they all have the same density, the following numbers represent their masses, Saturn's mass being unity :—

Mimas ...	1/500,000	Rhea ...	1/32,000
Enceladus	1/270,000	Hyperion	1/1,800,000
Tethys ...	1/75,000	Japetus	1/110,000
Dione ...	1/85,000		

The mass of Saturn's rings has been found 1/620 that of the planet by observations of the rotational movement which it imparts to the major axes or line of apsides of the satellites.

The masses of the satellites of Uranus and Neptune are not known to any degree of accuracy. The two satellites of Mars have had their masses deduced from photometric measures, but they are so small—about 10 kilometres in diameter, being no larger than the smallest known asteroids—that the numbers found cannot be very exact.

Masses of some Stars.

M. Tisserand rightly gives a dissertation, full and clear withal, of this subject. Sir William Herschel was the discoverer of the relative motions of binary stars in 1802. The obvious conclusion from such a discovery was that the laws of gravitation were universal. Truly, it was not logical to make such an assumption, and some objections have been raised, but the *onus probandi* rests with those who doubt it. In considering the motions of the components of a binary star system, it must be remembered that they revolve round a common centre of gravity. It is usual, however, to consider the principal stars as fixed, but augmented by the mass of its satellite, the latter having an orbit which is the mean of the two. Knowing the fall of the satellite to its primary in one second, we may calculate what it would be if at the same distance from it that the earth is from the sun. But we know by how much the satellite would fall towards the sun, since it would fall as the earth. Hence the consideration of the two falls will give the sum of the masses of the stars in terms of the sun's mass.

The following is the formula employed :—

$$\frac{m + m'}{M} = \left(\frac{a}{p}\right)^3 : T^2 ;$$

m and m' are the masses of the two stars ; M that of the sun ; a is the angle, expressed in seconds, which is subtended at the earth by the semi-major axis of the satellites orbit ; p is the "annual parallax" of the binary group expressed in seconds ; whilst T is the time in years of one revolution of the satellite. These are the numbers that have been obtained for four groups, the distances of which from the earth are known :—

Star.	Parallax.	Magnitude.	Sum of Masses.
α Centauri ...	0″·80 ...	1 ...	1·8
η Cassiopeiæ ...	0″·15 ...	4 ...	8·3
70 ρ Ophiuchi ...	0″·17 ...	4·5 ...	2·5
σ^2 Eridani ...	0″·22 ...	4·5 ...	1·0

Sirius and its Companion.

The article concludes with a complete history of the work which suggested the existence of a companion to Sirius. Bessel had determined the proper motion of thirty-six stars by observations of their right ascensions and comparing with Bradley's, but he found that in the case of Sirius the hypothesis of a uniform variation was irreconcilable with them, and suggested that the irregularities might be produced by the action of some obscure body. As a proof that obscure bodies exist in the heavens, the case of Tycho Brahé's Nova is quoted, this being a star which suddenly appeared in Cassiopeia in 1572, and then gradually disappeared without change of place. After Bessel's death Peters found that it was possible to account for the irregularities by the supposition that Sirius described an orbit in fifty years whose eccentricity was about 0·8. Safford, in 1861, from a discussion of the declinations of Sirius, came to the same conclusion as Peters ; whilst Auwers, in 1862, after investigating about 7000 right ascensions and 4000 declinations, found the time of revolution to be forty-nine years, and the eccentricity 0·601. At the same time as Auwers was engaged with his calculations, Alvan Clark discovered a small star only about 10″ from Sirius, which appeared to be the companion. Future considerations supported the surmise, and proved that this body was precisely what was required to account for the orbit of Sirius round the common centre of gravity.

If Gill's measure of the parallax of Sirius be taken as correct, *viz.* 0″·38, the sum of the masses of the two stars is equal to 4·4 that of the sun. Sirius has about twice the mass of its companion, and they are separated by a distance a little more than twice the distance of Uranus from the sun.

From a discussion of similar little irregularities in the proper motion of η Cassiopeiæ, Struve found its mass to be 6·6 compared with the sun, whilst its companion was 1·7 times as great.

A reflection on the inability of astronomers before Copernicus to make such measurements as those preceding, concludes this retrospect.

R. A. GREGORY.

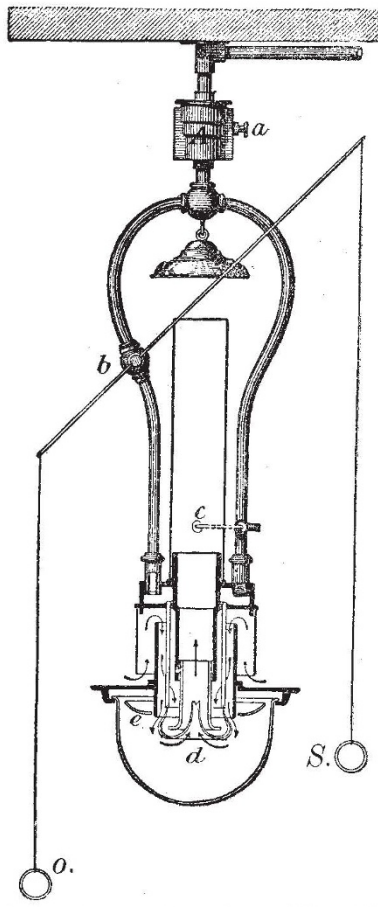
A NEW FORM OF REGENERATIVE GAS-LAMP.

FROM the time when Mr. Frederick Siemens first introduced regenerative gas-burners, now ten years ago, down to the present day, this method of burning gas for illuminating purposes has been adopted all over the world, and has come to the assistance of the gas companies by illustrating the fact that, with proper appliances, gas can produce the same brilliant effects as are ordinarily produced by means of electricity, at much less expense both as regards first cost and working. We would explain that in regenerative lamps the heat which is usually wasted in ordinary burners is to a great extent returned to the flame. The manner in which this result is brought about is by intercepting, by means of a regenerator, the heat passing away with the products of combustion, and applying the heat thus saved to raise the temperature of the air which feeds the flame, thus increasing the temperature of the latter, and its illuminating power ; for it may be admitted that the higher the temperature of a body rendered incandescent by heat, the greater is the proportion of light rays emitted out of the total amount of energy radiated. This being the case, the amount of heat carried from such a source of illumination to the surrounding atmosphere by conduction and convection must be less than in the case of a burner consuming the same quantity of gas burning at a lower temperature, which circumstance, combined with the well-known economy resulting from the use of these burners, accounts to a great extent for the popularity which regenerative lamps have attained.

Mr. Frederick Siemens has lately introduced a new form of regenerative gas-lamp, which we understand is highly efficient, and is in consequence being largely adopted ; its construction is shown in the accompanying diagram. It is known as the Siemens inverted type, and is produced in various ornamental designs, which have been much admired. After passing through the governor A, and the tap *b*, the gas enters an annular casing ; in the lower portion of this, a number of small tubes are fixed, forming the burner, from which tubes the gas passes out in separate streams. By this means, combustion of a very perfect character takes place, as the air is directed round each separate stream of gas, and thus enabled to combine most intimately with it. Within the circle of small tubes is a trumpet-shaped porcelain tube, *d*, and around the outside and inside of this the gas burns downwards and slightly upwards, as indicated by arrows,

thus producing a steady powerful flame of beautiful appearance. This porcelain tube forms the lower portion of the chimney, around which is placed the regenerator. The products of combustion, in passing away, heat the regenerator by conduction, through the metal of the same; and the air, passing upwards and downwards between its metallic surfaces, as also indicated by arrows in the diagram, carries the heat back to the flame. The lamp is closed below by a glass globe, which, however, need not be removed for lighting, as a flash-light is provided for that purpose.

These lamps are made of different sizes, with a consumption varying from 10 to 40 cubic feet of gas per



hour; with London gas they give a light of from ten to twelve candles per cubic foot consumed per hour, which is from four to five times as much as is obtained with ordinary burners. It would have been easy to arrange the lamp we have just described so as to produce a much higher result than that given above; but, to produce this effect, the air supplying the burner would have to be passed through small channels, which would be liable to be partly closed up by oxidation, and thus, by reducing the air-supply, cause the lamp to smoke, whereas the Siemens lamp has been specially designed to provide against this unpleasantness, to which regenerative gas-lamps are more or less liable.

HEINRICH GUSTAV REICHENBACH.

ON the 6th inst., there died at Hamburg, in the sixty-seventh year of his age, a botanist long and familiarly known to his English colleagues, and one whose name will be preserved in the annals of botany.

Heinrich Gustav Reichenbach had been Professor of Botany and Director of the Botanic Garden at Hamburg since 1862. He was born in Leipzig, his father having been also a well-known botanist and Professor in Dresden from 1820 till his death in 1879. Much of the younger Reichenbach's work was done in association with his father, with whom he co-operated in the production of the later volumes of the carefully elaborated *Icones Floræ Germanicæ et Helveticæ*. But work of this character, carefully and critically executed though it was, was cast into the shade by the magnitude of his labours among the Orchidaceæ. Reichenbach the younger devoted more than forty years of his life, almost (though, as we have seen, not quite) exclusively to the study of orchids.

At the commencement of his career, Lindley was still in the plenitude of his powers, but when, some quarter of a century since, the great English botanist failed in health, and subsequently died, there was no one to question the supremacy of Reichenbach so far as orchids were concerned.

From that time to the present the Hamburg Professor has reigned with undisputed sway. His reign corresponds in its progress with the development of that passion for the cultivation of orchids which has attained such large proportions in this country. This is a fashion which at present shows no sign of waning here, whilst it is spreading widely in other countries. It has proved of signal service to orchidology in its systematic aspect, and to a less degree to morphology and biology, as witnesses, to cite only one illustration, the work of Darwin on the "Fertilization of Orchids." A hundred years ago about three hundred species were catalogued in the later editions of Linnæus's "Species Plantarum," and those three hundred were very imperfectly known or illustrated. About sixty years have elapsed since Lindley began his first systematic enumeration of the genera and species, a work in which he was at first greatly aided by the previous labours of Brown and by the splendid drawings of Bauer. In 1840, at the conclusion of the "Genera and Species," Lindley mentions that the total number of species included in that work amounted to 1980, of which the author himself had analyzed three-fourths. Later estimates in the "Vegetable Kingdom" bring the numbers up to 394 genera and 3000 species. Bentham, in 1883, calculated the known species as between 4500 and 5000; while Pfitzer, the most recent census-maker, gives the extreme number of species as 10,000. Granting that this latter figure is excessive, it at least suffices to illustrate the enormous increase in our knowledge of orchids. This advance has been, as we have said, chiefly due to the orchidomania which originated as a consequence of the exhibition of a few remarkable forms at the early meetings of the Horticultural Society, and which has been growing ever since. We never heard of any material good arising from the tulipomania; but the passion for orchids, involving, as it has done, the exploration of the countries where they grow, and the collection and transmission of countless thousands of specimens, live and dead, not only of orchids but of plants of other orders also, has most undoubtedly been of great service to botany, and it has served also to illustrate the great, but often unappreciated, value of gardens as instruments of scientific research. Dried specimens of orchids afford a sorry spectacle at best, and the characters upon which the distinction of genera and species depend are readily obliterated or lost in the drying process. But in gardens the material is often ample, and in the best condition for examination.

Reichenbach, as we have seen, was able to avail himself to a much larger extent than any of his predecessors of the facilities offered by gardens. He became the acknowledged referee on all questions of nomenclature, and to him were constantly submitted fresh specimens for examination. Of late years, also, hybridization has been practised to a large extent among orchids, and the resultant hybrids found their way to Hamburg, there to be