

the sound pulses; they act precisely as this tube does.

As you know, light cannot well get round a corner; neither can sound, though it does so more easily than light. This little bell acts automatically. I wind it up and start it. At a few feet distance the flame answers to each stroke. Placed behind a board, the flame becomes tranquil. I again bring it out from behind the board, and the flame jumps to each movement of the hammer. (For this experiment the sensitive flame was arranged as in Fig. 4, with a large glass funnel having its tubular end opposite the root of the flame; the board was held about 10 feet distant from the mouth of the funnel.) Sound therefore can be shaded off in the same way that light can be.

In this box, which is well padded, is a bell which I can set ringing at pleasure. The only way by which the sound can get out is this small square opening at one side of it. The bell is now ringing without affecting the sensitive flame (arranged as in Fig. 4); but when this box is turned round, so that its opening faces the quiet flame, we have it dancing and jumping as before.

In other respects also there is a similarity between the mode of action of sound and light.

When a beam from the electric lamp is allowed to fall

upon the glass mirror in my hand, it is reflected from the mirror, and the track of the beam being marked by the dust floating in the room, you can see the direction which it takes. This is in accordance with a well-known law, namely, that the angle of incidence is equal to the angle of reflection. It is perfectly plain to you that a line drawn so as to fall at right angles upon this mirror would divide that large angle formed by the two beams of light into two equal angles.

I hope now to make visible to your eyes the reflection of sound in obedience to the same law.

At one corner of the lecture table I place our sensitive flame (*b*), at the opposite corner the padded box containing the electric bell (*a*) with its opening directed in the path taken a moment ago by the beam of light, and I will hold this board (*c*), when everything is ready, where I before held the glass mirror. My assistant will now set the bell ringing. You observe that the flame is uninfluenced by it, but when I bring the board forward, the shortening of the flame at each stroke of the bell, proves that the law of the reflection of sound is the same as the law of the reflection of light: the angle of incidence is equal to the angle of reflection. In this case the flame is knocked down by an echo.

We have thus considered the reflection of sound from a

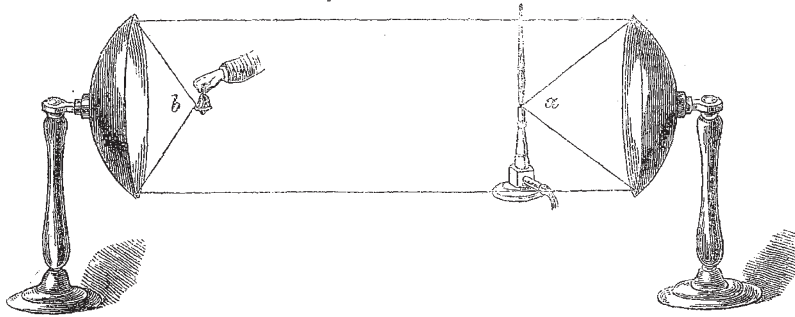


FIG. 6.

plane surface; let us now see if it behaves like light when reflected from plane surfaces.

The beam of the electric lamp is now directed upon the concave mirror. You can see the band of light marked in the fine dust floating in the air; as soon as it strikes the polished surface it is thrown back, but the rays no longer pursue parallel paths, they are converged, thrown together into one spot. By holding a piece of tracing paper at the point where they meet, termed the focus, the brilliant little star of light caused by their convergence is made visible.

Substitute for the lamp a small bell, and for the tracing paper at the focus of the mirror our sensitive flame, and the conditions are the same as in the previous experiment, sound-waves taking the place of the waves of light. You cannot see the track of these aërial pulses as you could the luminous ones, but their obedience to the same law of reflection is very manifest by the shortening of the sensitive flame as each sound wave reaches it. The flame when out of the focus of the mirror is unaffected; replace it in the spot when the sound waves are crowded together, and it responds to each stroke. Move the bell so that the sound pulses, though only having the same distance to travel to the flame, no longer fall on the mirror: the flame remains perfectly quiet.

We may go further still. Here are a pair of mirrors, the curvature and size of which is the same. They are arranged so as to face one another. A light is placed in the focus of one, that its rays which fall divergent upon the curved surface are reflected from it parallel, they travel to the opposite mirror, and are again converged; a

piece of tracing paper held at the focus of the farther mirror shows the spot of light as before (Fig. 6).

Sound is reflected in precisely the same way, and the sensitive flame when carefully manipulated can be used as a means of proving this fact. For these experiments it is essentially necessary that the flame be reduced to the proper pitch of sensitiveness. By reducing the pressure of the gas we can regulate the flame so that it will not respond unless strongly agitated. The flame is placed in the focus of the mirror (*a*), and when the bell is rung, not being in the focus of the conjugate mirror, there is no action. I now bring it into the focus (*b*) and the flame shows a very strong action.

By other modes of experimenting it has long been ascertained that sound was thus reflected from plane and curved surfaces; but never before have these phenomena been made visible. Hitherto these effects have been investigated by the sense of hearing; I have now been able to prove them by appealing to your eyes.

(To be continued.)

SCHOLARSHIPS AND EXAMINATIONS FOR NATURAL SCIENCE AT CAMBRIDGE, 1874

THE following is a list of the Scholarships and Exhibitions for proficiency in Natural Science to be offered at the several Colleges in Cambridge during the present year:—

TRINITY COLLEGE.—One or more of the value of about 80*l.* per annum. The examination will commence on

April 10, and will be open to all undergraduates of Cambridge and Oxford, and to persons under twenty who are not members of the Universities. Further information may be obtained from the Rev. E. Blore, Tutor of Trinity College.

ST. JOHN'S COLLEGE.—One of the value of 50*l.* per annum. The examination (in Chemistry, Physics, and Physiology, with Geology, Anatomy and Botany) will be in December, and will be open to all persons who have not completed a term of residence at the University, as well as to all who have entered and not completed one term of residence. Natural Science is made one of the subjects of the college examination of its students at the end of the academical year, in May; and Exhibitions and Foundation Scholarships will be awarded to students who show an amount of knowledge equivalent to that which in classics or mathematics usually gains an Exhibition or Scholarship in the college. In short, natural science is on the same footing with classics and mathematics, both as regards teaching and rewards.

CHRIST'S COLLEGE.—One or more, in value from 30*l.* to 70*l.*, according to the number and merits of the candidates, tenable for three-and-a-half years, and for three years longer by those who reside during that period at the college. The examination will be on March 24, and will be open to the undergraduates of the college, to non-collegiate undergraduates of Cambridge, to all undergraduates of Oxford, and to any students who are not members of either University. The candidates may select their own subjects for examination. There are other Exhibitions which are distributed annually among the most deserving students of the college. Further information may be obtained of Mr. John Peile, Tutor of the College.

GONVILLE AND CAIUS COLLEGE.—One of the value of 60*l.* per annum. The examination will be on March 24, in Chemistry and Experimental Physics, Zoology, with Comparative Anatomy and Physiology, and Botany, with Vegetable Anatomy and Physiology; it will be open to students who have not commenced residence in the University. There is no limitation as to age.—Scholarships of the value of 20*l.* each, or more if the candidates are unusually good, are offered, for Anatomy and Physiology, to members of the College.—Gentlemen elected to the Tancred Medical Studentship are required to enter at this College; these Studentships are five in number, and the annual value of each is 100*l.* Information respecting these may be obtained from Mr. B. J. L. Frere, 28, Lincoln's Inn Fields, London.

CLARE COLLEGE.—One of the value of 60*l.* per annum, tenable for two years at least. The examination (in Chemistry, Chemical Physics, Comparative Anatomy and Physiology, Botany with Vegetable and Animal Physiology, and Geology) will be on March 24, and will be open to students intending to begin residence in October.

DOWNING COLLEGE.—One or more of the value of 40*l.* per annum. The examination (in Chemistry, Comparative Anatomy, and Physiology) will be early in April, and will be open to all students not members of the University, as well as to all undergraduates in their first term.

SIDNEY COLLEGE.—Two of the value of 40*l.* per annum. The examination (in Heat, Electricity, Chemistry, Geology, Zoology and Physiology, Botany) will be on March 24, and will be open to all students who intend to commence residence in October.

EMMANUEL COLLEGE.—One of the value of 70*l.* The examination on March 24 will be open to students who have not commenced residence.

PEMBROKE COLLEGE.—One or more of the value of 20*l.* to 60*l.*, according to merit. The examination in June, in Chemistry, Physics, and other subjects, will be open to students under 20 years of age.

KING'S COLLEGE.—One of the value of about 80*l.* per annum. The examination, on April 14, will be open to

all candidates under 20, and to undergraduates of the college in their first and second year. There will be an examination in elementary Classics and Mathematics, in addition to three or more papers in Natural Science, including Physics, Chemistry, and Physiology.

Although several subjects for examination are in each instance given, this is rather to afford the option of one or more to the candidates than to induce them to present a superficial knowledge of several. Indeed, it is expressly stated by some of the colleges that good clear knowledge of one or two subjects will be more esteemed than a general knowledge of several.

Candidates, especially those who are not members of the University, will, in most instances, be required to show a fair knowledge of Classics and Mathematics, such, for example, as would enable them to pass the previous examination.

There is no restriction on the ground of religious denominations in the case of these or any of the Scholarships or Exhibitions in the Colleges or in the University.

Further information may be obtained from the Tutors of the respective Colleges; and the names, with certificates of character, date of birth, &c., must be sent to the Tutor of the College, in each case, several days before the examination.

It will be observed that in several instances the time of the examination is the same, certain of the Colleges having combined together so as to hold one or two examinations instead of each College holding a separate examination.

Some of the Colleges do not restrict themselves to the number of Scholarships here mentioned, but will give additional Scholarships if candidates of superior merit present themselves; and other Colleges than those here mentioned, though they do not offer Scholarships, are in the habit of rewarding deserving students of Natural Science.

It may be added that Trinity College will give a Fellowship for Natural Science, once, at least, in three years: and that most of the Colleges are understood to be willing to award Fellowships for merit in Natural Science equivalent to that for which they are in the habit of giving them for Classics and Mathematics.

ASTRONOMICAL ALMANACS*

X.—*Remodelling of the "Nautical Almanac" and the "Fahrbuch."*

NEARLY all the reforms which concerned astronomy were realised by Encke in the *Fahrbuch* for 1830, which appeared in May 1828. The appearance of this volume created an enormous sensation in England. The contest between Young and his opponents was then at its height. Strengthened by the help which had come to it from Berlin, the Astronomical Society redoubled its complaints and renewed its action; but the death of Thomas Young (May 10, 1829) soon occurred to simplify matters. In order that the question might not be hastily decided, the Society got the *Nautical Almanac* provisionally entrusted to the care of the Astronomer-Royal, J. Pond; at the same time it appointed a commission of forty members, composed of the directors of all the observatories and the principal astronomers and mariners, English and foreign.†

At last, at its annual meeting in February 1830, the Society awarded to Encke its gold medal for the great service which he had rendered to astronomy. "It would be superfluous," said Sir James South, President of the Society, in the address which he gave on that occasion, "for us to enlarge upon the merit of this well-known work, which, beyond all rivalry, ought to be regarded as the only ephemeris on a level with the requirements of

* Continued from p. 49.

† Struve took part in this commission.