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The Elbe-Weser shore-based radar system

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Summary

In the estuaries of the rivers Elbe and Weser a chain of radar stations is being erected, of which some are accommodated in buildings on the river banks and others in lighthouses amidst mudflats. These radar stations form a system protecting shipping in the waterways. They employ equipment of advanced design in which tubes are largely replaced by transistors.

After an outline of the preparatory work a description is given of the system, with a few particulars about the techniques used in the equipments.

1***). Introduction

1.1. *General*

About 7 years ago the Ministry of Traffic of the German Federal Republic agreed to have an investigation instituted into the possibility of raising the safety of shipping on the rivers Elbe and Weser by means of shore-based radar. For this purpose the Nederlandsch Radar Proefstation of Noordwijk was invited to act as an advising body.

In order to gain an insight into the problems connected with shipping activities in this area, it was regarded a good policy first to build an experimental radar station in Cuxhaven (1953) whilst shortly afterwards a second experimental set-up was taken into use at Brunsbüttelkoog. The latter station is situated at the entrance of the Nord-Ostsee-Kanal as seen from the Elbe.

The experimental radar sets were specially designed for this

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***) The Nederlandsch Radar Proefstation did us the great favour of supplying us with the information.

work: the horizontal beamwidth of the antenna was 0.6°, the R.F. pulse duration 0.1 μsec whilst the display unit, equipped with a 15" cathode-ray tube, incorporated electronic measuring aids which permitted the bearing and range of certain objects to be evaluated and three electronic reference lines.

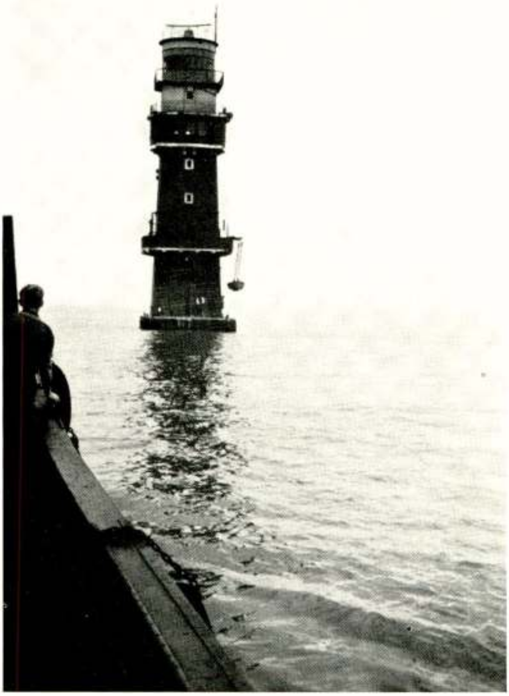

Fig. 1
Antenna on lighthouse (Robbenplate)

In addition the investigators could make use of portable VHF transmitter-receiver sets, also called Portophones, which enabled operational experience to be acquired under working conditions typical of the shipping activities in this area. It was clear already at the outset that it would be downright impossible to collect with these two stations enough information for the shipping trade in the Elbe, but, after all, it had been agreed to begin with readily accessible points where buildings were situated already. Cuxhaven is where the pilot service and a department of the Ministry of Traffic are located. The reasons which explain, why these organisations have settled there also account for the fact why Cuxhaven has been selected for a radar station.

The site at Brunsbüttelkoog is strategically a vantage point from which the shipping traffic joining or leaving the Elbe traffic can be surveyed easily.

In cooperation with the authorities a working plan was drawn up for preparing the nautical requirements which would have to be complied with by the radar system.

By the middle of 1957 so many results had been obtained that the complete specification for the radar plan could be submitted.

The investigations on the sites of the Weser radar system were conducted more or less along the same lines as those for the Elbe stations although geographical conditions differ widely.

Owing to the width of the estuary and the distance of the fairway to the shore, three of the prospective stations had to be accommodated in existing lighthouses in the Weser estuary. Because the fairway is only a few hundred metres wide in places, a high degree of accuracy was found to be essential.

It will stand to reason that installing an experimental radar station on a lighthouse simply could not be done; it would be too inaccessible, as a rule, for technical and operational staff and there would be insufficient accommodation for spending a night.

Add to this that it would be next to impossible to mount the radar antennas with their large dimensions, weights and inertia (under rotational and wind force), as used in the experimental stations, over the optical system of the lighthouse (vibrations).

For this reason it was decided to try out a radar station in Bremerhaven. This was demolished in 1958 when a new station came into use in Weddewarden, a few miles north of Bremerhaven. This station is of up-to-date design: a light-weight slotted radiator, the antenna type which will be used in the final design, duplication of the radar transmitter-receiver and two display units with comprehensive electronic measuring facilities.

Finally, in the beginning of 1958, the Hamburg Company Elektro Spezial received the order to carry out the radar project; shortly before that a large number of Portophones had been ordered from that firm.

1.2. *The Radar Project*

In the design of a shore-based navigation radar system it is of vital importance first to study the nautical situation exhaustively in order to be able to fix the minimum number of stations required to supply navigational data of sufficient accuracy.

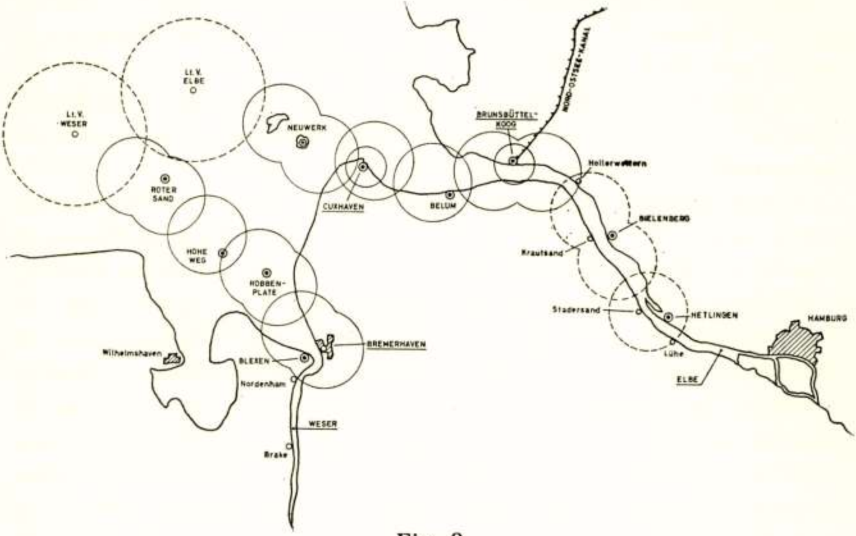

Fig. 2
Positions of radar stations and operational centres.

In the Elbe plan (estuary) the nautical research led to 4 shore-based stations with two operational centres, viz. Cuxhaven and Brunsbüttelkoog. The area under consideration here extends from light vessel Elbe I to the entrance of the Nord-Ostsee-Kanal.

It is expected that the light vessel will also be equipped with radar in due time.

The 4 stations are shown in Fig. 2.

The station which is to come farthest out into the sea will be sited on the isle of Neuwerk.

Because of housing problems for the staff required, as mentioned above, it had been agreed beforehand that unattended and semi-attended stations suitable for being controlled remotely were to be reckoned with.

For the second station, Alte Liebe (Cuxhaven) was singled out. A specially designed building is rapidly approaching its completion there. This is close to the landing stages near the semaphore.

This station will serve as the operational centre for the Neuwerk, Cuxhaven and Belum radar stations; the last one is about 10 miles upstream from Cuxhaven and is the third station in the chain.

Finally the 4th station will be erected in Brunsbüttelkoog, at the entrance to the locks of the Nord-Ostsee-Kanal. This station is the second operational centre which will be served by the stations to be located further upstream. These will be put out to contract later, when the present project will have been extended to include the stretch of Elbe from Brunsbüttelkoog to Hamburg. The radar system for the Weser, which will be built up simultaneously with the Elbe system, will also consist of 4 stations to start with. It is expected that the Weser light vessel will be equipped with a special radar set later on.

Three of the four Weser stations will be accommodated in lighthouses, viz. Robbenplate, Hohe Weg and Rotersand. The fourth station is placed in a tower at Blexen, which is situated across from Bremerhaven on the western bank of the Weser; this tower has been built specially for this purpose and has been completed recently. The operational centre has been projected in Bremerhaven on account of its favourable position.

As remarked above, the fact that lighthouses are used for the installation of radar sets has necessitated the use of lightweight antennas. The choice has been fixed on the type of slotted radiator developed for this purpose by the Nederlandsch Radar Proefstation at Noordwijk.

The presence of an efficient and reliable communication system is, of course, of paramount importance in this Elbe-Weser radar system. It is essential for the radar operator to be able to get rapidly into touch with any piloted vessel within his working area.

To make this possible a few VHF radio-telephone stations have been planned on the shore whilst every pilot is issued with a Portophone operating in the 160 Mc/s band.

During the International Maritime VHF Radiotelephone Conference held in The Hague in 1957 agreement was reached on the frequencies allocated for this function. In addition technical specifications were drawn up for the equipment used for this.

It may be anticipated that more and more sea-going vessels will be equipped with VHF equipment, not only for harbour radar purposes but also for considerations of safety, intercommunication between ships and calling facilities for the public.

The number of channels provided for by these sets, however, will usually be much less than the permissible maximum of 26. For this reason it is expected that the need for Portophones will continue to exist for piloting, however successful the plan for restricting the total number of channels may be.

In the Elbe-Weser project an overall number of 6 channels is regarded as essential.

All this has induced the German Authorities to place an early order for 600 6-channel Portophones, of which a number have been delivered already.

The use of semi-attended radar stations implies that other ways of communication will be called for, such as picture transmission and remote control.

It may be of interest to know that, as far as we know, no wireless radar picture transmission system has hitherto been used in the civilian sector.

All semi-attended radar stations incorporate Auxiliary Display Units (A.D.U.) to permit performance tests to be made from afar. For the sake of reliability all electronic units are duplicated with the exception of the Main Display Units (M.D.U.), for each operational centre incorporates one stand-by M.D.U. capable of taking over the function of a unit that gets out of order.

1.3. *Block diagram of the system* (Fig. 3)

Before having a closer look at the individual units we shall give a schematic account of the way the various signals are routed through the system.

The system may roughly be broken down into the equipment of the radar stations and that in the operational centres.

Each radar station contains a duplicated Transmitter-Receiver which produces the radio-frequency pulses radiated by the antenna.

The echoes received are converted by the receiver to video pulses which are passed on, together with the synchronizing pulses prepared in the Transmitter-Receiver, to the A.D.U. and Radar Data Modulator (both duplicated).

The antenna rotation data generated by means of a synchro transmitter are intended for the A.D.U. In addition there is

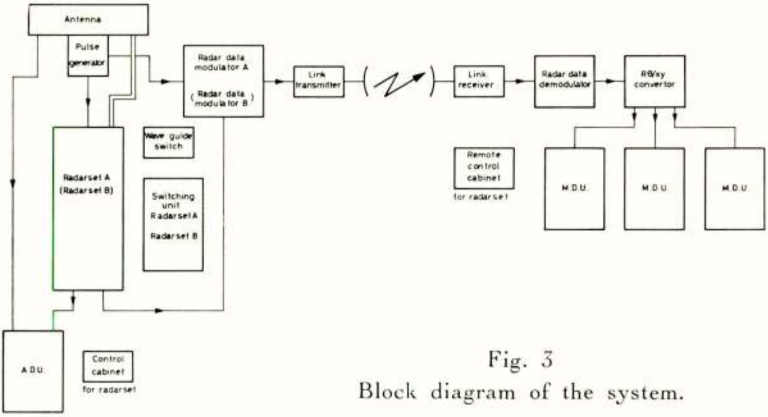

Fig. 3
Block diagram of the system.

a pulse generator coupled with the antenna. This sets up 0.7° pulses which are used to transmit the rotational information of the antenna to the operational centre and are, therefore, fed direct into the R.D.M. Further the pulse generator produces north pulses and Θ calibration pulses (every 5 degrees of rotation), which are distributed to the A.D.U. and R.D.M. via the radar Transmitter-Receiver as "North direction" and R-Θ calibration pulses.

The signals brought together in the R.D.M. are conveyed via a radio link to the operational centre.

The radar station further incorporates a waveguide switch and a switching unit; the latter takes care of the switching from radar set A to B and permits the radar sets to be controlled either locally by means of a control cabinet or remotely.

The equipment in the operational centre consists, in the correct order, of a radio link receiver, a Radar Data Demodulator and an R-Θ/X-Y convertor, which separate the signals received and translate them into a suitable form for a maximum of three Main Display Units (M.D.U.s).

2. **Antenna and drive system**

2.1. *General*

The antenna and its drive system (see Fig. 4) has been developed by the Nederlandsch Radar Proefstation.

One of the factors governing its design was the fact that some of the antennas would have to be installed above the optical systems of lighthóuses; this meant that the antennas

Fig. 4
Antenna

had to present a small surface to the wind and yet be light enough in weight.

Further the requirement was imposed that the design of the drive should permit maintenance and, where necessary, disassembly and assembly without the need for climbing on the roof of the lighthouse.

The antenna with drive system should give good performance under wind velocities up to 120 km/hour and withstand wind speeds as high as 180 km/hour.

2.2. *Specification and design data*

2.2.1. A few electrical data

Frequency: adjustable within the 8800 .. 9250 Mc/s band.
Bandwidth: ± 30 Mc/s referred to the centre frequency.
Horizontal beamwidth: 0.6°.
Vertical beamwith: approx. 16°, with the − 3 db points at about + 6° and − 10° out of horizontal.
Side lobe level: more than 27 db down from main beam.
Gain: approx. 36 db.
Polarization: vertical.
Standing wave ratio: less than 1.2.
Scanning speed: 20 revolutions per minute.

2.2.2. A few notes about the design of the slotted waveguide antenna.

The slots in the broad side of the waveguide are of the so-called series-shunt type, which means that they start from the middle of the broad side of the waveguide. Suppose that there is a line through this middle. The slot then forms a certain angle to this line and, in addition, the centre of the slot is outside this line.

It is characteristic for this type of slot that it permits the antenna to be adapted properly at the design frequency, so that the slots may be made at intervals spaced by a half waveguide wavelength. With respect to the bandwidth in relation to the impedance it is worth noting that this type of slot offers great advantages (about 20 % bandwith).

In order to avoid the *direction* of the antenna radiation pattern being a function of frequency, centre feeding is used. For this reason the bandwidth of the antenna is restricted to 60 Mc/s as far as the characteristics of its radiation diagram are concerned (see 2.2.1.).

An exception to this type of feed forms the stand-by antenna. This is end-fed and therefore has the dispersive property mentioned above. On the other hand it can be used at any frequency in the specified band without failing to meet the requirements.

2.3. *Mechanical design.*

The radiator is installed in the topmost part of the wing-shaped antenna under a cover of foam-polystyrene enveloped in "Teflon" foil. This radiator is a slotted waveguide which is centre-fed. The two halves of this radiator together form an angle of a few degrees, which is adjustable to some extent. The magnitude of this angle determines the nominal frequency of the antenna. At the top and bottom the radiator is fitted with plates forming an aperture horn; their function is to produce the desired radiation pattern and reduce backward radiation.

Although the antenna has a span of over 4 metres, it has been faired so successfully that it requires a drive motor of only a half h.p.. The power consumption at zero wind speed is 80 W.

At its bottom the antenna is supported by a hollow shaft through which the waveguide runs.

The hollow shaft fits in the hollow drive shaft of the gear box. In this way it is possible to disassemble the gear box from inside without having to remove the antenna.

Underneath the gear box there is a synchro transmitter on a separate shaft, which supplies antenna rotation data for the Auxiliary Display Unit, and there is a second shaft for the pulse generator. Both revolve at the same speed as the antenna.

The pulse generator (Fig. 20) consists of a central shaft on which four cams are mounted. One cam has 512 teeth and is used to generate $\frac{360}{512}$ = approx. 0.7° pulses. The second cam has 72 teeth and produces the 5° Θ calibration pulses. Round each of these cams there are two pick-ups (recording heads), one being in normal service and the other acting as a stand-by. A recording head consists of a coil and a magnetic circuit using a Ticonal magnet.

The amplitude of the induced voltages is about 30 mV. The third and fourth cams have a single projection only and are used to generate a north pulse. Two cams are used because duplication of the recording heads is necessary.

3. **Radar Transmitter-Receiver**

See block diagram, Fig. 5.

As Fig. 5 shows, the Modulator-Transmitter is triggered by the synchronizing unit.

The R.F. power pulses are passed through a duplexer to the antenna. The echoes returned by various objects pass via the

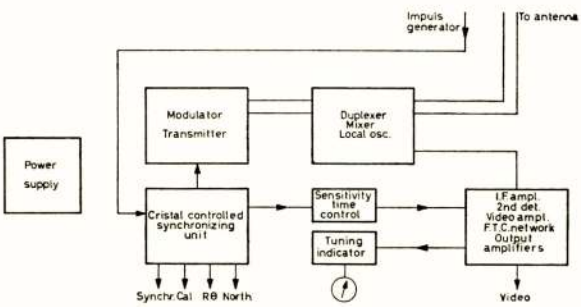

Fig. 5

Block diagram of the radar set.

duplexer and mixer to the receiver and, after being amplified and detected, they are applied to the output amplifiers as video pulses.

The S.T.C. unit, which is triggered by the synchronizing unit, has three positions (off — I — II), of which I and II can be adjusted as desired and are remotely controllable. In addition it contains a circuit determining the minimum range.

Data from the pulse generator in the antenna mount are converted by the synchronizing unit to $R - \Theta$ calibration pulses and North marker pulses. Finally the synchronizing unit supplies calibration pulses and sync. pulses which are applied to the A.D.U. and Radar Data Modulator.

It will be clear that a good number of provisions are required to make a radar set suitable for remote control. As stated above, conditions "off", "I" and "II" can be remotely selected for the S.T.C. unit. Remote control is also possible of other functions, such as switching the F.T.C. network of the set on or off (Diff. on-off); this is effected by means of relays, whose positions are indicated by lamps on the control panel of the radar set.

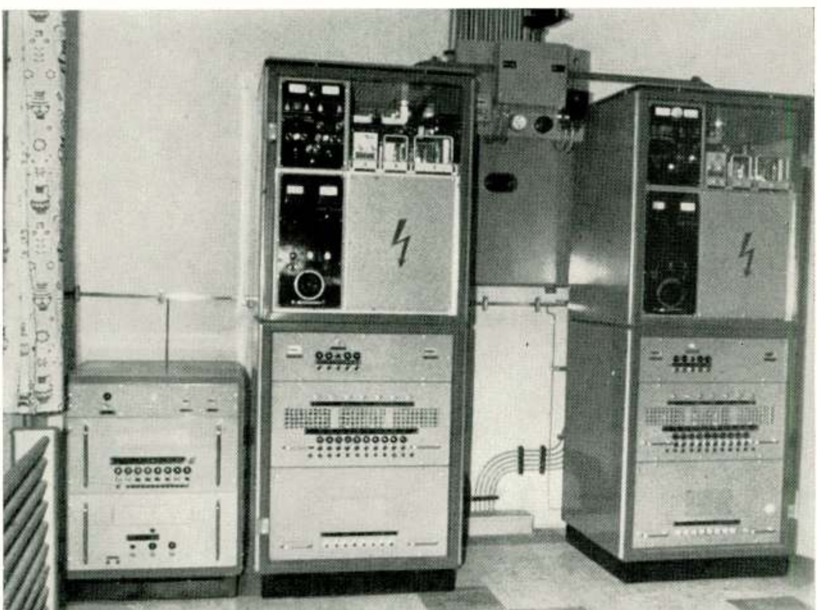

Fig. 6
Photograph of radar set

3.1. *Modulator - Transmitter*

3.1.1. Specification:

pulse length	:	0.08 ± 0.02 μsec
peak pulse power	:	more than 30 kW
frequency	:	adjustable from 8800 to 9250 Mc/s.

3.1.2. The transmitting tube used is a type *2J51A* magnetron because this covers the desired frequency band and has a minimum power output of 40 kW.

3.1.3. As the measuring accuracies specified call for a transmitter which is exceptionally jitter-free, a modulator of the "hard" type was used (see also the article "8 mm Radar", N.R.G., vol. 23, no. 1, 1958), in which the modulator tube is triggered by a vacuum tube circuit, not by a thyratron.

3.1.4. Various measurements on the type *2J51A* magnetron showed clearly that the minimum rise time of the high-voltage pulse laid down in the magnetron specification (at least 0.08 μsec must elapse between 20 % and 85 % of the high-voltage pulse) has to be adhered to very accurately, if an R.F. pulse of acceptable spectrum quality is desired. The spectrum quality has been specified insofar as the side lobes in the spectrum should not be more than − 10 db with respect to the main maximum.

3.1.5 If the magnetron is presented with a high-voltage pulse which has a minimum rise time and the shape shown in Fig. 7a, it is practically impossible to obtain an R.F. pulse whose length is nominally 0.08 μsec.

For this reason it was decided to build up the high-voltage pulse from two parts (see Fig. 7b), of which the part 20—85 % satisfies the rise time specified and the second part is much "steeper".

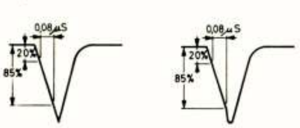

Fig. 7a Fig. 7b
Magnetron high-voltage pulse.

This technique has, indeed, enabled us to form short R.F. pulses (0.04 to 0.05 sec.) whose spectrum quality is good.

3.1.6. Design of the modulator
See block diagram, Fig. 8.

As Fig. 8 demonstrates, the trigger pulse for the "hard" modulator consists of 2 parts, obtained from channels I and II.

The pulse formed in channel I produces the initial slope

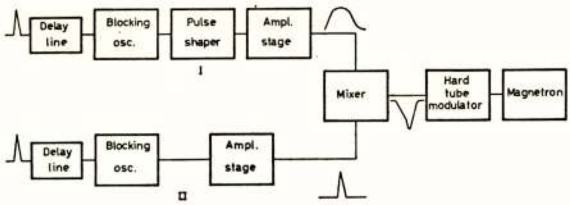

Fig. 8
Block diagram of modulator.

$(0 - 85\,\%)$ of the high-voltage pulse for the magnetron whilst channel II furnishes the steep remainder of this pulse.

A tapped delay line is used to ensure that the outputs of channels I and II are correctly timed.

3.1.7. Measurement of the R.F. pulse length

Generally speaking this measurement may be effected in various ways, e.g.:

a. from the current pulse of the magnetron
b. from the R.F. envelope of the transmitting pulse
c. by spectral analysis of the R.F. transmitting pulse, i.e. from the first "minima" on either side of the main maximum.

If method *a* is employed and the width is measured at half the height, the results will usually not differ more than $10\,\%$ from those obtained by method *b*.

In method *b* half the sum of the widths measured at $10\,\%$ and $90\,\%$ is taken. This generally also equals the width at $50\,\%$ height, provided the leading and trailing edges of the transmitting pulse are not "rough".

The application of method *c* requires an examination of the R.F. envelope, especially for asymmetrical pulses, because the relationship between R.F. pulse length on the one hand and the distance of the first "minima" on both sides of the main maximum on the other hand are largely determined by this.

In order to give you some idea of the variation in this re-

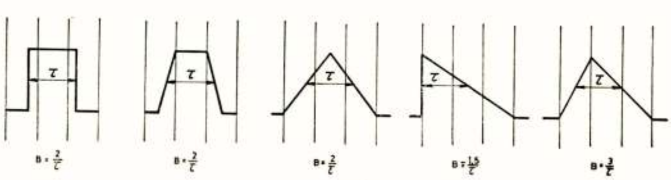

Fig. 9
Correlation between r.f. envelope and spectrum with regard to pulse length.

lationship you are referred to Fig. 9, the assumption being made that only amplitude modulation plays a role.

It has been found that method *c*, provided due allowance is made for the above, gives results which agree very well with those of methods *a* and *b*.

3.2. *Receiving Channel*

3.2.1. General

In the Transmitter-Receiver there is a simple R.F. mixer stage at the output of a duplexer. This duplexer is of the short-slot hybrid type.

Because tuning is possible only once in about 4 weeks, the local oscillator has to have a high stability. In addition to the conventional regulation of the power supply, also the filament supply has been stabilized.

The mixer stage is mounted on the I.F. preamplifier, whose gain is controlled by a sensitivity time control (S.T.C.) circuit. The S.T.C. circuit may be switched to three positions. Next comes the main amplifier, whose gain is controlled either automatically (by the Radar Data Modulator) or manually.

For a visible indication of the tuning a signal is taken from the second detector circuit in the main amplifier. After being amplified and rectified in the tuning indication amplifier, this signal is applied to the tuning indicator proper, consisting of a pointer type instrument.

The main amplifier is followed by the video amplifier and output amplifiers.

3.2.2. Specifications

Intermediate frequency:	60 Mc/s
I.F. bandwidth :	22.5 Mc/s between − 3 db points
Video bandwith :	18 Mc/s between − 3 db points
Min. range :	$\sim$ 25 m

3.3. *The Synchronizing Unit*

The synchronizing unit of the radar equipment delivers a number of pulses at various outputs.

These pulses are:

1. *R*-Θ calibration pulses.
   Whenever the antenna has turned through an integral multiple of 5 degrees in relation to North, a sequence of pulses

is fed out. Each of these pulse programmes starts with a pulse coinciding with the moment at which the radar receiver picks up the echo from 0 range; the second pulse appears at a time corresponding to a range of 1 km, next come pulses at ranges of 2, 3, 4, 6, 8, 12 and 16 km.

Every pulse lasts 0.5 μsec.

These pulses may be mixed into the video signal to which the display units respond. They produce on the screen short radial lines (the R-Θ calibration markers) whose form clearly distinguishes them from radar echoes. They are used for the calibration of the range and bearing measuring aids of the display units.

The pulse programme for the North direction differs slightly in presentation because additional pulses have been inserted at other radial distances. In this way they are easy to recognise.

The R-Θ calibration pulses are transmitted along with the radar signals from the Radar Station to the Operational Centre where the Main Display Units are installed.

The pulse programme has been selected in such a manner that in each of the range settings selected an adequate number of pulses is available without the risk of crowding. If the pulses should recur at every kilometre from 0 to 16 km, there would be too many of them in the 16 km range setting.

2. Range calibration pulses

   These are meant to trace range calibration rings on the Auxiliary Display Units of the Radar Station.

   Pulse trains for rings at 0.5, 1 and 2-km intervals are delivered at three different outputs.

3. A pulse with a p.r.f. of 2341.2 p.p.s., 1 μsec before 0 range, which is used to trigger the radar transmitter and the sensitivity-time control circuit of the radar receiver.
4. A pulse with a p.r.f. of 2341.2 p.p.s., about 4 μsec before 0 range, which is used to condition the transmitter for the triggering action.
5. A pulse with a p.r.f. of 2341.2 p.p.s., 1 μsec before 0 range to trigger the timebase of the Auxiliary Display Unit.
6. A pulse with a p.r.f. of 2341.2 p.p.s., *7.7* μsec before 0 range to trigger the timebase of the Main Display Unit, which may happen after transmission from the Radar Station to the Operational Centre.

7. A pulse with a p.r.f. of 2341.2 p.p.s. at about 110 μsec after 0 range (17 km) intended to suppress radar signals beyond 16 km in the picture transmission chain so as to clear this channel for about 300 μsec for the transmission of the antenna shaft code.
8. A pulse with a p.r.f. of 2341.2 p.p.s. at about 200 μsec (30 km) after 0 range to initiate the shaft code in the picture transmission system.

Incoming signals.

For its operation the synchronizing unit has to be supplied with the following signals:

1. North pulses set up by a pulse generator in the antenna. Whenever the antenna passes through the point in which it is oriented towards North this generator produces a pulse having a duration of about 5 *m*sec.
2. Θ calibration pulses, also set up by a pulse generator in the antenna. Whenever the antenna passes through a position which is removed from North by an integral multiple of 5°, this generator produces a pulse having a duration of about 5 *m*sec.

The operation of the synchronizing unit will now be explained by reference to the block diagram of Fig. 10.

The source of all the pulses is a crystal-controlled oscillator which operates at a frequency of 299.67 kc/s; this means that a single cycle of this signal takes up a time corresponding to a radar echo range of 500 m.

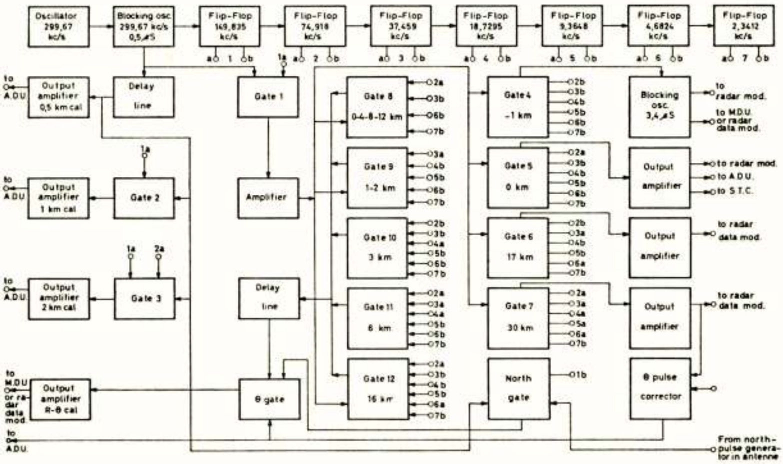

Fig. 10

Block diagram of synchronizing unit.

A blocking oscillator converts the sinusoidal output of the crystal-controlled oscillator into a train of pulses having a pulse repetition frequency of 299670 p.p.s. (128 x the radar p.r.f.).

This pulse train is fed to a bistable flip-flop. The successive pulses alternately bring it into its two stable states, so that its output gives 149,840 pulses per second. These pulses in turn operate a subsequent flip-flop, in which the frequency is halved again, giving 74,920 p.p.s.

In this way each of the following flip-flops halves the frequency so that in the end a frequency of 2341.2 p.p.s. is obtained. Each flip-flop has two outputs, *a* and *b*, which carry voltage alternately. The voltages change the moment the flip-flop enters into the other state.

The voltages at outputs *a* of the various flip-flops are shown in Fig. 11. Those of outputs *b* have the same shape but they are positive as long as those of *a* are negative, and vice versa. The range calibration pulses for the 0.5 km range rings on the Auxiliary Display Unit are taken from the 300 kc/s blocking oscillator and brought out via an amplifier.

The range calibration pulses for the 1 km range rings are selected from the available 0.5 km pulses by means of a gate controlled by the 150 kc/s flip-flop.

The range calibration pulses for the 2 km range rings are likewise selected from the 0.5 km pulses by means of a gate, but this is controlled jointly by the 150 kc/s and 75 kc/s flip-flops.

The train of 1 km range pulses is used as a source for all remaining pulses.

The pulse triggering the radar transmitter (1 μsec. before zero range), for example, is obtained by means of a gate controlled by flip-flops 2, 3, 4, 5, 6 and 7 in such a manner that one of the control wires of the gate is connected to the *a*-output of flip-flop 2 whereas the 5 other control wires are connected to the *b*-outputs of the other flip-flops mentioned.

The gate have been designed to give free passage to a pulse only when all its control wires (inputs) are positive. It will now be clear that only the pulse shown in Fig. 11-*l* will make its way through the gate during the appropriate period of flip-flop 7. This pulse is used to trigger the transmitter.

There is some delay in the triggering. Delays are further inevitable in the waveguide run of the radar transmitter-receiver and in the receiver.

As a result the echo of an object placed at zero range, that

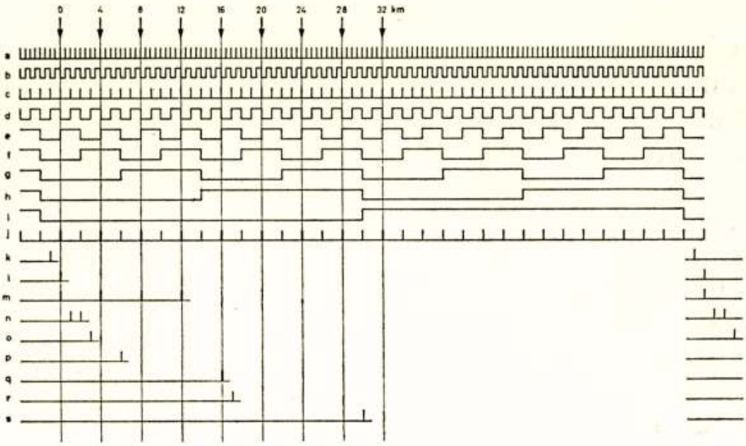

Fig. 11

Waveforms in synchronizing unit

a.	output	voltage	from	blocking osc.	299.67 kc/s
b.	,,	,,	,,	flip-flop 1	output a
c.	,,	,,	,,	gates 1 and 2	
d.	,,	,,	,,	flip-flop 2	output a
e.	,,	,,	,,	flip-flop 3	output a
f.	,,	,,	,,	flip-flop 4	output a
g.	,,	,,	,,	flip-flop 5	output a
h.	,,	,,	,,	flip-flop 6	output a
i.	,,	,,	,,	flip-flop 7	output a
j.	,,	,,	,,	gate 3	
k.	,,	,,	,,	gate 4	
l.	,,	,,	,,	gate 5	
m.	,,	,,	,,	gate 8	
n.	,,	,,	,,	gate 9	
o.	,,	,,	,,	gate 10	
p.	,,	,,	,,	gate 11	
q.	,,	,,	,,	gate 12	
r.	,,	,,	,,	gate 6	
s.	,,	,,	,,	gate 7	

is immediately in front of the antenna, will arrive about 1 μsec after the moment at which pulse 1 is released.

All other pulses, which are used to calibrate range, have to be corrected in this respect by means of delay circuits.

The state of affairs for the other output pulses of the synchronizing unit is the same as for the 0 km pulses and can be deduced readily from the illustrations.

The synchronizing unit uses transistors throughout.

4. The display units

4.1. *General*

The radar transmitter-receiver and the antenna produce a number of signals for use in the display units, notably:

1. *Synchronizing pulses*
   These are pulses which bear a fixed time relationship to the power pulses of the radar transmitter.
2. *Echo pulses* returned by ships, buoys and other objects.
3. *Antenna rotational data*
   These are signals from which the instantaneous position of the revolving antenna can be determined.
4. *Calibrating signals* for accurate calibration of range and bearing on the display units.

The following equipments are used to convert these signals into a useful picture:

1. an Auxiliary Display Unit.
2. a Main Display Unit.

The Auxiliary Display Units are installed in the various Radar Stations and serve chiefly as means for checking the performance of the radar transmitter-receivers.

The Main Display Units and associated equipment are erected in the three operational centres, notably those of Brunsbüttelkoog and Cuxhaven for the Elbe waterway and that of Bremerhaven for the Weser.

The following paragraphs will give a few particulars about these equipments.

4.2. *The Auxiliary Display Unit* (A.D.U.)

As stated above, an A.D.U. is intended mainly for performance checks on the radar transmitter-receivers.

They can perform the task of the Main Display Units, if desired, although their accuracy satisfies less exacting standards.

As far as the requirements they have to meet are concerned, they are very conventional PPI displays using 12-inch CRTs.

The requirements set by the user were as follows:

1. The range scale must be switchable to three different settings, to wit 3 km per picture radius, 6 km per picture radius and 12 km per picture radius (alternatives are 4, 8 and 16 km).

2. Facilities were to be incorporated for off-centring the radar picture up to $^3/_4$ of the radius.
3. Echoes from objects spaced 15 metres radially should be distinguishable as separate echoes at the shortest range.
4. In addition to the radar picture there should be the facility of displaying concentric range calibration rings at intervals equivalent to 0.5 km at the 3 km range scale, 1 km at the 6 km range scale and 2 km at the 12 km scale.
5. Where necessary it should be possible to admix a video map into the picture.

For a check on the synchronizing system of the radar transmitter-receiver it must be possible to display also the R-Θ calibration pulses. These are artificial echo signals of accurately known bearing and range, devised for calibrating the measuring aids on the Main Display Unit (see the Synchronizing Unit). Besides, bearing lines can be made visible.

The radar picture is traced in the most conventional manner, viz. by a deflection coil revolving round the neck of the CRT. Its rotation is in synchronism with the revolutions of the antenna, in this case 20 rev. per minute. The instantaneous position

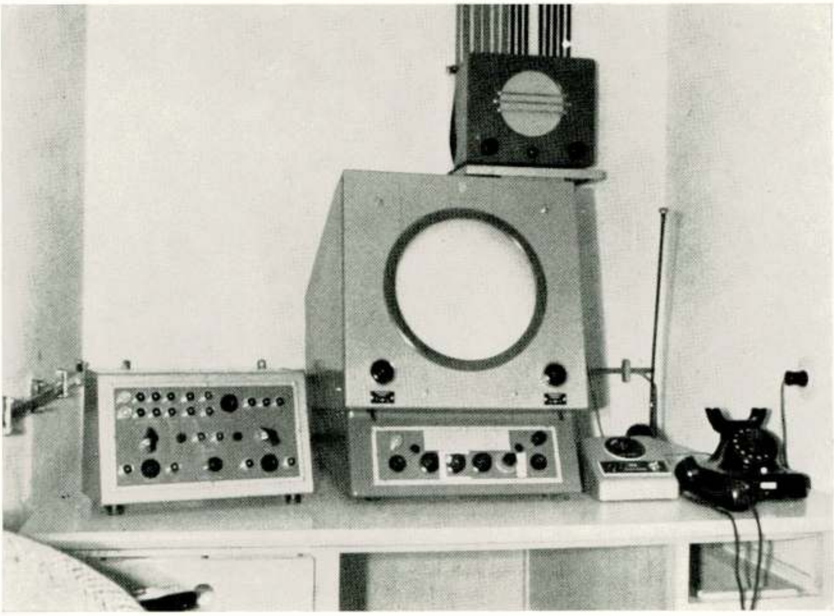

Fig. 12
The Auxiliary Display Unit.

of the deflection coil determines the instantaneous direction of deflection. Consequently the picture is written by means of radial sweeps.

The cycle of a complete sweep consists of:
a start from the rest condition (picture centre, corresponding with the geographical position of the radar antenna),
secondly a radial deflection which is linear with time and is intensity modulated by the radar echoes,
thirdly the flyback to the rest position, and
fourthly the interscan time lasting up to the next trigger pulse.

The line frequency is 2341.2 lines/sec. in the case under consideration (pulse repetion frequency of the radar).

The picture frequency is determined by the number of revolutions of the antenna, i.e. 20 pictures per minute.

The electronic circuits of the A.D.U.

The electronic circuitry of the Auxiliary Display Unit may be subdivided into the following functional units:

1. The CRT Unit.
   This comprises a cathode-ray tube with rotating deflection coil, focus coil and off-centre coils. Further it includes the deflection coil drive mechanism with 400 c/s servo motor and 400 c/s synchro control transformer.
2. The Servo Amplifier.
   This is driven by the error voltage formed by the synchro control transformer.
   The output voltage of this amplifier drives the servo motor at such a speed and in such a sense that the angular information which the control transformer receives from the antenna shaft is closely followed by the deflection coil with an accuracy of less than 0.1°.
3. The Timebase Generator, which feeds current through the deflection coil.
4. The Video Amplifier, by which the video signals from the radar are amplified, limited and fed to the CRT.
5. The E.H.T. Unit, which generates the accelerating voltage for the CRT.
6. The Brightness Control Unit.
   This suppresses the electron beam in the CRT in the time between two picture sweeps and protects the luminescent coating of the screen against burning in the event of faults in the timebase generator and other circuits.

7. The Control Panel with its various controls.

The power supply voltages required for all these circuits are furnished by a separate power supply unit.

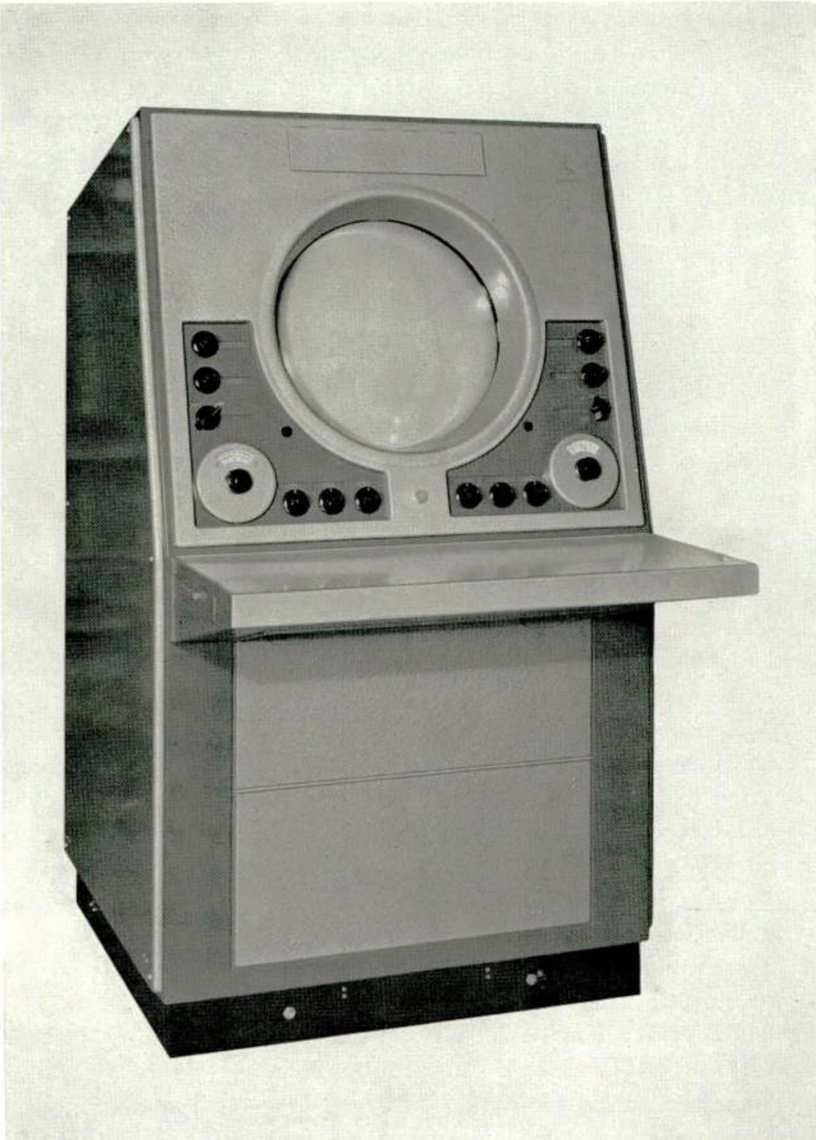

Fig. 13
The Main Display Unit.

With the exception of the video output tube the display unit uses transistors throughout.

4.3. *The Main Display Unit* (M.D.U.)

The ultimate object of the comprehensive equipment set-up is to present the various pictures on the Main Display Units, and

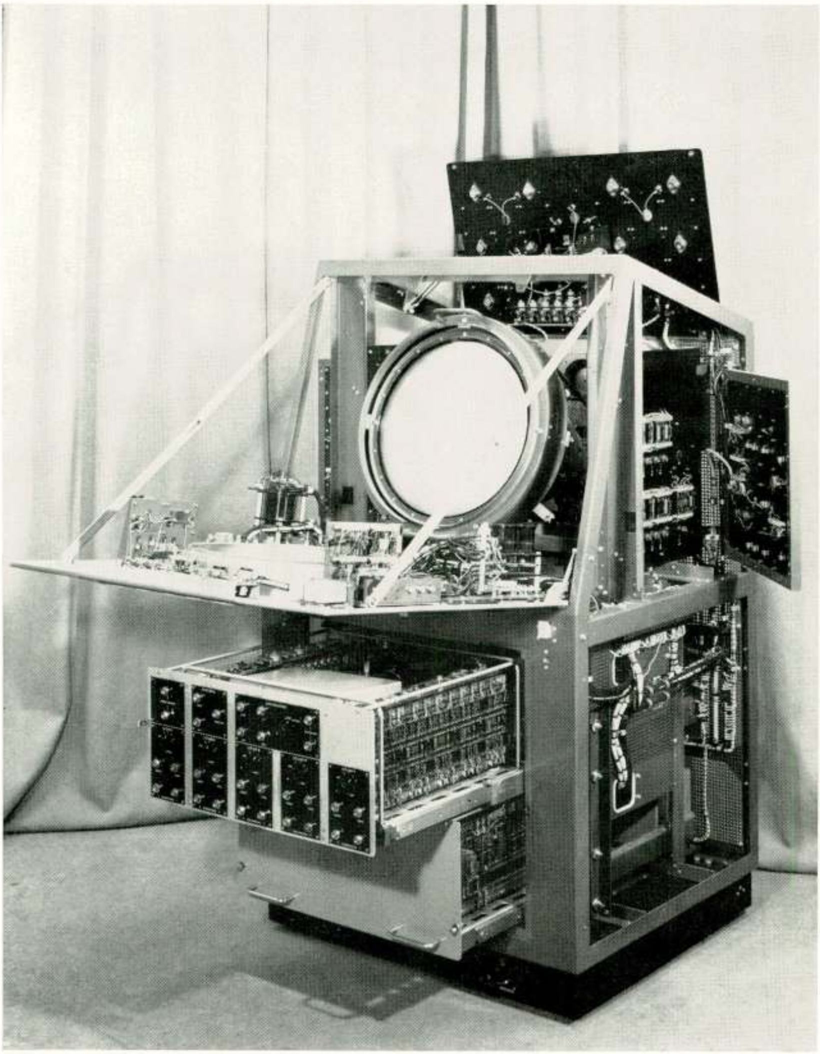

Fig. 14
The Main Display Unit, inside.

all good and bad characteristics of the equipment reveal themselves in the quality of these pictures.

The pictures are used by operators who maintain radio-telephonic contact with ships' pilots and supply them with information on their position in the fairway and on the general traffic situation in their vicinity.

The user has posed certain requirements for what has to be visible on the picture tube.
This includes:

1. A panoramic (plan-position) picture of the area covered by the pertinent Radar Station, with range scales of 3, 6 and 12 km per radius (alternatively 4, 8 and 16 km) and a radial resolution of at least 15 m at the shortest range.
2. Where necessary a video map.
3. Five straight lines of variable length, origin and direction.
4. A sixth straight line (cursor) for measuring purposes, with a range marker moving along it.
5. Calibration rings as on the Auxiliary Display Units.

The complete picture must be capable of being brought out of centre up to $^{3}/_{4}$ of the radius without mutual displacement of the elements composing the picture. The picture diameter is about 36 cm (14 in.). Fig. 15 shows such a picture. There is always a radar picture, but this may be supplemented by a video map. The meaning of a video map can be explained as follows:

Let us exemplify a Radar Station on top of a lighthouse: most of what the radar picture of such a station shows consists of ships and buoys. The buoys indicate the position of the fairway. It is obvious that one would like to see these buoys permanently on the display screen.
Now it happens that buoys become invisible to the radar, viz. when they are covered with ice in winter or when they are removed.

The fairway is then obscured on the radar screen. In order to make buoys visible in spite of this a video map is injected into the picture.

A video mapping unit may be regarded as a dummy radar. It produces signals exactly like radar echoes, except for the fact that these are obtained by scanning a map of the environment instead of the environment itself. The radar and video map signals can be displayed on one display unit provided the radar equipment and the video mapping unit are properly synchronized with each other.

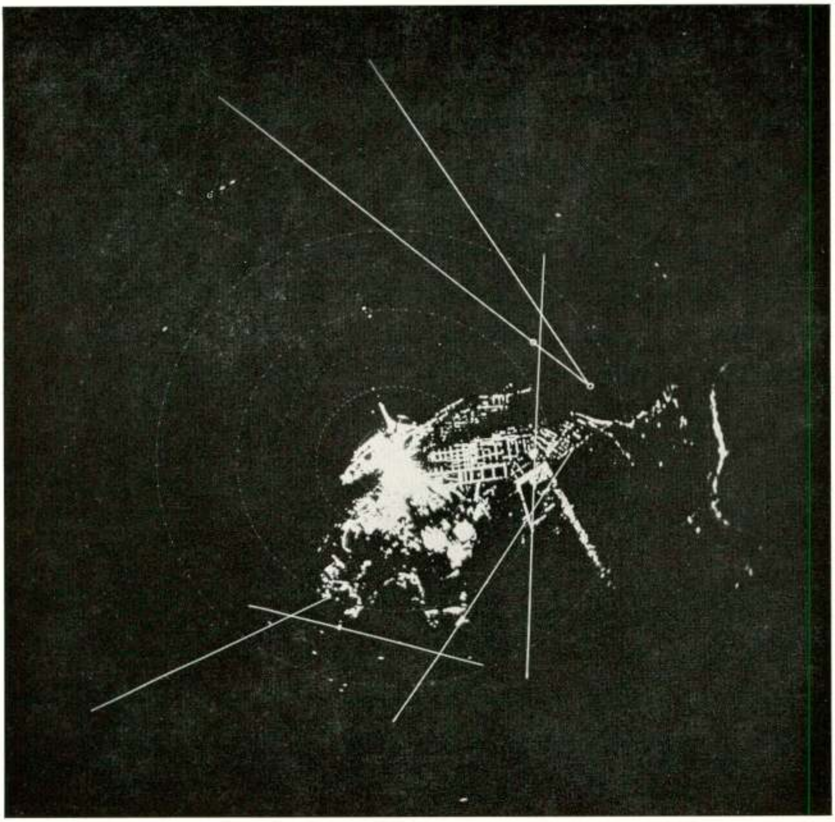

Fig. 15
Picture on the screen of the Main Display Unit.

If a buoy is shown in the correct place on the map as a dot, an echo will appear in this position on the radar screen, even when the actual buoy is submerged. The radar, in fact, is required only to give echoes of moving objects such as ships. Objects whose positions are fixed may be drawn on the map so that they will be visible on the screen at all time. Thus the complete fairway can be delineated.

There are 4 control knobs for each of the 5 straight lines mentioned in para. 3. They permit the line to be positioned anywhere in the picture. The lines may, for example, be joined together to form a broken line marking out a particular route, such as the centre of the fairway.

The origin of the cursor mentioned in para. 4 is clearly marked by a small circle. Two knobs permit this origin to be shifted to any point on the screen, the cursor retaining the orientation it originally had. A third control is used to rotate the cursor around its origin. This control is coupled with a dial, which permits the bearing position of the cursor to be read off in fractions of a degree.

A fourth control is provided for displacing a circular marker along the cursor. This control is also coupled with a graduated scale indicating the distance in metres between the spot where the circular marker is located and the place indicated by the origin of the cursor.

Last of all the user requires calibration rings that are fully identical to those of the Auxiliary Display Unit. These may be used for quick range estimation when no high accuracy is necessary.

So much about the user's requirements.

A picture of this type, however, provides insufficient facilities for checking whether:

1. the video map registers accurately with the radar picture;
2. the dial readings of range and bearing are accurate enough.

The permissible errors are very small. Thus, for example, the bearing indication should not deviate more than 0.4° from the actual situation, whilst the maximum admissible range measuring error is 20 metres $+ \frac{1}{4}\,\%$ of the total range setting.

This error is not much larger than the spot diameter on the picture tube.

For accurate alignment of such a system a fairly large number of potentiometers have to be adjusted, and this calls for reference signals whose accuracy is one class better than that of the actual measurements. These reference signals are generated in the synchronizing unit of the radar equipment.

They consist of a large number of artificial echoes, called the R-Θ calibration pulses.

They can be mixed into the radar picture signals so that they appear on the screen.

The bearing and range of these signals are defined within close limits, the bearing angle within about 0.1 degree and the range within about 5 metres.

The North direction requires additional pulses to be distinguished from other angular positions.

The R-Θ calibration pulses are used not only for lining up the cursor and the video mapping unit but also to determine the position of the cursor with increased accuracy. Thus it is possible to introduce corrections into a measurement by turning the cursor on to the nearest R-Θ calibration marker and checking up on the difference between the dial reading of the cursor and the true angle indicated by the R-Θ marker.

The picture scanning system of the M.D.U.

The radar picture frequency, as stated in the paragraph "Auxiliary Display Unit", is 20 images per minute.

Such a picture frequency is only acceptable for motionless or slowly moving pictures like the radar image, the video map, the range calibration rings and the R-Θ calibration markers. It is far too slow for tracing an electronic cursor, for it would take too much time to adjust the marker accurately on a target.

The cursor requires a much higher picture frequency. This is obtained by tracing the picture in the manner illustrated in Fig. 16.

The luminous spot moves as follows on the picture tube: Sync. pulse I — radial picture sweep I — movement to origin of cursor (1, suppressed) — cursor (2, visible) — flyback to the radar picture centre C (3) — sync. pulse II — radar picture sweep II (displaced a fraction of a degree relative to picture sweep I owing

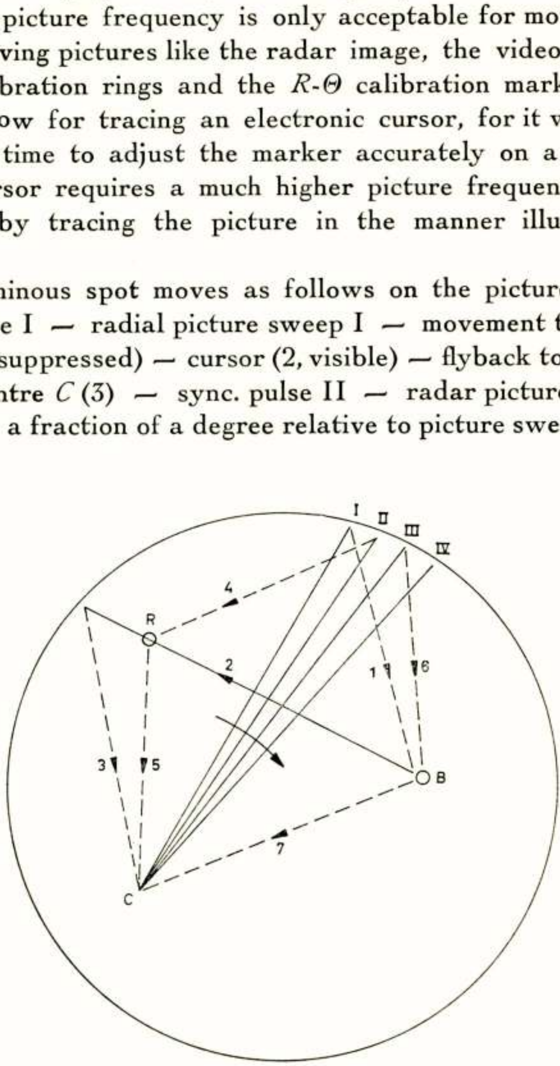

Fig. 16
Trace of the spot on the screen of the Main Display Unit

to antenna rotation) — movement to position of range marker R on the cursor (4) — tracing of this marker (a tiny circle) — return to radar picture centre (5) — sync. pulse III — radar picture sweep III — movement to origin of cursor (6) — tracing of this origin B (also a small circle) — return to radar picture centre (7), etc.

The angular displacement between successive radar sweeps is, of course, much less in reality than Fig. 16 shows.

This pattern might be repeated after the 4th, 7th, 10th, etc. radar line sweeps; the scanning frequency for the cursor and range marker would then be one-third of the radar line frequency, i.e. 780 sweeps per second at a pulse repetition frequency of 2340 p.p.s.

Actually, however, the intervals between the radar line sweeps are used also to write the 5 variable lines, giving 8 traces in all, whilst the facility for a 9th figure is reserved, too.

Each of these figures is written in the inter-scan time, i.e. between 2 radar line sweeps; this gives for each figure a frequency of 260 per second. This is much higher than necessary and since there are other considerations advocating a reduction of this frequency, a figure is traced only after every 8 radar line sweeps. This gives 32,5 images per second, which is sufficient to give the human eye the impression of a continuously persistent picture.

This inter-scan writing method, however, cannot be used with rotating deflection coils. The rapid change of direction of the sweeps of the luminous spot demands that the deflection coil performs an angular displacement of any desired magnitude within a few hundredths of a millisecond, which is far beyond the capabilities of any mechanical device.

Hence we make use of fixed deflection coils.

As in television sets such a system consists of 2 coils, whose fields are perpendicular to each other. The direction into which the luminous spot is deflected now depends on the ratio between the currents through the two coils, and the distance the spot is deflected from the centre depends on the sum of the squares of these currents.

For any displacement of the luminous spot this deflection has to be resolved into a sine and a cosine component, and the currents calculated from this should be fed through the deflection coils. The circuits of the two directions of deflection (X and Y) are fully identical.

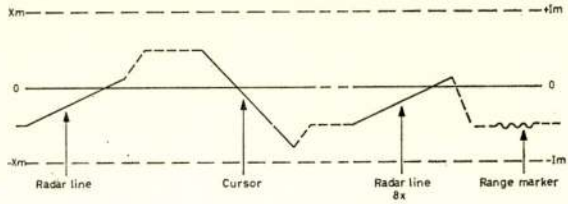

Fig. 17
Deflection current in the x-coil of the Main Display Unit.

Let us now plot a current-time graph of the current through one of the coils, say the coil for deflection in the X direction (Fig. 17).

Current I_m in this figure corresponds to full-radius deflection along the X-axis (horizontal). We can infer from the figure that the centre of the radar picture is displaced from the centre of the picture tube, and in such a manner that the projection of the radar picture centre on the X-axis is removed from the centre towards the left by half the picture radius. See Fig. 16.

The projection of the origin of the cursor is located towards the right of the origin by half a picture radius, the projection of the range marker is again about half a picture radius to the left of the origin.

The block diagram of Fig. 18 gives some impression of the electronic circuitry required to concretize the scanning system described above. Only the circuits for the X-component of the deflection are shown. A number of the circuits are, consequently, duplicated in the display unit for the Y-component.

The current for the X-deflection coil is furnished by a deflection current amplifier (1), whose output is exactly proportional to its input voltage.

This input voltage, in turn, is the sum of three voltages. One of these is produced by the marker generator (2) and is required to trace the range marker and the origin marker of the cursor (small circles). The second input voltage is produced by the deflection current preamplifier (3).

The gain of this preamplifier can be set to 3 different values by means of the range scale switch, which is used to select 3 different range scales. In one version full picture radius may be set to correspond to 3, 6 or 12 km, and in the other version to 4, 8 and 16 km.

The third input voltage is called the off-centre voltage as it permits the picture as a whole to be displaced across the

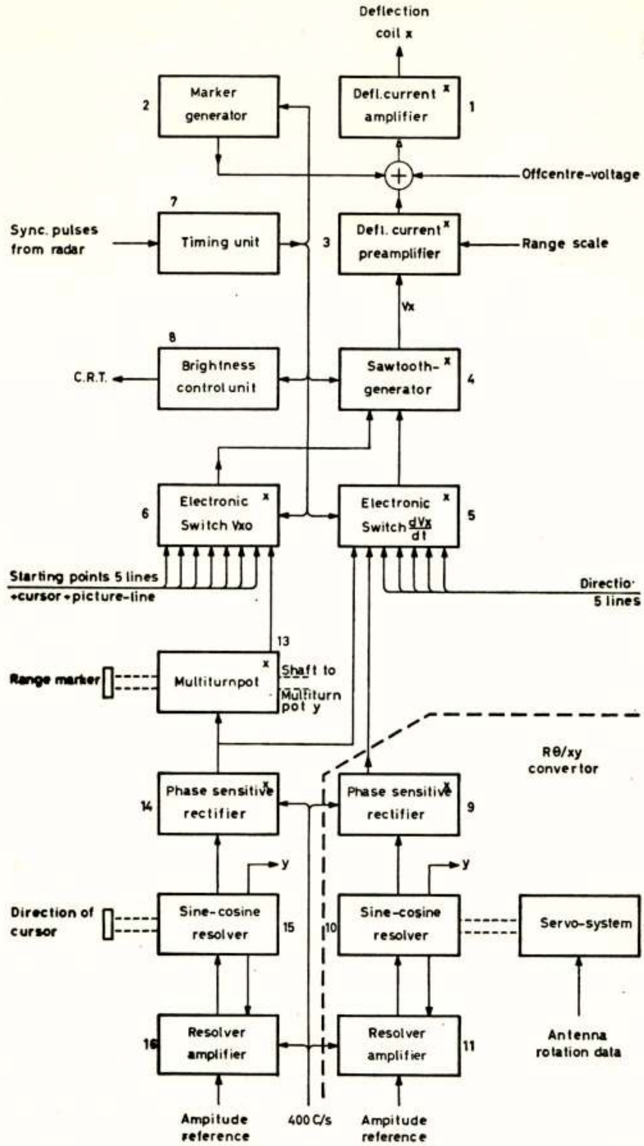

Fig. 18

Block diagram of the deflection system of the Main Display Unit.

viewing area up to $^3/_4$ of the radius of the picture tube in any direction.

Input signal V_x of the deflection current pre-amplifier is delivered by a sawtooth generator (4); this signal varies with time as shown in Fig. 19e. This waveform is determined, firstly

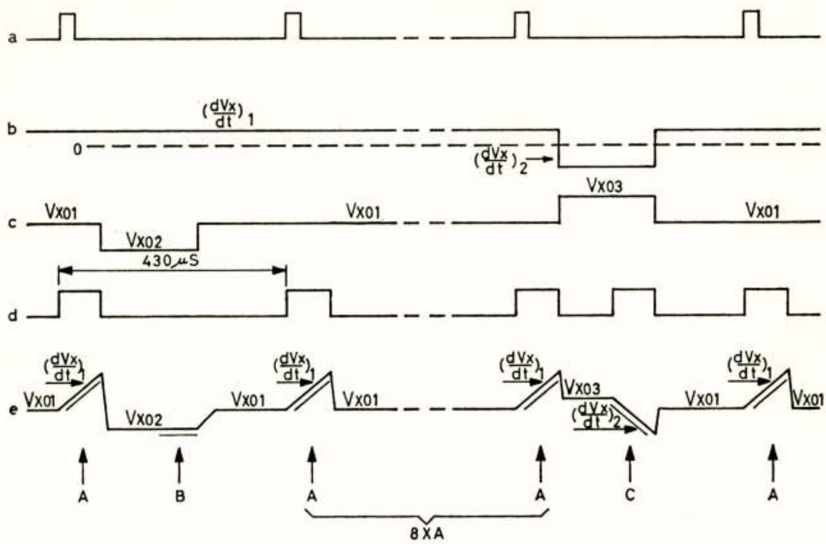

Fig. 19
Waveforms of the deflection circuit

a. Sync. pulses from radar
b. Current for the value of $\frac{dV_x}{dt}$
c. Value of V_{xo}
d. Key voltage for integrating (b) to get a sawtooth voltage
e. Output waveform of the sawtooth generator.

by the key voltages of the timing unit (*7*), secondly by quiescent voltage V_{xo} and thirdly by the slope of the sawtooth, $\frac{dV_x}{dt}$.

The values of V_{xo} and $\frac{dV_x}{dt}$ differ for each line and are selected by electronic switches (5 and 6). These switches are triggered in turn by the timing unit (*7*). In this way the various lines are built up independently of each other.

Fig. 19e shows a portion of signal V_x, viz. that portion which is used to write 10 radar picture lines, a range marker and a reference line.

Fig. 19a shows the sequence of synchronizing pulses of the radar fed into the timing unit. This timing unit provides various outputs with the keying pulses required to control the marker generator, the brightness control unit (8) and the electronic switches.

Electronic switch (5), which determines $\frac{dV_x}{dt}$, delivers to the sawtooth generator a current as depicted in Fig. 19b.

During the keying pulses (d) this current is capacitively integrated to form a V_x which changes linearly with time. At the end of the keying pulse the capacitor is discharged rapidly.

The voltage V_{xo} between successive sawteeth is determined by a current furnished by a separate electronic switch (6). This current is shown in Fig. 19c and is identical to the voltage it produces at the output of the sawtooth generator.

Thus V_{xo1} determines the point at which the picture sawtooth begins, V_{xo2} the position of the range marker and V_{xo3} the origin of the reference line in the X-direction.

The result of all this is output voltage V_x of the sawtooth generator, which is illustrated in Fig. 19e.

In this figure the intervals of time during which something is written on the picture tube are marked with double lines. At A the radar picture line is traced, at B a range marker and at C a reference line.

The current integrated into the picture sawtooth in the sawtooth generator (4) is obtained by way of the electronic switch (5) from phase-sensitive rectifier (9); this is fed from the sine output of a resolver (10).

The value of this current is proportional to the sine of the angle between the antenna axis and North direction.

In the Y-deflection system the value of this current is proportional to the cosine of this angle.

The outcome of this arrangement is that the slope of the picture sawtooth voltage for X-deflection is proportional to the sine, and that for Y-deflection proportional to the cosine of the antenna bearing angle; consequently the resulting direction of the deflection is the same as the direction into which the antenna radiates, it being understood that North corresponds to positive Y-deflection and East with positive X-deflection.

In order to transmit the antenna rotational information to the sine-cosine resolver, the latter is driven by the motor of a servomechanism controlled by a synchro in the antenna (this applies only to the case that the display unit and the radar are in the same building).

The sine-cosine resolver is fed with 400 c/s via a resolver amplifier which stabilizes the amplitude.

The phase-sensitive rectifier (9), resolver (10), resolver amplifier and the servo system together constitute the $R\text{-}\Theta / X\text{-}Y$ convertor. This is fitted, together with the 400 c/s generator, in a separate cabinet distinct from the display unit.

A similar technique is employed in writing the cursor. Here, too, there is a phase-sensitive rectifier (14), sine-cosine resolver (15) and resolver amplifier (16), except for the fact that the sine-cosine resolver is manually operated by means of a knob on the control panel.

The angular setting of the cursor can be read from a dial graduated in tenths of degrees. If the knob is turned so that the cursor crosses an echo, the dial shows the bearing of this echo relative to the origin of the cursor.

The output voltage of the phase-sensitive rectifier (14) is fed not only to electronic switch (5) but also to a multiturn potentiometer (13).

The slider of this component is connected to electronic switch no. 6. The portion of the output voltage of the phase-sensitive rectifier tapped by the multiturn potentiometer determines the value of V_{xo} in a certain time interval, namely at B in Fig. 19.

That is the interval in which the range marker is written on the picture tube.

For Y-deflection of the range marker there is another multiturn potentiometer on the same spindle.

The range setting of this marker, effected with a knob on the control panel, can be read from a graduated scale.

The circuits discussed so far are required to establish a relationship between the picture deflection and the antenna position and to trace the various measuring and marking aids. In addition to these circuits, which are shown in Fig. 18, there are the following electronic units:

1. A video amplifier for amplification and control of the incoming echo signals, video map signals and calibration signals for range and bearing.
2. A calibration unit generating the pulses which write range calibration rings.
3. An E.H.T. unit producing the 12 kV accelerating voltage for the picture tube.
4. A C.R.T unit comprising a cathode-ray tube, focus, deflection and centring coils.
5. The control panels with their various potentiometers, switches and other controls and adjustments.

Nearly all circuits use transistors instead of electronic tubes.

Only a few tubes are used, viz. one in the video amplifier, one in the phase-sensitive rectifier and one in each sawtooth generator.

5. Equipment for radar data transmission

5.1. *General*

For presentation of the data collected by the various radar stations on the main display units in the operational centres, the signals have to be transmitted from the radar stations to the centres.

This is accomplished by means of radio links.

At the radar stations, therefore, auxiliary equipment is required to convert the radar signals discussed in 4.1. into some form suitable for transmission over the radio link. This conversion is taken care of by the Radar Data Modulator.

In the operational centres the signals received have to be separated again and translated into the form required for the operation of the display units. This is effected by the Radar Data Demodulator.

There are techniques for reducing the bandwidth of the radar signals to be transmitted to a value that is considerably less than that normally demanded by the radar signals. An advantage of this is that the choice of transmitting frequencies is less restricted.

This bandwidth compression can be accomplished by writing the radar signals on a storage tube and scanning the resulting picture at a lower repetition frequency and, if possible, with a higher duty cycle.

The shore-based navigational radar system calls for a coverage of 16 km with a resolution of 15 metres, which comes down to 1067 cycles per radial scan.

If an angular error of 0.1° added by the bandwidth compressor to the errors already present is acceptable, the angular difference between successive scans must not exceed 0.2°, which gives 1800 scans per revolution of the antenna. With an antenna speed of 20 r.p.m. this gives $^1/_3 \times 1800 \times 1067 = 640$ kc/s.

Allowing for pauses between successive scans, a frequency band of about 800 kc/s is the result.

For direct transmission of the radar signals a bandwidth of 10 Mc/s is required.

The practical difficulties inherent in bandwidth compression, however, were such that this plan was abandoned. Consequently point-to-point radio links were selected for the transmission medium since these are fully capable of transmitting a 10 Mc/s band.

A special problem in the radar data transmission system was how to convey the antenna rotation data with adequate accuracy. The position of the antenna shaft had to be reproduced in the operational centres, and it was essential that no angular error in excess of 0.1 degree should occur at any time.

The following considerations played a major role in deciding on the nature of the angle transmission system:

a. the behaviour of the system under fading.
b. the sensitivity to disturbance caused by intermodulation with the other signals.
c. simplicity of alignment of the system.
d. sensitivity to external interference.
e. volume of equipment required.
f. intricacy of the equipment.
g. accuracy.

The following possibilities were contemplated:

1. A system in which sin Θ and cos Θ would be transmitted by pulsewidth modulation of two separate pulses.
2. A system in which Θ is transmitted as a phase difference of two alternating voltages of the same frequency.
3. A system in which the angular velocity $\frac{d\Theta}{dt}$ is transmitted as an alternating voltage varying proportionally in frequency.
4. A system in which the antenna position is continuously translated into a pulse code which is transmitted in the intervals between every two radar scans.

The following points may illustrate, with a view to the above-mentioned requirements *a* to *g*, what characteristics are to be expected from each of these four systems:

a. After fading phenomena systems 1, 2 and 4 will recover quickly (within a few tenths of a second after brief fading, within a few seconds after prolonged fading spells). In system 3 several minutes are required for recovery of the synchronization, and, besides, this recovery is not automatic.
b. Systems 1 and 4 are insensitive to intermodulation disturbance, 2 and 3 are sensitive to it, especially 2.

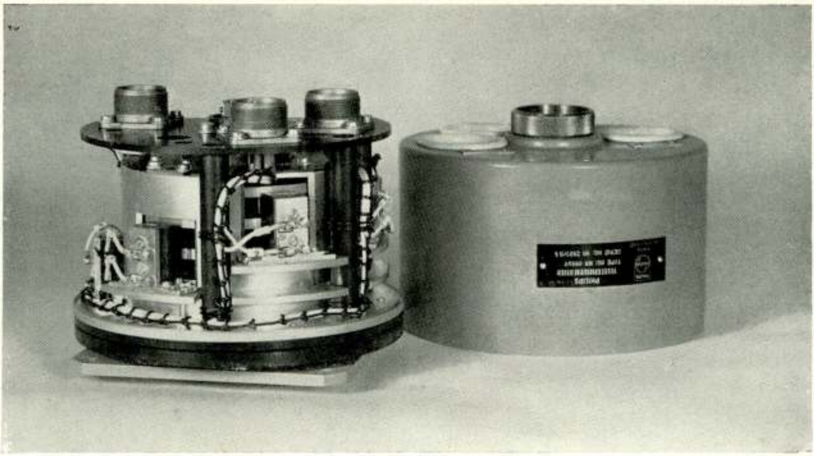

Fig. 20
The pulse generator for the antenna data.

c. To keep angular errors within limits it is necessary for systems 1 and 2 to be carefully realigned occasionally. In system 3 alignment is straightforward but has to be carried out more frequently by the operator at the Main Display Unit. System 4 rarely or never requires realignment.
d. System 2 is most sensitive to external interference and noise. System 4 is least sensitive; it works still when the echo signals are drowned in noise.
e. System 3 requires a minimum, system 4 a maximum of equipment.
f. System 3 is most straightforward, and system 4 comes next.
g. Under favourable conditions all 4 systems can comply with the accuracy requirements (about $\pm 0.1°$), but system 3 fails to do so when wind loads on the antenna cause speed variations.

The considerations listed above have led to the choice of system 4.

5.2. *The Radar Data Modulator*

The Radar Data Modulator receives the signals mentioned earlier from the radar transmitter-receiver.

Its output carries the signal shown in Fig. 21, which is fed into the point-to-point transmitter.

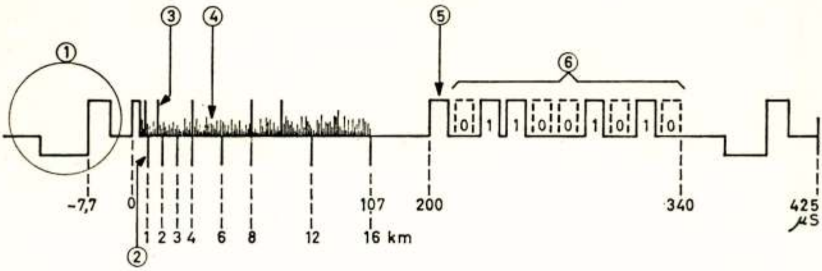

Fig. 21
Output from the Radar Data Modulator.

In this composite signal, (1) is the sync. signal. The R-Θ pulses (2) are negative, the echo signals (3) positive. (4) represents the noise of the radar set. (5) is the reference pulse for the binary shaft code of the antenna. This code itself is formed by pulse train (6), consisting of 9 pulses spaced 14 µsec.

The sync. signal has such a form that it can be separated easily from the remaining signals, for it begins with a negative-going portion lasting about 20 µsec. Next comes the synchronizing portion proper, a voltage step covering the full frequency deviation of the link transmitter.

The amplitudes of the echo signals are limited to a value as required by the link transmitter. Simultaneously the gain of the radar receiver is automatically controlled in such a manner that a signal-to-noise ratio of about 15 db is obtained. The control voltage used for this is derived from the noise level itself.

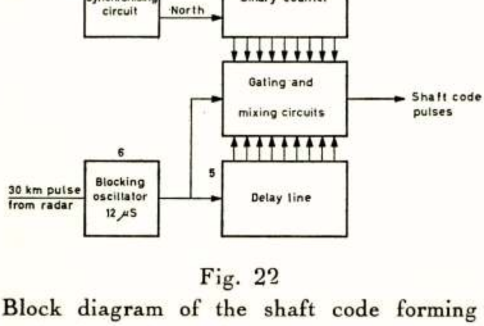

Fig. 22
Block diagram of the shaft code forming circuit in the Radar Data Modulator.

Of the available frequency deviation of the link transmitter, about 30 % is used for the calibration pulses and 70 % for the radar echoes and antenna shaft code.

The shaft code is formed as follows (see Fig. 22). A pulse generator (1) is coupled with the radar antenna shaft. When the antenna is rotating, it produces a pulse for every angular displacement of 360*deg*/512, so 512 pulses per revolution; that is about 170 pulses per second at a rotational speed of 20 revolutions per minute.

Each of these pulses advances a counter (2) by one step. The counter consists of 9 flip-flops in a cascade arrangement; the conditions of these flip-flops, therefore, give the angular position of the antenna in a binary form. The counter has a capacity of $2^9 = 512$ antenna positions.

Suppose that the two conditions of a flip-flop are called 0 and 1, for the sake of convenience. When the antenna is pointed at North, the counter registers 000.000.000. After an angular displacement of about 0.7° the next pulse arrives, setting the counter to 000.000.001, another 0.7° further on the counter registers 000.000.010, etc. After 511 pulses the count is 111.111.111 and after the 512th pulse it is 000.000.000 again, with the antenna looking dead north.

When the equipment is switched on, however, the probability is very low that the antenna and counter positions correspond. For this reason a second pulse generator is incorporated, which is also coupled with the antenna shaft and produces a pulse only when the antenna passes through north. This pulse is applied to all flip-flops of the counter and has the effect of resetting them all to 0.

If any cause should bring the counter out of step, this condition will be corrected the next time the antenna passes through north. The bearing pulses are not fed directly from the pulse generator to the counter but first pass through a pulse synchronizing circuit (3). The reason for this is explained below.

The counter position is converted into a pulse code by means of a gating system (4) and a delay line (5). A blocking oscillator (6) supplies the input of the delay line with a reference pulse which has a duration of about 12 μsec.

The delay line has 9 outputs at such taps that the pulse appears successively at these outputs with 14 μses intervals.

The outputs of the delay line are connected to the inputs of a gating system (4) which is so designed that each individual output of the delay line may or may not be connected to the output of the gating system. This 'may' or 'may not' depends on the condition of the corresponding flip-flop in the counter, condition 1 of the flip-flop establishing the connection and condition 2 interrupting it.

The output pulses of the gates are brought together with the reference pulses into one channel; when this channel contains, for example, the code shown in Fig. 22, the antenna has rotated at least $(2+8+32+128) \times 360/512$ degrees $= 170 \times 360/512$ degrees but less than $171 \times 360/512$ degrees past north.
The frequency at which the counter is scanned is the pulse repetition frequency of the radar, which means that 2341 reference pulses per second arrive at the input of the delay line.

Since the number of bearing pulses is about 170 per second, each position of the counter is transmitted about 14 times before the counter registers the next bearing pulse.

The time required for scanning the counter once is approx. 140 μsec. During this time, of course, the counter must not be set to a different position by a bearing pulse, otherwise the code which is transmitted would consist of two fragments of two different codes.

This is why a synchronizing circuit (3) is fitted between the pulse generator and the counter.

This sync. circuit receives not only the bearing pulses but also the radar trigger pulses.

Each bearing pulse is stored in the synchronizing circuit until the next radar trigger pulse arrives; only at that moment is a pulse produced at the output. The next radar trigger pulses do not set up a pulse at the output; the next output pulse will not appear until there is a fresh bearing pulse, etc. As a result the number of output pulses of the sync. circuit is equal to that of the bearing pulses, but they are slightly shifted in time to coincide with the radar trigger pulses. This means that the moments at which the counter registers the next count coincide with the radar trigger pulses.

The reference pulse scans the counter about 200 μsec later to ensure that the counter has reached a state of stability; the reference pulse is the 30 km pulse of the synchronizing unit in the radar.

The accuracy with which the pulse code indicates the antenna position is $\pm$ 0.35 degrees if it is assumed that there is no error in the bearing pulse generator.

This is the steady-state accuracy.

In reality, however, we have to do with a rotating antenna whose speed is fairly constant. This overcomes the inaccuracy resulting from the finite number of digits of the code, for at the moment the counter is advanced a step we know the true angular position of the antenna with more accuracy. The incertainty at that moment is due only to the difference in time between 2 radar trigger pulses because the synchronized bearing pulse appears between 0 and 430 μsec after the original bearing pulse.

At the moment a new count is made this introduces a maximum error of $\pm$ 215 μsec, equivalent to $\pm$ 0.025°, in the angular position.

In the mixing unit all signals are brought together into a single channel, whereupon it is fed into the link transmitter in the form shown in Fig. 21.

The radar data modulator uses transistors throughout.

5.3. *The Radar Data Demodulator*

The information transmitted over the radio link is received at the operational centre where it enters a Radar Data Demodulator; then it still has the form of Fig. 21, in which it was received by the link receiver of the operational centre.

This signal is applied first to a signal separating unit in the Radar Data Demodulator.

The following signals appear at the individual outputs of this unit:

1. a sync. pulse, appearing about 7.5 μsec before the radar echo for zero range.
2. the radar echoes and the radar receiver noise.
3. the R-Θ calibrating pulses at distances of 0. 1, 2, 3, 4, 6, 8, 12 and 16 km in range, and at 5, 10, 15, 20, 25, etc. degrees with respect to north.
4. a sync. pulse at 200 μsec from zero range, derived from the reference pulse for the antenna shaft code.
5. the antenna shaft code, commencing with the reference pulse.

The signals mentioned under 1, 2 and 3 are fed into the Main Display Unit.

The antenna shaft code has to be converted first before being of any use.

The R-Θ / X-Y convertor contains a sine-cosine resolver which has to rotate in synchronism with the radar antenna.

On the shaft of this resolver a pulse generator, identical in design to that fitted on the antenna shaft, is mounted. The bearing and north pulses of this generator are fed into the

Radar Data Demodulator. In the same way as in the modulator at the transmitting end (Fig. 22) the pulses are counted starting from North and the result is converted into a pulse code, preceded by a reference pulse.

The two pulse codes, one from the radar and one from the R-Θ/X-Y convertor, are now compared in a code comparison unit; any difference between the two codes is translated into an error voltage. This error voltage drives, via a servo system, a motor which is coupled with the resolver in the R-Θ/Y-X convertor.

This is accomplished in such a manner that the resultant change in speed reduces the difference between the two codes until both codes are in synchronism and the angular difference between the antenna and resolver shafts approaches 0.

If the antenna speed is constant, the shaft-to-shaft error will not exceed 0.1°.

Wind forces, however, may make the antenna speed inconstant. It is assumed that the accelerations due to this are never higher than those encountered when the antenne speed varies sinusoidally at the rate of two cycles per revolution, with a peak value equal to 10% of the average speed.

At this speed variation the maximum error remains within 0.15°. To obtain these characteristics a servo system is required which incorporates adequate damping and has an upper frequency limit of about 15 c/s.

The Radar Data Demodulator is fully transistorized.

6. **Communication**

6.1. *General*

It was said already in the Introduction that it is important for the operator to be able to get rapidly into touch with the pilot he desires to supply with nautical information.

To this end a VHF mast, entirely built up from tubes, has been erected, for example, in Cuxhaven to a height of about 100 metres. This enables the operational centre to establish contact with the pilots in the vicinity of light vessel 'Elbe I'.

The pilots are issued with Portophones, which will be discussed below.

Apart from this there are means of communication among the radar stations and from the latter to the parent operational centre. There is no need to go into detail about this.

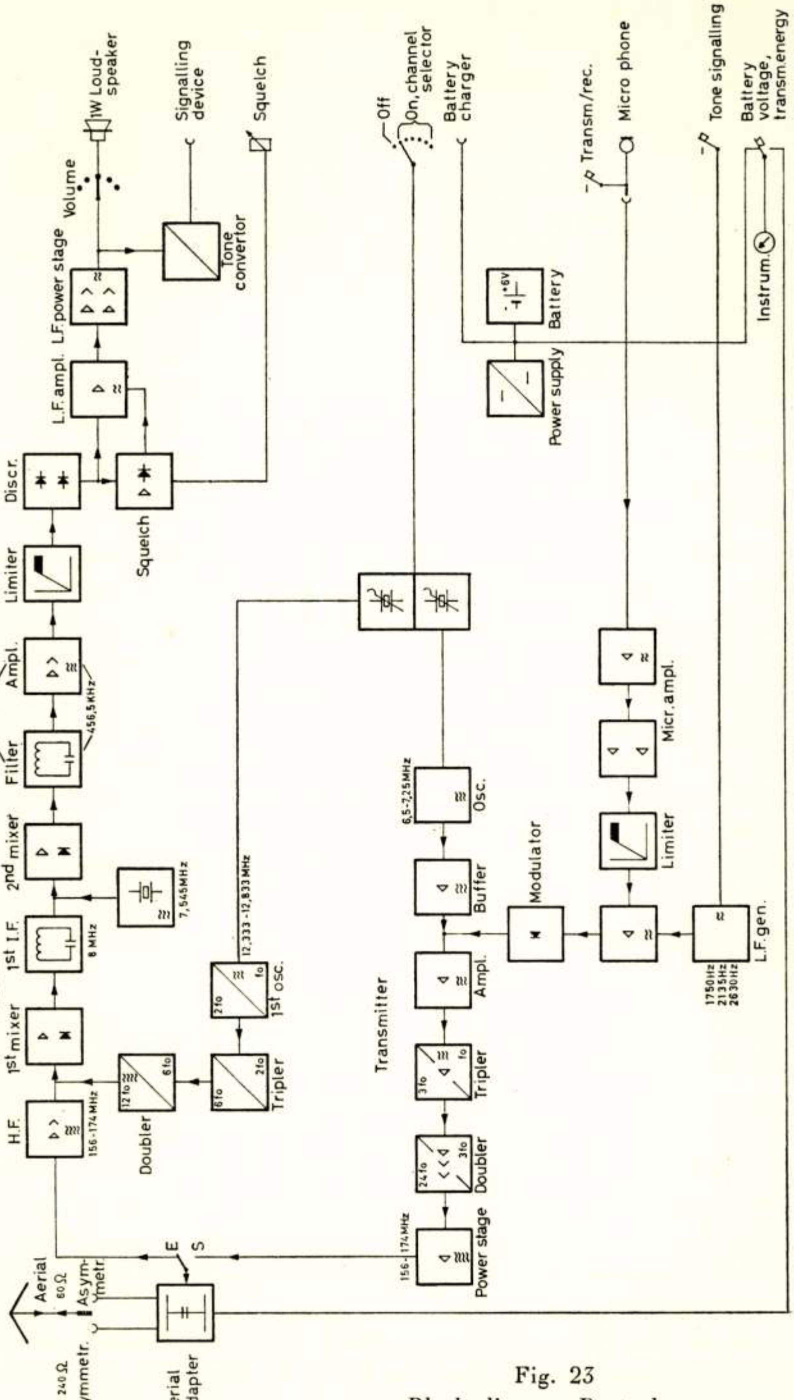

Fig. 23
Block diagram Portophone.

6.2. *Portophones.*

6.2.1. Specification.

Frequency:	6 channels in 31.7 - 41 Mc/s band,
	68 - 87.5 Mc/s band or
	156 - 174 Mc/s band.
R.F. Power:	1 W
Mode of modulation:	phase modulation (F 3)
Receiver sensitivity:	1 μV at 20 db signal-to-noise ratio
Receiver selectivity:	more than 6 db at 15 kc/s from centre of channel
	more than 100 db at 30 kc/s from centre of channel.
Power supply:	6 *V* 8 *Ah* battery giving 10 working hours, of which 20% used in transmitting.

6.2.2. Block diagram.

As shown in Fig. 23 the oscillator frequencies required for the transmitter and those for the receiver are prepared by crystal-controlled circuits.

To render the reception as free from interference as possible, a double superheterodyne receiver has been adopted; it has been attempted to minimize the risk of penetration of unwanted signals by generous filtering, especially in the two I. F. stages. The $\frac{\lambda}{4}$ whip aerial can be connected to the Portophone set either directly or by means of a 60-ohm coaxial cable. It is also possible to work with a 2-wire line because an extra 240-ohm output is provided.

This Portophone permits simplex working at one frequency per channel as well as restricted duplex working at a pair of frequencies per channel.

6.2.3. Mechanical design.

In the design of the Portophone full attention was given to the specific conditions in which this transmitter receiver set would be used. The pilot should take it with him when weather conditions make this necessary. A few of the principal features are:

a. reduced size and weight (transistors!)

b. resistant to impact

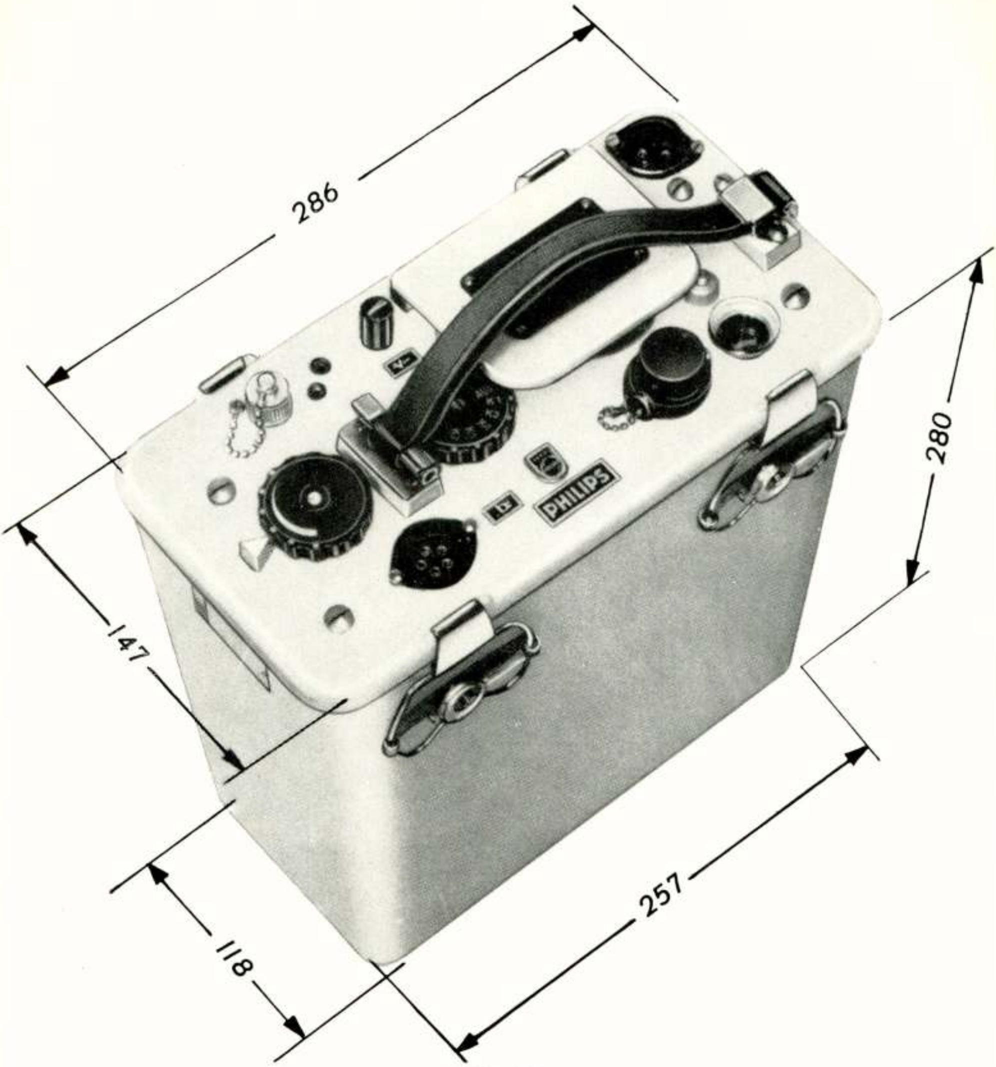

Fig. 24
Portophone ready for transport with aerial outlet and covering for loud-speaker closed and leather handle hooked in.

c. resistant to moisture, even sea-water
d. very high reliability (no duplicated circuits!)
e. easy to operate.

The set is accommodated in a box of polyester resin reinforced with glass fabric; the box is water-tight.

As you will see from Fig. 24, the cover supports the various controls and connectors as well as the loudspeaker.

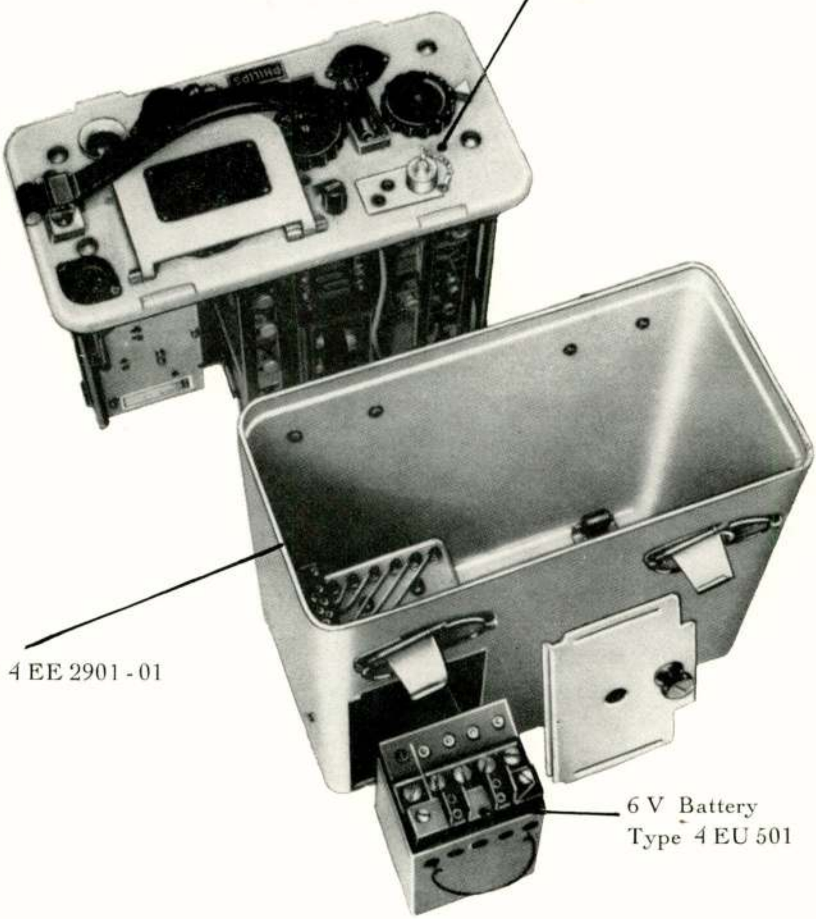

Fig. 25
Portophone broken down into main parts.

Fig. 25 shows the Portophone broken down into its main parts; you will see at once the location of the *6V* nickel-cadmium storage battery, which can be charged from the ship's mains without the need for removal.

For this purpose there is a terminating provision on the cover.

The system of readily replaceable building blocks has been used wherever possible, which greatly enhances the speed of servicing.

The Portophone, as well as the aerial and hand microphone, are carried in a canvas case.

Manuscript ontvangen 8 maart 1960

BOEKAANKONDIGINGEN

Sedert een aantal jaren worden door Dover Publications, inc., New York goedkope herdrukken uitgegeven van „klassieke" fysische werken.

Ditmaal verschenen:

The theory of Heat Radiation, door Max Planck (prijs $ 1.50). Het is een herdruk van de Engelse vertaling van de tweede druk die in 1914 verscheen.

Tensors for circuits, door Gabriel Kron (prijs $1.85).Dit boek werd oorspronkelijk gepubliceerd als „A short course in Tensor Analysis for Electrical Engineers" in 1942. Toegevoegd werd een lijst van de overige door Gabriel Kron geschreven boeken en verhandelingen over dit onderwerp.

Principles of quantum mechanics, door W. V. Houston (prijs $ 1.85). Het betreft hier een herdruk van de in 1951 verschenen eerste editie.

Microwave Transmission, door J. C. Slater (prijs $ 1.50). Dit boek verscheen voor het eerst in 1942. Hoewel de microgolftechniek sindsdien een groot aantal nieuwe aspecten is gaan vertonen bevat het boek veel waardevols zodat een herdruk zeker gerechtvaardigd was.

K.

CONGRESSEN

Non-linear magnetics and magnetic amplifiers Conference 1960, sponsored by AIEE and IRE.

Er wordt ter kennis van belangstellenden gebracht, dat bovengenoemde conferentie gehouden zal worden van 26 t/m 28 oktober 1960 in Philadelphia.

De conferentie is verdeeld in 3 secties met als onderwerpen

a. computer magnetics (memory components, logic elements, etc.);
b. combined semiconductor and non-linear magnetic devices;
c. theory, design and applications of magnetic amplifiers.

De voorzitter van het „Technical Program" is Mr. David Katz, Bell Telephone Lab. Inc., Whippany, New Jersey.

Société des Radioelectriciens.

Deze organisatie zal van 20-25 februari 1961 te Parijs een colloquium organiseren met de volgende titel:
„Colloque International sur les dispositifs à semiconducteurs". Dit colloquium zal samenvallen met de tentoonstelling van de „Fédération Nationale des Industries Electrotechniques".

Nadere inlichtingen zullen t.z.t. verstrekt worden.

Uit het Nederlands Radiogenootschap

VERSLAG VAN DE ALGEMENE JAARVERGADERING GEHOUDEN IN HET INSTITUTE OF SOCIAL STUDIES TE DEN HAAG OP 24 MAART 1960.

Van het bestuur zijn aanwezig: Ir. J. J. Vormer (voorzitter), Prof. Dr. Ir. J. L. H. Jonker (vice-voorzitter), Prof. Dr. C. E. Mulders (secretaris), Prof. Dr. Ir. J. P. Schouten (penningmeester), Ir. H. T. Hylkema, Ir. Y. Boxma, Ir. P. H. Boukema, Dr. Ir. A. van Weel.

Verhinderd: Ir. J. J. van Rijsinge.

De voorzitter opent te ca. 11.30 uur de vergadering, die in totaal ca. 30 leden en bestuursleden telt. De voorzitter herdenkt ons erelid Prof. Dr. Balth. van der Pol en de eerste secretaris van het Genootschap, Ir. Nordlohne, die in 1959 overleden zijn.

Het jaarverslag over 1959 wordt door de secretaris voorgelezen (het is in dit nummer gepubliceerd). Er zijn geen opmerkingen.

Het financieel overzicht van de penningmeester (eveneens in dit nummer gepubliceerd) wordt door de vergadering goedgekeurd, alsmede de begroting voor 1960. De kascommissie, bestaande uit de heren Ir. J. Rodrigues de Miranda en Ir. Th. J. Weijers, hebben schriftelijk hun accoord over het gevoerde beleid uitgebracht. De nieuwe kascommissie zal bestaan uit Ir. Th. J. Weijers en Prof. Ir. Dr. J. L. van Soest.

Aan de orde komt daarna de bestuursverkiezing. Door omstandigheden is het aantal mutaties dit jaar zeer groot, en zoals de heer Bloemsma opmerkt, eigenlijk groter dan voor de continuïteit in het beleid gewenst is. De voorzitter stemt hiermede in, doch merkt op dat het aftreden van enige heren aan bijzondere omstandigheden te wijten is, waartegen men zich moeilijk kan verzetten.

De heer Vormer merkt nog op, dat het in de bedoeling ligt een maximale zittingsduur van de bestuursleden van 6 jaar in het Huishoudelijk Reglement voor te schrijven, opdat meer dan in het verleden de functies in het Genootschap kunnen circuleren onder de leden. Bij een ledental van omstreeks 500 moet dit mogelijk zijn.

De door het bestuur voorgestelde nieuwe bestuursleden worden bij acclamatie door de vergadering gekozen. De heer Vormer bedankt de aftredende bestuursleden, in de eerste plaats Ir. Hylkema, die sinds 1952 hoofdredacteur is geweest en in deze periode met grote activiteit het tijdschrift door vernieuwde opzet aantrekkelijker heeft gemaakt en het beleid met nauwgezetheid heeft gevoerd. Als opvolger van de heer Hylkema heet de voorzitter thans de heer Ir. L. Krul in het bestuur welkom.

Tot de scheidende vice-voorzitter Prof. Dr. Ir. J. L. H. Jonker, die wegens drukke werkzaamheden moest bedanken, spreekt de heer Vormer bijzondere dank uit voor zijn activiteit als voorzitter van de SVEN. Prof. Jonker zal het voorzitterschap van de SVEN nog enige tijd blijven waarnemen.

Het bestuurslid Ir. Y. Boxma zal als vice-voorzitter in de plaats van Prof. Jonker treden.

Ir. van Rijsinge, sinds 1955 een zeer gewaardeerd medewerker in het bestuur, heeft wegens verandering van werkkring ontslag moeten vragen uit zijn bestuursfunctie. Hij wordt door Ir. Paling opgevolgd.

Ir. Vormer, over zichzelf sprekend, merkt op dat hij sinds geruime tijd de wens had af te treden, daar hij door drukke werkzaamheden dikwijls niet in de gelegenheid was zoveel aandacht aan het Genootschap te schenken als hij wenselijk achtte. Hij prijs zich gelukkig thans in Ir. J. D. H. van der Toorn een opvolger te kunnen begroeten, waaraan hij met het grootste vertrouwen zijn functie kan overdragen. Het Genootschap waardeert het bijzonder dat de heer Van der Toorn zich voor deze functie beschikbaar heeft gesteld.

De heer Van der Toorn zegt een enkel woord van dank aan het bestuur en de vergadering voor het vertrouwen dat zij in hem hebben gesteld. Het is met groot genoegen dat hij, nadat hij in vorige functies de radio vooral in de beleidssfeer had ontmoet, deze thans in de wetenschappelijke sector zal kunnen dienen.

Prof. Schouten bedankt de aftredende voorzitter voor zijn vele en belangrijke werk in dienst van het Genootschap. De heer Vormer is reeds op 10 april 1940 als penningmeester in het bestuur gekomen en bekleedt het voorzitterschap vanaf de 100ste vergadering op 30 maart 1951. Prof. Schouten geeft namens de vergadering, als een van de oudste fungerende bestuursleden, uiting aan zijn waardering voor hetgeen de scheidende voorzitter heeft verricht.

De heer Vormer antwoordt met een kort wederwoord.

Bestuursmededelingen. De voorzitter deelt mede, dat de plannen voor een tentoonstelling bij gelegenheid van ons 40-jarig jubileum nu zodanig gewijzigd zijn, dat de combinatie met de Firato is vervallen. Een expositie van bescheidener opzet in het Singer-museum in Laren is thans in voorbereiding. De jubileumvergadering en eventueel een diner kunnen in hetzelfde gebouw en vlak daarbij gehouden worden. De openingsdatum is vermoedelijk 7 oktober, waarna de tentoonstelling 14 dagen geopend blijft.

De voorzitter doet enige mededelingen over de kortgeleden opgerichte Beneluxsectie van het Institute of Radio Engineers. De heer Ir. Rinia is hiervan voorzitter. Wederzijdse introductie met ons Genootschap op vergaderingen is mogelijk. Op 25 april wordt een gecombineerde vergadering gehouden.

Rondvraag. De heer Bloemsma vraagt hoeveel candidaten aan het examen radioelektronicus hebben deelgenomen.

De heer Boukema deelt mede, dat aan het 1e gedeelte voor dit examen in januari 1960, 15 candidaten hebben deelgenomen; hiervan werden bij het schriftelijk gedeelte 7 afgewezen. Uiteindelijk slaagden na het mondelinge gedeelte 5 candidaten.

De heer Van Weel merkt op, dat vrijwel alle candidaten uit Eindhoven kwamen, waar op de H.T.S. een cursus wordt gegeven. Thans blijkt, dat men daar ook een schoolexamen zal gaan afnemen, waardoor veel cursisten niet bij het N.R.G. zijn gekomen.

De heer Boukema spreekt de vrees uit, dat nu, evenals bij het examen televisietechnicus, de animo ook voor dit examen zo gering zal blijken, dat de eraan bestede moeite niet beloond zal worden. De heer Van Weel verdedigt de doelmatigheid van het examen N.R.G. voor radioelektronicus, de heer Bloemsma staat er sceptisch tegenover.

De heer Van Slooten pleit voor een zakelijke stijl in de rubriek personalia. Prof. Schouten pleit voor uitbreiding van deze rubriek met foto's en levensschetsen van auteurs in het tijdschrift. De heer Hylkema deelt mede, dat hem gebleken is, dat de rubriek personalia zeer gewaardeerd wordt, maar klaagt over de geringe informatie, die door de leden verstrekt wordt. Toch moet de hoofdredacteur hier zijn bronnen vinden. Spreker pleit voor meer belangstelling voor het Genootschap, speciaal onder de jonge leden.

Te ca. 12.30 uur sluit de voorzitter de vergadering.

JAARVERSLAG VAN DE SECRETARIS OVER 1959.

In het verslagjaar werden de volgende vergaderingen gehouden:

5 februari

Gemeenschappelijke vergadering met de Geluidstichting te Hilversum. Onderwerp: Stereofonie. Sprekers: Prof. Dr. J. F. Schouten, Ir. N. V. Franssen, Dr. Ir. J. J. Geluk, J. L. Ooms en Ir. J. B. S. M. Kerstens.

Er waren ca. 100 toehoorders.

11 maart

139e zitting, tevens Algemene Jaarvergadering. De ochtendzitting werd met ca. 20 deelnemers zeer slecht bezocht. De middagzitting was gewijd aan de bespreking van enige problemen betreffende ionosfeeronderzoek en de radio-astronomie. Sprekers: Ir. F. R. Neubauer, Drs. A. D. Fokker, Drs. L. D. de Feiter.

Ca. 50 deelnemers.

25 juni

140e zitting, tevens bezoek aan de N.V. Philips Telecommunicatie-industrie te Huizen. Sprekers: Ir. R. S. H. Hylkema, Ir. J. J. van Rijsinge, Ir. J. G. M. Seppen, Ir. H. A. Teunissen, Ir. A. A. Potjer, Ir. G. Rosier.

Er waren ruim 100 deelnemers.

24 september

141e zitting, tevens bezoek aan Van der Heem N.V. te Den Haag. Sprekers: Drs. C. A. A. van Luttervelt, W. A. van Waasdijk, Ir. C. Dullemond, Ir. J. de Meij, J. A. G. van Everdingen, Ir. A. B. Idzerda.

Aantal deelnemers ca. 130.

18 en 26 november

Tweedaags symposium in samenwerking met de sectie voor Telecommunicatietechniek van het K.I.v.I., gehouden in Delft. Onderwerp: Filtersynthese, gebaseerd op het gebruik van functies met een complexe variabele. Sprekers: Prof. Dr. Ir. W. Th. Bähler, Ir. W. Nijenhuis, Ir. W. Milort, Ir. A. Fettweis.

Aantal deelnemers ca. 80.

Het bestuur vergaderde 3 maal. Op de Algemene Jaarvergadering werden de heren Boukema, Mulders, Van Rijsinge, Vormer en Van Weel als bestuurslid herkozen.

Het tijdschrift bevatte verslagen van voordrachten en op zichzelf staande artikelen, alsmede genootschapsmededelingen, personalia, boekbesprekingen e.d. De 24e jaargang bevat 390 pagina's. De heer Ir. H. T. Hylkema gaf de wens te kennen, na vele jaren het hoofdredacteurschap te hebben waargenomen, deze functie neer te leggen. Hij werd opgevolgd door Ir. L. Krul.

Aan de examens voor radiotechnicus en -monteur werd, met inbegrip van herexamencandidaten, door resp. 472 en 563 candidaten deelgenomen (vorig jaar resp. 408 en 501). Hiervan slaagden resp. 120 en 193 candidaten = resp. 25 % en 34 %. Het examen voor televisietechnicus werd alleen in het voorjaar afgenomen. Van de drie candidaten slaagde er een. Aan één candidaat werd de WERA-examenprijs voor een uitzonderlijk goed examen radiotechnicus toegekend.

De SVEN — Stichting tot bevordering van het elektronisch vakonderwijs in Nederland — waarin ons Genootschap, samen met de VEV een belangrijke rol speelt, kan op een succesvol jaar terugzien. Het jaarverslag van de Stichting zal in het tijdschrift worden opgenomen. Onze verdere relaties met de VEV waren eveneens aangenaam en vruchtbaar.

Het aantal leden van het Genootschap per 1 januari 1960 bedraagt volgens de ledenlijst van die datum 470, het vorig jaar 462. De groei van het ledenaantal was in het verslagjaar aanmerkelijk minder dan in vorige jaren. Wij mogen evenwel op goede gronden verwachten dat dit slechts een tijdelijke stagnatie in de groei van ons Genootschap betekent.

UIT HET JAARVERSLAG VAN DE PENNINGMEESTER OVER 1959.

Ontvangsten

De contributies van de leden zijn ook dit jaar weder vlot binnengekomen. Enkele leden zijn een paar maal aangeschreven, doch dit behoorde tot de uitzonderingen. Alle leden hebben inmiddels hun contributie betaald op een drietal na.

In het aantal donateurs is ook dit jaar geen wijziging gekomen, zodat het totaalbedrag aan donaties weder *f* 2.230,— bedroeg.

In de loop van het jaar is een fonds aangekocht ten bedrage van *f* 1.000,— 4½% Bank van Ned. Gemeenten 1958.

De opbrengst van de coupons bedroeg *f* 263,—.

Ook dit jaar is regelmatig het saldo van de girorekening overgeschreven op de Bankrekening, waardoor een rente van *f* 233,95 is gekweekt.

Uitgaven

Gedurende dit jaar zijn de rekeningen van het tijdschrift over het jaar 1958 van de drukker ontvangen, zomede over 3 nummers van het jaar 1959.

Gedurende dit jaar is één prijs van *f* 100,— van het Wera-fonds uitgereikt.

Aan honoraria is een totaalbedrag van *f* 1.430,— uitgekeerd, hetwelk iets boven het geraamde bedrag ligt.

Reserveringen

Voor de nog te betalen nummers van het tijdschrift over het jaar 1959 is een bedrag van *f* 3.000,— gereserveerd.

Voor het Jubileum-fonds is een bedrag van *f* 1.000,— gereserveerd.

Inkomsten en uitgaven over 1959

Inkomsten

	Geschat	Uitkomst
Contributies . .	f 9240,—	f 9155,—
Donaties . . .	„ 2230,—	„ 2230,—
Opbr. coupons .	„ 250,—	„ 263,—
Rente 1958 .	„ 250,—	„ 233,95
Wera Fonds .		„ 100,—
Overdrukken . .		„ 119,60
Lunches . . .		„ 238,—
Diversen . . .		„ 5,23
Gereserveerd tijdschrift . .		„ 6000,—
		f 18344,78

Uitgaven

	Geschat	Uitkomst
Tijdschrift '58 .		f 4018,91
Tijdschrift '59 .	f 6000,—	„ 4454,98
Onk. Bestuur .	„ 300,—	„ 350,88
Onk. Sprekers .	„ 400,—	„ 79,10
Onk. Red.Comm.	„ 300,—	„ 75,—
Zaalhuur . . .	„ 200,—	„ 60,—
Adm.kosten . .	„ 300,—	„ 300,—
Klein drukwerk	„ 450,—	„ 264,95
V.E.V. Contr. .	„ 40,—	„ 25,—
Wera Fonds .	„ 400,—	„ 100,—
Honoraria . .	„ 1200,—	„ 1430,—
Lunches . . .	„ 300,—	„ 398,60
Bankkosten . .		„ 16,74
Diversen . . .		„ 330,18
Aankoop effecten		„ 979,18
		f 12883,52
Nog te betalen:		
Tijdschrift . .	f 3000,—	
Te reserveren:		
Jubileum fonds	„ 1000,—	„ 4000,—
		f 16883,52
Voordelig saldo		„ 1461,26
		f 18344,78

Begroting voor 1960

Inkomsten

Contributies	f 9240,—
Donaties	„ 2230,—
Opbr. coupons	„ 260,—
Rente	„ 240,—
Nadelig saldo	„ 220,—
	f 12190,—

Uitgaven

Tijdschrift	f 6000,—
Onkosten Bestuur . . .	„ 300,—
Onkosten Sprekers . . .	„ 400,—
Onkosten Red.Commissie	„ 300,—
Zaalhuur	„ 200,—
Adm. kosten	„ 300,—
Klein drukwerk	„ 450,—
Kosten Opl. V.E.V. . . .	„ 40,—
Prijzen Wera Fonds . . .	„ 400,—
Hon. Publ. tijdschrift . .	„ 1500,—
Lunches	„ 300,—
Excursies	„ 500,—
Jubileum Fonds	„ 1000,—
Diversen	„ 500,—
	f 12190,—

Evenals voor het jaar 1959 is de ontvangst aan contributies geschat op f 9.240,—.

De donaties zijn weder geraamd op f 2.230,—.

De kosten van het tijdschrift zullen naar schatting weder f 6.000,— bedragen.

Aangezien is gebleken dat het uitgetrokken bedrag voor honoraria voor publicaties in het jaar 1959 is overschreden, is voor dit jaar een bedrag groot f 1.500,— uitgetrokken.

Kapitaal N.R.G.

Het kapitaal van het N.R.G. is gestegen van *f* 8.472,83 tot *f* 11.008,59.

Balans per 31 december 1959

Debet		*Credit*	
Saldo girorekening . . .	*f* 1191,15	Kapitaal N.R.G.	*f* 11008,59
Saldo bankrekening . .	„ 10932,50	Kapitaal U.R.S.I.	„ 4380,07
Effecten	„ 8465,01	Reserve jubileum	„ 1200,—
P.M. Instrumenten	„ —,—		
P.M. oude tijdschriften .	„ —,—	*Nog te betalen:*	
		Rek. Tijdschrift	„ 3000,—
		Res. Jubileum	„ 1000,—
	f 20588,66		*f* 20588,66

Staat van ontvangsten en uitgaven Examencommissie over 1959

Ontvangsten		*Uitgaven*	
Examengelden voorjaar .	*f* 22.040,—	Vacatiegelden	*f* 9.095,62
Examengelden najaar .	„ 19.015,—	Reis- en verblijfkosten .	„ 5.514,78
Rente spaarbank	„ 657,—	Zaalhuur	„ 2.825,90
Verkoop uitgewerkte examenopgaven	„ 393,—	Verbruiksartikelen . . .	„ 1.386,79
Diversen	„ 51,20	Meubilair, instrumenten gereedschappen	„ 369,46
		Onderhoud idem	„ 668,08
		Drukwerk	„ 1.502,87
		Porti	„ 959,21
		Telefoon, telegrammen .	„ 35,44
		Kantoorbehoeften	„ 484,09
		Samenstellen examenopgaven	„ 1.150,—
		Correctiewerk	„ 4.425,—
		Salaris administrateur . .	„ 2.500,—
		Publicatie examenopgaven	„ 258,88
		Terugbetaling examengelden	„ 469,75
		Diversen	„ 99,34
			f 31,745,21
		Voordelig saldo	„ 10.410,99
	f 42.156,20		*f* 42.156,20

Balans Examencommissie per 31 december 1959

Debet		*Credit*	
Saldo giro	*f* 1.237,44	Kapitaal	*f* 30.515,47
Saldo Nutsspaarbank . .	„ 24,953,04		
Saldo kas (incl. zegels enz.)	„ 758,75		
Instrumenten	„ 107,—		
Meubilair, kantoormachines	„ 2.865,45		
Gereedschappen	„ 593,79		
	f 30.515,47		*f* 30.515,47

Nederlands Nationaal Comité voor de U.R.S.I.

Ontvangsten

Evenals vorig jaar, bedroegen ook in 1959 de donaties weder *f* 2.350,—.

Uitgaven

De contributie bedroeg dit jaar *f* 1.893,34 terwijl aan onkosten een bedrag van *f* 12,02 werd uitbetaald.

Kapitaal U.R.S.I.

Het kapitaal van de U.R.S.I. is gestegen van *f* 3.935,43 tot *f* 4.380,07.

NIEUWE LEDEN

G. A. Bus, Larenseweg 120, Hilversum.
Ir. J. H. Geels, Melis Stokelaan 2246, Den Haag.
Ir. C. de Jong, de Genestetlaan 3, Voorburg.
Ir. S. Kukler, Beresteynstraat 3, Voorschoten.
Ir. M. J. Laarakker, Oude Amersfoortseweg 283, Hilversum.
Ir. W. Milort, Celsiuslaan 28, Hilversum.
Ir. J. Mulder, Nicolaas Beetsstraat 128, Amsterdam.
Ir. R. van Raamsdonk, Doornstraat 16, Scheveningen.
A. G. Robeer, Bosboom Toussaintlaan 73, Hilversum.
Ir. P. Stam, Anninksweg 96, Hengelo.
Ir. W. J. D. Steenaart, 14 Greenwood Drive, Millington, New Jersey, U.S.A.
Ir. J. M. M. Veldstra, Oude Amersfoortseweg 269, Hilversum.
Dr. Ir. M. T. Vlaardingerbroek, Bergmanstraat 83, Eindhoven.

VOORGESTELDE LEDEN

R. de Roo van Alderwerelt, Gouverneurkade 5, Voorburg (Standard-Electric).
Ir. W. Herstel, Kagerstraat 16, Leiden (R.U. Leiden).
Ir. C. van Schooneveld, Paradijsstraat 35, Voorburg (RVO-TNO).

NIEUWE ADRESSEN VAN LEDEN

P. R. Dijksterhuis, Julianalaan 3C4, Bilthoven.
Ir. B. van Dijl, Burchtlaan 15, Wassenaar.
J. A. Greefkes, Chopinlaan 51, Eindhoven.
Ir. B. T. Jurgens, 1158 José Ingeniéros, Olivos Buénos Aires.
Ir. J. C. de Munck, van Aldemondestraat 198, Delft (correctie).
A. J. M. W. v. Overbeek, Pauwlaan 5, Eindhoven.
F. J. Soede, p/a Mission de L'assistance technique, Organisation de l'Aviation Civile Internationale. RABAT-Chellah, Boite Postale 525 MAROC.
Ir. L. G. Wubben, Jan v. Eyckgracht 193, Eindhoven.
Ir. J. K. Zuidweg, Dr. Kuyperstraat 22, Zandvoort.

Dit nummer werd gedrukt op 19 mei 1960.