similar to those produced by 'butter yellow'. In female rats, it produces adenocarcinomas of the breast, although the substance itself does not appear to be œstrogenic. No other insecticides or phenothiazine derivatives have been found to have carcinogenic activity, but phenothiazone is toxic when fed in small amounts over a long period.

3 : 4-Benzpyrene was first isolated from coal tar ten years ago. Dr. I. Berenblum and Dr. R. Schoental, of Oxford, have recently investigated the carcinogenicity of fractions of coal tar separated by chromatographic methods. They find that the fraction containing the benzpyrene is less active than certain other fractions in producing cancer on the skin of mice and rabbits. American workers during the past year have published results showing that although benzpyrene is rapid in its action, the dose required to induce tumours in mice is much larger than the corresponding dose of 1 : 2 : 5 : 6-dibenzanthracene (W. R. Bryan and M. B. Shimkin, *J. Nat. Cancer Inst.*, 3, 503 ; 1943). In attempts to obtain new types of tumours in fowls at the Glasgow Royal Cancer Hospital, injections of benzpyrene and methylcholanthrene have failed to produce tumours. On the other hand, many tumours have been induced in chickens with dibenzanthracene. Experiments carried out at Sheffield suggest that cats are resistant to the action of benzpyrene and methylcholanthrene.

Dr. J. W. Orr has applied methylcholanthrene to the nostrils of mice from a strain (I.F.S.) in which breast tumours do not normally occur. No lung tumours were found, but of twenty-nine female mice treated in this way eighteen developed mammary cancer.

### Metabolism of Carcinogenic Hydrocarbons

Dr. I. Berenblum and Dr. R. Schoental, working at Oxford, have found that benzpyrene is converted into 8-hydroxybenzpyrene, and that 1 : 2-benzanthracene is converted into 4 hydroxy 1 : 2-benzanthracene in the intestinal tracts of mice and rats. These phenolic substances which are formed are not carcinogenic. The Oxford workers have collaborated with scientific workers of the Royal Cancer Hospital in studying the growth-inhibiting power of these metabolism products and their derivatives. The metabolism products themselves have no growth-inhibiting activity, although some hydroxy derivatives, such as 4 hydroxybenzpyrene, are active growth-inhibitors. Some methyl derivatives of the metabolism products can inhibit the growth of tumours. The active substances of this type are all monomethoxy compounds, such as 4'methoxy 1 : 2-benzanthracene and 8-methoxy benzpyrene. The dimethoxy derivatives of carcinogenic hydrocarbons appear to be devoid of growth-inhibiting activity.

### Bone Tumours in Mice

Some years ago Mr. F. C. Pybus and Dr. E. W. Miller of Newcastle-upon-Tyne developed a strain of mice in which bone tumours including sarcomas frequently occurred. In 1936, about one quarter of the mice which died had palpable osteomata or sarcomata, but since then the incidence of bone tumours has declined although the mice have been inbred. Over a ten-year period 21 per cent of females and 7 per cent of males of this strain died with bone tumours. The difference in incidence in the sexes suggests that œstrone might have some influence on the development of these tumours. Dr. J. W. Orr has studied the effect of œstrone on the histology of the bones of mice. The bones of female mice of this 'Newcastle bone tumour' strain are unusual in that there is a considerable amount of medullary bone and a mosaic appearance in the cortex. The bones of spayed females of this strain resemble those of normal mice. Treatment of mice of other strains with œstrone causes osteoclastic changes, including both resorption and production of bone. The mice of the Newcastle bone tumour strain are exceptionally susceptible to the action of œstrone. A sex hormone, in addition to other unknown factors, probably plays some part in causing the bone tumours that are found in this special strain of mice.

### Filterable Agents

Experiments carried out at the Middlesex Hospital show that injection of either proflavine or 5-aminoacridine into the breast tissue will localize the Rous sarcoma virus. The localization of the virus leads to the formation of a tumour at the site of injection of the acridines. Kieselguhr is a localizing agent, but is much less effective than the acridine compounds. Methylcholanthrene is a very feeble localizing agent. The effect is probably governed by the type of tissue reaction resulting from the injection. The acridine compounds have a mild toxic action and cause proliferation of muscle nuclei.

Only a few of the topics dealt with in the report have been mentioned, but it is clear that progress has been made in the face of difficulties and many new facts have been brought to light during the year under review. With its coming of age, the British Empire Cancer Campaign is to be thanked for the way it has raised funds to support cancer research and for the care with which it has organized and correlated the efforts of many scientific men working in fields directly and indirectly bearing on the subject.

E. BOYLAND.

---

## GYROSCOPIC PRINCIPLES AND APPLICATIONS

GYROSCOPY, since it belongs to classical mechanics, tends to be neglected by the modern physicist. We have now to depend on the engineers and applied physicists to maintain the teaching of the subject. Its applications cannot be ignored ; in the development of modern applied science we find many extremely important applications of gyroscopes ; and in the increased use of bodies rotating at angular speeds that are being continually increased from year to year, we find gyroscopic effects that must be taken into account in the design of the supporting structure whenever the rotating body, whether it be engine, wheel or propeller, has the direction of its axis of spin altered. When a motor-car turns to the left, the spin of the engine causes a transfer of load from rear axle to front axle, and the spin of the wheels gives a transfer of load from inner to outer wheels. When a single-engined aeroplane turns to the left, the nose tends to dip ; when the turn is to the right, the gyroscopic effect tends to raise the nose. When a twin-engined plane, with propellers turning in opposite directions, alters course, the leading edge of one wing tends to dip and the leading edge of the other tends to rise, so that additional stresses on the structure are intro-

duced. Jet propulsion will lead to the removal of the gyroscopic action of the propellers, and perhaps also to the removal of much of the gyroscopic action of the engines.

The subject is a difficult one; the mathematical treatment is not easy, and the translation of the mathematical results into application requires the powers of both mathematician and engineer. Prof. C. E. Inglis has both qualifications, and in the thirtieth Thomas Hawksley Lecture to the Institution of Mechanical Engineers*, he has given an excellent account of the theory of gyroscopy, and has detailed several practical demonstrations and applications, some new, all interesting. Usually the subject is approached from the idea of angular momentum, and the couple required to change the direction of this vector quantity. Prof. Inglis begins in a simpler way: if a point $P$ is travelling with a speed $v$ along a radius vector rotating with angular speed $\Omega$, then $P$ must have an acceleration $2v\Omega$ in a direction perpendicular to the radius vector. If now a gyroscope is spinning about a horizontal axis, and is being forced to precess about a vertical axis, every point in the upper half of the gyroscope requires an acceleration in a direction parallel to the axis of spin, and every point in the lower half requires an acceleration in the opposite direction. Hence the precession of the gyroscope about a vertical axis requires a couple about a horizontal axis perpendicular to the axis of spin. The simple working rule follows, that the axis of spin tends to turn towards the axis of the applied couple.

Excellent demonstrations by Prof. Inglis illustrate these points. A belt is running with velocity $v$ between two vertical pulley wheels mounted on a horizontal platform that can rotate about a central vertical axis with uniform angular velocity $\Omega$. Each horizontal part of the belt has to develop a horizontal acceleration $2v\Omega$, so that there is a transverse parabolic bowing of the belt, the upper part to one side, the lower part to the other side. A second demonstration of the same effect is given by means of a gyroscope, the disk of which is composed of several layers of paper. If the axis of spin of the gyroscope is horizontal, and the axis of the applied couple is vertical, the disk becomes warped about a horizontal axis perpendicular to the other two axes, and not about the axis of the applied couple.

In the next demonstration, a gyroscope spins about a horizontal axis, its axial supports being carried by a frame that is free to rotate, about a horizontal axis perpendicular to the axis of spin, in a second frame that is free to rotate about a vertical axis. A couple is applied, by means of a weight suspended from a point in the first frame, on the axis of spin produced. The axis of spin remains horizontal, but the gyroscope precesses about a vertical axis. In the demonstration, the gyroscope was a powerful one, of polar moment of inertia 25 lb.-ft.$^2$ and of angular speed 3,000 r.p.m., and the couple of 150 lb.-ft. was produced by the weight of a man suspended at a point one foot from the centre point of the gyroscope; the man was carried through a complete rotation about a vertical axis in about 10½ seconds. Hurrying the precession raised the man, retarding the precession lowered him. When the precessing frame of such a gyroscope hits a stop and is brought to rest, the gyroscope begins to tilt over; a very considerable couple is developed tending to remove the resistance to precession; this couple reaches a maximum at a tilt of about 35°, and decreases to zero at a tilt of 90°.

The general equations of motion of a precessing gyroscope are worked out in a mathematical appendix, and several important deductions are made. The frequency of nutation, in which there is a periodic interchange of kinetic energy between tilting and precession, is deduced, and emphasis is laid on the importance, for great stability, of a high natural frequency. In the paper a description is given of a new form of gyroscopic vibration damper, originated by Dr. R. N. Arnold, by means of which excessive chatter in a heavy armour-plate planing machine has been suppressed, the frequency of the gyroscope being tuned to the frequency of the chatter, and suitable fluid damping being applied.

The gyroscopic action of a pair of wheels of a locomotive or motor-car when the vehicle is rounding a curve is worked out; the load transferred from inner rail to outer rail for a typical pair of locomotive wheels and axle moving in a typical railway curve is shown numerically to be negligible. It is also shown that if one of the pair of wheels drops through a small distance at a rail joint on a straight part of the line, the resulting precession about a vertical axis is by no means negligible, and the practical conclusion is drawn that rail joints should be placed side by side, and not staggered.

Gyroscopic stabilization of a monorail truck is considered very fully, both in a second mathematical appendix and in descriptions of arrangements that lead up to the Brennan monorail stabilizer. The gyroscopic ship-stabilizer and the gyrocompass are treated in as simple a manner as the subjects will permit. The paper concludes with an explanation of the stability of a spinning top. Emphasis is given throughout to the principle, so valuable when appreciated and properly applied, that a spinning body can be given complete stability by hurrying the precession; the child's top rises to the sleeping vertical position because frictional forces at the peg hurry the precession; and the same principle leads directly to the realization of an artificial horizon for the navigator, and of a horizontal sighting platform for the bomb aimer. ROBERT C. GRAY.

* "Gyroscopic Principles and Applications". By Prof. C. E. Inglis. Being the Thirtieth Thomas Hawksley Lecture to the Institution of Mechanical Engineers, delivered on November 19, 1943. (Institution of Mechanical Engineers, Storey's Gate, London, W.C.1.)

# OBITUARIES

## Dr. H. A. Mess

HENRY A. MESS, reader in sociology in the University of London, whose death took place early in January, was one of the few men who have been fortunate enough to combine the academic life, which he loved, with very wide experience in the field of social administration. He came into the university world at a later age than is usual, but all his previous work was, in a sense, a preparation for his main interest and provided him with an inexhaustible supply of material on which to draw for his study of the structure of society.

Dr. Mess was born in 1884 in Stoke Newington and educated at Bancroft School, Woodford, but, owing to a decline in the family fortunes, he was not able to go to Oxford as he had hoped. While earning his living as a clerk in an insurance office, he attended evening classes and, in 1905, took first-class honours in modern languages as an external student of the