mine tailings, china clay and coal, no theoretical treatment has been proposed upon which the size of an installation and the power consumption for a specific duty can safely be based. The design engineer is still forced to rely on such published data as are available, relating to a restricted range of materials and operating conditions.

During recent years, however, systematic research has been in progress, notably in Britain and in France, in an effort towards obtaining a better understanding of the mechanisms involved. The results of some of this work were described in three papers read before the Institution of Chemical Engineers on March 15.

The first paper, by D. M. Newitt, J. F. Richardson, M. Abbott and R. B. Turtle (Department of Chemical Engineering of the Imperial College of Science and Technology, London), gave a brief summary of previous work and included an account of an experimental investigation into the behaviour of a wide variety of materials conveyed in a pipe of 1 in. diameter in a circulating system. Data were given for suspensions of graded solids from 0·0008 to 0·15 in. in diameter, specific gravities in the range 1·18–4·6, and volumetric concentrations up to 33 per cent.

It was shown that, over the range of velocities attainable in the system, five distinct modes of flow can occur, varying from fully suspended flow at high velocities to flow with a bed of solid moving at a uniform rate in the lower part of the tube, at low velocities. When pressure drop is plotted against velocity for a given concentration of suspended solid, a curve is obtained showing a minimum pressure drop at some critical value of velocity not far removed from that at which deposition occurs with subsequent choking. Some interesting observations were also made on the flow characteristics of suspensions of solids of mixed sizes. It appears that the transport of a coarse material may be facilitated by the admixture of a small proportion of fines, resulting in an increase in the overall carrying capacity of the system for a given pressure drop.

The results obtained with a 1-in. pipe can be correlated with reasonable accuracy by an equation based on simple theory. It is interesting to note that the equations are similar to the empirical relationships obtained by Durant, the only important difference being in the index of the pipe diameter term.

The second paper, by R. A. Smith, related to work carried out at the Billingham Division of Imperial Chemical Industries, Ltd., on the pumping of suspensions of sand in water through horizontal pipes of 2 and 3 in. in diameter. Measurements were made with closely sized and with mixed materials, and it was found that the pressure drop is always greater than that which would be obtained with a true fluid of the same density and viscosity as the suspension. With the non-uniform materials, the experimental results can be correlated with those for particles of a single size, by using a mean particle size, giving the same surface/volume ratio as for the mixture. The selection of a suitable pump, which will handle the suspension without serious risk of blocking and, at the same time, will have a reasonably high efficiency, is an important feature in the design of an installation. The pump used in the present work was of the centrifugal type, and was found to operate at an almost constant efficiency for volumetric concentrations up to 24 per cent.

In the third paper, by K. E. Spells (formerly with Imperial Chemical Industries, Ltd., Widnes, and now at the R.A.F. Institute of Aviation Medicine, Farnborough, Hants), the experimental results of a number of workers were discussed, and a dimensional analysis of the variables of the process was attempted. It was shown that, in all cases, there is a minimum velocity at which transport can safely be effected, corresponding to the condition where particles start to fall out of suspension. As the velocity is increased, the pressure gradient tends towards that obtained with a true fluid of the same density and viscosity as the homogeneous suspension. Although this condition is approached asymptotically, Mr. Spells claims that it is generally possible to assess fairly accurately the 'standard' velocity at which the two pressure gradients coincide. The correlations are obtained with both vertical and horizontal pipe-lines, but are limited to conditions where the particle size is small compared with the pipe diameter.

D. M. Newitt
J. F. Richardson

EMBRYOLOGY OF MAMMALS

In 1914, "Contributions to Embryology" was started to cater for those studies of the Carnegie Institution's Department of Embryology as were likely to prove too long and too lavishly illustrated for ordinary technical journals. Few ventures in scientific publication can ever have been better justified. The "Contributions" have become—what they promised to be at the beginning—the major single source of our information about mammalian embryonic development. The earlier volumes were devoted chiefly to descriptions of human embryos, and to accounts of placentation and the development of the systems of the body. Franklin P. Mall, who initiated the publication, and who was the Department's first director, was also keenly interested in the study of the mammalian reproductive cycle. The "Contributions" have, therefore, also had a profound influence on the development of experimental endocrinology. Vol. 2, published in 1915, carried an article by G. W. Corner, the present director, on the corpus luteum of gestation. Corner's analysis of the phases of the menstrual cycle in the rhesus monkey appeared in 1923, and in 1927 the "Contributions" published the first major experimental study, by the late Edgar Allen, of the hormonal basis of the primate reproductive cycle. The study of primate reproduction was taken an important step forward in 1933 with a description, by Lewis and Hartman, of the segmenting human ovum. Then, in 1941, side-by-side in the same volume, there appeared an account by Hartman and Corner of the first segmentation division of the fertilized egg of a monkey, and a description, by Hertig and Rock, of segmenting human ova no older than eleven to twelve days.

Vol. 35, which has recently been published*, goes yet further. In addition to a series of distinguished monographs that deal with regional embryological studies (among which is one by Bartelmez and Blount on the formation of the neural crest in man), as well as several of a more experimental kind (including one by Wells and van Wagenen on the induction of pseudo-hermaphroditism in monkeys), the volume provides a further description, by Corner and Bartelmez, of early embryos of the rhesus

* Contributions to Embryology, 35, Publication No. 603, Nos. 231–241 (1954). Pp. 237 + 54 plates + 57 figs. 12 dollars paper bound, 13 dollars cloth.

monkey; and an account by Hertig, Rock, Adams and Mulligan of four normal and four abnormal human ova ranging in age from the fifth day of development to as little as one day after fertilization. These showed, *inter alia*, that the human blastocyst is prepared for implantation slightly more rapidly than the monkey egg.

It is odd to think that until relatively recently the number of early human embryos that have been studied was so few that almost each had a name. The enormous increase in the amount of material that has become available for study is a direct consequence of the interest in the whole of this problem that has been generated by the Carnegie Department of Embryology. It is also a direct outcome of the researches on reproduction in which the Department has played so big a part, and which have made it possible to estimate when ripe follicles will be present in the ovaries, and when ovulation is likely to occur. Armed with this knowledge, it is possible to time certain types of operation that have to be carried out so as to increase the chances of recovering, for scientific study, the human egg in its first stages of development. The latest chapter of the story is not, however, told in Vol. 35 of the "Contributions". The December 1954 issue of the *Transactions of the New York Academy of Sciences*, and the February 1955 number of the *American Journal of Obstetrics and Gynecology*, include articles by Landon B. Shettles describing the *in vitro* fertilization of the human ovum and its transformation into an eight-cell morula. This is a great technical achievement, and it opens up the possibility of exploring still further some of the most basic problems of human development.

S. Zuckerman

ELECTRICAL PROPERTIES OF WOOD

The electrical properties of wood are of importance in high-frequency heating processes, in the use of wood as an insulator, and in the determination of moisture content by electrical means. Whereas the direct-current behaviour of wood can be specified solely by the electrical conductivity, the alternating-current behaviour requires two quantities—the relative permittivity (or dielectric constant) k, and the loss tangent tan δ—for its specification. In order to assess the effect of frequency, grain direction and moisture content on the dielectric properties of wood, R. F. S. Hearmon and J. N. Burcham have recently measured k and tan δ for twelve different species of wood in the three grain directions, at moisture contents up to 18 per cent and more, the frequency range being 2 kc./s.–60 Mc./s.*. The specimens were in the form of disks, approximately 5 cm. in diameter and 0·6 cm. thick, and tin-foil electrodes were attached to the flat faces with a thin film of 'Vaseline'.

The results for the two species, sitka spruce and oak, representing medium–light and medium–heavy timbers respectively, are presented and discussed in some detail. The permittivities change uniformly with moisture content and frequency, being closely related to the density, and a method is suggested by which the permittivities of any timber may be predicted approximately in terms of the density, moisture content and frequency. The inter-relationship between loss tangent and these three quantities is, however, highly complex, and it is not possible to predict values of tan δ with any accuracy. A few measurements were made, in addition, on oak of moisture content 75 per cent and on wych elm of moisture content 70 per cent, and although k and tan δ varied considerably with frequency, the electrical conductivity did not change greatly over the frequency range 1–100 kc./s. It is concluded that for low moisture contents the results are in accord with the qualitative description of the dielectric behaviour of wood, which can be given in terms of the dipolar mechanism of electrical conduction, but that for high moisture contents the effect of ionic conductivity becomes of greater importance and must be taken into account.

* Forest Products Research Special Report No. 8: The Dielectric Properties of Wood. By R. F. S. Hearmon and J. N. Burcham. Pp. iv+20. (London: H.M.S.O., 1954.) 1*s*. 6*d*. net.

CACAO RESEARCH

The staff of the Cacao Research Scheme at the Imperial College of Tropical Agriculture, Trinidad, comprises plant breeders, physiologists, soil chemists, a biochemist, a mycologist, an entomologist and estate personnel. The aim of the research programme is to improve the yield and quality of cacao beans, that is, it is essentially of an applied character, such fundamental research as may be undertaken being in direct relation to practical needs. In the Report for 1953 now published (obtainable from Trinidad or from the London Office, 40 Norfolk Street, W.C.2; November 1954; 10*s*. 6*d*.) an account is given of research completed, research in progress and research contemplated.

An interesting account is given of the 1952–53 collecting expedition to Colombia. This includes full notes on the different forms of cacao (*Theobroma cacao*) observed, together with some thirteen other species which were collected, and ten species of the related genus *Herrania*. This venture also yielded valuable information on the insects, and their parasites and predators, associated with these plants, and on the incidence of the witches' broom and *Monilia* fungal diseases. Many of the new materials have now been established in Trinidad. A more general result of the expedition has been to support the view that the centre of origin of cacao probably lies near the Colombian–Equadorian frontier on the eastern flanks of the Andes.

Experiments on the effects of shade and fertilizer applications have shown that, as light intensity increases, the trees become more vigorous but, at 75 and 100 per cent light, growth is dependent on fertilizer treatment: in the absence of additional nitrogen the plants are stunted, but with nitrogen they are very vigorous, yielding considerable lateral branching and a closed canopy. The mean yield increases with increasing light intensity up to 50 per cent light; thereafter it decreases progressively. This trend is, however, reversed by nitrogen additions, maximum yields being recorded at 75 per cent light. Light is especially important in determining the duration of the cropping period. At low light intensities there is a steady production of pods but no peak harvest, whereas with 50 per cent light, or more, all pods mature in a peak period. Fertilizer applications both advance the onset of harvesting and yield a distinctive peak as compared with the controls.

A new, effective and relatively cheap technique for the rooting of cacao cuttings has now been suggested. Baskets of soil, with a central core of composted