we knew that steel subjected to a certain heat treatment had its mechanical qualities altered. Microscopic investigation, aided by improvements in the preparation and treatment of the samples to be examined, has enabled us now to trace out, step by step, the changes which take place at various stages of the treatment, as well as the effect—in the case of alloys—of modifications in the proportions of the constituents. Microscopic research also promises to be of value in providing definite information as to the changes of structure in different metals when injured by fatigue, or are just on the point of fracture, and Sir Robert Hadfield has made some valuable experiments in this direction.

During the last few years a most important addition has been made to our methods of discovering defects in materials or workmanship by the application of the X-rays. Great progress has been made, and there is every promise of further developments in the early future. At present steel or iron can be searched to depths of about 3 inches, aluminium and its alloys to about 6 inches, and timbers of various kinds from about 15 to 20 inches.

Researches on the thermal efficiency of the steam engine during the last few years have related chiefly to the development of the steam turbine. Prior to 1903 the best economical result obtained with a steam turbine was that of a 1500-kilowatt alternator built by Messrs. Parson in 1902; this machine had a steam consumption corresponding to about 13.5 lb. per indicated horse-power per hour. A test carried out in 1918 on a 10,000-kilowatt unit by the same makers gave a consumption of 7.75 lb. per horse-power per hour—a reduction of about 43 per cent. on the 1902 performance. The corresponding thermal efficiency is nearly 27.7 per cent. Bearing in mind certain points in the design of this turbine and making allowance for them, it appears that a thermal efficiency of 30 per cent. for a steam motor is within our reach.

Mechanical gearing in turbines has proved in a number of cases to be unsatisfactory. The question of how to prevent the defects which have occurred forms probably the most important problem which has demanded the attention of mechanical engineers for many years past. The failures have been variously

attributed to the use of unsuitable metal for the gears, to irregularity in the gear cutting, to disturbance in the alignment of the shafts and to other causes. The whole subject deserves more systematic and thorough investigation than it has received hitherto.

The development of the steam turbine has been the result of an enormous amount of strenuous and original work, both theoretical and constructional. On the theoretical side, the determination of the laws controlling the discharge of steam through orifices of various shapes is yet very far from being complete, and there are many other problems, such as the critical speeds of shafts, the best number of stages to be adopted under different conditions, and so on. On the constructional side may be mentioned the selection of suitable materials for the blades and the mode of fixing the latter, devices for preventing steam leakage, securing efficient lubrication, and methods of governing and of obtaining the high vacua so essential for securing economic performance.

The pistons of reciprocating engines have speeds ranging from 600 to 800 feet per minute. In steam turbines the blades are being run successfully at 600 feet per second. A small turbine (150 horse-power), made recently by Messrs. Ljungström of Stockholm, runs at 40,000 revolutions per minute and has a blade speed of 952 feet per second—more than 11 miles per minute.

In conclusion, Dr. Maw directed attention to one fact which appeared to him of far greater importance than all the others: in none of the researches referred to, varied and extensive as they have been, is there the slightest trace of finality. Much as has been discovered and great as has been the progress made, it is most certain that we have at present effected only the preliminary opening up of the mine of knowledge and that the real wealth of its contents is as yet unknown to us. We can only say that the "impossible" of yesterday has become the "possible" of to-day, and in the early future many of these possibilities bid fair to become accomplished facts. Surely this is a great inheritance, which should invite our coming generations of engineers to make most strenuous efforts to secure greater—and still greater—developments, so that they may in their turn leave behind them a heritage more glorious still.

Radio-Telephony and Broadcasting.¹

By A. P. M. FLEMING, C.B.E.

IN considering the development of radio-telephony, it is frequently overlooked that the earliest methods of communication, such as by sound and light, do not involve the use of wires; the negative and non-descriptive term "wireless" has, therefore, been displaced by the term "radio." Radio waves are electro-magnetic in character, being pulsations in the æther of space, and they differ among themselves and from radiant heat, light, and X-rays, only in their amplitude and wave-length. Some waves change and diminish gradually in amplitude, and are said to be "damped"; others maintain their amplitude and are "continuous." Radio waves exist and are used which vary in wave-length from a few yards to ten or twelve miles; they are the longest electro-magnetic waves.

Given the means whereby electrical waves can be produced and detected, it is comparatively simple to arrange to send signals by the morse code, and this is done every day in ordinary radio-telegraphy.

Radio-telephony is in some respects analogous to ordinary telephony. The ordinary telephone circuit of microphone transmitter, line, and receiver contains a battery which sends a continuous current round the circuit and through the telephone receiver. If speech is made in the microphone, the vibration of the microphone diaphragm varies the pressure on carbon grains in the microphone. This varies the resistance in the battery circuit, and the current, instead of flowing steadily, rises and falls according to the sound waves impinging on the transmitter diaphragm. The fluctuating current varies the pull on the diaphragm in the telephone receiver, and this sets up sound waves similar in character to those originally spoken into the transmitter. In radio-telephony there is a generator capable of producing very high-frequency oscillating current which can be radiated from an aerial, just as heat and light are radiated from a fire or lamp. This radiated oscillation is known as a "carrier wave." Near the generator is a modulator receiving the speech and modifying the amplitude of the high-frequency oscillation, and imparting changes in the carrier waves in

¹ Substance of a lecture delivered at a meeting of the North-east Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne, on Friday, December 15.

accordance with the speech vibrations, which result in a fluctuating current radiated to the receiver.

At the receiving end the oscillating current is changed into a uni-directional current, and made suitable for reception for hearing in an ordinary telephone receiver. It is an essential condition of reception that the receiving set be "tuned" to respond to the wave-length of the station it is desired to hear. Electrical waves emanating from a transmitter travel in all directions through space, and can be picked up by any number of receivers, provided these are tuned to receive the particular wave-length used.

Broadcasting stations comprise transmitting-room, studio, green-room, offices, listening-in room, and workshop. Programmes are designed to operate throughout the whole evening, and all tastes and ages are catered for. It is usual for artistes to operate at the station, but by means of ordinary telephone transmission it is possible to transmit a political speech or entertainment from a central hall in a city to the broadcasting studio, and to radiate it from the station to listeners.

The pioneer work in broadcasting as a means of public entertainment and instruction was undertaken by the Westinghouse Co. of Pittsburgh, U.S.A., in December 1920. The Metropolitan-Vickers Co. of Great Britain has close technical association with this company and has the advantage of this pioneer experience. There are now more than 500 broadcasting stations in the United States, and their growth without proper co-ordination has caused some confusion.

To avoid this confusion in Great Britain, the Government insisted that manufacturers of radio apparatus should co-operate in forming a Broadcasting Company to control broadcasting. Three stations of the eight contemplated are in operation, London, Manchester, and Birmingham, and it is intended that Newcastle shall have a station. The revenue of the Broadcasting Company for maintaining stations is provided by the manufacturers, but the Government assists by remitting a proportion of the licence fee.

Care should be taken in selecting a set suitable to the local conditions. A good crystal set costing about four or five pounds will receive satisfactorily over ten or fifteen miles. A two-valve set would pick up over fifty or one hundred miles, and in addition to this, a further two-valve amplifier could be arranged to increase the distance to 300 miles, or would permit the use of a loud speaker up to fifty miles. Sets sold by reputable manufacturers are very efficient and simple to operate.

The development of radio-telephony will have a very profound influence upon social life. It will overcome the isolation of the rural worker, the invalid, and those who are confined indoors, and it has unique potentialities for entertainment, instruction, and the development of public taste.

Excavations at Borg en Nadur, Malta.

AT a meeting of the Royal Anthropological Institute held on November 21, Prof. F. G. Parsons, vice-president, in the chair, Miss Murray gave an account of some excavations carried out by her at Borg en Nadur, Malta, during the past summer. The excavation was purposely limited to a small area to the west of the so-called "dolmen" of Borg en Nadur in a terraced field which had been made over this site, as high as the cap-stone of the dolmen, and completely covering the remains of the ancient buildings. The principal building found was an apsidal structure of the type peculiar to Malta. From the small size of the stones and the primitive

style of the building, Miss Murray is of the opinion that Borg en Nadur is considerably older than Mnajdra and Tarxien. The principal results of the excavation are (1) the discovery of types of pottery transitional between the neolithic and bronze age; (2) the finding of painted pottery showing Cretan influence, perhaps of the Middle Minoan era, thus connecting prehistoric Malta with another ancient civilisation.

In the discussion which followed the reading of the paper, Prof. J. L. Myres said the pottery of Malta presents a puzzling problem. Evidence is needed as to which of the large number of types are contemporary. The pottery from the "window tombs" of the lower levels of the ravines with flat alluvial bottoms, which form the characteristic watercourses of Malta, presents certain affinities with the "Sikel" pottery of Sicily. Miss Murray distinguished between "neolithic" and "bronze age" pottery; but, whereas she found the latter at ground level in the apsidal building, at Hal Tarxien the lower occupation layer, resting on ground level, contained no metal, and the bronze age interment had been found over a sterile layer of some thickness imposed upon the neolithic stratum and at a considerable height up the great stones of the temple. The painted pottery, for which a Cretan affinity had been suggested, is of the type found in Sicily and Southern Italy for which Prof. Peet had traced a Thessalian rather than an Ægean relationship. Prof. Myres also expressed his opinion that the Borg en Nadur building was of late and degenerate type rather than early and primitive. Mr. H. J. E. Peake said that Miss Murray's suggestion of a type of pottery transitional between the neolithic and bronze age types was new and needed substantiation. The restricted distribution of the "bronze age" type suggested that it might be an intrusion, of which Miss Murray's transitional type was an attempted copy.

University and Educational Intelligence.

BIRMINGHAM.—Dr. Dorothy Margaret Patrick has been appointed assistant lecturer in physiology, Grade III.

Mr. T. V. Barker, of the department of mineralogy at Oxford, has been invited to deliver a course of lectures, during the spring term, on chemical crystallography.

The annual meeting of the Court of Governors will be held on Thursday, February 8.

The vice-chancellor (Sir Gilbert Barling, Bart.) is to represent the University at the celebration of the 800th anniversary of the foundation of St. Bartholomew's Hospital in June next.

The new hall of residence for men students is to be known in future as Chancellor's Hall.

GLASGOW.—The University has received a gift of 25,000*l.* from Mr. Henry Mechan, of Mechans, Limited, engineers and contractors, Glasgow, for the foundation of a new chair of public health.

LONDON.—At a meeting of the Senate on December 13, a resolution was adopted accepting a bequest of 3000*l.* made by the late Sir William Meyer, fellow of University College and High Commissioner for India, to be applied at the discretion of the Senate "with special reference to the encouragement of proficiency in European History, and in the History and Geography of India." An offer from the council of the Society of Antiquaries to continue the Franks studentship in archæology, of the value of 100*l.* per annum, for a further period of five years was accepted with thanks.