One would therefore predict that the U bursts should originate from activity in the region of bipolar sunspots. This prediction is confirmed by the observations, which show that 80 per cent of the U bursts were associated with flares, and of these flares 80 per cent occurred over bipolar areas. (This latter result, however, is not unexpected, as nearly 80 per cent of all flares occur over bipolar areas[6].)

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A. MAXWELL
G. SWARUP

Harvard Radio Astronomy Station,
Fort Davis, Texas.
Nov. 22.

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## Electron Emission from Silicon *p–n* Junctions

IT is well known that silicon *p–n* junctions emit infra-red radiation when operated in the forward direction[1] and visible light in the breakdown region of the blocking direction[2,3]. The experimental study of non-thermionic electron emission from solids showed that there is often a correlation between the electron emission and the luminescence, as was stressed particularly in the work by Bohun[4,5]. The question now arises whether the electroluminescence in *p–n* junctions is accompanied by emission of electrons.

The experiments were carried out with grown silicon *p–n* junctions of about 0·2 cm. × 0·2 cm. cross-section cut from a single crystal and etched in a hot mixture of concentrated nitric acid (1 part) and hydrofluoric acid (2 parts). The junctions had a breakdown voltage of about 100. The point of a Geiger counter, operated at normal air pressure (as described in refs. 4, 6), was placed at a distance of 2–7 mm. from the junction; the voltage was about 2,000. With the current flowing in the forward direction we failed to observe any electron emission. This is not surprising, as it is scarcely possible to imagine how the electrons could gain an energy of several electron volts necessary for them to escape from the crystal. However, in the breakdown region of the blocking direction, we did observe emission of electrons. It was accompanied by the usual emission of light. First, it was necessary to ascertain whether the electron emission observed was not caused by the ionizing action of the light emitted from the junction. That this is not the case was shown by covering the emitting junction with a thin sheet of lithium fluoride transparent to visible and ultra-violet light, which immediately stopped the emission. Further, it was verified that the electron emission is not caused by the rise in temperature of the junction when electric current is flowing, but is connected with the current flow itself. Finally, it is considered improbable that the effect is caused by an external gas discharge across the junction, as the voltage was below the sparking potential of air[7].

In the exploratory experiments reported here, no simple relation was found between the intensity of the light emitted and the number of electrons emitted per unit time. The electron emission seems to arise from the spots situated on the surface which emit white light. When only red spots are observed, emission of electrons is either small or is not detectable. However, when the junction breakdown was made 'soft' by slightly working the surface, bright white spots appeared at a low voltage (cf. ref. 2), which were often poor electron-emitters. Maximum emission was observed on freshly etched junctions with 'hard' characteristics operated in the avalanche breakdown region, when the whole junction appeared as an almost continuous bright white line.

In the blocking direction, the electrons in the conduction band can gain considerable excess kinetic energy from the electric field. From the point of view of energies involved, it is plausible that some electrons can leave the crystal if one compares the depth of the conduction band as determined by Esaki[8] (3·47 eV.) with the light emission spectrum from silicon *p–n* junctions, which, according to Chynoweth and McKay[3], extends over photon energies greater than 3·2 eV

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JAN TAUC

Institute of Technical Physics,
Czechoslovak Academy of Sciences,
Prague.

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## Vacuum Breakdown in Dielectric-loaded Wave-guides

A SLOW wave structure suitable for an electron linear accelerator or a high-power travelling-wave tube can be obtained by loading a metal wave-guide with a dielectric, either in the form of a coaxial tube or a series of disks.

A low-loss dielectric must be used, and it is also advantageous for the dielectric constant to be high. To meet these and other requirements a most promising material is a titanium dioxide ceramic which has a loss tangent of about 0·0003 and a dielectric constant of about 90 at a frequency of 3,000 Mc./s. In principle it is possible to design structures[1,2] using this material which have a higher efficiency and better frequency characteristics than can be obtained by the conventional method of loading by means of metal disks.

Experimental work at Malvern[1] indicated that when operated at electric field strengths of the order