conduit à ce résultat. Il va paraître un extrait de mes recherches dans les *Ast. Nach.* J'aurais donc pu, Monsieur, me dispenser de Vous en écrire, si je n'avais eu à remplir le devoir de Vous remercier pour l'intéressant ouvrage que Vous m'avez adressé.

"Vous verrez, Monsieur, que je démontre qu'on ne peut satisfaire aux observations d'Uranus qu'en introduisant l'action d'une nouvelle Planète, jusqu'ici inconnue: et ce qui est remarquable, il n'y a dans l'écliptique qu'une seule position qui puisse être attribuée à cette Planète perturbatrice. Voici les éléments de l'orbite que j'assigne à cet astre:

Demi-grand axe de l'orbite	36,154
Durée de la révolution sidérale	217 ans,387
Excentricité	0,10761
Longitude du périhélie	284° 45′
Longitude moyenne: 1er janvier 1847	318° 47′
Masse	$\frac{1}{9300}$
Longitude héliocentrique vraie au 1er janvier 1847	326° 32′
Distance au Soleil	33,06

"La position actuelle de cet astre montre que nous sommes actuellement, et que nous serons encore, pendant plusieurs mois, dans des conditions favorables pour le découvrir.

"D'ailleurs, la grandeur de sa masse permet de conclure que la grandeur de son diamètre apparent est de plus de 3″ sexagésimales. Ce diamètre est tout-à-fait de nature à être distingué, dans les bonnes lunettes, du diamètre fictif que diverses aberrations donnent aux étoiles.

"Recevez, Monsieur, l'assurance de la haute considération de Votre dévoué serviteur

"U.-J. LE VERRIER.

"Veuillez faire agréer à Mr. Encke, bien que je n'aye pas l'honneur d'être connu de lui, l'hommage de mon profond respect.

"A Monsieur J. GALLE,
"Astronome à l'Observatoire Royal de
"Berlin, à Berlin."

THE NEW ZEALAND SURVEY.

IN a report which has recently been published, the Surveyor-General of New Zealand describes the work of his department during the year 1909–10. A large area of country has been surveyed, but the urgency for pushing forward the topographical and settlement surveys, and the survey of native lands, leaves little opportunity for dealing with the major triangulation of the country. It is satisfactory, however, to see that besides some 320 square miles of minor triangulation, a commencement of a secondary triangulation has been made, and a base-line some eight miles in length has been measured. There is said to be a pressing need for this form of control, which may "bring into harmony different groups of practically uncontrolled minor work with their different standards of length, &c." The experience of many other regions goes to show that not only is such control indispensable, but adequate expenditure on it is the best economy, and very soon repays itself.

As the report is arranged by districts, it is difficult to appreciate fully the character of work done; but the demand for land surveys on large scales is very large, and the want of ample and accurate triangulation of second- as well as the present third-order series is no doubt a real one.

The measurement of a base of the secondary triangulation at Wairarapa was carried out with two five-chain invar tapes; a third of greater width, a quarter of an inch instead of an eighth, was also used for the first two sections only. The tension was determined by a Salter spring balance, and not by weights, as is now the more usual method. The tapes were supported at intervals of fifty links by special stands. Four measurements were made of all sections, two with each tape, and of the first four two additional measurements were made; the probable error of the final value adopted for the base is given as 1 part in 2,962,000. The standard of length for controlling the invar tapes was a steel 100-link tape, of which the true length was known at 62° F. and under a tension of 15 lb., but not its coefficient of expansion and modulus of elasticity. A second base is now in hand, and with the increase of this important high-grade work greater facilities for comparison and verification of base apparatus will doubtless be introduced. The work of the department also includes the harmonic analysis of the tidal observations of the Dominion for the New Zealand Nautical Almanac, and arrangements have been made to furnish advance proofs to the Admiralty.

The work of the magnetic observatory has provided an unbroken series of magnetograms from the Adie instruments, and also a large number of seismograms from the Milne seismographs.

THE JAPAN MAGAZINE.[1]

THE great development of Western education in Japan has naturally led to the extensive publication of newspapers and magazines of a very varied kind, and many of them are of a high literary, scientific, or philosophical quality. *The Japan Magazine* is one of the most recent additions, and although its editor seems to be a European, almost all the writers are Japanese. The issue for October, which has just come to hand, is a very good combination of readable matter, which at the same time is of great interest to all who know Japan.

The first article is on "Torii," the characteristic and picturesque gateways to be found at the entrance to every Shinto shrine. It is one of the best which we have seen, and is illustrated by some of the most striking examples in the country. Mr. Seiichi Tejima, the director of the Higher Technological School in Tokyo, gives an interesting description of the organisation and work of his school which will be read with advantage by those engaged in similar work in this country. In addition to the technical part of the curriculum, the importance which is given to the training of character should be specially noted. Mr. Tejima points out that a person engaged in any occupation may be tempted to bargain his honour for venal purposes if the basis of his morals is not sound, and thereby lose the credit of an expert, and it is therefore the school's principal line of policy in education to give moral training on one hand and engineering practice on the other. Mr. Tejima was recently in London in connection with the Japan-British Exhibition, and no doubt some of our readers made his acquaintance and admired the exhibit shown by his school and other educational institutions in Japan. Viscount Taneko, the well-known statesman and writer, gives some readable reminiscences of American statesmen which throw interesting sidelights on some of the problems arising between America and the Far East.

The chief city engineer of Tokyo, Mr. Benjiro Kusakabe, has a descriptive article on "The New Tokyo," which gives a good idea of the transformation which has taken place and almost made the city unrecognisable by those who knew it in former times. Of course this magic transformation is, after all, not so marvellous as it appears, for the reconstruction of a city of wood cannot be regarded as so colossal a task as would be the rebuilding of a stone city like London or Berlin. But the story of the modernisation of Tokyo is none the less interesting as an indication of the tact, skill, and expedition with which the Japanese attempt and achieve great things, and Mr. Kusakabe thinks that when all the new buildings now either in course of construction or contemplated in the near future are completed, and the city's plan of public improvements carried out, Tokyo will be, both in appearance and reality, one of the finest capitals in the world.

Mr. Yaichi Haga tells "How Western Civilisation came to Japan," and Mr. Yoso Kubo, of the Investigation Bureau, has an important article on "The Remaking of Manchuria," which explains Japanese policy and methods in that part of the world. There are very good articles on "The Art of Judo," or of physical training, with special relation to its ethical aspects, on the "Silk Indus-

[1] Published by the Japan Magazine Co., Tokyo. Subscription, in Japanese Empire, per year in advance, 4.50 yen, in foreign countries 6.100 yen.

try," on "Fruit Culture in Japan," and on "The Art of Flower Arrangement," as well as others of special interest to all who study things Japanese. Altogether, the magazine makes very good reading, and if it maintains the standard of the issue which we have been considering it will take a high place among publications on the Far East.

H. D.

RADIATION FROM HEATED GASES.[1]

On the Radiation from Gases.

IN the first and second reports of the committee reference was made to the part played by radiation in the cooling of the products of an explosion, and to its bearing on the measurements of volumetric and specific heat with which those reports were principally concerned. The general question of radiation from heated gases has, however, from the point of view of the committee, an interest and importance of its own which are sufficient to justify a detailed study of it in its wider aspects. Radiation plays a part comparable with that of conduction in determining the heat-flow from the gas to the cylinder walls in the gas engine, and it is this flow of heat which is the most important peculiarity of the gas engine, and to which are chiefly due the leading characteristics of its design. Even to the uninstructed eye the most obvious features about large internal-combustion engines are the arrangements for cooling, and the great size and weight for a given power which is necessitated mainly by those arrangements. The difficulties which the designer has to meet are due in the main to the stresses set up by the temperature gradients which are necessary to sustain the flow of heat. In the present state of the art it is probable that the most important service which science could render to the gas-engine constructor would be to establish definitely the principles upon which depends the heat-flow from hot gases into cold metal with which they are in contact, and thus to enable him to predict the effect upon heat-flow of changes in the temperature, density, or composition of the charge, and in the state of the cylinder walls.

The committee does not propose in this report to deal with the whole of this large question, but will confine its attention to one important factor in heat-flow, namely, radiation. The subject is a wide one, which has excited much attention among physicists and chemists, and on several important points agreement has not yet been reached. No attempt will therefore be made to do more than state shortly the experimental facts, and to define the issues which have been raised in regard to the explanation of these facts.

Practical Effects of Radiation.

It is believed that the first instance in which radiation from a flame was used in an industrial process, with knowledge of its importance, was the regenerative glass furnace of Frederick Siemens, which he described at the Iron and Steel Institute in 1884. Here the combustible gas was burnt in a separate chamber, and the hot products of combustion were led into the furnace. The objects to be heated were placed on the floor of the furnace out of contact with the stream of flame which flowed above them. They would therefore receive heat only by radiation, and it was supposed that this radiation came in a large measure from the flame. Siemens, however, was of opinion (in 1884) that the radiation was due to incandescent particles of carbon, and that there was little radiation from a non-luminous flame.[2]

In 1890 Robert von Helmholtz measured the radiation from a non-luminous coal-gas flame 6 mm. diameter, and found it to be about 5 per cent. of the heat of combustion.[3] The radiation from a luminous flame was greater, but not very much greater—rising to a maximum of $11\frac{1}{2}$ per cent. for an ethylene flame. Discussing the Siemens furnace in the light of these results, R. von Helmholtz calculated that radiation from the flame in the furnace could only account for a small fraction of the actual heat transmission. He pointed out, however, that a large flame would probably radiate energy at a greater rate than a small one. But while admitting that for this reason gaseous radiation might play a part in the heat transmission, he suggested that a more important agent was radiation from the roof of the furnace, which received heat by direct contact with the hot gas, and so reached a very high temperature. He showed by calculation that a comparatively small excess of temperature in the roof over that of the floor would cause a sufficient flow of heat.

But though the discussions on the Siemens furnace and the work of Helmholtz show that the idea that a flame, even if non-luminous, might radiate large amounts of heat, was a familiar one to many people twenty years ago, its possible importance in causing loss of heat during and after a gaseous explosion, and in determining the heat-flow in a gas engine, does not appear to have been appreciated until quite recently. Prof. Callendar was probably the first to direct attention to its significance in this connection. In the discussion on a paper about explosions, read before the Royal Society in 1906, he said that he had found a non-luminous Bunsen flame to radiate 15 to 20 per cent. of its heat of combustion, and expressed the opinion that the loss from this cause in a closed-vessel explosion would be of the same order.[1]

There are, in fact, several points about the behaviour of gas engines which suggest the importance of radiation as a cooling agent. The particular matter which attracted Callendar's attention was the effect of speed on thermal efficiency. His experiments showed that a part of the loss of efficiency in an internal-combustion motor, as compared with the corresponding air-cycle, was independent of the speed at which the engine was run. The loss of heat per cycle could, to a first approximation, be represented by an expression of the type $A+B/n$, where n is the number of revolutions per minute and A and B are constants. The term A represents a constant loss of heat per explosion, and among the many causes contributing to this constant loss of heat, radiation from the flame is probably important.[2]

Another phenomenon which is difficult to explain, except as the result of radiation, is the effect of strength of mixture on heat-loss. The following table shows some results which were obtained by Hopkinson upon a 40 horse-power gas engine[3] :—

Percentage of gas in cylinder contents	8·5	11·0 per cent.
Total heat-loss per minute	1510	2300 B.Th.U.
Total heat-loss as percentage of total heat-supply	29	34 per cent.
Temperature of piston	300° C.	430° C.

It will be observed that the proportion of heat-loss to the walls increases very materially as the strength of mixture is increased. If the transfer of heat were wholly due to conduction it might be expected, apart from the disturbing influence of speed of ignition, which in this case was not very important, that the percentage of heat-loss would rather diminish with increase of charge, because the temperature with the stronger mixture should be relatively less on account of the increase of volumetric heat. The increased temperature of piston and valves would work in the same direction. The existence of radiation, however, which increases more rapidly in proportion to the temperature, would account for the increased heat-flow. The practical importance of questions of this kind is illustrated by these figures, from which it appears that the piston is 50 per cent. hotter, though the charge of gas is only increased 30 per cent.

More direct evidence of the importance of radiation is furnished by experiments on the effect of the surface of the walls. In the second report of the committee reference was made to the belief, which is widely spread among those who are concerned with the practical design and operation of gas engines that polishing the interior of the

[1] From the Third Report of the British Association Committee, consisting of Sir W. H. Preece (Chairman), Mr. Dugald Clerk and Prof. Bertram Hopkinson (Joint Secretaries), Profs. Bone, Burstall, Callendar, Coker, Dalby, and Dixon, D. Glazebrook, Profs. Petavel, Smithells, and Watson, Dr. Harker, Lieut.-Col. Holden, Capt. Sankey and Mr. D. L. Chapman, appointed for the Investigation of Gaseous Explosions, with special reference to Temperature. Presented at the Sheffield meeting of the Association, 1910.

[2] Capt. Sankey has prepared an abstract of papers relating to the Siemens furnace.

[3] "Die Licht- und Warmestrahlung verbrennender Gase," Robert von Helmholtz. (Berlin, 1890.)

[1] Hopkinson, Proc. Roy. Soc., A. vol. lxxvii., p. 400.

[2] Proc. Inst. Automobile Eng., June, 1907.

[3] Proc. Inst. C.E., vol. clxxvii. (1909).