may be assured that they will find every convenience and comfort immediately at hand. Only in the problematical case of an exceptionally large sectional meeting will it be necessary to make use of another building.

It is unnecessary in this article to describe in detail the long programme of work, a copy of which can be obtained from the headquarters of the association. The journal, giving full particulars, will, as usual, be issued daily throughout the meeting. The general public will probably be most interested in the papers and discussions relating to scientific work in the war, on such subjects as tanks, submarine mining, the paravane, air photography, the progress of aviation, airships, and directional wireless. Of special topical interest will also be the discussions arranged by the Economics Section on the National Alliance of Employers and Employed, price-fixing, with special reference to Australian experience, transport, finance and taxation, and the gold standard; by the Agriculture Section on war-time food production; by the Physiology Section (jointly with that of Economics) on the influence of the six-hour day on industrial efficiency and fatigue; by the Education Section on various problems of modern education; and by the Geography Section on long-distance air routes, the geography of Imperial defence, frontiers in the East of Europe, and the colonisation of Africa.

Following the precedent set in Birmingham in 1913, citizens' lectures will be delivered in outlying parts of the town during the week, in co-operation with the Workers' Educational Association. These will comprise lectures by Prof. H. H. Turner on "Modern Astronomy," Prof. S. H. Reynolds on "Purbeck Isle and its Geology and Scenery," and Prof. J. L. Myres on "Woman's Place in Nature from an Anthropological Point of View."

Numerous excursions will be made to places of interest in the neighbourhood. The Engineering Section will, by special permission of the Admiralty, visit the Royal Naval Cordite Factory at Holton Heath, a vast organisation which has sprung up during the war, and will also inspect the Bournemouth and Poole Gas and Water Works and the power stations of the tramways and electric light undertakings. The Geology Section will journey each afternoon to points of geological interest in the locality, including such favourite haunts of geologists as Lulworth Cove and Kimmeridge. The Botany Section will find much material for work and discussion in the New Forest, at Shell Bay, and elsewhere. The Agriculture Section is arranging a visit to Iwerne Minster, in the neighbouring county of Dorset; while the Anthropology Section will organise an excursion to the Channel Islands if sufficient names are received before the meeting. Communications on the last-named subject should be addressed to Dr. R. R. Marett, Exeter College, Oxford, who is to read a paper on recent discoveries of archæological interest in the Channel Islands.

It may also be mentioned that Lord Montagu of Beaulieu, president of the Conference of Delegates of Corresponding Societies, has offered to show members and their friends over the beautiful Beaulieu Abbey, with its thirteenth and fourteenth century remains; and Sir Merton and Lady Russell Cotes have consented to throw open to them the East Cliff Hall and its fine collection of art treasures.

From the social point of view, those attending the meeting will find the Bournemouth week a very pleasant one, even though official functions on a large scale are not contemplated. Various local clubs and institutions will be ready to receive them as honorary members during the period of the meeting, and in other ways a great deal will be arranged in the way of hospitality and entertainment.

SUBMARINE ACOUSTICS.

THE war has been responsible for great developments in many branches of science. As a consequence of the submarine menace, close attention has been given to the subject of marine physics, with the result that notable advances have been made in several directions, especially in that of submarine acoustics. Much of what has been accomplished is still regarded as confidential information, but some interesting disclosures have recently been made by Prof. W. H. Bragg in the Tyndall lectures delivered before the Royal Institution, and in a lecture at the British Science Guild's Exhibition at Westminster.

The singular property which distinguishes a submarine from other ships is its capacity of rendering itself invisible when pursued or when seeking and attacking its prey. Robbed of this power, it is an extremely vulnerable craft, and falls a ready victim to more heavily armed and armoured surface ships when once its presence has been detected and its position located.

The acoustic method of detecting a submerged submarine moving in the open sea was found to be far more sensitive and to give a much longer range than all other methods. Instruments used for this purpose are called hydrophones. Many varieties of hydrophone have been evolved and perfected, but by far the largest class consist essentially of a microphone attached to a diaphragm which forms one wall of a watertight cavity. The microphone is connected through a suitable electrical circuit to ordinary telephone receivers, the complete installation resembling a unit of an ordinary land telephone system. In use the hydrophone is suspended from the bulwarks of a stationary ship, or mounted in tanks attached to the hull, or trailed behind in a suitable "fish" body in the case of a moving ship. The range of a hydrophone depends upon the size and speed of the source of sound, the depth and state of the sea, the presence of other sources of sound, etc., and may vary from a few hundred yards to several miles.

The difficulty of ascertaining the *direction* of

a source of sound has been overcome in a number of ways. One type of directional hydrophone is shown in Fig. 1. In this instrument *both* sides of the sensitive receiving diaphragm are in contact with the sea, the microphone being encased in a small capsule at the centre of the diaphragm. If used in this form the instrument is deaf to sounds in its equatorial plane, but can hear sounds coming from other directions. It is, in

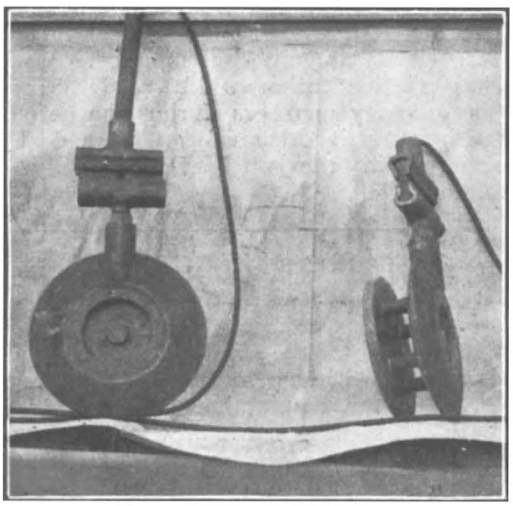

FIG. 1.—Uni-directional hydrophone.

fact, the reciprocal of the hypothetical "double source" of Helmholtz. The polar curve, showing the dependence of its response upon its orientation with respect to the source, is given in Fig. 2.

It is obvious that the ambiguity involved in the *bi-directional* qualities of such an instrument would seriously diminish its efficiency in actual practice, and accordingly a modification was introduced to eliminate this defect. This consisted in

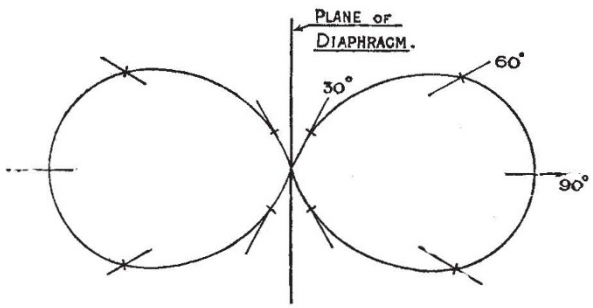

FIG. 2.—Direction-sensitiveness polar curve of a bi-directional hydrophone.

the attachment to the hydrophone carcass, at some distance away from the sensitive diaphragm, of a bias plate, or "baffle," as it is now called. This can be seen in the side view of Fig. 1. When correctly adjusted in position, the "baffle" modifies the polar curve of Fig. 2, so that it takes the form shown in Fig. 3, and, as can be readily seen, renders the hydrophone *uni-directional*.

The construction and properties of "baffles" are very interesting, and have been the subject of prolonged investigation. The mathematical theory of their action has not been worked out fully, as it is difficult to specify all boundary conditions. Moreover, the phenomena are of the diffraction type, in which the obstacle is small compared with the wave-lengths of the incident disturbances. A fairly complete empirical knowledge of their properties has, however, been obtained. The essential feature of their construction is the inclusion of a film of gas in a non-resonant enclosure. If the "baffle" is placed too close to the receiving diaphragm, the hydrophone becomes non-directional, a limiting case being that in which one side of the diaphragm is completely enclosed, and, therefore, "over-baffled."

In his lectures Prof. Bragg also briefly described two other methods by which the direction of an under-water source of sound could be ascertained by making use of a number of hydrophones which do not themselves possess intrinsic directional properties. In the first of these use is made of the binaural principle. Two hydrophones are mounted on a rotating arm at a dis-

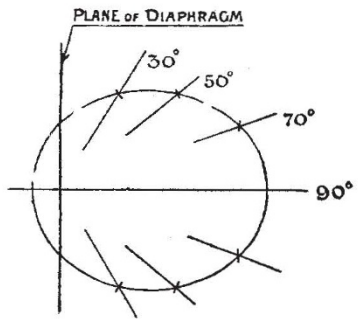

FIG. 3.—Direction-sensitiveness polar curve of a uni-directional hydrophone.

tance apart of from six to eight feet, one hydrophone being connected to the right ear-piece of the observer's telephone, and the other to his left ear-piece. If now the wave-front of the oncoming sound strikes the right-hand hydrophone first, the sound appears to come from the observer's right. On rotating the arm the hydrophone on the left side can be advanced so that the sound appears to come from the left. By rotating the device until the sound appears to come from ahead or astern, the observer is enabled to detect the direction of the source, a simple rule enabling him to resolve any fore-and-aft ambiguity. Instead of rotating the arm carrying the hydrophones, the angle which the wave-front makes with it can be found by compensating for the difference of path in water by introducing an equivalent length of air column between one or other of the observer's ear-pieces and his ear. In this case three hydrophones have to be used in pairs in order to obtain the direction of the source uniquely, the bearings being read off from the calibrated scale of the "compensator."

The second method consists in making use of

the phase relationships between a number of hydrophones distributed at regular intervals in a straight line. It is obvious that in this case sound-waves from a distant source arrive in phase only when it is situated on the beam of the line of hydrophones. By making use of a multiple "compensator" the phases can be corrected for all directions, and the bearing of the source read off from the "compensator" when the observer has determined the setting for maximum intensity.

One gratifying feature of the work on submarine acoustics done during the war is the possibility which it provides of rendering navigation more safe in times of peace. Used in conjunction with suitable sound signalling apparatus fitted to vessels, and submarine bells moored near dangerous shoals and rocks, the improved hydrophones developed for war service should greatly reduce the dangers of collisions and shipwreck, due to fog, etc.

Already hydrographic surveys of the North Sea are being carried out in which the position of danger spots are located for charting purposes by exploding depth charges and recording the resulting disturbances at a number of hydrophones connected to land stations. This method of submarine sound-ranging is by far the most accurate method of locating such spots, and also provides a means of enabling a ship at sea to obtain its correct bearings. By dropping a bomb hundreds of miles at sea, a ship can in a few minutes communicate its position to the nearest shore station and receive this information itself back again by wireless.

F. LLOYD HOPWOOD.

POWER ALCOHOL.

THE annual importation of petrol into this country rose to more than 100,000,000 gallons before the war. Most of this came from the United States. At that time the consumption in the States was about ten times this figure, but in 1919 will probably prove to be not less than thirty times as much. With these values to face it is impossible not to wonder whether the rapid expansion of usage in the States will allow the exportation—at any practicable price—of even the small relative quantity used in the United Kingdom before the war, to say nothing of any additional supply to meet the growth of our own needs for road, sea, and air.

These considerations suffice to render inquiry into the subject a matter of immediate moment, but there is an additional argument available to those who take a longer view. Any fuel product drawn from oil wells or coal mines has the nature of a fortunate dip in a "lucky bag." No one knows how long such supplies will last, nor what untapped stores there yet may be (nor where they are). Moreover, their renewal is a matter of hundreds, if not thousands, of thousands of years. For this reason it is wise for mankind to prepare to supply its future needs by drawing on the current account of the sun's radiant energy and to touch the capital as little as may be.

In most previous discussions on this subject it has been assumed that alcohol obtained from the potato crop is as feasible a source of supply as any that could be named. It now appears from the investigations of the Inter-Departmental Committee on Power Alcohol (Cmd. 218, 1919, price 2*d.* net) that whilst potatoes yield 20 gallons of alcohol per ton, the sun-dried flowers of the Indian mahua tree (costing about 30*s.* per ton delivered at the factory) will yield as much as 90 gallons of alcohol per ton. Here, as in so many other cases, it seems that raw material comes most abundantly and most economically from the tropics, which, indeed, in the present instance is not to be wondered at, seeing that it is the daily solar radiation the energy of which it is desired to tap.

The Government Committee above mentioned, with most praiseworthy energy, has also taken a decided step forward in probing the problems relating to the best use of the alcohol when produced. With this in view it has arranged with the London General Omnibus Co. for a complete fleet of motor omnibuses to be run for six months on both alcohol-benzol and alcohol-benzol-petrol mixtures, and for the results to be compared with running on petrol or other fuel. To use alcohol without any admixture might prove difficult owing to its reluctance to fire in a cold engine; moreover, for good thermal efficiency a high-compression pressure would be needed, and this again makes starting difficult. That, however, is but one of a series of problems which the Committee has arranged to have investigated at Manchester in the laboratory of Prof. H. B. Dixon, whose work on similar lines is well known. Both these investigations—scientific and commercial—should begin to bear fruit very shortly, and by Christmas it may not be too much to hope that the Committee will be able to publish information of such value as to enable the Government to take definite steps towards rendering power alcohol available for all internal-combustion engine users.

THE FORESTRY BILL.

THE Forestry Bill came before the Commons in Committee of the whole House on August 8, when amendments to several of the clauses were suggested. An important amendment increased the number of Commissioners from seven to eight, with the object of having one unpaid Commissioner sitting in the House of Commons, thus enabling the House to keep itself acquainted with the progress of the afforestation work. This amendment was agreed to, as was also another by Major W. Murray that not fewer than two of the Commissioners should have special knowledge and experience of plantation and forestry in Scotland.

Sir Philip Magnus strongly advocated the view put forward by the British Science Guild that at least one of the Commissioners should be a person