.

Naturally, the invention is not restricted to the examples shown, but many modifications and other designs are possible. In particular, instead of the light indication, an indication could be given by mechanical members such as tongues, pointers or the like. In the embodiment according to Figs. 4 and 5, instead of interposing a soft iron pole piece, a preponderance of the magnetism on the one side could also be attained in a different way, e. g., by a permanent magnet or by an electromagnet excited by the echo impulse.

Using the potential method according to the example illustrated in Fig. 6, the potential given by the potentiometer to the voltmeter at the instant of the echo impulse could be retained by a single condenser connected in parallel with the voltmeter instead of by a special relay contact. A relay with a number of movable contact members corresponding to the number of the desired indication values would then no longer be necessary, but a normal relay could be used, the moving contact member of which on deflection would apply the potential controlled by the time-giving member for a short interval of time to the condenser in parallel with the voltmeter until this has taken up a charge corresponding to the new potential and has then again returned into its initial position. It is possible to use a condenser which is so large that its potential does not appreciably vary in the interval of time between two echoes due to the load caused by the voltmeter. Preferably a high ohmic voltmeter is used.

ROBERT WELLENSTEIN.