densation occurring until the density of the vapour was about eight times that of saturation at the lower temperature, but that beyond this point the condensation was so dense as to suggest that a natural limit of supersaturation had been reached. Experiments on steam-jets by Barus and others suggested a similar limit for steam at high temperatures free from air, though the precise ratio of density required could not be directly obtained from such experiments. Taking the density ratio given by Wilson as the limit of supersaturation, the discharge through a nozzle was calculated by Callendar (*Proc. Inst. Mech. Eng.*, January, 1915), and shown to afford a reasonable explanation of well-known anomalies.

Admitting the supersaturation limit thus defined, the discharge through a nozzle comes out about 5 per cent. greater than that given by the older view, and agrees much better with the results of experiment. The available heat-drop to the supersaturation limit is about 5 per cent. less, involving a corresponding loss of work. So far the result is definite, depending only on the limit assumed and the equation of the adiabatic, which is fairly certain. Beyond this point the loss must depend on the rate of expansion, but it is still possible to calculate an upper and a lower limit. The maximum heat-drop is obtained by assuming that, when once condensation has started, the temperature follows the ordinary saturation limit in isentropic expansion, in which case there is no further loss of available heat-drop. On the other hand, assuming that the temperature cannot fall appreciably below the supersaturation limit, however rapid the expansion, the maximum loss is obtained by assuming that the temperature follows the supersaturation limit, in which case the loss continually increases with increase of entropy, but reaches a nearly constant percentage, about 8 per cent., of the total heat-drop at low pressures.

In the work before us the author adopts a slightly different definition of the supersaturation limit. Instead of taking a simple ratio of densities as proposed by Wilson, he assumes that the effective radius of the supersaturation nucleus remains constant at different temperatures. In the absence of experimental evidence at high temperatures, it is scarcely possible to decide between the two assumptions, except that the first is the simpler in application. The two corresponding curves for the supersaturation limit agree so closely at pressures between 1 lb. and 15 lb. that they give practically identical results when applied to any turbine problem. Now that one of the leading exponents of turbine theory has set the example we may confidently expect that other useful applications of the supersaturation hypothesis will follow, and that more accurate determinations of the limit will be made in the near future.

The "New Theory" gives an example of one such application of great practical interest—namely, the effect of superheat in improving the efficiency, which confirms the hypothesis of supersaturation, and throws light on the probable state of the steam in an actual turbine by comparing theory with experiment.

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According to the older theory of isentropic expansion of saturated steam, the effect of a moderate degree of superheat in improving the relative efficiency of a turbine should be practically negligible, whereas even the earliest experiments in this direction showed that the improvement was strongly marked. The improvement was generally attributed to elimination of friction due to the presence of water (Stodola, "Steam Turbines," p. 137), but Osborne Reynolds showed this explanation to be unsatisfactory. The supersaturation theory of expansion requires that the improvement should be most marked in the early stages of superheat, owing to the reduction of supersaturation losses, which diminish most rapidly with the first rise of temperature. The most trustworthy and recent experimental results on the improvement due to superheat are probably those given by the correction curves of Baumann (*Journ. Inst. Elect. Eng.*, 1911), which are generally regarded as accurately representing the case of the modern high-speed turbine.

Mr. Martin shows that these results can be satisfactorily explained on the supersaturation hypothesis provided that we are prepared to admit that the temperature of the steam, after condensation has set in, remains much nearer the supersaturation than the saturation limit, dividing the interval in the ratio 1 to 4. His method, involving the estimation of reheat factors, may appear indirect, but tends, if anything, to exaggerate the effect of superheat in reducing the supersaturation losses. The present writer has made many similar calculations, which corroborate Mr. Martin's, and tend to show that the temperature of the steam must be very near the supersaturation limit in the later stages of expansion in a high-speed turbine. A result so strongly at variance with the generally accepted theory cannot fail to act as a stimulus to further research on the effects of supersaturation, and may lead to appreciable improvements in design when proper account is taken of these essential physical properties of steam.

H. L. CALLENDAR.

THE EPIDEMIOLOGY OF PHTHISIS.¹

TUBERCULOSIS, and particularly pulmonary tuberculosis (phthisis, or consumption of the lungs), still remains one of the health problems of the age. The Medical Research Committee has, therefore, been well advised to institute an inquiry into the epidemiology of phthisis in Great Britain and Ireland, of which this report by Dr. John Brownlee is the outcome.

The present investigation is a statistical analysis of the Registrar-General's returns of mortality, mainly for the five decades 1851-60 to 1891-1900, for the constituent countries as a whole and also for certain districts of them. By this means remarkable differences are brought out respecting the age at which the maximum death-rate from phthisis occurs in different localities. If we take the deaths of males from phthisis in England and

¹ An Investigation into the Epidemiology of Phthisis in Great Britain and Ireland. Medical Research Committee, Special Report Series, No. 18.

Wales for 1901-10, the death-rate rises from 250 per million at fifteen years of age to a maximum of 2750 per million at forty-seven years of age, after which it steadily declines to 500 per million at eighty years of age, the curve being almost symmetrical. For London the curve is much the same, though steeper, because the maximum death-rate is higher, being 4500 per million at fifty years of age. Lancashire and Staffordshire show a very similar curve. If, however, we take the figures for North Wales for males for the same period (1901-10), the death-rate rises abruptly from 500 per million at fifteen years of age to 2800 per million at twenty-three years of age, continues at about this level up to fifty years of age, then rises slightly up to sixty years of age, and then declines (the curve for Norfolk is much the same). The curves for London and for North Wales are thus utterly different. Cornwall shows a well-marked secondary rise, and the form of the curve is the same whether the tin-miners, who are specially prone to phthisis, be included or not. For this county the phthisis death-rate rises to about 2600 per million at thirty years of age, declines to 1300 per million at forty years of age, rises again to 3250 at sixty years of age, and then falls.

Similar differences are met with in Scotland. The phthisis death-rate among males in Shetland for the years 1881-1900 rises steeply to 6000 per million at twenty-three years of age; it then falls almost regularly to 1500 per million at fifty years of age, and continues at about this level until seventy is reached. For Midlothian, including Edinburgh, on the other hand, the curve is very similar to the London one, with a maximum death-rate of 3750 per million at 42½ years of age. For Ireland the curve is not unlike the Shetland one, a maximum death-rate of 4500 per million being attained at twenty-seven years of age, with the exception that it declines almost regularly to 500 per million at seventy-five.

From these and other data the conclusion is arrived at that phthisis or consumption of the lungs is not a single disease, but rather a group of diseases, of which one type attacks the young adult, the commonest age of death lying between twenty and twenty-five; a second type has its incidence at middle life, killing most commonly between forty-five and fifty, while a third type may exist, but less certainly distinguished, with its chief mortality between fifty-five and sixty-five. In diseases such as cerebro-spinal fever and pneumonia four or five different races or varieties of the respective specific micro-organisms are now known to exist, and the results of this statistical inquiry suggest that something of the same nature may obtain as regards the tubercle bacillus of pulmonary tuberculosis or phthisis. In the introduction to the report it is stated that the bacteriologist has not yet discovered "type" differences among the human tubercle bacilli of phthisis. This statement is not altogether correct, for certain observers have arrived at the conclusion that there are at least two types of the human tubercle bacillus of phthisis with distinctly dif-

ferent properties, which may be differentiated by certain methods. Other matter of considerable interest is also included in the report, viz. an examination of the phthisis death-rate in London since 1631, the relationship of phthisis to certain occupations (among tin-miners the death-rate is 16,500 per million at fifty to fifty-five, while among coal-miners it never rises above 2000), and the relationship of phthisis to environment. The report is illustrated with twenty-six diagrams showing the phthisis and other death-rates in graphic form, which give a far better idea than words could do of the variations alluded to above.

R. T. HEWLETT.

NOTES.

THOSE engineers who have been advocating the electric drive of ship propellers will read with mixed feelings the announcement made on January 2 by Mr. Daniels, the Secretary of the U.S. Navy, that in the future all the capital ships of that Navy will be electrically driven. There is no reason to doubt that the new American Dreadnought—the *New Mexico*—is a great success. Steam turbines are used, and in order to get their highest efficiency they must be kept running at high speeds. The ship's propellers run at much lower speeds, and so direct driving is out of the question. The turbines are directly coupled to dynamos, and the electric power generated is transmitted to motors directly coupled to the propellers. The relative speed of the turbines and the shafts can be adjusted to any desired value with the greatest ease by merely turning the controller-handle. The experiments undertaken in this country a few years ago were carried out in a timid and hesitating way both from the engineering and the financial point of view, and the results were generally disappointing to the electrician designers. It is possible, but by no means probable, that slow-speed turbines may be developed in the future. In the meantime, we hope that British shipbuilders will make larger use of the electric drive in the future than they have in the past.

THE *Times* for January 3 announces that the world's altitude record has been broken by a British biplane, which flew from Martlesham Heath and attained a height of 30,500 ft.—1500 ft. higher than the summit of Mount Everest. The machine was piloted by Capt. Andrew Lang, R.A.F., with Lieut. Blowes as observer, Capt. Lang having previously made two attempts to beat the American record. It is of considerable interest to note that the height attained was limited by the failure of petrol-pump pressure, due to the rarity of the air, and not by the aerodynamic performance of the machine. The machine was fitted with a Napier Lion engine, but it is not stated whether forced induction was employed to keep up the engine power at this enormous altitude, where the air density is only 28 per cent. of its ground value and the temperature of the order -40°C . It would appear, however, that even greater heights could be reached if minor difficulties, such as those connected with carburation at low temperatures and the maintenance of the pilot's comfort, were overcome. Meanwhile, it is gratifying that the record should be held by British aviators, and we hope that it may continue to be so held in the future.

PRESIDENT WILSON has been given a most cordial reception in Rome during the past few days. He has been admitted a member of the ancient Accademia dei