

Again, in like manner, a "resonator" was always found to give the node in different positions according to the size of the "vibrator" employed. This is what would be expected from the principle of resonance, a resonator being able to respond to any member of the "band" it would itself give out when acting as a radiator, the central period of course with the greatest

ease. Some such factor as $e^{-(\lambda - \lambda_0)^{2n}}$ could, perhaps, express this sort of thing, where λ belongs to the period of the radiation, supposed for the moment "monochromatic," falling on the resonator, and λ_0 belongs to the "period" of the resonator, or that of the centre of its "band."

The position of the node was also found to vary on altering the character of the dielectric surrounding the resonator; even laying a piece of sealing-wax on the wire of the resonator was sufficient to be observed. This might be employed to determine "V" in a dielectric of which only a small quantity was obtainable.

It is obviously of importance for the "central period" of the resonator employed to coincide with that of the vibrator, especially when determining the velocity of the disturbance, for this is presumably the period given by theory. This is practically always done when arranging their relative sizes, so as to obtain greatest intensity. So that the caution urged by M. Cornu in connection with Prof. Hertz's measurements of this velocity seems, from these considerations, to be to a great extent unnecessary.

It would obviously be of importance to investigate what form the resonator should take, so as to give out a radiation most approaching one definite period. FRED. T. TROUTON.

Bourdon's Pressure Gauge.

As there does not seem to be in any of the more familiar text-books of Physics or Engineering any satisfactory explanation of the action of the Bourdon gauge, the following may be of use to some of your readers.

What we have to explain is the uncurling of the gauge under internal pressure whether of gas or liquid.

Instead of the usual flattened tube of more or less elliptical section

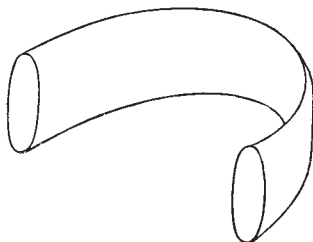


FIG. 1.

bent into the arc of a circle as in Fig. 1, think, for convenience, of one of rectangular section, such as AB of Fig. 2, in which A

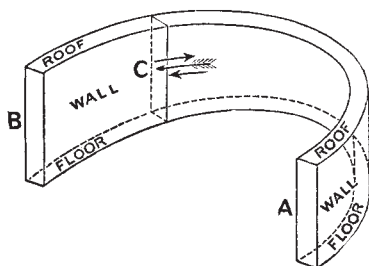


FIG. 2.

is the fixed and B the free end, and in which we shall distinguish, as indicated, the walls, roof, and floor.

If the annulus of tube were complete, as shown in the central cross-section (Fig. 3), then it is evident that under the influence of internal fluid pressure the outer wall would be everywhere in a state of tension in the direction of its length, and the inner wall in a state of compression. In the immediate neighbourhood of the ends A and B this state of compression or

extension will be somewhat modified, but at a sufficient distance from either the condition of the walls will be the same as if the annulus really were complete.

If T be the tension of the outer wall in the direction of its length, P the pressure of the inner, and R the resultant fluid pressure on any cross-section such as A or B (Fig. 2), then for the equilibrium of the half of the annulus lying on either side of the diameter AB (Fig. 3) we must have

$$T = P + R.$$

Consider now the equilibrium of any portion BC (Fig. 2) contained between the free end B and a cross-section C at some little distance from B, when the internal pressure is applied, and before uncurling takes place.

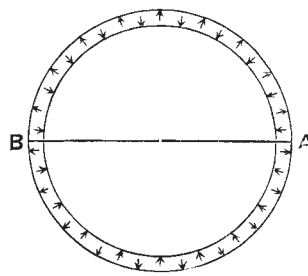


FIG. 3.

Imagine the fluid within BC to be solidified, then the external forces acting on BC (see Fig. 4) reduce to

- (1) A tension, T, due to the action of the outer wall beyond C.
- (2) A pressure, P, " " " " inner " " "
- (3) A resultant fluid pressure, R, acting at the centre of pressure of the cross-section c.

and since $P + R = T$, these reduce to a couple tending to uncurl the tube, and the same holds for all sections sufficiently removed from A and B.

As the tube uncurls, however, new forces come into play, viz. the resistance to bending of the walls, but especially of the floor and roof of the tube, whose width in the direction of a principal

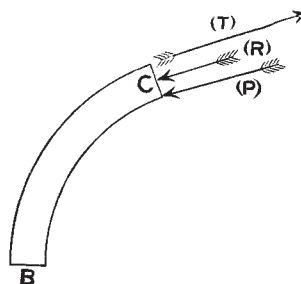


FIG. 4.

radius of the annulus, and consequently whose resistance to bending, is much greater than that of the walls. Uncurling goes on till the moment of the couple resisting flexure is equal to the moment of the bending couple.

It is evident from this explanation that even a tube of circular section would tend to uncurl, but that it would be very insensitive on account of its strength to resist flexure, and that up to a certain point sensitiveness is gained by having the walls of thin material, high, and very near together.

Devonport, December 23, 1889.

M. WORTHINGTON.

Foreign Substances attached to Crabs.

REFERRING to Mr. F. P. Pascoe's letter (NATURE, December 26, p. 176), I cannot refrain from expressing my astonishment at his inability to "see where protection comes in" in the case of crabs covered with sponges, Polyzoa, &c. I should have thought it obvious to everybody that slow-moving crabs, such as all those he mentions and many others that I have seen, would have a much better chance of escaping their enemies when

covered with material that renders them almost indistinguishable from the stones and gravel in which they are found than if they were naked.

As regards the use of the peculiar hind legs in the Anomoura and *Dorippe*, perhaps the enclosed extract from a paper read by me on December 12 before the Chester Society of Natural Science may be of interest. It will shortly be published in vol. iv. of the Transactions of the Liverpool Biological Society.

ALFRED O. WALKER.

London, W., January 17.

"An interesting fact, illustrating the ingenuity shown by more than one species of Crustacea in concealing themselves, came under my notice last summer. Having dredged a number of Amphipoda, I placed them in a vessel of sea water till I could examine them. Among them I noticed what seemed to be a piece of dead weed swimming rapidly about and occasionally falling to the bottom. Examination with a lens showed that the piece of weed was carried by an Amphipod (*Atylus swammerdamii*), which grasped it by the two first pairs of walking legs (peræopoda). When it came to the bottom the animal concealed itself beneath the weed, which was much larger than itself.

"In connection with this habit of *A. swammerdamii*, it may be mentioned that another species, *Atylus falcatus* (Metzger), resembles the first-named minutely in every respect but one, viz. that the first peræopod has the claw (dactylus) immensely developed, while at the base of the next joint are two or three strong blunt spines or tubercles into which the point of the claw fits. This would appear to give the latter species a great advantage over its congener in grasping an object for purposes of concealment. It is a rare species, but I have met with a few specimens this summer: I am not aware of its having been recorded as British yet.

"In some of the Podophthalmata the same instinct has been observed, and especially among the Anomoura. All these have the last or hindmost pair of legs of a shrunken and apparently almost abortive form. They never appear to be used for walking, and are generally carried turned up on the back; but they are utilized by some species of curiously shaped, flat-bodied crabs (*Dorippe*) to carry the valve of a bivalve mollusk over their backs, under which they can squat and hide. From this it is an easy transition through various stages to the hermit crabs (*Paguridae*), which ensconce themselves altogether in a univalve shell, and use the curiously abortive hind limbs to cling to the inside whorls. My friend Surgeon-Major Archer has seen crabs of the genus *Dorippe* protecting themselves (probably from the scorching tropical sun), at low tide, on the mud flats at Singapore, by carrying large leaves over their backs (Journal of Linn. Soc., vol. xx. p. 108)."

I CAN corroborate Mr. Ernest Weiss's remarks on the use of the modified legs of Dromia. A small one I had in an aquarium would, when the sponge was removed from the back, hunt about until it found something—a shell, a pebble, or even a dead fish—to replace the sponge. When there was nothing in the aquarium which it could seize, it was evidently in an unhappy condition.

With regard to foreign substances on other crabs, I have caught spider-crabs so completely covered with sponges as quite to hide their shape, and, until they moved, it was impossible to say what they were.

DAVID WILSON-BARKER.

Thought and Breathing.

WITH reference to Proi. Leumann's researches into the influence of blood circulation and breathing on mind life, referred to in NATURE of January 2 (p. 209), it is worthy of note that regulation and suppression of the breath (*Prāṇāyāma* or *Hatha-Vidyā*), is an all-important religious observance amongst Hindus.

It is one of the eight chief requisites of the Yoga philosophy, for attaining "complete abstraction or isolation of the soul in its own essence," and minute instructions exist for the exercise, which is adopted, apparently, as an immediate aid to deep meditation. Some of these instructions are quoted in Prof. Monier-Williams's recent work on Buddhism (p. 242), and he also quotes, in connection with this subject (p. 241), Swedenborg's opinion that thought commences and corresponds with respiration.

Swedenborg also says:—"It is strange that this correspondence between the states of the brain or mind and the lungs has not been admitted in science."

R. BARRETT POPE.

Brighton.

On the Effect of Oil on Disturbed Water.

HAVING seen the interesting article by Mr. R. Beynon on the above subject (NATURE, January 2, p. 205), shortly before leaving England, I propose to make a few observations on the theoretical aspect of the phenomena described by him.

The simplest case of wave-motion in a viscous liquid arises when two-dimensional waves are propagated in a liquid whose depth is so great in comparison with the lengths of the waves that the former may be treated as infinite. If at any particular epoch, which we may choose as the origin of the time, the form of the free surface is determined by the equation $\eta = A e^{i m x}$, where $2\pi/m$ is the wave-length, its form at any subsequent time may be represented by $\eta = A e^{k t + i m x}$, and the object of a theoretical solution is to find the value of k . The equation for determining k is given in the last chapter of my "Hydrodynamics"; and it is there shown that if the viscosity of the liquid be sufficiently small, k will be of the form $-a \pm i\beta$, where a and β are real positive constants. Hence the equation of the free surface, in real quantities, may be written—

$$\eta = A e^{-a t} \cos (m x - \beta t) \dots \dots (1)$$

which represents periodic motion whose amplitude diminishes with the time, and which therefore ultimately dies away, the rapidity with which the motion decays depending upon the magnitude of a . If, however, the viscosity be large, the solution changes its character, since in this case k is a real negative quantity, and the equation of the free surface becomes

$$\eta = A e^{-a t} \cos m x \dots \dots (2)$$

which represents non-periodic motion, which rapidly dies away.

The phenomena discussed by Mr. Beynon are somewhat different from the special case of deep-sea waves, inasmuch as a thin film of a highly viscous liquid, viz. oil, whose thickness is very small compared with the wave-length, is spread over the surface of water, which is a liquid whose viscosity is so small, that it might probably be neglected altogether. The action of the wind would also introduce an additional complication; but the circumstance that the thickness of the oil is small compared with the wave-length, would, on the other hand, facilitate the calculations which would be necessary in order to obtain a theoretical solution. There can, however, I think, be little doubt that the free surface would be given by equations of the forms either of (1) or (2); where a is so large, that after a short time has elapsed after the film of oil has spread itself over the water, the amplitude of the existing motion would be small compared with that of the original motion.

A. B. BASSET.

Hôtel Beau Site, Cannes, January 11.

Luminous Clouds.

IN the correspondence that has taken place on luminous clouds, totally different classes of phenomena have been mentioned. There are *self-luminous* clouds entirely distinct from what I have termed "sky-coloured clouds," which latter, though by some deemed self-luminous, have been generally admitted to shine by reflecting the direct light of the sun.

The self-luminous clouds described by Mr. C. E. Stromeyer (p. 225) appear to have been a part of the aurora which was visible at the same time; but other correspondents have mentioned self-luminous clouds which have apparently not been of a truly auroral character, and the nature of these clouds seems not to be understood, and requires investigation; there may be various kinds of these and causes of their luminosity. I have myself not unfrequently seen what I call *irregular auroras*, which may be one form of what others call self-luminous clouds. They consist of bands which, unlike regular auroras, appear indifferently in all parts of the sky, and lie in any direction; they are usually much fainter than the Milky Way, and are always feebler near the zenith than near the horizon. The bands composing them are generally parallel, or nearly so, and 3° to 10° wide. They differ from ordinary cirrus in being, so far as I can judge, perfectly transparent, and also in moving extremely slowly, giving one the impression that they are much higher up in the atmosphere than cirrus. Their spectrum is