

# RADIOMETER

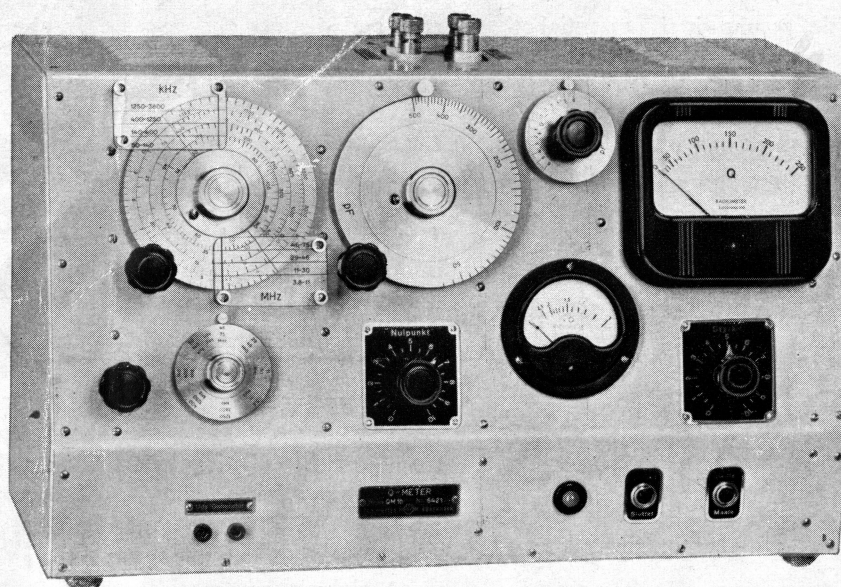
Q - M e t e r

type QM1

**Elektriske måleapparater**  
til videnskabelig og  
industriel anvendelse







M 760

## Q-Meter type QM 1

### Introduction:

The Q-Meter gives a direct indication of the figure of merit,  $Q$ , of coils and can be used for determining the losses in condensers and dielectrics. Furthermore it can be used for measuring capacitance and inductance at high frequencies.

The  $Q$  of an inductance coil designates the ratio of reactance to series resistance. If the losses of a series resonant circuit are concentrated in the coil, an impressed voltage is multiplied by  $Q$  when the circuit is tuned to resonance. This constitutes the fundamental operating principle of the Q-Meter.

### Description:

The principle of the Q-Meter appears from the functional schematic diagram fig. 1: The coil to be measured  $L$ , together with the built-in condenser  $C$  form a resonant circuit. A small non-inductive resistor  $r_m$  is inserted in series with the circuit. An HF-current which is measured with the thermocouple meter  $I$  and supplied from the generator  $G$  flows through  $r_m$ . In other terms, a generator of known voltage having the internal resistance  $r_m$  is connected in series with the LC-circuit.

At resonance the voltage across the condenser  $C$  will rise to  $Q$  times the voltage across  $r_m$ . A built-in vacuum-tube voltmeter is connected across  $C$ . The voltmeter is directly calibrated in  $Q$ -units from 30 to 250. If  $Q$  is greater than 250, it can be measured by reducing the current flowing through  $r_m$ . The thermocouple meter is calibrated to indicate the multiplication factor for the  $Q$  reading.

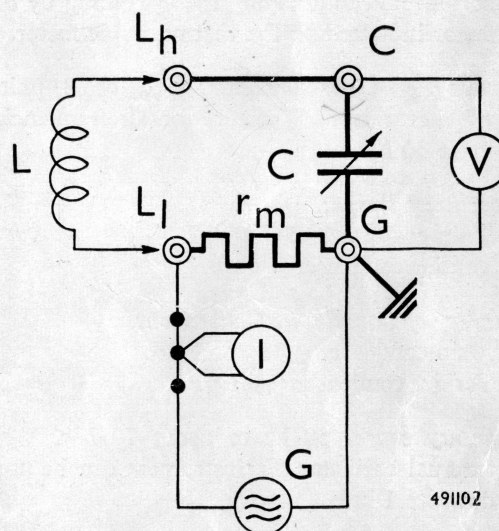


Fig. 1: Functional schematic diagram of Q-Meter.



To obtain reliable results it is essential that the coupling resistor  $r_m$  be non-inductive. In the Q-Meter type QM1 this has been achieved by means of a special concentric design, which is theoretically non-inductive. As the conductive metal layer is very thin, the resistor is exposed to changes arising from corrosion. It is therefore made of gold. In this instrument the unwanted effect of the temperature coefficient of the gold layer is eliminated by introducing a similar but inverse effect into the voltmeter.

The condenser C consists of a vernier condenser with a capacitance range of  $\pm 6$  pF in parallel with a main tuning condenser together covering the range 40 to about 500 pF. Measurements with greater capacitance can be made by connecting a condenser of good quality across the terminals G and C.

The vacuum-tube voltmeter consists of an infinite-impedance detector with negligible dynamic losses. The meter can be short-circuited through a switch to protect it against shocks when the galvanic connection between the terminals  $L_h$  and  $L_1$  is broken.

The HF-oscillator covers the range from 50 kc to about 70 Mc in 8 ranges, calibrated on a direct reading dial. The oscillator coils are mounted on a turret. A gear mechanism provides for

easy and distinct change-over. In the frequency range 1—50 kc measurements can be made in conjunction with an external oscillator.

Losses in condensers can be determined by connecting the condenser under test in parallel with the tuning condenser C or in series with the coil L, retuning and noting the decrease in Q. Detailed information on the procedure together with formulas is given in the instruction booklet.

## Internal Losses

If the losses of the resonant circuit are concentrated in the coil, the Q-Meter will indicate the true Q of the coil. In some cases it may become necessary to take various other dissipation sources into account. This can easily be done by means of a correction chart, supplied with the instrument, giving the internal losses.

The internal losses are mainly due to the coupling resistor  $r_m$  (about .04 ohm). Other dissipation sources are dielectrical losses at the terminal insulators, and the series resistance of the tuning condenser. The latter is proportional to the square root of the frequency and is therefore especially important at high frequencies. The said correction chart states the total internal dissipation factor as a function of the capacitance C with the frequency as parameter.

## SPECIFICATIONS:

**Q-Range:** 30 to 250 direct reading. Q values up to 625 can be measured by reducing the HF-current and multiplying the Q reading by the factor indicated on the thermocouple meter.

**Accuracy of Q-measurements:** 5% or 2 units, whichever is the greater, for all frequencies up to 30 Mc.

**Capacitance Range:**  
Main condenser 45—500 pF.  
Vernier condenser  $\pm 6$  pF.

**Accuracy of Capacitance Calibration:**  
Main condenser  $\pm 1\%$  or 1 pF.  
Vernier condenser  $\pm 0.1$  pF.

**Frequency range:** 50 kc to about 70 Mc. With external oscillator the instrument can be used down to 1 kc.

**Accuracy of Frequency Calibration:** Within 1% for frequencies below 30 Mc. Above 30 Mc within 3%.

**Power supply:** 110, 127, 150, 200, 220, 240 volts a-c, 50—60 cycles.

**Consumption:** about 30 VA.

**Finish:** grey enamel.

**Over-all dimensions:** Height: 330 mm.  
Width: 480 mm.  
Depth: 220 mm.

## Extra Accessories

Shielded coils Type QM1-N for use when measuring losses in condensers or dielectrics, can be supplied on request. The following inductance values are standard:

1-2.5-10-25-50-100-250-500  $\mu$ H.  
1-2.5-5-10 mH.

Data subject to change without notice.





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### Units used in formulas

$L$  = self inductance in henry

$C$  = capacity in farad

$f$  = frequency in cycles per second

$\omega = 2\pi f$

$C_e$  = self capacitance of coil

$C_r$  = capacitance read on the tuning condenser

$C_1$  and  $Q_1$  = readings of capacity and  $Q$  of the circuit proper

$C_2$  and  $Q_2$  = readings of capacity and  $Q$  of the circuit loaded with  
the unknown component

$C_x$  = capacity of unknown component

$L_x$  = self induction of unknown component

$d_x = \frac{1}{Q_x}$  = power factor of unknown component

$d_i$  = power factor of the components of the measuring circuit  
(internal losses)

$R$  = parallel resistance

$r$  = series resistance

$r_m$  = coupling resistor

$r_{KL}$  = h-f resistance of terminals

$r_c$  = series resistance of tuning condenser



## Type QM1 Q-Meter

### Description

The Q-Meter permits the measurement of the Q of self-inductance coils. It can also be employed for determination of h-f resistance, h-f losses in insulating materials and power factors of condensers as well as for measuring self-inductance and capacitance.

The Q of a coil is expressed by:

$$Q = \frac{\omega L}{r}$$

$\omega = 2\pi f$  being the angular frequency, L being the self-inductance of the coil measured in henrys, and r the h-f resistance of the coil in ohms at the frequency f.

When making certain computations it may be convenient to use the power factor d, which is expressed by the ratio of resistance to impedance. When Q is greater than 10, d is equal to the ratio of the resistance to the reactance. Thus:

$$d = \frac{r}{\omega L} = \frac{1}{Q}$$

The power factor of a condenser is:

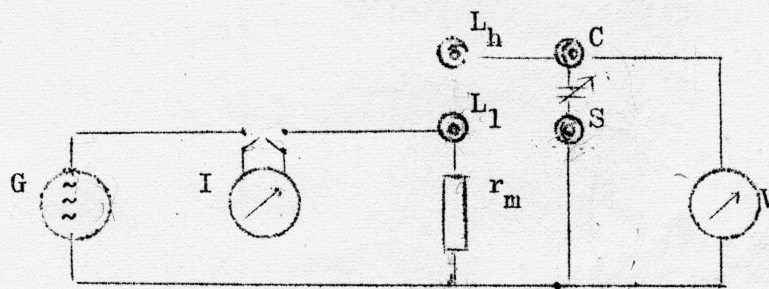
$$d = r \omega C = \frac{1}{Q}$$

r being the effective series resistance in ohms and C the capacitance in farads.

The Q-Meter contains an h-f generator, a thermocouple meter, a tuning condenser and a vacuum-tube voltmeter as well as an eliminator.

The principle of the instrument appears from the sketch overleaf:





From the generator G an h-f current of  $\frac{1}{2}$  amp is transmitted through the non-inductive resistor  $r_m$  of about  $40 \cdot 10^{-3}$  ohms. The current is measured by means of the thermocouple meter I. A coil connected to the terminals  $L_h$  and  $L_1$  in conjunction with the tuning condenser constitutes a circuit in which the resistor  $r_m$  is in series with the coil. When the generator is tuned to resonance with the circuit the voltage of about 20 millivolts over  $r_m$  will produce a current in the circuit giving a voltage over C, being Q times greater than the voltage over  $r_m$ . The vacuum-tube voltmeter is calibrated so that Q values from 30 to 250 can be read directly on the scale. If Q is greater than 250 the current through  $r_m$  must be decreased. The Q value is then found by multiplying the reading of the vacuum-tube voltmeter by the reading of the thermocouple meter.

#### The h-f generator

covers the frequency range from 50 kilocycles to about 73 megacycles in 8 ranges. The change-over from one frequency range to another is made by means of a coil revolver with a gear mechanism securing a convenient operation and a distinct marking of the positions.

The generator is able to furnish 0.5 amp to the coupling resistor in all ranges except the highest frequency range in which the maximum current is somewhat lower and somewhat dependent on the frequency. The current furnished can be controlled by controlling the anode voltage of the oscillator tube by means of the knob "Power". In none of the ranges the generator will furnish so strong a current that the thermocouple will burn out. However, the instrument should only operate for a shorter period with more than full deflection on the thermocouple meter.



The frequency accuracy of the oscillator is better than  $\pm 1\%$  except in the highest frequency range in which the accuracy is about  $\pm 3\%$ , as the frequency varies somewhat with the setting of the power control.

The anode voltage of the oscillator is stabilized by means of glow discharge tubes, and the current that flows from the oscillator through the coupling resistor is therefore practically not influenced by line voltage variations.

#### The thermocouple meter

measures the current through the non-inductive resistor  $r_m$ . For 0.5 amp a-c it deflects to the last division designated 1, and for 0.25 amp the meter deflects to the division 2, etc. The scale is calibrated in steps of  $1/10$  between 1 and 2 and is also calibrated at 2.5. For adjustment of the sensitivity of the meter a resistor of about 1 ohm is provided in one of the leads to the meter.

#### The coupling resistor

is designed so that its self-inductance is so small that it is of no importance at measurements below 30 megacycles. The resistor is located between terminal  $L_1$  and the cabinet and is connected to the terminal by means of a very short lead.

The resistor is made of gold and its temperature coefficient of 0.4% per degree centigrade is of no importance, because the temperature coefficient of the sensitivity of the vacuum-tube voltmeter is about minus 0.4% per degree centigrade.

The exact value of the resistor at  $25^{\circ} \text{C}$  is stated in the chart. As it is very small (about  $40 \cdot 10^{-3}$  ohms) it is generally of no importance when measuring  $Q$  in the frequency range below 2 megacycles.



### The tuning condenser

which is part of the measuring circuit is calibrated directly in pF. A fine tuning condenser is in parallel with the main condenser. The total circuit capacitance appears as the sum or difference of the two scale readings. The main dial covers a range of 45 to about 530 pF, and the fine tuning condenser can be varied between -5 and +5 pF with reading for every 0.2 pF. So the minimum capacitance is 40 pF. The accuracy of the calibration is about 1%  $\pm 1$  pF for the main condenser while that of the fine tuning condenser is about  $\pm 0.1$  pF.

The series resistance of the tuning condenser is about  $8 \cdot 10^{-3}$  ohms at 1 megacycle, and it varies proportionally with the square root of the frequency. Its exact value is stated in the chart appended to the instruction manual.

### The vacuum-tube voltmeter

consists of an infinite input-impedance detector with so low dynamic losses that they do not affect the measurements. The grid of the triode is connected directly to the terminal  $L_h$  by means of a very short lead. The anode voltage of the tube is stabilized by means of a type 4687 glow-discharge tube so that line voltage variations do not affect the sensitivity. The line voltage, however, does affect the electrical zero to some extent.

As the grid of the triode has no connection to chassis when there is no galvanic connection between the terminals  $L_h$  (or C) and chassis, the meter needle may be thrown violently off scale when the operator touches one of the terminals  $L_h$  or C. The meter can be protected against this by setting the switch "Measure-Shift" to position Shift thus short-circuiting the meter.



### The terminals

for connecting coils and condensers are drilled to take banana plugs. The distance between the terminals is 25 mm. The terminals are designed with a view to small losses. The resistance is about  $10^{-3}$  ohms at 1 megacycle for 2 terminals and it increases proportionally to the square root of the frequency.

The terminals for connecting coils are marked  $L_h$  and  $L_l$ .  $L_h$  being the high potential end of the coil and  $L_l$  the low potential end as the non-inductive coupling resistor is mounted between this terminal and the chassis. Terminal C is connected to terminal  $L_h$ , and terminal G is connected to chassis.



### Directions for use

Before turning on the Q-Meter adjust it to the line voltage available. By means of the line voltage switch located behind the plate fastened with screws to the back panel of the instrument, the Q-Meter can be adjusted to one of the following line voltages: 110 - 127 - 150 - 200 - 220 or 240 volts. A 1-amp fuse is mounted on the line voltage switch preventing damage of the line transformer if the instrument is connected to d-c by mistake.

The instrument is switched on by means of the line switch marked "Off-on" and the meter switch is set to position "Shift" by which the meter is short-circuited so that the needle will not move off scale when one of the terminals  $L_h$  or C are touched.

### Measuring coils

The coil to be measured is connected to the terminals  $L_h$  and  $L_1$ . The mechanical zero of the meter is controlled and the meter switch is set to position "Measurement", and the electrical zero is adjusted by means of the potentiometer "Zero". During this adjustment it is important that the generator and the measuring circuit are not at resonance or close to resonance.

The oscillator is now set to the frequency required. First choose the proper frequency range by means of the knob located to the lower left on the front panel. Then read the frequency from the proper scale on the frequency dial (with 5 scales), i.e. from the scale below the part of the index having the same marking as the frequency range chosen. The 8 ranges of the oscillator cover the frequency range from about 50 kilocycles to about 73 megacycles. By means of an external generator the range can be extended down to 1 kilocycle.

The measuring circuit is now tuned to resonance with the generator by means of the built-in tuning condenser and by multiplying the indication on the two meters, the Q of the circuit is had directly if the self-capacitance is small in proportion to the tuning capacitance. The deflection of the thermocouple meter should always be as great as possible, so as to have the most accurate measurement. The measuring range of Q is 30 to 625.



The self-inductance proper of the coil may be calculated from the formula  $L = \frac{1}{\omega^2(C_1 + C_e)}$ ,  $C_1$  being the reading of the tuning condenser and  $C_e$  the self-capacitance of the coil. The self-capacitance  $C_e$  is determined by repeating the measurement at another frequency.

If the reading of the tuning condenser is denoted  $C_1$  at the frequency  $f_1$  and  $C_2$  at the frequency  $f_2$ ,  $C_e$  may be calculated from the formula

$$C_e = \frac{f_1^2 C_1 - f_2^2 C_2}{f_2^2 - f_1^2}$$

#### Corrections at coil measurements

1. Self-capacitance. The Q-Meter indicates directly the Q value of the circuit  $Q_c$  constituted by the coil and the internal circuit components of the Q-Meter if the self-capacitance of the coil is small in proportion to the tuning capacitance. At a small tuning capacitance or great self-capacitance the value read,  $Q_{read}$ , should be corrected for the self-capacitance according to the formula below:

$$Q_c = Q_{read} \left( 1 + \frac{C_e}{C_r} \right)$$

$C_e$  being the self-capacitance of the coil and  $C_r$  the reading of the tuning condenser.

2. Internal Losses. The inevitable internal losses in the Q-Meter entail that Q is less than the Q of the coil,  $Q_{coil}$ . The easiest way to take the internal losses into consideration is by allowing for the power factor

$$d = \frac{1}{Q}$$

instead of the Q value, and we then have:

$$d_{coil} = d_{circuit} - d_i$$

$d_i$  being the power factor of the part of the circuit constituted by the tuning condenser, coupling resistor, vacuum-tube voltmeter and the terminals. On the appended chart  $d_i$  is shown as a function of the capacitance  $C_r$  and with the frequency as parameter.



At frequencies below 20 to 30 megacycles the accuracy of the corrected value of the Q of coil is about 5%. At higher frequencies it is smaller. The accuracy also depends on the deflection of the meter needles, as the percentage of the scale error being about 1% of full deflection is higher at small deflections.

Measuring capacitance and power factor of condensers below 400 pF

At any measurement on the Q-Meter it is necessary that a coil be connected to the terminals  $L_h$  and  $L_1$ .

When measuring condensers, choose a coil having a circuit resonance at the frequency wanted. Tune the generator to resonance with the circuit and do not touch it during measurement. The Q of the coil chosen should be as great as possible when measuring condensers with very low losses.

First measure the Q of the circuit without connecting the unknown condenser. Note the indication  $Q_1$  and the tuning capacitance  $C_1$ . Then connect the unknown condenser to the terminals C and G and note the indication  $Q_2$  and the new reading  $C_2$  on the circuit condenser. Put the circuit in resonance to the generator by adequately decreasing the reading of the tuning condenser.  $C_1 - C_2$  will then indicate the value of the unknown condenser and the power factor is found from the formula:

$$d_x = \frac{C_1}{C_1 - C_2} \cdot \frac{Q_1 - Q_2}{Q_1 \cdot Q_2} = \frac{C_1}{C_x} (d_2 - d_1),$$

$Q_1$  and  $Q_2$  being the values read, possibly corrected for self-capacitances of the coil. However, no correction is to be made for the internal losses.

As the result for  $d_x$  depends on the difference between two almost equal figures, when  $d_x$  is small, the accuracy in this case is limited and most dependent on the care with which the readings are taken.

At high frequencies it may be necessary to correct for the change in the internal losses which occur when changing the setting of the tuning condenser, and also for the influence of the terminal resistance.



The corrected value of the power factor may then be found from

$$d_x = \frac{C_1}{C_x} (d_2 - d_1) + r_c \omega (C_1 + C_2) - 2r_{KL} \omega C_x$$

If  $C_1$  and  $Q_1$  are values belonging together without  $C_x$  connected, and  $C_2$  and  $Q_2$  are values belonging together with  $C_x$  connected, the following applies to the above formula:

$$C_x = C_1 - C_2$$

$$d_1 = \frac{1}{Q_1'} , \quad Q_1' = Q_1 \left(1 + \frac{C_e}{C_1}\right)$$

$$d_2 = \frac{1}{Q_2'} , \quad Q_2' = Q_2 \left(1 + \frac{C_e}{C_2}\right)$$

$C_e$  = the self-capacitance of the coil

$$2r_{KL} = V f_{Mc} \cdot 2r'_{KL}$$

$2r'_{KL}$  is the resistance of the terminals at 1 megacycle, which is stated in the correction chart.

$$r_c = \sqrt{f_{Mc}} \cdot r'_c$$

$r'_c$  is the series resistance in the tuning condenser at 1 megacycle, which is stated in the correction chart.

#### Measuring condensers over 400 pF

is made by connecting the condenser in series with the coil. Connect the condenser between the one end of the coil and the terminal  $L_1$  by means of leads as short as possible. In order to make a d-c connection between the grid of the vacuum-tube and the chassis the condenser must be shunted with a resistor of 10 to 20 megohms.

Short-circuit the condenser by means of a heavy lead, and resonate the circuit to the generator. Take down the capacitance  $C_1$  of the tuning condenser and the  $Q = Q_1$  of the circuit. Remove the short-circuit and re-resonate the circuit to the generator by means of the tuning condenser in the circuit. Take down the new values  $C_2$  and  $Q_2$ . The capacitance of the condenser is then found from

$$C_x = \frac{C_1 \cdot C_2}{C_2 - C_1}$$



If  $C_1$  is greater than  $C_2$  it means that the impedance of the condenser is inductive and its self-capacitance is

$$L_x = \frac{C_1 - C_2}{C_2} \cdot L_s$$

$L_s$  being the self inductance of the coil.

The power factor of the condenser is:

$$d_x = \frac{C_1 Q_1 - C_2 Q_2}{(C_2 - C_1) Q_1 Q_2}$$

When measuring small condensers at low frequencies the necessary shunting of the condenser with a high ohmic resistor will entail an error in the measurement.

If the external parallel resistance of the condenser is denoted  $R_c$  the corrected value of the power factor is:

$$d_{cor} = d_x - \frac{1}{\omega C_x R_c} \quad \begin{matrix} (R_c \text{ in ohms}) \\ (C_x \text{ in farads}) \end{matrix}$$

Note that the value of  $R_c$  to be inserted in the formula is not the d-c value of the resistor but the value the resistor has at the measuring frequency. This resistance may be determined separately as mentioned below.

#### Measuring high resistance and h-f leakage

Connect a coil to the terminals  $L_h$  and  $L_1$ . The coil must be of such a magnitude that resonance is obtained at the frequency wanted and with such a setting of the tuning condenser that resonance can be obtained with the oscillator frequency maintained, even when the component is connected to the terminals C and G.

If the Q of the circuit without the components is  $Q_1$  and  $Q_2$  with the component connected to the terminals C and G, the high frequency resistance is found from

$$R = \frac{Q_1 Q_2}{2\pi f C_1 (Q_1 - Q_2)} \quad \begin{matrix} (f \text{ in cycles per second}) \\ (C \text{ in farads}) \end{matrix}$$

whereas the capacitance is found as the difference between the two readings of the tuning condenser.



The measuring range depends on the frequency and on the  $Q$  of the circuit employed. When measuring high h-f resistances a coil with high  $Q$  and small tuning capacitance should be employed.

#### Measuring resistors of low values

is made in the same way as those of high values. A circuit is resonated with the generator at the frequency required and its  $Q$  is measured at  $Q_1$ . The resistor is inserted between the coil and the terminal  $L_1$ , and the new value of  $Q = Q_2$  is recorded after re-resonating by means of the tuning condenser. If the two readings on the tuning condenser are  $C_1$  and  $C_2$  the value of the resistance is found from

$$r_s = \frac{1}{2\pi f C_1} \cdot \frac{\frac{C_1}{C_2} Q_1 - Q_2}{Q_1 Q_2},$$

$f$  being the frequency in cycles and  $C_1$  the capacitance in farads.

If  $C_1$  is greater than  $C_2$  the impedance of the resistor is inductive and its self-capacitance is

$$L_r = L_1 \frac{C_1 - C_2}{C_2},$$

$L_1$  being the self-inductance of the tuning coil which may be calculated from

$$L_1 = \frac{1}{\omega^2 C_1} = \frac{1}{4\pi^2 f^2 C_1}$$

If  $C_2$  is greater than  $C_1$  the resistance is capacitive, and its series capacitance is

$$C_r = \frac{C_1 C_2}{C_2 - C_1}$$

#### Measuring by means of external generator

The  $Q$ -Meter is provided with 2 jacks marked "Ext. Gen." for connecting an external generator which is coupled when the coil switch is set to position "Ext. Gen.". By this means the frequency range can be extended downwards so that measurements can be made down to 1 kilocycle.



The generator must be able to furnish  $\frac{1}{2}$  amp in about 1 ohm, and if it can furnish more than 1 amp, necessary care should be taken when operating the instrument so as to prevent the thermocouple from burning out, if the fuse before the thermocouple should fail.

As self-inductances for the frequency range 1-50 kilocycles generally have a high self-capacitance it should be noted that it is necessary to correct the indication if the tuning capacitance is low in proportion to the self-capacitance of the coil. The tuning capacitance can be increased by connecting an extra condenser to the terminals C and G.

The frequency response is linear down to 10 kilocycles.

At 5 kilocycles the indication is					1% low
" 2	"	"	"	"	2% "
" 1	"	"	"	"	4% "
" 0.5	"	"	"	"	10% "

The values of "Q" read should be corrected accordingly.

#### Replacement of tubes, etc.

##### The type EC81 oscillator tube

can be replaced right away. If its capacitance deviates from that of the old tube it may be necessary to trim the generator a little. The trimming is made through the two holes in the back panel of the oscillator box, the upper hole being placed opposite the iron-core coil and the lower hole opposite the trimmer. The coil for the highest frequency range has neither iron core nor trimmer, and across the coil for the lowest frequency range there is no trimmer, but an interchangeable condenser.

##### The type EF6 vacuum-tube voltmeter tube

should be aged and selected so that the meter gives full scale deflection for a voltage of  $\frac{1}{2}r_m \cdot 250$  and deflects to  $Q = 100$  for a voltage of  $\frac{1}{2}r_m \cdot 100$ .

A coarse adjustment of the sensitivity for full scale deflection can be made by changing the part of the cathode resistor of the tube located between the plus pole of the meter and the chassis. A fine adjustment can be made by changing the series resistor of the meter or by slightly shunting the meter.



The type EZ40 rectifier tube and the type 4687 stablovolt tubes can be replaced right away. The rectifier tube may be substituted by a type AZ1 tube, as the filament winding of the rectifier tube has an output at 4 volts.

#### Testing the non-inductive resistor

The test can be made by connecting an accumulator in series with a milliammeter and a variable resistor to the terminals "Ext. Gen." and make  $\frac{1}{2}$  amp flow through the resistor. The coil switch must be in position "Ext. Gen.". The voltage present across the terminals  $L_1$  and G is measured with a millivoltmeter. The value of the resistance at  $25^{\circ}$  C is stated in the appended chart. If the measurement is made at a different temperature, corrections should be made. The temperature coefficient of the resistor is +0.4% per degree centigrade. If the value measured deviates more than a few % from the value stated, the instrument should be returned to the factory for repair.

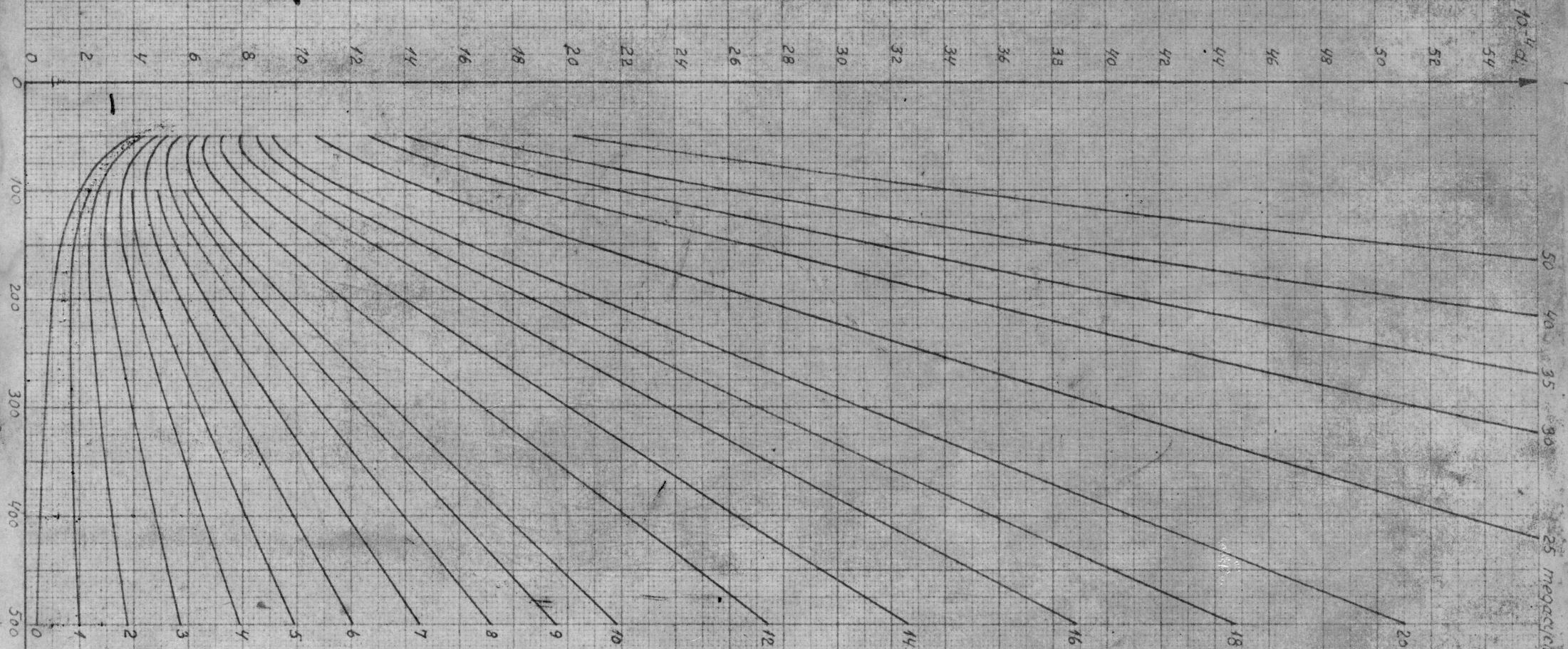
#### Testing thermocouple and xQ-meter

The meter must deflect to the x1 division for  $\frac{1}{2}$  amp a-c. The test is made by setting the coil switch to position "Ext. Gen." and connecting an a-c generator in series with an a-c ammeter to the terminals "Ext. Gen.". The test cannot be made by d-c current as the thermo-element of the thermocouple employed is not insulated from the heating filament, so its emf depends on the direction of the current.

If the sensitivity of the thermocouple has changed because of overload it is advisable to return the instrument to the factory. If the sensitivity has become too high it may be corrected on the spot by increasing the series resistor of the meter a little. If the sensitivity has become too low it is recommended to return the thermocouple and the meter to the factory.



Correction chart for QM1 no. 11232 date 3-10-52



$$Q_{\text{coil}} = d_{\text{circuit}} - d_i$$

$$d_i = \text{internal losses}$$

$$Q_{\text{coil}} = \frac{1}{d_{\text{coil}}}$$

Parallel resistance:

HF-resistance of two terminals:

Series resistance of tuning condenser:  $r_c = 8$  milliohms at 1 megacycle.

Coupling resistor:

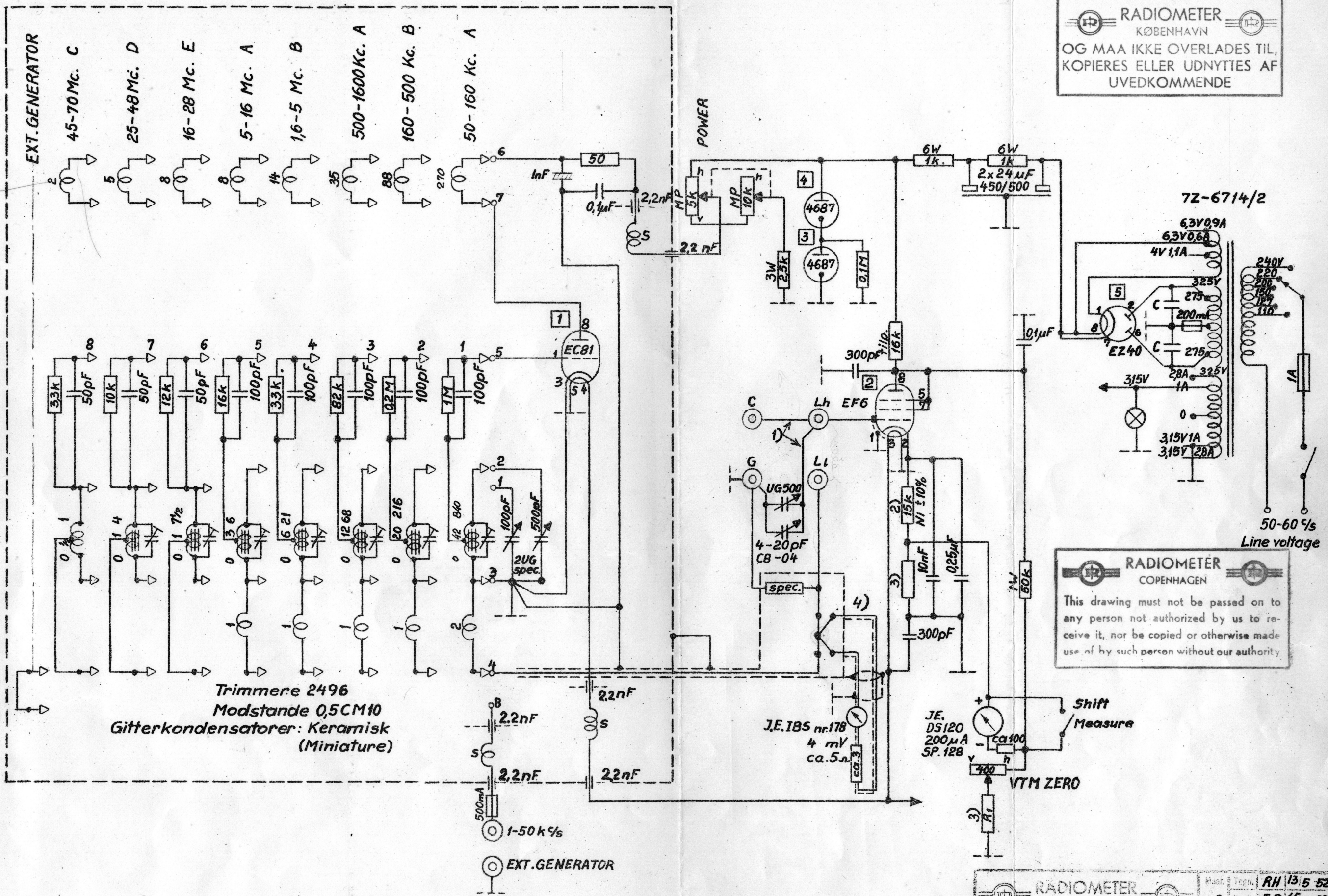
$R = 8$  megohms at 1 megacycle.

$2r_{kl} = 1$  milliohm at 1 megacycle.

$r_m = 38$  milliohms.



DENNE TEGNING TILHØRER  
**RADIOMETER**  
 KØBENHAVN  
 OG MAA IKKE OVERLADES TIL,  
 KOPIERES ELLER UDNYTTES AF  
 UVEDKOMMENDE



**RADIOMETER**  
 COPENHAGEN  
 This drawing must not be passed on to  
 any person not authorized by us to re-  
 ceive it, nor be copied or otherwise made  
 use of by such person without our authority

<b>RADIOMETER</b> KØBENHAVN		Maat. Tegn. <b>RH 13/5 52</b> Type <b>EP 15/5 52</b>
<b>Q Meter</b> Type <b>QM1f</b> Diagram from No 11222-		Erstatning: <b>696-A3</b> Erstatt. af: