ample density without it; no clearing baths are necessary, and the original developer works excellently for the second treatment—in all these details the manipulation of the new plate is simpler than what is desirable, if not necessary, in the case of the autochrome. The colours of the omnicolore plate are much more transparent than those of the autochrome, being applied as paints or varnishes instead of being absorbed by translucent starch granules; but this method has its drawbacks as well as its advantages, for the density of the colour is not even all over each little patch of red and green. The colour is lighter towards the margins of the patches, and their shapes, too, are rather irregular, but doubtless improvements will be made in these directions. The plates, as they are, are simple and easy to manipulate, and give results that must be distinctly useful to those who wish to reproduce, or, more correctly, to imitate, by the simplest known method, the colours of the objects they photograph.

OUR ASTRONOMICAL COLUMN.

Observations of Comet Morehouse.—Comet 1908*c* was observed, with the 284 mm. Amici equatorial, at Arcetri on forty-one days between September 4 and December 7, 1908, and 127 determinations of its position were made with the micrometer. These are now recorded by Prof. Abetti in No. 4316 of the *Astronomische Nachrichten*, together with a valuable set of notes describing the comet's visual appearance on a number of days.

Mr. Metcalf's note and excellent photographs are also reproduced, from the Harvard Circular No. 148, in the same journal.

A series of six photographs taken at the Dominion Observatory, Ottawa, between October 6 and November 26, is reproduced and described by Mr. Motherwell in No. 1, vol. iii., of the Journal of the Royal Astronomical Society (Canada). The comet was visible at Ottawa for more than three months, but dense smoke and unusual cloudiness prevented an extensive series of photographs from being obtained. Those reproduced show similar knots in, and displacements of, the tail-matter, as previously recorded. On October 20 the head of the comet passed over an eighth-magnitude star without perceptibly dimming it.

Observations of the comet, made with a sextant on board the German steamship *Paranaguà*, are recorded in No. 4317 of the *Astronomische Nachrichten*.

Measures of Double Stars.—The micrometer measures of double stars made by Dr. Lau and Herr Luplau-Janssen at the Copenhagen Observatory during 1908 are recorded in No. 4315 of the *Astronomische Nachrichten*. The stars observed chiefly lie between declinations 0° and 20°, special attention having also been paid to neglected pairs. In addition to the date, position-angle, and distance, the authors give brief notes concerning the colours of the components, and, where possible, compare the values obtained with those computed from previously published elements.

Diameter and Position of Mercury.—In these columns on December 24, 1908 (No. 2043, vol. lxxix., p. 232), we noted the corrections to the diameter and position of Mercury, derived by Prof. Stroobant from the observations of the transit of the planet, on November 14, 1907, made at thirty-three observatories. Since the publication of the memoir in which he gave those corrections, Prof. Stroobant has received observed values from eleven additional observers, and has incorporated them in the final results which appear in No. 4317 of the *Astronomische Nachrichten*.

These show, from the time between first and second contact, that the planet's apparent diameter was $9''.166$, whilst the observations of the third and fourth contacts give, similarly, $9''.092$. These values correspond to diameters, at unit distance, of $6''.20$ and $6''.15$ respectively, the latter being probably the more correct.

The corrections to the equatorial and ecliptical coordinates are found to be $\Delta\alpha = +0.070s.$, $\Delta\delta = -0''.25$, and $\Delta\lambda = +1''.03$, $\Delta\beta = +0''.02$, respectively, in the sense observed-calculated.

The agreement of the Italian observations of this passage of Mercury with the data given in various ephemerides is discussed by Signor Pio Emmanuelli in No. 110 of the *Revista di Fisica, Matematica e Scienze Naturali* (Pavia) for February.

The Vatican Observatory.—We learn from the *Times* Milan correspondent that the inauguration of the new section of the Vatican Observatory, which was to have taken place on March 18, was postponed because one of the components of the 40-cm. object-glass for the new equatorial refractor was found to be defective, and has to be re-cast.

When this new section is complete the Gregorian Specola will be abandoned, and the whole of the observatory will be located on the summit of the Vatican hill, 100 metres above the square of St. Peter's, where Father Lais has been engaged, since 1891, in taking the photographs for the International Astrographic Chart (the *Times*, Engineering Supplement, April 7).

PRODUCER GAS FOR ENGINES.

I.—Processes and Plants.

It is well known that what is technically called 'producer gas" has been in use for many years in connection with furnace work. Herr Bischof, of Mägdesprung, was the first to use an internally fired gas producer for this purpose in 1839; but little progress was made in our country until 1857, when the late Sir William Siemens introduced the combined gas producer and regenerative furnace with which his name is associated. Some twenty years later it occurred to me that a gas engine might be worked with producer gas if a suitable plant were devised. For furnace work the hot gas is taken direct from the producer to the furnace without cooling or cleaning, and the condensable hydrocarbon vapours, which usually accompany the gas, and add appreciably to its value, are burnt. But for engine work it is essential to wash and clean the gas, especially as it must be free from tar. It is also desirable that the gas should be cool when it enters the cylinder of the engine. Incidentally, this involves the removal by condensation, &c., of the condensable hydrocarbons which leave the producer, and after their removal the gas must still be strong enough to fire well and give good working results in the engine. I succeeded in making a suitable plant, and it was first tried with a small Otto engine in 1879; the results were good, and they encouraged the makers of the engines to build them of larger size so as to compete favourably with steam-power. Many thousands of horse-power are now working with gas plants of this type, and during the last few years a still further impetus has been given to the subject by the use of a modified plant, which is known among engineers as a *suction plant*, and which will be more fully described later.

For the moment we will consider briefly the process of making producer gas, and some of the chemical reactions involved. Producer gas is made by forcing or drawing air, with or without the addition of steam or water vapour, through a deep bed of incandescent fuel in a closed producer. Usually the fuel is fed in at the top, and the currents of air, or of steam and air, enter at the bottom, the gas outlet being near the top. An important characteristic of the process is that no external heat is applied to the producer, as in the case of an ordinary gas retort. When once the burning of the fuel *inside* the producer has been started, the air which is used to make the gas keeps up a continuous process of combustion, and a sufficiently high temperature is maintained to decompose the steam and to effect other necessary reactions.

We know that if there were a shallow fire of carbonaceous fuel and a sufficient supply of air, the carbon would be completely oxidised. The product of this complete combustion would be carbon dioxide, with the development of a large amount of sensible heat; but if there were a considerable depth of carbon in the producer (as there should always be in practice) the resulting gas would be carbon monoxide instead of carbon dioxide, for when there is an excess of highly heated carbon the dioxide formed in the lower part of the fire is reduced to the monoxide. Carbon monoxide may also be formed by the direct combustion of the carbon with oxygen, and actually both these reactions may, and probably do, occur. Theoretically, if we were dealing only with carbon and air, about 30 per cent. of the heat of combustion would be liberated in the producer, and about 70 per cent. would be liberated when the carbon monoxide is afterwards burnt to carbon dioxide in a furnace or engine, &c.; the practical result, however, is still less favourable, and *primâ facie* the conversion of solid fuel into gas does not seem a promising performance.

It is true that not all the heat set free in the producer need be lost if the gas can be used while it is hot (as in furnace work); but for gas engines it must be cold. Apart from this, the liberation of so much sensible heat in the producer overheats it, and indirectly it promotes the formation of clinker, which is a practical drawback. To avoid these and other difficulties, the almost invariable practice is to add a certain proportion of steam or aqueous vapour to the air sent into the producer.

It should, however, be clearly understood that from the point of view of the heat quantities involved, the use of steam in a gas producer is simply a means for absorbing the sensible heat developed by the partial combustion of the fuel, and storing it for future use. Obviously there can be no actual increase of the total amount of heat which can be obtained from a given quantity of fuel. Besides avoiding excessive heat in the producer, the use of steam has the further practical advantage that a gas of considerably greater calorific power per unit volume can be obtained than is possible when air alone is used. The use of air necessarily involves the presence of the diluent nitrogen, and when steam is decomposed the resulting hydrogen and carbon monoxide displace some of the nitrogen.

With the exception of coke and charcoal, all ordinary fuels give off volatile substances when subjected to heat; and in a gas producer, working in the ordinary way with an upward draught, each fresh charge of fuel is heated, and is then subjected in some degree to a process of distillation before it descends into the zone where partial combustion takes place. The gas actually obtained may therefore be regarded as producer gas obtained from carbon, mixed with the volatile substances given off by the distillation. The actual composition of the gas depends a good deal on the nature and amount of these volatile substances, and they vary considerably, the fuels used being chiefly anthracite, coke, and bituminous or semi-bituminous coal. Both these coals give off a considerable quantity of tarry matter, which may represent as much as 8 per cent. or 9 per cent. of the total heat value of the fuel. When the gas is cooled and scrubbed before use, the tar which is removed has little value; it is therefore desirable that producers should be designed to burn the tar in the producer itself, or to decompose it and convert it into combustible gases which will not condense at ordinary temperatures. Even anthracite when heated yields both hydrogen and methane, and this is why it makes a better gas than coke.

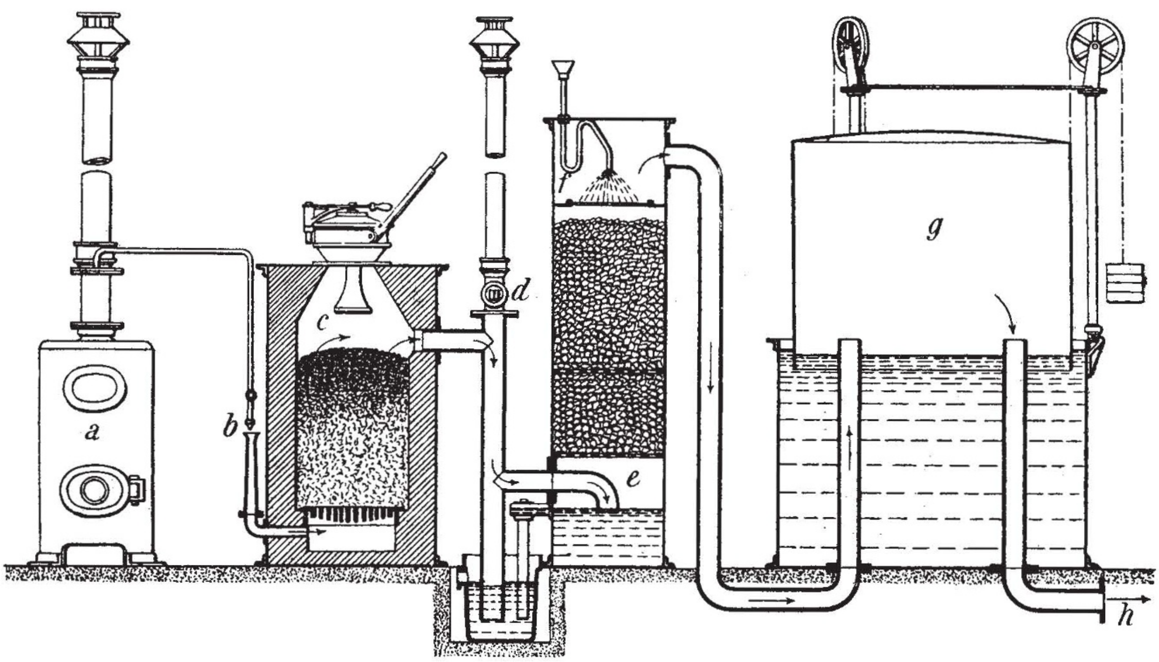

FIG. 1.—*Steam-jet pressure plant.* *a*, superheating steam boiler; *b*, steam jet and air injector; *c*, gas producer; *d*, waste cock and pipe; *e*, coke scrubber with water seal; *f*, water sprayer; *g*, gas-holder and tank; *h* gas outlet.

We are therefore led to consider how steam reacts with the carbon with which it comes in contact. If the carbon is at a sufficiently high temperature, the steam (H_2O) is decomposed, and an equal volume of hydrogen is produced; the oxygen of the steam combines with the carbon to form either carbon monoxide or carbon dioxide, according to the conditions under which the reaction takes place. When hydrogen combines with oxygen to form water vapour heat is liberated, and when this water vapour is decomposed by the reaction of highly heated carbon (or by any other means) an equal amount of heat is absorbed. The combination of the oxygen of the steam with the carbon is accompanied by the evolution of heat, but the quantity of heat thus evolved is much less than the quantity of heat absorbed by the decomposition of the steam, and this is why the addition of small quantities of steam to the air going into the producer reduces the working temperature. Part of the sensible heat is absorbed by the reactions which take place between the steam and the incandescent carbon, so that the gas leaves the producer at a lower temperature than is the case when air alone is used; the heat so absorbed is stored up in the gas, and is again set free when the gas is burnt.

In Fig. 1 we give a typical example of a gas plant in which the producer is worked with a jet of superheated steam which injects the air required.

In some plants the steam required is produced by the sensible heat of the gas after it has left the producer, and this effects a certain saving; but even then the gas must leave the steam-raising apparatus at a higher temperature than that of the steam, and there is still a considerable loss of heat when the gas is cooled for use in an engine. There is also the loss due to radiation from the producer. Other conditions which have to be considered are the depth of fuel, its porosity, the size of the pieces used, and the velocity of the air blast—all are interdependent; for example, the depth of fuel required to give the best results will depend on the nature of the fuel, its size, and the velocity of the currents passing through it. It is obviously desirable that this velocity should not be excessive, and the producer should have a sectional area large enough for a given maximum rate of production.

The fuel consumption and the cost of repairs with a gas engine worked with a pressure plant, as shown in Fig. 1, have been much lower than can possibly be obtained with the best steam engines and boilers of the same horse-power; but in recent years the modification called a suction plant has given even better economical results for moderate powers. In some of the early gas producers for furnace work air was drawn into the producer by suction, instead of being forced in under pressure, and the idea of working the producer by suction has been reverted to in connection with gas engines. In 1862 Dr. Jacques Arbos, of Barcelona, patented a combination of gas plant and gas engine in which the latter drew gas direct from the producer. It was not a very practical arrangement, and the charge of gas and air was not compressed before ignition, but it deserves to be mentioned as one of the early suction plants devised. The first to give effect to this idea in a practical way, in a compression engine, was M. Léon Bénier, of Paris. His first patent was in 1891, and he afterwards took out others; the engine had a suction pump by the side of the motor cylinder, and this pump was connected by a pipe with the outlet of the gas plant. As soon as the fire was lighted it was blown up with a hand-power fan, and when the gas was good enough to work the engine the latter was started. The pump on the engine then drew gas from the producer and forced it into the motor cylinder. This suction of gas from the producer lowered the pressure in the latter, and as a consequence air from the outside flowed in. Steam was produced in the apparatus and mixed with the air, so that both steam and air were drawn together into the fire. By suitable adjustments the volume of air drawn in varied with the rate at which gas was consumed in the engine; in other words, the rate of producing the gas was governed automatically by the engine itself, and the gas-holder and the independent boiler used in a pressure plant were dispensed with. As this plant, and those of which it is the type, work by suction, they are now generally known as suction plants, to distinguish them from pressure plants worked by air and steam at pressure.

The results obtained with this combination of gas plant and engine were disappointing, and the fuel consumption with a full load was greater than with a pressure plant; with a low load it was relatively worse. The gas was poor in quality compared with that made in a pressure plant, and there were other drawbacks; but the idea was an ingenious one, and it was seen that the working of a plant by suction, in combination with an engine, would have distinct advantages if the practical details could be worked out satisfactorily. Several engineers gave their attention to the subject, and the next step of importance was to do away with the pump on the engine and to use the suction of the engine itself, *i.e.* the suction caused by the out-stroke of the piston in the motor cylinder, to draw gas from the gas plant. This reduced appreciably the loss from friction. Various methods have also been devised for producing the steam required and for removing the clinker formed in the producer, as those adopted by M. Bénier were not satisfactory. In Fig. 2 we give a typical example of a modern suction plant.

The production of the steam required to make gas of good quality and to keep the temperature of the fire low enough to prevent the formation of an excessive amount of clinker, presents many difficulties. Steam at pressure is not needed, and some makers have a water vapouriser inside the producer, sometimes near the bottom of the fire, but more often near the top. They heat it by the fire or by the hot gas which leaves the fire, and in some cases both these sources of heat are used. On the other hand,

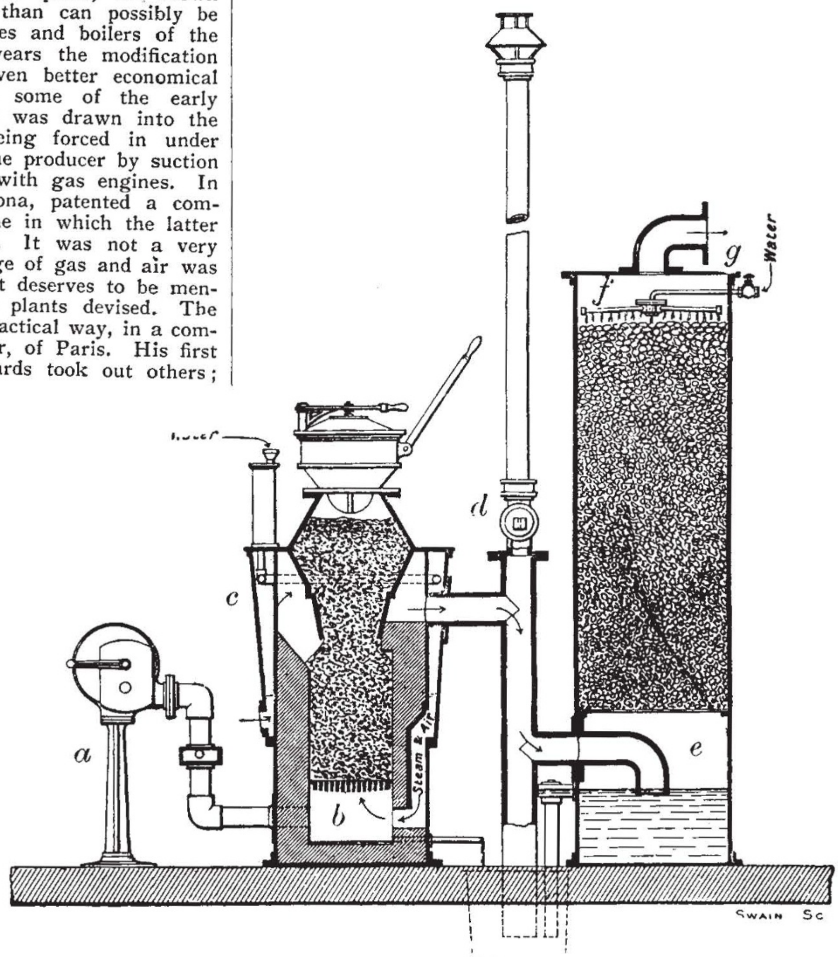

FIG. 2.—*Suction plant.* *a*, starting fan; *b*, gas producer; *c*, water vaporiser; *d*, waste cock and pipe; *e*, coke scrubber with water seal; *f*, water sprayer; *g*, gas outlet.

some makers prefer to have the vapouriser outside the producer, and to heat it by the sensible heat of the gas after it has left the producer. The latter system has the advantage of cooling the gas more, but the amount of steam raised is less than in other systems, and there is the risk that gas will not always be hot enough to make the full quantity of steam required. This not only affects the percentage of hydrogen, &c., in the gas, but has an important bearing on the formation of clinker.

Apart from producing a sufficient quantity of steam when the maximum volume of gas is required, there is the further necessity for regulating the quantity of steam drawn into the fire when the load on the engine is variable. By some it has been supposed that when less gas is produced, *i.e.* when less air is drawn into the fire, the lowering of the temperature which follows causes less steam to be produced, and that in this way the quantity of steam produced is proportional to the quantity of gas required. This is only partly true, as actually the temperature of the fire does not vary as quickly as the load on the engine may vary, and although there may be a considerable fall in the load, there is usually heat enough in the fire to produce more steam than is then desirable. If this excess of steam continues, it not only causes an excess of carbon dioxide to be formed, but it damps down the fire. Then, when the load is increased suddenly, the temperature of the fire is not high enough to develop the power required. Some makers of suction plants try to get over this difficulty by having regulating valves worked by the engine, by means of which the admission of steam to the fire is governed by the engine. Some merely allow a vent in the vapouriser for the excess of steam to escape when the load is reduced, some make no special provision at all, while others use the suction of the engine to draw water into the vapouriser in very small quantities, just enough at each suction-stroke to give the steam required for the quantity of gas to be consumed. This can only be done provided the vapouriser flashes the water into steam; if the vapouriser holds a body of water, as in a boiler, steam is given off continuously, and although there might be a governing of the feed-water, the quantity of steam produced would not be governed. J. EMERSON DOWSON.

(*To be continued.*)

THE SCOPE OF EUGENICS.

THE first edition of the Robert Boyle lecture "On the Scope and Importance to the State of the Science of National Eugenics," delivered by Prof. Karl Pearson in 1907 before the Oxford University Junior Science Club, being out of print, the author has re-issued the same through Messrs. Dulau and Co. as the first of a "Eugenics Laboratory Lecture Series," intended to place the purport of the investigations conducted in that laboratory before the public in a simple form. The series should serve a useful purpose, as many of the original memoirs are somewhat repellent even to a reader of rather more than average intelligence owing to the use of highly specialised statistical methods. A translation of the lecture into German, by Dr. H. Fehlinger, has been published by the firm of Teubner (Leipzig and Berlin) in the *Archiv für Rassen- und Gesellschafts-Biologie*.

In the present lecture Prof. Pearson gives in brief the whole eugenics argument. "The Darwinian hypothesis asserts that the sounder individual has more chance of surviving in the contest with physical and organic environment. It is therefore better able to produce and rear offspring, which in their turn inherit its advantageous characters. Profitable variations are thus seized on by natural selection, and perpetuated by heredity." If these ideas apply to the case of man, "we must have evidence (1) that man varies; (2) that these variations, favourable or unfavourable, are inherited; (3) that they are selected." On the first head special evidence is hardly necessary; our own eyes afford evidence day by day that man varies, but there is plenty of definite knowledge also as to the amount and magnitude of variation. There is similarly a growing mass of evidence that such variations are not mere individual fluctuations, but are heritable. On the third head, however, the evidence is weaker and somewhat conflicting. In the population at large, natural selection appears to be operative to a greater or less extent, as we find that the age at death is inherited. It would be quite possible, however, for that selection to be ineffective if the weaker stocks nevertheless survived to a sufficient age to reproduce their kind as freely as the stronger stocks, and this seems to be the case to a large extent. The families of deaf-mutes, the tuberculous, and the mentally defective are as large as those of normal individuals, and the lower we go from one social grade to another the higher does the fertility rise. In these facts lies the stimulus to possible action directed towards the betterment of the race, negatively by placing hindrances in the way of the reproduction of the hopelessly unfit, positively by creating an altered tone and public spirit which may lead to a more normal and less restricted reproduction of the prosperous and the intellectual classes.

If one sentence may be cited with special approval, it is a statement near the commencement of the lecture:—"Our science does not propose to confine its attention to problems of inheritance only, but to deal also with problems of environment and of nurture." The improvement of the environment is as much a method of improving the qualities of future generations as the method of selection, not, of course, because somatic variations are heritable (which we do not believe that they are), but because the improvement of the environment endures. In so far as housing, education, and the treatment of the diseased are improved in this generation, the next starts from a fresh basis. Eugenic and eugeic methods should aid each other, and racial improvement be based on care of both the seed and the soil. Hitherto the methods have been too often treated as if they were opposed.

SCIENTIFIC WORK OF THE LOCAL GOVERNMENT BOARD.

THIS report[1] of the Local Government Board is the first to be submitted by Dr. Newsholme, and in the introduction he pays a graceful tribute to the work of the retiring principal medical officer, Sir William Power.

The vaccination returns show a slight increase in the percentage of births vaccinated and of infants exempted under certificates of "conscientious objection."

In the appendix on auxiliary scientific investigations carried out for the Board, Dr. Klein has continued his studies on immunity in plague, and shows that a watery extract of the liver and spleen of a rabbit which has recovered from an attack of plague possesses curative properties.

Drs. Andrewes and Gordon contribute a report on the defensive mechanisms of the body against infection by the pyogenic cocci, and, while admitting that the chief means of defence is a phagocytic one, conclude that the bacteriolytic power of the body fluids is by no means negligible.

Dr. Andrewes has also investigated the micro-organisms present in sewer air, with the result that the bacteria of sewage are to be found in the air of sewers and drains, and that therefore sewage in certain circumstances gives up its bacteria to sewer and drain air, though such bacteria ordinarily form but a small proportion of those present in sewer air. So far, the organisms detected are not in themselves known to be prejudicial to health, but their presence suggests that the more harmful sewage-borne microbes may likewise gain access to sewer air.

Dr. Savage submits a report dealing with the bacterial contamination of milk as obtained from healthy cows, and with the examination of milk samples obtained from cows suffering from an inflammatory disease, garget (mastitis), of the udder. In another report he details the results obtained in an examination of the intestinal contents of domestic animals for bacteria belonging to the Gaertner group—organisms which cause certain outbreaks of meat poisoning. From three bullocks and six pigs the results were negative, but from a calf numerous organisms belonging to this group were isolated.

Of late the view has been gaining ground that acute rheumatism is a microbial disease, and various organisms have been described by investigators. Dr. Horder contributes a report on the subject, but his results are mainly negative, and further research is evidently called for.

The action of the *Streptococcus faecalis* and of its chemical products has been investigated by Dr. Sidney Martin. The organism is capable of producing various disease conditions in man, such as cystitis and septicæmia. Preliminary experiments on the toxin of the microbe suggest that the main poisonous product is an endotoxin.

In an appendix Dr. Blaxall and Mr. Fremlin record experiments on the effect of cold on the potency of vaccine lymph, and show that a temperature of $-180°$ C. has no effect, and that lymph stored at $-5°$ C. for a year suffered no diminution in potency.

It will thus be seen that the volume contains papers of considerable importance in scientific medicine and hygiene.

R. T. H.

[1] Thirty-sixth Annual Report of the Local Government Board, 1906–7. Supplement containing the Report of the Medical Officer for 1906–7.