ried out with that accuracy of detail which is, we believe, attained by the statistical department of the English Board. In this connection Prof. Heincke states (p. 66):—"The appendix to this report contains a number of these tables drawn up by me from the English measurements. Close inspection will show, that here and there inaccuracies and errors have crept in during the preparation of the tables. Thus, in the case of large numbers which are the sum of many measurements, smaller or larger differences may be present between the English data and my tables. These small discrepancies will perhaps be excused, when the enormous amount of calculating work is considered; I do not believe that any essential error is present, which might lead to erroneous conclusions." In the opinion of the writer of this note there can be no excuse for a slovenly and inaccurate treatment of statistical data, and figures should not be published until errors such as those alluded to by Prof. Heincke have been eliminated.

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## *SURFACE COMBUSTION.*[1]

DURING his researches upon flame,[2] Sir Humphry Davy discovered, in 1817, that the constituents of a combustible mixture will combine slowly below the ignition temperature; this led him to inquire whether, seeing that the temperatures of flames far exceed those at which solids become incandescent, a metallic wire can be maintained at incandescence by the combination of gases at its surface, without actual flame. He thereupon tried the effect of introducing a warm platinum wire into a jar containing a mixture of coal-gas and air rendered non-explosive by an excess of the combustible constituents; the wire immediately became red hot, and continued so until nearly the whole of the oxygen had disappeared.

During the twenty years which followed Davy's discovery, several distinguished chemists (William Henry and Thomas Graham in this country, but more particularly Dulong and Thénard, and independently Döbereiner in France) experimented upon the slow combination of gases at temperatures below the ignition point, in contact with hot solids, whereby it was established (1) that hot solids, and pre-eminently metals of the platinum group, have the power of inducing gaseous combustion at relatively low temperatures; and (2) that hydrogen is, of all combustible gases, the most susceptible to this action.

The mechanism of this induced slow surface combustion formed the subject of a celebrated controversy between Faraday and De la Rive in 1834–5. De la Rive held the view that it consists essentially in a series of rapidly alternating oxidations and reductions of the surface; Faraday, on the other hand, contended that the function of the surface is to condense both the oxygen and the combustible gas, thus producing in the surface layers a condition comparable to that of high pressure. But, owing to lack of crucial experiments, no satisfactory theory of the phenomenon could be evolved, nor, with the exception of the famous "Döbereiner lamp," was there any practical outcome of this early work. In 1836 interest in the subject suddenly dropped, and was not revived for half a century.

Meanwhile, the researches of Deville upon the dissociation of steam and carbon dioxide at high temperatures led to the notion, which was strongly upheld by the late Frederick Siemens, that inasmuch as incandescent surfaces promote dissociation, they must necessarily hinder combustion. This, of course, is fallacious; we now recognise that if, as Deville proved, an incandescent surface accelerates the dissociation of steam, it must, according to a principle enunciated by Ostwald, of necessity accelerate the combination of oxygen and hydrogen in like degree, provided always that the surface remains chemically unaltered.

A notable demonstration of the possibility of realising a flameless incandescent surface combustion in contact with metals other than those of the platinum group was given by Thomas Fletcher in a lecture at the Manchester Technical School so far back as 1887.[3] He injected a mixture of gas and air on to a large ball of iron wire, flame being used at first in order to heat the wire to the temperature necessary to induce a continuous surface combustion; on extinguishing the flame, by momentarily stopping the gaseous mixture, the combustion continued without any flame, but with an enormous increase of temperature. Fletcher grasped three important points, namely, (1) that "this invisible flameless combustion is only possible under certain conditions"; (2) "that the combustible mixture shall come into absolute contact with a substance at high temperature . . ."; and (3) that "in the absence of a solid substance at a high temperature, it is impossible to cause combustion without flame"; but, so far as I am aware, he did not follow up the matter beyond this point, either in its theoretical aspects or practical applications, and his work had but little influence upon contemporary opinion or practice.

My own investigations upon surface combustion began in 1902 with a systematic attempt to elucidate the factors operative in the slow combination of hydrogen and of carbon monoxide in contact with various hot surfaces (*e.g.* porcelain, fire-clay, magnesia, platinum, gold, silver, copper, and nickel oxides, etc.) at temperatures below 500°.[4] Into the details of these earlier experiments, which preceded and led up to the technical developments about which I shall speak later, I do not propose to enter; it will be sufficient for my present purpose if I say that it was proved beyond all question:—(1) That the power of accelerating gaseous combustion is possessed by *all* surfaces at temperatures below the ignition point in varying degrees, dependent upon their chemical characters and physical texture; (2) that such an accelerated surface combustion is dependent upon an absorption of the combustible gas, and probably also of the oxygen, by the surface, whereby it becomes "activated" (probably ionised) by association with the surface; and (3) that the surface itself becomes electrically charged during the process. Finally, certain important differences between homogeneous combustion in ordinary flames and heterogeneous combustion in contact with a hot surface from a chemical point of view were established, so that there can be no longer any doubt as to the reality of the phenomenon.[4]

If hot surfaces possess the power of accelerating gaseous combustion at temperatures below, or in the neighbourhood of, the ignition point, the same power must also be manifested in even a greater degree at higher temperatures, and especially so when the surface itself becomes incandescent. Indeed, there are experimental grounds for the belief that not only does the accelerating influence of the surface rapidly increase with the temperature, but also that the differences between the catalysing powers of various surfaces, which at low temperatures are often considerable, diminish with ascending temperatures until at bright incandescence they practically disappear.

Such considerations as I have thus briefly explained

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[1] From a discourse delivered at the Royal Institution on Friday, February 27, by Prof. W. A. Bone, F.R.S.

[2] Collected Works, vol. vi., p. 8.

[3] Journal of Gas Lighting, 1887, i, p. 168.

[4] Bone and Wheeler, Phil. Trans. Roy. Soc., 1906 (A. 206, pp. 1–67), also further (unpublished) results (1905–12) in collaboration with Messrs. G. W. Andrew, A. Forshaw, and H. Hartley, which are summarised in *Berichte der Deutschen Chem. Ges.*, 1913.

convinced me some years ago that if an explosive gaseous mixture be either injected on to or forced through the interstices of a porous refractory incandescent solid under certain conditions, which will be hereafter explained, a greatly accelerated combustion would take place within the interstices or pores, or, in other words, within the boundary layers between the gaseous and solid phases wherever these may be in contact—and the heat developed by this intensified combustion would maintain the surface in a state of incandescence *without any development of flame*, thus realising the conception of *flameless incandescent surface combustion*, as a means of greatly increasing the general efficiency of heating operations wherever it can be conveniently applied.

There are critics who, whilst admitting the accelerating influence of an incandescent surface upon gaseous combustion, are sceptical about the process being really flameless. The force of such objections largely disappear when we get into close quarters with the phenomenon, and realise how extremely slow a transaction flame combustion really is when considered in terms of molecular time. Take, for example, the case of such a quick-burning mixture as electrolytic gas $(2H_2+O_2)$. When this is ignited at atmospheric pressure, the flame is initially propagated by conduction with a uniform slow velocity of 20 metres a second, and during this initial period of "*inflammation*," the total duration of chemical change in each successive layer is something like the order of 1/50 second, an interval of at least one hundred million times as long as the average interval between successive molecular collisions in the gas. Even after "*detonation*" has been set up in the mixture, when the combustion is propagated from layer to layer as a wave of adiabatic compression, at a velocity of 2820 metres a second, the total duration of chemical change is still of the order of 1/5000 or 1/10,000 second, or about a million times as long as the interval between successive molecular collisions.

### *The New Processes of Incandescent Surface Combustion.*

Leaving the theoretical aspects of the subject, I will now describe some of the more important features of two processes of incandescent surface combustion evolved at the works of Messrs. Wilsons and Mathiesons, Ltd., in Leeds, under my direction, with the assistance of Mr. C. D. McCourt, in which a homogeneous explosive mixture of gas and air, in the proper proportions for complete combustion (or with air in slight excess thereof), is caused to burn without flame in contact with a granular incandescent solid, whereby a large proportion of the potential energy of the gas is immediately converted into radiant form. The advantages claimed for the new system, now known as the "Bonecourt" system, are:—(1) The combustion is greatly accelerated by the incandescent surface, and, if so desired, may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperatures is possible without the aid of elaborate regenerative devices; and (4) owing to the large amount of radiant energy developed, transmission of heat from the seat of combustion to the object to be heated is very rapid. These advantages are (as I believe) so uniquely combined in the new system that the resultant heating effect is, for many important purposes not only pre-eminently economical, but also easy of control.

### *Diaphragm Heating and its Applications.*

In the first process the homogeneous mixture of gas and air is allowed to flow under slight pressure through a porous diaphragm of refractory material from a suitable feeding chamber, and is caused to burn without flame at the surface of exit, which is thereby maintained in a state of red-hot incandescence. The diaphragm is composed of granules of firebrick, or other material, bound together into a coherent block by suitable means; the porosity of the diaphragm is graded to suit the particular kind of gas for which it is to be used. The diaphragm is mounted in a suitable casing, the space enclosed between the back of the casing and the diaphragm constituting a convenient feeding-chamber for the gaseous mixture which is introduced at the back. Such a mixture may be obtained in either of two ways, namely, (1) by means of suitable connections through a Y-piece with separate supplies of low pressure gas and air (2 or 3 in. W.G. is sufficient), or (2) by means of an "injector" arrangement connected with a supply of gas at a pressure of 1 to 2 lb. per sq. in.; the gas in this case draws in its own air from the atmosphere in sufficient quantity for complete combustion, the proportions of gas and air being easily regulated by a simple device.

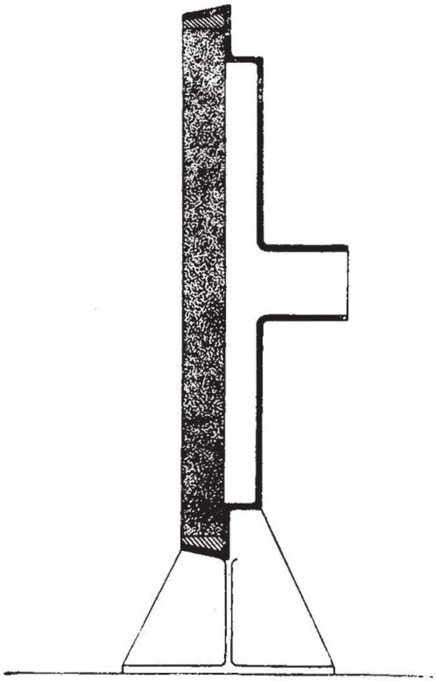

FIG. 1.—Diaphragm.

We will now start up a diaphragm (Fig. 1). Gas is first of all turned on and ignited as it issues at the surface; air is then gradually added until a fully aerated mixture is obtained. The flame soon becomes non-luminous, and diminishes in size; a moment later, it retreats on to the surface of the diaphragm, which at once assumes a bluish appearance; soon, however, the granules at the surface attain an incipient red heat, producing a curious mottled effect; finally, the whole of the surface layer of granules becomes red-hot, and an accelerated "surface combustion" comes into play. All signs of flame disappear, and there remains an intensely glowing surface throwing out a genial radiant heat which can be steadily maintained for as long as required.

Whilst the diaphragm is in operation before you, I may point out some of the more striking features of the phenomenon which it presents. First, the actual combustion is confined within a very thin layer—$\frac{1}{8}$ to

¼ in. only—immediately below the surface, and no heat is developed in any other part of the apparatus. Kindly observe that while the front of the diaphragm is intensely hot, the back of the apparatus is so cold that I can lay my hand on it. Secondly, the combustion of the gas, although confined within such narrow limits, is perfect; for when once the relative proportions of gas and air have been properly adjusted, no trace of unburnt gas escapes from the surface. Thirdly, the temperature at the surface of the diaphragm can be instantly varied at will by merely altering the rate of feeding of the gaseous mixture; there is practically no lag in the temperature response, a circumstance of great importance in operations where a fine regulation of heat is required. Fourthly, a plane diaphragm such as this may be used in any position, *i.e.* at any desired angle between the horizontal and vertical planes. Fifthly, the diaphragm method is amenable to a variety of combustible gases—coal or coke oven gas (either undiluted or admixed with water gas), natural gas, petrol-air gas, carburetted water gas are all well suited in cases where unimpeded radiation is required. Finally, the incandescence in no way depends upon the external atmosphere. When once the diaphragm has become incandescent, and the proportions of air and gas supplied in the mixing chamber at the back have been properly adjusted, the surface will maintain its incandescence unimpaired, even in an atmosphere of carbon dioxide.

I need scarcely point out to you the many obvious purposes, domestic and industrial, to which "diaphragm heating" may be applied. In the domestic line the boiling of water, grilling, roasting, and toasting are at once suggested, and although the best existing types of gas fires are thoroughly hygienic and efficient, I think that the diaphragm may come in for the heating of apartments; at any rate experiments are being carried out in that direction.

### *Incandescent Surface Combustion in a Bed of Refractory Granular Material.*

The second process is applicable to all kinds of gaseous or vapourised fuels; it consists essentially in injecting, through a suitable orifice at a speed greater than the velocity of back-firing, an explosive mixture of gas (or vapour) and air in their combining proportions into a bed of incandescent granular refractory material which is disposed around or in proximity to the body to be heated (Fig. 2).

This process is capable of adaptation to all kinds of furnace operations, as, for example, to the heating of crucibles, muffles, retorts, and to annealing and forging furnaces generally. Moreover, it is not essential that the bed of refractory material should be very deep; indeed a quite shallow bed suffices to complete the combustion. Neither is it necessary that the bed shall be disposed *around* the vessel or chamber to be heated; for if contact with the burnt products is not objectionable, a shallow bed may be arranged *within* the heating chamber itself; or the refractory material may be equally well packed into tubes, or the like, traversing the substance or medium to be heated. The last-named modification is, as we shall see later, specially important in relation to steam-raising in multitubular boilers.

By means of this process much higher temperatures are attainable with a given gas than by the ordinary methods of flame combustion without a regenerative system, and, as a matter of fact, we have found that with any gas of high calorific intensity (such as coal gas, water gas, or natural gas) the upper practicable temperature limit is determined by the refractoriness of the material composing the chamber to be heated (*i.e.* the muffle or crucible) rather than by the possibilities of the actual combustion itself. When I tell you that in a crucible fired by coal gas on this system we have melted Seger-cone No. 39, which according to the latest determination of the German Reichsanstahlt melts at 1880° C. (3416° F.), and also that we can easily melt platinum, you will appreciate the possibilities of the method in regard to high temperatures with gas-fired furnaces.

### *Surface Combustion as Applied to Steam Raising.*

I now come to an important application of the new process to the raising of steam in multitubular boilers; not that the application of surface combustion is limited to boilers of the multitubular type, but because our investigations have so far been principally made with these.

Our first experiments in Leeds were made with a single steel tube 3 ft. in length and 3 in. in diameter, packed with fragments of granular refractory material, meshed to a proper size, and fitted at one end with a fire-clay plug, through which was bored a circular hole, ¾ in. in diameter, for the admission of the explosive mixture of gas and air at a speed greater than that of back-firing. The tube was fitted into an open trough, in which water could be evaporated at atmospheric pressure.

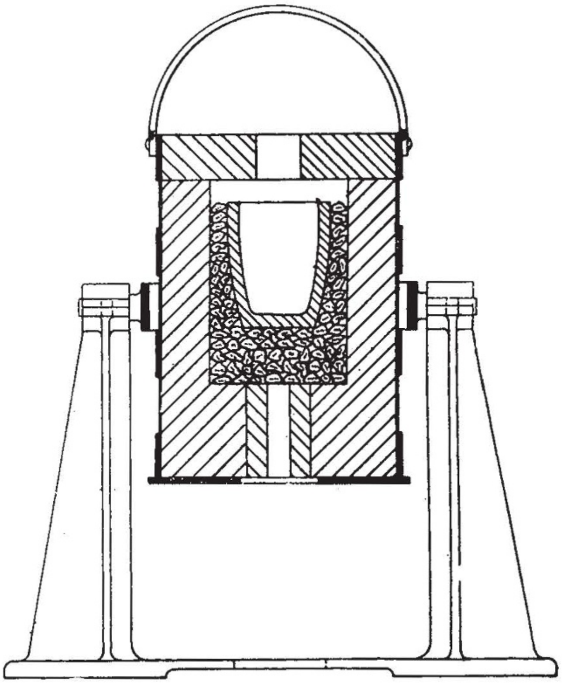

FIG. 2.—Crucible furnace.

Such a tube may be appropriately termed the fundamental unit of our boiler system, because boilers of almost any size may be constructed merely by multiplying the single tube, and as each tube is, so to speak, an independent fire or unit, the efficiency of the whole is that of the single tube, or, in other words, the efficiency of the whole boiler is independent of the number of tubes fired.

Experimenting with such a tube, it was found possible to turn completely a mixture of 100 cu. ft. of coal gas plus 550 cu. ft. of air an hour, and to evaporate about 100 lb. of water from and at 100° C. (212° F.) an hour (20 to 22 lb. per sq. ft. of heating surface), the products leaving the further end of the tube at practically 200° C. This meant the transmission to the water of 88 per cent. of the net heat developed by the combustion, and an evaporation per sq. ft. of heating surface nearly twice that of an express locomotive boiler. The combustion of the gas was completed within 4 or 5 in. of the point where it entered the tube, whilst the temperature of the products leaving the tube was about 200° C. Of the total evaporation, no less than 70 per cent. occurred over the first linear foot of the tube, 22 per cent. over the second foot, and only 8 per cent. over the last foot. This points to a very effective "radiation" transmission from the incandescent granular material in the first third of the tube, where the zone of active combustion is located, although it should be remarked that the *loci* of actual contact between the incandescent material and the walls of the tube are so rapidly cooled by the transmission of heat to the water on the other side that they never attain a temperature even approaching red heat. The granular material in the remaining two-thirds of the tube serves to baffle the hot products of combustion, and to make them repeatedly impinge with high velocity against the walls of the tube, thus materially accelerating their cooling, and either preventing or minimising the formation of the feebly-conducting stationary film of relatively cold gases which in ordinary boiler practice clings to the tube walls, seriously impairing the heat transmission.

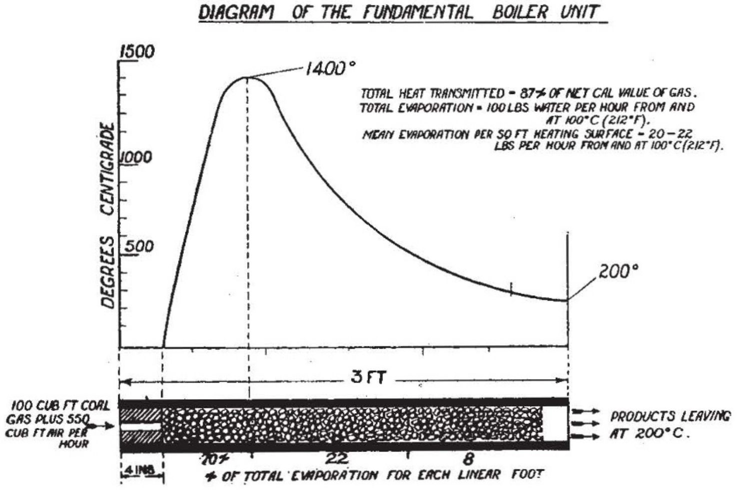

FIG. 3.—Fundamental boiler unit.

Having thus satisfied ourselves of the efficiency of the fundamental unit as an evaporator, we proceeded to construct our first experimental boiler, made up of ten tubes, each 3 ft. long and 3 in. in diameter, fixed horizontally in a cylindrical steel shell capable of withstanding a pressure of more than 200 lb. per sq. in. The gaseous mixture was forced through the tubes under pressure from a special feeding chamber attached to the front plate of the boiler; the products of combustion, after leaving the boiler, passed through a small feed-water heater containing nine tubes, each 1 ft. long and 3 in. in diameter, filled with granular material to facilitate the exchange of heat.

This combination of boiler and feed-water heater proved remarkably successful in every way; its thermal efficiency was 94 per cent., with an evaporation of from 21 to 33 lb. per sq. ft. of heating surface per hour.

*The 110-Tube Boiler at the Skinningrove Ironworks.*

Six months' continuous experience with our first experimental unit gave us great confidence in its trustworthiness, so that when in the early months of 1911 we received an inquiry from the Skinningrove Iron Co., Ltd., for a boiler of about ten times the capacity of the experimental unit, to be fired by means of the surplus gas from their new Otto by-product coking-plant, we had no hesitation in accepting a commission to install our first large boiler there, under a strict guarantee as to its output and efficiency.

The plant was successfully started up on November 7, 1911, for a month's trial run—day and night continuously—after which it was opened up for an official inspection by the representative of a Boiler Insurance Company. Everything worked without a hitch during this trial; steam was generated at 100 lb. gauge pressure, from a feed-water of about 4° of hardness, whilst the average temperature of the waste gases leaving the feed-water heater was reduced to 80° C. (say 175° F.), a sure indication of the high thermal efficiency of the plant. When, at the conclusion of the month's trial, the boiler was opened up for inspection, the combustion tubes were found to be in good condition and free from scale; indeed, owing to the extremely high rate of evaporation, the scaling troubles experienced with other types of multitubular boilers appear to be completely obviated, the scale being automatically and continuously shed from the tube in thin films (about 1/30 in. thick) as fast as it is formed; a very important advantage, as anyone who is plagued by scaling troubles will appreciate. An independent trial of the plant on July 29, 1912, gave a thermal efficiency of 92 7 per cent.

Within the last few months the firm of Krupps have put down a boiler in connection with one of their coking plants in the Ruhr district of Westphalia, from the plans of the Skinningrove plant. This boiler has been running successfully since October last, and about three weeks ago underwent its official steam trials, which were carried out by the Bergbauliche Verein. Pending the official publication of the results in the German technical Press, I am precluded from giving any details now, but, I am informed, that they have entirely confirmed the Skinningrove trial.

I have perhaps said enough already about the boiler and its working to convince you that it combines high thermal efficiency and concentration of power, in a unique degree, and perhaps I may be permitted to summarise the other important advantages which may be claimed for it. First, from the constructional point of view, nothing could be simpler or more compact than a cylindrical shell only 4 ft. long by 10 ft. in diameter, traversed by straight tubes, supported on a casting, and requiring neither elaborate brickwork setting nor expensive chimney flues and stack. Secondly, it has a further advantage over all multitubular boilers in that the front plate can never be heated beyond the temperature of the water, however much the firing may be forced, a circumstance which, coupled with the extremely short length of the tubes, implies an absence of strain and greatly reduces the risk of leaky joints. Thirdly, the high rate of mean evaporation obviates scaling troubles, and the very steep evaporation gradient along each tube causes a considerable natural circulation of water in the boiler, a factor of great importance from the point of view of good and efficient working; in this connection I may remind you that under normal working conditions we obtain a *mean evaporation* of 20 lb. per sq ft. of heating surface an hour, and can, if need be, force this up to 35 lb.; of this total evaporation, 70 per cent. occurs over the first *third* length of the tube, 22 per cent over the *second* third, and only 8 per cent. over the last third. Fourthly, inasmuch as each tube of the boiler is, so to speak, an independent combustion unit, capable of being shut off or lit up without affecting the others, and as it only takes five minutes after lighting up a cold tube to attain its maximum steam output, it is obvious that not only is such a boiler highly responsive to rapid variations in the load, but also it works with equal efficiency at both small and big loads; indeed, within very wide limits, its efficiency is practically independent of the load.

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## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

ABERDEEN.—Lord Elgin has been elected Chancellor of the University in succession to Lord Strathcona.

LONDON.—The following courses of advanced lectures, addressed to students of the University and to others interested in the respective subjects, to which admission is free without ticket, are announced in the issue of the *London University Gazette* of April 8:—Five lectures on the earlier Palæozoic land plants at University College, by Dr. D. H. Scott, on Wednesdays, May 6 to June 3; two lectures on plant pigments at University College, by Prof. R. Willstätter, professor of chemistry in the University of Berlin, on Monday, May 4, and Tuesday, May 5; two lectures, in French, entitled "La Catalyse, et mes divers travaux sur la Catalyse," at King's College, by Prof. Paul Sabatier, of the University of Toulouse, on Thursday, May 14, and Friday, May 15; eight lectures on the rate of the blood-flow in man in health and disease, in the Physiological Laboratory of the University, South Kensington, by Prof. G. N. Stewart, professor of experimental medicine, Western Reserve University, Cleveland, U.S.A., on Tuesdays, May 5–23; eight lectures on oxidation in the tissues, at University College, by Dr. C. Lovatt Evans, on Fridays, May 8 to June 26; four lectures on the regulation of the composition and volume of the blood, in the Physiological Laboratory of Guy's Hospital, by Dr. J. S. Haldane, on Thursdays, May 7–28; four lectures on the gaseous exchanges of the body, in the Physiological Laboratory of King's College, by Prof. T. G. Brodie, professor of physiology in the University of Toronto, on Monday, June 8, Wednesday, June 10, Monday, June 15, and Wednesday, June 17; three lectures on the morphology of the cranial muscles in vertebrates, in the Zoological Department, University College, by Prof. F. H. Edgeworth, professor of medicine in the University of Bristol, on Monday, May 4, Tuesday, May 5, and Wednesday, May 6; five lectures on the measurement of social phenomena, at the London School of Economics and Political Science, by Dr. A. L. Bowley, University reader in statistics, on Mondays, April 27 to May 25.

Among the public lectures, to which admission is free without ticket, announced to be delivered at University College during the third term of the present academic year, the following may be mentioned:—Four lectures on the ethnology and pathology of the ancient Egyptians, by Dr. D. E. Derry, beginning on May 5, at 5 p.m.; a lecture on Ptolemy's map of Germany and the Cimbric Chersonese, by Prof. Gudmudd Schütte, on May 11, at 5 p.m.; an introductory lecture on recent discoveries in Egypt, by Prof. Flinders Petrie, on May 21, at 2.30 p.m.

GLASGOW.—The following doctorates were among the degrees conferred on April 20:—Doctor of Philosophy (D.Phil.): L. J. Russell; thesis, "The Development of the Philosophy of Leibniz, 1666–86." Doctors of Science (D.Sc.): Margaret B. Moir; thesis, "The Influence of Temperature on the Magnetic Properties of Carbon Steels; Sensitive Magnetic State induced by Thermal Treatment and by Strain; Magnetic Properties of Chrome Steels at Ordinary and Low Temperatures: Permanent Magnetism of Chrome Steels; with other papers." F. Mort; thesis, "North Arran: a Physiographic Study; with others papers." Maggie M. J. Sutherland; thesis, "Camphenanic Acid, its Isomers and Derivatives; with other papers."

*Science* states that a contribution of 10,000*l.* from Mrs. E. H. Harriman to the endowment fund of Barnard College, Columbia University, is announced toward the million dollar fund now being raised for the twenty-fifth anniversary of the institution. The amount now promised is 110,000*l.*

MR. H. NORMAN EDGE has been appointed honorary lecturer on meteorology to the Lancashire (Navy League) and National Sea Training Homes. As increased attention is now being given to the subject of marine meteorology, and a number of vessels keep a four-hourly log, the instruction in the keeping of the meteorological log to boys being prepared for a seafaring life is of real practical value.

IT is announced in the *Times* that the late Mr. H. B. Noble, of Douglas, Isle of Man, left practically all his large estate for educational and charitable purposes in the island. The trustees of his will have decided to devote 20,000*l.* for the fostering of agriculture in the island. In connection with this gift a Bill has been introduced into the Manx Legislature constituting a Board of Agriculture for the island. The Board will administer the income arising from the gift, and will, in addition, have a fund placed at its disposal by the Government of the island.

A COMPREHENSIVE resolution dealing with the age of exemption from attendance at school, continuation classes, and child labour, was passed by the National Union of Teachers at the Lowestoft conference on April 15. The resolution, which was moved by Mr. G. Sharples, was as follows:—That all regulations recognising the half-time system, labour examinations, and other forms of early exemption from attendance at school should be abolished; that no child should be exempt from attending under the age of fourteen; that local authorities should be empowered to make by-laws requiring the attendance of children up to the age of fifteen; that all wage-earning work, and particularly all street trading, should be prohibited for all children under fourteen, both in urban and rural districts; and that a system of compulsory attendance at continuation classes should be established for children between the ages of fourteen and eighteen who are not otherwise receiving a suitable education, such a system to be accompanied by a statutory limitation of the hours of child labour.

A WEAK point in most of the Continental educational systems is that there is no easy bridge by which the public elementary and trade continuation class pupil can pass into the higher ranks of his vocation and complete his studies in the polytechnic or university. The avenue to these higher institutions is almost solely through the gymnasial secondary schools. In the facilities offered by scholarships for the transference of gifted pupils from primary schools to secondary schools and through these to universities and like places of advanced learning, we have nothing to learn from Continental methods. The scholarship systems of the education authorities of English counties and county boroughs provide the means by which any elementary-school pupil of little more than average