is thought to have had some small share in aiding the formation of a lake basin here as elsewhere along the piedmont belt; but the evidence of this is in chief part borrowed from the district of Lake Zurich, and that evidence has been somewhat discredited, as far as lake-making is concerned, in recent years. A chapter is given to the systematic relations of the lake; the element of time, or stage of development, is given too small a share in the proposed classification. Neither the interglacial valley in the Deckenschotter nor the later glacial advances are described in terms of youth, maturity or old age. Temperature, color, transparence, waves, currents, changes of level, and composition are all duly considered. The monograph as a whole is very clearly written; its chapters are closed with concise summaries, and it has current page headings and an excellent index; advantages that do not always accompany scientific publications. W. M. DAVIS.

THERMODYNAMICS OF THE GAS-ENGINE.

THE second report of the Gas-Engine Committee of the Institution of Mechanical Engineers of Great Britain was presented on the 18th of October by Professor Burstall, of Birmingham University, and the results of experiments, preparations for which were described in the first report (*Proceedings*, 1898) were given. They involve some important details of a novel character and throw some light upon previously obscure points in the theory of that now important prime mover.

Illuminating gas was employed having a mean heating value of about 4.8 calories per liter. A new form of igniting apparatus permitted the ignition of even very weak charges with completeness and certainty, the current being obtained from four cells of the storage battery, with a low voltage and a comparatively heavy current, insuring a 'short and thick' spark.

Varying compression was adopted to determine the effect of such variation upon the efficiency of the motor, and, with each compression, varying mixtures of air and gas, changing about one per cent. at each new series of tests, supplied data for ascertaining the relative values of these mixtures.

For the first time, so far as the writer is aware, the theory of the gas-engine as here applied was constructed with the assumption of a variation of specific heats with temperature, following MM. Mallard and Le Chatelier. The following are Professor Burstall's formulas:

$$K_v = a + sT; \qquad K_p = b + sT;$$

$$K_p - K_v = \text{const.} = b - a = R.$$

$$H_v = (w_1 + w_2) \int_{T_1}^{T_2} (a + sT)\, \delta T;$$

$$= (w_1 + w_2)\, [a(T_2 - T_1) + s/2 \cdot (T_2^2 - T_1^2)].$$

$$H_p = (w_1 + w_2) \int_{T_2}^{T_3} (b + sT)\, \delta T;$$

$$= (w_1 + w_2)\, [b\,(T_3 - T_2) + s/2 \cdot (T_3^2 - T_2^2)];$$

where H_v and H_p are the quantities of heat added during the periods of constant volume and constant pressure, respectively; w_1 and w_2 are the weight of air and gas, and the weight of residual products from the previous stroke in the clearance spaces.

The equation of the adiabatic also differs from that for constant values of specific heats, thus:

$$\delta q = K_v \left(\frac{dT}{dp}\right) \delta p + K_p \left(\frac{dT}{dv}\right) \delta v;$$

$$dT/dp = v/R; \; dT/dv = p/R;$$

$$\delta q = K_v v/R \cdot \delta p + K_p p/R \cdot \delta v = 0.$$

$$(a + sT) v dp + (b + sT) p dv = 0.$$

$$(b - a) \log_e v + a \log_e (pv) + spv/R = \text{const.}$$

$$p^a v^b e^{s \frac{pv}{R}} = \text{constant}.$$

The correspondence of the actual expansion lines of the indicator diagram with the adiabatic for variable specific heats was found much closer than for the usual assumption of constant values with varying temperatures. In the computations of the heat-balance the usual method would give results about fifteen per cent. lower than with variable specific heats.

The entropy equation becomes, in the latter case,

$$\phi = a \log_e \frac{T}{T_0} + R \log_e \frac{V}{V_0} + S(T - T_0);$$

where V and V_0 are the volumes at temperatures T and T_0, respectively.

In determining the temperatures, the Callendar platinum instrument was employed; but a peculiar and ingenious special construction was adopted to secure safety of the instrument against injury by the action of the charge. Among other interesting determinations made with this thermometer, were the temperatures of the charge at various distances from the cylinder-wall. It was found that the charge was distinctly hotter at the core than adjacent to the metallic surface of the cylinder, the difference ranging from one to two hundred degrees centigrade.

The gas used required 5.49 volumes of air for combustion and produced 0.5672 volumes of CO and 1.257 volumes of steam. After combustion the volume is, total dry, 4,996. The weights were, gas, per meter, 0.6; air, 1.29. Heating values were 553 B. T. U. per cubic foot, 4,850 cal. per cubic meter.

The engine was six inches by twelve and ran at about 200 revolutions per minute and at from 90 to 100 per cent. of its rated power; usually at about 95. The compression in Series I. ranged up to from 200° C. to 300° C., and the index of the compression-curve, $pv^n = C$, from 1.28 to 1.445; its maximum being found at 311° C.; but the irregularities of the figure are too great to reveal any law. Probably 1.33 may be taken as the figure for approximate computations. The expansion-curve value of $n = 1.4$, as an average, or very nearly that, ranging from 1.328 to 1.501. The mechanical efficiency was from 68 to 80 per cent., averaging about 75.

In the final series of trials, with compression ranging from 327° C. to 452° C. as maxima, the index of the expansion-curve was about 1.3, varying from 1.2 with an exhaust temperature of 637° C. to 1.344 with a temperature of exhaust of 862° C. The compression-curve was less variable; the index averaged very nearly 1.35. The mechanical efficiency varied from 0.64 to 0.83, and the thermal efficiency from 18.1 to 22.7 per cent.

The employment of compression produced, on the whole, an increasing total efficiency with increasing terminal pressure, though reducing mechanical while augmenting thermodynamic efficiency. From 13 to 16 per cent. of the heat-supply appeared as useful work outside the machine. The gas used ranged from an average of 24.6 cu. ft. per I.H.P. per hour to 19.7, and from 34.9 per B.H.P. to 28.5. The jacket carried away about 30 per cent. of the heat developed, the exhaust about 45 per cent. and radiation about 3. The heat-balance for the most efficient case was

$$\underset{\text{I.H.P.}}{23.1} + \underset{\text{Jack.}}{30} + \underset{\text{Exh.}}{42.6} + \underset{\text{Rad.}}{3} + \underset{\text{Loss.}}{1.3} = \underset{\text{Total.}}{100.}$$

R. H. THURSTON.

THE NEW STAR IN PERSEUS.

PROFESSOR W. W. CAMPBELL, director of the Lick Observatory has issued the following bulletin:

A discovery of extraordinary interest to astronomers has just been made by Professor Perrine in reference to the new star in the constellation Perseus. This star appeared suddenly and unexpectedly last February, having been discovered by Anderson in Edinburgh. In some four days its brightness increased from invisibility in ordinary telescopes until it became the brightest star in the northern sky. All available astronomical resources throughout the world were immediately devoted to the investigation of this remarkable object.

Many interesting facts concerning it have been brought to light. To mention only a few, its brightness diminished irregularly from that of the most prominent star in the northern sky in February until in June it was on the limit of visibility for trained and sensitive eyesights, where it has since remained. The star's atmosphere was violently disturbed, as shown by a study of its spectrum in the spring months and since June, at least, the spectroscope has shown that it is now a nebula, though retaining to the eye and in the telescope the point-like form of an ordinary star. The disturbance that gave rise to the new star was sufficiently violent to convert it from a dark invisible body into a gaseous nebula.

In August Professor Max Wolf, of Heidelberg, Germany, secured a four-hour exposure photograph of the region of the sky containing the new star. His negative showed the existence of some extremely faint nebulous patches