CHAPTER II

EXPERIMENTAL SET UP.

A. THEORY OF MEASUREMENT OF RADIO FREQUENCY CONDUCTIVITY.

The block diagram of the experimental arrangement of radio frequency conductivity can be represented by a simple network, shown in figure (2.1).

Let Z_p be the equivalent impedance and for parallel combination

$$Z_p = \frac{R}{1 + j\omega CR}$$

$$= \frac{R(1 - J\omega CR)}{1 + \omega^2 C^2 R^2} \qquad \ldots (2.1)$$

In case of series combination

$$Z_p = R' - \frac{J}{\omega C'} \qquad \ldots (2.2)$$

From equation (2.1) and (2.2)

$$R' = \frac{R}{1 + \omega^2 C^2 R^2} \qquad \ldots (2.3)$$

$$\frac{1}{\omega C'} = \frac{\omega C R^2}{1 + \omega^2 C^2 R^2} \qquad \ldots (2.4)$$

As $\omega^2 C^2 R^2 > 1$

$$C' = C$$

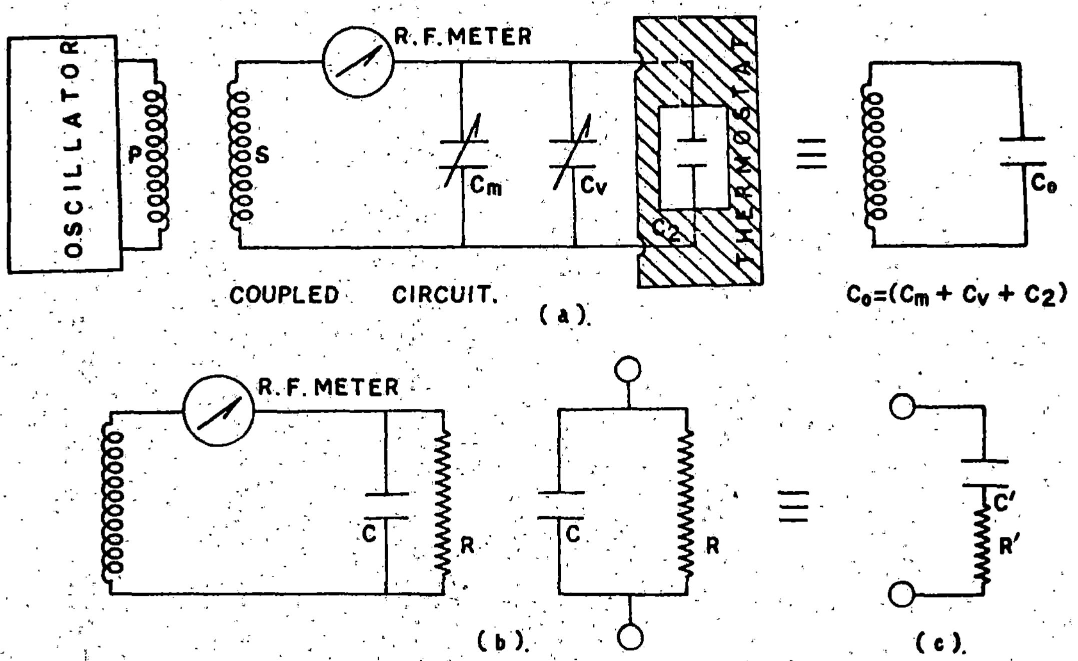


FIG. 2.1. EXPERIMENTAL METHOD FOR DETERMINATION OF RADIO FREQUENCY CONDUCTIVITY OF POLAR DIELECTRICS.
(a). CIRCUIT ARRANGEMENT,
(b). EQUIVALENT CIRCUIT FOR THE COUPLED SECTION AND
(c). EQUIVALENT CIRCUIT FOR THE PORTION RIGHT OF R. F. METER IN (b).

Further the resonant current with the cell in the circuit but without liquid

$$I_o = \frac{E}{R_o} \qquad \ldots (2.5)$$

where R_o is the radio frequency resistance of the secondary tuning circuit and is given by

$$R_o = \frac{C_2 - C_1}{2\omega C_2 C_1} \sqrt{\frac{I_1^2}{I_o^2 - I_1^2}}$$

where I_o is the resonant current in the R.F. milliammeter and C_1 and C_2 are the capacitance for reducing the resonant current to a value I_1 which is equal to $\frac{1}{\sqrt{2}}$ of I_o. The mathematical deduction of the value of radio frequency resistance R_o has been given in the next section of this chapter.

Further the resonant current with cell filled with the liquid is given by

$$I_2 = \frac{E}{R_o + R'} \qquad \ldots (2.6)$$

Putting $\frac{I_1}{I_2} = \alpha \qquad \ldots (2.7)$

and simplifying the equations (2.3), (2.5), (2.6) and (2.7)

$$\alpha - 1 = \frac{R}{R_o(1 + \omega^2 c^2 R^2)}$$

$$R = \frac{1 \pm \sqrt{1 - 4R_o^2(\alpha - 1)^2 \omega^2 c^2}}{2R_o(\alpha - 1)\omega^2 c^2}$$

In the present experimental set up $4R_o^2(\alpha-1)\omega^2c^2 \ll 1$

then

$$R = \frac{1}{R_o(\alpha-1)\omega^2c^2}$$

The radio frequency resistance of the polar liquid

$$R = \rho \cdot \frac{l}{S}$$

where ρ is the specific resistance, l is the length i.e. ~~interelec~~ interelectrode spacing and 'S' is the cross-sectional area of the electrodes. Since $\rho = \frac{1}{K'}$ where K' is the specific conductivity

$$K' = \frac{l}{SR}$$

The tuning condenser is a parallel plate condenser so the capacity of the tuning condenser

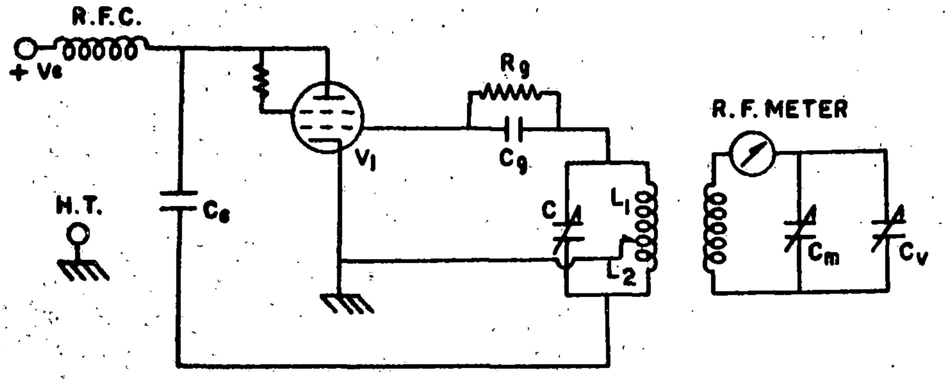
$$C_o = \frac{S}{4\pi l}$$

Therefore the radio frequency conductivity can be expressed as

$$K' = \frac{1}{4\pi R C_o} \quad \ldots (2.8)$$

B. MEASUREMENT OF RADIO FREQUENCY RESISTANCE OF THE SECONDARY TUNING CIRCUIT AND ITS THEORY.

The method used here for determining radio frequency resistance may be stated as reactance variation method. The secondary tuning circuit consists of an inductance, a variable main and verneir condenser and a radio frequency milliammeter. The inductance, variable main condenser and the r.f. milliammeter are all connected in series whereas the vernier condenser is connected in parallel with the main condenser. The vernier condenser is fitted with vernier scale in order to note precisely the position of the condenser. The secondary tuning circuit is loosely coupled to the radio frequency oscillator (Hartley type) which is the driving oscillator of desired frequency shown in figure (2.2). The empty dielectric cell is fitted in parallel to the tuning condenser. The secondary tuning circuit is tuned to the desired frequency of the driving oscillator by proper adjustment of the tuning condensers both main and vernier. The resonant current in the radio frequency milliammeter and the capacitance of the tuning condensers are noted. Then the capacitance of the tuning condenser are adjusted to the value C_1 and C_2 on either side of the resonant value so that the current in the r.f. meter I_1 becomes $\frac{1}{\sqrt{2}}$ times of the resonant current i.e. 70.7% of I_0. The reading for C_2 and C_1 are noted. When the tuning circuit is sharply tuned to desired frequency, the induced voltage in the secondary circuit becomes equal to E_0. Therefore, $E_0 = I_0 R_0$ where R_0 is the radio frequency resistance of the circuit. When detuned, let the



(a) (b)

List of components:

V_1 = 6L6

R_g = 20KΩ

C_g = 0·001 μF.

C_m & C = 0–500 P.F.

C_s = 0·01 μF.

C_v = 0–60 P.F.

R.F.C. = RADIO FREQUENCY CHOKE

R.F. METER = RADIO FREQUENCY MILLIAMMTER.

FIG. 2.2 (a). RADIO FREQUENCY OSCILLATOR
(b). SECONDARY TUNING CIRCUIT.

change in reactance value is ΔX . So the series impedance is $R_o + J\Delta X$ and hence

$$E_o = I_1\sqrt{R_o^2 + \Delta X^2}$$

Therefore

$$\frac{I_o}{I_1} = \frac{E_o/R_o}{E_o/\sqrt{R_o^2+\Delta X^2}} = \frac{\sqrt{R_o^2+\Delta X^2}}{R_o}$$

$$\frac{I_o^2}{I_1^2} - 1 = \frac{R_o^2+\Delta X^2}{R_o^2} - 1 = \frac{\Delta X^2}{R_o^2}$$

$$R_o^2 = \Delta X^2\left(\frac{I_1^2}{I_o^2 - I_1^2}\right) \qquad \text{... (2.9)}$$

The slight change of reactance at the upper half and of the lower half power of maximum power respectively

$$\Delta X = \omega L - \frac{1}{\omega C_2} \qquad \text{... (2.10)}$$

$$\Delta X = \frac{1}{\omega C_1} - \omega L \qquad \text{... (2.11)}$$

where $\omega = 2\pi f_r$, f_r is the resonant frequency. Additing (2.10) and (2.11)

$$2\Delta X = \frac{C_2 - C_1}{\omega C_2 C_1}$$

$$\Delta X = \frac{C_2 - C_1}{2\omega C_2 C_1}$$

Putting the value of ΔX in equation (2.9)

$$R_o^2 = \left(\frac{C_2 - C_1}{2\omega C_1 C_2}\right)^2 \left(\frac{I_1^2}{I_o^2 - I_1^2}\right)$$

Thus the radio frequency resistance

$$R_o = \frac{C_2 - C_1}{2\omega C_1 C_2} \sqrt{\frac{I_1^2}{I_o^2 - I_1^2}} \quad \ldots (2.12)$$

So knowing the values of C_2, C_1, I_1 and I_o, the radio frequency resistance R_o of the circuit has been calculated by using the equation (2.12).

C. APPARATUS USED.

The apparatus used for the measurement of radio frequency conductivity are (a) Radio frequency Oscillator, (b) Secondary tuned circuit (c) R.F. Milliammeter (d) Stabilized power supply, (e) Thermostat (f) Communication broadcasting receiver, wave meter and R.L.C. bridge, (g) Liquid purification arrangement (h) Dielectric cells (i) Ostwalds's viscometer, (j) Chemical balance and weight box (k) Measuring cylinders, Beakers etc. (l) Arrangement for cleaning of the glass apparatus. The description of some of the important apparatus and their associated circuits is given.

Radio frequency Oscillator:- The radio frequency oscillator used here is of Hartley type and the circuit diagram is shown in figure (2.2). The frequency range of the designed oscillator has been found to be from 300 KHz to 8.5 KHz. The inductance L of the tank circuit is divided into two parts L_1 and L_2 and their common point is connected to the cathode terminal of the vacuum tube 6L6. The end of L_2 is connected to the grid through Rg Cg, a parallel combination which is used for providing the grid bias voltage. The end of L_2 is connected to the plate of the oscillator valve 6L6 through the blocking condenser Cc. A condenser C is placed in parallel with the inductance thereby making a complete tank curcuit. The amplified energy in the plate section is fed back to the grid circuit due to inductive coupling and the amount of coupling will depend upon the number of turns in L_1 and L_2. The direct component of the plate current is supplied from a stabilized power supply through a radio frequency choke. The blocking capacitor Cc which has a small reactance compared with load impedance, allows a path to the a.c. component while the d.c. from the power supply is prevented. The gang condenser dial has been calibrated against frequency by the help of communication broadcasting receiver and also by an absorption wave meter.

Secondary tuned Circuit:- The secondary tuning circuit consisting of inductance, a variable tuning main condenser, a radio frequency milliammeter are all connected in series. The circuit is loosely coupled to the Hartley oscillator's tank circuit. A variable vernier condenser is fitted parallel to the main condenser of the secondary circuit in order to improve the accuracy of tuning the desired frequency. The dial of the tuning condensers both main and vernier has been calibrated interms of capacitance with the help of R.L.C. bridge. The dial reading against capacitance of both the main and vernier condenser are shown in figure 2.3 (a) to 2.3 (d).

Calibration of the dial of the tuning condenser (Main)of the receiver circuit.

Table 2.1

Dial reading in degree	Capacitance in μμF	Dial reading in degree	Capacitance in μμF
0	490	19	128
1	470	20	115
2	447.5	21	103
3	426	22	91.5
4	405	23	81
5	384	24	71.5
6	363	25	63
7	340	26	55
8	320	27	48
9	299	28	41.5
10	280	29	36
11	260	30	31
12	241	31	27
13	222	32	23
14	205	33	20
15	188	34	18
16	171	35	17
17	155		
18	141		

Calibration of the dial of the tuning condenser (vernier) of the receiver circuit.

Table 2.2

Dial reading in degree	Capacitance in μμF	Dial reading in degree	Capacitance in μμF
0	60.3	10	36
1	58	11	33.5
2	56.5	12	31.2
3.	53	13	28.8
4	50.6	14	26.4
5	48.1	15	24.2
6	45.6	16	22.6
7	43.2	17	21.4
8	40.8	18	20.7
9	38.5		

Radio frequency milliammeter:- The radio frequency milliammeter ranging from 0 to 200 m.a. is a thermocouple type and it is sensitive upto 30 MHz.

Stabilized power supply:- A stabilized power supply unit has been used to supply power to the oscillator. The basic circuit of the stabilized power supply of the degenerative type is shown in Figure (2.4) and actual circuit diagram shown in Figure (2.5).

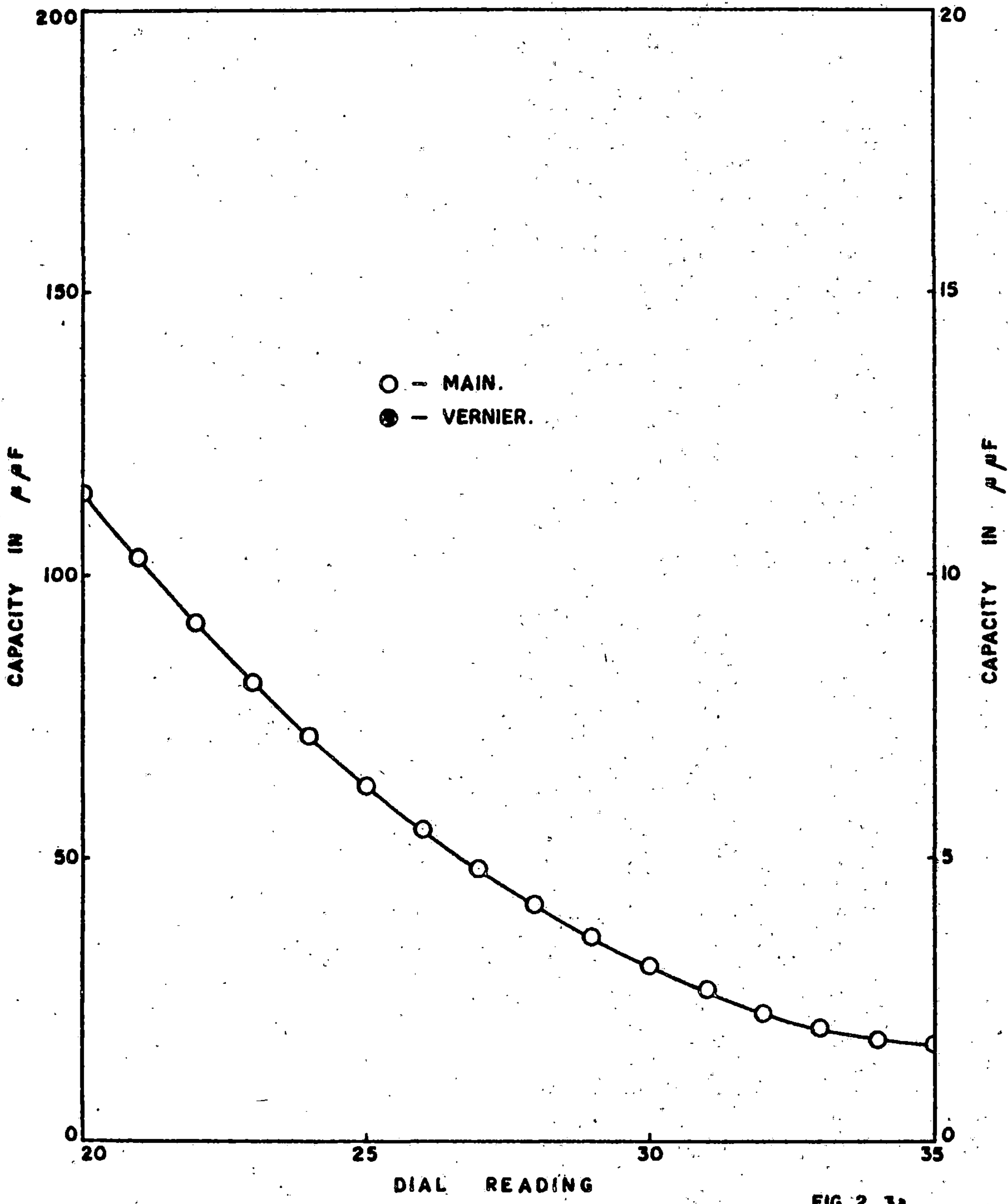

200
150
100
50
0
20
15
10
5
0
20
25
30
35
○ – MAIN.
● – VERNIER.
CAPACITY IN µµF
CAPACITY IN µµF
DIAL READING

FIG. 2. 3a.

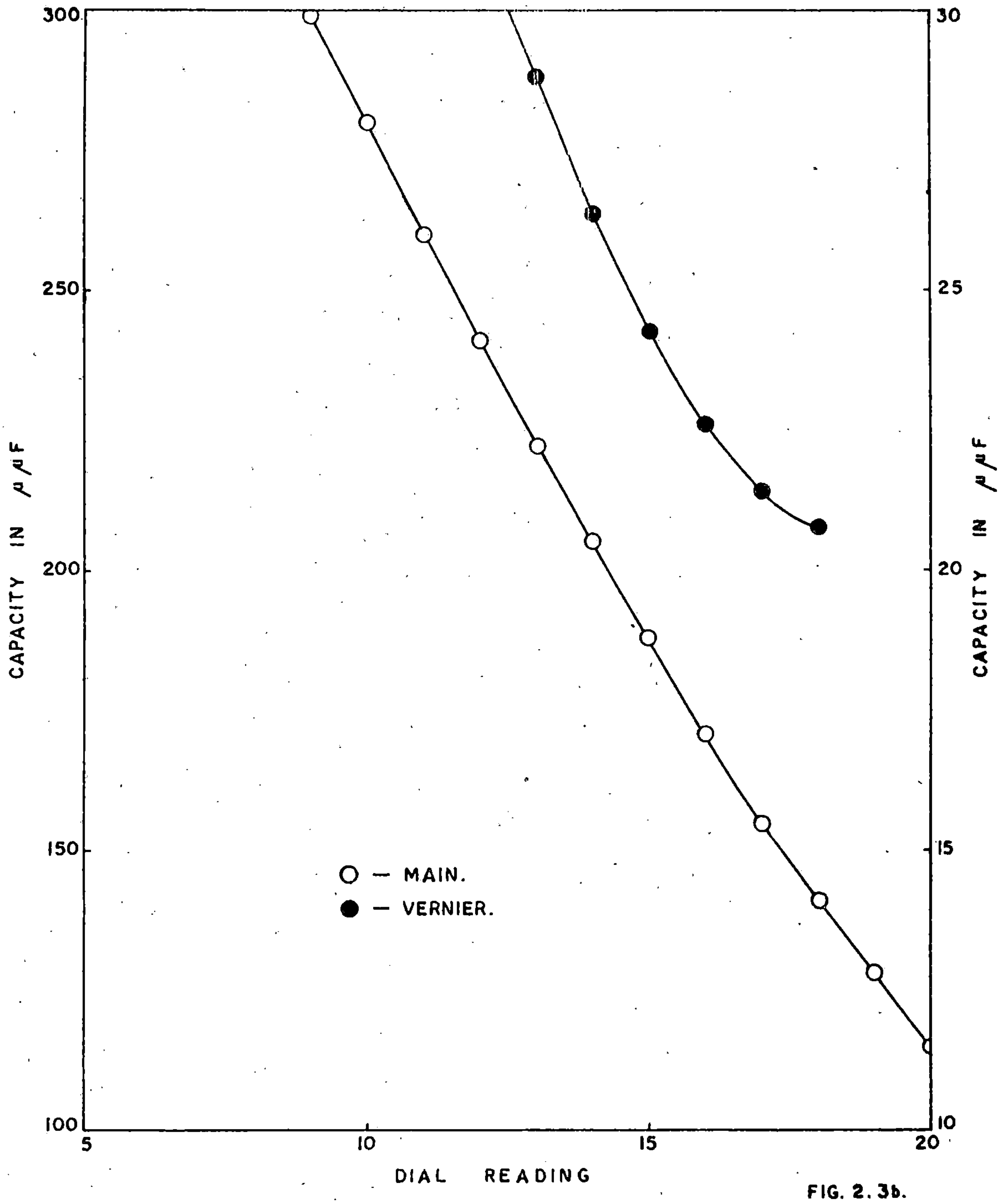

300
250
200
150
100
30
25
20
15
10
5
10
15
20
CAPACITY IN μμF
CAPACITY IN μμF
DIAL READING
○ — MAIN.
● — VERNIER.

FIG. 2.3b.

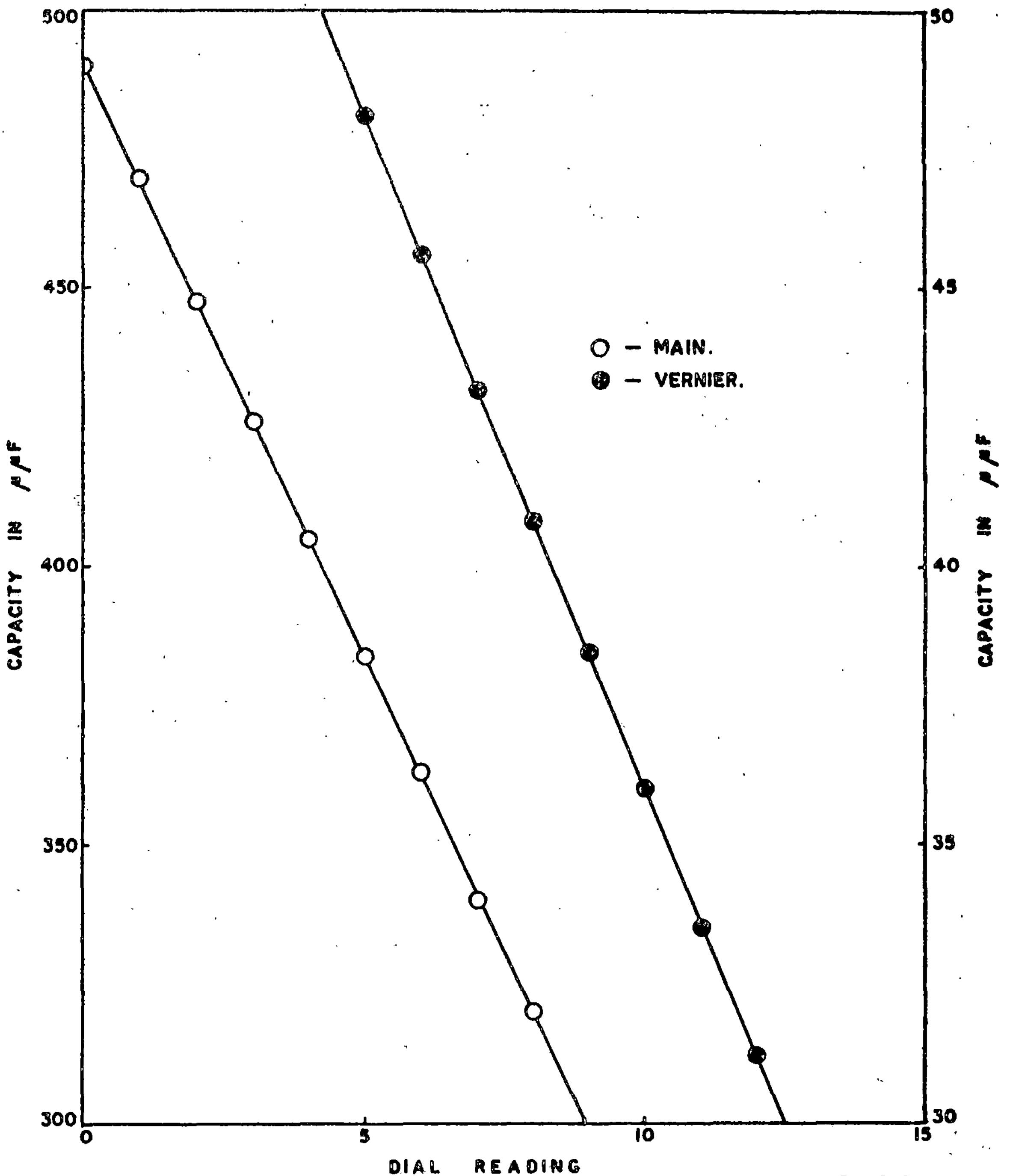

500
450
400
350
300
50
45
40
35
30
0
5
10
15
CAPACITY IN μμF
CAPACITY IN μμF
DIAL READING
○ – MAIN.
● – VERNIER.

FIG. 2.3e.

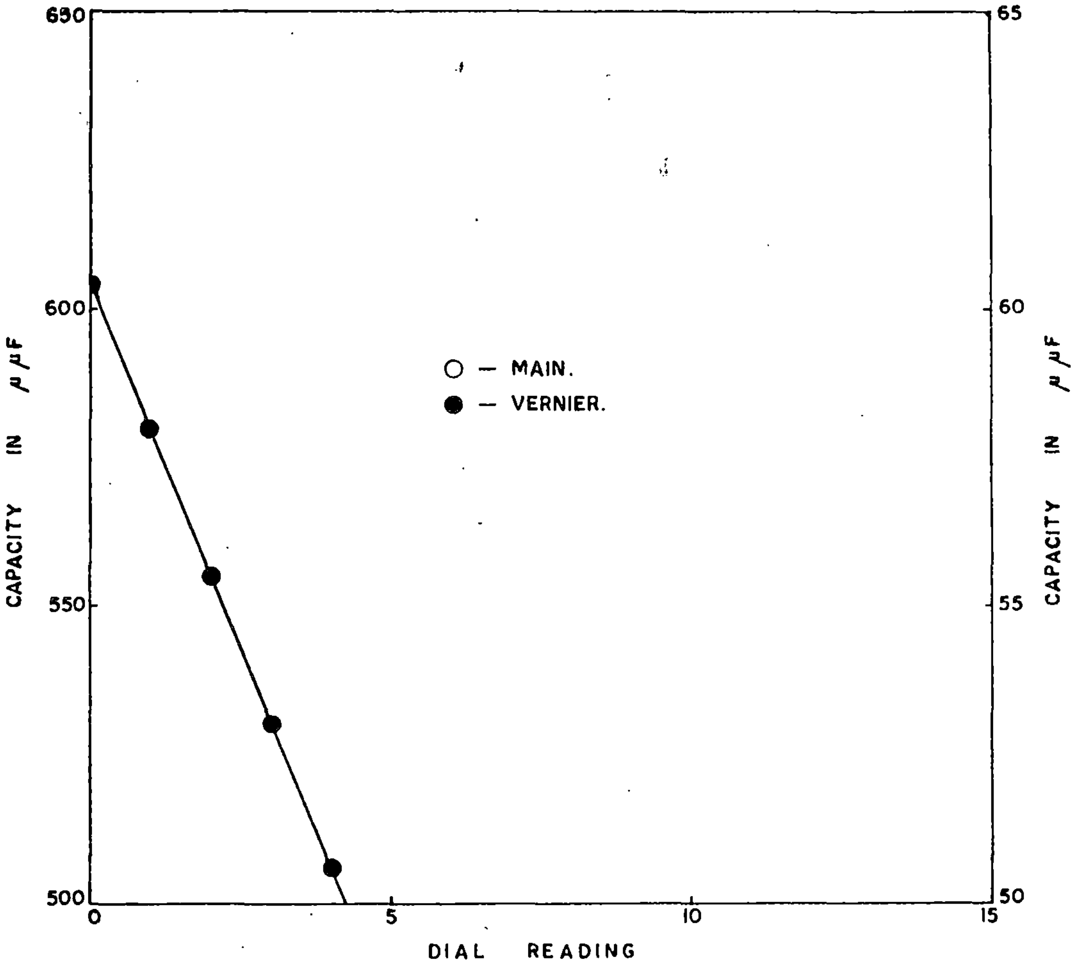

650
600
550
500
65
60
55
50
0
5
10
15
CAPACITY IN μμF
CAPACITY IN μμF
DIAL READING
○ — MAIN.
● — VERNIER.

FIG. 2. 3d.

The circuit of Figure (2.4) may be considered as conventional transformer-rectifier and filter (T.R.F.) circuit to obtain d.c. voltage from a.c. main supply. This unstabilized voltage is given to the regulator part consisting of series tube T_1 (i.e. pentode power tube) and an amplifier of gain G. A fixed reference voltage E_r (obtained from V.R. tube) and the difference amplifier of gain G is used to control T_1, so as to afford degenerative compensation for any change in circuit conditions that tend to alter the existing output voltage. The reactance of the condenser C at ripple frequency may be made small compared with resistance in shunt with it. This condenser helps the stabiliser in reducing the ripple and it is not made large for avoiding undesirable transient oscillation in the out put voltage. In order to obtain a practically ripple free out put and almost perfect regulation a two stage d.c. amplification have been introduced in the circuit. The main supply line voltage is 220 volts, 50 c/s. Single phase is connected to the primary of the transformer and regulated d.c. voltage is obtained at output of the circuit whose range is 0 to 300 v. and current 200 mA. maximum.

A circuit arrangement is made along with the stabilized power supply to get -ve bias voltage supply. The negative bias supply is taken from a separate silicon rectifier IS95 regulated by a tube OA2. The variable negative bias voltage is obtained from 0 to 100V. by means of a potentiometer providing maximum load of 5 mA. only. The ripple

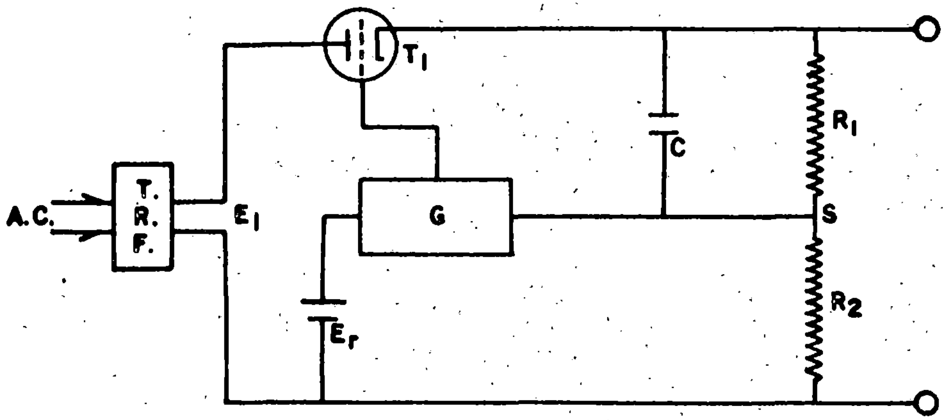


FIG. 2.4. BASIC CIRCUIT OF THE STABILIZED POWER SUPPLY OF THE DEGENERATIVE TYPE.

voltage output is less than 3 mV. in the positive supply and less than 10 mV. in the negative supply. A voltmeter calibrated from 0 to 300 volts is connected at the output terminal to read the d.c. output voltage. The practical circuit diagram of the regulated power supply unit is shown in Figure (2.5).

The components of power supply unit are given below:

1. Resistances:-

Circuit Ref.No.	Description	Circuit Ref.No.	Description
R_1	5	R_{17}	160 K
R_2	8	R_{18}	100 K
R_3	1K	R_{19}	15 K
R_4, R_5	470 K	R_{20}	68 K
R_6	10 K	R_{21}	47 K
R_7, R_8, R_9	100 K	R_{22}	470 K
R_{10}	2.2 M	R_{23}	470 K
R_{11}	5 K	R_{24}	220 K
R_{12}, R_{13}, R_{14}	10 K	R_{25}	470 K
R_{15}	1 K	R_{26}	200 K
R_{16}	15 K	R_{27}	100 K
		R_{28}	1.5 K

II. Capacitor

C_1	0.1 MFd
C_2, C_4	16 MFd
C_3, C_5	16 MFd
C_6	8 MFd
C_7, C_8	0.001 MFd
C_9	0.042 MFd
C_{10}	0.2 MFd

III. Potentiometer

P_1	10K
P_2	50 K

IV Valves

V_1, V_3, V_6	EL 86
V_2, V_4	ECC 83
V_5	OA2

V. Diodes

D_1, D_2, D_3	IS 95

VI. Switches

S_1	DPDT (ON/OFF)
S_2 (A,B)	DPDT (0-100V and (100-300V)
S_3	DPDT (Meter Selector)

VII. Transformer

TP	46 Mains Transformer

VIII. Fuses

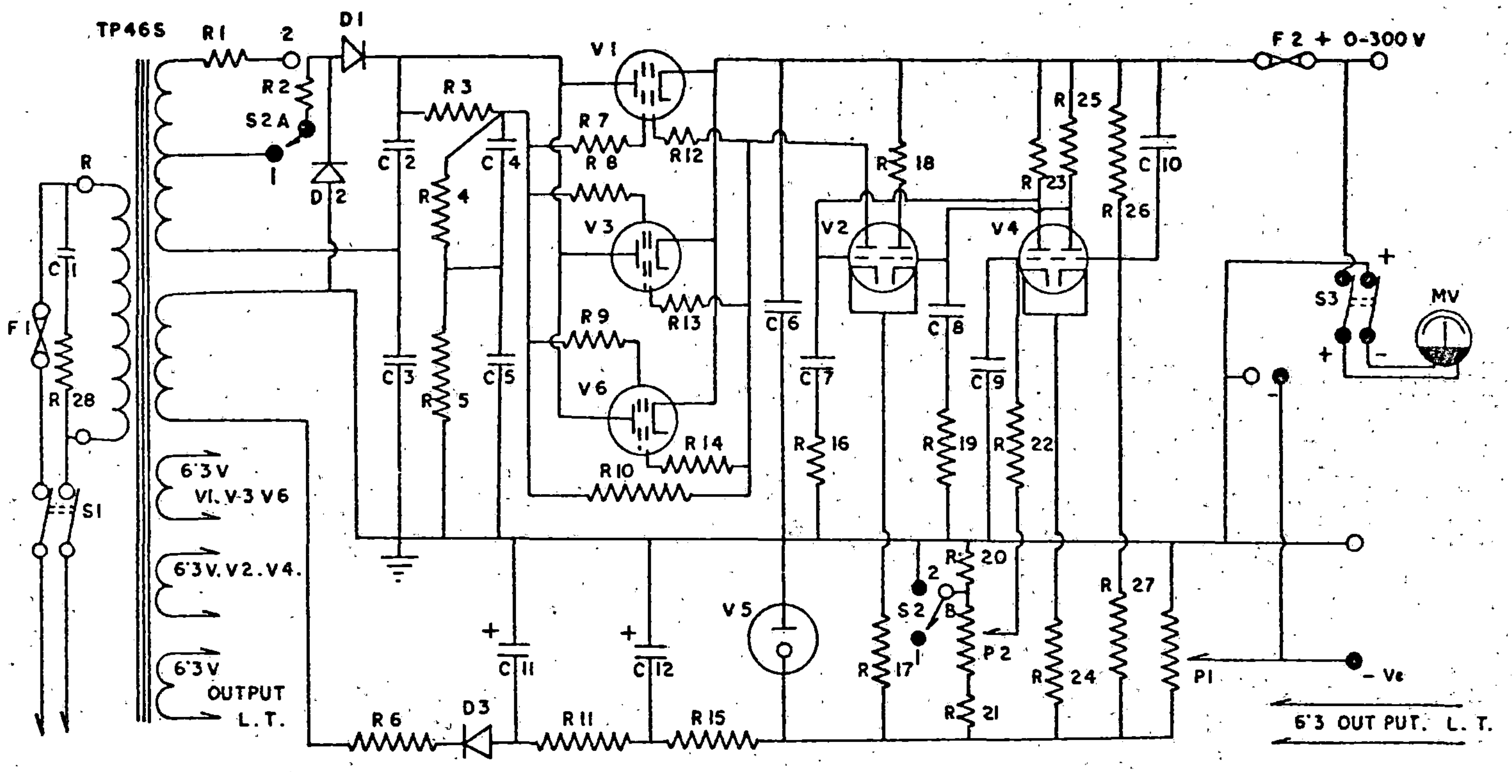
F_1	Main fuses 1 Amp.
F_2	H.T.Fuse 250 mA

IX. Meter

Voltmeter (0 - 300 V)

Thermostat: A well temperature controlled thermostat has been utilized to maintain the constant temperature as well as for the variation of temperature of the dielectric cell. The dielectric cell introduced in the thermostat can be seen from outside by a glass window situated on the front side of the thermostat. It is operated by 220 V, 50 C/s. A.C. supply and can be controlled at any desired temperature, the maximum range of which is 150°C.

Dielectric Cell: Different types of dielectric cells as shown in figure 2.6 (a) to 2.6 (c) have been used throughout the conductivity measurement of organic liquids. Mainly a pyrex glass cell which is fitted with two parallel plate circular electrodes separated by a fixed distance have been utilized. The choice of material used in designing the

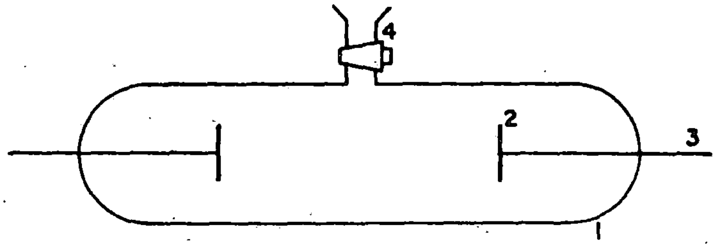


REGULATED POWER SUPPLY UNIT.

FIG- 2.5.

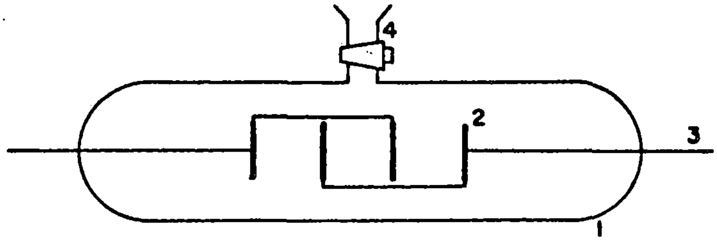
electrodes is an important factor in carrying out the experiments specially in conductivity measurement as an electrochemical reaction between electrodes and liquids may take place. The cell used during the radio frequency conductivity measurements of polar liquids as well as mixture of polar and nonpolar is a cylindrical glass tube of diameter 2.62 cm. fitted with two circular gold plates 1.08 cm. apart. (Figure 2.6 (a)). Each gold plate is connected with a platinum wire which is sealed with the glass tube whereas in d.c. conductivity measurement described in chapter VI, brass material has been used as electrodes with a gap 0.22 cm. fitted with tungsten wire in cylindrical glass tube of diameter 2.96 cm. (Figure 2.6 (c)). In order to find the effect of any electrochemical reactions between electrodes and liquid studied, the experiments have been repeated a number of times and in each case same results have been obtained. Brass electrodes have been used by many workers previously and more recently by Prabhakara Rao and Govinda Raju (1970) and Sen and Ghosh (1975).

In the other case i.e. to observe the change of dielectric constant of polar liquid in magnetic field whose experimental set up has been described in Section D of this chapter, two identical cells have been used in the measurement. Each cell consists of a cylindrical glass tube of diameter 2.75 cm. being fitted with four circular parallel electrodes made of silver. Two alternate plates are connected in parallel with a tungsten wire which is sealed with glass tube [Figure 2.6 (b)] .



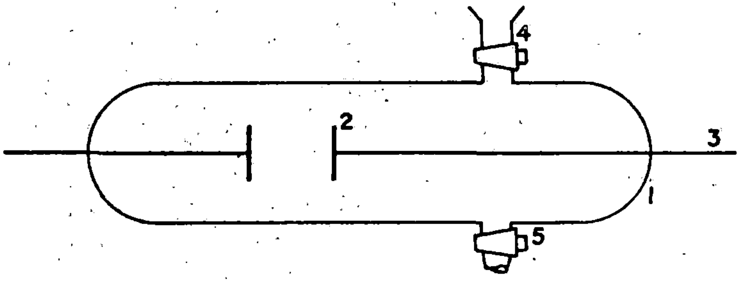
1. PYREX GLASS. 2. CIRCULAR HIGHLY POLISH GOLD ELECTRODE. 3. PLATINUM WIRE. 4. FILLING TUBE WITH GROUND GLASS STOP COCK.

FIG. 2.6(a). GOLD ELECTRODE CYLINDRICAL CELL.



1. PYREX GLASS. 2. CIRCULAR HIGHLY POLISH SILVER ELECTRODE. 3. TUNGSTEN WIRE. 4. FILLING TUBE WITH GROUND GLASS STOP COCK.

FIG. 2.6(b). SILVER ELECTRODE CYLINDRICAL CELL.



1. PYREX GLASS. 2. CIRCULAR HIGHLY POLISH BRASS ELECTRODE. 3. TUNGSTEN WIRE. 4. FILLING TUBE WITH GROUND GLASS STOP COCK. 5. OUTLET TUBE WITH GROUND GLASS STOP COCK.

FIG. 2.6(c). BRASS ELECTRODE CYLINDRICAL CELL.

Washing and Cleaning of the dielectric cell: The dielectric glass cells are thoroughly washed with chromic acid and care has been taken that no chemical reactions took place during washing particularly for brass electrode glass cell. After that cells are thoroughly washed with NaOH solution and washed several times with distilled water. To remove traces of water, the washed cells are kept inside a thermostat. The dried cells are again washed with dehydrated pure benzene and dried.

Other glass articles such as viscometer, beakers, pipet, measuring cylinder, specific gravity bottle etc. are washed and cleaned thoroughly in the same way as the dielectric cell.

Purification of liquids: The purity of liquid is a very important factor in the study of electrical conduction and breakdown in dielectric liquids. It is not possible to obtain reproducible results if the liquid is of insufficient purity and the characteristic properties of a liquid are often masked by phenomena arising due to presence of impurities. Traces of water and other electrolytic impurities are naturally the most important. The removal of these and small physical impurities such as dust particles is very important in all the purification method. In our present work, we have used the spectroscopic pure liquids of different reputed companies namely, E.Merck, British Drug House (B.D.H.) etc. All these chemicals were dried by dehydrating agents and then were distilled by fractional distillation. The proper fractions were distilled several times again under reduced pressure before use in the investigations.

Measurement of viscosity:- The coefficient of viscosity of the pure liquids and also of the solutions has been measured with the help of Ostwald type viscometer. If the time of fall of the experimental liquid and distilled water between two fixed marks in the viscometer which was placed inside the thermostat to maintain the constant temperature are t_1 and t then $\eta_1 = \eta \frac{d_1 t_1}{d.t}$ where η_1 and η are the coefficient of viscosity of the experimental liquids and water respectively and d_1 and d are their respective density at that temperature. The value of η and d of water are taken from international critical table. Thus by measuring d_1, the value of η_1 has been calculated from the observed times of fall using the above expression. The measured coefficient of viscosity in the present investigation for different polar liquids is found to be in good agreement with the respective values reported in literature .

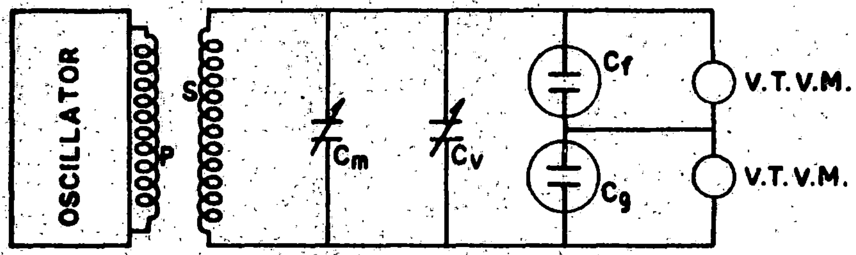
Measurement of static dielectric constant:- The static dielectric constant of liquids at a particular temperature has been measured by resonance method using the same apparatus that has been utilized to measure the r.f. conductivity of different organic liquids (figure 2.1). The observation has been carried out at a frequency of 400 KHz. At any particular temperature which is maintained by thermostat, the dielectric constant is measured by comparing the capacity of the dielectric cell with liquid as dielectric to the capacity of the cell with air as dielectric. The capacity of the empty cell has been found out from the measurement of capacity of the cell filled with some standard liquids whose dielectric constant has been given in the literature. It is observed that the values of static dielectric constant so obtained agrees well with those given in standard literature.

D. THEORY OF MEASUREMENT OF ϵ/ϵ_H

The block diagram of the experimental arrangement of measuring ϵ/ϵ_H where ϵ and ϵ_H are the dielectric constant of polar liquid in absence and presence of magnetic field respectively, can be represented by a simple network shown in figure (2.7).

The method used in the present study is almost similar to that utilized in measuring the dielectric constant of liquids by resonance method. Only the difference lies in the present circuit, is that instead of using a single dielectric cell, two dielectric cells C_f and C_g have been used and the detectors used are two valve tube voltmeters which are connected in parallel to the cells C_f and C_g as shown in figure (2.7). C_m and C_v are the main and vernier condensers. The detailed description of the cells [figure 2.6 (b)] have been described in Section C of this chapter. The experiment has been performed at a frequency of 800 KHz. and at a temperature of 30°C.

During the experiment the cell C_g is placed in the magnetic field whereas the cell C_f is placed outside the magnetic field. Both the cells are filled with experimental liquids. Keeping the oscillator adjusted at the desired frequency, resonance is obtained by adjusting the capacitance of the secondary tuning circuit until the voltage developed



P – PRIMARY COIL. S – SECONDARY COIL.

C_m – MAIN CONDENSER. C_v – VERNIER CONDENSER.

C_f & C_g – DIELECTRIC CELL. V.T.V.M. – VALVE TUBE VOLTMETER.

FIG. 2.7. BLOCK DIAGRAM FOR MEASUREMENT OF ϵ/ϵ_H

at the V.T.V.M. in the secondary tuning circuit reaches the maximum. Let at any particular value of C_m and C_v (say at resonance) the voltage developed at C_f and C_g are V_1 and V_2 respectively. If I_1 be the current flowing through the secondary circuit at this condition then we have

$$I_1 \times \frac{1}{\omega C_1} = V_1$$

and

$$I_2 \times \frac{1}{\omega C_2} = V_2$$

where C_1 and C_2 are the capacitance of the cell C_f and C_g respectively when filled with experimental liquids. Hence

$$\frac{C_2}{C_1} = \frac{V_1}{V_2}$$

$$\frac{C_2/C}{C_1/C} = \frac{V_1}{V_2}$$

$$\epsilon = \frac{V_1}{V_2} \cdot C_1/C \qquad \ldots (2.13)$$

where ϵ is the dielectric constant of the liquid and C is the capacitance of the empty cell.

When the magnetic field is applied only to the cell C_g let the voltage developed are V_1' and V_2' across the two cells. Since only the capacitance in the cell C_g changes, let I_2 be the current flowing in the secondary circuit. Then in the similar way we have

$$I_2 \times \frac{1}{\omega C_1} = V_1'$$

$$I_2 \times \frac{1}{\omega C_2'} = V_2'$$

which gives

$$\frac{C_2'}{C_1} = \frac{V_1'}{V_2'}$$

$$\epsilon_H = \frac{V_1'}{V_2'} \cdot \frac{C_1}{C} \qquad \ldots (2.14)$$

where ϵ_H is the dielectric constant of the liquid in presence of magnetic field.

From equations (2.13) and (2.14)

$$\frac{\epsilon}{\epsilon_H} = \frac{V_1}{V_2} \cdot \frac{V_2'}{V_1'} \qquad \ldots (2.15)$$

Thus by observing only the voltages before and after application of the magnetic field, one can find directly the value of ϵ/ϵ_H.

<u>Advantages of the Procedure:</u> The procedure described above though does not give the absolute value of the change of dielectric constant of polar liquid in presence of magnetic field but it can be easily determined from equation (2.15) as ϵ value of pure liquid can be obtained from any standard literature. Only the voltage measured before and after application of the magnetic field is sufficient for the purpose which is the speciality of the procedure that has been adopted

here. Secondly it is well known that to measure the static dielectric constant by resonance method, it is required to calibrate accurately the capacitor of the secondary tuning circuit. But the method described here indicates that the calibration of the secondary tuning capacitor is not a primary factor, the experiment can be performed at any convenient position of the secondary tuning condenser.

E. APPARATUS USED FOR THE MEASUREMENT OF $\frac{\epsilon}{\epsilon_H}$

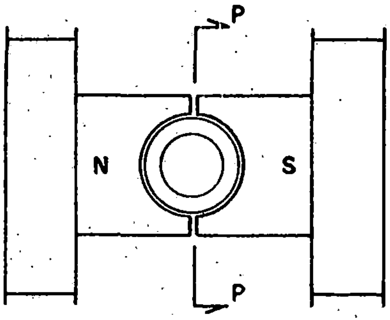
The apparatus used in this experiment are almost the same as that used in radio frequency conductivity measurement of dielectric liquids except V.T.V.M. and electromagnet. The dielectric cells, R.F. oscillator, secondary tuning circuit, stabilised power supply etc. are all described in Section C of this chapter. The description of the V.T.V.M. and an electromagnet are given below.

<u>V.T.V.M.</u> The two V.T.V.M. used as detectors are the vacuum tube voltmeter of Marconic Instruments Ltd. Model No. TF 1041C.

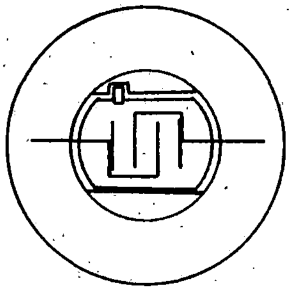
<u>Electromagnet:</u> A large electromagnet (coil diameter 27.5 cm, resistance - 16 ohms per coil, number of turns - 800 per coil, distance adjustable of pole pieces - 7 cms.) has been used during the experiment. As it is evident from the theory that the effect of magnetic field on the change of dielectric constant is enhanced if the liquid is subjected to a magnetic field from all sides and in fact the effect is solely dependent

upon the ability of the applied magnetic field to compress the liquid. A simple configuration of the magnetic field such as either transverse or longitudinal magnetic field cannot produce the desired effect. Unless the liquid is compressed from all sides the effect would be negligible and hence a special design of the magnetic pole pieces has been made in order to obtain radial magnetic field.

Originally the pole pieces made of soft iron was cylindrical in nature and of diameter 8.3 cm. From each flat surface of the circular pole pieces, a portion of the material is cut-off in such a way that a cylindrical cavity of diameter 2.85 cm. is formed if the pole pieces are joined together along the axis which is radially perpendicular to the magnetic field. During the experiment the cell C_g is introduced totally inside the cylindrical cavity and the gap between the two middle points of the curvature is 3.0 cm. The remaining flat surface of the pole pieces was covered with thin mica sheet. This particular geometry of design produces a magnetic field which can compress the liquid from all sides. The sectional view of such a magnetic field arrangement is shown in figure (2.8). The field inside the cavity has been measured by a flux meter and is found to have maximum value at the centre of the cavity and gradually diminishes outwards. The main point is to compress the liquid from all sides and hence a slight deviation from uniform field has been tolerated. Thus an average value of magnetic field has been used during the calculation. The magnetic field for different currents



SIDE ELEVATION.



CROSS SEC. ON 'PP'

FIG. 2.8. SECTIONAL VIEW OF THE MAGNETIC FIELD ARRANGEMENT.

has been measured by a Gauss meter, Hall probe type, model No. GM 867 supplied by E.C.I.L., Hyderabad. A calibration curve drawn of the magnetic field against current in the coil of the electromagnet is shown in figure (2.9), keeping the pole pieces as it is after taking away the cell from cylindrical cavity of the pole pieces.

Calibration of electromagnet.

Table 2.3

Current in ampere through the coil of the magnet.	Average value of magnetic field in Gauss.
2	1500
3	2050
4	2550
5	3050
6.1	3450

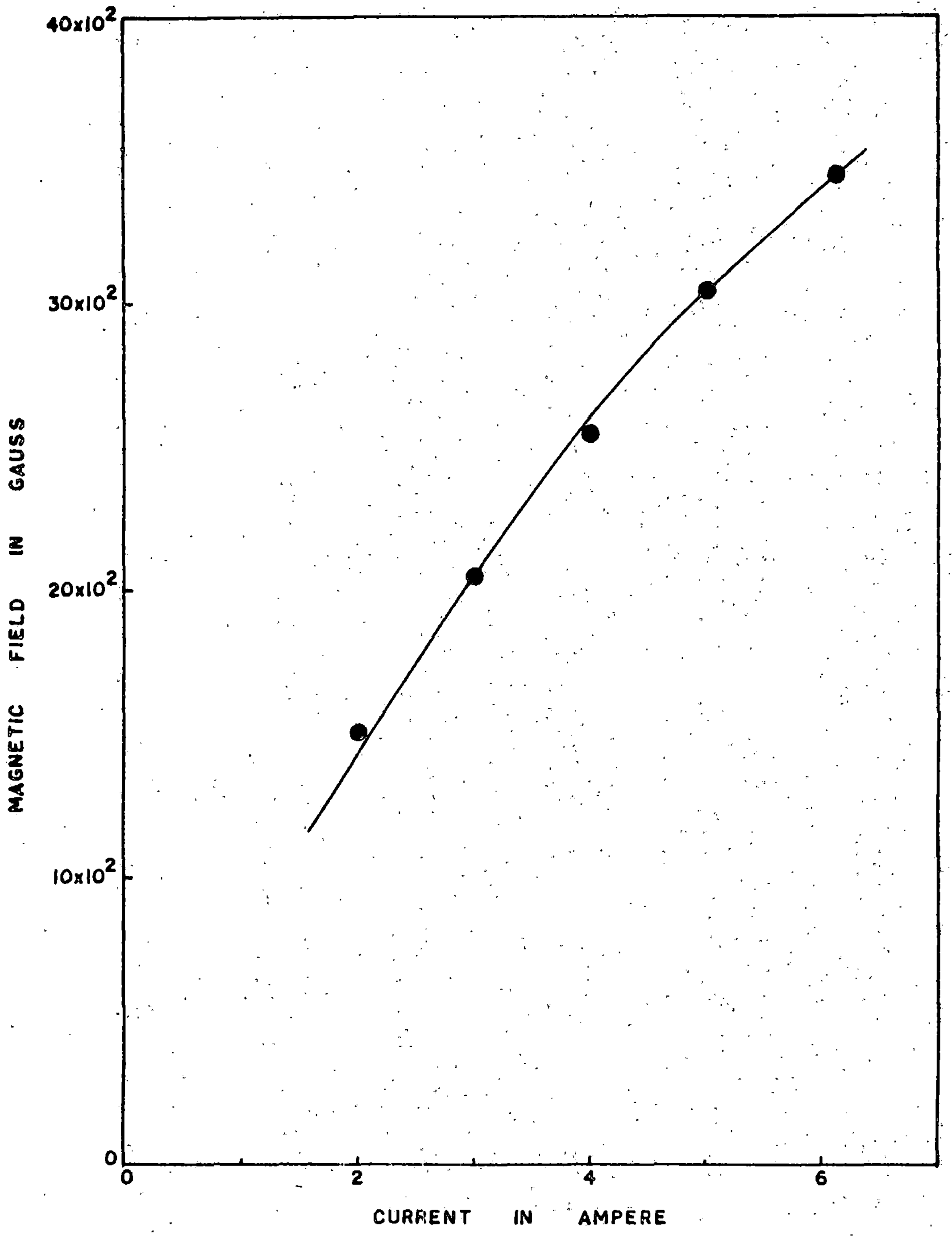


FIG. 2.9. CALIBRATION OF MAGNETIC FIELD.

REFERENCES

Daniels, F., Mathews, J.H., Bender, P. and Alberty, R.A. (1956), Experimental Physical Chemistry (McGraw Hill Book Co., Inc., New York).

Prabhakara Rao, P. and Govinda Raju, G.R. (1970), J. Phys. D. (Appl. Phys.) 3, 341.

Sen, S. N. and Ghosh, R. (1975), J. Phys. Soc. Japan, 38, 1445.

Smyth, C.P. (1955), Dielectric Behaviour and Structure (McGraw Hill Book Co., Inc., New York).

Timmermans, J. (1950), Physico-Chemical Constant of Pure Organic Compounds (Elesevier Publishing Co., Inc., New York).