TWO VELOCITIES OF SOUND IN HELIUM-II

A CONSEQUENCE of the theory put forward in 1941 by the Soviet physicist, Landau, to explain the peculiar flow-properties of liquid helium[1] was the co-existence of two speeds of sound in this medium. Prof. E. N. da C. Andrade, in his recent account[2] of contemporary physical research in the U.S.S.R., stated that Peshkov had succeeded in demonstrating that a 'second' sound did actually occur in helium-II. A paper giving details of the theoretical background and the experimental technique used was delivered earlier in 1945 by E. M. Lifshits and V. P. Peshkov before a gathering of the Physico-Mathematical Section of the Academy of Sciences of the U.S.S.R., and a summary of the work appears in an issue of the Academy's *Herald*, which has recently been received[3].

According to Landau's theory, liquid helium at temperatures below the λ-point, 2·19° K., is a 'mixture' of two types of helium, superfluid and normal, which differ in their rates of flow. On this basis he was able to give an explanation of most of the known flow-properties of helium-II and to indicate a way in which the theory might be tested. An application of the hydrodynamic equations to the study of the propagation of sound in superfluid helium showed that there ought to occur, in addition to the 'primary' sound wave, a wave of another type ('secondary') which would be peculiar to helium-II. The primary wave corresponds with normal sound waves; it is propagated at 240 m. per sec. and the speed is nearly independent of the temperature. The speed of the secondary wave should change rapidly with temperature and be nil at the transition point. According to Lifshits's analysis, the primary wave occurs when the particles of superfluid and normal helium in any given element of volume vibrate so that the liquid moves as a whole; the secondary, when there is relative movement between the particles, governed by the principle that the centre of gravity of each element remains stationary. In the latter case the amplitude of pressure oscillation is small and the effect of temperature is great; the reverse applies to the primary wave.

This picture made it necessary to suppose that all the usual methods of exciting sound waves would produce only the one primary type of sound in liquid helium-II. A special method employing temperature variations instead of pressure variations was required. This was found in the vibrations of a solid surface, the temperature of which could be made to change periodically with time. A thermal oscillator was designed by Peshkov so that, theoretically, only the secondary sound wave should be radiated.

A glass tube, 2 cm. in diameter and 25 cm. long, was placed in liquid helium. The bottom of the tube was closed with a flat glass disk and the other end was left open. Through this end was pushed a flat cylindrical piston with a heater of very thin constantan wire wound on the end of it. There was a small opening in the middle of the piston through which a small thin-walled steel tube could move. At the end of this tube was fixed a small ivory bobbin on which a resistance thermometer of extremely thin phosphor-bronze wire was wound. The electrical resistance of phosphor-bronze changes rapidly with temperature at the temperatures of liquid helium; hence, if the temperature of the helium is made to change periodically and the wire of the thermometer is sufficiently thin to reflect the temperature changes in the helium, then the resistance of the thermometer must also change periodically. When a continuous current is passed through the thermometer, the voltage drop will be proportional to the resistance and it will follow the change of temperature of the helium. It was found, however, that the voltage variations were very small and that they had to be amplified a million times before they could be examined on a cathode ray oscillograph.

On the passage of an alternating current through the heater on the end of the piston, thermal waves of double the frequency were produced. These waves were taken up by the helium, passed to the bottom of the tube, were reflected back to the piston, were reflected again and so on. If the distance between the piston and the bottom of the tube was not equal to a whole number of half-waves, then the phases of the various waves were different and no temperature oscillation was observed at all. If a whole number of half-waves could be packed into this distance, then resonance occurred, standing waves were produced, and a periodic temperature change was indicated on the cathode ray oscillograph.

By changing the position of the thermometer in the tube, it was found possible to measure the length of the waves and, consequently, with a known frequency, to determine the speed of propagation of the thermal vibration. It was thus discovered that the speed increases from 19·5 mm. per sec. at 1·35° K. to 20·4 m. per sec. at 1·65° K. and then rapidly falls, becoming nil at the λ-point (2·19° K.). At these temperatures normal sound travels at about 250 m. per sec. It is stated that within the frequency-range of 100–10,000 cycles per second, a 'dispersion' of speed was not observed.

The experimentally determined values for the speed of the 'second' sound do not agree exactly with those predicted by Lifshits; but it is considered probable that the experimental data upon which the calculations were made were inaccurate. In any event, the results of the work provide a remarkable confirmation of Landau's theory. G. STANLEY SMITH.

[1] See Smith, G. S., *Nature*, **155**, 598 (1945).
[2] Andrade, E. N. da C., *Nature*, **156**, 223 (1945).
[3] *Vestnik Akademii Nauk*, No. 4, 117 (1945).

SOCIAL SURVEY OF KITCHENER–WATERLOO, ONTARIO

IN the early part of 1944 the Canadian Chamber of Commerce sponsored a community fact-finding survey in the twin towns of Kitchener–Waterloo, Ontario. Its purpose was "to find out just what changes had resulted from four and a half years of war, to discover what were the expectations of municipal authorities and business men as to their own post-war needs and opportunities, and to search out and assemble the plans of individuals for themselves and their families". Public interest was enlisted, and the survey met with overwhelming public support. The British Government's Social Survey has a similar experience of public sympathy with surveys, although that organisation has not had the benefit of widespread explanation of its purposes and methods.

In most countries, hitherto, economic intelligence has been for the main part based on national and