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CONFIDENTIAL

Report No. 1466

German Transpondor Meteorological Instrument

A new type of German meteorological instrument was found near Tonbridge, Kent on 9/12/43.

The equipment consists of:-

a) The transmitter - receiver unit as described in the accompanying National Physical Laboratory report. Two photographs of this unit and the circuit diagram are attached to this report.

b) The balloon. This weighs 1,250 grams. and is somewhat larger than is usual for radiosondes.

c) The parachute. This is of peculiar design. It is small (21") for the weight of the instrument. It is in alternate black and white segments. Two wooden rods are attached inside the parachute and are hinged at the apex. It is presumed that this arrangement ensures the opening of the parachute.

d) Reward label. This is apparently for use within Reich territory only, as this type of label is not found attached to radiosondes released in occupied countries.
Information derived from this card is as follows:-

i) Apparatus No. 141768 (which does not agree with any number found on the instrument).

(ii) Date of ascent 6/12/43.

(iii) The address to which the instrument should be returned:-

An das Aeronautische Observatorium
der Reichamts fur Wetterdienst
Lindenberg.

Report of the National Physical Laboratory (Dr. H.G. Hopkins).

1. General

This Wehrmacht instrument fell in England attached to a parachute and a partially inflated balloon: an associated label indicated that a meteorological station in Germany was interested in its return, although no meteorological elements (e.g. barometer or thermometer) were recovered with the instrument.

Briefly the instrument is a combined receiver and crystal controlled transmitter connected so as to form a transpondor. A low frequency oscillator is included in the instrument and the output from this is fed to the modulating grid of the transmitter in series with the audio frequency output from the receiver. The low frequency oscillator is normally quiescent, but the circuit arrangements are such that it may be used in conjunction with a separate barometer or thermometer to indicate when the balloon passes definite pressure or temperature levels.

It therefore appears that the instrument is used for wind finding purposes, the transpondor in conjunction with a modulated ground transmitter being used to measure slant range, while height is given by a separate barometer associated with the balloon low frequency oscillator: alternatively, height measurements may be derived from measurements of angle of elevation made with a beamed ground transmitter.

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2.1. Mechanical description

The instrument is made from thin aluminium sheets on which the various components are mounted: the batteries clip to a small bracket running the length of one side of the assembly. A cylinder 6" in diameter by 8" in length would contain the equipment and batteries. It seems unlikely that the instrument would be sent aloft without some form of protecting cover, but none was recovered. From the ends project aluminium cylindircal cases $1\frac{1}{2}$" diameter by $3\frac{3}{4}$" long, which serve as convenient handling posts and along the axes of which pass insulated tubes containing the leads feeding the receiving and transmitting aerials. The latter is a half wave flexible stranded steel wire which also carries the instrument on the parachute; the receiver aerial was not recovered, but probably consists of a short rod projecting axially from the lower handling post.

The instrument included transmitting aerial and the part of the battery pack recovered weighs $2\frac{1}{2}$ lbs; the all up weight of the instrument at launch, including items not recovered, is probably about 3 lbs.

2.2. Electrical description

Figure 1 shows the circuit diagram of the equipment together with other relevant information.

The receiving aerial is inductively coupled to a super-regenerative detector (LS3 directly heated diode triode) operating at 285 Mc/s; quench voltages are derived from a 100 kc/s. (approx.) oscillator which uses one half of one of the DDD11 double triodes. The band width of the detector for a large signal input is about 10 Mc/s. There is no direct connection between the triode and dio portions of the LS3; however, audio frequency output from the triode super-regenerative detector is passed on to the audio frequency amplifier stages from the diode. Both triodes of the other DDD11 are wired in cascade to form a two stage resistance capacity amplifier, at the input terminals of which is connected a filter having a sharp acceptance peak at 7.5 kc/s., and which has high attenuation for frequencies above about 15 kc/s. The amplifier alone will pass frequencies up to at least 40 kc/s., so that the filter at its input terminals serves to suppress quench frequency voltages and to accentuate audio frequency voltages centred around 7.5 kc/s; these are passed on to the suppressor grid of the RL2P3 crystal controlled transmitter valve. It is interesting to note that the 7.5 kc/s. filter incorporates ceramic condensers of interesting design which have probably been chosen to ensure a pass characteristic sensibly independent of temperature changes. This point is discussed in greater detail in Section 3.

The gain of the amplifier stage is held roughly constant as the H.T. batteries run down by means of a bleeder resistance connected across the G.B. supply to the amplifier: in this way the bias will gradually fall to conform with the gradual reduction of H.T. voltage with time of flight.

The other triode portion of the DDD11 quench valve is arranged as a 3 kc/s. oscillator which is normally quiescent due to the -20 volts of bias on its grid. This bias is removed when the tags T are short circuited, and it is suggested that a convential German baro-switch or thermometer is connected across these terminals; while such an instrument was not recovered, examination of the tags showed that leads had in fact been connected to the tags and which might have joined to an external barometer or thermometer unit. If this explanation of the 3 kc/s. oscillator is correct, then the circuit is such that a 3 kc/s. dash of a few seconds duration would be transmitted at definite pressure or temperature levels.

The sockets labelled A and B in the circuit diagram provide 3 kc/s. output and are protected by a cover plate during flight: they are probably used during the calibration of the meteorological element and obviate the need for a receiver during this process.

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The transmitting pentode is arranged in a conventional crystal controlled R.F. oscillator circuit operating at 26.87 Mc/s. and energizes the half wave aerial through a condenser tapped down on the tank output circuit. It is estimated that the radiated power is of the order of 100 m. watts.

The power supply for the transmitter is derived from three different types of cell. The L.T. supply consists of four two volt units of normal German radiosonde type joined in parallel while the H.T. voltage is supplied by conventional small dry cells. Grid bias voltages are derived from very small dry cells each separately mounted in a plastic cylinder measuring 7/16" diameter by 9/16" long. The cardboard box containing the H.T. and G.B. batteries measures $3\frac{7}{8}$" x 7" x 1" deep, and supports a smaller cardboard box containing the L.T. cells.

A colour-coded cable joins the batteries to a large multi-electrode plug which in turn plugs into a socket on the instruments assembly.

3. Test work

The power supply was not recovered complete; the voltages allocated to the various circuits shown in Figure 1 were arrived at from consideration of battery box size and from the circuit arrangements.

The approximate currents taken by the various component parts of the equipment under the conditions shown in the figure are detailed below.

Valve	Function	Heater volrs	Heater current (amps.)	H.T. current (milliamps.)
LS 3	Detector	2.0	0.07	2.5
DDD11	Amplifier	1.4	0.1	1.0
DDD11	Quench/3/kc/s. oscillator	1.4	0.1	0.8 (V_g= -20): 1.4 (V_g= -1.5)
RL2P3	Transmitter	2.0	0.07	8.0

It should perhaps be stressed that the DDD11 tubes employ 1.4 volt heaters, the voltage being dropped to this value by means of a suitable series resistance.

It was at first supposed that the 3 kc/s. oscillator was locked by an incoming carrier modulated with a strong 3 kc/s. component, or that it provided half sine wave modulation from a pulse input. This view was not supported by the following facts.

(a) The voltage available from the receiver alone at 3 kc/s. for modulation purposes was not markedly less than that provided by the 3 kc/s. oscillator. In other words, no triggering or locking action would result in a worthwhile improvement in modulation percentage.

(b) The 3 kc/s. oscillator would not lock readily to a 3 kc/s. voltage derived from the receiver.

(c) The peak in the receiver characteristic at 7.5 kc/s., the use of the soldering tags T in the 3 kc/s. oscillator grid circuit, and the method of using the 20 volts grid bias were all unexplained.

In view of these difficulties, the behaviour of the equipment when

/receiving

receiving a carrier modulated at 7.5 kc/s. was investigated in detail. The examination led to the conclusion that a received signal from a ground transmitter on 285 Mc/s. modulated at 7.5 kc/s. is used directly to modulate the 26.87 Mc/s. balloon transmitter and that the 3 kc/s. oscillator is used to indicate when some other instrument connected across the soldering tags T has a short circuited output impedance. The obvious use for the complete balloon borne equipment in conjunction with the ground transmitter is for radio wind finding purposes, the range from the ground transmitter to the balloon being derived from a comparison of the phase of the outgoing 7.5 kc/s. modulation with that of the modulation on the carrier "reflected" by the balloon apparatus: the height of the balloon would be given by a baroswitch connected across T.

Points supporting this view are:

(a) 7.5 kc/s. is a convenient modulation frequency to use for ranging purposes as a complete phase cycle measured at the ground transmitter between the outgoing and returned modulation is equivalent to a change in slant range of 20 kms.

(b) The L.F. amplification of the receiver is designed to be highest at 7.5 kc/s.

(c) The overall phase transfer characteristic of the balloon equipment at 7.5 kc/s. is quite stable with respect to changes in supply voltages and temperature: further the temperature coefficient of the transfer angle has been arranged to compensate very largely for the supply voltage changes.

This point may be seen from the following figures: in all cases a lead of the outgoing modulation voltage from the balloon transmitter with respect to that arriving at the balloon is taken as a positive phase angle.

Phase coefficient with respect to H.T. variation - 2° per volt.
Phase coefficient with respect to L.T. variation - 200° per volt.

(It should be noted, however, that the instrument does not operate if the L.T. falls by more than 0.1 volt.)

Phase coefficient with respect to temperature (average over range +12 to -60°C.) + 0.75° per °C

Providing the voltage of the L.T. units remains reasonably stable with temperature, it seems likely that the systematic range error will be small in practice and will have a magnitude of the order of 50 metres per kilometre height of the balloon.

During the low temperature tests under constant voltage conditions, it was observed that the receiver and transmitter cease to operate at about -60 and 65°C respectively.

The temperature coefficient of the transmitter crystal is $+20 \times 10^{-6}$ per °C.

4. Nature of signals likely to be intercepted

On 285 Mc/s. a carrier modulated - probably continuously - at 7.5 kc/s. may be intercepted, although this is rendered improbable by the likelihood that the ground transmitter is beamed on to the balloon.

On 26.87 Mc/s. a crystal controlled carrier modulated - probably continuously - at 7.5 kc/s., on which is superposed a long 3 kc/s. dash at infrequent and irregular intervals, may be intercepted in this country particularly when winds are easterly.

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5. Nature of ground equipment

The transmitter probably utilizes an array rotatable in azimuth: there is no evidence to show whether it can rotate in the vertical plane. The 7.5 kc/s. phase comparator for measuring slant range may be of goniometer type.

It seems, that of the various alternatives for measuring the other parameters necessary for wind velocity measurements the method described below is the most likely.

Determine azimuth by direction finder observations on the 26.87 Mc/s. balloon transmitter. Possibly an Adcock is used here, although some form of split method could be employed. Determine the height of the balloon by a baroswitch connected to the 3 kc/s. oscillator in the balloon instrument. (There is a possibility that angular measurements are carried out by using some form of switched lobe technique on the ground transmitter. This seems rather unlikely, however, in view of the A.V.C. characteristics of the super-regenerative balloon borne receiver which would make the equisignal zone unreasonably large.)

It is impossible to say whether the beamed transmitting array is mounted directly on the directional receiver, but it seems very likely that these two major units are arranged so as always to "face" in the same direction: in this way the direction finder operator will automatically keep the transmitting array aligned in the azimuth of the balloon and so achieve the maximum "reflected" signal from the balloon transpondor.

At the moment nothing is known of any ground installation such as is suggested in the N.P.L. report.

G Wilkinson F/L

(G. WILKINSON)
for Wing Commander.

A.I.2.(g).
11th March, 1944

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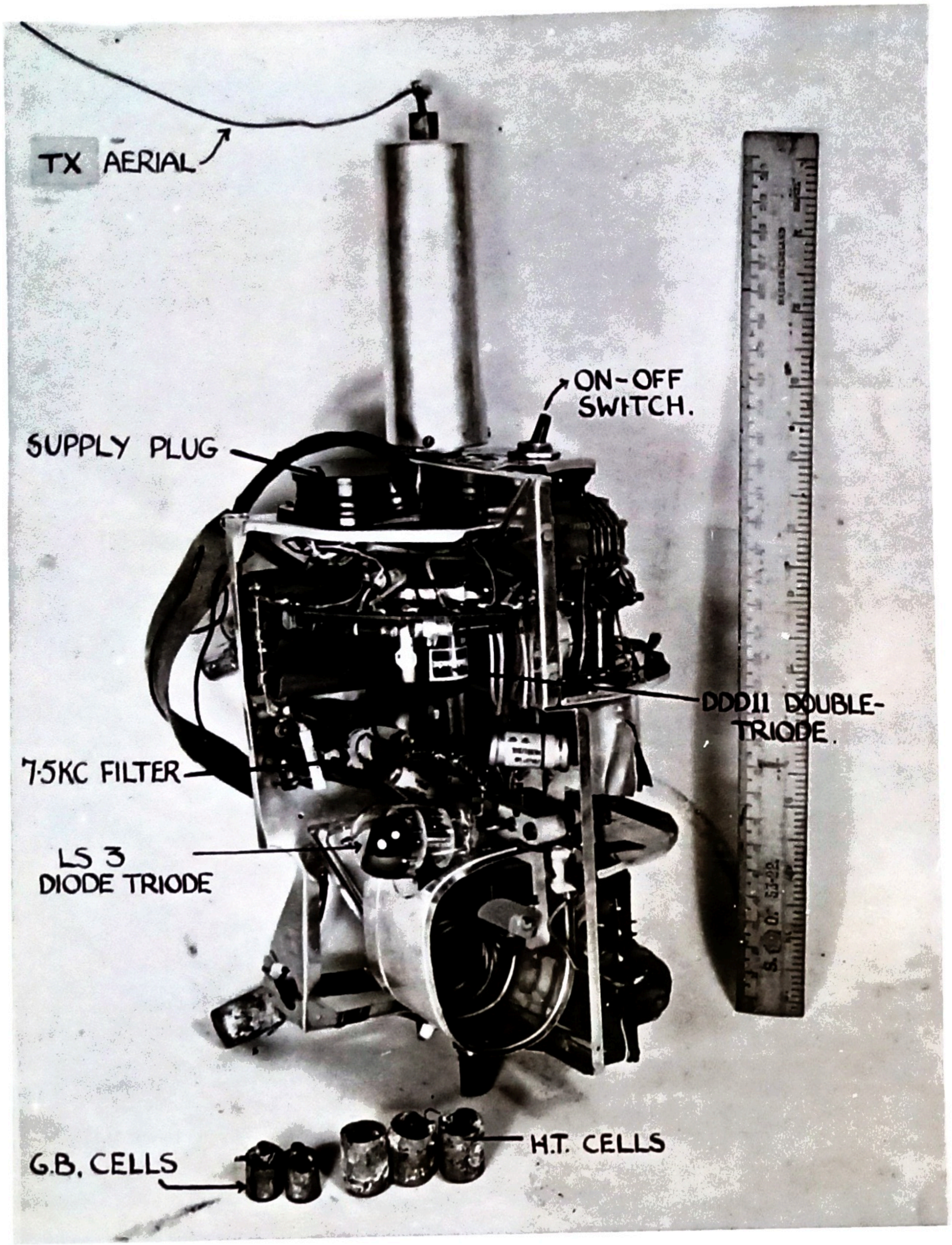
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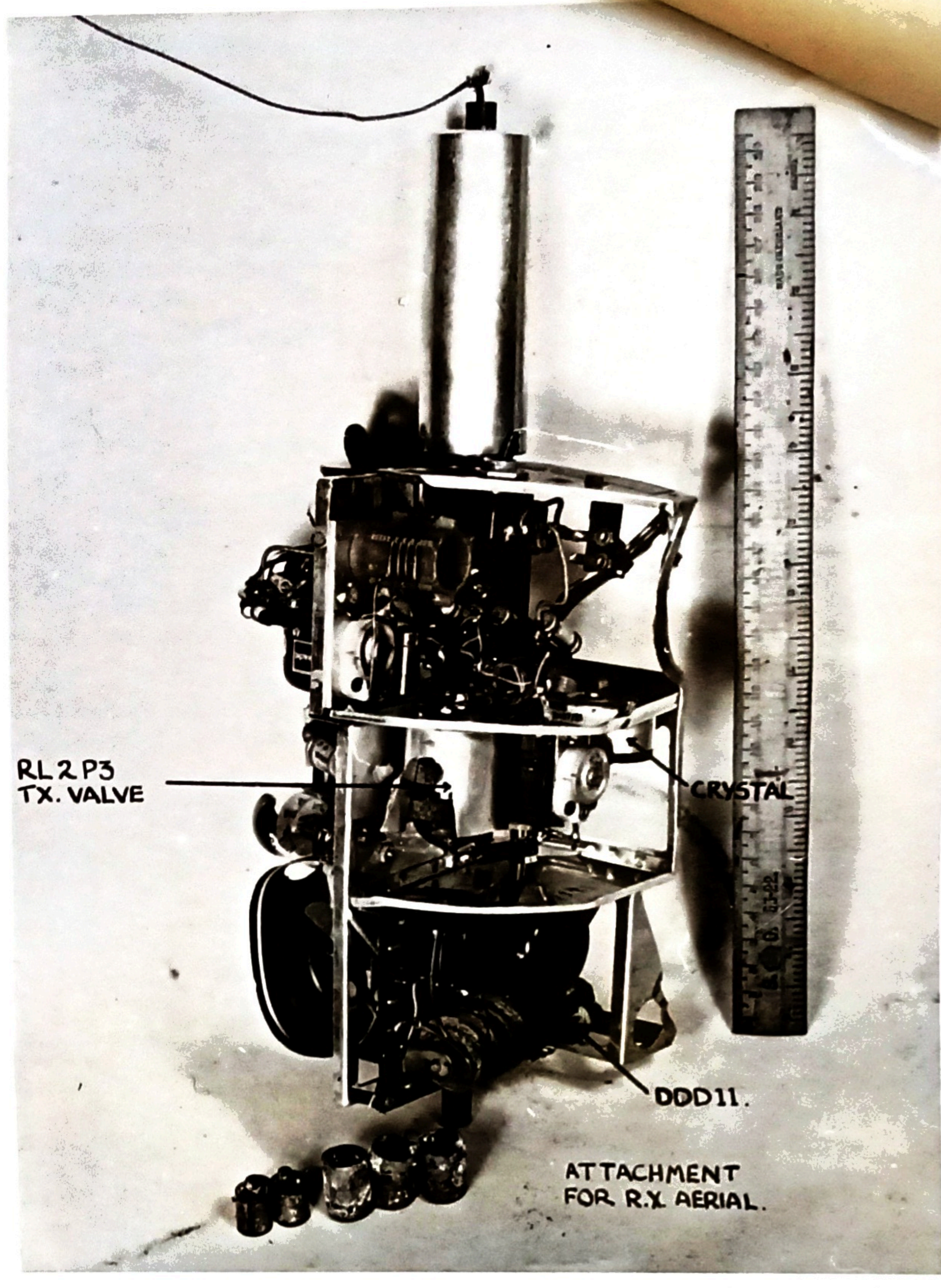
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