

scopical examination directly, without any transference of the infusion; and the bulb E being filled with calcined air, enables the experimenter, when the whole piece of apparatus is closed at J, to restore air to the bulb A containing the infusion, by breaking the thin septum F by means of the comparatively heavy piece of platinum H, which opens a communication between E and A.

Figure 27. Is the same as the above, except for the added tube MN. This is intended to be used if the fluid should prove to be sterilized, for the purpose of inoculating it again by means of a piece of platinum which is charged with the fluid in which the organism is abounding. This is introduced into the tube, which is at once closed at M. It is then made to break the septum L, and falls into the fluid inoculating it, to discover if it still has the power to sustain the organism.

All the drawings of the organism are magnified 3,000 diameters, except where otherwise indicated on the plates.

II. "On the Reversal of the Lines of Metallic Vapours." By G. D. LIVEING, M.A., Professor of Chemistry, and J. DEWAR, M.A., F.R.S., Jacksonian Professor, University of Cambridge.  
No. II. Received March 26, 1878.

Since our last communication to the Society we have succeeded in reversing characteristic lines of the vapours of rubidium and cæsium. Considering the known volatility of these elements, and the small quantity of their compounds at our disposal, we thought it better to try the effects first in glass tubes. For this purpose a piece of combustion tubing had one end drawn out and the end turned up sharply, and sealed off (like an ill-made combustion tube of the usual form) so as to produce an approximately plane face at the end of the tube; a small bulb was then blown at about an inch from the end, and the tube drawn out at about an inch from the bulb on the other side, so as to form a long narrower tube. Some dry rubidium or cæsium chloride was next introduced into the bulb, and a fragment of fresh cut sodium, and the narrow part of the tube turned up, so as to allow the tube and bulb to be seen through in the direction of the axis of the tube. The open end was then attached to a Sprengel pump, and the air exhausted; the sodium was then melted, and afterwards either dry hydrogen or dry nitrogen admitted, and the end of the tube sealed off at nearly the atmospheric pressure. We found it necessary to have this pressure of gas inside the tube, otherwise the metal distilled so fast on heating it that the ends were speedily obscured by condensed drops of metal. Through these tubes placed lengthways in front of a spectroscope, a lime light was viewed. On warming the bulb of a tube in which rubidium chloride had been sealed up with sodium, the D lines were of course very soon seen, and very soon there appeared two dark lines near the extremity of the violet light, which, on measure-

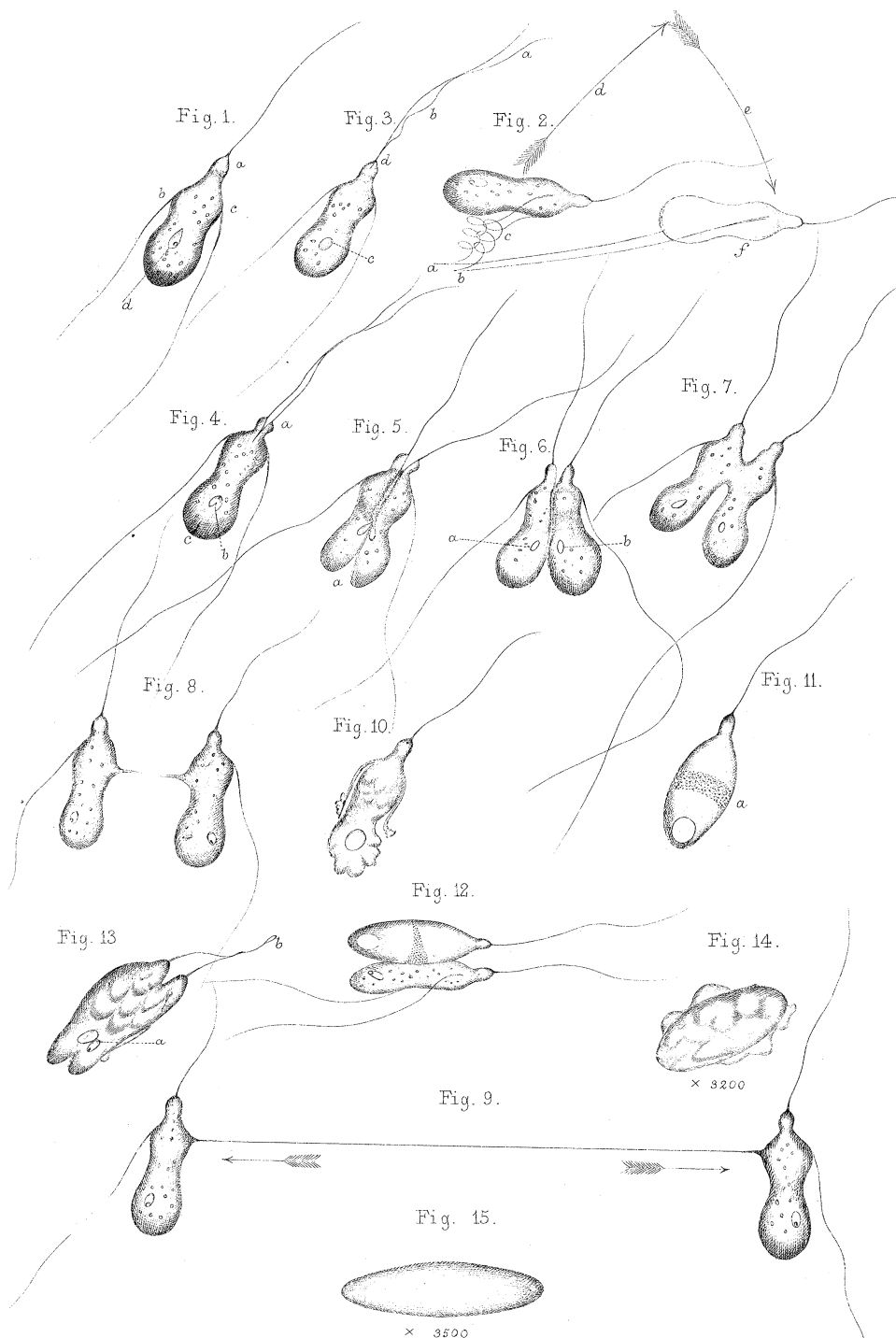


Fig. 16.

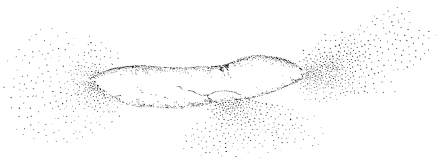


Fig. 18.



Fig. 19.



Fig. 17.



Fig. 20.



Fig. 21.



Fig. 22.



Fig. 23.



Fig. 24.

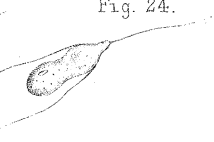


Fig. 25.

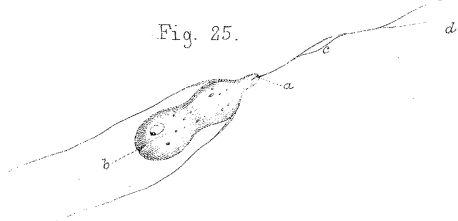


Fig. 26.

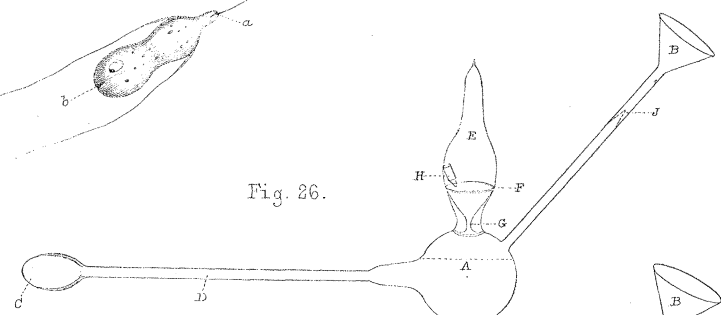
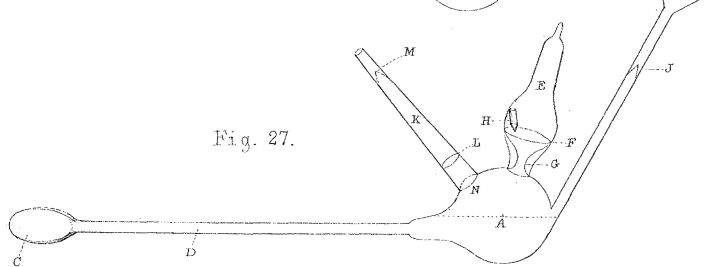


Fig. 27.



ment, were found to be identical in position with the well-known violet lines of rubidium. Next appeared faintly the channelled spectrum of sodium in the green, and then a dark line in the blue, very sharp and decided, in the place of the more refrangible of the characteristic lines of cæsium in the flame spectrum. As the temperature rose these dark lines, especially those in the violet, became sensibly broader; and then another fine dark line appeared in the blue, in the place of the less refrangible of the cæsium blue lines. During this time no dark line could be observed in the red, but as the temperature rose a broad absorption band appeared in the red, with its centre about midway between B and C, ill-defined at the edges, and though plainly visible not very dark. The lines in the violet had now become so broad as to touch each other and form one dark band. On cooling, the absorption band in the red became gradually lighter without becoming defined, and was finally overpowered by the channelled spectrum of sodium in that region. The double dark line in the violet became sharply defined again as the temperature fell. There are two blue lines in the spectrum of rubidium taken with an induction-coil very near the two blue lines of cæsium, but they are comparatively feeble, and the two dark lines in the blue which we observed in the places of the characteristic blue lines of cæsium we believe must have been due to a small quantity of cæsium chloride in the sample of rubidium chloride. These blue lines were not, however, visible when some of the rubidium chloride was held in the flame of a Bunsen's burner, nor when a spark was taken from a solution of the chloride; but the more refrangible of them (Csa) was visible in the spark of an induction-coil, without a Leyden jar, taken between beads of the rubidium chloride fused on platinum wires.

When a tube containing cæsium chloride and sodium was observed, in the same way as the former, the two dark lines in the blue were seen very soon after the heating began, and the more refrangible of them broadened out very sensibly as the temperature increased. The usual channelled spectrum of sodium was seen in the green, and an additional channelling appeared in the yellow, which may be due to cæsium or to the mixture of the two metals. We have at present no metallic cæsium wherewith to decide this question. Indeed the cæsium chloride used was not free from rubidium, and the dark lines of rubidium were distinctly seen in the violet.

It is remarkable that these absorption lines of cæsium coincide with the blue lines of cæsium as seen in the flame, not with the green line which that metal shows when heated in an electric spark of high density. It is to be observed, however, that when sparks from an induction-coil without a jar are taken between beads of cæsium chloride, fused on platinum wires, a spectrum similar to the flame spectrum is seen, and it is only when a Leyden jar is used that the spectrum is reduced to a green line. In like manner both the violet lines of

rubidium are reversed in our tubes, and both these violet lines are seen when the spark of an induction-coil, without jar, is passed between beads of rubidium chloride fused on platinum wire, though only one of them appears when a Leyden jar is used.

We have not repeated these observations on caesium and rubidium in iron tubes, because the light emitted from the hot iron does not extend so far into the violet as the rubidium lines, and the amount of caesium at our command at present is very small.

We have extended our observations on the absorption of magnesium and of mixtures of magnesium with potassium and sodium, using iron tubes placed vertically in a small furnace fed with Welsh coal, as described in our former communication.

The result of several observations, when commercial magnesium (*i.e.*, magnesium with only a small percentage of sodium in it) was used, is that the absorption produced by magnesium consists of—

(1.) Two sharp lines in the green, of which one, which is broader than the other, and appears to broaden as the temperature increases, coincides in position with the least refrangible of the *b* group, while the other is less refrangible, and has a wave length very nearly 5,210. These lines are the first and the last to be seen and very constant, and we at first took them for the extreme lines of the *b* group.\*

(2.) A dark line in the blue, always more or less broad, difficult to measure exactly, but very near the place of the brightest blue line of magnesium. This line was not always visible, indeed rarely when magnesium alone was placed in the tube. It was better seen when a small quantity of potassium was added. The measure of the less refrangible edge of this band then gave a wave length of very nearly 4,615. It was also seen when sodium and magnesium were used together, but it was more difficult to get a measure of it in this case, as the sodium obscures the blue part of the spectrum. A measure taken when sodium was used gave a wave length 4,580, but this can only be regarded as an approximation.

(3.) A third line or band in the green rather more refrangible than the *b* group. This is best seen when potassium as well as magnesium is introduced into the tube, but it may also be seen with sodium and magnesium. The less refrangible edge of this band is sharply defined, and has a wave length about 5,140, and it fades away towards the blue.

These absorptions are all seen both when potassium and when sodium are used along with magnesium, and may be fairly ascribed to magnesium, or to magnesium together with hydrogen.

But besides these, other absorptions are seen which appear to be due to mixed vapours.

\* On one occasion a dark line corresponding to  $b_2$  was also seen.

(4.) When sodium and magnesium are used together a dark line, with ill-defined edges, is seen in the green, with a wave length about 5,300. This is the characteristic absorption of the mixed vapours of sodium and magnesium, it is not seen with either vapour separately, nor is it seen when potassium is used instead of sodium.

(5.) When potassium and magnesium are used together, a pair of dark lines are seen in the red. The less refrangible of these sometimes broadens into a band with ill-defined edges, and has a mean wave length of about 6,580. The other is always a fine sharp line, with a wave length about 6,475. These lines are as regularly seen with the mixture of potassium and magnesium as the above-mentioned line (5,300) is seen with the mixture of sodium and magnesium, but are not seen except with that mixture.

(6.) On one occasion, with a mixture of potassium and magnesium, another dark line was seen in the blue, with a wave length nearly 4,820. This line is very near one of the bright lines, seen when sparks from an induction-coil, without a Leyden jar, are taken between electrodes of magnesium, and may very likely be due to magnesium alone, and not to the mixture of vapours, as we only observed it on one occasion.

There is a certain resemblance between the absorptions above ascribed to magnesium, and the emission spectrum seen when the sparks of a small induction-coil, without Leyden jar, are taken between electrodes of magnesium. This emission spectrum is the same, with the addition of some blue lines, as that seen when the sparks are taken from a solution of magnesium chloride, as accurately described by Lecoq de Boisbaudran (*Spectres lumineux*, p. 86), and as that seen in burning magnesium (Dr. W. M. Watts, *Phil. Mag.*, 1875), and consists, as we have observed, of lines with the following wave lengths:—4,481, 4,590 (Thalèn 4,586), 4,570 (Thalèn 4,565), 4,797, 4,930, 4,945, 4,957, 4,969, 4,980, 4,990, 5,000, the well-known *b* group, and 5,528 (Thalèn).

The pair of lines (1) correspond nearly with the *b* group, but slightly displaced towards the red; the shaded band (3) corresponds less closely to the series of seven lines 5,000 to 4,930, which progressively decrease in brightness towards the blue, and is also a little less refrangible than that series; the broad line in the blue (2) corresponds to the pair of lines 4,570 and 4,590; and the remaining line (6) with the line 4,797, also both displaced a little towards the red. No absorption corresponding to the extreme lines 4,481 and 5,528 was observed. There is plainly no exact reversal except of the line  $b_1$ , and even in that case it may be an accident if we suppose the two dark lines (1) to represent the extreme line of the group *b*. It may be noted in connexion with this that the absorption lines described by us in our former communication as seen with sodium and potassium

(wave lengths 5,510 and 5,730) are near to, but *more* refrangible than, well-known emission lines of those elements.

The absorptions produced by the mixtures of vapours plainly offer a wide field for further observation. At present we have not succeeded in observing those produced by mixtures of vapours other than those here recorded; and it seems needful to use tubes of a less fusible material than iron, which, notwithstanding the protection of fire-clay, very quickly gives way at the temperatures we have used.

With regard to those above described, we may observe that there is in the solar spectrum an absorption line, hitherto unaccounted for, closely corresponding to each of them. Thus, on Ångström and Thalén's map there are dark lines at 6,580 and 6,585, with more or less continuous absorption between them, a broad dark line between 6,474 and 6,475, and a dark line at 5,300. There are also dark lines nearly, if not exactly, coincident with the series of seven bright lines of magnesium above described, which we have not seen strictly reversed. The coincidences of the series of the solar spectrum hitherto observed have, for the most part, been with lines given by dense electric sparks; while it is not improbable that the conditions of temperature, and the admixtures of vapours in the upper part of the solar atmosphere, may resemble much more nearly those in our tubes.

We intend to pursue our observations, using higher temperatures, if we can obtain tubes which will stand under those circumstances.

### III. "Preliminary Note on Experiments in Electro Photometry."

By Professor JAMES DEWAR, F.R.S., Jacksonian Professor  
University of Cambridge. Received March 26, 1878.

Edmond Becquerel, in the year 1839, opened up a new field of chemical research through the discovery that electric currents may be developed during the production of chemical inter-actions excited by solar agency.

Hunt, in the year 1840, repeated, with many modifications, Becquerel's experiments, and confirmed his results.

Grove, in 1858, examined the influence of light on the polarized electrode, and concluded that the effect of light was simply an augmentation of the chemical action taking place at the surface of the electrodes.

Becquerel, in his well-known work, "La Lumière," published in 1868, gives details regarding the construction of an electro-chemical actinometer formed by coating plates of silver with a thin film of the sub-chloride, and subsequent heating for many hours to a temperature of 150° C.

Egeroff, in 1877, suggested the use of a double apparatus of

Fig. 1.



Fig. 3.



Fig. 2.

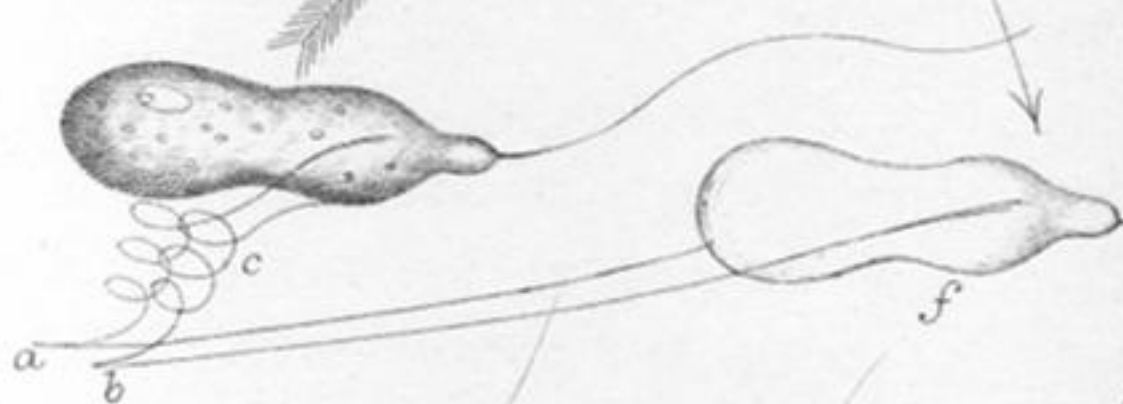


Fig. 4.



Fig. 5.



Fig. 6.

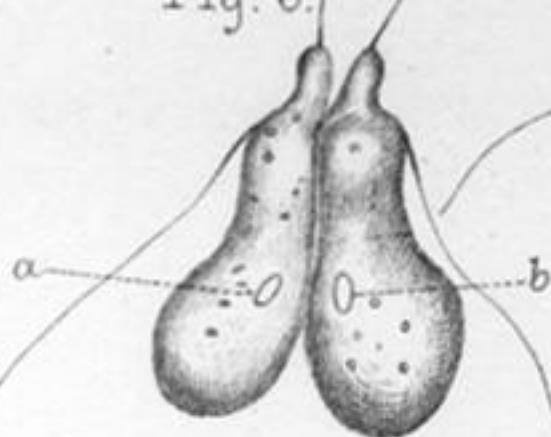


Fig. 7.



Fig. 8.

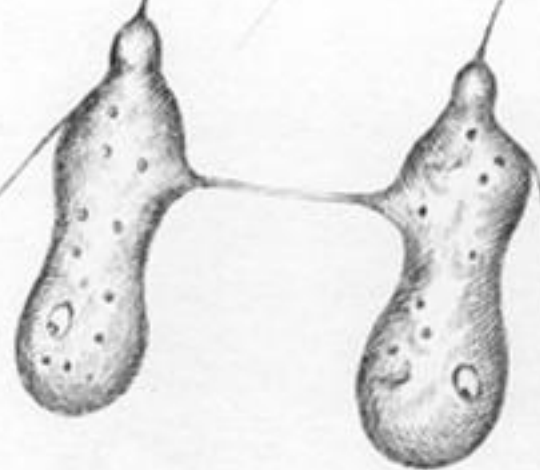


Fig. 10.



Fig. 11.



Fig. 12.

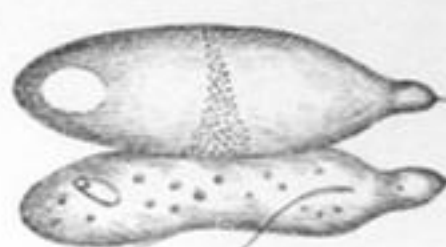


Fig. 13.



Fig. 14.



× 3200

Fig. 9.

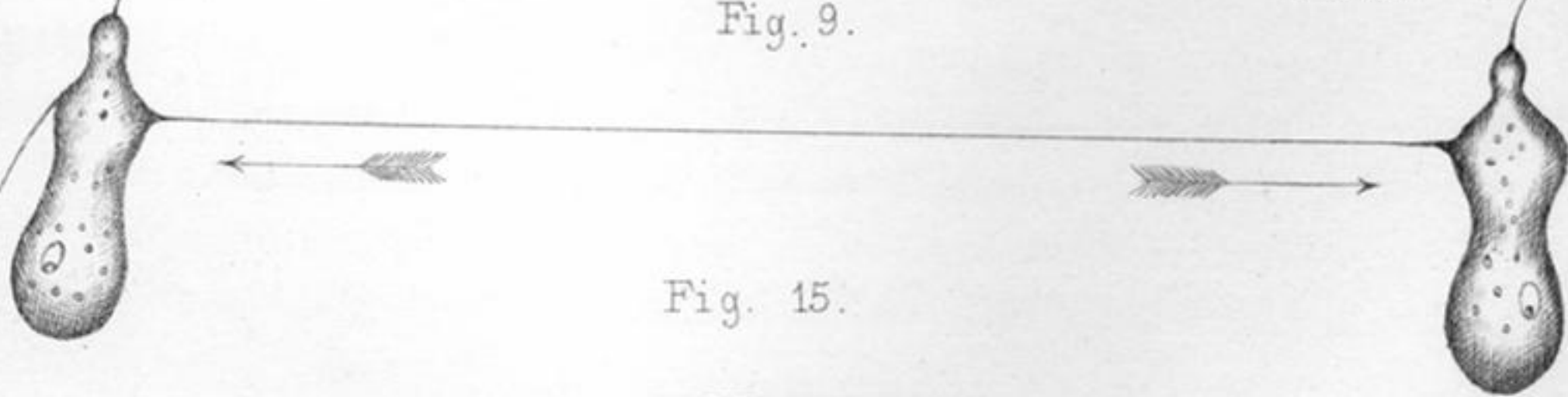


Fig. 15.



× 3500



Fig. 16.



Fig. 18.



Fig. 19.



Fig. 17.



Fig. 20.



Fig. 21.



Fig. 22.

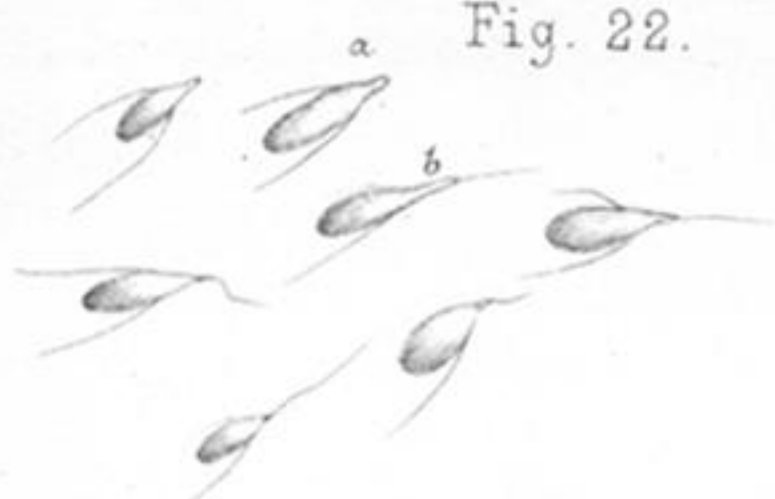


Fig. 23.



Fig. 24.

Fig. 25.

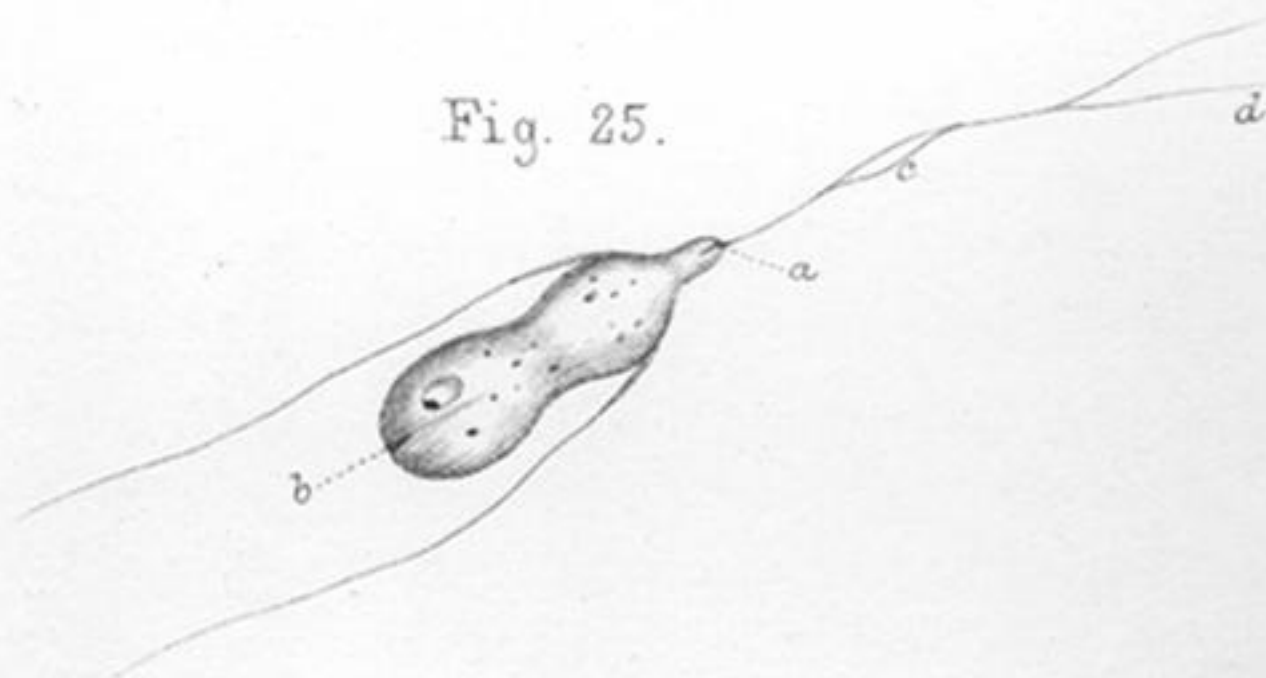


Fig. 26.

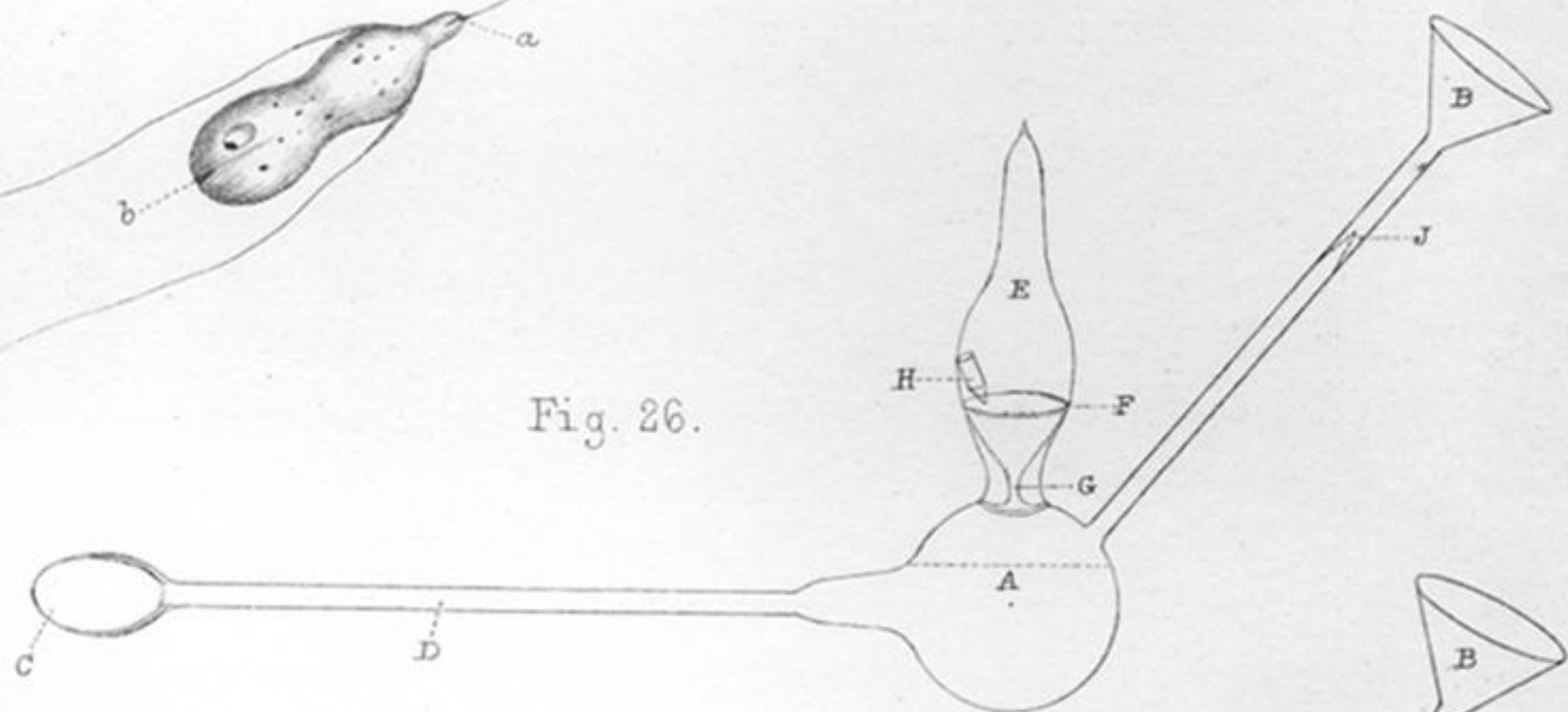


Fig. 27.

