enable us to modify the processes of our bodies more in accordance with our wishes—to stimulate our faculties when we need high-tension work, but without evil after-effects; to relax them without the use of harmful soporifics. It seems clear that temperament, even more important than pure intellect in achieving success, is largely an affair of the balance of the various glands of internal secretion—thyroid, pituitary, reproductive, adrenal, and the rest. It may well be that the applied physiology of the future will discover how to modify temperament.

But I must close. Let me emphasise that while pure science will make discoveries so long as she exists, while technology will apply those discoveries so long as profit is to be made out of their application, it is in the long run the average man and woman who decide *how* that application shall be made. Whether the discoveries of science will in the ultimate event be beneficial, as those of us trust who believe in progress, or whether they are leading the human race to destruction, as many sincere and many far-sighted men assert—that will be decided by the use to which the human race decides to put them. In themselves, apart from their intense personal value to their discoverers, and to others on the plane of pure intellect, they are, like any other tool, neutral.

Developments in the Use of Echo-Sounding Apparatus.

THE use of compressional waves in water for the measurement of the depth of the sea beneath a vessel now lacks the novelty which it possessed some years ago, when practical schemes for using them in navigation were first put forward. Briefly, all such schemes reduce to three essential parts—the source of the compressional impulse, the receiver of the echo from the ocean bed, and the mechanism for recording the time interval between the emission of the original disturbance and the moment of receipt of the echo, or, in some cases, the direction of the returning wave front. Small explosive charges dropped into the water, automatic hammer-blows on diaphragms, and diaphragms which are caused to vibrate electrically are used as sources of compressional disturbances within the audible range and form parts of actual sounding sets which are obtainable commercially. Microphones attached to diaphragms exposed to the sea are in general use for receiving the echo and for transforming the sound energy into electrical power. Various mechanisms, some of which are simple and ingenious, while others appear, from their descriptions in technical papers, to be unduly complicated and too delicate for continued sea-going use, are favoured by different firms who have embarked on the manufacture of echo-sounding gear. A typical echo-sounding apparatus for use in shallow water was described in NATURE in an article dealing with the use of the method in navigation.[1]

All the systems of sonic echo sounding covered by the remarks in the preceding paragraph involve the creation of an audible disturbance, but there is one system in which the initial disturbance has a frequency which lies above the upper limit of the range of frequencies audible to the normal human ear. The practical form of this apparatus is described in a recent publication issued by the International Hydrographic Bureau,[2] and the principles of its operation have already been described in these columns,[3] where it was observed that this 'supersonic' or 'ultra-sonic' system was of great scientific interest. It is clear that much skill and ingenuity have been expended in the design of the mechanisms embodied in the gear as now manufactured.

For sounding installations from which nothing more is demanded than an accurate measure of the depth of shoaling water beneath a ship, it appears that sonic systems are capable of answering navigational requirements, but the merit of the supersonic system lies in its ability to locate comparatively small objects, such as wrecks or rocks, in shallow water. This advantage is gained by the supersonic system because the energy is transmitted through the water in a beam the direction of which can be altered, whereas the sonic impulses are more nearly in the form of spherical waves spreading through the water without marked directionality. The supersonic gear cannot, however, be relied upon to detect projections which are small in comparison with the breadth of the beam, and at great depths therefore this system cannot be expected to show much greater power than the sonic gear to resolve discontinuities in the depth of water, unless either the size of the oscillator, or the frequency of its oscillation, is increased so as to make the beam sharper. There are limits beyond which both of these courses become impracticable.

Judging from published descriptions of the supersonic gear as manufactured by the Société de Condensation et d'Applications Mécaniques, the equipment must be decidedly costly and must require skilled operators and attention in case of defects. For these reasons it is to be expected that the simpler and less costly forms of sonic gear will be more popular and that the use of the supersonic apparatus will for some time be limited to special purposes where the sonic gear fails. On the other hand, disappointments with the echo-sounding gear must be anticipated and be looked upon as certain to come. The final form of every new thing is reached by stages, and it may be years before the defects which are bound to occur in existing echo-sounders are all eliminated and so great a mass of evidence for the reliablity and usefulness of the gear becomes available that the wholesale adoption of this invention is inevitable. It is scarcely necessary to quote examples in which events have followed a course similar to that which may be anticipated in the case of echo sounders, but the gyro-compass and the use of directional wireless in navigation may be mentioned. Both these aids to navigation 'hung fire' for years and the gyro-compass is only now coming into general use, while the application of directional wireless is still somewhat under a cloud, owing to errors in the readings taken, which are partly due to the effect of the ship's structure on the apparatus and partly to imperfectly understood effects such as the apparent coastwise refraction of the electric waves. One cannot blame the experienced navigator, upon whom the onus of a disaster falls, if he is chary about accepting the claims

1 NATURE, March 29, 1924, pp. 463-65.
2 Special Publication No. 14 of the International Hydrographic Bureau, Monaco, August 1926.
3 NATURE, May 9, 1925, pp. 689-90.

which well-informed people are making for sonic-sounding gear, but one is fully justified in urging that the method should not be condemned on the evidence of a few initial failures.

Further experiments, of which no detailed description has yet been observed in the English scientific press, have been made in France by the Société de Condensation et d'Applications Mécaniques with a supersonic transmitter for guiding ships along a channel. In these experiments, according to newspaper reports, a supersonic oscillator is fixed at the entrance to a channel and arranged so that its beam may be projected horizontally and rotated in azimuth. In order to obtain the bearing of a vessel, the transmitter may, as in the well-known wireless beacon system, be rotated at a constant rate, or may be made to emit signals corresponding to the bearing of the oscillator. Alternatively, wireless signals might be used to indicate the instantaneous bearing of the beam. A vessel entering the channel would be swept intermittently by the beam and would thereby be informed of its bearing with respect to the transmitting station. The distance of the vessel from the transmitting station could easily be obtained by recording in the ship the difference between the times of arrival of the wireless and sound signals, the principle being the same as that which is used in the radio-acoustic system of position-finding at sea.

The value of such an installation in fog is obvious, for the underwater beam does not suffer from those extraordinary effects of reflection and refraction which make aural observation of the direction of a fog signal or siren station so unreliable in these circumstances. On the other hand, it would be necessary to fit each vessel using the system with a special receiver of high-frequency oscillations, since hydrophones and other instruments which are suitable for use with submarine bells or oscillators of the Fessenden type, are useless as detectors of the ultra-audible vibrations which compose the supersonic beam. The press accounts of the actual system used by the Société de Condensation et d'Applications Mécaniques are not very precise in the description of the manner of obtaining the ship's position relative to the transmitting station, but it is clear that the position might be obtained without the use of any underwater gear in the ship itself. The ship, in fact, acts as reflector of the supersonic beam, so that the operator of the shore station, hearing an echo, would know that a ship was on a certain bearing from him, while the range of the ship can clearly be deduced by the measurement of the 'echo-interval' as in ordinary depth sounding. This information could then be signalled to the ship by wireless telegraphy.

Judging from the cold reception which was given to the leader gear system by shipping companies, it is feared that development of the underwater beam system of guiding ships into harbour is unlikely to be hailed with enthusiasm, and that masters of vessels will prefer to wait for clear weather rather than trust the indications of apparatus of which only a part is under their immediate control. The difficulties which stand in the way of the general adoption of any new schemes such as these are undoubtedly great, and the real trouble is to form a body of opinion in favour of their general use.

Echo-sounding gear of the sonic type has been used also for the determination of the height of an airship above the ground in fog or darkness. The apparatus which was tried for this purpose in the ZR.3 before her journey across the Atlantic in 1924 was almost a replica of that which is used in one of the commercial systems of sonic echo sounding. The source of sound was a small explosive charge, and the time interval was recorded by a spring-driven wheel which was started and stopped by the outgoing shock and the returning echo respectively. It is clear that a machine which is capable of giving the pilot of an aeroplane or airship a continuous record of his height above ground would add greatly to the safety of aerial navigation, and experiments which have already been made indicate the possibility of attaining this end. It is probable that any apparatus which proves suitable for underwater sounding would require to be redesigned before being applied to aircraft, not only because of the necessity for cutting down weight, but also because diaphragm oscillators of the kind used at sea are incapable, when working in air, of delivering enough energy to be effective over any useful distance. The explanation of this is, of course, similar to that given by Stokes, in his classical paper on the communication of vibrations from a vibrating body to a surrounding gas, of Leslie's observation, made in 1837, that the sound of a bell vibrating in hydrogen is exceedingly feeble compared with the sound of the same bell vibrating in air.

Apart from its use as a navigational instrument, sonic-sounding gear has already been found valuable in making rapid hydrographic surveys in deep water. A large number of 'sections' have been made during the past year by vessels of the United States Navy in the course of ordinary voyages, and the results are believed to be in good agreement with charted depths when comparison is possible. The British Admiralty has made a fresh survey of the Challenger Bank using the Admiralty sonic-sounding installation in a survey vessel, and it is understood that a deep-water sounding set has been fitted in a recently built cable-laying vessel for oceanic use.

As an aid to hydrographic, hydrological, and fishery research the sonic sounder has already proved its importance, and it is noted that the German Research Vessel *Meteor* was equipped with no less than four sets of echo-sounding gear. A recently published account [4] of rather less than eight months' work in the Atlantic shows that some twenty thousand soundings were taken, the maximum depth recorded being 6110 metres. In a series of 89 comparisons between echo and wire soundings, the mean depth was 3420 metres and the wire sounding was, on the average, 2·2 per cent. greater than the echo sounding. This discrepancy may be due in part to drift and sag of the sounding wire, or, more probably, to the fact that the echo does not in general return from a point directly beneath the sounding vessel. This point is dealt with in the two paragraphs which follow. Since the echo-sounding gear is really a time-measurer we also require to know, for great accuracy, the velocity of sound in the different layers of water, between the surface and the bottom, through which the sound passes. This velocity will not differ markedly from that at the surface, but it will be affected to a calculable extent by changes in salinity, temperature, and the alteration in compressibility at great depths.

[4] Beiheft zu den *Nachrichen für Seefahrer*. Nr. 7, 1926.

The systematic under-estimation of depth by non-directional sonic-sounding gear is considered in another more recent report of the *Meteor* expedition,[5] and the matter is of sufficient interest to be discussed briefly. In an ideal echo-sounding apparatus, the receiving instruments would be arranged so as to detect an infinitesimally small amount of energy, and if such an instrument could be made, the time interval recorded would be the time which elapses between the emission of an infinitely short impulse and the return of the echo from *the nearest point* of the bottom. If the bottom is not horizontal, the echo would in general come from a point not vertically beneath the ship, but from some point on a tangent plane to a sphere the centre of which is at the transmitter, and the true contour of the bottom would be a series of such intersecting tangent planes. The depth recorded would be the distance of the nearest tangent plane and would generally be less than the vertical depth of water beneath a ship.

In actual practice it is not possible to build a receiver which would be sensitive to excessively small quantities of energy, nor would it be possible, on account of parasitic noises which cannot be eliminated, to use it at sea if it could be made. The impulses emitted by practical sonic transmitters are of finite duration and the receivers operate on a finite amount of echo energy. It is therefore obvious that the received echo comes from an area of the bottom and not from a point on it, and that the observed time will in general be less than the time corresponding to the depth of water vertically beneath the vessel, since the area from which the echo is received is not in general directly beneath the ship. In water of gradually decreasing depth the echo comes from an area in advance of the vessel and vice versa, but the error made in estimating the depth will not be great except when the slope of the bottom is large. A warning of an imminent decrease in depth is given to a vessel using sonic gear before the vessel is actually over the obstruction, and this is an advantage in navigation.

A series of echo soundings was made in the autumn of 1925 by four submarines and the depot-ship *Pelikaan* of the Dutch Navy in the Indian Ocean to the south of Java and Bali.[6] The submarines were submerged to a depth of 12-30 metres during the observations and the ordinary sound-signalling gear for inter-ship communication was used with stop-watches, for ascertaining the depths. The results are generally in good agreement with the charts and are of particular interest owing to the peculiar configuration of the bottom, which includes a row of submarine elevations in about 11° south longitude, to the north of which is a long deep depression having a maximum depth of about 7400 metres. These soundings have a particular interest to seismologists, because the deep valley in and near Wijnkoops Bay coincides with the origin of a great many earthquakes. The use of the echo method in Dr. Meinesz's gravity survey in a Dutch submarine has already been reported in NATURE in an article dealing with the new pendulum apparatus for gravity observations.[7]

In the German publication[4] to which reference has been made above, it is stated that 548 soundings were taken in rather less than four days at intervals of about one sea mile. This works out at one sounding every 10½ minutes approximately. While there is nothing remarkable in this, and the number could easily have been increased if desired, the figures given permit a comparison to be made between the rapidity of sonic sounding and wire sounding. Since, when the wire is used, the whole series of operations of slowing down and getting up speed, paying out and winding in the wire, must be repeated for each observation, the time expended in making an equal number of soundings would have been enormous. Even in depths of about 200 fathoms, about a quarter of an hour is lost per sounding, while in about 3000 fathoms, 2½-3 hours is required to do with the wire what is done practically instantaneously with the echo gear.

J. B.

[5] *Ibid.*, Nr. 41, 1926.

[6] Koninklijk Mag. en Met. Observatorium te Batavia. *Verhandelingen* No. 17, 1925.

[7] NATURE, April 10, 1926, pp. 531-33.

Tectonic Features of New Guinea.

DUTCH New Guinea is still geologically one of the least known parts of a region which, from Malacca to New Zealand, presents a bewildering tangle of structural problems. A pioneer account of the north coast and its hinterland by J. Zwierzycki, one of the geologists attached to the Dutch East Indies Department of Mines, is therefore unusually welcome.[1]

The Cyclops Mountains along the north coast of the Dutch territory are made up of ancient crystalline rocks, including typical members of the greenschist and amphibolite facies associated with marble and gneisses, and intruded by gabbro and serpentine. Across the Australian boundary to the south-east, the old rocks, though interrupted and hidden by bays and deltas, can be traced through the Bougainville and other coastal mountains to the lofty peaks of the Finisterre group. E. R. Stanley, the Government geologist of Papua, describes the latter as composed of schists, and recognises the terrane as part of a marginal geanticline related to Halmahera and New Britain. West of the Cyclops the crystalline rocks are hidden beneath a low-lying swampy coastal plain. Off the coast, however, there are coral islands with others of serpentine, leading to the mountainous ridge of Jappen Island, which again is built of schists and serpentine. At this point Zwierzycki suggests that the trend line turns north through Geelvinck Strait to the open Pacific, but it seems far more probable that the marginal rocks continue beneath Geelvinck Bay to reappear in the Arfak Mountains. These have been briefly referred to by Suess as an ancient massif flanked by unfolded Mesozoic strata. Moreover, the island of Waigeo, at the north-west corner of New Guinea, carries on the belt of serpentine and peridotite intrusions, and so links up the coastal ranges with Halmahera, where these very significant rocks are widely distributed east of the volcanic line. Actinolite schists are recorded from the south of Halmahera, and gneisses from Bachian.

[1] "Notes on the Morphology and Tectonics of the North Coast of New Guinea," *Philippine Journal of Science*, April 1926, p. 505.