Circular nodal lines unaccompanied by intersecting lines cannot be produced in the manner described; but may be got either by drill- ing a small hole through the centre, and drawing a horse-hair along its edge to bring out the note, or by attaching a long thin elastic rod to the centre of the plate, at right angles to it, holding the rod by the middle and rubbing it lengthwise with a bit of cloth powdered with resin, till the rod gives a distinct note; the vibrations are communicated to the plate, which consequently vibrates transversely, and causes the sand to heap itself into one or more concentric rings.

Paper, parchment, or any other thin membrane stretched over a square, circular, &c., frame, when in the vicinity of a sufficiently powerful vibrating body, will, through the medium of the air, be itself made to vibrate in unison, and, by using sand, as in previous instances, the nodal lines will be depicted to the eye, and seen to vary in form, number and position with the tension of the plate and the pitch of the originating sound. The membrana tympani or drum of the ear, has, in like manner and on the same principles, the property of repeating the vibrations of the external air which it communicates to the internal parts of the ear.

*Bells* may be regarded as somewhat like circular plates vibrating with radial nodes, and with the edges turned down. Lord Rayleigh has shown that there is a tangential motion as well as a motion in and out. Ordinarily when a bell is struck the impulse primarily excites the radial motion, and the tangential motion follows as a matter of course. When a finger-glass (an inverted bell), is excited by passing the finger round the circumference, the tangential motion is primarily excited and the radial follows it. Some discussion of the vibrations of bells will be found in Rayleigh, *Sound,* vol. i. ch. 10 (see also Bells).

*Singing Flames.—*A " jet tube,” *i.e.* a tube a few inches long with a fine nozzle at the top, is mounted as in fig. 40, so as to rise out of a vessel to which coal-gas, or, better, hydro- gen, is supplied. The supply is regulated so that when the gas is lighted the flame is half or three-quarters of an inch high. A “ sound­ing tube, say an inch in diameter, and some­what more than twice the length of the jet tube, is then lowered over the flame, as in the figure. When the flame is at a certain distance within the tube the air is set in vibration, and the sounding tube gives out its fundamental note continuously. The flame appears to lengthen, but if the reflection is viewed in a vertical mirror revolving about a vertical axis or in Koenig's cube of mirrors, it is seen that the flame is really intermittent, jumping up and down once with each vibration, sometimes apparently going within the jet tube at its lowest point. For a given jet tube there is a position of maximum efficiency easily ob- tained by trial. The jet tube, for a reason which will be given when we consider the maintenance of vibrations, must be less than half the length of the sounding tube.

A series of pipes of lengths to give any desired series of notes may be arranged. If two tubes in unison are employed, a pretty example of resonance may be obtained. One is adjusted so as just not to sing. The other is then made to sing and frequently the first will be set singing also.

*Sensitive Flames and Jets.—*When a flame is just not flaring, any one of a certain range of notes sounded near it may make it flare while the note is sounding. This was first noticed by John Le Conte (*Phil. Mag.,* 1858, 15, p. 235), and later by W. F. Barrett (*Phil. Mag.,* 1867, 33, p. 216). Barrett found that the best form of burner for ordinary gas pressure might be made of glass tubing about ⅜ in. in diameter contracted to an orifice 1/16 inch in diameter, the orifice being nicked by a pair of scissors into a V-shape. The flame rises up from the burner in a long thin column, but when an appropriate note is sounded it suddenly drops down and thickens. Barrett further showed by using smoke jets that the flame is not essential. John Tyndall *{Sound,* lecture vi. § 7 seq.) describes a number of beautiful experiments with jets at higher pressure than ordinary, say 10 in. of water, issuing from a pinhole steatite burner. The flame may be 16 in. high, and on receiving a suitably high sound it suddenly drops down and roars. The sensitive point is at the orifice. Lord Rayleigh *{Sound,* ii. § 370), using as a source a “ bird-call,” a whistle of high frequency, formed a series of stationary waves by reflection at a flat surface. Placing the sensitive flame at different parts of this train, he found that it was excited, not at the nodes where the pressure varied, but at the loops where the motion was the greatest and where there was little pressure change. In his *Sound* (ii. ch. 21) he has given a theory of the sensitiveness. When the velocity of the jet is gradually increased there is a certain range of velocity for which the jet is unstable, so that any deviation from the straight rush-out tends to increase as the jet moves up. If then the jet is just on the point of instability, and is subjected as its base to alternations of motion, the sinuosities impressed on the jet become larger and larger as it flows out, and the flame is as it were folded on itself. Another form of sensitive jet is very easily made by putting a piece of fine wire gauze 2 or 3 in. above a pinhole burner and igniting the gas above the gauze. On adjusting the gas so that it burns in a thin column, just not roaring, it is extraordinarily sensitive to some particular range of notes, going down and roaring when a note is sounded. lf a tube be placed over such a flame it makes an excellent singing tube. The flame of an incandescent gas mantle if turned low is frequently sensitive to a certain range of notes. Such a flame may jump down, for instance, to each tick of a neighbouring clock.

*Savart's Liquid Jets.—*If a jet of water issues at an angle to the horizontal from a round pinhole orifice under a few inches pressure, it travels out as an apparently smooth cylinder for a short distance, and then breaks up into drops which travel at different rates, collide, and scatter. But if a tuning-fork of appropriate frequency be set vibrating with its stalk in contact with the holder of the pipe from which the jet issues, the jet appears to go over in one continuous thread. Intermittent illumination, however, with frequency equal to that of the fork shows at once that the jet is really broken up into drops, one for each vibration, and that these move over in a steady procession. The cylindrical form of jet is unstable if its length is more than *π* times its diameter, and usually the irregular disturbances it receives at the orifice go on growing, and ultimately break it up irregularly into drops which go out at different rates. But, if quite regular disturbances are impressed on the jet at intervals of time which depend on the diameter and speed of outflow (they must be somewhat more than π times its diameter apart), these disturbances go on growing and break the stream up into equal drops, which all move with the same velocity one after the other. An excellent account of these and other jets is given in C. V. Boys' *Soap Bubbles,* lecture iii.

*Maintenance of Vibrations.—*When a system is set vibrating and left to itself, the vibration gradually dies away as the energy leaks out either in the waves formed or through friction. In order that the vibration may be maintained, a periodic force must be applied either to aid the internal restoring force on the return journey, or weaken it on the outgoing journey, or both. Thus if a pendulum always receives a slight impulse in the direction of motion just about the lowest point, this is equivalent to an increase of the restoring force if received before passage through the lowest point, and to a decrease if received after that passage, and in either case it tends to maintain the swing. If the bob of the pendulum is iron, and if a coil is placed just below the centre of swing, then, if a current passes through the cofl, while and only while the bob is moving towards it, the vibration is maintained. If the current is on while the bob is receding the vibration is checked. If it is always on it only acts as if the value of gravity were increased, and does not help to maintain or check the vibration, but merely to shorten the period. In a common form of electrically maintained fork, the fork is set horizontal with its prongs in a vertical plane, and a small electro-magnet is fixed between them. The circuit of the electro-magnet is made and broken by the vibration of the fork in different ways—say, by a wire bridge attached to the lower prong which dips into and lifts out of two mercury cups. The mercury level is so adjusted that the circuit is just not made when the fork is at rest. When it is set vibrating contact lasts during some part of the outward and some part of the inward swing. But partly owing to the delay in making contact through the carriage down of air on the contact piece, and partly owing to the delay in establishing full current through self- induction, the attracting force does not rise at once to its full value in the outgoing journey, whereas in the return journey the mercury tends to follow up the contact piece, and the full current continues up to the instant of break. Hence the attracting force does more work in the return journey than is done against it in the outgoing, and the balance is available to increase the vibration.

In the organ pipe—as in the common whistle—a thin sheet of air is forced through a narrow slit at the bottom of the embouchure and impinges against the top edge, which is made very sharp. The disturbance made at the commencement of the blowing will no doubt set the air in the pipe vibrating in its own natural period, just as any irregular air disturbance will set a suspended body swinging in its natural period, but we are to con- sider how the vibration is maintained when once set going. When the motion due to the vibration is up along the pipe from the em­bouchure, the air moves into the pipe from the outside, and carries the sheet-like stream in with it to the inside of the sharp edge. This stream does work on the air, aiding the motion. When the motion is reversed and the air moves out of the pipe at the embou- chure, the sheet is deflected on to the outer side of the sharp edge, and no work is done against it by the air in the pipe. Hence the stream of air does work during half the vibration and this is not abstracted during the other half, and so it goes on increasing the motion until the supply of energy in blowing is equal to the loss by friction and sound.