APPLIED SCIENCE.

Some Curious Investigations.

"SINGING AND DANCING" FLAME.

The following abstract of Professor Tyndall's curious experimental lecture upon singing and dancing flame, delivered at the Royal Institution, has been contributed by himself to the last number of the *Philosophical Magazine.*

The sounding of a hydrogen flame when inclosed within a glass tube was, I believe, first noticed by Dr. Higgins, in 1777. The subject has been since investigated by Chladni, De La Rive, Faraday, Wheatstone, Rijke, Sondhauss, and Kundt. The action of unisonant sounds on flames inclosed in tubes has been investigated by Count Schaffgotsch and myself. The jumping of a naked fish-tail flame, in response to musical sounds, was first noticed by Professor Leconte at a musical party in the United States. He made the important observation that the flame did not jump until it was near flaring. That the discovery was not further followed up by this learned investigator was probably due to too great a stretch of courtesy on his part towards myself. Last year, while preparing the experiments for one of my "Juvenile Lectures," my late assistant, Mr. Barrett, observed the effect independently; and he afterwards succeeded in illustrating it by some very striking experiments. With a view to the present discourse, and also to the requirements of a forthcoming work on sound, the subject of sounding and sensitive flames has been recently submitted to examination in the laboratory of the Royal Institution. The principal results of the inquiry are embodied in the following abstract:—

"Pass a steadily burning candle rapidly through the air, you obtain an indented band of light, while an almost musical sound heard at the same time announces the rhythmic character of the motion. If, on the other hand, you blow against a candle flame, the fluttering noise produced indicates a rhythmic action. When a fluttering of the air is produced at the embouchure of an organ pipe, the resonance of the pipe reinforces that particular pulse of the flutter whose period of vibration coincides with its own, and raises it to a musical sound. When a gas flame is introduced into an open tube of suitable length and width, the current of air passing over the flame produces such a flutter, which the resonance of the tube exalts to a musical sound. Introducing a gas flame into this tin tube three feet long, we obtain a rich musical note; introducing it into a tube six feet long, we obtain a note an octave deeper—the pitch of the note depending on the length of the tube. Introducing the flame into this third tube, which is fifteen feet long, the sound assumes extraordinary intensity. The vibrations which produce it are sufficiently powerful to shake the pillars, floors, seats, gallery, and the five or six hundred people who occupy the seats and gallery. The flame is sometimes extinguished by its own violence, and ends its peal by an explosion as loud as a pistol shot. The roar of a flame in a chimney is of this character; it is a rude attempt at music. By varying the size of the flame, these tubes may be caused to emit their harmonic sounds. Passing from large pipes to small ones, we obtain a series of musical notes which rise in pitch as the tube diminishes in length. This flame, surrounded by a tube 17½ inches long, vibrates 458 times in a second; while that contained in this tube, 10½ inches long, vibrates 717 times in a second. Owing to the intense heat of the sounding column, these numbers are greater than those corresponding to organ pipes of the same length sounding in air. The vibrations of the flame consist of a series of partial extinctions and revivals of the flame. The singing flame appears continuous; but if the head be moved to and fro, or if an opera glass directed to the flame be caused to move to and fro, or if, after the method of Wheatstone, the flame be regarded in a mirror which is caused to rotate, the images due to the revivals of the flame are separated from each other, and form a chain of flames of great beauty. With a longer tube and larger flame, by means of a concave mirror, I can project this chain of flames upon a screen. I first clasp my hand round the end of the tube so as to prevent the current of air which causes the flutter from passing over the flame; the image of the flame is now steady upon the screen before you. I move the mirror, and you have this continuous luminous band. I withdraw my hand, the current of air passes over the flame, and instantly the band breaks up into a chain of images. A position is to be chosen in the tube at which the flame burns spontaneously into song. A position may also be chosen where the flame is silent, but at which, if it could only be started, it would continue to sound. It is possible to start such a silent flame by a pitch-pipe, by the siren, or by the human voice. It is also possible to cause one flame to effect the musical ignition of another. The sound which starts the flame must be nearly in unison with its own. Both flames must be so near unison as to produce distinct beats. A flame may be employed to detect sonorous vibrations in air. Thus, in front of this resonant case, which supports a large and powerful tuning fork, I move this bright gas flame to and fro. A continuous band of light is produced, slightly indented through the friction of the air. The fork is now sounded, and instantly this band breaks up into a series of distinct images of the flame. Approaching the same flame towards either end of one of our tin tubes with the sounding flames within it, and causing it to move to and fro, the sonorous vibrations also effect the breaking up of the band of light into a chain of images. In this glass tube, fourteen inches long, a flame is sounding. I bring the flat flame of a fish-tail burner over the tube, the broad side of the flame being at right angles to the axis of the tube. The fish-tail flame instantly emits a musical note of the same pitch as that of the singing flame, but of different quality. This sound is, in fact, that of a membrane, the part of which it here plays. Against a broad bat's-wing flame I allow a sheet of air, issuing from a thin slit, to impinge. A musical note is the consequence. The note can be produced by air or by carbonic acid, but it is produced with greater force and purity by oxygen. The pitch of the note depends on the distance of the slit from the flame. Before you burns a bright candle flame. I may shout, clap my hands, sound this whistle, strike this anvil with a hammer, or explode a mixture of oxygen and hydrogen; though sonorous waves pass in each case through the air, the candle is absolutely insensible to the sound; there is no motion of the flame. I now urge from this small blowpipe a narrow stream of air through the flame of the candle, producing thereby an incipient flutter, and reducing the brightness of the flame. I now sound the whistle; the flame jumps visibly. Matters may be so arranged that when the whistle sounds the flame shall be either almost restored to its pristine brightness, or the amount of light it still possesses shall disappear. Before you now burns a bright flame from a fish-tail burner. I may, as before, shout, clap my hands, sound a whistle, or strike an anvil; the flame remains steady and without response. I urge against the broad face of the flame a stream of air from the blow-pipe just employed. The flame is cut in two by the stream of air; it flutters slightly; and now, when the whistle is sounded, the flame instantly starts. A knock on the table causes the two half flames to unite and form for an instant a flame of the ordinary shape. By a slight variation of the experiment, the two side flames disappear when the whistle is sounded, and a central tongue of flame is thrust forth in their stead.

"Passing from a fish-tail to a bat's-wing burner, I obtain this broad, steady flame. It is quite insensible to the loudest sound which would be tolerable here. The flame is fed from this gas-holder, which places a power of pressure at my disposal unattainable from the gas-pipes of the Institution. I turn on more gas. The flame enlarges, but it is still insensible to sound. I enlarge it still more, and now a slight flutter of its edge answers to the sound of the whistle. Turning on a little more gas, and sounding again, the jumping of the flame is still more decided. Finally I turn on gas until the flame is on the point of roaring, as flames do when the pressure is too great. I now sound my whistle; the flame roars and thrusts suddenly upward eight long quivering tongues. I strike this distant anvil with a hammer; the flame instantly responds by thrusting forth its tongues. Another flame is now before you. It issues from a burner formed of ordinary gas tubing by my assistant. The flame is eighteen inches long, and smokes copiously. I sound the whistle; the flame falls to a height of nine inches, the smoke disappears, and the brilliancy of the flame is augmented. Here are two other flames, also issuing from burners formed by my assistant. The one of them is long, straight, and smoky; the other is short, forked, and brilliant. I sound the whistle; the long flame becomes short, forked, and brilliant; the forked flame becomes long and smoky. As regards, therefore, their response to the sonorous waves, the one of these flames is the exact complement of the other. Here are various flat flames, ten inches high and about three inches across at their widest part. They are purposely made forked flames. When the whistle sounds, the plane of each flame turns ninety degrees round, and continues in its new position as long as the whistle continues to sound. Here, again, is a flame of admirable steadiness and brilliancy, issuing from a single circular orifice in a common iron nipple. I whistle, clap my hands, strike the anvil, and produce other sounds; the flame is perfectly steady. Observe the gradual change from this apathy to sensitiveness. The flame is now four inches high. I make its height six inches; it is still indifferent. I make it ten inches; a barely perceptible quiver responds to the whistle. I make it fourteen inches high, and now it jumps briskly the moment the anvil is tapped or the whistle sounded. I augment the pressure; the flame is now sixteen inches long, and you observe a quivering which announces that the flame is near roaring. I increase the pressure; it now roars, and shortens at the same time to a height of eight inches. I diminish the pressure a little; the flame is again sixteen inches long, but it is on the point of roaring. It stands, as it were, on the brink of a precipice. The whistle pushes it over. Observe, it shortens when the whistle sounds, exactly as it did when the pressure was in excess. The sonorous pulses, in fact, furnish the supplement of energy necessary to produce the roar and shorten the flame. This is the simple philosophy of all these sensitive flames.

"The pitch of the note chosen to push the flame over the brink is not a matter of indifference. I have here a tuning-fork which vibrates 256 times in a second, emitting a clear and forcible note. It has no effect upon this flame. Here are three other forks, vibrating respectively 320, 384, and 512 times in a second. Not one of them produces the slightest impression upon the flame. But, besides their fundamental notes, these forks can be caused to sound a series of over notes of very high pitch. I sound this series of notes; the vibrations are now 1600, 2000, 2400, and 3200 per second respectively. The flame jumps in response to each of these notes, the response to the highest note of the series being the most prompt and energetic of all. To the tap of a hammer upon a board the flame responds; but to the tap of the same hammer upon an anvil the response is much more brisk and animated. The reason is, that the clang of the anvil is rich in the higher tones, to which the flame is most sensitive. Here again is an inverted bell, which I cause to sound by means of a fiddle bow, producing a powerful tone. The flame is unmoved. I bring a half-penny into contact with the surface of the bell; the consequent rattle contains the high notes to which the flame is sensitive. It instantly shortens, flutters, and roars when the coin touches the bell. Here is another flame, twenty inches long. I take this fiddle in my hand, and pass a bow over the three strings, which emit the deepest notes. There is no response on the part of the flame. I sound the highest string; the jet instantly squats down to a tumultuous bushy flame, eight inches high. I have here a small bell, the hammer of which is caused to descend by clock-work. I hold it at a distance of twenty yards from the flame. The strokes followed each other in rythmic succession, and at every stroke the flame falls from a height of 20 to a height of 8 inches. The rapidity with which sound is propagated through air is well illustrated by these experiments. There is no sensible interval between the stroke of the bell and the shortening of the flame. Some of these flames are of marvellous sensibility, one such as is at present burning before you. It is nearly 20 inches long, but the slightest tap on a distant anvil knocks it down to 8. I shake this bunch of keys or these few copper coins in my hand; the flame responds to every tinkle. I may stand at a distance of 20 yards from the flame; the dropping of a sixpence from the height of a couple of inches into a hand already containing coin, knocks the flame down. I cannot walk across the floor without affecting the flame; the creaking of my boots sets it in violent commotion; the crumpling of a bit of paper or the rustling of a silk dress does the same; it is startled by the plashing of a raindrop; I speak to the flame, repeating a few lines of poetry; the flame jumps at intervals, apparently picking certain sounds from my utterance to which it can respond, while it is unaffected by others.

"In our experiments down stairs we have all observed this vowel flame, because the different vowel sounds affect it differently. Vowel sounds of the same pitch are known to be readily distinguishable. Their qualities or clang-tints are different, though they have a common fundamental tone. They differ from each other through the admixture of higher tones with the fundamental. It is the presence of these higher tones in different proportions that characterizes the vowel sounds; and it is to these same tones, and not to the fundamental one, that our flame is sensitive. I utter a loud and sonorous U, the flame remains steady; I change the sound to O, the flame quivers; I sound E, and now the flame is affected strongly. I utter the words boot, boat, and the beat in succession. To the first there is no response; to the second the flame starts; but by the third it is thrown into violent commotion; the sound Ah! is still more powerful. When the vowel sounds are analyzed, their constituents are found to vary in accordance with the foregoing experiments, those characterized by the sharpest overtones being the most powerful excitants of the flame. (See Helmholtz in Pogg. 'Annalen,' vol. cviii, p. 286.) The flame is peculiarly sensitive to the utterance of the letter S. If the most distant person in the room were to favor me with a 'hiss,' the flame would be instantly shivered into tumult. The utterance of the word 'hush' or 'puss' produces the same effect. The hissing sound contains the precise elements that most forcibly affect the flame. The gas issues from its burner with a hiss, and an external sound of this character added to that of a gas jet already on the point of roaring, is equivalent to an augmentation of pressure on the issuing stream of gas. I hold in my hand a metal box containing compressed air. I turn the cock for a moment, so as to allow a puff to escape—the flame instantly ducks down, not by any transfer of air from the box to the flame, for I stand at a distance which utterly excludes this idea; it is the sound of the issuing air that affects the flame. The hiss produced in one orifice precipitates the tumult at the other."

LEGAL NOTICES.

ESTATE OF CHARLES HEPBURN, DECEASED.—Letters testamentary upon the Estate of CHARLES HEPBURN, deceased, having been granted to the undersigned by the Registrar of Wills of Philadelphia, all persons indebted to the Estate will make payment, and those having claims will please present them immediately to

JAMES FARIES, Executor.
No. 311 CARPENTER Street;

Or to his Attorney,
E. COPPEE MITCHELL,
No. 502 WALNUT Street.

PHILADELPHIA, February 21, 1867. 2 21 th6t

MEDICAL BOARD FOR THE EXAMINATION OF CANDIDATES FOR ADMISSION INTO THE NAVY AS ASSISTANT SURGEONS.

BUREAU OF MEDICINE AND SURGERY,
NAVY DEPARTMENT,
December 29, 1866.

A Board of Medical Officers is now in session at the NAVAL ASYLUM, Philadelphia, for the examination of candidates for admission into the Medical Corps of the Navy.

Gentlemen desirous of appearing before the Board must make application to the Honorable Secretary of the Navy, or to the undersigned, stating residence, place and date of birth. Applications to be accompanied by respectable testimonials of moral character.

Candidates must not be less than twenty-one nor more than twenty-six years of age.

No expense is allowed by the Government to candidates attending the sessions of the Board, as a successful examination is a legal pre-requisite for appointment in the Navy.

The many vacancies existing in the Medical Corps insure immediate appointments to successful candidates.

P. J. HORWITZ,
Chief of Bureau.
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