true that with some of the new forms of circuit breakers and storage batteries, an induction coil can be made to work fairly well during prolonged runs; but storage batteries are troublesome, and a break that will work on voltages ordinarily supplied for lighting is yet to be made.

The following method of driving an induction coil not only does away with its former disadvantages, but gives a much more powerful means of exciting X-ray tubes. A condenser of considerable capacity is first charged by connecting its terminals to the ordinary lighting mains; it is then disconnected, and discharged through the primary of an induction coil. Any good induction coil can be used in this way with a single change, viz. a new primary. The primary should be a few turns of heavy wire on a finely laminated core.

A six-inch Ritchie vertical coil with a new primary winding of about thirty turns of heavy wire (6 B.S. gauge) gives, when a condenser of 27 micro-farads charged at 220 volts is discharged through its primary, a long thin zig-zag spark, resembling that from a static machine with small condensers. If now some form of rotary commutator be used to charge and discharge the condensers, and this be run at sufficient speed, a continuous discharge of sparks will take the place of the single discharge at the secondary terminals.

The commutator used has six segments. If this is run at 2000 revolutions per minute by a small fan motor, there will be 12,000 discharges through the coil per minute, or 200 per second. At this speed there is a continuous discharge of zig-zag sparks a little over six inches long. We have not yet run the commutator above 2000 revolutions, but there is no indication that we are near the limit of speed. Sparking on the commutator is slight, and the power taken from the mains is but a few amperes.

It is necessary to have the primary of the coil well insulated, not only from the secondary, but its own turns must be well insulated from one another and the core. An easy and effectual way in the case of a vertical coil is to place the laminated core in a glass tube, upon this wind the primary, then place the whole in a large heavy tube closed at the bottom, and fill with oil. Without insulation there is a tremendous brush discharge within the primary. Undoubtedly the efficiency of the coil would be considerably increased by using an oil insulated secondary, but it is questionable whether the gain would be enough to off-set the trouble and dirt of oil insulation.

An X-ray tube of the focus type and proper resistance connected to the terminals of the coil lights up brilliantly, and with a spark gap in series, the length of which seems to make very little difference, shows no indication whatever of anything but a unidirectional discharge through the tube.

Fluorescent screens become brilliantly illuminated. In a darkened room all the bones of the hand and forearm can be distinctly seen on a calcium tungstate screen at a distance of eight feet from the tube. The penetration seems to be unusually strong. The whole of the trunk can be examined with the greatest ease with the tube several feet distant. The hand can be distinctly seen through the abdomen, the most opaque part of the body.

Photographically, X-rays obtained in this way are no less powerful. Excellent fully-timed photographs of the hand can be taken in twenty-five seconds with the tube twelve inches from the plate, photographs not merely showing the outline of the bones, but showing the details of the bones, the finger-nails, tendons, &c. Forty-five seconds is an over-exposure. One of the best photographs of a small object—a pocket-book—we have seen, was taken in less than a second.

It seems apparent that we have a simple method for exciting X-ray tubes that is far more powerful and efficient than any that has yet been used. It is a method that ought to be particularly adapted to the needs of the physician, and requires no more skill or knowledge of physics than the ordinary practitioner can supply.

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Semi-Permeable Films and Osmotic Pressure.

LORD KELVIN'S very interesting problem concerning molecules which differ only in their power of passing a diaphragm (see NATURE for January 21, p. 272), seems only to require for its solution the relation between density and pressure for the

fluid at the temperature of the experiment, when this relation for small densities becomes that of an ideal gas; in other cases, a single numerical constant in addition to the relation between density and pressure is sufficient.

This will, perhaps, appear most readily if we imagine each of the vessels A and B connected with a vertical column of the fluid which it contains, these columns extending upwards until the state of an ideal gas is reached. The equilibrium which we suppose to subsist will not be disturbed by communications between the columns at as many levels as we choose, if these communications are always made through the same kind of semi-permeable diaphragm as that which separates the vessels A and B. It will be observed that the difference of level at which any same pressure is found in the two columns is a constant quantity, easily determined in the upper parts (where the fluids are in the ideal gaseous state) as a function of the composition of the fluid in the A-column, and giving at once the height above the vessel A, where in the A-column we find a pressure equal to that in the vessel B.

In fact, we have in either column

$$dp = -g\gamma dz,$$

where the letters denote respectively pressure, force of gravity, density, and vertical elevation. If we set

$$\frac{1}{\gamma} = F'(\rho),$$

we have

$$F'(\rho)d\rho = -g dz.$$

Integrating, with a different constant for each column, we get

$$\begin{aligned} F(\rho_A) &= -g(z - C_A) \\ F(\rho_B) &= -g(z - C_B) \\ F(\rho_A) - F(\rho_B) &= g(C_A - C_B). \end{aligned}$$

In the upper regions,

$$\begin{aligned} F'(\rho) &= \frac{1}{\gamma} = \frac{at}{\rho} \\ \therefore F(\rho) &= at \log \rho, \end{aligned}$$

where t denotes temperature, and a the constant of the law of Boyle and Charles. Hence,

$$at \log \rho_A - at \log \rho_B = g(C_A - C_B).$$

Moreover, if $1:n$ represents the constant ratio in which the S- and D-molecules are mixed in the A-column, we shall have in the upper regions, where the S-molecules have the same density in the two columns,

$$\begin{aligned} \gamma_A &= (1+n)\gamma_B & \rho_A &= (1+n)\rho_B \\ g(C_A - C_B) &= at \log (1+n). \end{aligned}$$

Therefore, at any height,

$$F(\rho_A) - F(\rho_B) = at \log (1+n).$$

This equation gives the required relation between the pressures in A and B and the composition of the fluid in A. It agrees with van 't Hoff's law, for when n is small the equation may be written

$$F'(\rho_A)(\rho_A - \rho_B) = atn$$

or

$$\rho_A - \rho_B = atn\gamma_A.$$

But we must not suppose, in any literal sense, that this difference of pressure represents the part of the pressure in A which is exerted by the D-molecules, for that would make the total pressure calculable by the law of Boyle and Charles.

To show that the case is substantially the same, at least for any one temperature, when the fluid is not volatile, we may suppose that we have many kinds of molecules, A, B, C, &c., which are identical in all properties except in regard to passing diaphragms. Let us imagine a row of vertical cylinders or tubes closed at both ends. Let the first contain A-molecules sufficient to give the pressure ρ' at a certain level. Then let it be connected with the second cylinder through a diaphragm impermeable to B-molecules, freely permeable to all others. Let the second cylinder contain such quantities of A- and B-molecules as to be in equilibrium with the first cylinder, and to have a certain pressure ρ'' at the level of ρ' in the first cylinder. At a higher level this second cylinder will have the pressure which we have called ρ' . There let it be connected with the third cylinder through a diaphragm impermeable to C-molecules, and to them alone. Let this third cylinder contain such quantities of A-, B-, and C-molecules as to be in equilibrium with the

second cylinder, and have the pressure p'' at the diaphragm; and so on, the connections being so made, and the quantities of the several kinds of molecules so regulated, that the pressures at all the diaphragms shall have the same two values.

It is evident that the vertical distance between successive connections must be everywhere the same, say l ; also, that at all the diaphragms, on the side of the greater pressure, the proportion of molecules which can and which cannot pass the diaphragm must be the same. Let the ratio be $1:n$. If we write $\gamma_A, \gamma_B, \&c.$, for the densities of the several kinds of molecules, and γ for total density, we have for the second cylinder

$$\frac{\gamma_A + \gamma_n}{\gamma_A} = 1 + n.$$

For the third cylinder we have this equation, and also

$$\frac{\gamma_A + \gamma_n + \gamma_c}{\gamma_A + \gamma_n} = 1 + n$$

which gives

$$\frac{\gamma_A + \gamma_n + \gamma_c}{\gamma_A} = (1 + n)^2.$$

In this way, we have for the r th cylinder

$$\frac{\gamma}{\gamma_A} = (1 + n)^{r-1}.$$

Now the vertical distance between equal pressures in the first and r th cylinders, is

$$(r - 1)l.$$

Now the equilibrium will not be destroyed if we connect all the cylinders with the first through diaphragms impermeable to all except A-molecules. And the last equation shows that as γ/γ_A increases geometrically, the vertical distance between any pressure in the column when this ratio of densities is found, and the same pressure in the first cylinder increases arithmetically. This distance, therefore, may be represented by $\log(\gamma/\gamma_A)$ multiplied by a constant. This is identical with our result for a volatile liquid, except that for that case we found the value of the constant to be at/g .

The following demonstration of van 't Hoff's law, which is intended to apply to existing substances, requires only that the solutum, *i.e.* dissolved substance, should be capable of the ideal gaseous state, and that its molecules, as they occur in the gas, should not be broken up in the solution, nor united to one another in more complex molecules.

It will be convenient to use certain quantities which may be called the *potentials* of the solvent and of the solutum, the term being thus defined:—In any sensibly homogeneous mass, the *potential* of any independently variable component substance is the differential coefficient of the thermodynamic energy of the mass taken with respect to that component, the entropy and volume of the mass and the quantities of its other components remaining constant. The advantage of using such *potentials* in the theory of semi-permeable diaphragms consists partly in the convenient form of the conditions of equilibrium, the potential for any substance to which a diaphragm is freely permeable having the same value on both sides of the diaphragm, and partly in our ability to express van 't Hoff's law as a relation between the quantities characterising the state of the solution, without reference to any experimental arrangement (see *Transactions of the Connecticut Academy*, vol. iii. pp. 116, 138, 148, 94).

Let there be three reservoirs, R', R'', R''' , of which the first contains the solvent alone, maintained in a constant state of temperature and pressure, the second the solution, and the third the solutum alone. Let R' and R'' be connected through a diaphragm freely permeable to the solvent, but impermeable to the solutum, and let R'' and R''' be connected through a diaphragm impermeable to the solvent, but freely permeable to the solutum. We have then, if we write μ_1 and μ_2 for the potentials of the solvent and the solutum, and distinguished by accents, quantities relating to the several reservoirs,

$$\mu_1'' = \mu_1' = \text{const.}, \quad \mu_2'' = \mu_2''.$$

Now if the quantity of the solutum in the apparatus be varied, the ratio in which it is divided in equilibrium between the reservoirs R'' and R''' will be constant, so long as its densities in the two reservoirs, γ_2'', γ_2''' , are small. For let us suppose that there is only a single molecule of the solutum. It will wander through R'' and R''' , and in a time sufficiently long the parts of the time spent respectively in R'' and R''' , which for convenience we may

suppose of equal volume, will approach a constant ratio, say $1:B$. Now if we put in the apparatus a considerable number of molecules, they will divide themselves between R' and R'' sensibly in the ratio $1:B$, so long as they do not sensibly interfere with one another, *i.e.* so long as the number of molecules of the solutum which are within the spheres of action of other molecules of the solutum is a negligible part of the whole, both in R' and R''' . With this limitation we have, therefore,

$$\gamma_2''' = B\gamma_2''.$$

Now in R''' let the solutum have the properties of an ideal gas, which give for any constant temperature (*ibid.* p. 212)

$$\mu_2''' = a_2 t \log \gamma_2''' + C,$$

where a_2 is the constant of the law of Boyle and Charles, and C another constant. Therefore,

$$\mu_2'' = a_2 t \log (B\gamma_2'') + C.$$

This equation, in which a single constant may evidently take the place of B and C , may be regarded as expressing the property of the solution implied in van 't Hoff's law. For we have the general thermodynamic relation (*ibid.* p. 143)

$$vdp = \eta dt + m_1 d\mu_1 + m_2 d\mu_2,$$

where v and η denote the volume and entropy of the mass considered, and m_1 and m_2 the quantities of its components. Applied to this case, since t and μ_1 are constant, this becomes

$$dp = \gamma_2'' d\mu_2''.$$

Substituting the value of $d\mu_2''$ derived from the last finite equation, we have

$$dp = a_2 t d\gamma_2''$$

whence, integrating from $\gamma_2'' = 0$ and $p'' = p'$, we get

$$p'' - p' = a_2 t \gamma_2'',$$

which evidently expresses van 't Hoff's law.

We may extend this proof to cases in which the solutum is not volatile by supposing that we give to its molecules mutually repulsive molecular forces, which, however, are entirely inoperative with respect to any other kind of molecules. In this way we may make the solutum capable of the ideal gaseous state. But the relations pertaining to the contents of R'' will not be affected by these new forces, since we suppose that only a negligible part of the molecules of the solutum are within the range of such forces. Therefore these relations cannot depend on the new forces, and must exist without them.

To give up the condition that the molecules of the solutum shall not be broken up in the solution, nor united to one another in more complex molecules, would involve the consideration of a good many cases, which it would be difficult to unite in a brief demonstration. The result, however, seems to be that the increase of pressure is to be estimated by Avogadro's law from the number of molecules in the solution which contain any part of the solutum, without reference to the quantity in each.

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New Haven, Connecticut, February 18.

Changes in Faunæ due to Man's Agency.

PROF. HADDON'S interesting article in *NATURE* of January 28 certainly deserves serious attention. Probably few naturalists realise the rapid changes which are being brought about through the agency of man. The way in which the Coccidæ (scale-insects) are carried from country to country is amazing; and with them go their hymenopterous parasites in many instances. Thus, in 1894, Mr. L. O. Howard described the chalcidid *Homalopoda cristata* from St. Vincent, W.I.; in 1896 I described *Aspidiotus secretus*—a coccid—from Japan. Later, in 1896, Mr. Howard was able to report that Mr. Green had bred his St. Vincent chalcidid from my Japanese coccid—in Ceylon! Mr. Howard, in 1896, described another chalcidid, parasitic on scale-insects, from Ceylon; and the day he received the separate copies of his paper, he received the chalcidid from the Southern U.S. Aurivillius, in 1888, described a remarkable parasite of Coccidæ bred by him in Sweden; already it is known also from two localities in the United States, and from Ceylon. As early as 1863, Prof. A. Costa described from Italy a remarkable genus of Chalcididæ, after taking great pains to learn that it was unknown in Europe; but, as Mr. Howard has lately shown, it had been described (the very same species) in 1859 by Motschulsky from Ceylon, whence it had undoubtedly been