around other comets, amply confirming his prediction. There can be few theoreticians who have made such far-reaching predictions with so much success.

Biermann's work on comet tails is one aspect of his long interest in astrophysical plasmas, and more especially the solar chromosphere and corona. In 1964 two solar problems of central importance were the calculation of the coronal temperature from the degree of ionization, and the mechanism responsible for the maintenance of the chromosphere and corona. Biermann made pioneering contributions to both problems, and was the first to suggest the possibility of the chromosphere, at least, being heated by absorption of acoustic waves generated below the photosphere. He had a continuing interest in convection and early in his career he suggested that a sunspot is dark because its magnetic field inhibits the transport of energy by convection. This is not a complete explanation, but it was a fruitful idea and is still a factor in sunspot theory that is discussed today.

Looking at Biermann's work it becomes apparent that he has considered at some time all of the regions of a star from its centre to interstellar space. Following Eddington, he worked in the 1930s on stellar models, his particular original contribution here being on the rôle of convection in the transport of energy and the use of a mixing length theory. This led to a first quantitative discussion of convection zones in stars, and the realization that a fully convective star, of the kind envisaged by Hayashi many years later, is possible.

It is impossible to convey to you in a short space the breadth of his ideas and achievements—he even calculated oscillator strengths in his early days—but I trust that I have said sufficient to demonstrate the merit of his award.

THE GOLD MEDAL
PROFESSOR KEITH BULLEN

The Gold Medal of the Society has been awarded to Professor Keith Bullen for his studies of the structure of the Earth's interior.

Professor Bullen was born in Auckland, New Zealand, and after graduating there he came to Cambridge in 1931. Although he intended to study for Part II of the Mathematics Tripos, he decided instead to become a research student under the supervision of Sir Harold Jeffreys, and thus began an association that has continued to the present day. The work that he did in Cambridge set the pattern for his life-long devotion to investigations of models of the Earth's interior using data provided by seismic and other methods. His starting point was the relation between distance from the epicentre of an earthquake
(defined as the point on the Earth’s surface vertically above the source of the earthquake) and the travel time of the disturbance. As some part of the disturbance travels deep through the Earth and its speed of propagation depends on the physical properties of the rocks, including their density, it is possible to build up a general picture of the interior of the Earth from these travel times. However, the existing tables were rather crude, and he and Jeffreys set about producing improved ones using data from some 80 earthquakes. The new tables were published in 1935, were adopted by the International Seismological Survey in 1948, and are still in use.

From then onwards it was a matter of successive refinements. One of these involved the ellipticity of the Earth. This correction is needed because the onset of a disturbance can be timed to a fraction of one second, whereas a terrestrial ellipticity of $1/300$ combined with a travel time of $20$ min could lead to a correction of as much as $4$ s. In this investigation, travel times were found by integration along paths through the Earth assuming hydrostatic conditions and a variation of density that is entirely due to pressure.

Such models were still insufficient to explain completely the observed travel times, in particular an increase in the surface velocity of the $P$-wavefront at a distance of about $20^\circ$ from the epicentre. This increase had already been noted by Byerly, and it was confirmed by Jeffreys and Bullen who proposed that it is due to an increase in the $P$-wave velocity at a depth of $400$ km, which in turn is associated with an increase in density of about $0.6$ g cm$^{-3}$. This discontinuity in density was subsequently attributed to a change of state at high pressure. There followed a great amount of experimental work at high pressures, although Bullen did not take any part in this.

On this kind of basis, and also by making various assumptions, such as that at sufficiently high pressures all substances tend to the same bulk modulus, Bullen has constructed over a period of years a series of models of the Earth which extend to the central core. The models have become a fundamental part of geophysics, and it is chiefly for his work in this field that the Society honours Bullen.

**THE HERSCHEL MEDAL**

**DR PAUL WILD**

The Herschel Medal of the Society has been awarded to Dr Paul Wild, Chief of the Division of Radiophysics at the CSIRO in Australia for his work on radio emission from the Sun.

Although the Sun appears relatively quiescent when observed in the visible spectrum, it often shows an extraordinary activity in the radio