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RADIO DEPARTMENT

TECHNICAL NOTE

Nº RAD. 209

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Technical Note No. RAD.209

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October, 1944.

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

German Ground Radar Equipment
The Precise Range Measuring Unit Type OK106 of the "Freya" and "Seetakt" installations

- by -

H.P. Bailey

SUMMARY

This note describes the electrical and mechanical features of the unit OK106, used in Seetakt and Freya installations, for accurate range measurement. The unit comprises an adjustable delay network, indicating range directly by dial and counter. Only one echo can be dealt with at a time, and the operator must be given the approximate range of the desired signal from the main observation Unit "N". Discrimination in range to 0.05 Km (about 55 yards) is possible and the accuracy of any observation is said to be better than 0.1%, at the nominal P.R.F. of 500 c.p.s.

CONTENTS

LIST OF FIGURES

1. Introduction

This unit has been operated in conjunction with other equipment, in connection with the reconstruction of Radar installations, of the Freya and Seetakt (or Coastwatcher) type. The mechanical and electrical features are described in this note but the operational performance is not discussed.

The unit was in good condition, except for grit in the mechanical parts. It functioned satisfactorily after cleaning, and the replacement of two faulty resistors. Available information comprised a captured document describing the complete Freya installation with circuits and parts lists of all units, together with two complete circuit diagrams of Seetakt installations.

Where reference is made to other units, associated with the one described, the German type numbers will be quoted. See References 7.3 and 7.4

2. Purpose of Unit

This unit, in conjunction with its associated high speed display unit OB110, is used to give an accurate, direct reading of range of a selected echo. It is housed with unit OB110 in a weatherproof box of cast light-alloy, forming a single unit referred to as "Apparatus O". As the fast time-base shows only 20 km of the total range, the operator is responsible for giving accurate figures for an echo whose approximate range has been passed to him from the main observation unit "Apparatus N".

3. Description of Unit

3.1 Method of Range Measurement

In general, range measurement in radar equipment depends on measurement of time delay from emission of transmitted pulse to receipt of reflected pulse. In the equipment described, the fast time base on unit OB110 is produced by the linear part of an amplified 500 c.p.s. sinewave, fed from the master oscillator Z100. The unit OK106 is a tapped network, inserted between the master oscillator and the time base amplifier. The same sinewave is fed, through a variable phase shift in the Master Oscillator to the modulator unit and so controls the time of the transmitted pulse. When setting up the apparatus the network is adjusted to give zero delay, and the phase of the modulator sinewave adjusted, until the ground ray coincides with the zero line, provided on unit OB110. By increasing the time delay in unit OK106, any selected echo can be brought to the zero line. The delay introduced will be a measure of the range (See Appendix 1). The unit is calibrated and gives a direct reading of range on dials and a counter up to the maximum of 200 km. Provision is made in the Master Oscillator to adjust the P.R.F. to values ranging from 494 c.p.s. to 506 c.p.s. to avoid mutual interference between adjacent stations. The unit OK106 is designed to give readings of range accurate to better than 0.1% at the extreme P.R.F.'s even at ranges over 100 km. At short ranges, this accuracy will be subject to the minimum step of 0.05 Km.

3.2 Electrical Performance of the Network

Fig. 6 shows a circuit diagram of the network.

In discussing the network it is convenient to refer to the actual range, corresponding to the time delay in any section of the network rather than the phase angle or time delay itself. The network is arranged in four main groups, which are designated in the German literature, as follows:-

"B" group	giving	19	steps	of	0.05 Km	each.
"C"	"	9	"	"	1 Km	"
"D"	"	9	"	"	10 Km	"
"E"	"	1	step	"	100 Km	"

Thus the total range 0-200 Km is produced with a minimum step of 0.05 Km, which is equal to the visual discrimination at the tube face.

Referring now to fig. 6, the 500 c.p.s. sinewave is fed from unit Z100 through terminal K14, to a switch controlling the B group. This group forms a single L-section, whose series arm is a chain of 10 centre-tapped adjustable inductances 100-109, with condenser 178 as shunt arm. The tappings give a phase shift of 3.6' per tap which corresponds to 0.05 Km. This section is followed by an attenuator pad 277, 278 presenting an impedance of 1000 ohms to the following D, E or C groups.

From the B groups the sinewave passes to the D and E groups. The D group consists of 9 similar sections arranged in units of 1, 1, 2 and 5 sections giving a range of 0 to 90 km in steps of 10 km. These units are switched in or out of circuit as required. When a unit is out of circuit, it is replaced by an attenuator consisting of an appropriate number of L pads, one for each section, thus keeping the total attenuation constant, irrespective of the switch setting. The phase changing sections are constructed in pi form, a typical section having a series arm comprising inductance 126 with adjustable inductance 110 giving 0.5% variation. The shunt arms are provided by a double fixed condenser, 166, with trimmers 142, 143, giving 0.3% variation in capacity. Resistors 218, 219 in shunt with the capacity, compensate for the resistance of the series arm, to approach as near as possible to the condition for distortionless transmission through the network for a range of P.R.F.'s. The alternative attenuation pad 183, 205 gives an attenuation of the same order as that of the corresponding reactive section, with zero phase shift, and has an iterative impedance of 1000 ohms, equal to that of the reactive sections. The phase change per section is 12° corresponding to 10Km (See Appendices 1 and 2).

The E group is a single unit of 2 sections, similar in formation to those of the D group, with circuit elements to give 50 Km per section, and hence 100 Km for the group. No provision is made for trimming the shunt capacities, and the phase change per section is 60°.

Tapping points are provided between the 2 sections of the E group and also between the corresponding attenuator sections. Similar tapping points are provided between the first two sections of the 50 Km unit in the D group. The purpose of such tapping points is not clear though they may possibly be used in individual sections to their correct values.

Following the D and E groups comes the C group which consists of a tapped ladder network of 5 sections, terminated by a 1000 ohm resistor equal to the iterative impedance. This terminating resistor is a special multi-section wire-wound component, with a stated tolerance of ± 0.04%. The phase change per section is 2° 24' corresponding to 2 Km. Across the series arm of each section are two precision resistors of 1000 ohms each, in series. The centre point is brought out to the tapping switch, along with the terminal points of the sections. As the centre point carries half the attenuation and phase shift of the whole section, this arrangement provides the 9 steps of 1 Km each, with only 5 sections. The input end of the C group is connected permanently to the rest of the circuit while the tapping point selected by the switch is brought out to terminal K16, which is the output point of the apparatus. Terminal K15 is the common side of the network. The framework is separately earthed at K13. As the network is properly terminated, it is necessary that the unit feed into a high impedance of more than 100,000 ohms with low capacity, which is provided by the input circuit of the time base amplifiers in unit OB110.

The maximum voltage fed to the unit, is of the order of 1.5 volts R.M.S.

The whole measuring network has been carefully designed so that the calculated error when the P.R.F. is varied from 500 to 494 or 506 is of the order of - or + 0.1% respectively. This agrees with German claims in this respect. It is also claimed that the unit can be set up to measure range with an accuracy better than ± 0.1% and that it will hold this performance over long periods.

3.3 Electrical Components

Fig. 5 shows a selection of the components used. The components used in the network are of special interest because of the close tolerances quoted. The fixed capacitors used in the shunt arms of the network have a tolerance of ± 0.1%. They consist of silvered mica elements enclosed in porcelain cells. Adjustable capacitors are of the usual half silvered ceramic disc type. Presumably the material has a low temperature coefficient.

The fixed inductances used, are toroidally wound on ring cores of powdered magnetic material, and are mounted in rectangular cans closed by a tag-board carrying tappings from the coil. Tolerances quoted for these coils are from ± 0.4% to ± 0.6%. Adjustable inductances, which are provided for trimming purposes, consist of a moulded base with a cup-shaped dust-core containing the coil. A second similar dust-core is carried in a moulded cap running on a very fine thread on a central brass rod. This enables the air gap between the two core-halves and hence the inductance to be adjusted. All resistors forming part of any series impedances in the network are of the precision type non-inductively wound, (on small, moulded bobbins with manganin wire). They have a negligible temperature coefficient. Tolerances quoted vary from ± 0.5% to ± 1.0%. All individual components, and units such as switches, are identified by numbers, which are indicated by labels, fixed to each item. The numbers are quoted in the parts list, given in Para. 6.

In general, the components are very suitable for their purpose, and the production effort, which must be involved in making quantities of such close-tolerance units, is noteworthy.

3.4 General Construction

Figs.1, 2, 3 and 4 show the general construction and layout of the unit which is mounted on a rectangular cast light alloy framework. The electrical components are disposed on panels on the sides of the framework. The lowest panel on each side carries adjustable condensers and hinges outwards for accessibility when setting up the unit in factory or workshop. A recess at the rear, contains the nine inductances forming the B group.

On top of the frame is a cast light alloy box containing the gears for driving the switches which are mounted one on each side of the box and one at the rear. The main switch at the rear consists of 10 cams operating 10 sets of transfer contacts, to connect in sequence the D and E groups of the network. The corresponding range is shown on the main left hand dial. The switch connected to the C group is mounted on the right side of the gear box and is of the flat, commutator type with 10 brass segments. The wiper arm carries spring loaded brushes of carbon-silver mixture. The corresponding range is shown on the middle dial. The third switch is similar and located on the left side, but has 20 segments. It is connected to the B group, and its setting is shown on the third dial. A sample switch of the commutator type is shown in Fig.5. Thus the complete range setting is obtained by adding the readings of the three dials. In addition, however, a complete indication of range is given by a counter mechanism immediately below the dials (see figs.1 and 8). The gearing for driving the indicating mechanism is carried in a cast housing mounted on the front of the gear box. Provision is made for illuminating the dials and counter by small lamps fed with 12V AC from unit OB110 via terminal K7 and K8. Below the counter is the direct driving knob giving coarse adjustment of range by operation of cam switch only, and hence the D and E groups only. Below this again is the main drive - a cast wheel with offset handle. This operates the gear box through a roller chain tensioned by jockey pulley and so drives all three switches. The driving handles shown in figs.1, 2 and 3 are normally mounted on the outer cover of the box, containing the two units forming Apparatus "O". As this cover is hinged, the drive is transferred by disc couplings, which engage as the cover is closed. The cover also carries a window of green tinted glass through which the dials and counter are observed. The unit as a whole is of sound construction. The two commutator type switches are of good design, but the cam switch is not perhaps, the most suitable type, for the duty involved. It was found, during a period of operation, covering a few weeks, that the contacts became dirty, and gave trouble on a number of occasions. This might be improved, if the contacts had a self-cleaning action. The motion of the switch is not very smooth, which results in a certain amount of jerkiness in the drive, when the apparatus is operated.

At the rear alongside the cam switch (Figs.3 and 4) is a unit not described in the captured documents. This device was damaged but seems to consists of a network brought into circuit by transfer contacts operated by a push button on the outer cover. This enables the operator to rapidly check the zero setting of the ground ray without resetting the main phase-shifter to zero. Components (279 to 286 inclusive) relating to this unit are included in the parts list.

3.5 Gearbox

A photograph, showing interior of gearbox is given in fig.2, while fig.7 shows a schematic diagram of the shafts and gearing, and fig.8 the drive to dials and counter.

The Coarse Driving Knob operates the cam switch directly, and also drives the main dial and the "Tens" part of the counter. The cam switch has a spring loaded "click plate", so that it comes to rest in one of 19 definite switch settings corresponding to the different combinations of the D and E groups.

Referring to fig.7, the Main Driving Knob handle drives the 20 segment switch direct through 1 to 1 bevel gears (1). Hence one revolution of the handle gives 1 Km change in range. The driving shaft also drives a Geneva mechanism (2) through 5 to 1 reduction spur gearing (3). A face cam (4) operated by the main shaft engages a dog clutch (5) once per revolution so that the drive is transmitted from the Geneva wheel through 5 to 2 reduction bevel gears (6) to the 10 segment switch. As the Geneva wheel turns through 90° for each revolution of the driving disc, the switch rotates for 1/10 of a revolution from one segment to the next. The lever operating the dog clutch also unlocks the switch and relocks when the movement is complete. Hence 10 revolutions of the main handle gives one revolution of the C group switch. The function of the 5 to 1 reduction, (3) to the driving disc is to allow the Geneva mechanism four idle movements while the drive is transmitted on the fifth. This ensures that each of the four slots in the Geneva wheel transmits the load in turn so distributing wear equally.

The shaft (7) driven by the Geneva mechanism also drives through a gear train (8), of 5 to 1 reduction, a dog clutch (9) which engages with the driving spindle connected to the cam-switch. The motion is intermittent as it depends on the Geneva mechanism. The main driving spindle carries two spur gears (10) of 24 and 28 teeth engaging with two idle wheels (11) of 60 and 56 teeth respectively. The idle wheels have extended bosses with flats cut on their periphery. As the main shaft rotates it can be seen that the flats coincide after every 10 revolutions. A rocker arm bears on the two bosses and keeps the dog clutch open, except when the flats coincide, when a spring pulls the clutch into engagement. This allows the Geneva mechanism to turn the cam switch to the next position.

The Geneva mechanism is employed here to give a high velocity at the instant of changeover. In the case of the C switch this occurs only when the B switch is at zero position, and in the case of the cam switch only when the C switch reaches zero. Thus the range reading is smoothly built up as the handle is rotated. The motion is fairly smooth except when the cam switch is operated, when the additional loading is considerable. The unit involves careful design and construction of the mechanism and the amount of work involved in manufacture of mechanical parts is considerable.

4. Setting-up and Test Procedure

The unit is set up by adjustment of inductance and capacitance to give the correct reactances for the series and shunt arms of each section. The correct phase shift must be obtained for each section and impedance matching from section to section must be as near perfect as possible so that accurate range indication is given over the whole scale, with minimum error at P.R.F.'s other than 500. The long period stability of the unit is described as being of the order of 0.1%, and in view of the care taken in regard to component design this is a reasonable claim. The unit is set up by the manufacturer, presumably by reference to a standard of comparison for the conditions at each tapping or section throughout the network. These adjustments are then sealed before despatch by the manufacturer. As testing with D.C. type instruments might permanently alter the inductance values, a warning notice prohibiting any such tests, is fixed to the framework. Tests in the field are limited to those possible with a source of 500 c.p.s. supply, and an oscilloscope. Such tests are sufficient to show an actual breakdown in the unit but not to check accuracy of range observations made with it. It is assumed that a periodic test and replacement scheme is operated, with the aid of a central test station carrying facilities similar to those available to the manufacturer. No information is available at present regarding such test procedure.

5. Conclusions

The unit described demonstrates the German ability to develop complex mechanical and electrical devices, which is in marked contrast to their less ambitious efforts in regard to Radar problems as a whole. But, having decided on the use of small tube displays, they have carried out the electrical and mechanical design of the necessary range measuring unit in a competent manner. The performance, as regards the measurement of range of a given echo, is very good. It is difficult however to deal with a number of targets and the general method of range measurement suggests that the equipment may have first been developed for naval gun ranging.

Considerable expenditure of labour and materials is apparent. The mechanism involves a great deal of machining and both materials and workmanship are of a high standard as are the electrical components used. It would seem that the designer has been free to meet the performance requirements in any way he though fit, without reference to possible production difficulties. This is in contrast to usual British practice. In view of the expensive nature of the design it is very unlikely that it would be adopted in this country even for those applications for which it might be particularly suited.

6. Parts List

No.	Component	Description
100 to 109 incl.	Chokes	each 0.632 mH ± 2%
110 to 118 incl.	Chokes	each 1.5 mH ± 10%
119 and 120	Chokes	each 5.6 mH ± 10%
121 to 125 incl.	Chokes	each 0.2 mH ± 10%
126 to 134 incl.	Chokes	each 65.10 mH ± 0.6%
135 and 136	Chokes	each 274.7 mH ± 0.6%
137 to 141 incl.	Chokes	each 13.22 mH ± 0.4%
142 to 146 incl.	Trimmer Condensers	each 20-100 pF; 500V
147 and 148	Trimmer Condensers	each 20-100 + 100 pF; 175V
149 and 150	Trimmer Condensers	each 20-100 pF; 500V
151 to 156 incl.	Trimmer Condensers	each 20-100 + 100 pF; 175V
157 to 164 incl.	Trimmer Condensers	each 20-100 pF; 500V
165	Trimmer Condenser	20-100 + 100 pF; 175V
166 to 174 incl.	Fixed Condeneers	each 2 x 33120 pF ± 0.1%; 175V

No.	Component	Description
175	Fixed Condenser	2 x 6465 pF ± 0.1%; 175V
176 and 177	Fixed Condensers	each 2 x 13130 pF ± 0.1%; 175V
178 to 182 incl.	Fixed Condensers	each 0.1 μF ± 10%; 250V
183 to 191 incl.	Precision Resistances	each 16.4 ± 1%; 0.1 watt
192 and 193	Precision Resistances	each 161.5 ± 2%; 0.1 watt
194 to 203 incl.	Precision Resistances	each 1 k ± 0.5%; 0.1 watt
204	Precision Resistances	1 k ± 0.04%; 1 watt
205 to 213 incl.	Resistances	each 60 k ± 1%; 0.5 watt
214 and 215	Resistances	each 5.2 k ± 2%; 0.5 watt
(Nos. 216 and 217 not used).		
218 to 235 incl.	Resistances	each 118 k ± 2%; 0.5 watt
236 to 239 incl.	Resistances	each 8600 ± 2% 0.5 watt
240	Resistance	700 k ± 5%; 0.5 watt
241 to 244 incl.	Resistances	each 300 k ± 5%; 0.5 watt
245	Resistance	700 k ± 5%; 0.5 watt
(Nos. 246 to 269 not used).		
270	Incandescent Lamp	12 V; 5 watt
270a	Holder for above	
271	Incandescent Lamp	12 V; 5 watt
271a	Holder for above	
272	Incandescent Lamp	12 V; 5 watt
272a	Holder for above	
273	Incandescent Lamp	12 V; 5 watt
273a	Holder for above	
274	Rotary switch	20 steps
275	Rotary switch	10 steps
276	Cam switch	
277	Precision Resistance	161.5 ± 2%; 0.1 watt
278	Resistance	5.2 k ± 2%; 0.5 watt
279 to 282 incl.	Precision Resistances	each 5000 ± 5%; 0.1 watt
283	Resistance	500 k ± 5%; 0.5 watt
285	Switch	Spring loaded single pole transfer contact
286	Toroidal Inductance	93.5 mH.

7. References and Relevant Reports

7.1	Technical Description of Freya Equipment	A.A.D.I.Sc. Report No.26
7.2	Electrical Circuits and Wave Filters	A.T. Starr
7.3	Display Unit O.B.110. Seetakt and Freya installations	R.A.E. Technical Note No. RAD.224
7.4	Master Oscillator Unit ZP100. Seetakt and Freya installations	R.A.E. Technical Note No. RAD.232
7.5	Transmitter T.106 (Freya)	R.A.E. Technical Note No. RAD.156
7.6	Main Display Unit NB110 of Coast Watcher and Freya installations	R.A.E. Technical Note No. RAD.204
7.7	Transmitter of G.E.M.A. Coast Watcher installation	R.A.E. Technical Note No. RAD.210
7.8	Receivers used in Freya and Coast Watcher Stations	R.A.E. Technical Note No. RAD.223

APPENDIX 1

Range Measurement

In general, range measurement in Radar equipment depends on measurement of the time delay from transmission of the pulse, to receipt of the reflected signal. Then:-

$$R = t/2 \times C$$

where R is range in Kms, t the total time in secs. and C the velocity of propagation of E.M. waves. The maximum range which can be measured before the emission of the following pulse, is a function of the P.R.F. (f) and can be stated thus:-

$$R\ (\text{max.}) = 1/2f \times C$$

This corresponds to 1 cycle of pulse recurrence, or 2π radians. Hence any phase angle θ ($< 2\pi$) would represent a range:-

$$R = \theta/2\pi \times 1/2f \times C$$

$$\text{or } R = \theta \times K/f$$

$$\text{where } K = C/4\pi \text{ if } \theta \text{ is in Radians}$$

$$\text{or } = C/720 \text{ if } \theta \text{ is in degrees}$$

APPENDIX 2

Attenuation and Phase Change in a Typical Network

In general, the ratio of input current I_1 to output current I_2, for a section of a network, such as in Fig. 10(a) can be expressed in the form

$$\frac{I_1}{I_2} = e^{\theta} \qquad \text{.....................(1)}$$

θ is referred to as the Propagation Constant and is in general complex. Then:-

$$\theta = \alpha + j\beta. \qquad \text{.....................(2)}$$

Hence (1) can be rewritten:-

$$\frac{I_1}{I_2} = e^{\alpha + j\beta} \qquad \text{.....................(3)}$$

The ratio of the currents therefore consists of two factors α and β. The former represents a change in magnitude and the latter a change in phase. α is known as the attenuation constant and β as the phase constant. Hence in passing through n sections, as in Fig. 10(a) the current will be attenuated by a factor $n\alpha$ and will experience a phase retardation of β radians.

The application of Kirchoff's Laws to the network of Fig. 10(a) gives the following result:-

$$\text{Cosh } \theta = 1 + Z_1/2Z_2 \qquad \text{.....................(4)}$$

The performance of a section of the network, as in Fig. 10(b) will depend on the nature of the series and shunt impedances, Z_1 and Z_2 respectively, and can be assessed by discussing the ratio between them. A convenient form is $Z_1/4Z_2$. This quantity will be, in general, complex, and can be stated thus:-

$$\frac{Z_1}{4Z_2} = U + jV \qquad \text{.....................(5)}$$

Now, combining (4) and (5), we get:-

$$\cosh (\alpha + j\beta) = (1 + 2U) + j\,2V \quad \text{..............(6)}$$

and:-

$$\cosh \alpha \cos \beta + \sinh \alpha \sin \beta = (1 + 2U) + j\,2V \quad \text{........(7)}$$

Equating real and imaginary parts:-

$$\cosh \alpha \cos \beta = 1 + 2U \quad \text{..............(8)}$$

$$\sinh \alpha \sin \beta = 2V \quad \text{..............(9)}$$

From these equations, expressions can be obtained for α and β:-

$$\alpha = \sinh^{-1} \sqrt{2\left[\left\{(U + U^2 + V^2) + V^2\right\}^{\frac{1}{2}} + (U + U^2 + V^2)\right]}$$

$$C\beta = \sin^{-1} \sqrt{2\left[\left\{(U + U^2 + V^2) + V^2\right\}^{\frac{1}{2}} - (U + U^2 + V^2)\right]}$$

where C = +1 or -1.

These expressions were used in calculating α and β for the various sections of the network investigated. In the case of the sections of the D group, Z_2 must be taken as half the shunt reactance as each shunt arm is in parallel with another similar arm, when it is in circuit.

In the case of a half section as in Fig.10(c) the propagation constant can be found from the following expression:-

$$\theta = \tfrac{1}{2} \cosh^{-1} \left(1 + \frac{Z_1}{2Z_2}\right) \quad \text{..............(10)}$$

Hence α and β can be calculated as before.

APPENDIX 3

Operation of Geneva Mechanism

Fig. 9 shows the Geneva Mechanism as used in Unit OK106.

The driving member A is a disc with an offset pin E. The driven member B is a disc with 4 slots at 90° intervals. The pin E is a running fit in the slot, and engages with each slot in turn as A is rotated. Hence B rotates only through 90° for each revolution of A. The periphery of B between the slots is cut away to form surface G which is a running fit with the annular surface C on the member A.

Starting from position as shown with A rotating with constant velocity Pin E moves towards the bottom of the slot, reaching maximum depth, when A and B have moved through 45°. In this position B has maximum angular velocity. During the next 45° rotation the angular velocity of B falls to zero, when the pin leaves the slot at point F. The surface C in contact with surface G serves to prevent further movement of B while the driving member idles through 270° to engage with the next slot and to repeat the cycle. The surface C is recessed at D behind the driving pin to provide clearance for the end of the slot arms, during the working cycle.

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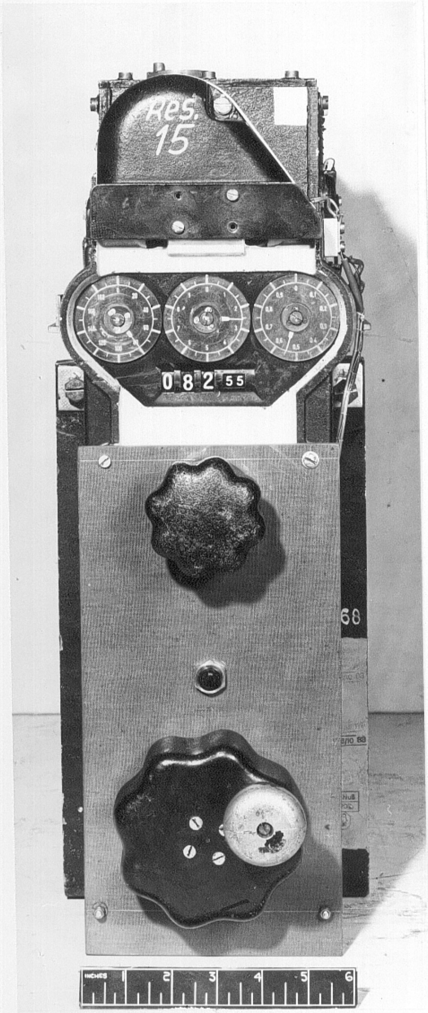
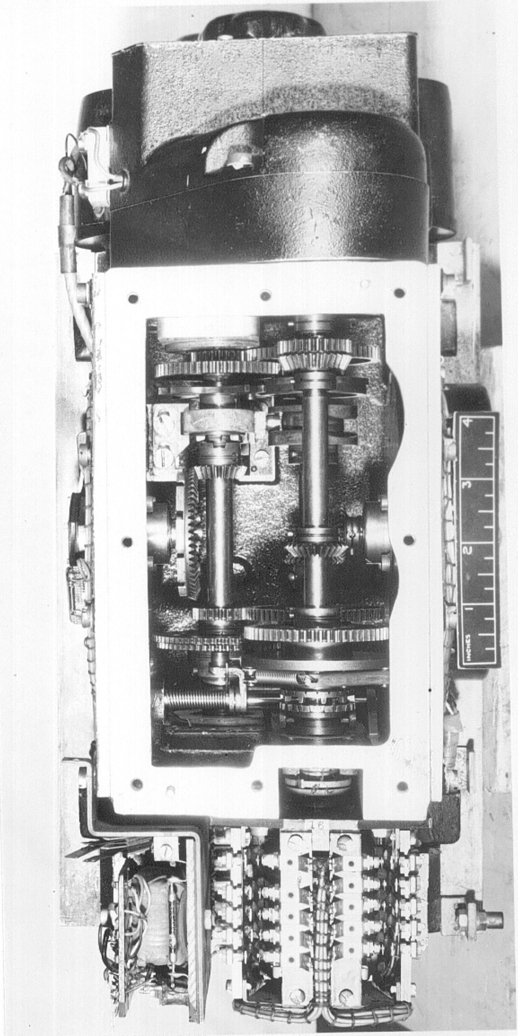


FRONT. FIG.1



TOP. FIG.2

PRECISE PHASE SHIFTER OK 106

FIG.1 & 2

ROYAL AIRCRAFT ESTABLISHMENT PHOTOGRAPHIC DIVISION	
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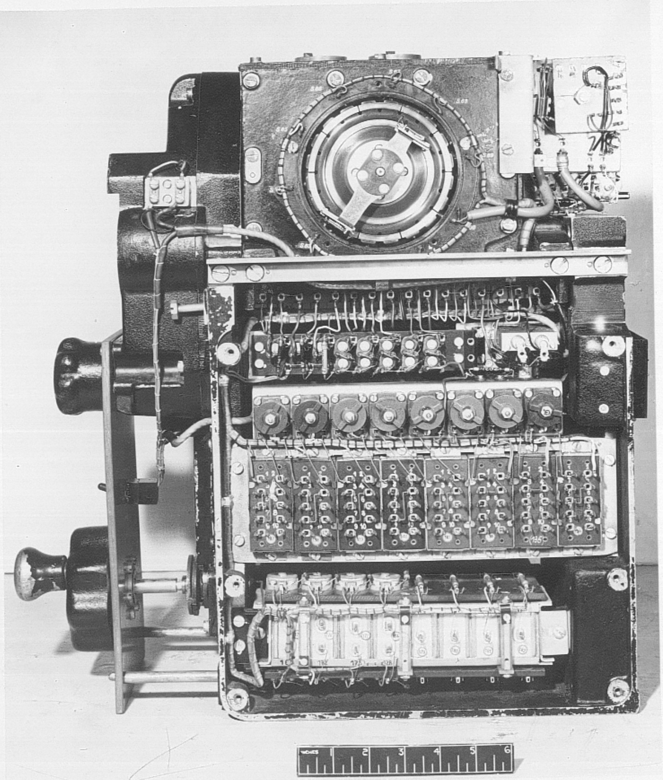

FIG. 3

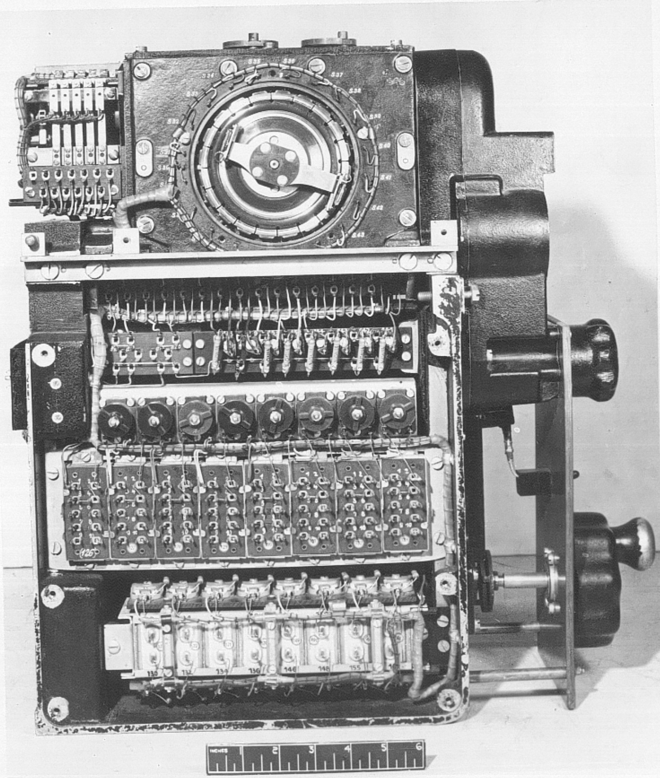

FIG.4

PRECISE PHASE SHIFTER OK 106. SIDE VIEWS

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FIG.3&4

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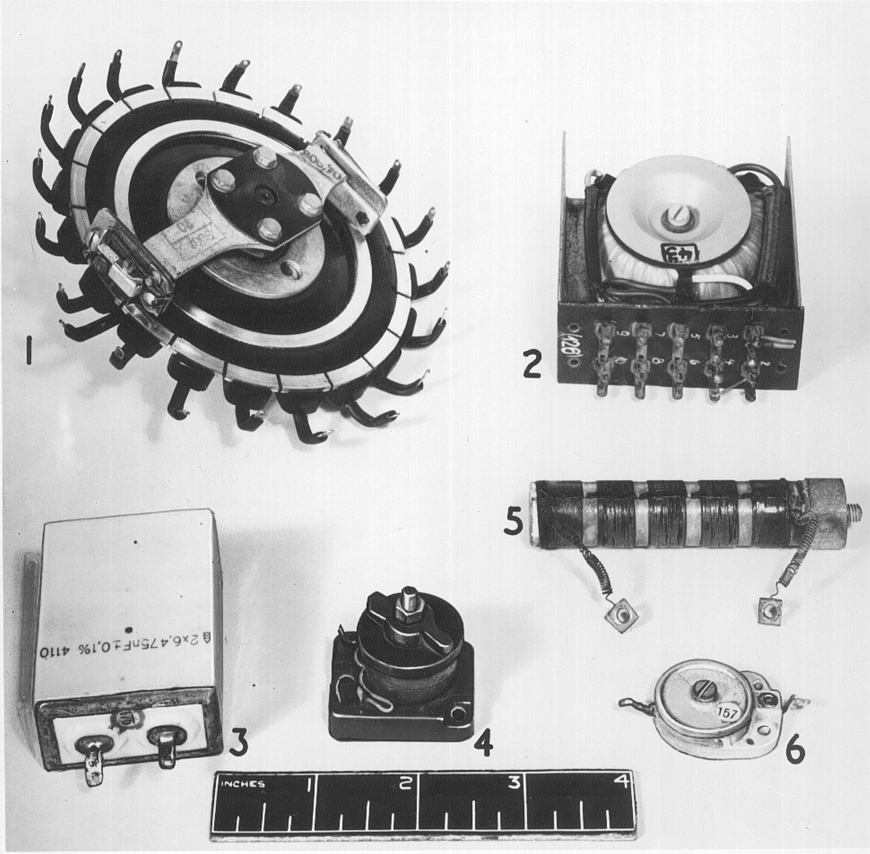

1 20-SEGMENT SWITCH

2 TOROIDAL INDUCTANCE

3 FIXED CONDENSER

4 TRIMMER INDUCTANCE

5 TERMINATING RESISTOR

6 TRIMMER CONDENSER

PRECISE RANGE MEASURING UNIT OK 106

FIG.5

ROYAL AIRCRAFT ESTABLISHMENT
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DATE 12.10.44

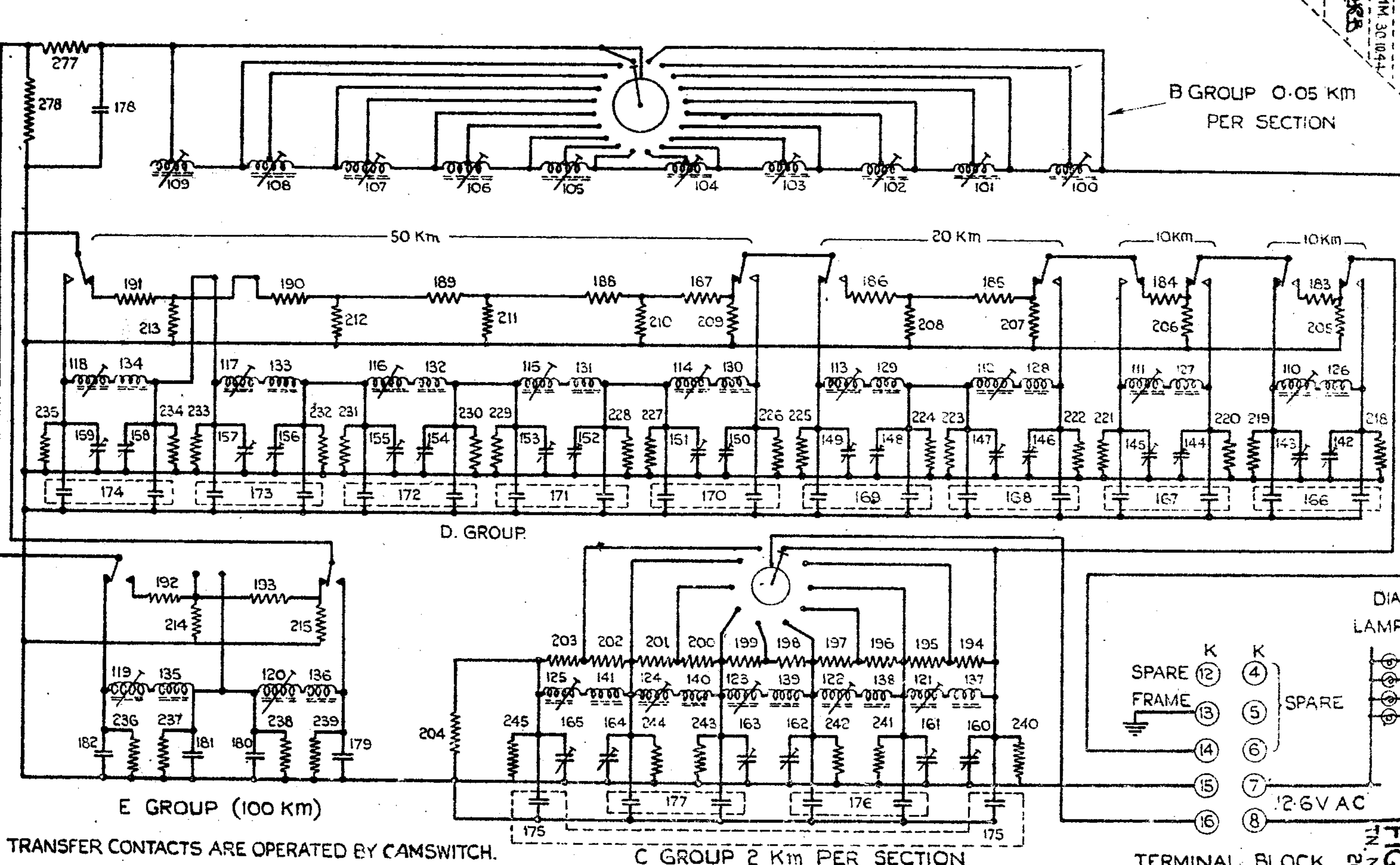
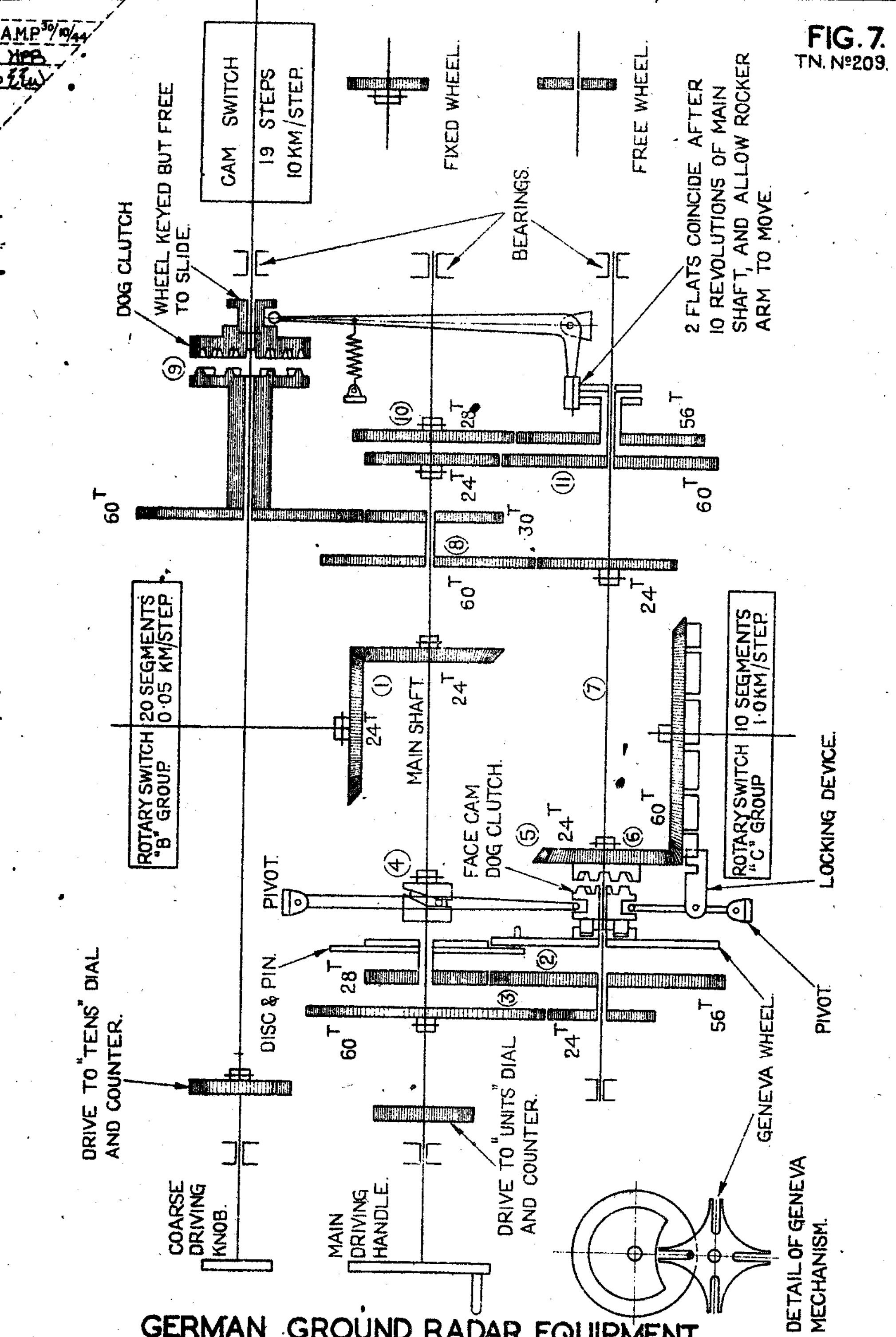


FIG.6. TN. No. 209

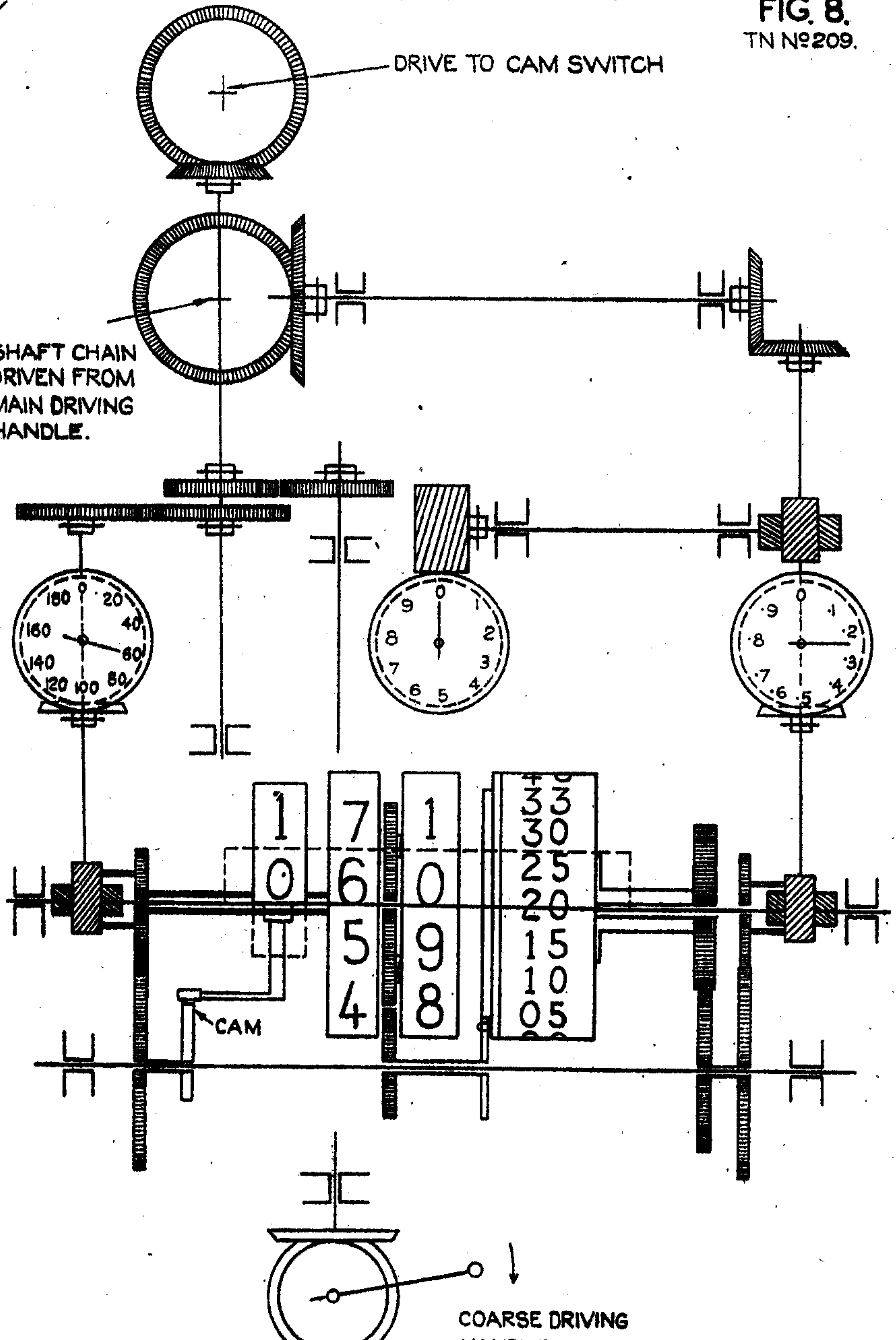
FIG. 7.
TN. Nº209.



GERMAN GROUND RADAR EQUIPMENT
FREYA AND SEETAKT.

DIAGRAM SHOWING OPERATION OF DRIVING MECHANISM.
PRECISE RANGE MEASUREMENT

FIG. 8.
TN No209.



GERMAN GROUND RADAR EQUIPMENT

FREYA AND SEETAKT.

DIAGRAM SHOWING OPERATION OF RECORDING MECHANISM.

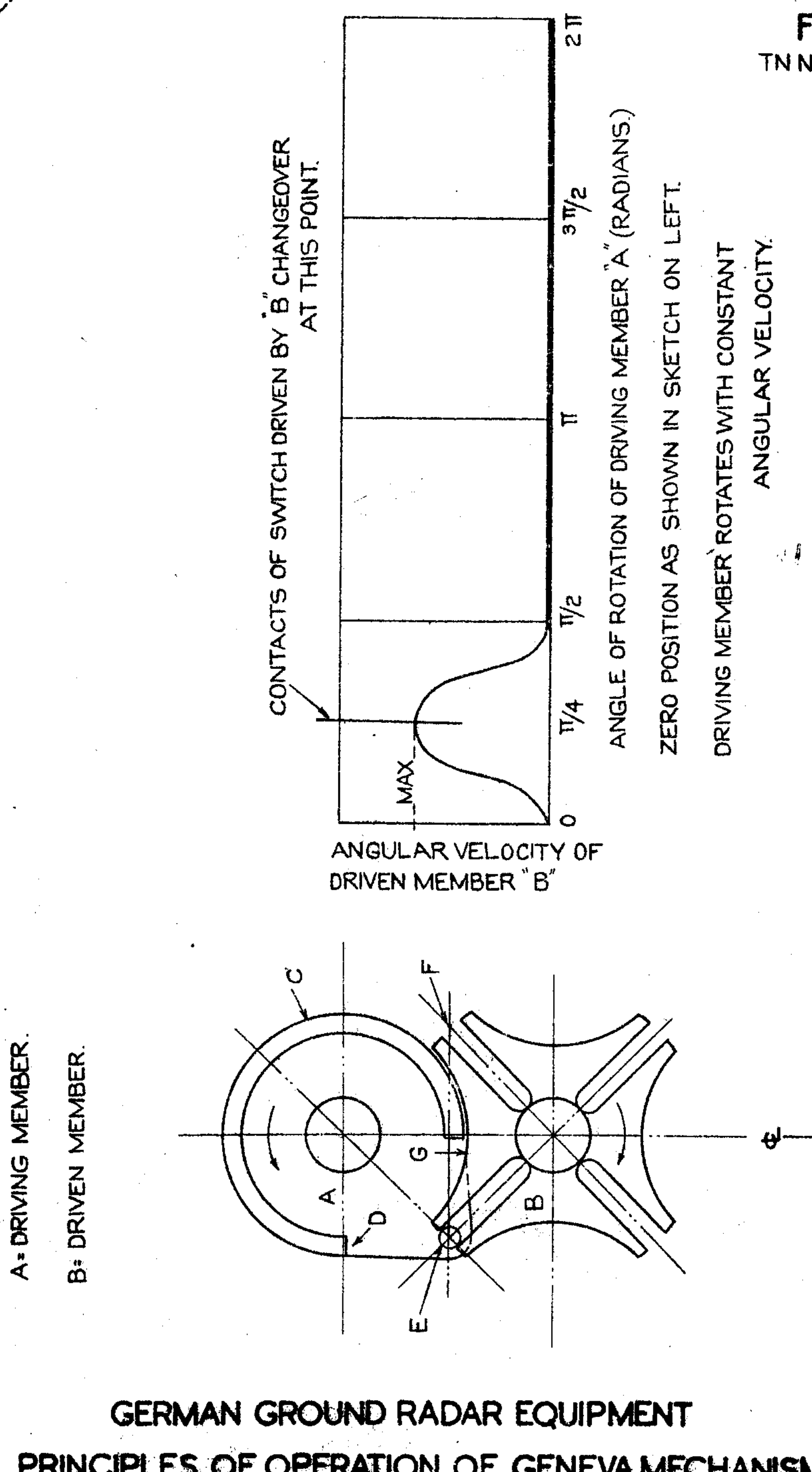
PRECISÉ RANGE MEASUREMENT UNIT (OK 106).

No 11123 B.

7.10.44

FIG.9.

TN No 209.



GERMAN GROUND RADAR EQUIPMENT

PRINCIPLES OF OPERATION OF GENEVA MECHANISM.

APPENDIX TO DESCRIPTION OF RANGE MEASURING UNIT OK106.

DRG. N° 1124 B.
DATE 20.10.44
HRB
P.
(Eu)

FIG. 10.

TN. N° 209.

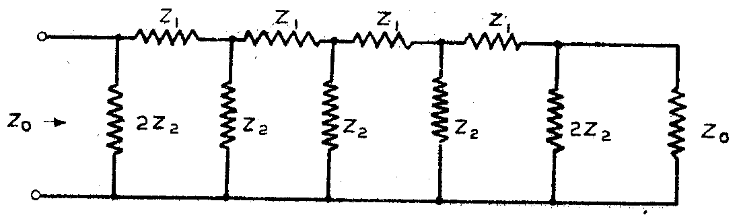


FIG. 10 (a)

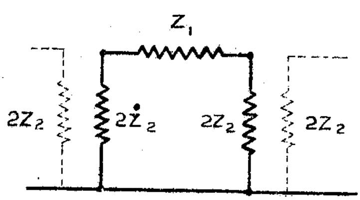


FIG. 10 (b)

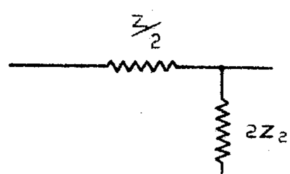


FIG. 10 (c)

TYPICAL SECTIONS.

(TO BE READ IN CONJUNCTION WITH APPENDIX 2.)