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N.V. PHILIPS' GLOEILAMPENFABRIEKEN

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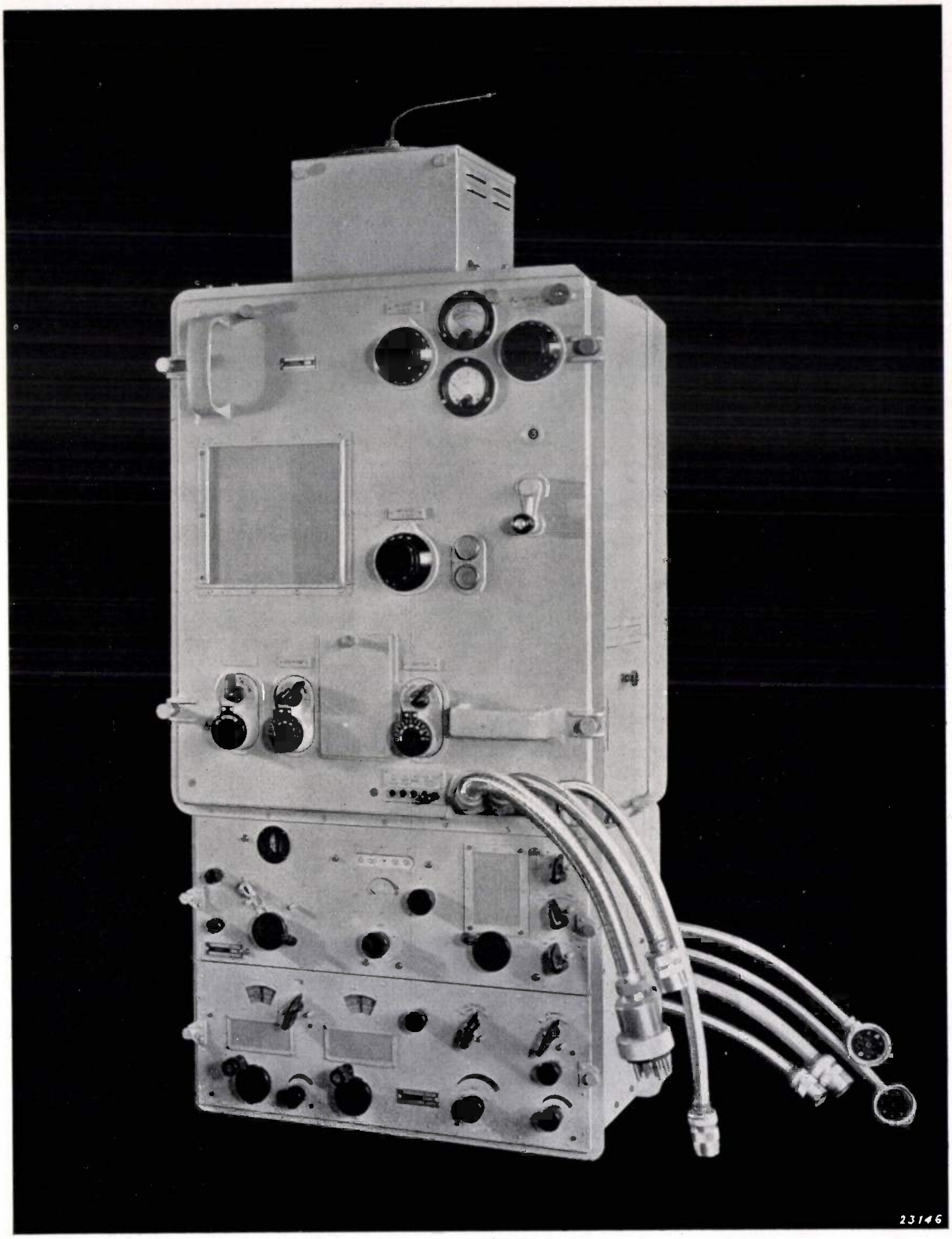
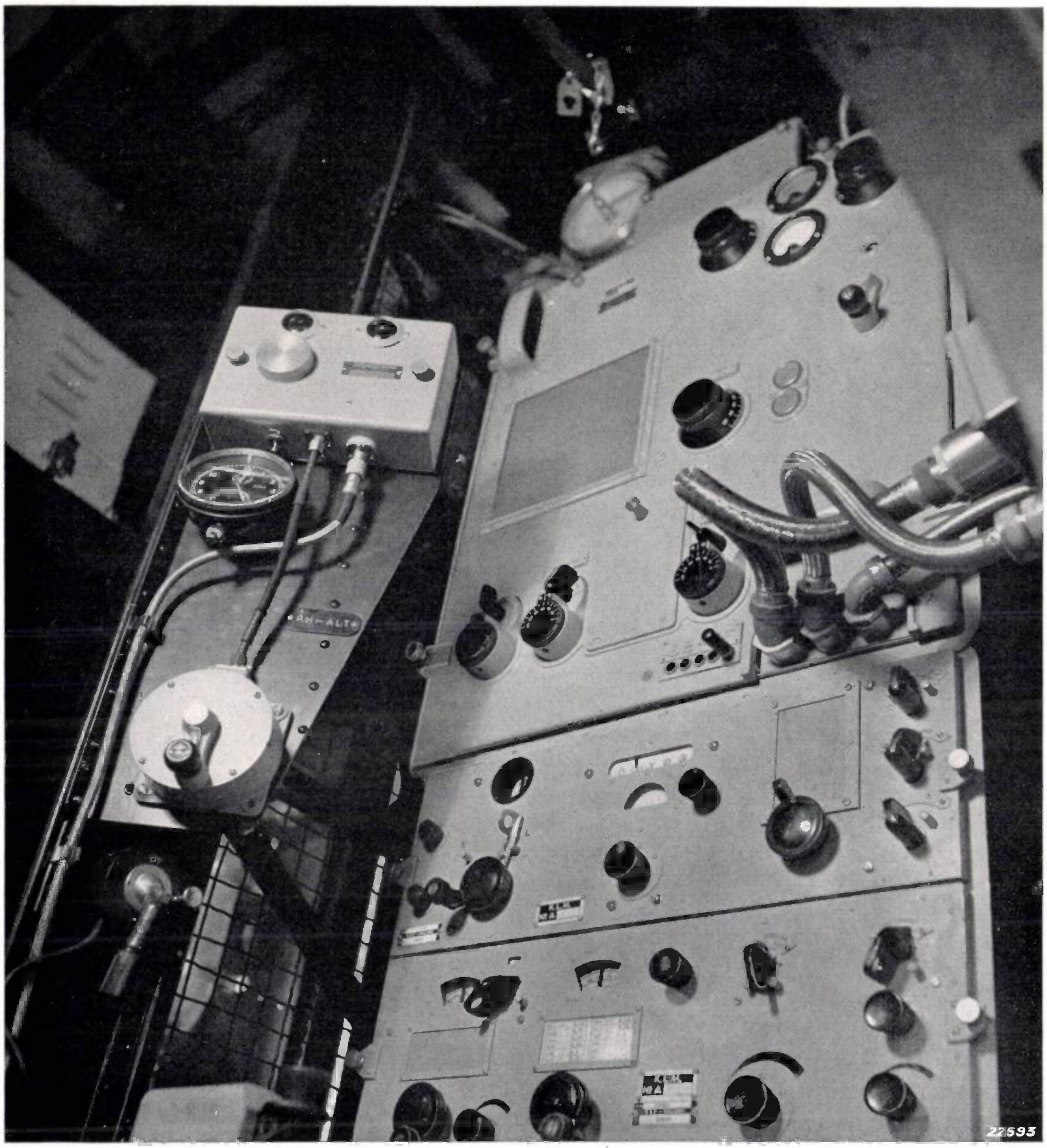
TWO PHOTOGRAPHS OF THE TRANSMITTING AND RECEIVING EQUIPMENT V.R. 35 COMBINED WITH THE AUTOMATIC PILOT V.P.K. 35.



The three section switchboard contains from the top downwards: the transmitter, the automatic pilot and the receiver.



The same transmitter and receiver installation installed in a Douglas aircraft, combined with the automatic pilot or course finder. On the left next to the receiver is the Morse key. The crank on the left next to the automatic pilot serves for controlling the frame aerial, whose position is indicated at the round windows in the small box above the crank. The equipment is installed behind the pilot. The wireless operator sits sideways so that the switchboard is close to his right hand side. A detailed description of the course finder is given in the article commencing on pag. 184 of this issue.

POSITION FINDING AND COURSE PLOTTING ON BOARD AN AEROPLANE BY MEANS OF RADIO

Summary. In this article several radio receiving arrangements are described, with which it is possible to plot the course and take radio bearings on board an aeroplane.

Introduction

The necessity of determining the position of aeroplanes by means of radio has become more urgent now that more and more flying is being done in the upper air. Originally a pilot had to depend for his navigation entirely upon the ground service, which at his request gave his position and the compass course he should follow. To do this the aeroplane asks one of the direction-finding stations on the ground to determine his position with at least one other D-F station. The aeroplane transmits a continuous signal for some time so that the D-F stations can determine the direction from which the signals are received. One of the ground stations then works out these cross-bearings on the map and signals the resulting position to the aeroplane. Even with long practice the taking of such cross-bearings of an aeroplane occupies at least two ground stations for several minutes. If in a given region there are other aeroplanes which are demanding their position or their course, they must await their turn. With the increase in speed of aeroplanes such a wait became more and more of a disadvantage, while because of the increasing density of air traffic it has become more and more unavoidable. An attempt is being made to limit as far as possible the demand for bearings from the ground service by equipping the machines with instruments which make it possible for the pilots to determine their own course and position.

If there is a radio transmitter in the line of flight of an aeroplane, then the correctness of the course followed can be checked with a relatively simple instrument, a so-called course finder, which can be installed in even small private aeroplanes. If, however, one's course is toward an aerodrome where there is no transmitter in the neighbourhood the course can be checked by finding the position at short intervals by means of a radiogoniometer. In order to take such radio bearings one must be provided with a more highly perfected measuring instrument, a so-called homing device which can be installed on board the larger aeroplanes. When bearings are being taken, however, the radio-telegraphist must neglect his ordinary radio traffic service duties, such as receiving weather reports and the like, and enquiring about the landing possibilities.

Course finder

With the aid of the Philips' course finder V.P. 4, shown in *fig. 1*, which can be used in series with an ordinary receiver, one is able to check the correctness of the course followed in a simple way. The action of this instrument is based upon the directional reception by means of a loop aerial, which is situated on or in the case of wooden construction inside the body of the aeroplane with its plane perpendicular to fore and aft line of the machine.

Fig. 1. Course finder, type V.P. 4.

Fig. 2 shows the horizontal polar diagram of a vertically placed loop receiving a constant signal. If the North-South direction is perpendicular to the plane of the loop, the polar diagram consists of two circles touching each other along the line of that direction as drawn in fig. 2 (figure-eight diagram). If we choose a course directly toward a radio station, it will be received with minimum strength on the loop which is directed with its plane perpendicular to the direction of flight. If one flies in any other direction, the signal is received

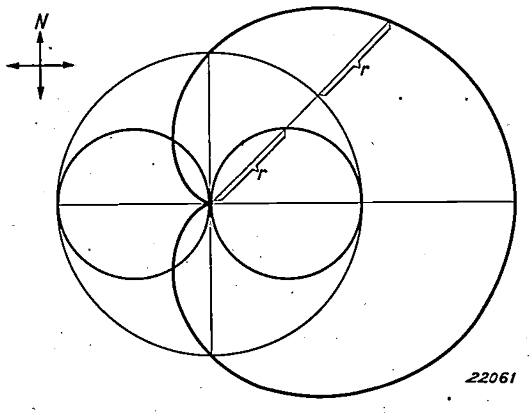


Fig. 2. Diagram of the receiving strength of a loop aerial (figure-eight shape) and non-directional aerial (circle). The heart-shaped diagram is obtained by combining these two in an appropriate way.

with greater intensity. The strength of the signal, however, gives no indication as to whether one must turn to the right or the left in order to regain the correct course.

In order to obtain an indication of the direction in which one must steer, the course finder is so arranged that the electromotive forces which are generated in the loop are combined with those induced in the ordinary receiving aerial of the airplane. The polar diagram of the received signal strength on an entirely non-directional aerial is a circle as shown in fig. 2. The ordinary aerial of an airplane, it is true, does not give a truly circular diagram, but an oval one, which is symmetrical with the axis of the aeroplane, so that in principle the following considerations may be applied to it. At a given position of the combination switch the aerial and the loop electromotive forces are in phase with each other for the right half of the polar diagram, and just in opposite phases for the left half of the diagram. We therefore obtain a heart-shaped diagram (cardioid) for the receiving strength of the course finder, as is shown in fig. 2. When the combination switch is reversed, the heart-shaped diagram is obtained on the other side of the north-south direction. If in fig. 2 the signal does not come exactly from the north, but a little to the east, then in the course finder the electromotive force in the ordinary aerial is increased by a small electromotive force in the loop. When the switch is reversed, the latter is subtracted from the former and the signal thus becomes fainter. A signal which in fig. 2 comes from west of north, however, becomes stronger on commutation.

In this simple course finder the commutation is done by hand, while reception is exclusively by ear. A second commutator may be introduced at some distance from the course finder, for instance on the control stick. This reversing of the switch by hand offers no great practical difficulty, since it is only necessary while the course is being found. When the course in once found, the course finder may be disconnected from the ordinary aerial so that the course is kept by means of the minimum loop reception.

Direction finder-homing device

The pilot can be provided with a visual indication of his course by providing for a periodical commutation. This can be done by means of an electrical, mechanical or electromagnetic circuit arrangement. The Philips direction finder-homing device V.P.K. 35 (*fig. 3* and photographs on page 182 and 183) is a combination of a direction finder and a course finder, which is furnished with an automatic commutation arrangement and a visual indicator. As the name indicates, the apparatus serves not only for "homing", but also for taking bearings. It is used in all the new Douglas DC 3 machines of the K.L.M.

The apparatus is suitable for:

1) Normal, non-directional reception when a special vertical aerial alone is connected to it. This aerial is introduced into a hollow aerial mast made of insulation material on top of the fuselage.

2) Taking bearings, whereby the angle between the direction of the sending station and the axis of the aeroplane is measured with the help of a loop aerial, which is erected on top of the aeroplane body, and rotatable about a vertical axis. In fig. 2 the figure-eight diagram of the receiving strength is that when the loop plane is assumed to be perpendicular to the north-south direction. At minimum reception the plane of the loop is perpendicular to the direction from which the signal comes. In order to obtain a sharp minimum the action of the loop as a non-directional aerial, the so-called aerial effect of the loop, is compensated. The signal may still, however, have come from one of two opposite directions, and one can decide which of these is the correct one by:

3) Sense determination. As with the course finder the signals received on the loop and on the

[1]) In a later number of this periodical, in an article about the measurement of field strengths, a more detailed explanation will be given of the way in which the aerial effect can be compensated.

vertical aerial must be combined to give the heart-shaped diagram of the receiving strength as in fig. 2. The loop is now, however, not fixed immovably with its plane perpendicular to the longitudinal direction of the aeroplane, but may be rotated about the vertical axis, so that the north-south direction in fig. 2 can be arbitrarily oriented with respect to the axis of the machine.

If, when the position of the plane of the loop is perpendicular to the north-south direction in fig. 2, we have a minimum reception on the loop alone, the signal may still come either from the north or from the south. If the loop is turned slightly to the right, the combined receiving strength on loop and vertical aerial will decrease for a signal coming from the north and increase for a signal from the south. If the phase of the loop signal is reversed, the heart-shaped diagram is mirrored with respect to the north-south direction of the diagram, and the changes in the received strength upon turning the loop in the neighbourhood of the position of minimum reception are exactly opposite.

4) Homing. The phase of the electromotive force generated in the loop is periodically according to a dot-dash rhythm having a time interval relation of 1 : 7. During the long dash interval the received signal strength is as shown in the heart-shaped diagram of fig. 2, while during the short dot interval this diagram is mirrored with respect to the north-south direction. If the signal in fig. 2 comes from the east, i.e., from the right when the plane of the loop is perpendicular to the axis of the aeroplane, we then hear strong dashes and weak dots, while a signal coming from the left half plane gives strong dots and weak dashes. When the course is directly toward the transmitter one hears a continuous dash. Not only is the pilot able to hold his course toward a radio transmitter, by ear, but also he has the course-line toward the transmitter concerned given on the visual course indicator which is installed on the dashboard.

5) Beacon reception of the Philips long-wave beacon, B.R.A. 101, which is installed at all the aerodromes in the Netherlands. This beacon has an aerial system which, like that of the bearings finder, consists of a loop and a vertical rod which are both fixed with respect to the earth. The radio beacon sends with loop and rod, and the phase of the electromotive force in the loop is reversed in a dot-dash rhythm. In a direction perpendicular to the plane of the loop a continuous dash occurs, while to the right of the beacon line, which may for the present be assumed to be along the north-south direction of the diagram of fig. 2, the dashes are heard more clearly, and to the left the dots. If the aeroplane receives the beacon signal only on the vertical aerial, then the same effect occurs in the detector as is caused by a non-directional transmitter with the help of the automatic commutator arrangement in a bearings finder. It may thus be seen by means of the visual course indicator on which side of the beacon line one is.

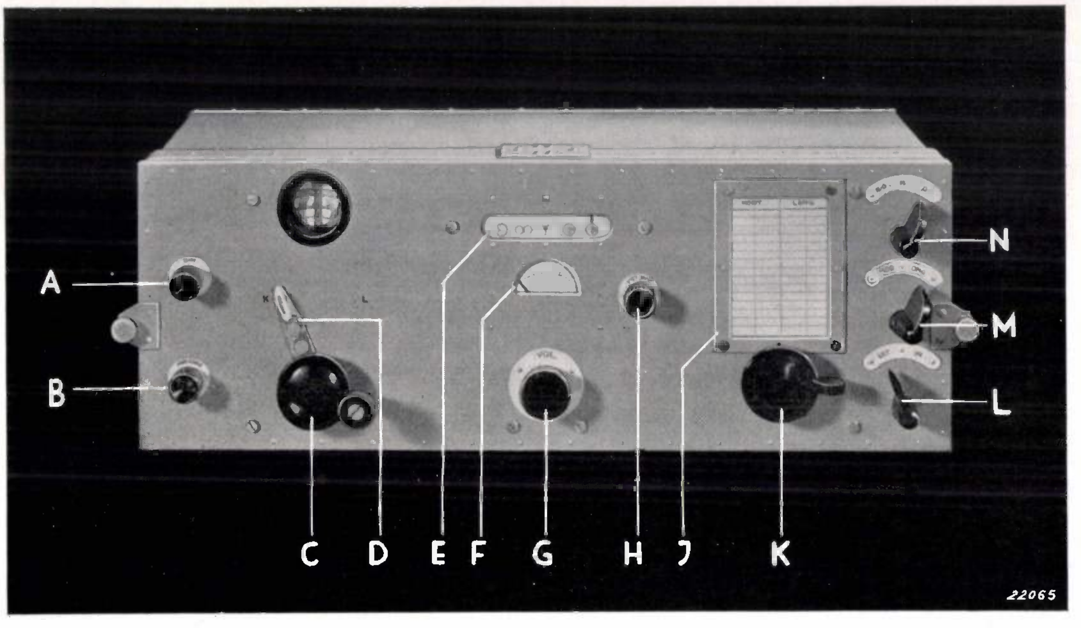


Fig. 3. Direction finder-homing device (Type V.P.K.P.. 35).

In the methods of reception described in 4) and 5) simultaneous indication by eye and ear is possible. Experience has shown that some pilots can keep a steadier course by ear than by visual indication; with others the reverse is true. All of them, however, appreciate the simultaneous information of sight and hearing, where one of the two acts as control and complement of the other. When receiving with atmospheric disturbances the visual course indicator is "restless", while in the telephone the desired signals may be distinguished adequately, since they may be adjusted to give a constant tone of any desired pitch, which can be plainly distinguished from the disturbances.

Flying in the direction of a broadcasting station, the carrier wave can be heard as a continuous dash with the aid of a beat oscillator. After the beat oscillator has been switched off, the modulation of the transmitter concerned may be listened to, without disturbance of the visual course indication. This may be of importance for the reception of weather reports, which are sent out periodically by many broadcasting stations. Furthermore one can check whether or not one's course is toward the right transmitting station, for instance by means of the announcements between the items of the programme.

Construction of the direction-finder homing-device

On the front plate of the apparatus various controls may be seen (fig. 3). The lighting of the various scales for night flying can be regulated with knob *A*. By compensation of the aerial effect of the loop with knob *B*, one can attain a sharp minimum. The wavelength region 250-670 m (1200-488 kilocycles) is chosen by setting the switch *D* in the left-hand position, while in the right-hand position wavelengths 790-2000 m (380-150 kilocycles) are received. The apparatus V.P.K. 35 is thus not only suitable for the shipping and air traffic bands, but also for the most important part of the medium-wave broadcasting band. Tuning is done with knob *C*, while the scale in the upper left-hand corner of the front plate is the wavelength scale.

On scale *E* is shown the kind of reception for which the receiver is adjusted by means of the switch *K*. On the measuring instrument *F* one may control the strength of the signal which is added to the visual course indicator situated on the pilot's dashboard. This signal strength is adjusted by means of knob *H*, while *G* operates the volume control for radio reception. On the plate *J* the position of the wavelength scale for reception from the most commonly used transmitting stations may be noted. The whole installation may be switched off with switch *L*, while with *M* the beat oscillator for carrierwave reception can be switched in. In order to make a distinction between the knobs frequently used and those seldom used, the former are larger.

The mixing switch *N* makes it possible for the wireless operater to listen to the direction-finder homing-device or the ordinary radio receiver (for traffic and weather reports) or to both at once, while at the same time the pilot, by means of a bridge circuit, receives only and without disturbance the signals of the direction-finder. Through the possibility of simultaneous listening to the receiver on board and the direction-finder, the operator may be called by a ground station via the receiver on board during the tuning of the direction-finder homing-device or during the taking of radio bearings.

A meter for checking the strength of the signal added to the visual course indicator is introduced not only on the front of the apparatus itself, but also on the instrument board of the aeroplane. In this way the pilot also can read the signal strength received.

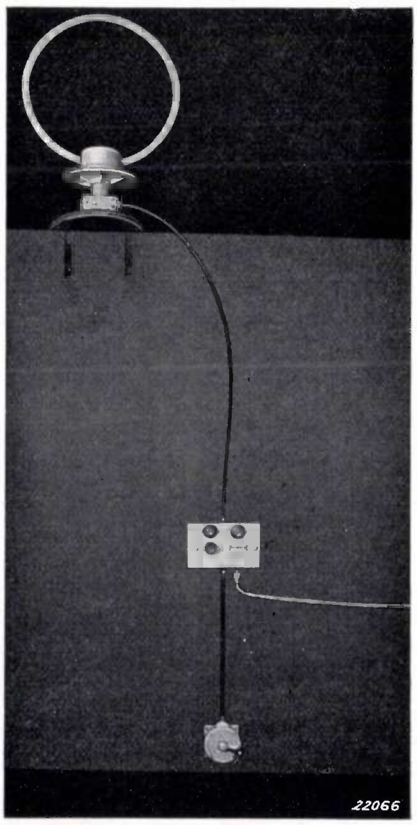


Fig. 4. Rotating loop aerial, angle indicator and arrangement for rotating the loop, for apparatus type V.P.K. 35.

Fig. 4 shows the loop and the arrangement for rotating it. In order to make it possible to read from the scale at eye-height and at the same time turn the loop easily with the hand, reading scale and handle are kept apart. The course direction with respect to the fore and aft line of the aeroplane can be read off from an angular scale which turns past an index mark. On a pelorous circle which is adjustable with respect to the course circle, and whose north-point can be set according to the compass, magnetic bearings can be found. The positions of the scales can be read clearly by means of a lens. With the help of a second lens one may read the deviation curve, which gives the amount by which the measured bearing direction must be corrected for every position of the loop with respect to the aeroplane as a result of the distortions of the electro-magnetic field by the body of the aeroplane. The two scales are lighted clearly by a small lamp, care having been taken that in the case of night flying no glaring light falls directly into the pilot's eyes.

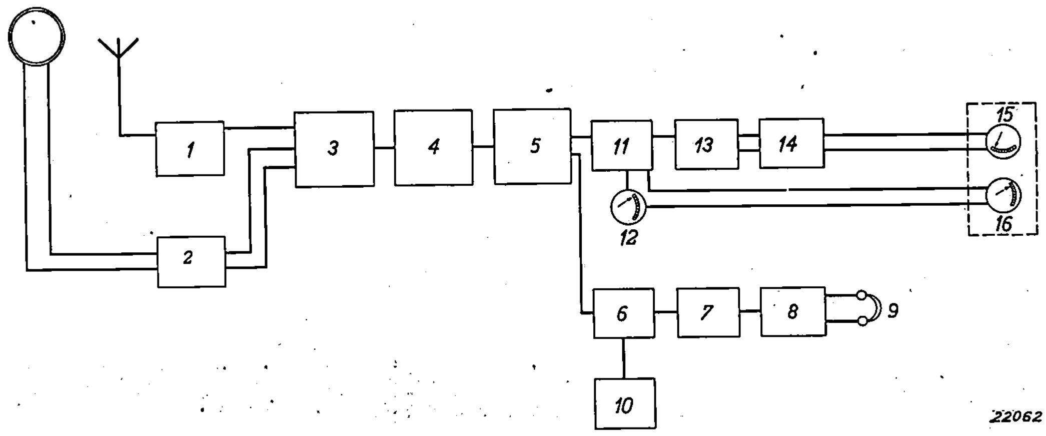


Fig. 5. Diagrammatic representation of the circuit of the apparatus VK. 35.

Circuit of the direction-finder homing-device

The action of the apparatus is explained below with the aid of the block diagram (*fig. 5*).

The aerial signal is amplified by the high-frequency amplifier stage, the loop signal by the high-frequency amplifier stage, the loop signal by the high-frequency stage in which there are two valves with grids in parallel and anodes connected in opposite phase. By blocking one or the other of the valves in these high-frequency amplifier stages by means of the switch which determines the kind of reception, mixing takes place in the way required for the various kinds of reception, namely:

a) For non-directional reception only the aerial signal must be allowed to pass. For this purpose both the valves of the loop stage *2* are blocked by a high negative grid potential.

b) The same is done for beacon reception.

c) For blind flying the phase of the loop signal with respect to the aerial signal must be reversed periodically in a dot-dash rhythm. This is attained by blocking the valves of loop stage *2* alternately in this time relation. It is done by means of a commutator operated by the converter for the anode potential.

d) For the determination of the directon (heart-shaped diagram) one of the two valves in the loop stage *1* is blocked.

e) In taking bearings (figure-eight diagram) only the loop signal must be allowed to pass. Not only one of the valves of stage *2*, but also the valve of the aerial stage *1*, is blocked.

The signals thus allowed to pass and amplified are combined in stage *3*, where the high-frequency signals are also converted to a constant intermediate frequency by means of an auxiliary oscillator. The stages *1* and *2* and the input circuit of stage *3* are tuned to the frequency to be received, and a special circuit in the aerial stage *1* provides for the correct phase relation of acrial and loop signals.

The intermediate-frequency signals are now first amplified in the intermediate-frequency amplifier stages *4* and *5*, and then division takes place to the detectors *11* and *7* for visual and auditory reception respectively.

For auditory reception the intermediate-frequency signal is detected in stage *4*, and the low-frequency signal therby obtained is amplified by the low-frequency amplifier stages *7* and *8* and fed to the telephone *9*.

For the purpose of listening to unmodulated signals an oscillator (*10*) is added, which gives an audible beat with the intermediate frequency. Since the longwave beacon signals are always unmodulated in the position for "beacon reception" of the switch governing the kind of reception, this oscillator is automatically connected, while in the positions for other kinds of reception it may be connected when necessary by means of a separate switch.

For the visual indication in course and beacon flying the intermediate frequency signal is rectified in stage *22*. For the most satisfactory functioning of the indicator part it is necessary that the intermediate-frequency signal to be rectified be of a definite strength. This signal strength may be adjusted with the knob *H* on the front plate of the apparatus, and may be checked on a

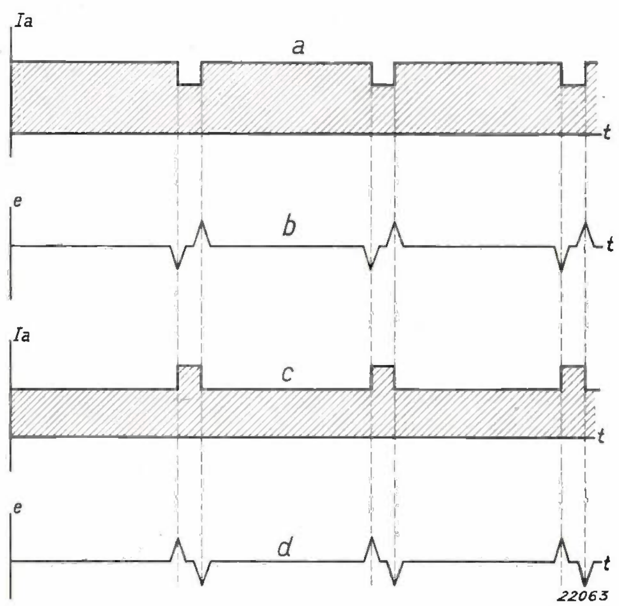


Fig. 6. Diagrammatic representation of the action of the visual indicator of the direction-finder homing-device, type V.P.K. 35.

current meter in the detector circuit (*F* in fig. 3, and *F* in fig. 5; in addition, a meter *16* in series with this latter is installed on the dashboard in front of the pilot.

Further it is desirable that in flying a course and in beacon reception the strength of reception remain the same upon approaching a transmitting station. An automatic volume control is introduced for this purpose. It controls the conversion stage *3* and the intermediate-frequency stages *4* and *5*, and is set in operation by the switch controlling the kind of reception. The automatic volume control has such a great time lag that the difference in intensity of reception between dots and dashes is not eliminated. The current pulses obtained after detection are conducted to a direct-current amplifier in stage *13* via a filter, which suppresses any audio-frequency modulation. In the anode circuit of this amplifier no current variations will occur when flying on the course line. When of the course, however, such variations will occur. In the region of dashes the plate current will have the character of *fig. 6a*, in the dot region of *fig. 6c*.

In the secondary windings of a transformer in the anode circuit, potentials are generated by these current variations, which have a character like that of fig. *6a* for the dash region and of fig. *6d* for the dot region. From the figs. *6b* and *d* it may be seen that the first impulse of the impulse combination in the dash region is oppositely directed to that in the dot region. Therefore, if only the first impulse of every impulse combination is passed through, the indicating instrument will react oppositely for dots and dashes.

This is attained in stage *14*, where two valves in bridge connection are connected to the secondary winding of the above-mentioned transformer. In the grid circuit there is a special arrangement for blocking. The valves are so adjusted that their operating point lies in the region of the greatest curvature of the characteristic. As soon as the anode current on one valve increases due

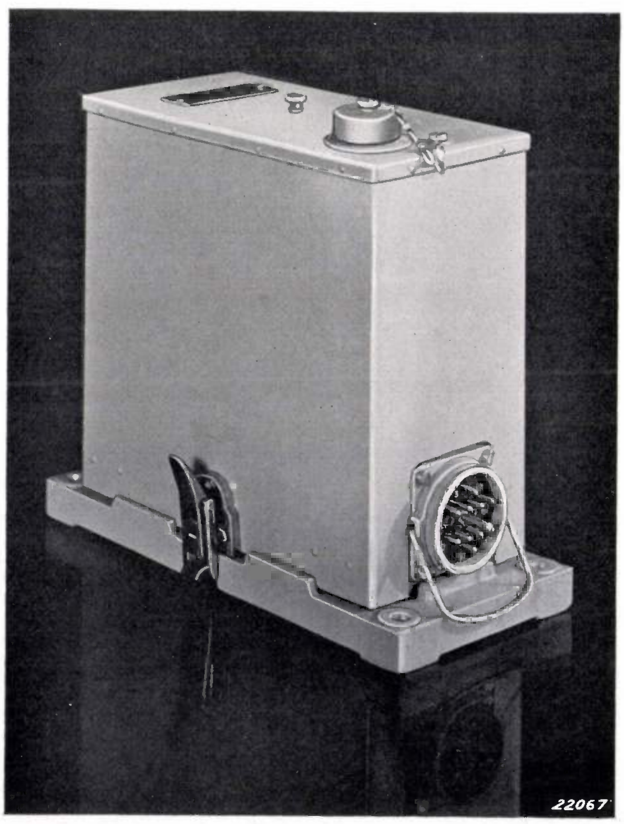


Fig. 7. Converter with interference suppressor for feeding the direction-finder homing-device, type V.P.K. 35.

to an impulse both valves are blocked during at least the time period of one dot, so that impulses occurring in this time are not passed through. As a result only the one valve operates for dots and the other for dahes. The pointer of the indicator *15*, which is connected between the anodes of both valves, will take up the middle position when on the line of course and show a deviation for dots and dashes respectively in opposite directions.

The energy for the direction-finder is taken from the accumulator on board. The filaments of the indirectly heated valves are connected directly to the battery, while the anode potentials are obtained from a converter which runs from the battery on board. This converter is installed in a box with its interference suppressor and fuse (*fig. 7*). The suppression of interference is such that when the direction finder is adjusted to its greatest sensitivity, no disturbance, for example from commutator sparking, is observable even on the shortest waves.

The apparatus is very light in construction and weighs in total only 21.3 kg, to which the direction finder contributes 11.4 kg and the converter 4.2 kg. The rotating loop aerial which is fitted to the outside of the aeroplane is only 43 cm high.

Compiled by G. P. ITTMANN.

REVIEW OF RECENT SCIENTIFIC PUBLICATIONS OF THE N.V. PHILIPS GLOEILAMPENFABRIEKEN

No. 1153: J. A. M. van Liempt: Die Anätzung von Molybdän durch alkalische Ferricyankalilösungen (Rec. Trav. chim. Pays Bas, **55**, 989 - 990, Nov. 1936).

The etching of molybdenum by ternary mixtures of water, sodium hydroxide and potassium ferricyanide was studied and the results were given in a diagram. From the experiments a formula was deduced for a solution which is very suitable for metallographic etching and for the investigation of the so-called intermediate substance.

No. 1154: H. C. Hamaker: A gencral theory of lyophobic colloids I. (Rec Trav. chim. Pay Bas **55**, 1015 - 1025, Nov. 1936).

The point of departure of this article is the common assumption that the reciprocal action between the particles of a colloid whose hydration may be neglected is caused by the superposition of an attraction according to v. d. Waals and London and an electrostatic repulsion. When this simple conception is worked out to its logical conclusion, it leads to essentially more complicated phenomena than were hitherto expected. With the conceptions given here a more extended range of phenomena can be treated than could be explaned theoretically up to the present.

No. 1155*: W. Elenbaas Zur Frage der Berechtigung des Minimumprinzips in der Theorie der Bogenentladiung (Elektrotechn. Z. **57**, 1497 - 1498, Dec. 1936).

In this article objection is raised to the minimum principle in the theory of the electric arc defended by Kesselring nad Koppelmann, according to which the arc will burn with a temperature and a diameter such that the current flows under the influence of the smallest possible drop in potential. Elenbaas shows that in some cases the arc is already wholly determined before one has made use of the minimum principle from which fact it follows than one no longer has the liberty of then introducing such a principle.

No. 1156: W. G. Burgers and J. J. A. Ploos van Amstel: "Oriented" oxidation of barium (Physica, **3**, 1057 - 1063, Dec. 1936).

Films of metallic barium were obtained by evaporating the metal in a vacuum and then condensing it on a plane polished copper plate. Depending among other factors upon the temperature

*) There is not a sufficient number of reprints of articles marked * for distribution. The administration of the Natuurkundige Laboratorium, Kastanjelaan, Eindhoven, will on request be glad to send reprints of the other articles.