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H.F. INSTRUMENTS & MEASURING TECHNIQUES.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

H.F. INSTRUMENTS AND MEASURING TECHNIQUES

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
32, Bryanstone Square, London, W.1.

B.I.O.S. 1998 - REPORT ON H.F. INSTRUMENTS & MEASURING TECHNIQUES

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(1)

(a) A.E.G. Hamburg. Dr. Borden is on the legal side of the firm and could not give much information on the technical activities. It was learned that A.E.G. themselves produced very little in the way of H.F. instruments but they control Telefunken and the latter firm carries out all the radio research work.

Most of their technical staff are at Stuttgart where they have done some work on refrigeration using the process known as magnetic refrigeration, some details of which were stated to be available at Stuttgart. The pumps used in this device work on the vibrator principle. They are also the manufacturers of the Magnetophon, the chief engineer on this work being Dr. Schippelman. Model K7 is to be manufactured at Hamburg, this being a tape machine to work from radio. The address of Dr. Schippelman's deputy in Hamburg is Dr. Schuller, Kochmannstrasse 12-14 (Ceifert Co.).

(b) A.E.G. Stuttgart. The A.E.G. factory at Bad Constatt near Stuttgart was not producing any H.F. instruments, and according to Dr. Schaeffe their main concern at the moment is making electric tools, drilling machines, shears, grinding machines, etc; also a certain amount of power transformer work is in hand and they are starting to make H.T. switchgear again.

(2)

(a) Telefunkan, Hamburg. Interview with Dr. Kleen, an expert on valves. He was questioned regarding measurement technique. He showed a series of books called "Bucherei der Hochfrequency-Technic" which he had written in collaboration with Dr. Rothe (now at Munich). These books have been published since the war, and it is strongly recommended that copies be obtained. Most of the books deal with valves, and the last volume "The Behaviour of Electrontubes at H.F." (Vol. 6) is at Munich in manuscript only. The rest were published at Leipsig in the Russian zone. This work appeared most important and it might be worth while translating and publishing.

Dr. Kleen informed us that the specialised work in measuring equipment was carried out by Dr. Meinke who now lives at Hamburg Bergendorf, Uhlanderstrasse 5. See Section (3).

Dr. Kraft was questioned on the methods used for testing high power water cooled valves but was not conversant with these himself. He said that this work had been done in Berlin by Dr. Gunthe Wolf. It was a method by which characteristic curves of a valve could be plotted point by point over the full working range and was developed in 1942-1943. Other schemes were worked out for small valves by which the characteristic curves were shown directly on a cathode ray screen. He said that high power valves capable of working down to 10 cm. with an output of 100 kW had been made.

Work on aerials was done by Dr. Kotowski who is now in the Russian Sector of Berlin. The transmitter work was handled by Dr. Bushbeck who now works with the Russians on guided rockets but who is allowed to go to his home in Grunewald once a week. Dr. Bruck was also associated with the valve testing plant and is living at present at Osnabruck but is not working. All the best Telefunken technicians are working in Berlin for the Russians directed by Dr. Steiner who lives at Zehlendorf, Geothestrasse 2a.

Work on wave guides was carried out under code names Rudolf and Michel by Herr Spiegel who is in the Russian zone, but Herr Maas in Munich would have some information on this work.

Dr. Ulbricht was also present and stated that his work during the war was on direction finders of the Adcock type. He had, however, adjusted the medium wave aerial at Norddeich to cover the British forces zone to serve which it is now used. The aerial system at this station has 10 masts, 4 in line as a director, behind which are 2 in line which are driven, and behind them again 4 more in line as a reflector, set up on a bearing to cover England and originally designed to operate on 758 kc/s. To work for the British forces network, 3 masts were selected, one of the directors, one of the drivers and one reflector to give radiation 150° away from the original direction.

The H.F. bridges used by the Telefunken Company were made chiefly by Siemens & Halske of Berlin, but all such apparatus has been taken by the Russians. Others were made by Rodhe & Schwarz and a few were made by Telefunken themselves at Berlin. No details of this equipment were available.

(b) <u>Telefunken, Stuttgart</u>. Telefunkens are operating in a very small way in the Mahle factory carrying out repairs to broadcast receivers. The whole place is equivalent to a Radio Dealer's repair shop and is of no interest.

(c) Telefunken, Maxstrasse 8, Berlin. Here again very little work of interest to our team was being carried out since they were producing a small type of portable radio receiver, mains operated. It was learned that the Chief of vacuum tube development was Dr. Steiner who is now working in the Russian sector as head of an Institute for controlling various researches. Steimel?

An interesting calibration device for calibrating transmitters automatically was described. The method was a photographic one, a sensitised plate being placed in the position normally occupied by the dial and a beam of light was transmitted on to this from a special projector. This projector was fitted with a film which had the scale markings inscribed on it, i.e. lines of different lengths and the appropriate numbers where they occur. The method in use was as follows:-

A standard crystal control oscillator was used and the transmitter was slowly tuned by a motor. When a beat note occurred between these two, arrangements were made for the motor to be stopped and when stationery a flash from a discharge tube passed a beam of light through the projector which was thrown on to the sensitised plate, projecting an image of the appropriate line on to it. The projector then automatically moved to the next position and the motor was restarted. This operated continuously until all the points were exposed on the sensitised dial plate. This dial plate was of similar grade to that used for process work. It was then developed and used on the transmitter. A 100 kc/s crystal oscillator was used and it was arranged to be divided so that 1, 5, 10, 50 and 100 kc/s points were available and these were brought out depending upon the frequency on which the points were required on the scale. The motor was arranged so that when the 5,000 c.p.s. beat note was passed the motor went slowly, and at 70 c.p.s. the motor was cut out out and the inertia of the system brought it down to zero beat.

(d) Telefunken, Sickingerstrasse, Berlin. Dr. Max Weth, President of the Board, was seen but he was non-technical and we later saw Dr. Gunthe Wolf and Dr. Paul Wolf. In the laboratory some experiments in induction heating were being made using a self-oscillator on 2 - 5kW output. The use to which the heater was being put at the time was for hard soldering on the cap of an all-metal valve to the metal baseplate, and it was arranged so that the maximum heating occured round the work. The heating element is shown in Fig. 1 and will be seen to consist of a coil of some 10 turns round a heavy copper cylinder having a longitudinal slit in it and cup shaped at the bottom to provide a seating for the work. Means are provided to rotate the work on this seating whilst it is heated and by this means even heating round the periphery of the article is obtained. Another induction heating apparatus was being used for degassing anodes of transmitting valves.

Some examples of the 100kW transmitting valve, No. 564.RS, suitable for short wave use up to 25 Mc/s were seen; this is a double ended type valve, the thoriated tungsten cathode requiring 180 amps at 18 volts for a peak emission of 100 amps. The cathode is in three sections, each brought out to a terminal and also connected internally in parallel. The centre points of each section are strapped together and brought out to one end of the tube. There is no filament seal cooling and the grid connections are brought out to the opposite end. Overall the valve is about a metre long and it was understood that they are being produced for use in transmitting stations which are in operation in Germany.

It was unfortunate that neither Dr. Gunthe Wolf nor Dr. Paul Wolf spoke English with any fluency as they developed the valve characteristic measuring techniques. However, Dr. Gunthe Wolf was asked for a report on this subject as applied to high power valves.

(e) Plate Marking Works. A visit was made to the Siemens Plate Marking Works where dyed anodising name plates and dials were made. The master scale was anodised initally either in a sulphuric acid bath (20%) with a potential of 15 volts at a current density of 2 amps per square decimeter, D.C. or A.C. being used; in the latter case two anodes being employed so that twice the amount of work could be done in one bath. If the dial is required to be of a brass colour, oxalic acid (5 to 7%) is used for the anodising bath. The temperature of the baths should be kept at 20 degs. C. for normal anodising and it is interesting to note that precautions were taken to pass cold water through the solution if necessary. Where oxalic acid is used the colour of the anodising can be varied by the temperature of the bath and sometimes temperatures up to 40 degs. C were used. The anodised plate was then taken to an offset printing machine and the resist was printed either from an engraved plate or from positive type using a special ink. The plate was then put into a vat of dye for colouring. Care is taken to see that the vat is not above 70 deg. C for above this temperature the crystaline structure of the oxide surface of the aluminium becomes closed. The length of time the parts are left immersed in the vat varies depending on the depth of the colouring required and the type of dye. After dyeing the resist is washed using petroleum type spirit.

If a multi-colour dial is required, a new resist may be printed and the part redyed but it should be noted that certain colours drive out other colours and the dyes do not follow the normal laws applying to pigments. In other words, yellow cannot be mixed with blue to produce green - the yellow dye will completely displace the blue dye and the part will show yellow. When the dyeing process is complete the aluminium panel is either boiled in water to close the grain or may be sprayed with a lacquer.

Another process comprises sensitising the oxide coating with a photographic process which is roughly as follows:-

(a) Anodise

(b) Treat with ammonium chloride (NH_4Cl)

(c) Treat with sulphuric nitrate ($Ag. NO_3$)

and finish in a bath of $Au.Cl._3$. After fixing it is sprayed with a cellulose lacquer (Pantarol).

(3) Herr Meinke

H.F. signal generator. This unit covered the range 42-80 cms and could be extended down to 20 cms by the use of harmonics. The unit was constructed entirely on unplated brass and consisted of two circular transmission lines in a tuned plate-tuned grid circuit using an LD5 osc. valve with grounded cathode. Through a capacity attenuator matched to 70 ohms, a maximum output of 4 watts was obtainable. The attentuator is shown in Fig. 2 and consists of a circular ceramic tube which fits snugly within the copper tube on top of the generator. A similar ceramic tube with a coppered outer surface is pressed into this so that a constant capacity exists between it and the outer copper tube. A brass slug is then soldered to the base of this and acts as the pick up and is placed as close to the anode lead as possible. For attenuation the whole ceramic structure is moved out in the copper tube, thus decreasing the energy pick up, but at the same time keeping the capacity between the pick up and tube constant. (This tube and all of box A is at H.T. as shall be seen later.) The energy is fed off through a co-axial line whose central conductor is fed to the pick up slug through a 70 ohm resistor. The equivalent circuit is shown in Fig. 3, where R is 70 ohms, Cv is the cap between the anode lead and pick up slug, and Cc is the cap across the outer ceramic tube.

The two copper transmission lines are circular and are supported by circular polystyrene insulators; see Fig. 4. The plate line and grid line are in separate copper boxes which must be (although Dr. Meinke didn't clarify this point) separated by a thin sheet of dielectric. This is necessary because box A is at H.T. and Box B is grounded with respect to D.C. but they are at the same effective potential with respect to the frequency for which the unit is designed.

The tuning is performed by a phosphor bronze slider which is rotated around the lines by means of a central ceramic shaft (see Figs. 5 and 6). As these sliders rotate, they short the transmission lines and vary the frequency of the oscillator. Because the shorting path of the spring was too long, a small piece of copper foil was placed across the spring ends and this proved very satisfactory.

This equipment was used only for standing wave measurements and no attempt was made at pulse modulation. The output was switched through a special R.F. switch to either a bolometer or to the load. The bolometer method was quite standard but the R.F. switch is interesting.

R.F. 70 ohm switch. This switch developed from the necessity of switching signals of from 20-80 cms and yet keeping the input and output lines properly matched. To ensure good contacts, he employed compression springs inside the phosphor bronze moveable contacts. These were in turn brazed on to the rotating copper sleeve. The proper match was obtained by controlling the ratio of the contact diameter to the outer diamter D of the switch. See Fig. 7.

Bolometers. For his work on the bolometer see: "Das Bolometer als Lustigemesser bir Hoher Freq." Elekt. Nach: Tech 19 (1942), 27. He published much between 1940-44 and it might be well to look it over.

Attenuators. He worked on an experimental absorbtion attenuator and calculated various sizes and shapes for zero reflection coefficients. Complete notes on this subject were obtained and are attached. The general view of this attenuator (wide range) for cm waves is shown in Fig. 8.

The input is fed to a carbon coated ceramic tube of resistance 70 ohms for a match. Inside this tube is moved a brass plunger connected to the output line through another carbon 70 ohms resistance. Thus both input and output lines are matched. By moving the plunger any amount of energy from maximum to zero may be obtained. For such a unit to be successful, complete absorbtion of the incident energy is necessary and for this purpose Dr. Meinke used the exponential brass spinning shown. As long as $\Delta = 1/8$ D he has shown that complete absorbtion will take place in this horn for a 70 ohm line. For further details see evacuated literature sheet, also his papers.

Rotating Standing Wave Indicator. One equipment of which he was especially proud was his rotating S.W. indicator. This unit was adapted to 10 cms and also to 3 cms by replacing the co-axial with a guide. The unit consists of a circular piece of co-axial with the outer conductor slotted on the inner diameter; see Fig. 9. A motor-driven revolving arm with a small pick up probe which is capacity coupled to the inner conductor, rotates at 25 r/sec. The distance between the pick up probe and the inner conductor is quite large (several mms.) in order to minimise the percentage variation as the pick up rotates. A signal generator supplies energy into one end of the line and the unit whose characteristics are desired is connected to the other. (The system was designed for a 70 ohm line.) As the probe rotates it picks up the energy distribution along the line and passes it through a rotating capacity coupling (see his literature for details) to a superhet receiver and thence displayed on an oscilloscope. The problem is to reduce the diagram on the scope to a straight line i.e. no energy variation on the line and therefore a perfect match of the unknown. Antennae, unknown lines and so on were checked and developed by this means.

Decimetre Wide Band Antenna. Finally, he described his wide band directional antenna. Its construction is pretty well standard and consists of three dipoles separated by $\lambda/2$ for the mean band frequency. The size of the centre dipole and the separation of each side are so arranged that looking into the antenna, the impedance remains relatively constant over the required range.

Variable Cap Wavemeter. He described another wavemeter, good to 42 cms using a tuning condenser system. The stator consisted of six plates mounted concentrically about a central point P. The rotor consists of five small plates of the same radius of curvature which revolve about P on a suitable ceramic arm. (See Fig. 10.) The construction of the stator plates was of three "U" shaped section spot welded. He worked on a 10 cm model of this but the constructional details could not be obtained.

Dr. Meinke stated that there were 45 reports on such apparatus as we desire at Telefunken, Munich. He had written these but had none available. He also stated that despite the lower limit on his signal generator of 42 cms he had used it to 18 cms by picking out harmonics. Of course no voltage measurements were taken. In the laboratory, these designs of attenuators and generators were used down to 10 cms. His knowledge of 3 cms and lower was slight. He had worked on non-reflecting coatings for U-Boats and had prepared a report for a Mr. Morgan of MAP; this report had, at the time of our meeting, not been collected. He also did much work on non-reflecting isolating spacers, frequency couplers, noise absorbers, etc., especially along the iron dust absorbtion principles. Literature regarding this work was removed for copying. As these are the only notes he has, and it represents about six years' work, it is essential that they be returned. It should be emphasised that all the information obtained was described by Dr. Meinke by memory and that details therefore are not possible. If further information is desired on any of these equipments a trip to his laboratory in Bavaria should prove fruitful.

(4) Dr. Kroebel, Schloss Bredeneek, Breetz, near Kiel.

Dr. Kroebel gave us a short description of the work which he had in hand. A pulse generator and time base had been developed for cable fault finding and also for measuring the building up time of amplifiers (Einschwingzeit). He also proposed to use this in conjunction with a crystal clock to measure the variation of 'g' at one spot on the earth's surface. One model of the short pulse generator and time base was in operation and its use in locating the distance of a fault in a cable was illustrated. The initial pulse put into the send end of the cable was shown on a cathode ray screen and the reflection from the fault superimposed. From the distance between these two pulses, the distance along the cable could be calculated. Since the time base was not linear, the time interval was not directly measured on the cathode ray screen but found by setting first the initial pulse and then the reflected pulse to a central line on the screen by shifting the bias on the deflecting amplifier. Having obtained the time interval, the distance of the cable is of course dependent on the velocity of the propagation and to establish this a short known length of the cable is first measured.

Dr. Kroebel claims that the pulse width is of the order of 10^{-8} seconds and that the spread of the time base is 10^{-7} seconds. Actually the pulse seen had a width at its best of some 6×10^{-8} seconds and was by no means rectilinear. The pulse was not amplified or modulated.

The pulse generator and sweep unit is built on a chassis about 15" x 10" x 10" with a separate power supply. The construction was of normal German care and compactness and a 3"

C.R.T. was used for display. For sweep generator he used gas valves of the type EC 50. A block diagram of his circuit is given in Fig. 11. A 1000 cycle sine wave generator (p) feeds three identical pulse shaping circuits, whose initial stages consisted of condenser phase shifters. The sine waves were then squared and shaped and from (n) a pulse was sent down the line to be tested. Similar pulses were developed in (c) and (k) but their relative phase depended on (a) and (h). The pulse from (c) was used to open the square wave generator (d) and the pulse from (k) was used to close it and hence by varying the phase as (h) we may shorten or lengthen the pulse from (d) and vary the duration of the sweep output from (e). The sweep voltage from (e) is about 300 volts in amplitude. A detailed circuit diagram is given in Fig. 13 without the sine wave generator and line pipper circuits. Some items of interest may be noted:

(a) The pip generation is done through a gas tube and is limited by the ionization and de-ionization time as well as the temperature variation of gas valves. At the time this unit was examined the pulse was

Not square, but rather wedge shaped.

Not 10^{-8} seconds duration but rather 6×10^{-8} seconds at the base.

Whereas this pulse is short, considering it is unmodulated and not amplified it is very poor compared with modern allied standards.

The time base is a condenser discharge through a valve impedance and is hence exponential. Also since the output of (d) is not square but wedge shaped (see Fig. 12) the time taken for the sweep valve to saturate and cut off is noticeable and hence the start and finish of the time base are slow. The sweep voltage - time diagram is roughly shown in Fig. 13. It can be seen that it is definitely not linear. This time base is short and by adjusting Cx, Cy and Cz (Fig. 16) it can be reduced to 10^{-7} seconds, but since no attempt is made to make it linear it is not very impressive compared with modern production linear time bases of 1 micro-second and less duration.

This model was a hand made laboratory unit and required a fair amount of handling to get the desired results. It is certain that if it were attempted to produce a variable amplitude, square pulse and also a linear time base, this fundamental design would not work satisfactorily.

In the actual equipment seen, the non linearity was overcome by first bringing the transmitter pulse under a hair line by means of phase shift (1), then bringing the reflected pulse under the same line using the same control. From the change in capacity the time interval could be calculated.

In conclusion, therefore, despite the claims of Dr. Kroebel, it is felt that this unit is below the standard set by allied equipments both in pulse and sweep generation.

Signal Generator. Here again Dr. Kroebel considered his signal generator as being the last word but was evidently out of touch with the latest achievements in Britain and U.S.A. It was developed for laboratory use and covered a frequency range of 10 kc to 30 Mc in seven ranges:-

10 - 30 kc
30 - 100 kc
100 - 300 kc
0.3 - 1 Mc
1 - 3 Mc
3 - 10 Mc
10 - 30 Mc

Each range was spread over a scale approximately 10" long and an engraved dial enabled each division of the main scale to be read to one tenth. Adequate screening was obtained by the use of a double screening box.

The instrument comprised a master oscillator E.F.12 using powdered iron cores at all frequencies, cup type for the four lower ranges and screw core for the higher. Only one calibrated scale was used, the circuits being adjusted by trimmers and the screws cores to match. The wave range switch was of the wafer type. Tuning was carried out by a well-built condenser geared mechanically to the controls although wires were used on the final drive to the dial which was of the rectangular type about 3" x 10". An incremental dial calibrated in degrees was also in the gearing system. The oscillator was controlled by a diode to keep the output constant and fed to an amplifier and modulator unit. The modulator was fed by a step type variable oscillator covering 200 cycles to 4 kc/s. Provision was also made for external modulation. The modulation was monitored by a meter calibrated directly in percentage modulation, and only a low accuracy of depth measurement could be expected.

The amplifier output was monitored by a diode voltmeter indicating on a panel meter (50 uA).

The slide wire system was a double potentiometer with little to commend it, driven from the panel by wires. This was followed by a switch attenuator using wire paralleled elements and carbon series elements, usually considered to be bad practice. The output had two sockets, one giving one volt and the other variable from .1 uV to 100 mV.

A built-in crystal oscillator was employed for frequency checking working at 3 Mc/s and 0.1 Mc/s and provision for using either was made. It was claimed that this enabled the instrument to be used as a frequency standard or as a wavemeter. The instrument also includes an audio output meter to couple to a receiver.

Filter Characteristic Tester. For the measurement of filter characteristics and for use as a panoramic receiver, a cathode ray oscilloscope with a time base proportional to frequency and incorporating wide band amplifiers for the signal has been developed. The frequency spread was obtained by rotating ganged variable condensers controlling the common beat oscillator used for the time base and for the signal amplifiers. The condensers are turned on a shaft driven by a small electric motor. This speed can be controlled by a simple band brake. Alternatively, the frequency spread can be obtained slowly by hand operation. The total frequency range covered in one spread could be varied so that a small portion of a given band containing a large number of signals can be displayed over the full width of the tube (6"). For a frequency range of 1 : 2 the oscillator frequency is changed directly together with the tuning of the amplifiers. For greater ranges a beating oscillator is employed. The whole equipment was approximately 9" x 13" x 16" and weighed about 30 lbs.

Panoramic Receiver. A panoramic receiver based on the principle described above has also been made. This comprises a rotating variable condenser, synchronised to the time base of a cathode ray tube which changes the oscillator and pre-selector (if required) frequency over the required range. This is followed by an I.F. amplifier and detector, and the signal is passed to a cathode ray tube.

A standard receiver is used in conjunction with the Panoramic Receiver tuned manually to obtain the modulation of the signal being received.

The Panoramic Receiver now uses two I.F. channels and two mixers both fed from the scanning local oscillator. One channel receives the outside signal as described, and the other signal comes from the manually tuned receiver local oscillator. The I.F. frequencies are arranged so that the manually tuned receiver pre-selector frequency is synchronised with the same signal on the Panoramic Receiver. The output of the secondary channels is fed to the C.R.O. control grid and is phased to brighten the spot at its response point. It thus indicates the tuning position of the manual receiver relative to the Panoramic one.

For indicating the characteristics of filters over a given frequency range, the output from an oscillator rich in harmonics is fed through the filter and the output from this filter is applied to the vertical deflecting plates of the oscillograph. As the time base sweeps over the frequency range, the vertical deflection is then inversely proportional to the attenuation of the filter.

The same apparatus can be used for displaying the harmonics of a generator and for this purpose the time base swing between 10 - 150 Mc or 100 kc and 10 Mc is employed. Dr. Kroebel stated that this arrangement could be used to resolve the components of a frequency modulated source.

In addition to the above, Dr. Kroebel had developed apparatus for the Fourier analysis of a pulse using a pulse width of 10^{-6} seconds.

Dr. Kroebel was requested to provide detailed reports on all this apparatus.

(5) Hartman & Braun, Frankfurt.
Interviewed Mr. Muller. We were informed that no new developments had been made during the war and examination of the factory confirmed this. Only 1,000 employees out of 5,000 are now employed as 70% of the works was destroyed.

Scale marking. The scale marking methods employed were examined and the device was of interest. It comprises essentially a rotating table on which the dial to be marked was held. This table had a quadrant fixed to it, adjustable for pre-setting. This quadrant had a finely divided scale in degrees and fractions. Radiating from the centre of the table were a number of arms which could be clamped to the quadrant at a given angle, a pointer being provided to show the position. On these arms free sliders are fitted with a socket in each. Into these sockets a flat flexible strip with plugs is fitted at particular distances. The strip was divided into certain multiples - 5 or 10 as a rule. When the arms are set to pre-determined angles the strip takes up a shape, corresponding to the law of the scale, and an arm is fitted which is located in the slot and rotates the scale to the required angle. A pen of the mechanical drawing type is arranged on a parallel motion travel mechanism and a lifting device operated by one control twisting for lifting the pen and pushing for traversing it. Stops were fitted to enable different lengths of line to be drawn. Calibration of the scales is done against a standard degree scale and the results noted on a special form. These scales are afterwards printed with the numerals, type number and serial number using an offset binding press working from positive type. This type is held in a quick release type holder marked in angles for fast setting.

An instrument for controlling the temperature of a furnace which had some interesting features was also seen, a number c these were being made. It appears in their latest catalog and only a brief description will be given here. The temperature of the furnace is read by a thermo-couple which deflects the pointer of the instrument. The pointer carries a small vertical bridge which, when the temperature is correct, opens the supply to the furnace. The correct temperature is set by means of a self balancing potentiometer, the null point being controlled by a subsidiary pointer capable of being set at any point on the scale of the instrument and carrying contacts associated with the supply to the furnace. The upper edge of the bridge carried on the temperature pointer engages with these contacts when it comes into the desired control position. The mechanism which actuates the controlling switches consists of a thin strip of metal which is bent to conform with the scale over which the pointer moves and which is continuously being raised and lowered by means of a synchronous motor mechanism. When it is raised therefore it engages the lower edge of the pointer bridge and pushes it upwards a small amount by bending the arm. When this bridge is directly underneath the controlling contact this is operated every time the lower metal strip is raised. In addition to controlling the supply to the furnace at an even value, this value can be varied throughout any time period required since the subsidiary pointer carrying the controlling contacts is capable of being moved over any portion of the scale by means of a rocker arm travelling over the profile of a cam also driven by a synchronous motor. Thus the cam profile being cut to give the range in temperature desired over any time period, the temperature at which the furnace is controlled varies with this desired curve. Alternatively, if the desired variation in controlled temperature is not repetitive, an endless band, whose profile is that of the temperature variation required is passed through the instument and the actuating arm follows this profile. The instument is, of course, generally suitable for controlling many other supplies.

An electrostatic voltmeter reading 0 - 2.5 kV was seen in which the movement of the pointer was controlled by a light vane normally suspended centrally between two plates, one a shield and the other the H.V. plate. See Fig. 15. When the voltage is applied the vane is attracted to one side and through a normal link mechanism its movement actuates the pointer. Magnetic damping is applied to the pointer at its bearings. The stop mechanism is interesting. A fine brush is used to hold the moving plate and a light spring presses on the magnetic damping vane. The moving plate, which was of aluminium, was supported by a hinge consisting of a fine strip of metal clamped on to the plate and to an anchor on the meter body. The upper of the plate was approximately 5" x 1½". It was stated that this instrument could be used up to 10 kc. A voltmeter of similar pattern suitable up to 150 volts has also been made but no model was available.

A few thermo-couples for measuring currents of 1 ma to 25 ma and from 25 ma upwards were seen, these being enclosed in a glass envelope and with indirect heating for 1 ma to 25 ma and direct heating for 25 ma upwards. The firm has no facilities for making these couples now and the last batch was dated August, 1944.

(6) S.A.B.A. Villingen.

The S.A.B.A. Works are still manufacturing a broadcast receiver of pleasing exterior appearance but with no feature of any special interest. The ganged condensers are controlled by a tuning mechanism which had been designed to spread the band evenly over the scale, such that a given angular movement of the tuning knob produced a different angular movement of the condenser over its range. See Fig. 16. The condensers are well made with calit rod insulators between the fixed and moving vanes consiting of small pillars pressed into the housing. Contacts between the moving vanes and the housing were of silver working on a bronze plate.

An instrument for testing coils for short circuited turns consisted of two balanced coils fed from an oscillator via a coil placed centrally between them. By bringing up the coil under test to one of the balanced coils, the circuit was thrown out of balance and a voltage produced which was in turn used to light up a series of neon lamps. The number of lamps lit indicates the degree of the unbalance.

Gang condenser tester - Used for aligning three ganged condensers. These were not tested for law, but matching was carried out using the centre condenser as standard. The method used had oscillators working at 30 kc/s tuned by the condensers under test. Any frequency difference produced as the condensers were rotated was detected, amplified and the output indicated on a neon. The accuracy required was 0.3%. The centre condenser was then tested for maximum capacity using a 30 kc/s bridge, balance being indicated on a neon. Balance was obtained by a stud switch which had 21 studs marked 0-10, the centre stud 5 being exactly correct. These studs were 0.25% apart. In practice the centre section of the condenser was tested, and the stud number written on; for example - if the balance point came at 8, that number would be used.

Inductances were tested in the same way. It was arranged that they are marked in the same way and were employed in practice by using an 8 condenser with a 2 coil or a 5 condenser with a 5 coil, etc.

Automatic Capacity Bridge.
Another piece of apparatus developed by this firm was an automatic power factor measuring bridge by which a condenser under test is compared with a standard condenser and the meters read directly the capacity difference and the power factor. This instrument could measure the power factor and capacity of condensers from 50 pF to 0.5 mfd. and the frequency of the oscillator employed was 800 c.p.s.

The Director stated that only 5% of the factory was working although they appeared to be rapidly repairing their machines and had a good stock of dies and press tools.

(7) Lumophon, Nuremberg.
This firm was making a cheap receiver and carrying out repair work. There was very little of interest to be seen and only a small portion of the factory was in operation. They have a licence for making refrigerators but cannot obtain the material.

(8) Rohde & Schwarz, Munich.
This firm appears to expect investigators to call and has set out such instruments as they wish to be seen in a room for this purpose. There are, however, only their standard lines, most of which are well-known in this country. Dr. Rohde is

obviously reluctant to divulge all his latest designs and admitted that he was holding these back until he could once again market them as a business proposition. Since this firm is in the U.S. zone and the American authorities tend rather to complain that investigating teams are upsetting production, little could be done to go more deeply into the latest developments of the factory. It is suggested, however, that such an investigation should be carried out with any compulsory powers that might be necessary.

Their quartz clock was on view and was seen operating in the laboratory. A short period accuracy of 10^{-7} and a long period accuracy of 10^{-8} is claimed for this gear. It is housed in a bay of standard width and 9' high containing all the supplies, standard crystal and 1000 fork. The principle is the control of a 1000 cycle fork by means of a 100 kc crystal. The fork is maintained by its own oscillator at approximately 1000 cycles per second by means of a coil placed outside the tines. On the other side is a pick-up coil and between the tines is a third coil. The pick-up coil carries the fork frequency to a series of multipliers where it is multiplied 100 times and combined with the output of the standard crystal oscillator. Thus, when the fork frequency changes, a beat note is produced which is rectified and the rectified D.C. passed back to the coil between the tines which introduces damping and so regulates the frequency of the fork. Steady D.C. is normally passed through this coil so that if the fork frequency is low the current through the damping coil is reduced. The 1000 cycle output of the fork is also used to drive a phonic wheel at 600 r.p.m. on the shaft of which is a 50 cycle generator. The 50 cycle supply is then used to operate the mains type of electric clock. In addition through reduction gearing a cam is driven round which actuates a contact once a second. This contact can be moved round the cam shaft so that the actual time at which the contact is made can be advanced or retarded in relation to the phase of the 50 cycle generator. Thus a series of impulses is obtained and used to trigger a thyratron generating pulse. For comparison with a standard clock giving similar impulses the two sets are combined together and passed in opposite sense through a meter. If the two sets of pulses start exactly together the meter is not deflected, but if one is occurring slightly before the other, then there will be deflection of the meter either positive or negative, which can be corrected by moving one of the contacts relative to its actuating cam shaft. Since one complete rotation of the contact corresponds to a second difference in time between the two sets of pulses, the amount of rotation required to bring the two sets of pulses into synchronism can be directly measured as a time interval, and thus as one clock gains or loses on the other, the amount of gain or loss can be read as so many fractions of a second. The control of the contact can be either by hand or via relays which automatically correct the clock under test. Counters are fitted to these relays, one of which reads 'fast' impulses and the other 'slow' impulses to show how the test clock is performing over a period. The crystal was of the bar type suspended between solid contacts in an evacuated glass envelope. It was in an oven controlled at 39°C to an occuracy of .001°C. The frequency variation was 10^{-9} per .01°C. A crystal clock of this type, which is SC/21-01 Type CFQ, has been in operation for some years in the cellars of the firm and has been regularly compared with the standard time emissions from other countries.

A harmonic analyser, mains operated, capable of measuring harmonics between 50 cycles and 15,000 cycles working on the crystal gate principle was seen. It had an unusual feature in that a logarithmic amplifier was used and the scale of the indicating instrument covered three decades. This means that an analysis can be carried out without the necessity of readjusting the gain of the voltmeter for each harmonic measured. This provides for an analysis down to 0.2% and is satisfactory for most purposes. The range could be varied so that the reading of 1,000 could be obtained with either 1, 10 or 100 volts. Alternatively, by the operation of a switch, the meter could be made linear and a direct reading of the voltage under test obtained. Another interesting feature is that the gate circuit uses a 15 kc/s crystal instead of the usual 100 kc/s making it much easier to obtain the required selectivity. This again is described in the firm's catalogue.

<u>F.M. - A.M. Signal Generator</u>. There was a frequency modulated generator operating between 20 and 200 Mc/s with a deviation of ± 100 kc and a modulated frequency between 50 and 100,000 cycles. The maximum modulated generator is described in the leaflet No. B.N.4140 which also gives the specification. It follow general F.M. generator practice, deviation being kept constant from range to range by a resistance which is switched into position, ganged with the coil drum. A variable resistor is geared to the condenser drive by wires which keep the deviation constant over the range. The main drawback of the unit is that the output is measured before the final amplifier valve, and therefore assumes that the gain through this circuit remains constant for all frequencies and, what is probably most serious, for all valves.

Impedance Measuring Instruments. No impedence bridges of any sort were found. Two models of tuned circuit impedance measuring devices were seen and covered respectively 100 kc/s to 10 Mc/s, and 10 Mc/s to 100 Mc/s. The circuit is relatively simple and is shown in Fig. 17. Ln is actually made up of ten switchable coils and Cn is a single air tuneable condenser. The system of measuring impedance is to place the unknown across x, close s and tune Cn for resonance, as indicated on U. Then vary K to bring U to centre scale. Now open S and retune Cn to resonance. From this the change in capacity ΔCn can be found and therefore the impedance $1/\omega \Delta$ Cn. For these measurements R must be set to maximum. For pure resistance measurements, the above is repeated except after retuning to resonance, R is varied to bring the meter U back to centre scale. R is calibrated in ohms and is read directly. Depending on the frequency used the following figures can be obtained:-

	Set I	Set II
Frequency	100 kc/s - 10 Mc/s	10 Mc/s - 100 Mc/s
Capacity	5 - 1100 pF	0.5 - 80 pF
Inductance	0.5 µH - 50 mH	0.05 µH - 50 µH
Resistance	1 K-ohm - 200 M-ohm	1.0 K-ohm - 10 M-ohm

(9) Light Technical Institute, Karlsruhe.

This was a part of the Karlsruhe University but when visited had been badly damaged and no work was being carried out. All that had been salvaged from the laboratory was a number of test instruments such as used for student demonstrations and there was nothing of interest at all.

(10) Kaiser Wilhelm Institute, Stuttgart.

The original address of this institute was traced and found to be in the centre of a very badly bombed area. There was no evidence of any work being carried out and no responsible person could be located. It is possible that the Institute is carrying on at another address but there was insufficient time to carry out the necessary enquiries.

(11) Siemens & Halske, Berlin.

Dr. Hoffmann said that their specialists in H.F. measuring instruments were Dr. Thilo and Dr. Kuhlman, who were at present in Munich. The manufacture of instruments is partly at Munich and partly at Berlin. Dr. Thilo was fortunately on a visit to Berlin and was able to explain the operation of some of their instruments.

Out of their originally very comprehensive range of instruments, some of which are still being made, they have a short list of instruments which have been developed during the war, and the instruments of interest to this team were discussed. There are a number of signal generators of rather cheap construction, also a signal generator frequency modulated and one giving an output of 0.1 microvolts to 100 microvolts with a frequency up to 300 Mc/s; a resistance attenuator which is good up to 100 Mc/s, having an input impedance of 240 ohms and an output of 60 ohms; a diode voltmeter for use at 200 Mc/s; a cavity resonator used for power factor and capacity measurements; an R.L.C. bridge for measurements up to 10,000 cycles; a low capacity measuring bridge; an indicator for drawing response curves of filters, etc.; a series of L.F. instruments used on telephone and broadcast transmitter programme input equipment. The pulse generators and the like are being developed at Asche and a voltage measuring set 10 - 1,000 Mc/s.

High Frequency Bridge. An interesting description of an H.F. bridge suitable for operation on frequencies between 0.1 and 20 Mc/s was given, two models being developed, one capable of measuring from 100 ohms to 2 megohms, and the other from 0.1 ohms to 100 ohms, with an overall accuracy of 5%. The standard resistance elements in both these models consisted of a resistor having a negative temperature coefficient in the form of a bar 2 cm long and 2 x 5 mm in section. This resistor has a resistance of 100 ohms between the 20 and 2 mm faces and 1000 ohms between the 2 and 5 mm faces. It is composed of a molecular mixture of nickel and cobalt oxides pressed into the above form and sintered at 1000°C. Connections are made by painting silver solution over those faces giving the required resistance and this is fired at 800°C. Connections are then made directly to these faces. The whole is included in a glass envelope. The characteristic is not straight but is of the following form:-

Temperature	Temperature Variation
-20°C	- 5%
20°C	- 2½%
200°C	- 1%

The variation in resistance is therefore obtained by passing a 50 cycle current through the resistor and varying the heating until the H.F. side of the bridge is balanced. The bridge itself consists of four equal condensers each approximately 500 pF and which can actually be varied independently. See Fig.18. They are, however, normally set to fixed values to make the range of the bridge easily calculable. The unknown is placed across one condenser and the standard resistor across the similar condenser across the other arm of the bridge. A heating current is applied via chokes and is obtained from an amplifier. The heating current is applied across a subsidiary bridge circuit of 50 cycle design, one arm being the standard resistor and the other three arms being ordinary 50 cycle type resistors. The amplifier applies a voltage across one diagonal and the output from this subsidiary bridge is taken back to the amplifier and controls its gain. Thus should the 50 cycle section of the bridge be out of balance, the gain of the amplifier is greatly reduced but the sensitivity at the null point is at its maximum. By means of the ratio arms and the 50 cycle balancing resistor, the effective resistance of the element in the H.F. bridge can be measured to an accuracy normally obtained with 50 cycle techniques. On the H.F. side the measuring frequency was injected via one of the series of input transformers in the original form and the receiver had one side earthy and thus the bridge was earthed on one diagonal to which also the unknown impedance was connected, which indicates that it was suitable for measuring unbalanced impedances only. The resistance gives a range of 10 : 1 and by altering the ratio of the bridge condensers the ranges stated above could be covered. It was pointed out, however, that for the low values of resistance, 0.1 - 10 ohms, the standard resistance was placed in series with the condenser instead of in parallel. This bridge is not being made now as it has proved too complicated for their present facilities but they have in mind a development which will eliminate the input transformers. Modulated H.F. is here fed through the bridge and the detector consists of a crystal actually wired in circuit with the bridge, the output being taken from it through chokes. Thus only the modulation of the signal is used for detection purposes and no H.F. connection cables are required.

Low loss resonance circuits under the code Nos. ENTW2407 suitable for operation up to 800 Mc/s have been developed on the cavity resonator principle and were tuned by squeezing in the waist between the two cavities. This has been developed for use as an instrument for comparing capacities and power factors of condensers.

Frequency modulated signal generator 300 - 700 Mc/s, Code No. REL.ENTW.2556, deviation 300 kc. The oscillator worked on the Lecher wire principle, the wires being terminated in capacities. Across one of these a reactance tube was connected and the modulation applied via this tube which varied the effective capacity terminating the Lecher wire and was swung with frequency over the required deviation. It is understood that this arrangement worked in the laboratory but up to the time they stopped development their production models had given a considerable amount of trouble.

The main signal generator was REL.SEND.2009 and oscillated between 5 and 300 Mc/s giving an output variable between 0.1 microvolt and 100 volts into 50 ohms. Suitable for local modulation at 30% at 1000 cycles and external modulation from 30 cycles to 2 Mc/s. This was developed in 1940.

Variable low pass filters had been made in two ranges, 50 kc to 26 Mc, and 20 Mc and 300 Mc. It is possible to vary the meter cut off frequency of these filters.

During the course of the discussion Dr. Ruf mentioned that a programme line for television between Berlin and Hamburg, and Berlin and Munich had been installed suitable for frequencies up to 4 Mc with repeaters every 30 to 35 kilometres.

The voltage measuring set 10 - 1,000 Mc/s, REL.MSE.167A, works on the comparison method, the voltage under test being mixed with a standard frequency and the resulting beat compared with either of three representative frequencies, 10, 20 and 100 Mc/s.

Dr. Ruf knew nothing about the centimetre band developments which were handled by a Herr Schuckmann. However, literature on two U.H.F. instruments was asked to be evacuated.

(a) A magnetron low power oscillator variable between 22 and 5.5 cms.

(b) A series of H.F. cavity wavemetres consisting of 6 silver plates plates screwed together and a very fine calibrated screw thread for the plunger (See Fig. 19). The largest of these covered the band 9.4 - 7.6 cms and a series of them was capable of completely covering the region from 9.4 - 2.3 cms.

Dr. Thilo then went on to discuss the work of Siemens on the development of the cavity resonator. In 1937 they developed the toroidal brass cavity which could be used as an effective low loss oscillator down to 35 c.m.s. It consisted of a hollow brass doughnut with the inner span joined by two parallel plates. The separation of these plates altered their capacity and hence the frequency of the oscillator. In this manner tuning was performed by means of a plunger pushing on one of these plates. Excitation and pick up were usually performed by loops at diammetrically opposite points in the doughnut.

A unit for measuring R.F. voltages of from 10 - 1000 Mc/s. It was a comparison method consisting of a heterodyne receiver with an I.F. of bandwidth 100-400 kc/s. The oscillator supplies frequency from 10 - 20 Mc/s and they use up to the 5th harmonic to get to 100 Mc/s and another coil supplies 100 - 200 and again the 5th harmonic gives up to 1000 Mc/s. The input and the amplifier must be flat over the band and the oscillator voltage must be large compared to the signal. For measurements, the unknown is fed in and a reading taken, then this is compared to a calibrated internal oscillator at the same frequency and hence the voltage is determined.

Documents

Some notes prepared by Dr. Meinke will be lodged with Board of Trade, German Division (Documents Unit), Lansdowne House, Berkeley Square, W.1. Tel; Grosvenor 4060 Ext: 2923. All applications for permission to inspect these notes should quote BIOS/Docs/1998/2221

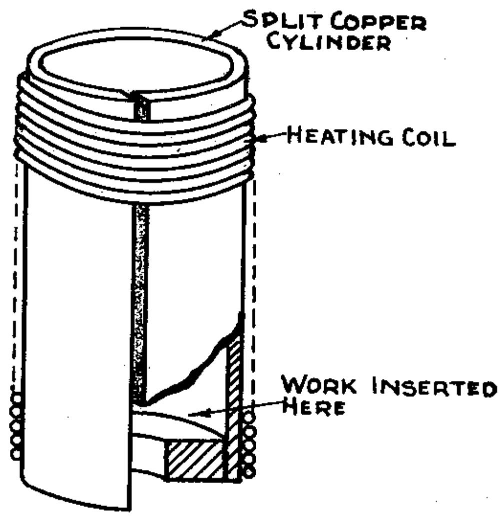


FIG. 1 (SECTION 2. d)

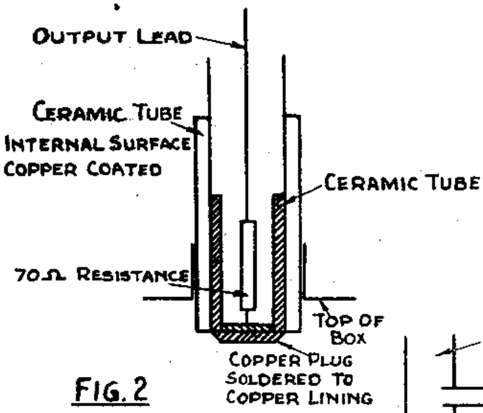


FIG. 2

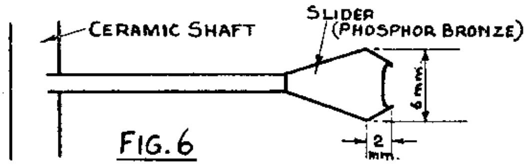


FIG. 6

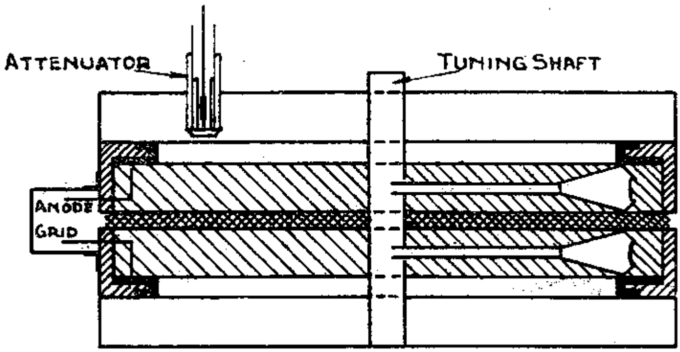
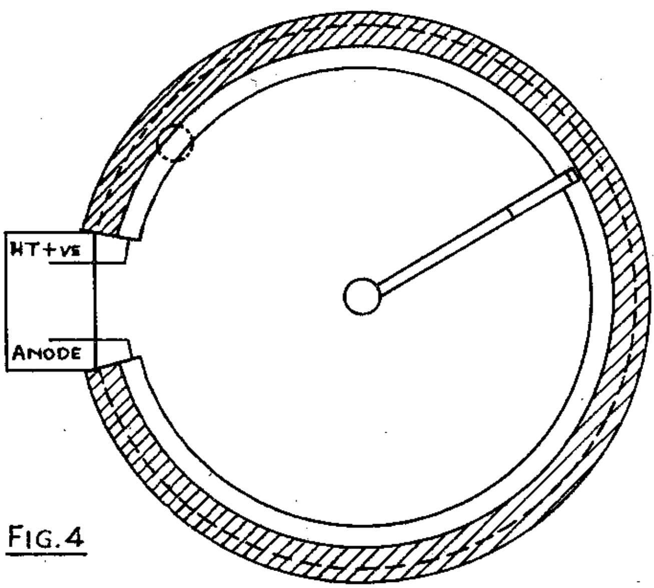


FIG. 5



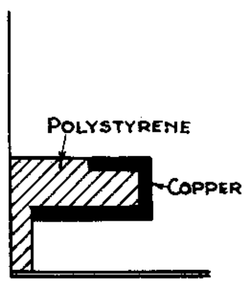


FIG. 4

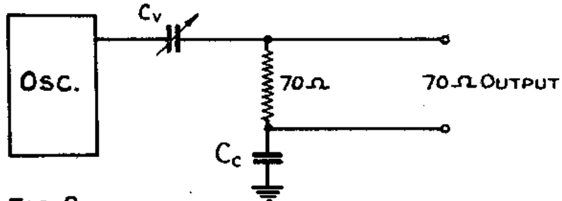


FIG. 3

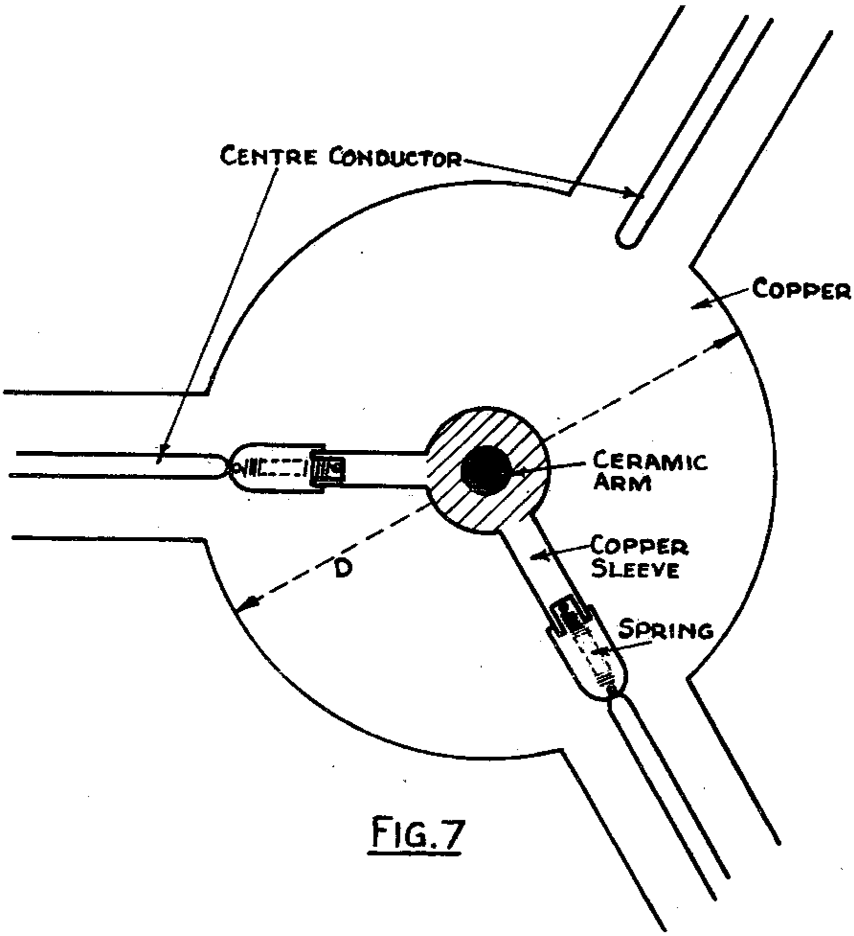

CENTRE CONDUCTOR
COPPER
CERAMIC ARM
COPPER SLEEVE
D
SPRING

FIG. 7

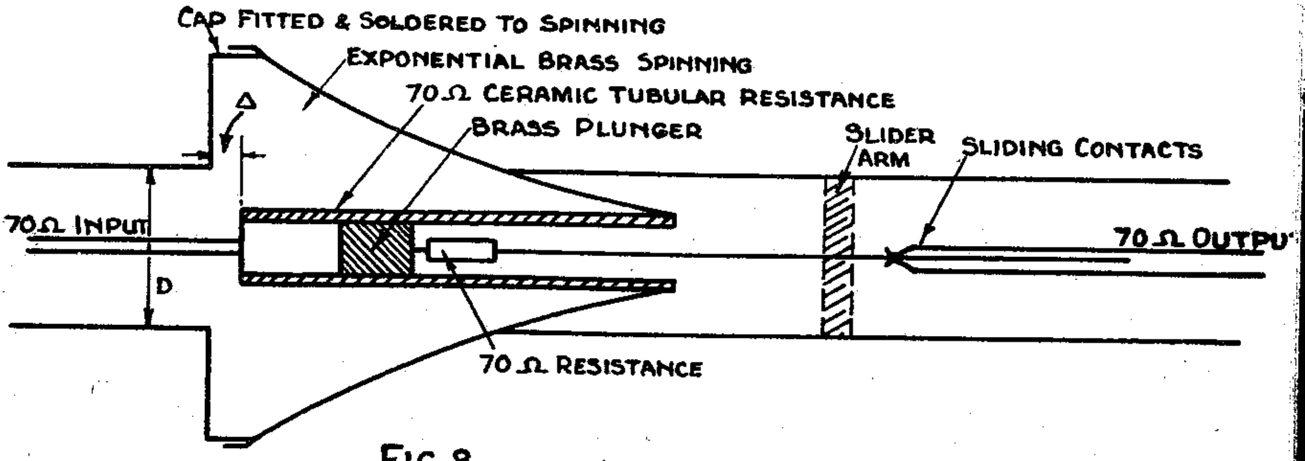
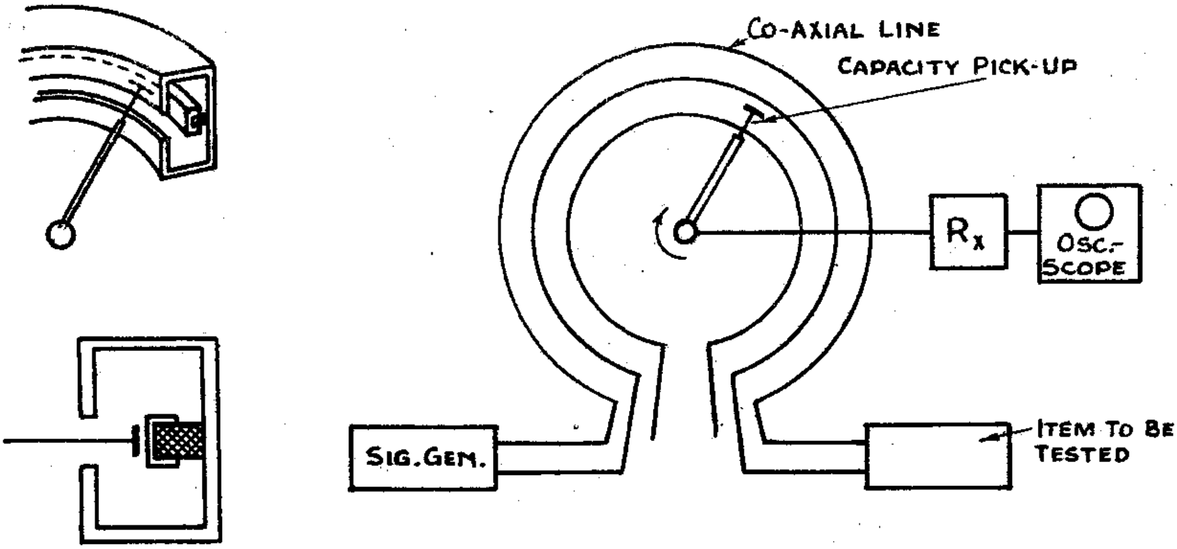

CAP FITTED & SOLDERED TO SPINNING
EXPONENTIAL BRASS SPINNING
Δ
70 Ω CERAMIC TUBULAR RESISTANCE
BRASS PLUNGER
SLIDER ARM
SLIDING CONTACTS
70 Ω INPUT
70 Ω OUTPUT
D
70 Ω RESISTANCE

FIG. 8



CROSS-SECTION

FIG. 9

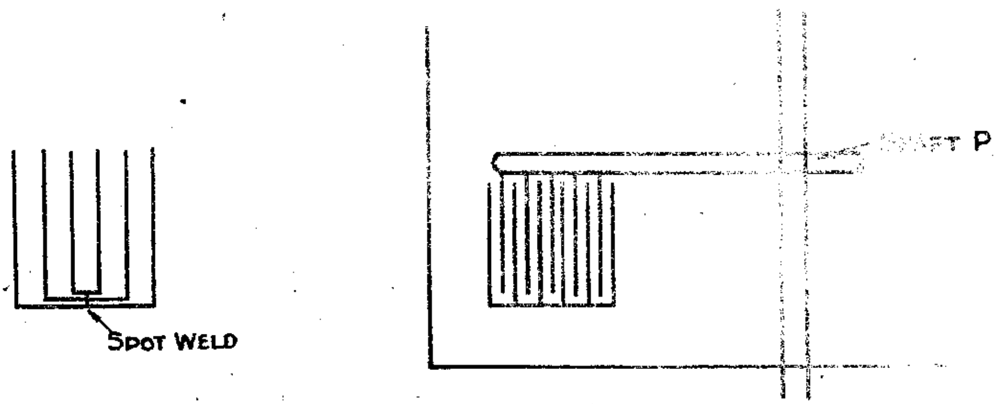


FIG. 10

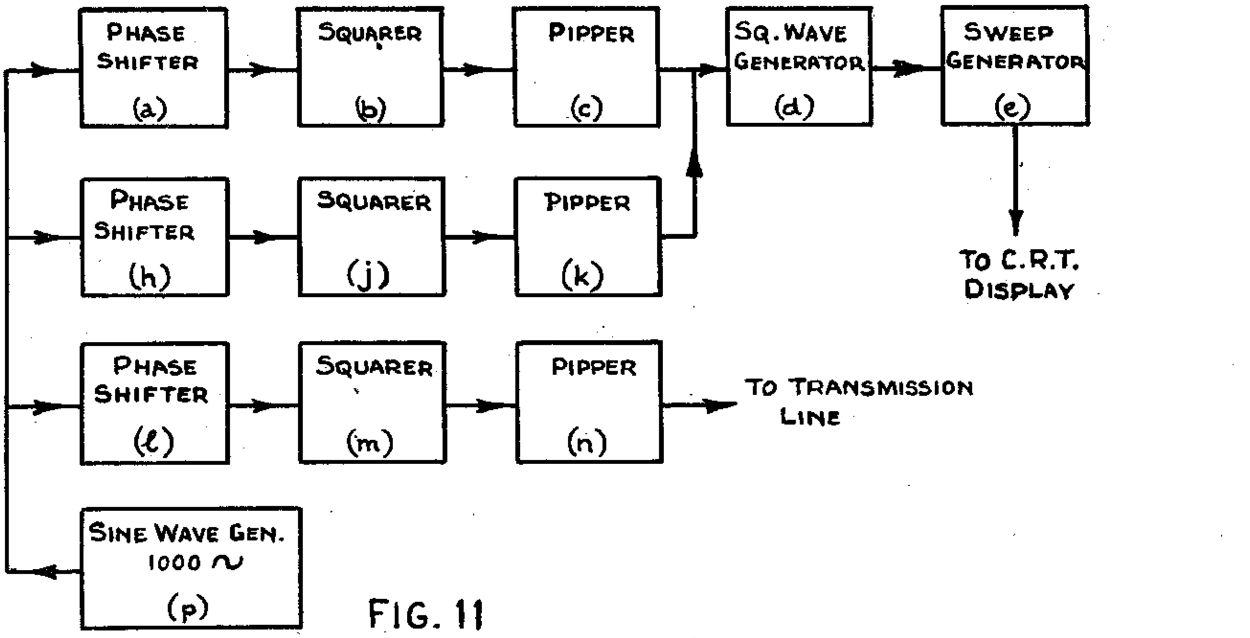


FIG. 11

BLOCK DIAGRAM OF SWEEP GENERATOR

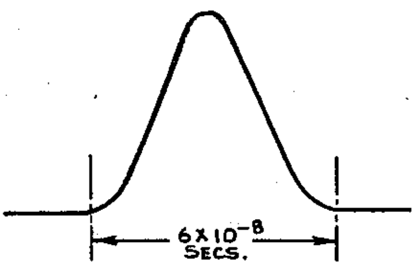


FIG. 12

OUTPUT FROM PIPPER (n)

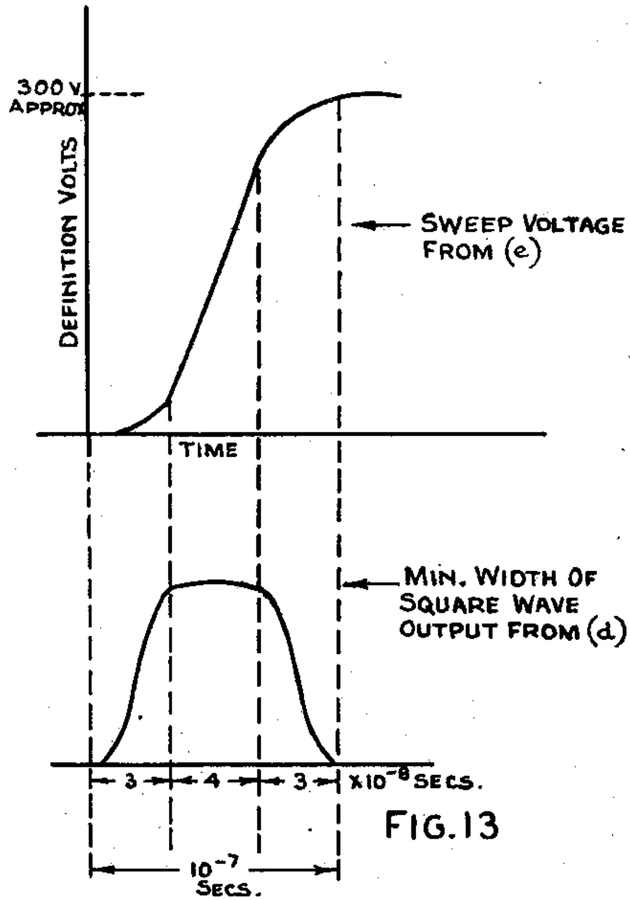


FIG. 13

RELATION BETWEEN OUTPUT FROM (d) AND DEFINITION VOLTAGE FROM (e)

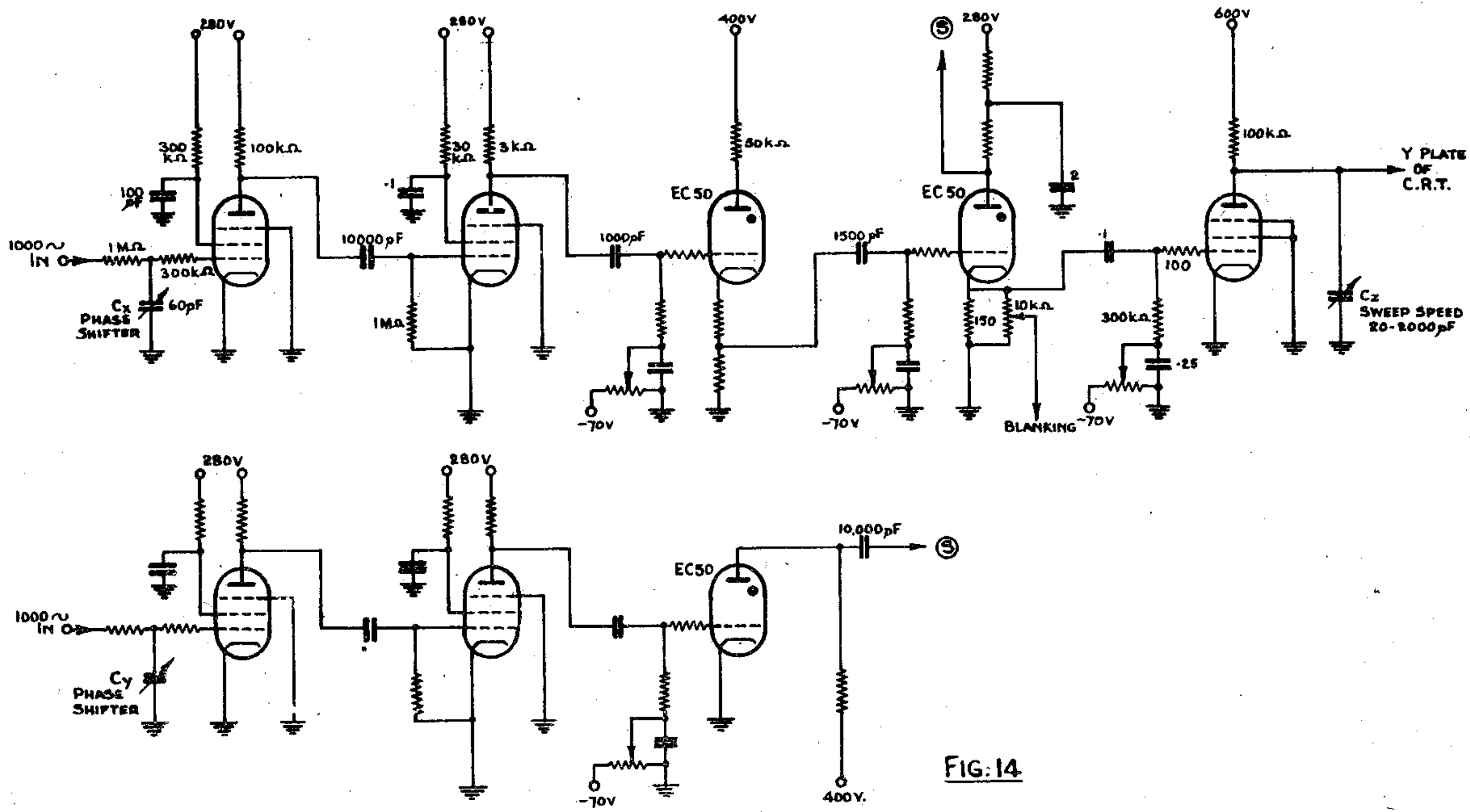

280V
300 kΩ
100 pF
100kΩ
1000~ IN
1MΩ
300kΩ
Cx PHASE SHIFTER
60pF
10000pF
280V
30 kΩ
3kΩ
·1
1MΩ
1000pF
400V
EC50
50kΩ
-70V
1500pF
280V
EC50
2
150
10kΩ
BLANKING
-70V
·1
100
300kΩ
·25
600V
100kΩ
Y PLATE OF C.R.T.
Cz SWEEP SPEED 20-2000pF
280V
1000~ IN
Cy PHASE SHIFTER
280V
EC50
-70V
10,000pF
400V.

FIG. 14

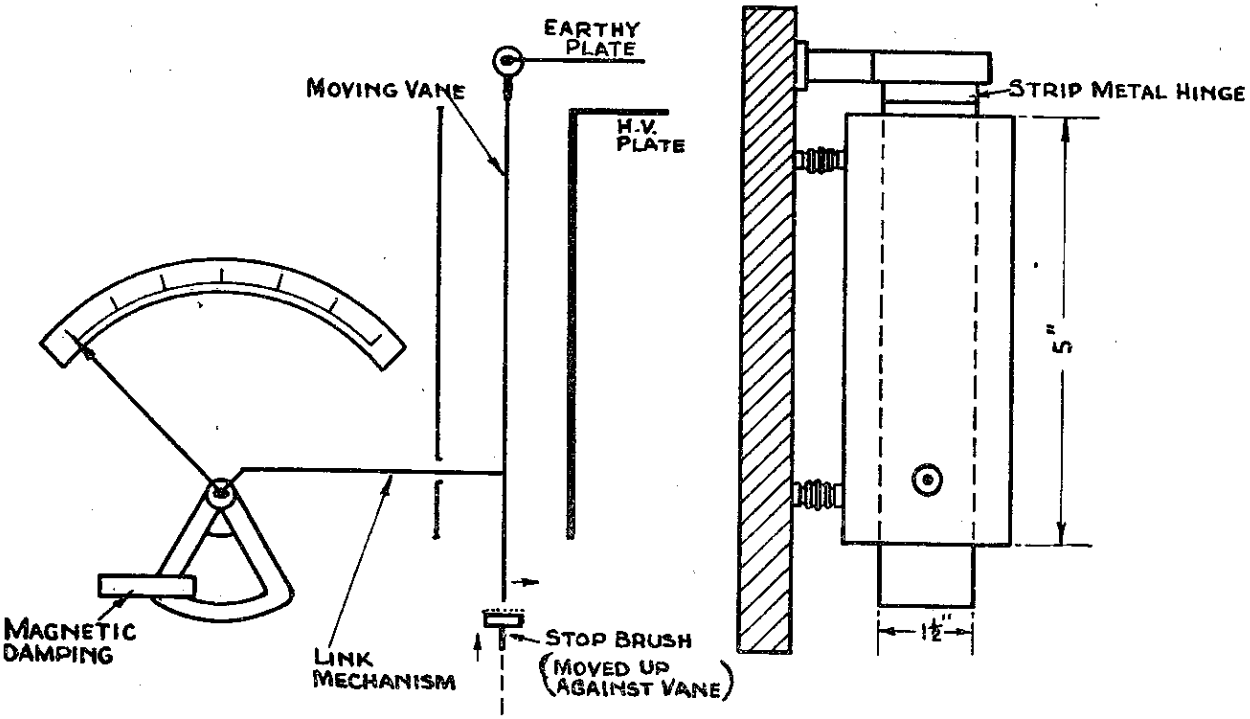

EARTHY PLATE
MOVING VANE
H.V. PLATE
STRIP METAL HINGE
5"
1½"
MAGNETIC DAMPING
LINK MECHANISM
STOP BRUSH
(MOVED UP AGAINST VANE)

FIG. 15

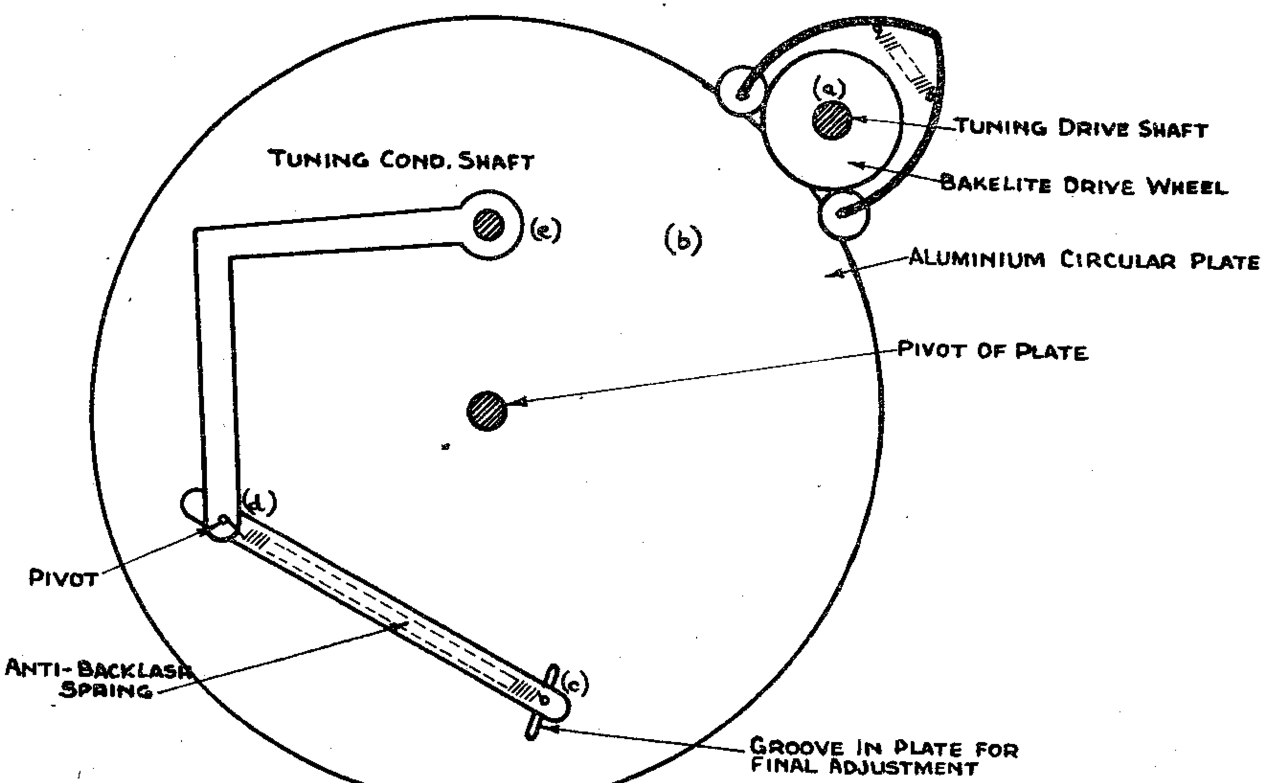

(a)
TUNING DRIVE SHAFT
TUNING COND. SHAFT
BAKELITE DRIVE WHEEL
(e)
(b)
ALUMINIUM CIRCULAR PLATE
PIVOT OF PLATE
(d)
PIVOT
ANTI-BACKLASH SPRING
(c)
GROOVE IN PLATE FOR FINAL ADJUSTMENT

FIG. 16

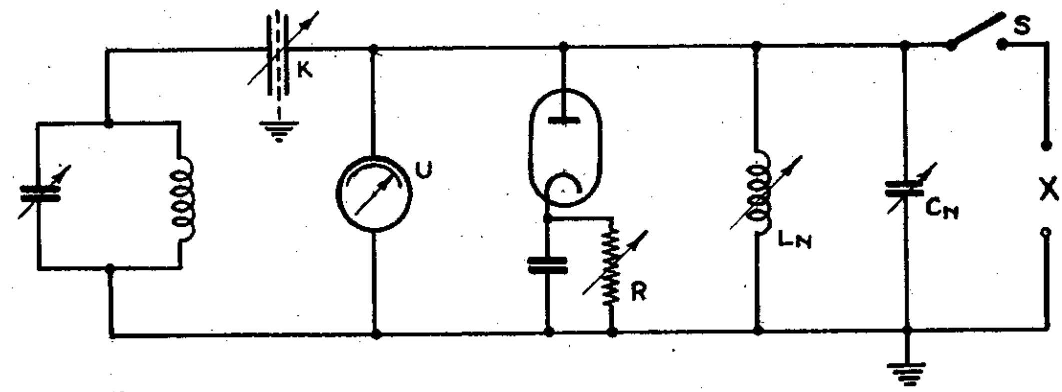


FIG. 17. R & S IMP. MEASURING INSTRUMENT

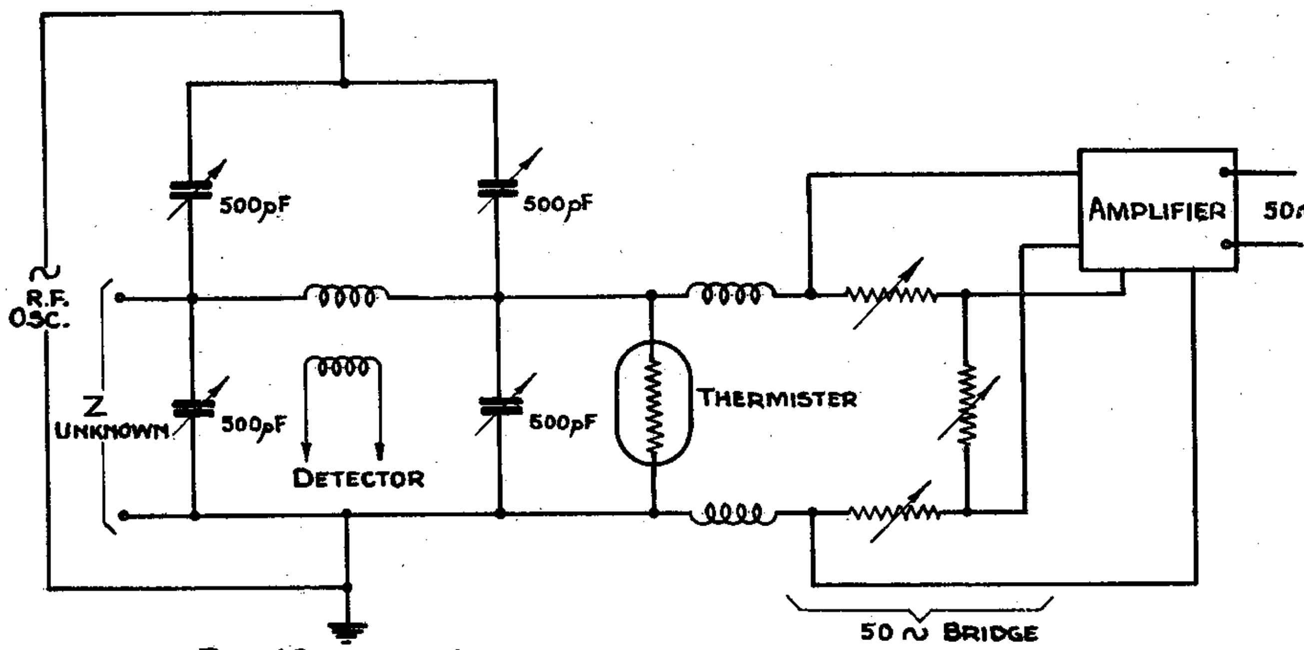


FIG. 18. H.F. BRIDGE

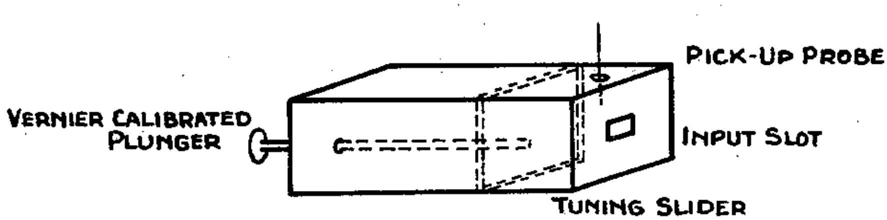


FIG. 19. CAVITY WAVEMETER