SUMMARY OF THE PRESENT SERIES OF STUDIES.

I) Determination of azimuthal radio-frequency conductivity in an arc plasma by studying the eddy current effect.

When a conductor is placed inside a coil carrying a radio-frequency current a portion of the radio-frequency power is lost due to (a) the stray capacitance by-pass of r.f. current and (b) the eddy current heating of the plasma. The later effect is very small in the radio-frequency range in the case of a glow discharge plasma. In the case of an arc plasma where the percentage of ionization, and hence the conductivity is much higher, power loss is essentially due to the eddy current heating of the plasma. In the present study it has been possible to estimate the azimuthal radio-frequency conductivity of a mercury arc plasma by measuring the reflected resistance of a primary coil wound around a mercury arc tube with the study of eddy current effect. A generalised theory has also been developed in this regard. A linear relationship between the azimuthal conductivity and the discharge current has been obtained. The non-linearity and the existence of maxima observed by previous authors in the change in band-width versus axial conductivity curve have been explained theoretically by considering a generalised equivalent circuit. It has also been pointed out that the asimuthal conductivity determination by this method is possible only when the conductivity of the plasma is farily high.

II) Radial distribution function for the azimuthal conductivity of an arc plasma.

By extending the technique developed during the first study mentioned above —— the non-immersive radio frequency coil probe technique —— it has been possible to find a distribution function for the radial variation of the azimuthal conductivity of an arc plasma. It has been shown that the simultaneous measurement of the change in the band-width of a coil wound around the positive column of an arc tube and the longitudinal field across the positive column can provide valuable information regarding the structural behaviour of the electrical conductivity or the electron density of the plasma column. Though it is well-known that the radial distribution of electrons in a gas discharge is governed by the Bessel function, yet it is observed that in case of arc plasma there is a distribution of electron density or electrical conductivity which is not governed by Bessel function if the arc current is gradually increased. The parameters of the distribution function which has been proposed here have been obtained experimentally. The calculation of half-width from the distribution function further indicates that the plasma becomes more and more concentrated along the axis with the increase of the arc current.

III) Analysis of the previous coil probe experiment.

The approach discussed in the previous work to obtain the structural behaviour of the conductivity region by fitting the distribution class $\sigma(r) = \sigma_0 \left[1-\left(\frac{r}{R}\right)^2\right]^n$ (please refer Ghosal, Nandi and Sen, 1978) chosen in an adhoc manner, with two types of average conductivity results (longitudinal and azimuthal) is prone to criticism leading to the following questions :-

(i) Is it possible to make any conclusion regarding the radial structure of the conductivity profiles on the basis of only two measured moments of $\sigma(r)$?

(ii) Are the obtained informations (σ_0's and half-widths) independent of the choice of the class of function $f(r,n)$?

In the present analysis the above two questions have been discussed and some very important conclusions have been drawn in this regard which may be summarised in the following way:

(i) While seeking the conductivity informations the measurement of azimuthal conductivity alone, on the basis of average conductivity model can give completely false picture of the conducting region if the measurements are not supplemented by other informations.

(ii) From the results of simultaneous measurements of azimuthal electrical conductivity (coil probe method) and longitudinal electrical conductivity (Langmuir probe method) of a plasma it is possible to obtain valuable informations on the major characteristics of the conducting medium such as, maximum extension of the plasma, lower and upper boundaries of the peak conductivity and other important parameters and the obtainable informations are independent of the choice of the profile form.

(iii) The above results of measurements can be conveniently extrapolated to obtain the afore-mentioned plasma characteristics with reduced uncertainties.

(iv) If the profile form of the plasma can be predicted theoretically even under crudest approximation, which, however, can always be done, it will always be possible to determine the peak conductivity and effective extension of the plasma with a very good accuracy on the basis of simultaneous measurements of azimuthal and longitudinal conductivity.

(IV) Heat flow processes active in the positive column of a low pressure mercury arc.

In continuation of the present series of studies of an arc plasma a very important phenomenon like the heat flow processes within a low-pressure mercury arc with water-cooled walls has been investigated utilising the first order pertubation technique to Boltzmann transport equation incorporating the term for the observed high gradient of radial distribution of azimuthal electrical conductivity. It has been shown that the loss is due to heat conductivity of electrons, ions and neutral particles and also due to ambi-polar diffusion by electrons. The experimental results enable us to calculate separately the contribution by the different processes and it is shown that the major part of the heat loss is due to diffusion and the loss due to conduction by electrons, ions and neutral particles is comparatively small. Further from the theory developed and the experimental results obtained, it has been possible to calculate the collision cross-section of electrons with the mercury atoms for electron energies less than 1 eV.

(V) Determination of electron-atom collision frequency of a mercury arc plasma by using radio-frequency coil probe in conjunction with a steady longitudinal magnetic field.

It has been seen by many researchers in plasma physics that the situation becomes quite different and sometimes more information can be derived about the state of the plasma if it is subjected to a magnetic field. In the present investigation an experiment has been carried out to study the behaviour of the conductivity of a mercury arc plasma by placing its positive column inside an uniform longitudinal steady magnetic field. It has been shown that the conductivity becomes a tensor in this situation. Also by simultaneous measurements of azimuthal and axial conductivities in presence and in absence of the magnetic field it has been possible to obtain experimentally a very important plasma parameter viz., the momentum transfer collision frequency of the electrons.