High Uniaxial Stress on Germanium Causes Gunn-Effect Oscillations

By applying 10 000–20 000 atmospheres along the [111] axis of n-type germanium at room temperature, John E. Smith Jr at IBM Watson Research Center has produced microwave current oscillations. Smith attributes the oscillations to bulk negative differential conductivity.

Bulk negative resistivity, predicted by B. K. Ridley and T. B. Watkins in 1961 and predicted (by Cyril Hilsum in 1962) to occur in n-type gallium arsenide, was found in 1963 by J. B. Gunn. To produce the effect in gallium arsenide one applies an increasing electric field. At a threshold of 3000 V/cm, electron drift velocity decreases with increasing field.

Gunn showed experimentally that beyond threshold a high-field domain forms near the cathode that reduces the electric field in the rest of the sample and causes the current to drop. Then the high-field domain drifts with the carrier stream across the sample and disappears at the anode. To keep voltage constant, electric field and current rise again to the threshold value. Then a new domain forms at the cathode and the cycle repeats. The frequency is the ratio of the distance between the two contacts and the drift velocity of the domain (constant for a given material).

This mechanism modulates the generating microwave power. One finds that the alternating component of current is out of phase with the voltage and the material has a negative resistance.

In the model of Ridley, Watkins and Hilsum, the conduction band has two valleys with different energies and mobilities. Three conditions must be satisfied: Electrons in the lower valley have much higher mobility; the energy difference between valleys is several times greater than thermal energy, and the energy difference between valleys is smaller than the energy difference between the conduction and valence bands. Then as one applies more electric field, the electrons transfer from the lower valley to the upper where they have much less average velocity.

By applying a uniaxial stress to the germanium, Smith explains, he alters its many-valleyed conduction band so that the transferred-electron effect can occur. He believes that the same technique may work in other semiconductors with many-valley conduction bands, such as silicon, lead telluride and gallium phosphide.

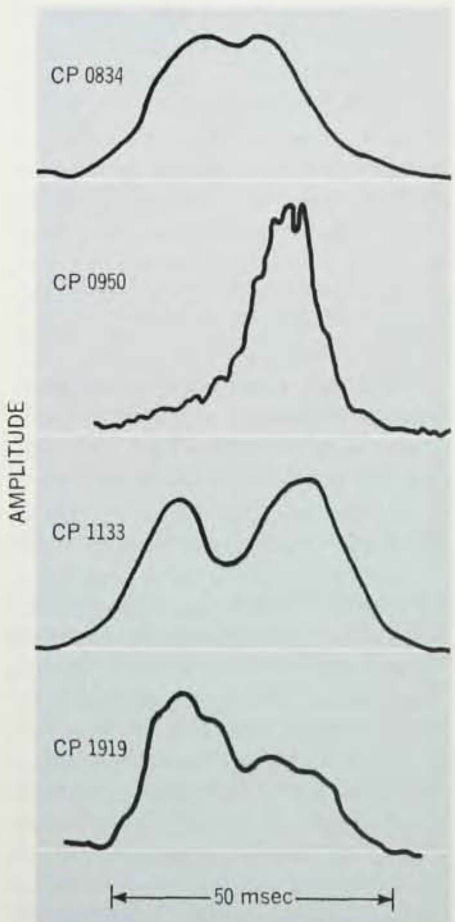
In addition to gallium arsenide, bulk negative differential conductivity has been found in several polar semiconductors, and, by lowering the temperature to 120 K, in n-type germanium. Several theorists have proposed mechanisms other than transferred electrons to explain the results in cooled, unstrained n-type germanium. —GBL

Astronomers Need More Observations to Explain Pulsars

More information is available now on the four pulsed radio sources discovered last December at Cambridge, but no new ones have been found and theoreticians still argue about what they are. Called "pulsars," these sources emit pulses at radio wavelengths with remarkably constant repetition intervals that range in the four known cases from 0.25 to 1.33 sec (PHYSICS TODAY, May, page 75). We recently visited the Mullard Radio Observatory at Cambridge and the Nuffield Radio Observatory of the University of Manchester at Jodrell Bank to talk to astronomers engaged in these observations.

At Cambridge, Anthony Hewish stressed the need for further observation of the four original pulsars and for a careful search for others before conclusions are drawn concerning their nature. "We need accurate positions, optical identification, spectra," he said, but admitted that their current program consisted partly of catching breath after the hectic period following the original discovery last December. Particularly desirable would be searches in the southern hemisphere, Hewish thinks, perhaps by copying the new phased array at Cambridge, which was built quite cheaply in twelve months with student labor.

This new antenna array, with its 21 000-m^2 collecting area, is a very sensitive instrument for rapid searches, and its electronics can be arranged to track four beams at once. The current search with this array could find pulsars with repetition intervals between 0.05 sec and 1 min. Once found with this antenna a pulsar can be tracked and studied with a pencil-beam dish telescope for periods of up to about half an hour. The phased array, which lies in a fixed horizontal plane, loses sensitivity for objects close to the horizon, and Jodrell Bank has been helping with the search in those parts of the sky that are at too low a



MEAN PULSE PROFILES for the four pulsars. These pulses were received at 408 MHz and averaged over 8 min.