

disc therefore does not act where it is not. It sets the air next it in motion by pushing it, this motion is communicated to more and more distant portions of the air in turn and thus the pressures on opposite sides of the suspended body are rendered unequal, and it moves toward the disc in consequence of the excess of pressure. The force is therefore a force of the old school, a case of *vis a tergo*, a shove from behind."

It has been customary with me for several years, when occasion invited it, to demonstrate to my musical friends the physical action existing in the sounding organ-pipe, to show them (taking up a chance wood-shaving lying on the floor of the workshop or a strip of tissue paper) that, heterodox though the teaching be, the stream of air at the mouth of the organ-pipe constitutes a free-reed—visibly before them the film-like wood-shaving is drawn into the motion of the air, and the beautiful curve of the reed's swing displays itself beyond dispute; then to show them that the air-moulded tongue obeys every law of the free-reed, has its own definite rate of vibration, that the current is so directed that it shall pass not strike the lip, that it is an air-moulded or *aëroplastic* reed as definitely fashioned in substance, strength, proportion, and form, as metal reeds are to produce a required and determinate rate of vibration. First, the velocity of current, a constant upward force; then, the periodicity of vibration as a secondary mode of its activity. The *aëroplastic* reed forming with the pipe a system of transverse vibration associated with longitudinal vibration, and possibly another phase of vibration across the width of the reed enabling it to synchronise with the harmonic range of the pipe; the principle of action of the whole being termed, in my non-academic phraseology, suction by velocity; but if a more exact expression is found its explanation should imply, or better still, include the axiomatic phrase of Sir W. Thomson, "in a moving fluid the pressure is least where the velocity is greatest." To state the existence of an air-moulded free-reed is to give the key to its nature. Flutes, flageolets, whistle-pipes, disc-whistles, form one group with organ-pipes; all are of one type. Then there is another group of free-reeded instruments including the vocal organs, the trumpet, bassoon, oboe, harmonium, and the like, the only distinction between the two groups being that the one possesses reeds of air of definite pitch; and the other possesses reeds of grosser substance, whether it be membrane wood or metal, alike of definite pitch, but in every one the degree of elasticity or pliancy in the substance determines how much of that pitch shall be maintained as the work is done. Velocity is power, and in every conjunction of reed and pipe the reed is the dominant. Most distinctly it should be recognised that the air-reed does work and expends power in doing it. A rod or a string delivers up under a single blow the whole vibrating energy it is capable of—not so the air-column in the organ-pipe, which needs to be beaten the precise number of blows requisite for the pitch of tone elicited.

Reeds of the oboe are as truly free-reeds as are the vocal cords. The stream of air does not necessarily pass down the organ-pipe, but in the oboe it is essential it should pass down the pipe. The action of this orchestral instrument is best explained under the law of "least pressure," showing an identity in principle but with difference of mode; instead of the stream with a lapping action as an air-tongue at the mouth of the organ-pipe, we have an air-current passing between two sensitive reeds down a narrow straw-like tube into the main body of the pipe. The velocity in the little tube immediately causes "least pressure" in the interior, effecting approach and closure of the pair of lip-like reeds, and so on, a perpetual renewing and breaking of contacts, the periodicity of such movement being determined by the sensitiveness of the reed in relation to the air-tube through which the impulses must move before the "dispersion of the vibrations" into the air *relieves* the reed and fixes the *period* of its stroke. In further proof that the flue organ-pipe is a free-reed instrument, compare the flute, its representative, with the oboe and clarinet. So little is understood concerning the nature of these wind instruments, that, whenever in the science of acoustics they are referred to, it is stated that the clarinet is a closed pipe, and the oboe an open pipe; that the former produces the series of uneven harmonics and the latter the even series, and the explanation given is that the tube of the one is cylindrical, and the tube of the other is conical. The explanation does not really explain. It is true that the clarinet gives in relation to its length the pitch corresponding to that of a closed pipe, whilst the oboe, though of similar length (scale of key allowed for), is of the pitch of an open pipe, with relative harmonics; yet this difference

arises not in any degree from the shape of bore cylindrical or conical. As well denominate the oboe "a closed pipe" if structure is compared; the one is not more a closed pipe than the other, the true cause of the diversity is in the rate of *reed-vibration* of the clarinet being only half the rate of that natural to the oboe. The proof is clear and open to anyone intent to observe. Place the oboe head on the clarinet-tube, and you will get from this same tube only the two-foot tone instead of the four-foot tone, and with this transformation of pitch the series of harmonics previously wanting. Place the flute-head on the clarinet-tube and the same results follow; showing that the velocity of vibration originates with the reed, and that the flute rightly considered is a free-reeded instrument.

The experience of years justifies me in presenting these conclusions, and should they not be disproved, questions will suggest themselves whether physicists should not look to the disturbance of the equilibrium of air-pressure as the chief element in determining the pitch of sounds produced in organ pipes; whether the long conserved doctrine of "the column of air within being alone the cause of sound" has not been detrimental to investigation as was in older times; the doctrine that "nature abhors a vacuum," which, as Whewell points out, retarded science a century by pre-occupying men's minds against observation; and whether it is not through the presence of the law of "least pressure" that vibration of any kind becomes possible.

HERMANN SMITH

### The Hegelian Calculus

YESTERDAY evening a copy of NATURE for the 10th instant, sent to my late address at Piershill, reached me here. The sender annexes the initials W. R. S.—those, presumably, of Mr. W. R. Smith. It was only thus that I became aware of that gentleman's letter on "The Hegelian Calculus," in said issue; and, as I am called upon by name therein, I should be obliged if, in an early number of the valuable publication referred to, you would kindly allow me insertion of this explanatory word in return.

In my rejoinder, mentioned by Mr. Smith as appearing in the current number of the *Fortnightly*, and which (rejoinder) treats, as Mr. Smith truly says himself, his own paper in the same pages "as a virtual concession of the entire case," I speak thus:—

"He that, with whatever tincture of mathematics, will but cast a single glance into the situation as it veritably is, will perceive at once that Mr. Smith's present paper is of such a character as not to demand any further answer from me. It is of such a character, however, that it may be put on the level of a business transaction, and if Mr. Smith can persuade any competent mathematician—say the greatest alive, Sylvester, he being at once mathematician, metaphysician, and German scholar, and at the same time wholly unknown to myself—if, I say, Mr. Smith can persuade any such competent expert to see in this matter with Mr. Smith's eyes, I shall consent to be mulcted in what pecuniary penalty this expert may please."

Of course with reciprocity in the other event. I hope Mr. Sylvester will kindly pardon me for having thus, almost involuntarily, made free with his name; but, if I could say the above then, certainly not less can I say the above now—after this letter of Mr. Smith's. The "character" in allusion is one, I believe, hitherto unexampled in literary controversy, and such that, as I also believe, the most important interests call forth thorough understanding of it. It is in consequence of this "character" that, as I have intimated, I cannot, with any respect to myself, enter into further direct relations with Mr. Smith, and that I must confine myself to what has been said above. All, for that part, may be confidently left to time. Napoleon snipped off, and put in his pocket the alleged gold tassel, assured that use would disclose the tinsel in suspicion. So, as regards the—to me—extraordinary operations of Mr. Smith—not but every *Kenner* must see what is concerned at a glance—I can leave them fearlessly to the intrusions of the public.

Further proceeding, let me intimate in conclusion, however formidable it may look, must, so far as I am concerned, be arranged by a friend on the one part, and a friend on the other. Longer to trouble the public with these altercations can only seem to it impertinent. I, at least, shall be satisfied if it will but consider the result in the end.

Edinburgh, April 18

J. HUTCHISON STIRLING