CHAPTER VIII

PERSISTENCE TIMES IN AFTERGLOWS IN MERCURY ARC MAINTAINED BY r.f. FIELD IN PRESENCE OF MAGNETIC FIELD.

8.1. Introduction

Study of the afterglow process in decaying plasma and the measurements of the coefficient of recombination have been carried out by a large number of investigators. The study has provided us with information regarding the various processes of electron ion dissociative and radiative recombination and their relative importance in a decaying plasma. The afterglow we are considering here is of a different type than that investigated hitherto in the sense that whereas in a normal afterglow the decaying time is of the order of a microsecond or less, in our experiments the glow was allowed to exist for a few tens of seconds by applying a radiofrequency field which provided additional ionization and allowed the plasma to decay at a much slower rate. The object is to study the ionization and loss mechanism in a decaying plasma.

Since the ionization and loss mechanism processes are functions of an externally applied magnetic field, it was thought worthwhile to study the persistence time of an afterglow in presence of a magnetic field. The perturbation

in the deionization processes that will occur due to the presence of magnetic field is expected to help us in identifying the main operating factors. Hence in the present investigation, the variation of persistence time of a decaying afterglow plasma in mercury vapour has been investigated in presence of a radio frequency field both in the presence and in absence of external magnetic field.

8.2. Experimental arrangements

Investigation has been carried out in a mercury afterglow (admixed with dry air) in a cylindrical discharge vessel. As we are more interested to study the behaviour of a recombining plasma with and without a magnetic field, the effect due to diffusion transport of charge carriers is to be lessened. Since the characteristic time of disappearance of charges by diffusion, varies with the square of the diffusion length, a better study of particle recombination can be achieved by taking a discharge vessel of large diameter. Hence a discharge vessel of diameter 3.6 cm. and 9 cm. long was placed in between the pole-pieces of an k electromagnet.

An outline of the discharge vessel fitted with a simple mercury trap through a standard joint is shown in Fig. (2.1). A d.c. mercury arc was generated inside the discharge tube. To increase the pressure inside the

discharge tube so that diffusion of charged particles which is definitely ambipolar in nature, can further be diminished, dry air which acts as a buffer gas influencing only the diffusion and mobilities of the charges, was introduced by a variable microleak of a needle valve. Two aluminium couplers, clamped in the middle of the discharge tube from outside, was connected to a Hartley oscillator to supply the radio frequency voltage. The couplers were seperated, by 2.35 cm. The level of the r.f. power supplied by the oscillator was low enough so as not to cause a breakdown of the gas.

The arc discharge was run for a few minutes so that a steady condition was reached and the outside wall temperature was noted. Then the primary arc discharge was switched off. A glow which developed in wake of switching off persisted for a few seconds and then disappeared. Time of persistence of the glow was recorded by two stop watches. When there was no r.f. power to the coupler, no glow was visible after the switching off of the parent discharge. The glow time was measured under different conditions of the discharge e.g. pressure, current of the parent arc discharge, outer wall temperature and with and without an axial magnetic field.

8.3. A description of the decay of visual intensity during the afterglow

The time variation of the total visual intensity has been shown in Fig. 8.1. When the d.c. arc was swtiched off, a greenish white glow existed throughout whole of the discharge vessel as shown in Fig. 8.1 A. Thereafter, the glow in the furthest regions from the coupler vanished first and this process of gradual disappearance of glow continued for a few seconds. Ultimately the glow survived only in between the couplers where the r.f. field existed as shown in Fig. 8.1D. In between the couplers, the glow shape was first an ellipsoid, then a sphere and lastly a spheroid. The colour of this glow, in between the couplers, was a bluish white and after an interval of a few seconds it also vanished.

It was observed that the persistence times of the glows in the field free region (outside the couplers) and in the region with an applied r.f. field (in between the couplers) vary in different ways with other parameters of the discharge. This led us to divide the total period of persistence of the glow in two parts. The first part is the persistence time type 1 which is the measure of period starting from switching off of parent arc discharge to the moment when the glow was confined only in between the couplers. Thus in this period the glow in the field free

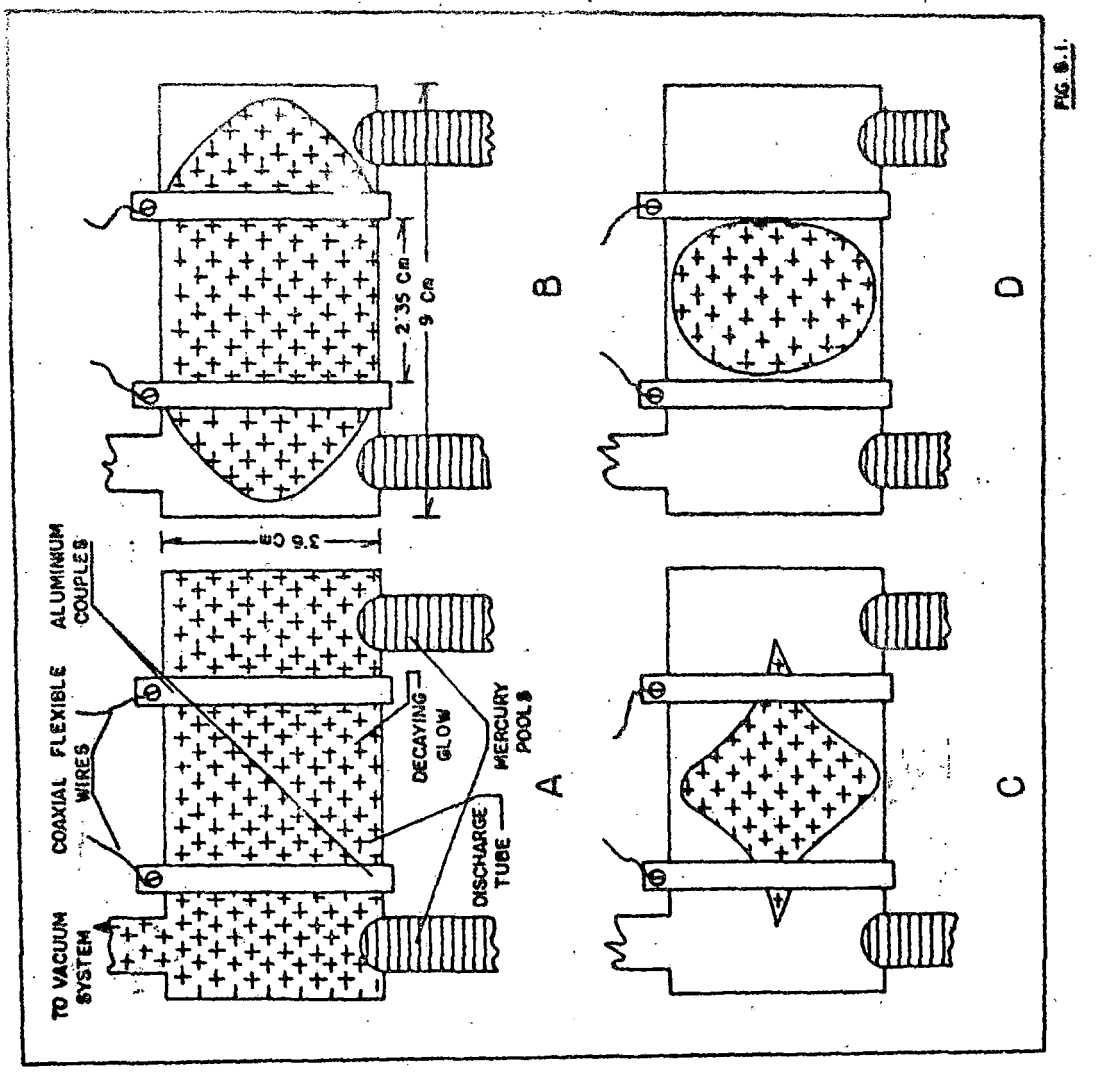

Fig. 8.1. Decay of mercury afterglow maintained by r.f. field: At the beginning the afterglow filled the total discharge tube (A) then the glow at the furthest points from the couplers disappeared gradually (B and C) and lastly the glow survived only in between the couplers (d) for a while and then disappeared completely.

region, outside the couplers, slowly diminishes in size and ultimately gives away to the glow surviving ℓ in between the aluminium couplers. The next part, persistence time type 2 is the record for persistence of glow in between the couplers only. As soon as persistence time 1 was over, recording of persistence time 2 begins until the glow disappears totally.

As these two types of persistence times vary differently with discharge conditions, it may be concluded that different mechanisms are responsible for their survival and extinction.

It may be noted that persistence of the glows was observed visually and times were recorded by two stopwatches. The demarkation between the two types is not a sharp one, rather the transformation is gradual. As such, an error of $\pm$ 1 to 2 seconds in recording times could not be avoided. Nevertheless, the persistence times for glow are in the order of tens of seconds, so this possible error in the recordings of times is expected to cause not much appreciable error. In this investigation, we have, however, recorded the persistence times only. Generally for fuller information of an afterglow, densities of different particles are measured as a function of time. A plot of them is analysed with rate or continuity equations of particles and with a knowledge of electron temperature relaxation, different macroscopic co-efficients for

the particles are measured. Simply a knowledge of persistence time, can not give a clear picture of the decay rates of particles. Lastly, the disappearance or occurence of a discharge was inferred by visually observing the glow. So when the glow vanished, we considered that the afterglow ceased to exist. But the decay rate of charged particles may be different from the decay rate of excited atoms which are responsible for creating the visual picture of the glow. Generally it is believed that, during the decay, production of new charged particles ceases, and concentrations of charged particles then decreases by different loss mechanisms like recombination, ambipolar diffusion etc., approaching a finite but small value. However, for an analysis of experimental data we have correlated the visual glow with the plasma since the radiation is definitely an electron - atom process (either it is a recombination radiation or a electron excitation radiation). Hence, due to this limitation no attempt has been made to put forward a quantitative analysis of the experimental results.

8.4. Results and Discussions

8.4.1. Without a magnetic field

(a) Variation of persistence time 1 with pressure

Two types of glow persistence times e.g. persistence time 1 and persistence time 2 are found to

vary with conditions of the discharge differently. Fig. 8.2 shows a plot of persistence time 1 Vs $1/p_{tot}$. Here p_{tot} is the total pressure inside the discharge tube i.e. $p_{tot} = p_{air} + p_{Hg}$. It can be seen that when p_{tot} is comparatively large ($p_{tot} > 0.5$ torr), persistence time 1 is directly proportional to $1/p_{tot}$. In the field free region, when the arc current is off, the electrons of the parent discharge will be lost by ambipolar diffusion, attachment and by dissociative recombination. It is, however, assumed that the r.f. field produces ionization in between the couplers and due to the diffusion of charged and other particles from the source region (region with an r.f. field in between the aluminium couplers), the loss processes in the field free region will be delayed, thus making the glow in field free region to continue for a longer time. After being created in the source region, the charged particles will diffuse away through the couplers, hence the diffusive gain term will be proportional to $1/p_{tot}$.

For attachment loss, three processes may be considered,

$$e + Hg + Hg \longrightarrow Hg^- + Hg \qquad (8.1)$$

$$e + O_2 \rightarrow O^- + O \qquad (8.2)$$

and

$$e + O_2 + X \longrightarrow O_2^- + X \qquad (8.3)$$

For first of the processes (8.1) the reaction rate will be proportional to n^2_{Hg} i.e. p_{Hg}^2. But as

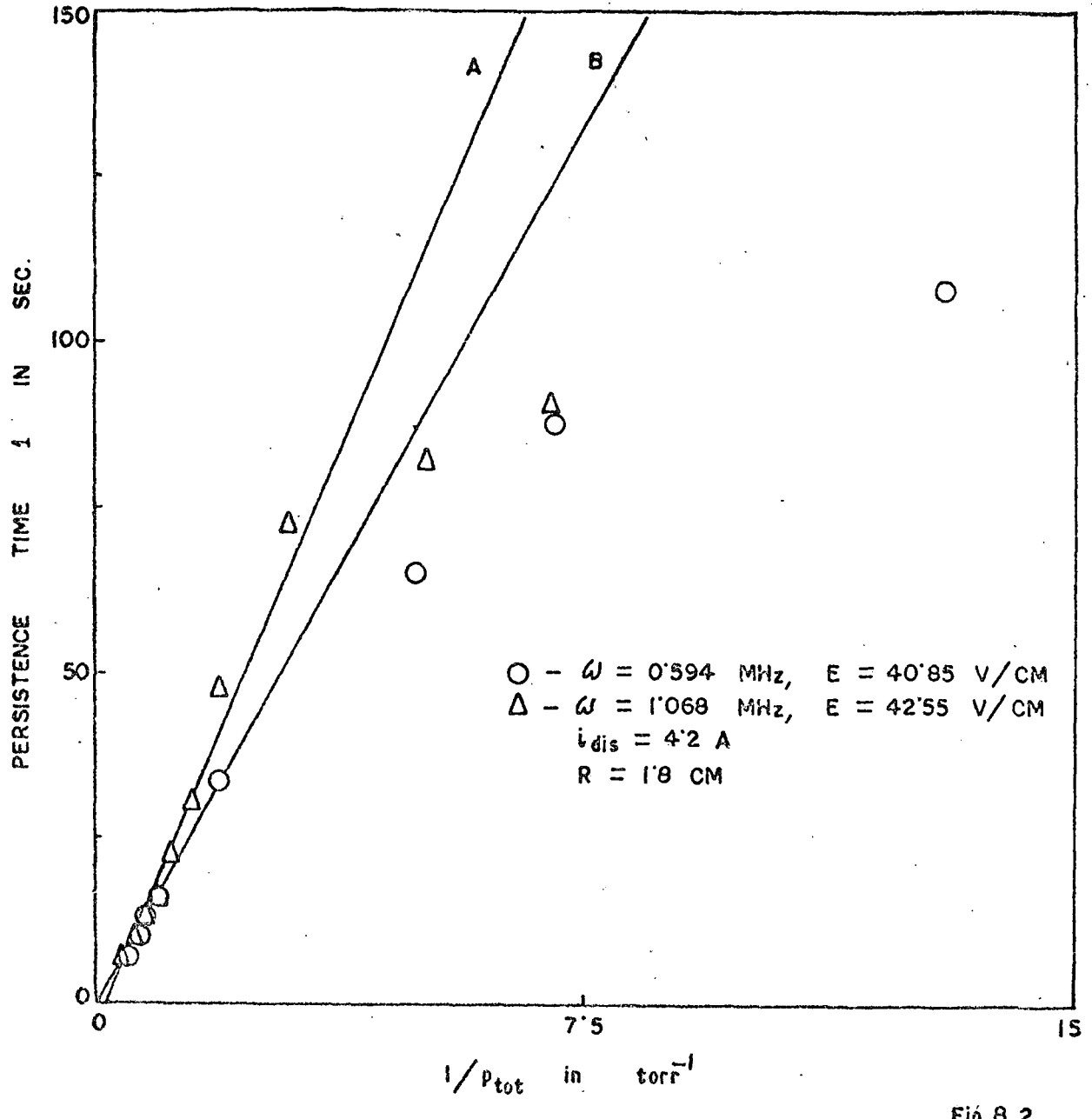

Fig. 8.2.

Fig. 8.2. Variation of persistence time 1 with inverse of total pressure.

oxygen, an electromagnetive gas, is present in abundance when $p_{air} > p_{Hg}$ (when $p_{tot} > 0.5$ torr), we can disregard the process. The dissociative attachement process (8.2) is generally believed to be of importance when T_e is comparatively high. Hence where T_e (as is the case in a decaying discharge) is comparatively small, this process will be of lesser importance. The threebody attachment process (8.3) is proportional to p_{air}^2 . X is a stabilising molecule, both O_2 and N_2 molecules can take part in the process of stabilisation. Where attachment of electron is a dominating loss mechanism, it is observed that negative ions generally accumulate in the volume. They tend to remain in the body of the afterglow owing to the disposition of electric field which builds up. This accumulation of -ve ions which should be proportional to time, influences the electron ambipolar diffusion coefficient D_{ae}. Truby (1968) has shown that

$$D_{ae} = D_{a+}\left(1 + \frac{n_-}{n_e}\right) \qquad (8.4)$$

here D_{a+} is the ambipolar diffusion coefficient for positive ions and n_- is the number density of negative ions. Thus, D_{ae} increases as n_- increases for a constant value of D_{a+} throughout the electron decay process. In this way attachment loss can be interpreted as an enhanced f diffusion process.

The last of the loss processes is the recombination process. For mercury it is a dissociative recombination and the dissociative recombination being a two body process is independent of p_{air}.

In the comparatively high pressure region, the straight line (passing through the origin) plot of persistence time 1 with $1/p_{tot}$ suggests that the gain of particles by a diffusive flow from the source is balanced by recombination which is pressure independent. The breakdown from linearity in the low pressure region, may be interpreted in terms of other pressure dependent loss mechanisms like ambipolar diffusion. It is evident from Fig. 8.1 that at the further point from the source the glow in field free region begins to disappear first, then this process is conducted away towards the source. The way, glow in field free region diminishes, suggests that loss processes is a volume phenomenon.

(b) Variation of persistence time 1 with r.f. field strength.

In Fig. (8.2) the dependence of persistence time on r.f. field strength may be observed. The persistence time 1 increases with the r.f. field which was applied to the source. This dependence is also evident in Fig. (8.3) where corresponding to p_{air} = 1 torr, persistence time 1 is plotted against r.f. field applied to the source. Thus it may be

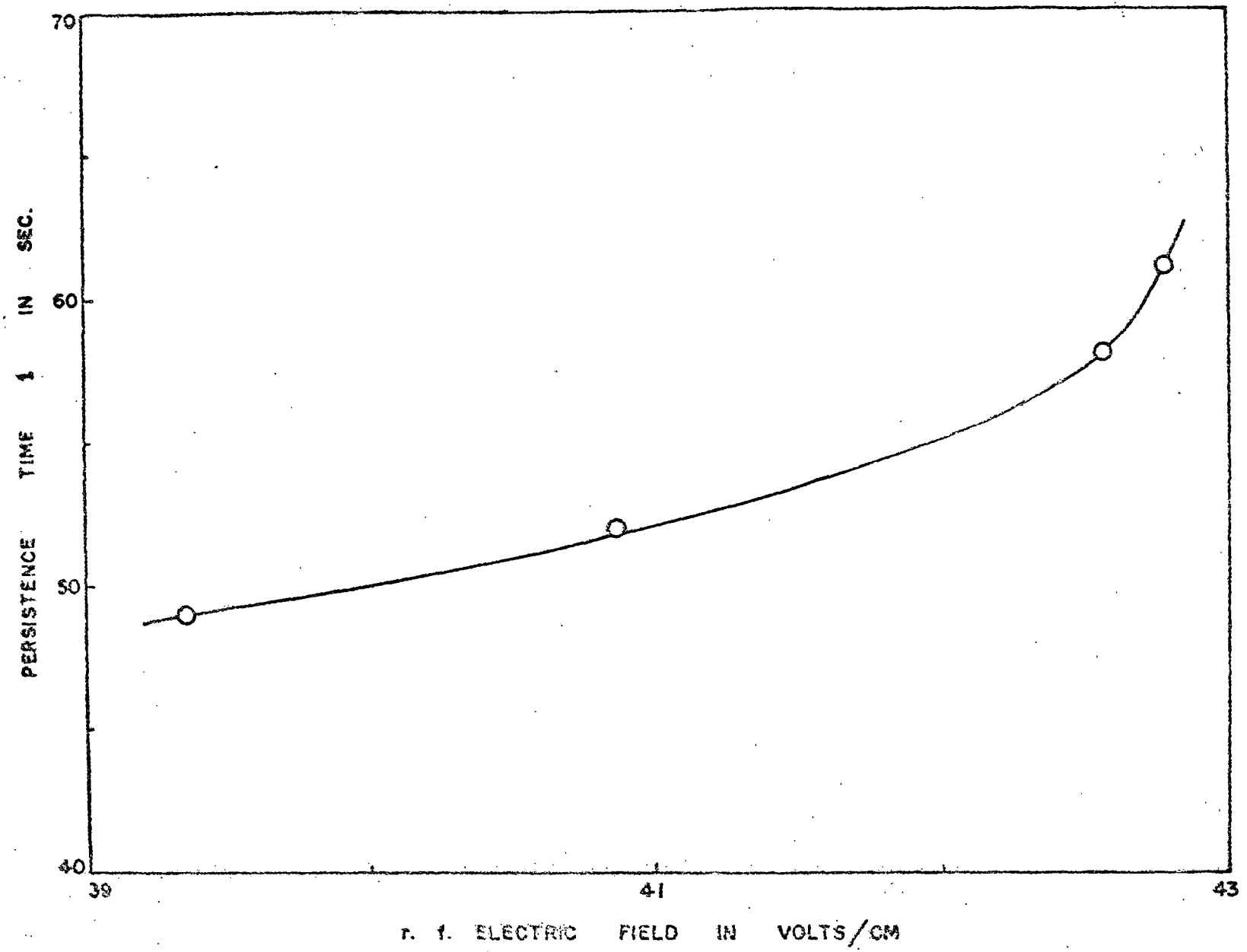

FIG. 8.3.

Fig. 8.3. Variation of persistence time 1 with r.f. electric field supplied to the couplers (p_{air} = 1 torr, i = 2.4 A).

assumed that electrons and ions that diffuse out axially from the source also carry their energies which should be proportional to E/p_{tot}, where E is the r.f. field in the source. As these electrons further diffuse axially in the field free region, they loose much of their energies in elastic collision with air molecules. Some of them, the high energetic ones, loose energies in inelastic collision like collisional excitation of mercury atoms and vibrational excitation of nitrogen and oxygen molecules. They may also gain some energy in collisions of second kind. The relaxation time of T_e should be directly proportional to p_{tot}. Thus at the furthest point of the source electrons may be considered to be nearly thermalised, making recombination high and the glow disappears. It may also be noted that as time elapses, gas temperature also decreases as heat is radiated to the surroundings by the discharge vessel. This reduction of gas temperature will be effective in an enhanced recombination of charged particles. For the reduction of gas temperature, the number density of mercury atoms n_{Hg} will also be effectively reduced. So there exists a gradient of T_e in the field free region along the axis of discharge tube.

(c) Variation of persistence time 2 with pressure

The persistence time 2 varies with pressure in a different way. This variation has been shown in Fig. (8.4). It is observed that persistence time 2 first increases with pressure. In a certain interval of pressure, the glow in between the couplers, giving rise to persistance time 2, never diminishes so long r.f. power is supplied. Thereafter, persistence time 2 decreases as pressure increases.

When the primary arc is switched off, n_e is in the range of 10^{13} cm^{-3} corresponding to the arc. As time passes on, n_e decays. When n_e equals a critical value n_{cr} a glow is sustained in between the couplers. In this region electrons are heated by the r.f. field. During this period, visible mercury lines (only mercury lines were observable) was observed through a constant deviation spectrograph. The line intensities increased markedly with the increase of r.f. electric field. It appeared that the glow intensity (type 2) did not diminish with time slowly, on the otherhand it remained fairly constant and at a certain moment very rapidly became zero and the glow disappeared. The only factor that changes during this period is the neutral particle temperature T_g or outerwall temperature T_w, owing to the radiative cooling of the discharge vessel. So a cooling down of discharge vessel effectively influences the production and loss processes of this sustained glow. Owing to the decrease of T_w when

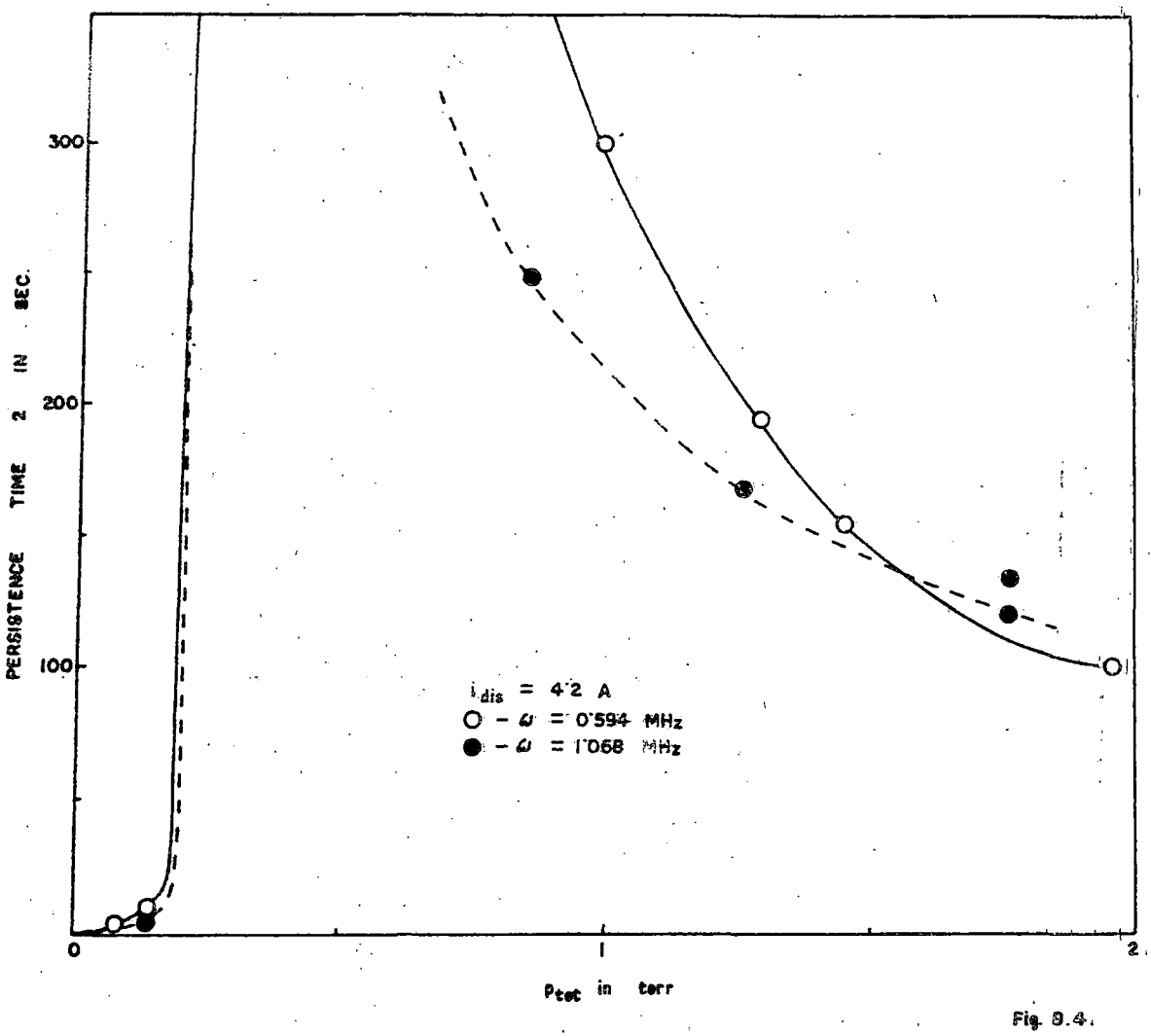

Fig. 8.4.

Fig. 8.4. Variation of persistence time 2 with pressure inside the discharge tube.

the gain and loss processes can not balance each other, the glow vanishes. The processes in this glow are very complex. As T_w drops, p_{Hg} hence p_{tot} also is reduced. This will make ν_m the collision frequency of electrons for momentum transfer to change with time. Since E_e, the effective field that will produce the same energy transfer as a steady field, is given by

$$E_e^2 = E^2 / \left(1 + \frac{\omega^2}{\nu_m^2}\right) \qquad (8.5)$$

where E and ω are the r.m.s. r.f. field and angular frequency of r.f. source. E_e decreases with time and so the power absorbed from the r.f. field will decrease. It is well known that for an r.f. discharge ionisation rate is a very strong function of electric field, a substantial change in ν_i can be caused by a tiny change in E_e. Thus at a time when production terms can not supplement for the losses, the r.f. glow in between the coupler vanishes.

It was observed that as p_{air} (hence p_{tot}) increases, the outerwall temperature corresponding to ceasing of persistence time 2 ~~ix~~ first decrease and then increases. The cases of subsistance of glow so long r.f. power is supplied in some pressure interval may be interpreted by considering that the temperature at which

these glows will disappear are definitely below room temperature. As p_{tot} increases, E_e/p increases which will make ν_i/p to increase. For this glow where T_e is comparatively high, radial ambipolar diffusion loss will be most dominating loss mechanism. $D_a = kT_e / M\nu_{in}$ where M is the mass of heavy particles and ν_{in} is ion-neutral collision frequency, also decreases with pressure. But at comparatively high pressure, owing to increased energy loss of electron in elastic (also rotational and vibrational excitation) collisions, ionisation rate will be decreased. The pressure dependence of T_W (hence, the particle generation and loss processes) may best be interpreted by considering the a.c. ionisation coefficient defined by Brown Rox (1959). When loss is by diffusion, a.c. ionisation coefficient $\xi = \nu_i / D_a E^2$ first increases rapidly, then after passing through a maxima decreases as E/p increases.

Since rate of cooling, determining T_W, has significant effect on the discharge, care was taken in the recordings of persistence time 1 and 2 that the discharge tube may cool down in the same surrounding.

(d) Dependence of persistence times with varying arc currents

Dependence of persistence times with current of the primary arc discharge was observed in two different ways.

First the primary arc was allowed to burn for different currents for different time interval so that T_w at the moment of swiching off of primary arc, remained same. In this way the heating effect of the current may be disregarded and only the dependence of persistence times with n_e of primary arc may be observed. Results have been shown in Table 8.1. Secondly, the primary arc was burned for a fixed time interval of 4 minutes with different current. In this way T_w during swhiching off varied as well as n_e . In Table 8.1, it is seen that persistence time 1, probably depends on n_e but persistence time 2 does not. But considering the range of accuracy of measurement nothing specific may be concluded upon.

When primary arc was burned for fixed interval of 4 minutes so that T_w at switching off varied persistence time 1 is seen to vary linearly with current (Fig. 8.5). In this fig. variation of T_w with current has also been shown. It appears that proportionality constants for variation of persistence time 1 and T_w at swiching off with current are the same.

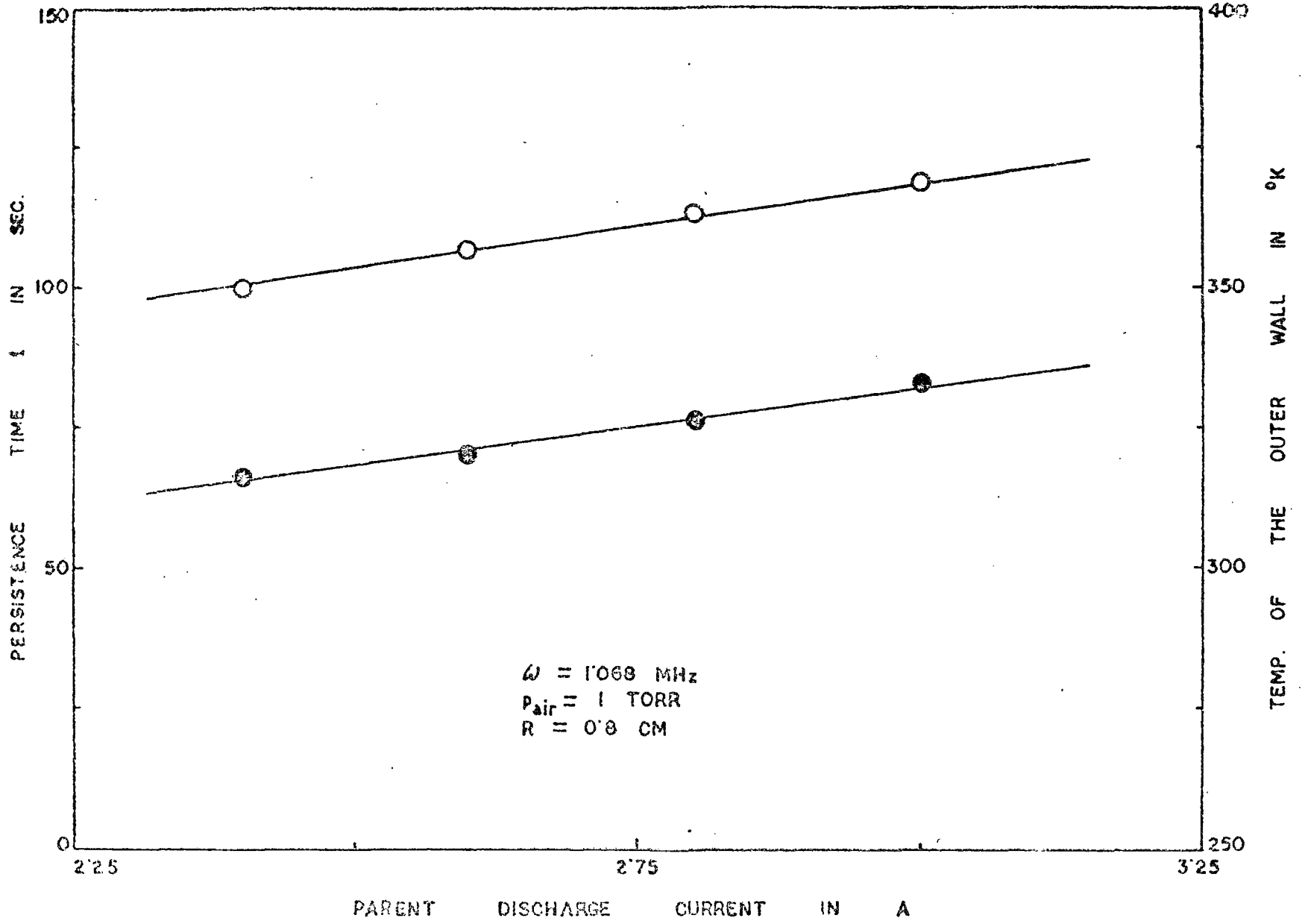

FIG. 8.5.

Fig. 8.5. Variation of persistence time 1 (black circles) and temperature of the outer wall (white circles) with current of the parent arc discharge.

TABLE 8.1

Variation of persistence time with n_e.

p_{air} (torr)	r.m.s. field of r.f. source (volts/cm)	Current in primary arc (ampere)	Persistence time 1 (Sec)	Persistence time 2 (Sec)	T_w at the moment of switching off of primary arc (°C)	T_w when the glow inside r.f. field disappear (°C)
0.975	40.86	2	74	106	85.5	69
		2.4	77	109	85.75	68.5
		2.8	77	103	85	69
		3	79	107	85.5	68
1.2	42.56	3.8	19	277	69.5	52.75
		4	19	277	69.5	53.5
		4.2	18	281	69.5	52.5
		4.4	20	275	69.5	53
		4.6	21	276	69.75	54

So it may be concluded that rise in T_w is the chief cause for the increase of persistence time 1. This is further evident in Fig. (8.6) where persistence time 1 is plotted against T_w at the switching off of primary arc discharge of 2.4 amp., run for different time intervals.

Considering the case of persistence time 1 we may consider the ways how T_w (also T_g) enters into the rate processes.

i) In the process of associative ionisation in the formation of Hg_2^+, T_g enters explicitly in the reaction rate. In chapters VI & and VII it has been shown that Hg_2^+ ions are the chiefly ionised species.

ii) Quenching rate for heavy particle metastable levels will increase with T_g. An effective quenching process of mercury 6^3P_1 atoms by N_2 is $Hg\ (6^3P_1) + N_2 \rightarrow Hg\ (6^3P_0) + N_2 + 0.218$ eV. ....(8.6)

It has been discussed by Mitchel and Zemansky (1961) that the energy discrepancy of 0.218 eV. in this reaction is taken up by N_2 molecules as vibrational energy. But when the neutral particles are hot enough, much of N_2 molecules will be in vibrational state, so that reverse reaction e.g.

$$Hg\ (6^3P_0) + N_2^* \rightarrow Hg\ (6^3P_1) + N_2 \qquad ....(8.7)$$

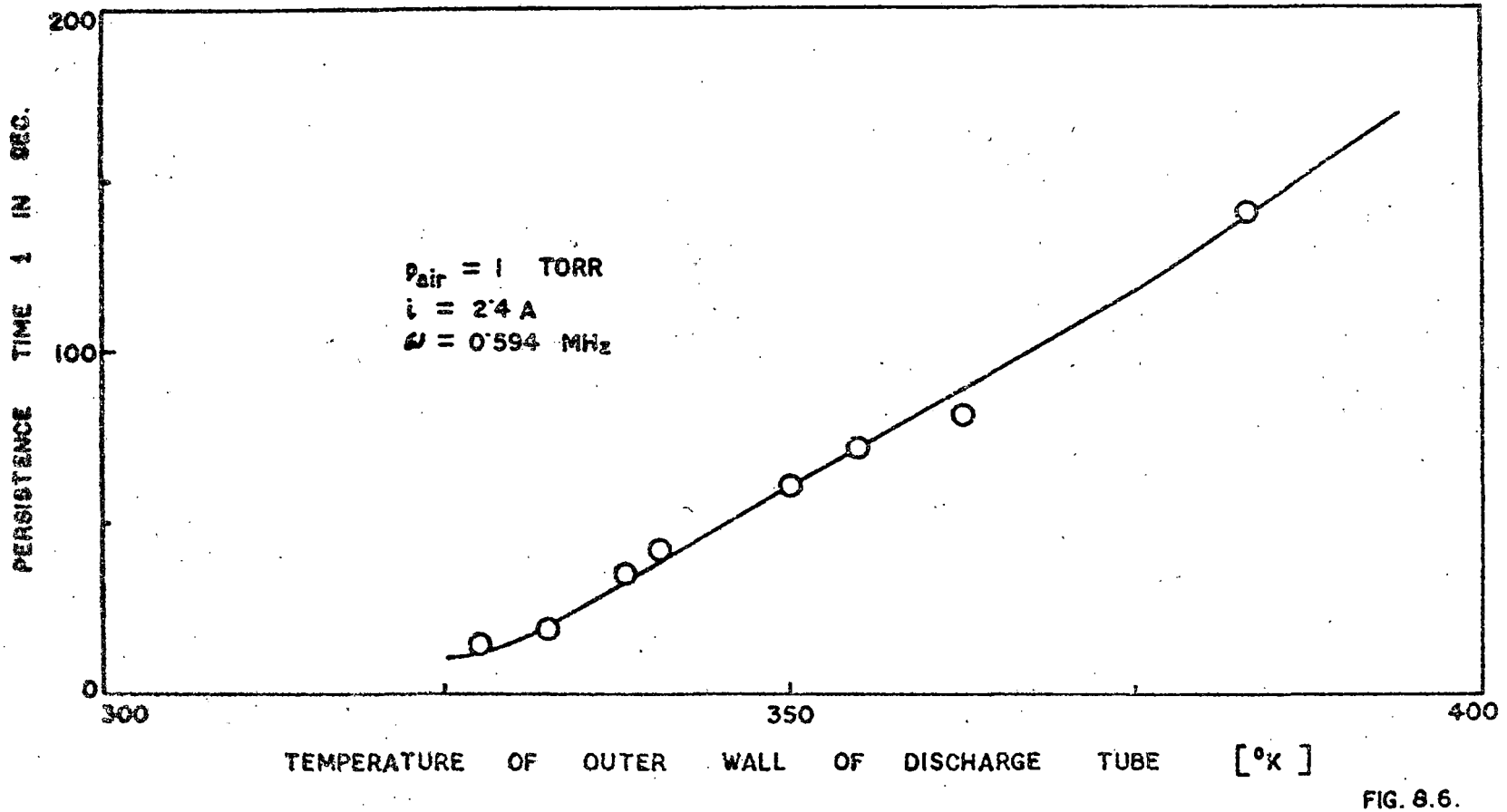

Fig. 8.6. Variation of persistence time 1 with temperature of the outer wall.

may be one of the important processes that populate 6^3P_1 level.

iii) As T_g increase, T_e also increases.

iv) The diffusion coefficient of metastable atoms decreases with gas temperature. It has been shown by Chapman and Cowling (1970) that coefficient of mutual diffusion of a gas is given by

$$D_{12} = \frac{3}{8(n_1+n_2)\bar{\sigma}_{12}^2}\left\{\frac{kT_g(m_1+m_2)}{2\pi m_1 m_2}\right\}^{1/2} \qquad (8.8)$$

where $\bar{\sigma}_{12} = \frac{1}{2}(\sigma_1+\sigma_2)$ the diameters of atoms with densities n_1, n_2 and masses m_1 and m_2. Equation (8.8) predicts a decrease of diffusion coefficient of metastable atoms with decrease of gas temperature.

For a better understanding of invididual reaction processes in persistence time 1, we write down the continuity equation of the particles. For molecular ions Hg_2^+ with density n_{2+}

$$\frac{dn_{2+}(r,z,t)}{dt} = \nabla.\Gamma_{2+}(r,z,t) - \alpha n_{2+} n_e + \frac{1}{2} n_o n_1 \langle v\sigma\rangle_{ass} + \nu_c P_{tot}^2 n_{1+} + f\left(\frac{1}{P_{tot}},t\right) \qquad (8.9)$$

here Γ is a particle flux, n_o, n_1 and n_{1+} are the number densities of 6^3P_0, 6^3P_1 and Hg^+ ions

respectively. α is the two body dissociative recombination coefficient, ν_c is the collision integral for three body conversion of atomic ions to molecular ions. $\langle \upsilon \sigma \rangle_{ass}$ is the collision integral for associative ionisation and $f(1/p_{tot}, t)$ is the diffusive ~~diffusive~~ source term. The source term may be considered as

$$f = \nabla . D_a \nabla_z n_e(t)$$

$n_e(t)$ is the average particle density at the position of coupler and z is the direction of discharge tube axis. The flux due to r.f. field mobility may be disregarded.

For atomic ions,

$$\frac{dn_{1+}(r,z,t)}{dt} = \nabla . \Gamma_{n_{1+}}(r,z,t) - \nu_c p_{tot}^2 n_{1+} + f(1/p_{tot}, t) \quad (8.10)$$

We have disregarded recombination of Hg^+ ions which may of the type

$$A^+ + e + BC \longrightarrow A^* + BC^* \quad (8.11)$$

where BC is a vain molecule which is excited rotationally and vibrationally to BC*.

In the above rate equations it has been assumed that apart from associative ionisation no further ionisation takes place in the field free region. Of course field builds up for the space charges that produce ambipolar diffusion. The plasma is field free in the sence that space charge field is so small that it can not contribute to ionization.

Since charged particle neutrality is not appreciably disturbed, for electrons,

$$\frac{dn_e}{dt} = \frac{dn_{2+}}{dt} + \frac{dn_{1+}}{dt} \qquad (8.12)$$

For 6^3P_0 atoms,

$$\frac{dn_0}{dt} = -\nu n_0 + \delta(p,t) \qquad (8.13)$$

where νn_0 is the loss term given by

$$\nu n_0 = \frac{n_0}{\tau_0} + n_0 n_1 \langle v\sigma \rangle_{ass} + n_0 n_{Hg} \langle v\sigma \rangle_{que} + n_0 n_{N_2} \langle v\sigma \rangle_{que} \qquad (8.14)$$

the first term being diffusive loss, the second loss for associative ionisation and the other terms are quenching by heavy particles. $\delta(p,t)$ is the gain term given by δ = gain by recombination

$$+ f(1/p_{tot}, t) \qquad (8.15)$$

Here also electron collisional excitation transfers are neglected and f may be considered to be equal to $\nabla . D_m \nabla_z n_o$

For 6^3P_1 atoms, mechanisms will be different depending on Z co-ordinate. 6^3P_1 being a resonance level its effective life time is of the order of 10^{-5} sec. which is very much smaller than the persistence time. So at a point nearer the source, loss for 6^3P_1 atoms will be mainly supplemented by diffusive flow from the source whereas at the furthest points, generation will be mainly by reactions of type (8.7).

These continuity equations along with an equation for time variation of T_e, giving proper weightage for the nature of electron energy distribution function and its space variation, if solved simultaneously the phenomena of afterglow can be described. In simplified conditions like, particles diffuse in their fundamental diffusion mode, α does not depend on space and time, electron energy distribution is Maxwellian and space and time independent, the continuity equations can be solved for appropriate boundary conditions and equations may be obtained for time variation or decay for particle densities. However, persistence time can not be calculated from the solutions.

8.4.2. When an axial magnetic field is present

Results, when an axial magnetic field was present, have been shown in Table (8.2). For all sets, the primary arc was run for 3 minutes at a current of 4.2 ampere. The discharge tube cooled in the same envioronment during time recording. Magnetic field was stiched on just before the switching off of primary discharge. For readings marked by a star (*) in Table (8.2), an instability developed during late times of persistence time 2, the glow flickered and ultimately disappeared. It is observed that persistence time 1 does not change with magnetic field, whereas persistence time 2 definitely increases with magnetic field. The outerwall temperature when glow in the r.f. field ceases to exist, decrease with the magnetic field. Visually it was observed that as magnetic field increases, the r.f. glow, generating persistence time 2, becomes more bright. When an axial magnetic field is present, effective, r.f. field is given by

$$E_{eff}^2 = E^2 \left[\frac{\nu_m^2}{\nu_m^2 + (\omega - \omega_b)^2} + \frac{\nu_m^2}{\nu_m^2 + (\omega + \omega_b)^2} \right] \quad (8.16)$$

where $\omega_b = |eB/m| = 1.77 \times 10^7 B$, B is the value of magnetic field in gauss. As B increases, E_{eff} decreases and so the power absorbed. A magnetic field will

affect the glow in another way. The path of electrons lost by ambipolar diffusion will be changed and diffusion will be reduced as fundamental diffusion length is changed to

$$\frac{1}{\Lambda^2} = \frac{\nu_{en}^2}{\nu_{en}^2 + \omega_b^2}\left(\frac{2.405}{R}\right)^2 + \left(\frac{\pi}{L}\right)^2 \qquad (8.17)$$

As diffusion of charged particle towards the wall decreases, the energy carried by a pair of charge particles towards the wall where they are neutralized by recombination, also decreases. For discharges we are considering, energy is carried mainly by diffusing charged particles and deposited to wall as neutralisation energy. So the magnetic field affects the energy balance terms of the wall. As the glow exists for longer time in a magnetic field due to a reduction of diffusion loss, T_w cools down.

It is interesting to note the invariance of persistence time 1 with axial magnetic field. We have already discussed the continuity equations for the particles. The chief production process is the axial diffusion of particles from the source. Since axial diffusion does not depend on an axial magnetic field, the production process will not depend on magnetic field. Hence the constancy of the persistence time 1 in magnetic field makes the particle loss terms also independent of magnetic field. The ambipolar

diffusion, one of the loss process will be mainly axially (as L is shorter than R in the field free region) which will be invariant in magnetic field (equation 8.17). The pressure inside the discharge tube and its size was so chosen that recombination may dominate over diffusion. So it may be concluded that sum total of recombination and diffusion losses does not depend on magnetic field. Conversely, since losses do not depend on magnetic field, dissociative recombination is the only dominating loss mechanism in the field free region. This is the same argument that was forwarded by Kuckes et al (1961) while investigating the decay of helium plasma in B-1 stellarator. As they observed that loss rate is independent of magnetic field between 2.9 and 3.5 kilo gauss, it was concluded that plasma was recombination dominated (for helium it is collisional radiative recombination), and diffusion is negligible.

However, in our experiment magnetic fields used were comparatively low so that no definite conclusion can be drawn for the bahaviour of recombination reaction in a strong magnetic field as desired by Fowler (1978).

TABLE 8.2

Behaviour of persistence times in an axial magnetic field.

p_{air} (torr)	r.f.field (volts/cm)	Magnetic field (gauss)	Persistence time 1 (sec)	Persistence time 2 (sec)	T_w at switching off of primary discharge (°C)	T_w when r.f. glow disappears (°C)
		0	16	233	68	56.5
		180	16	261	68	55
1.05	42.56	350	16	306	67.75	52.25
		520	15	374	67.75	49.5
		675	15	351 (*)	68.5	50.5 (*)
		0	12	179	68.75	60.5
		180	13	241	69.75	57.25
1.2	42.56	350	13	247 (*)	69	57.00 (*)
		520	13	294	69.5	54.5
		675	13	358	69.5	51.5
		0	10	159	71	63
		180	11	167	70.5	62.5
1.4	42.56	350	9	187	69.5	61
		675	11	206	70.5	60.5
		1090	12	234	71.5	59
		0	13	167	69.25	62.5
		180	14	177	69	61.75
1.2	40.86	350	13	196	69.25	60.5
		520	14	223	69.25	58
		675	13	298	69.25	54.75

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