

the intensity of the light was reduced until the threshold of the eye was reached for the minimum visible light intensity: the shape of the holes could be recognized and recorded photographically to a certain extent.

These experiments show that structure in the object can be resolved with an aperture of the optical instrument smaller than that postulated by the formula. Therefore it was desirable to test whether two points could be separated if their distance is too small to be separated otherwise than by this new principle.

Fig. 5. Shows the two holes imaged through a small aperture which does not enable them to be separated.

Fig. 6. Shows the effect of reduced intensity: discrimination of two points (the holes are not resolved) is achieved.

The effect has been reproduced on microscopic objects as well and the experiments are being published elsewhere.

Arising from the experiments described above, it is suggested that a factor *I* for the intensity of the light should be included in the formula of resolution. The value of *I* cannot be given as a constant as it necessarily varies with the light source employed. In my experiments it had the rough value of 0.1, judging by the respective times of exposure necessary to record the effect.

My thanks are due to the Council of the Middlesex Hospital Medical School and to the Trustees of the Sir Halley Stewart Trust Fund for facilities which enabled this work to be carried out.

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¹ Airy, G. B., *Trans. Camb. Phil.*, 5, 238 (1834).

² Lommel, E., *Beugungerscheinungen an einer Kalisronschen Öffnung*, München, 1884.

³ Preston, T., "The Theory of Light", 327 (London, Macmillan & Co., Ltd., 5th Edition, 1928).

The Modern Centrifugal Pump as a Plankton Collector

THE elimination of the many sources of error encountered in some form or another when collecting plankton for quantitative work with silk nets is a problem that has been attacked many times. During the last fifty years, a number of workers, many of them with some measure of success, have from time to time used a pump and filter as a means of collecting a small, but quantitatively accurate sample, of plankton.

Encouraged by the obvious possibilities and advantages of this method, we have recently conducted experiments with a modern centrifugal pump. The experiments were made from the Research Ship *Explorer*, Fishery Board for Scotland, and the results have proved to be of great value and interest. We are preparing a paper on the subject in which the whole aspect of the problem of sampling is discussed, and the historical position of the plankton pump reviewed.

The experiments were conducted with a water meter included on the delivery side of the pump, and show how a comparatively large volume of water (two and a half cubic metres) was filtered in ten minutes with a two-inch pump. A three-inch machine

would deal with almost double the volume (five cubic metres) in the same time, and it is a pump of this calibre that we suggest for general use.

Filtering can be done either by suspending the net in a tank of water to take up the force of heavy delivery, or direct on to the ship's deck. This latter method was used in our work and the results show that the plankton so collected is little, if at all, damaged in passing the impeller at 2,000 revolutions per minute. Even complicated chains of diatoms and delicate forms such as *Aglantha* remained whole, while some of the zooplankton forms were seen swimming actively in the filtered sample. The suction action is more than ample to take all forms of life, so that the collections are in no sense selective, and the results obtained indicate clearly the greater quantity of small forms, both of phyto- and zooplankton, as compared with the larger forms.

The suction hose, which is made in jointed lengths of 25 feet (8 metres), can be readily attached to a steel warp weighted with lead, and though in the experiments only two such lengths were used, they presented no difficulty in handling. As the pump was designed to overcome the frictional resistance in ten or more such sections, there would presumably be no more difficulty with 100 metres of pipe than with 12-15 metres. The joints are made with a quickly meshed screw thread, and are water-tight; and it was found that sections of much greater length than those used could be employed without difficulty.

This modern method of plankton pumping overcomes many obstacles familiar to the quantitative worker, and should be of widespread interest.

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Symmetry of Symbols

THE application of the theory of symmetry to decorative designs is well known to students of crystallography and to mathematicians interested in the theory of groups. Text-books on design do not discuss these simple rules for the construction and classification of patterns, most likely because the subject up to the present has been treated only in the technical language of mathematics.

In preparing some articles which have as their purpose to explain the subject in a simpler form, I came across the following example which may be of more general interest. If we classify the letters of the alphabet according to their symmetry characteristics, we find the following five groups (in mathematical language they are the sub-groups of the symmetry group of the rectangle):

- (I) FGJKLPQR
- (II) AMTUVWY
- (III) BCDE
- (IV) NSZ
- (V) HIOX

I. Those letters which have no real symmetry properties.

II. Those of which the left half is the mirror image of the right half.

III. Those of which the upper half is the mirror image of the lower half.

IV. Letters which can be rotated over half a circle without changing; they remain the same when the page is turned upside down.

V. Letters which have all the above characteristics combined.

What stands out in this classification is that the letters *N*, *S* and *Z* are together in one group. They are just the characters which are always written

incorrectly by uneducated people. It seems, therefore, that their type of rotation symmetry is slightly more difficult to grasp than the more common reflection symmetry. In this connexion it may be noted that many of the magic symbols used by ancient people possess such rotation symmetry over a half, a third or a quarter of a circle. This may perhaps help to understand why various primitive tribes independently have come to worship symbols like the swastika.

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Points from Foregoing Letters

PROF. E. A. MILNE relates considerations recently advanced by Dirac with his own results, but concludes that there is no inference as to the creation of matter. The form of the differential relation connecting intervals for the $t \rightarrow \tau$ transformation is stated.

Under very feeble illumination the eye sees the visible spectrum in a uniformly grey colour (scotopic vision). It had been found that the maximum luminosity for equal energy is at 5000–5040 Å., while the maximum absorption of the visual purple pigment in the eye is at 5100 Å. Dr. H. J. A. Dartnall and C. F. Goodeve point out that if instead of comparing energies one compares equal quantum intensities, then the two maxima coincide. They consider this, and also further approximate calculations of the relative intensities of the light absorbed at different wave-lengths, to give support to the hypothesis that the primary process in scotopic vision is the absorption of light quanta by visual purple.

Recent experiments on the resistance of ferromagnetics show a sharper Curie point than the specific heat measurements. Prof. N. F. Mott and Dr. H. H. Potter state that this is to be expected, because the resistance depends on long-range order (domain of more than about 8,000 atoms) and the magnetic energy depends on the interaction of electronic spins at close range.

The percentage of glutamic and aspartic acids in Cotswold wool and in seagull quill has been determined by Dr. J. B. Speakman and F. Townend. They conclude that the results support the 'salt-linkage' theory developed by Speakman to account for the elastic properties of wool-fibres in solutions of varying acidity. According to that theory, the long peptide chains of the keratin molecule are bridged by linkages arising from the combination of the acid side-chains of aspartic and glutamic acids, with the basic side-chains of arginine, lysine and histidine.

A study of spore-forming bacilli by a vital staining technique leads Dr. L. A. Allen, Miss J. C. Appleby and J. Wolf to the conclusions: (1) that a single species of bacillus may show alternative methods of forming endospores, resulting in two different cell structures extraneous to the spore; (2) that the spores, after being released from the cells, are at first refractile, but may later (in old cultures) take up stain, revealing an internal structure which undergoes rearrangement during a considerable period of time.

The ovary and testis of young and embryonic rats and mice have been grown *in vitro* by P. N. Martinovitch. The ova developed and survived for three weeks, but at the end of a month the whole organ degenerated. Spermatogenesis was less successful, stopping at the pachytene phase during the chromosome reduction stage during meiosis.

Some of the changes taking place when the larvæ of the oyster settle and become 'spat' are described by H. A. Cole. Within ninety hours a considerable metamorphosis occurs while the diameter of the shell increases from 0.3 mm. to 0.6 mm. There is still a gap in the life-history of the oyster, since the next stage described is one in which the diameter of the shell has reached 1.2 mm.

It is suggested by Dr. J. R. Baker that the breeding seasons of equatorial birds may be controlled by changes in the intensity of visible and ultra-violet illumination.

Lieut.-Colonel L. M. Davies finds evidence that the Ranikot (Palæocene) Sea of India extended from Sind to the Tirah, and from the Tirah to Tibet. It was apparently isolated from the contemporary marine waters of Europe.

A. M. Hocart adduces a few examples and impressions of lineages which voluntarily isolate themselves for breeding purposes. These he considers give a clue to the segregation of species in Nature.

From recent observations by Rossi and Benedetti, H. J. Bhabha infers that the number of cosmic particles arising from a direction 30° west of the meridian is appreciably less than the number arriving vertically. These, he reasons, must be negatively charged, and if the radiation formulæ of quantum mechanics hold for the high energies involved, then either negative protons or some other negatively charged particles hitherto unknown must be assumed to be present in appreciable numbers in cosmic radiation.

An effect of increased resolving power of telescopes and microscopes produced by means of reduced light intensity in some diffraction experiments is described by Dr. K. B. Merling-Eisenberg.

S. G. Gibbons and J. H. Fraser have experimented with a modern high-speed centrifugal pump for collecting plankton, and find that even delicate organisms are undamaged. They claim that accuracy is obtained by this quantitative method of sampling.