amount that increases with the Curie point of the metal.

For steel the arcing voltage of 33 V. drops to 16·2 V. when the bulk of the metal is raised to a temperature at which it is a bright red, above the Curie point.

These results, which will be described fully elsewhere, give very considerable support to a new theory of electron emission from non-thermionic cathode spots, outlined in the following communication.

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The Arc Cathode

It is generally agreed that none of the theories that has been suggested gives a complete and convincing account of the mechanism of the non-thermionic arc cathode. Combinations of, say, thermal and field emission do not fare much better, particularly for cases like the mercury arc cathode[1]. What follows is a new approach which goes some way, if not all the way, towards a satisfactory theory.

In the pinch effect in a plasma the inward radial force is balanced by an increase in gas pressure which is, of course, unbalanced axially. The plasma maintains its state of electrical neutrality under the pinch forces. If, however, we consider what occurs in the metal, the fact that the positive charge centres—the crystal lattice points—are not free to move means that the pinch-effect forces are not balanced by an electron gas pressure but by space charge forces: that is, the pinch effect sets up a negative space charge in the region of high current density near the cathode spot. The density of this space charge is easily shown to be:

$$\rho = \mu \varepsilon J \bar{v} \qquad (1)$$

where μ and ε have their usual meanings, J is the current density, and $\bar{v}$ is the mean velocity of the electrons carrying the current just inside the metal surface. But the electrons that can escape across the potential boundary must have energies greater than $W + \varphi$, where W is the Fermi energy and φ the work function, and so the appropriate value of $\bar{v}$ in equation (1) is of the order of

$$[(2/m)(W + \varphi)]^{1/2} \qquad (2)$$

Near the surface, therefore, the Fermi equilibrium is disturbed; there is a deficit of high p_z electrons, and to restore equilibrium a corresponding number of $-p_z$ electrons would require to be injected. These high $-p_z$ electrons would gradually degenerate to mean p_z as we move in from the surface and simultaneously the current would be transferred to the normal drift velocity appropriate to the centre of the metal. It is this 'slowing-down' length that determines the fall-off in space charge density as we move inwards from the surface.

The effect of the negative space charge is to lower the potential barrier and therefore the effective work function φ by an amount $\Delta\varphi$ which is of the order of $\mu\varepsilon J\bar{v}\Lambda^2 e$, where Λ is the slowing-down length. Characteristic values show this to be about 2–3 eV. in the case of, say, copper. Note that the value of φ in (2) must now be replaced by $\varphi - \Delta\varphi$. At high temperatures, where the simplified form of the Fermi distribution can be used, we then get an expression for the current density given by (Richardson formula):

$$J = AT^2 \exp(-\varphi/kT)\exp(\Delta\varphi/kT)$$

where $\Delta\varphi$ is the solution of:

$$\Delta\varphi \sim \mu\varepsilon J \Lambda^2 e[(2/m)(W + \varphi - \Delta\varphi)]^{1/2} \qquad (4)$$

that is to say, (3) is an implicit equation for J.

The space charge produced by the pinch effect is thus responsible for lowering φ sufficiently to account for the electron emission.

This changes much of the usual picture. The current density in the metal produced in this way, together with the increased resistivity ($\propto p^2$) is responsible for the heating and evaporation of the metal at the cathode spot, which is therefore a purely secondary effect. The molten metal will itself have higher resistivity, and the depth of liquid below the surface is therefore involved. The result is that there is a considerable ohmic voltage drop *within* the metal. This has been pointed out by Reece (previous communication), who has shown, in the case of vacuum arcs, that the arc voltage is a function of the boiling point of the metal multiplied by the thermal conductivity of the metal and that a large part of the cathode fall is accounted for in this way. An unusual feature of the theory is the dependence on μ, which will have the effect of increasing the current density and therefore the cathode fall in the ferromagnetic metals. This is strikingly corroborated in Reece's experiments. Again, since there is always a parallel path of lower resistance through cold metal, the position of the arc is inherently unstable and hence must be in continual random movement.

Another consequence of this theory is that the time of disappearance of the cathode mechanism is just that of the dispersal of the electron space charge in the metal. It is in fact of exactly the same order as that observed for mercury arcs, namely, 10^{-9} sec.

There are several other consequences of the theory which, together with a more complete theoretical treatment and numerical verification, will shortly be published elsewhere.

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[1] Lee, T. H., *J. App. Phys.*, **28**, 920 (1957).

Preliminary Investigations of the Silicon Boride, SiB_6

Although there has been a good deal of experimental work on the borides of silicon dating back to Moissan[1], current reports (ref. 2 and Parthe, E., M.I.T., private communication) have been somewhat confusing as to the exact phases present in the boron–silicon system. We now wish to report that we have prepared single crystals of silicon boride (SiB_6) by fusion of the elements. The wet chemical analysis after removal of excess silicon agrees with stoichiometric values for the compound SiB_6 as are shown by the following determinations:

B—69·05, 70·16, 69·3
Si—29·43, 29·48, 30·4

The density as determined by pycnometer methods is 2·45 gm./c.c.

Preliminary investigations of the compound by Laue and rotation photographs have indicated an