

structure light enough to be flown as a kite has been pointed out by Prof. Simon Newcomb in an article in McClure's Magazine, published in September, 1901, entitled "Is the Air Ship Coming?" and this difficulty had so much weight with him at that time as to lead him to the general conclusion that—

"The construction of an aerial vehicle which could carry even a single man from place to place at pleasure requires the discovery of some new metal or some new force."

This conclusion the Wright brothers, and now Santos Dumont, have demonstrated to be incorrect; but Prof. Newcomb's objections undoubtedly have great force, and reveal the cause of failures of attempts to construct large-sized flying-machines upon the basis of smaller models that actually flew. Prof. Newcomb shows that where two aerial vehicles are made exactly alike, only differing in the scale of their dimensions, the ratio of weight to supporting surface is greater in the larger one than in the smaller, the weight increasing as the cube of the dimensions, whereas the supporting surfaces only increase as the squares. From this the conclusion is obvious that if we make our structure large enough it will be too heavy to fly—even by itself—far less be the means of supporting an additional load like a man and an engine for motive power. This conclusion is undoubtedly correct in the case of structures that are "exactly alike excepting in their dimensions," but it is not true as a general proposition.

EVADING AN OLD LAW.

A small bird could not sustain a heavy load in the air; and while it is true that a similar bird of double the dimensions would be able to carry a less proportionate weight, because it is itself heavier in proportion to its wing surface than the smaller bird—eight times as heavy in fact, with only four times the wing surface—still it is conceivable that a flock of small birds could sustain a heavy load divided equally among them; and it is obvious that in this case the ratio of weight to wing surface would be the same for the whole flock as for the individual bird. If, then, we build our large structure by combining together a number of small structures each light enough to fly, instead of simply copying the small structure upon a larger scale, we arrive at a compound or cellular structure in which the ratio of weight to supporting surface is the same as that of the individual units of which it is composed, thus overcoming entirely the really valid objections of Prof. Newcomb to the construction of large flying-machines.

In my paper upon the tetrahedral principle in kite structure I have shown that a framework having the form of a tetrahedron possesses in a remarkable degree the properties of strength and lightness. This is specially the case when we adopt as our unit structure the form of the regular tetrahedron, in which the skeleton frame is composed of six rods of equal length, as this form seems to give the maximum of strength with the minimum of material. When these tetrahedral frames or cells are connected together by their corners they compose a structure of remarkable rigidity, even when made of light and fragile material, the whole structure possessing the same properties of strength and lightness inherent in the individual cells themselves.

The unit tetrahedral cell yields the skeleton form of a solid, and it is bounded by four equal triangular faces. By covering two adjoining faces with silk, or other material suitable for use in kites, we arrive at the unit "winged cell" of the compound kite, the two triangular surfaces in their flying position resembling a pair of wings raised with their points upward, the surfaces forming a dihedral angle (Fig. A).

Four of these unit cells, connected together at their corners, form a four-celled structure having itself the form of a tetrahedron containing in the middle an empty space of octahedral form equal in volume to the four tetrahedral cells themselves (Fig. B).

In my paper I showed that four of these four-celled structures connected at their corners resulted in a sixteen-celled structure of tetrahedral form containing, in addition to the octahedral spaces between the unit cells, a large central space equivalent in volume to four of the four-celled structures (Fig. C).

In a similar manner four of the sixteen-celled structures connected together at their corners form a sixty-four-celled structure (Fig. D).

Four of the sixty-four-celled structures form a two hundred and fifty-six-celled structure, etc., and in each of these cases an empty space exists in the center equivalent to half of the cubical contents of the whole structure, in addition to spaces between the individual cells and minor groups of cells.

Kites so formed exhibit remarkable stability in the air under varying conditions of wind, and I stated in my paper that the kites which had the largest central spaces seemed to be the most stable in the air. Of course, these were the structures that were composed of the largest number of unit cells, and I now have reason to believe that the automatic stability of these kites depends more upon the number of unit cells than upon the presence of large empty spaces in the kites; for I have found, upon filling in these empty spaces with unit cells, that the flying qualities of a large kite have been greatly improved. The structure, so modified, seems to fly in as light a breeze as before, but with greatly increased lifting power, while the gain in structural strength is enormous.

I had hitherto supposed that if cells were placed directly behind one another without providing large spaces between them comparable to the space between the two cells of a Hargrave box kite, the front cells

would shield the others from the action of the wind, and thus cause them to lose their efficiency; but no very marked effect of this kind has been observed in practice. Whatever theoretical interferences there may be, the detrimental effects upon the flying qualities of a kite are not, practically, obvious, while the gain in structural strength and in lifting power outweighs any disadvantages that may exist. I presume that there must be some limit to the number of cells that can be placed in close proximity to one another without detrimental effect, but so far my experiments have not revealed it.

EXPERIMENTS WITH "THE FROST KING."

To test the matter, I put together into one structure all the available winged cells I had in the laboratory—1,300 in number. These were closely attached together, without any other empty spaces in the structure than those existing between the individual cells themselves when in contact at their corners.

The resulting kite, known as "The Frost King," consisted of successive layers or strata of cells closely superposed upon one another. The lowest layer, or floor of the structure, consisted of 12 rows of 13 cells each. The cells forming each row were placed side by side, attached to one another by their upper corners, and the 12 rows were placed one behind the other, the rear corners of one row being attached to the front corners of the row immediately behind. The next stratum above the floor had 11 rows of 14 cells; the next 10 rows of 15 cells, etc., each successive layer increasing the lateral dimensions and diminishing in the fore-and-aft direction; so that the top layer, or roof, consisted of a single row of 24 cells placed side by side. One would imagine that a closely-packed mass of cells of this kind, 1,300 in number, would have developed some difficulty in flying in a moderate breeze if the cells interfered with one another to any material extent; but this kite not only flew well in a breeze estimated at not more than about ten miles an hour because it did not raise white caps, but carried up a rope ladder, several dangling ropes 10 and 12 meters long, and more than 200 meters of Manila rope used as flying lines, and, in addition to all this, supported a man in the air.

The whole kite, impeding and all, including the man, weighed about 131 kilogrammes (288 pounds), and its greatest length from side to side was 6 meters at the top and 3 meters at the bottom. The sloping sides measured 3 meters, and the length from fore to aft at the square bottom was 3 meters. It is obvious that this kite might be extended laterally at the top to twice its length without forming an immoderately large structure. It would then be 12 meters on the top (39 feet) and 9 meters on the bottom from side to side, without changing the fore-and-aft dimensions or the height. It would then contain more than double the number of cells, and so should be able to sustain in the air more than double the load; so that such a structure would be quite capable of sustaining both a man and an engine of the weight of a man and yet be able to fly as a kite in a breeze no stronger than that which supported the "Frost King."

An engine of the weight of a man could certainly impart to the structure a velocity of 10 miles an hour, the estimated velocity of the supporting wind, and thus convert the kite into a free flying machine. The low speed at which I have been aiming for safety's sake is therefore practicable.

HORIZONTAL AEROPLANES FOUND UNSTABLE.

In the "Frost King" and other kites composed exclusively of tetrahedral winged cells there are no horizontal surfaces (or rather surfaces substantially horizontal, as in ordinary kites), but the framework is admirably adapted for the support of such surfaces. Horizontal aeroplanes have much greater supporting power than similar surfaces obliquely arranged, and I have made many experiments to combine horizontal surfaces with winged cells with greatly improved results, so far as lifting power is concerned. But there is always an element of instability in a horizontal aeroplane, especially if it is of large size, whereas kites composed exclusively of winged cells are wonderfully steady in the air under varying conditions, though deficient in lifting power; and the kites composed of the largest number of winged cells seem to be the most stable in the air.

In the case of an aeroplane of any kind the center of air pressure rarely coincides with the geometrical center of surface, but is usually nearer the front edge than the middle. It is liable to shift its position, at the most unexpected times, on account of some change in the inclination of the surface or the direction of the wind. The change is usually small in steady winds, but in unsteady winds great and sudden changes often occur.

The extreme possible range of fluctuation is of course, from the extreme front of the aeroplane to the rear, or *vice versa*, and the possible amount of change, therefore, depends upon the dimensions of the aeroplane, especially in the fore-and-aft direction. With a large aeroplane the center of pressure may suddenly change to such an extent as to endanger the equilibrium of the whole machine, whereas with smaller aeroplanes, especially those having slight extension in the fore-and-aft direction, the change, though proportionally as great, is small in absolute amount. Where we have a multitude of small surfaces well separated from one another, as in the tetrahedral construction, it is probable that the resultant center of pressure for the whole kite can shift to no greater extent than the centers of pressure of the individual surfaces themselves.

It is, therefore, extremely unlikely that the equilibrium of a large kite could be endangered by the shifting of the centers of pressure in small surfaces within the kite. This may be the cause of the automatic stability of large structures built of small tetrahedral cells. If so, one principle of stability would be: *Small surfaces, well separated, and many of them.* The converse proposition would then hold true if we desired to produce instability and a tendency to upset in a squall, namely: *Large surfaces, continuous, and few of them.* (To be continued.)

THE AIR WE BREATHE.*

By WILFORD M. WILSON, Director N. Y. Section, U. S. Weather Bureau.

FOR nearly eight months in the year the householder in this climate is confronted with the problem of heat, ventilation, catarrh, and coal bills. The other four months he tries to live out of doors in the open air to store up sufficient vitality to carry him through the winter. The condition of the air we breathe within our dwellings and offices during the long period requiring artificial heating is, therefore, worthy of attention.

It is conceded that the free, natural, out-door air is best fitted for the highest physical development in the healthy and in many instances a positive cure for the troubles of the ailing. Sanatoriums are established where the only medicine employed is the tonic of exercise and pure air. Many persons suffering from troubles associated with the air passages live in tents in their own back yards and are cured. Nature's atmosphere may, therefore, be regarded as the true tonic and the nearer the condition of the air within our artificially heated dwellings, offices, and school-rooms approaches that of the free out-door atmosphere the more health and comfort will be experienced.

Natural dry air is composed of 21 parts by volume of oxygen, 78 parts of nitrogen with one part of argon, helium and xenon and a trace of carbonic acid. These gases are not chemically combined but form a nearly perfect mixture. Although nitrogen is heavier than oxygen and argon is heavier than either nitrogen or oxygen, the law of diffusion of gases operates to maintain so nearly perfect a mixture that samples of air collected from all quarters of the globe from sea level to the highest elevations reached by means of mountains or balloons show essentially the same relative proportions of these various gases. Ammonia, nitrous acid and ozone, dust from the land, salt from the sea, the pollen and spores of plants and innumerable micro-organisms are occasionally met with but the presence of these incidental substances in no way affects the proportion of the chief gaseous elements. Each gas has its own particular office. The nitrogen gives the atmosphere weight and density; carbonic acid gas supports plant life, and oxygen aids combustion. The chemical union of the oxygen of the air drawn in through the lungs with the carbon of the tissues burns up the bodily waste, keeps the body warm and sustains life. The object of all systems of ventilation is therefore to carry off the gases resulting from this process of combustion and to supply air having the full proportion of oxygen. In addition to the principal gases named, which maintain such a remarkably uniform proportion under the most widely varying conditions of temperature and pressure, there is always present in the free air a variable quantity of aqueous vapor or moisture. Dry air is not found in nature nor is it fit to breathe until it has been toned down and softened by the addition of aqueous vapor. Neither plants nor animals will long survive in an atmosphere devoid of moisture and since moisture is an essential part of the natural out-door atmosphere it becomes the question to determine how far the natural proportion of moisture is disturbed by heating the air to the point of comfort. Before taking up the discussion of the effect of artificial heating in its relation to humidity it seems necessary to define as clearly as may be some of the terms to be employed.

The moisture or aqueous vapor in the atmosphere is called its humidity. For further distinction the terms relative and absolute humidity are employed. Absolute humidity is the actual amount of water present in the atmosphere and is usually measured in grains; it may be measured in pints or quarts. An illustration may be of assistance. Take a room 10 feet square and 10 feet high, containing 1,000 cubic feet of perfectly dry air at a temperature of 70 deg. Introduce one half pint of water, by pouring it over a cloth hung in the room. When the cloth is dry it is certain that the half pint of water has passed into the air and this half pint of water now in the form of an invisible vapor in the air is called its absolute humidity. It does not matter how much or how little actual water may be present in the air, a grain or a gallon, whatever the amount may be is its absolute humidity. If a little more than another pint, to be exact, 7,980 grains in all, be poured over the cloth it will all pass into the space in the room as before, but this is the limit of the 1,000 cubic feet of space at a temperature of 70 deg. to absorb moisture and the air is said to be "saturated." Although sanctioned by common usage it is not strictly correct to say that "the air is saturated" for it is a curious fact that exactly the same amount of water will pass into the given space if the air be not present and the room a vacuum, the only difference being that the process of diffusion proceeds a little more rapidly when the air is not present. The absorbing capacity of air, if we may retain that expression, varies with the temperature. At zero 1,000 cubic feet of air will

* Cornell Countryman.

absorb only 40 grains of water while at 70 deg. the capacity increases to 7,980 grains—a little more than one pint.

Relative humidity is expressed in percentage, zero indicating absolute dryness and 100 saturation. If a hygrometer, an instrument for measuring the relative humidity of the air, be placed in the room at the beginning of the experiment the needle or pointer will point to zero on the scale, indicating that the air is perfectly dry. As the first half pint of water is being absorbed the hand will move slowly toward the center of the scale until near the 50 mark, showing that the space is about half filled. The relative humidity is therefore 50 per cent. When the second half pint is absorbed the needle will rest at 100, indicating that the capacity of the space at the given temperature has been satisfied. The relative humidity is, therefore, 100 per cent, and the air in a condition of saturation. If the temperature of the air in the room be lowered from 70 deg. to 20 deg., 6,880 grains—nearly a pint of water—will be condensed, that is squeezed out of the air because air at a temperature of 20 deg. can retain only 0.11 grain per cubic foot. If the action of the hygrometer be noted during the process of cooling it will be seen that the pointer has remained stationary at 100 per cent, showing that although nearly a pint of water has been squeezed out of the air no effect has been produced on the relative humidity. We now have a volume of saturated air at a temperature of 20 deg., which, for the purpose of comparison, may be fairly taken to represent the average condition of the outside atmosphere during the period requiring artificial heating. The temperature of this volume of air will be raised to the point of comfort, 70 deg., and the effect on the relative humidity noted. As the temperature rises the pointer of the hygrometer will move slowly from the 100 mark toward the zero of the scale, passing 75, 50, 40, 30, finally resting at about 25 per cent. There is exactly the same amount of water in the air as when the needle pointed to 100, but the heat has so increased the capacity of the air for moisture that there is only about one-fourth enough to satisfy it. The relative humidity of air has, therefore, been reduced from 100 per cent saturation to 25 per cent by simply raising the temperature to the point of comfort. This is what results when outdoor air is heated to 70 deg. with no provision for supplying additional moisture, except that the outdoor air is not always at the point of saturation and therefore the final result is an atmosphere in which the relative humidity is even less than 25 per cent. Observations made in many buildings heated by hot air, hot water and steam show that there is little difference what system of heating is used, the effect on the relative humidity is practically the same. The relative humidity of nature's air, except in a few localities where peculiar climatic conditions exist, is about 75 per cent, but when artificially heated and thus robbed of over 60 per cent of its natural moisture, becomes drier than the driest climate known.

The evaporative power of air with a relative humidity of 25 per cent is very great. It will seek out and absorb every particle of moisture it can reach. Furniture will dry up and fall apart; books loosen in their bindings; seams open in the woodwork and unsightly cracks appear. Such an atmosphere is unnatural and unfit to breathe and tends to induce a condition of the respiratory tract that sooner or later invites disease. When the mucous membranes of the throat and lungs are subjected to this drying process, the glands which supply the membranes with moisture to keep them in proper physiological condition are irritated and stimulated to do increased work. An increase of work results in an increase of size and functional activity and thus tends to develop an abnormal condition which finally prepares the surface for the reception of the germs of disease. By far the greater proportion of catarrhal troubles in this climate are traceable directly to the lack of sufficient moisture in living rooms to bring the humidity to something near the natural condition of the outside air. Dr. Baxter, in his work on Weather Influences, shows very clearly that dry air in school rooms causes irritability, restlessness, and a condition of nervous tension both in teachers and pupils, the humidity and deportment curves being so uniform as to leave little room for doubt that the relation is other than that of cause and effect. That annoying cough that so often attacks children after coming in from play in the open air is due to the irritation caused by dry air and will continue until the glands of the throat respond to the call for a larger supply of moisture.

On the other hand the evaporation of a tea-kettle of water will be more effective than cough mixtures in bringing rest and quiet to a house disturbed by that irritating, brassy, winter-night cough of children. It is not impossible that the excellent results that have attended the outdoor treatment of pneumonia and kindred diseases are largely due to the natural condition of the atmosphere with respect to moisture thus obtained.

The economic advantage of atmospheric moisture as a coal saver is equally interesting. A moment's thought will recall the fact that we frequently sit out of doors in June with perfect comfort when the temperature is little above 60 degrees. Such a temperature indoors in winter would be decidedly uncomfortable. Have we any good reason for being comfortable at one time and chilly at another? The temperature in both cases is the same, but the outdoor air in June is moist while the indoor air in winter is dry. Dry air makes us cold. Our bodies being warmer than the surrounding air radiate heat into it. Moist air absorbs radiated heat and is warmed by it, but heat goes right through dry air without warming it very

much; so we lose more heat in a dry atmosphere than in a moist atmosphere.

Again, evaporation is constantly going on from the surface of our bodies. Evaporation requires heat and the heat in this case is drawn from the body. Evaporation proceeds more rapidly in dry air than in moist air and, so, more heat is taken from the body in the presence of a dry atmosphere than when the air contains a greater percentage of moisture. Prof. Johnson says: "Were it not for the moisture in the air it would be too cold to live in. Humidity in the air is Nature's great bed-blanket for all her children without which they would all perish. So, likewise, moisture in living rooms acts as clothing and helps to keep us warm."

Living rooms heated to 65 deg. and supplied with 50 per cent of moisture are more comfortable and more healthful than when heated to 70 deg. or 72 deg. with 25 per cent of humidity. The fuel required to raise the temperature from 65 deg. to 70 deg. might, therefore, better be saved.

It has been claimed that there will be little or no saving of fuel by heating to 65 deg., and supplying moisture because the heat used to evaporate water to supply the necessary moisture might otherwise be utilized to raise the temperature. It is true that heat is required to evaporate water, but the heat so used is not lost. It is stored up in the vapor, rendered "latent," and passes into the room with the vapor; and when the vapor is condensed on the cool surfaces the heat is set free or "liberated," which means that it again possesses the same power to raise the temperature as when it came direct from the furnace or the radiator. There can, therefore, be no loss of heat by using it to evaporate water to moisten the air in living rooms.

Unfortunately even in modern systems of heating, little attention is given to the need for moisture and the householder is left to supply the deficiency as best he may. Most hot air furnaces are equipped with water pans which if located where there is sufficient heat to evaporate a considerable quantity of water, say 6 to 8 quarts for a ten-room house in 24 hours, a fairly moist atmosphere will be obtained. In hot water and steam heating a water tank attached to the radiators will afford considerable relief but will hardly take the place of a well-filled tea-kettle on a kitchen range.

ENGINEERING NOTES.

Prof. A. G. Ashcroft has devised an interesting lecture table testing machine. The machine, which is used at the Central Technical College, is intended to exhibit to large classes the elastic and plastic properties of the materials used for constructive purposes, iron and steel being the most important. Small specimens, 10 inches long and $\frac{1}{4}$ of an inch square in section, are used. The elastic properties of the specimen are determined by gradually applying loads, which must not exceed the elastic limit, and observing the corresponding extension multiplied about 250 times by an extensometer. The plastic properties are shown by drawing a stress-strain diagram on smoked glass and projecting this, while being drawn, on a screen by a lantern.

Since the conclusion of the National Physical Laboratory's research on the resistance of surfaces in a uniform current of air, it has been suggested that valuable information would be obtained if similar experiments could be made at velocities approaching 1,000 feet per second. Further, as the existing experimental air-channel is not suitable for many of the tests on anemometers and other instruments used in a horizontal current, it is proposed to reconstruct the apparatus in such a way that the air will make a complete circuit. In this arrangement there would be three experimental chambers, one for horizontal currents and two for vertical currents, of high velocity and moderate velocity respectively. It is anticipated that the difficulties in setting up a current of the velocity required will be considerable and it is therefore proposed to make a small model of the arrangement initially, in order to form an idea of the power and number of the fans required.

The most recent statistics relative to the coal production in France show two economic facts which are striking. The first of these is that in the last six years, contrary to the preceding order, the consumption of coal in the country remains nearly stationary about 48.5 million (long) tons. In 1900 it was 48,800,000 tons, and comes to 48,200,000 in 1903 and 48,669,000 in 1905. The curve which up to that time rose regularly and about continuously from 18 or 19 millions in 1884 according to the usual manner of such curves relating to mineral substances and prime materials, becomes suddenly horizontal, and that of the production follows it, being parallel (34 to 25 million tons). This result, obtained from very trustworthy statistics, seems very paradoxical when we consider the economic development in the entire world and to a less degree in France. One of the causes seems to lie in the great and modern development of hydraulic power in the southeast and the east portions of the country. The practical problem which was advanced by economists for the relatively close epoch when coal would fail, commences to receive a practical solution, and it would be interesting to see whether the same is true all over the globe. Another cause is the better use of combustible, seeing that efforts are made to economize such materials owing to their increasing price, by a more rational method such as steam or hot air heating, use of waste gases of blast furnaces, etc., without speaking of accessory combustibles such as gasoline. The second

economic phenomenon which has an influence upon the first, is the rise in the price of coal, seen in the curve not by a continuous movement, for these are periodic fluctuations, but by the elevation of the minimum points of the curve. Thus can be seen a result of social measures which finally, when the equilibrium is established, always strike the consumers.

SCIENCE NOTES.

Dr. J. T. Bottomley, F.R.S., and Mr. F. A. King conducted experiments before the Royal Society with vacuum gold leaf electroscopes, on the mechanical temperature effects in rarefied gases. The apparatus exhibited consisted of a "radium clock" and various types of vacuum electroscopes. The vacuum electroscopes were set up to show the effects of radiations from sources of heat and light upon gold leaves hanging within highly exhausted inclosures. The gold leaves of the vacuum electroscope diverged when illumination of any kind fell upon them, and stood permanently apart when placed in bright daylight. By suitably manipulating such sources as a spirit flame, candle, or Nernst lamp, near the electroscope, forces which vary in direction and magnitude from point to point within the inclosure were generated, and cause the leaves to be twisted into curious shapes. The gold leaves will remain in this contorted condition for a considerable time after the exciting cause has been removed. Gold leaves hung in unexhausted inclosures are also exhibited for the sake of comparison.

During the course of the determinations of stellar velocities in the line of sight at the Mills Observatory in Chili, various changes in the appearances of the lines selected for measurement have been noted. Mr. S. Albrecht describes how from a discussion of numerous plates it has been concluded that many of these variations may be ascribed to the multiple character of the spectrum lines employed in the reduction. A very severe test for the validity of this view is the comparison of the types of stellar spectra, and it is shown with a considerable degree of certainty that there is a direct sequential variation of these special lines as we pass from stars of one spectral type to another. Now we know that many of the lines photographed in stellar spectra are multiple, although with the dispersion at present available the components may be indistinguishable. In passing from one type of star to another, one of these components may be strengthened or weakened relatively to the others, and thus alter the position of the center of the blended line, which is measured by its maximum intensity. Doubtless in many cases such variations have been measured as velocity changes, whereas they may not be so. Examples are given of definite cases of this type of blended line in the region covered by the Mills photographs, λ 4258 to λ 4468, with the corresponding changes of intensity in Arcturus, the solar spectrum, and the spectra of sunspots, and also short notes on the appearance of the lines in other stellar spectra.

M. Adrien Karl makes a study of some interesting luminous phenomena in a paper read before the Académie des Sciences. Certain substances have the property of emitting light when they are broken or crushed, and this property has been designated as "tribo-luminescence." It is not exactly known what are the causes of the phenomenon and what relation it has to phosphorescence. The author succeeded in preparing a class of bodies which possess this property in the highest degree, but whose phosphorescence due to exposure to the light is almost zero. These substances show such a high effect when crushed, that if they are crushed by a glass rod or metal, or rubbed with emery, we observe an emission of light which is visible even in daylight. In the dark the phenomenon is very strong and allows of distinguishing printed letters of a newspaper. The presence of air is not needed, for the same phenomenon is observed in water, carbon disulphide, ether, etc., and in tubes having had a vacuum made after filling with hydrogen or nitrogen. The substances which are most luminescent were prepared by the author by heating to a high temperature solid mixtures of sulphide of zinc and of salt which were quite varied, such as nitrate of manganese, silicic and stannic acids, zirconia, and silicates or zirconates of manganese. As an example the preparation of two of these bodies which show the phenomenon most clearly will be described. We mix by grinding in a mortar, nitrate of manganese 1 part and zinc sulphide 5 parts. The mixture is then heated to a temperature of about 1,200 deg. C. for 20 or 30 minutes. When the crucible is cooled the mass is thrown into water, then it is crushed, and dried after washing. The temperature of the heat is followed by a Le Chatelier pyrometer, and the influence of the proportions of the mixture is well observed. Another mixture consists of silicon or tin oxide 1 part and zinc sulphide 10 parts. Still better results are obtained by using silicate or stannate of manganese 0.75 part and zinc sulphide 5 parts. A too high heat has the effect of losing a great part of the zinc sulphide by sublimation. Oxide of zinc was substituted for the sulphide, but the substances are very slightly luminescent in this case. These substances in general have a crystalline appearance and their color varies from pinkish yellow to greenish yellow. Tests were made to see whether these bodies could be considered as well-defined chemical compounds. The author made a great number of analyses, but the results were too variable to give any chemical formulae. It does not appear certain that the property of tribo-luminescence is due to the presence of definite compounds, and may be due to the presence of impurities which are difficult to separate on account of