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Photo Central News Service

A military aeroplane ready to start for Kut with a cargo of provisions.

A NEW USE FOR AEROPLANES.—[See page 100.]

The Problem of the Chemical Origin of Solar Radiation*

In View of Facts That Make Physical Explanations Unsatisfactory

By E. Briner, University of Geneva

AMONG the numerous problems of astro-physics whose solution is a thing of the future, that of the origin of the solar radiation has been one of the most freely controverted. More and more, of late years, astronomers are abandoning the attempt to account for this phenomenon on purely mechanical or physical grounds, and are falling back upon the reactions of chemistry to explain the mystery.

An investigation of this sort should naturally be undertaken with a certain degree of diffidence, since we are forced by the very nature of the case to extend into a domain inaccessible to direct experiment laws verified for intervals of temperature and pressure relatively limited. In spite of this it seems that the modern theories of physical chemistry may be consulted to good result in this connection, with the well-understood reservation that new discoveries are liable to modify more or less any conclusions that may be formed. It is with this point of view that we propose to discuss the problem.

First let us state clearly its terms. The radiation of the sun is of such magnitude that each gramme of its enormous mass loses annually almost two calories of heat. At this rate, even though the solar matter possessed a very high specific heat and an enormous mean temperature, the complete refrigeration of the sun should be a matter of only a few thousand years at most. But since the radiation in question has continued without appreciable change throughout the stretch of historical time, and indeed throughout a great part of the stretch of geologic time, we are forced to believe, as Arrhenius so tersely puts it, that "our sun, in his debit and credit account, must have some source of income approximately equal to his apparent expenditures."

R. Mayer has supposed that the radiation is maintained by a continuous shower of meteorites upon the surface of the sun; but his hypothesis has slight intrinsic probability, and in addition meets insurmountable astronomical objections. Helmholtz, and later Lord Kelvin, have sought for the origin of this great store of energy in the contraction of the sun. But the calculations of these scientists do not permit us to fix at more than fifty millions of years the interval during which solar illumination of the earth would be possible; and, speaking geologically, this is not enough. Other physical explanations are equally unsatisfactory; so we are forced to inquire whether the key to the mystery does not lie in the reactions of chemistry.

To understand well the exigencies of the problem presented the chemist by this question, it may be recalled that a block of carbon of mass equal to that of the sun would be consumed in less than five thousand years if, by conversion into carbonic acid, it were to feed the solar radiation. In the presence of this fact, it obviously becomes difficult to find, in the current phenomena of chemistry, a satisfactory explanation. Nevertheless, the astronomer Faye attempted, in 1877, to construct a theory on this basis. He supposed that in the interior of the sun, by reason of a very high temperature, all substances exist only in an elementary state; and that, coming to the surface, these elements enter into a multitude of compounds, with tremendous and continuous liberation of heat. But aside from its inability to measure up to the test of numerical computation, this hypothesis is met by two capital objections. In the first place, the action which it postulates would certainly be accompanied by a return of the compounds formed to the center, there to be dissociated with absorption of energy equal in amount to that previously liberated. And in the second place, the existence of compounds at the sun's surface is in disagreement with observations made to the effect that the solar atmosphere consists entirely of uncombined elements. Then, too, it could be urged that the great viscosity of the central regions would present great resistance to this continual circulation of matter.

Recently, however, following the discovery of radio-active matter and the study of its properties, it has seemed that the liberation of solar energy could be accounted for, at least partially, by the assumption of a large reserve of radio-active substances stored up in the solar mass. With what we know of radium, it would suffice for the feeding of the radiation that each kilogramme of this mass contain two milligrammes of that element. This explanation, however, turns out to be no more acceptable than the others. According to Arrhenius, it implies either that heat is created out of nothing, or that the radium receives from space some radiation

which it absorbs and then transforms into heat. Besides, the life of radium is limited; according to recent estimates, it loses half its radio-activity in seventeen hundred years. So this suggestion is outlawed.

Impelled by the insufficiency of these various explanations, Arrhenius has set himself to the search for another source of the sun's energy, and has developed a theory of which we indicate the principal features. In the outer portions of the sun matter is found in an elementary state only, while deeper down it exists in the form of compounds; this much is established spectroscopically. Now as we penetrate into the interior of a star, the temperatures and pressures increase until they attain the inconceivable magnitudes of 6,000,000 degrees and 10,000,000 atmospheres, respectively. Under these conditions matter, even though gaseous in form, is strongly viscous.

Arrhenius assumed that at such extreme temperatures and pressures all matter must become gaseous. Now it is true that there exists a so-called critical temperature characterizing every liquid, in passing which that liquid will always take the gaseous form, however high the pressure to which it be subjected. And since the critical temperatures of the less volatile substances do not probably exceed 10,000 degrees—that attributed to platinum is about 7,000 degrees—we might conclude, at first glance, that above such a temperature all matter is necessarily gaseous. But it turns out that such necessity does not exist. It is now found that matter may revert to the solid form at temperatures above its critical point, under pressures sufficiently great.

This phenomenon has been produced experimentally with chloride of phosphonium and with carbonic acid. The former, as Guillaume has been able to show, becomes solid again at 102.4 degrees, although its critical point is only 49.1 degrees. But in the gaseous state (Briner), and probably also in the liquid, this compound is dissociated; so there is some question as to whether its critical temperature is properly comparable with that of a more stable substance. This doubt does not appear in the case of carbonic acid. Under pressures greater than 6,000 atmospheres, according to recent experiments of Bridgman, this acid, whose critical point is 31 degrees, presents unmistakable evidences of solidification at all temperatures. It must, therefore, be admitted that matter could exist in a solid state in the interior of the sun, in spite of the high temperature there ruling. The only question—and one, of course, difficult or impossible to answer—is whether the strong pressures there exercised are sufficient to overcome the high temperatures to the extent of making this solid condition possible.

It is clear that if the sun were thus a solid globe at the point of incandescence, we would have at once an explanation of the continuous spectrum which it gives. But the continuity of the spectrum does not of itself imply a solid (or liquid) state. Gases, at sufficiently high temperatures, in sufficient thickness, and under sufficient pressure—conditions all realized in the sun—might very well afford a continuous spectrum. So we have no conclusive evidence for or against the possibility of a solid core in the sun.

With the realization, then, that the establishment as fact of that possibility would relegate it to the scrap heap, we return to Arrhenius's hypothesis. He states that at such temperatures and pressures as prevail in the interior of the sun, there should be found, according to the principles of thermodynamics, substances whose formation is accompanied by absorption of heat and contraction. Such a substance, whose formation takes up heat and whose breaking up liberates heat, is called endothermic. Reminding the lay reader that "heat of formation" signifies heat given off in formation, it is clear that the heat of formation of an endothermic substance is negative. Following Arrhenius, we give as examples of such substances ozone, with heat of formation —36,200 calories; nitrogen proto-oxide, —18,000 calories; nitric oxide, —21,000 calories; nitrous anhydride, —6,800 calories; nitrogen peroxide, —7,700 calories; carbon disulphide, —28,700 calories; cyanogen, —71,000 calories; nitrogen sulphide, —31,900 calories; selenium sulphide, —46,200 calories. He mentions also the compounds of chlorine with nitrogen, and of hydrogen with sulphur; and he asserts that in addition to such substances of relatively simple constitution, others would be formed which, by reason of the extremely high temperature, would possess a degree of endothermicity beyond all comparison with known substances. He concludes: "It should then be clear that

in the central part of the sun there exist substances which, when brought to the surface, decompose with great liberation of heat and great increase in volume. We must consider these as explosives of enormous power, beside which dynamite and picric acid are mere playthings. Phenomena of this sort would be capable of supporting the sun's radiation for billions and trillions of years."

The theory proposed by Arrhenius is without doubt very attractive, and can readily be understood to have attained a certain degree of acceptance, even in competent scientific circles. None the less, it seems hardly reconcilable with certain of the latest researches. We shall discuss the matter from the viewpoint of these, and from this discussion draw indications of the road to pursue in search of a chemical solution of the problem proposed.

We have indicated one serious deficiency in that the hypothesis is not able to substantiate the gaseous state of the sun which it postulates. Another capital objection presents itself at the very start, apropos of the endothermic compounds cited as examples. The indicated values of their heats of formation are for ordinary conditions, and not for the conditions realized in the sun. That we do not here make a distinction without a difference will be clear from the following considerations. Given an elementary gaseous medium under any pressure whatever, if the temperature be sufficiently high the molecules will be dissociated into atoms. Modern researches have shown that this dissociation is already appreciable at temperatures, high, to be sure, but still within the reach of experiment. So that in dealing with chemical action in such a mass we have more and more, as temperature increases, to reckon with the formation of compounds from atomic aggregates instead of molecular ones. This means that the heat given out in the formation of a molecule, and hence absorbed in its breaking up into atoms preliminary to recombining, need not be furnished for this particular reaction, and that therefore the heat of formation of the substance being compounded is increased by just that much. So that heats of formation of all compounds from atomic bases are much greater than the corresponding heats from molecular bases. In the case of endothermic compounds it may very well be that the heat is sufficiently greater to become positive; i. e., that when formed of matter in the atomic state these compounds are actually exothermic.

The adjoined table illustrates the point. It shows, for several elements, the coefficient of dissociation for certain temperatures—that is to say, the percentage of a given mass of the substance in question which breaks down into atoms at the given temperature—and the calories of heat absorbed by the dissociation of a gramme-molecule—in other words, the heat of formation of a gramme-molecule from an atomic base.

	Temperature.	Coefficient of Dissociation.	Molecular Heat of Formation.
			Calories.
Iodine.....	1390	66	36,800
Bromine.....	1050	6	57,000
Chlorine.....	1670	1	113,000
Sulphur.....	2177	50	120,000
Hydrogen.....	2727	6	90,000

The heat of formation of a gramme-molecule of oxygen has been found equal to 160,000 calories; that of a gramme-molecule of nitrogen is unknown, but surely exceeds 150,000 calories. With respect to nitrogen, the stability of its molecule furnishes an immediate explanation of its inertia. This is not to be confused with the case of the rare gases of the atmosphere, as argon and helium, whose atoms are destitute of chemical affinity. Such is by no means the case with the nitrogen atom, which enters into many compounds, whereas all efforts to make helium and argon react have failed.

What are the consequences of the above figures as regards chemical equilibrium? First, that when formed from atoms, all compounds without exception are exothermic. This may be shown, for example, by calculating the heat of formation, from atoms, of the endothermic substance nitric oxide. We base this calculation on the ordinary thermodynamic equation



which indicates that the reaction is accompanied by absorption of heat. Considering the molecules of this equation to have been formed from atoms, and taking account of their heat of formation, as stated above, we have

*Revue générale des Sciences pures et appliquées.

merely to combine algebraically the above equation with the equation

$$N_2 + O_2 = 2N + 2O - 310,000 \text{ cal.}$$
getting as a result
$$2N + 2O = 2NO + 268,000 \text{ cal.}$$

whence it appears that the heat of formation of a gramme-molecule of nitric oxide from atoms of oxygen and nitrogen is some 135,000 calories—or more, since any error in the molecular heats of formation used is one of under-estimation. A similar calculation carried out for ozone shows that when formed direct from atoms this substance has heat of formation 200,000 calories, instead of the negative figure mentioned above for ordinary molecular origin.

A second consequence, following directly out of the first, is that under sufficient and continuous elevation of temperature, the formation of those compounds ordinarily endothermic, instead of being constantly accelerated, as has been supposed, eventually becomes retarded just like that of all other compounds. That is to say, so long as the substance remains endothermic, so that its formation necessitates absorption of heat, heating of the medium accelerates formation; but the moment dissociation into atoms under the influence of the high temperature has proceeded so far as to make the substance exothermic, requiring radiation of heat for its formation, further inculcation of heat of course retards that formation. The temperatures capable of producing this state of affairs, at ordinary atmospheric pressures, are not nearly so high as one might suppose; reference to the preceding table will indicate that they are without doubt inferior to those, of some 6,000 degrees to 8,000 degrees, prevailing at the periphery of the sun. In the case of hydrogen, for instance, we may place at 99 per cent the proportion of molecules dissociated into atoms at temperatures comparable to 6,000 degrees.

Consequently, contrary to the opinion upon which Arrhenius in part founded his theory, with increase in temperature alone, combinations eventually become entirely dissociated; at very high temperatures the only action possible is destruction of compounds. The medium realized at such temperatures, instead of being very complex, will be composed entirely of elements in the atomic state.

We have, however, to examine the role played by a strong compression. The latter will plainly accelerate reactions which are accompanied by a contraction in volume—which is to say, reactions between atomic bases. It is then seen to operate in inverse sense to increase of temperature, and if sufficiently strong makes possible, even at very high temperatures, the existence in molecular form of elements or compounds. To fix the ideas as to the magnitude of pressures capable of compensating the effects of certain high temperatures, we give several dissociation coefficients for hydrogen.

Temperature.	Pressure.	Dissociation Coefficient.
Degrees.	Atmospheres.	
3,000	1	6
4,000	1	25
5,000	1	92
6,000	1	99
6,000	10	80
6,000	100	53
6,000	1,000	19
6,000	100,000	2

These values are obtained, not by direct experiment, but by substitution in a well-known formula connecting molecular dissociation, temperature, pressure and heat of formation. Naturally it is not to be demanded of an expression of this sort, verified for very limited intervals of temperature and pressure, that it shall express with precision results for the extreme conditions called for by our problem. Nevertheless, the form of this equation rests upon the principles of thermodynamics, and it seems permissible to use it for obtaining at least a first idea as to the relative influence of the temperature and pressure factors, more especially in the case of hydrogen, which follows particularly well the empiric laws of perfect gases.

At 6,000 degrees and pressures below 100,000 atmospheres, hydrogen is found in a form almost entirely molecular, and if it obeys the same general rule up to the pressures and temperatures of the interior of the sun, its dissociation there cannot greatly exceed 10 per cent. Without insisting upon further numerical determinations, always a matter of great caution, we may conclude that at the interior of the sun, by virtue of the extreme pressure, the existence of complex systems, comprising alike atoms and molecules of both elements and compounds, may be considered possible. But there is no reason to suppose the medium thus obtained to comprise endothermic compounds to any great extent. We remark in this connection that the only compounds which Arrhenius claims to have identified in the depths of the sun-spots are magnesium and calcium hydrides and titanium oxide—all exothermic even at ordinary conditions.

On these grounds it may be concluded that a theory founded solely upon the destruction of endothermic substances accumulated in great masses at the center of the sun does not explain, in a way to conform with actual experience, the problem of the origin of the solar radiation.

All these considerations lead us to seek the participation in the solar radiation of chemical phenomena in the form, not of destruction of endothermic compounds, but of synthesis of molecules or compounds. Again placing ourselves, in this search, on the plane of practical experience, it is permissible, by reason of the elevated temperatures and pressures there ruling, to compare the interior of the sun to a more or less complex system of atoms and molecules in chemical equilibrium. In such a system, every loss of heat would be followed by a displacement of equilibrium, with formation of molecules from some of the atoms—reactions far richer in energy than the reduction to molecules of endothermic compounds. In support of this analogy we have the presence in the sun of many of the substances, which we know in the earth. In fact, in addition to coronium, a substance peculiar to the corona of the sun, the major part of the terrestrial elements is represented in the solar globe; and in particular, the existence of oxygen, basis of so many highly exothermic compounds, cannot be questioned. We may also recall, in this connection, the identification in the solar spots of such substances as metallic hydrides and oxides, exothermic even at ordinary temperatures and pressures.

The mechanism of chemical phenomena caused by refrigeration involves a gradual liberation of energy which would very well explain the continuity and regularity of the solar radiation. It remains to inquire whether the quantity of heat available from the operation of such reactions would be sufficient to account for the persistence of the radiation through the long geologic ages.

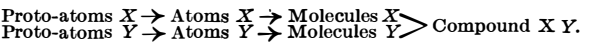
We have already indicated that a block of carbon of mass equal to the sun's could by its combustion support the solar emission of energy for a period of only five thousand years, at most. These figures, it is true, pertain to a reaction between molecules, of which the thermal value is much lower than that of a reaction between atoms. The latter thermal value, never heretofore available, can now be calculated with the aid of recent data, already cited, bearing upon the dissociation of element molecules. We append the results of such calculation for several compounds.

	Heat of Formation	
	From Molecules.	From Atoms.
	Calories.	Calories.
Hydrochloric Acid.....	22,000	144,000
Hydrobromic Acid.....	12,400	106,000
Hydroiodic Acid.....	0,450	85,000
Ammonia.....	12,000	250,000
Nitric Oxide.....	—21,000	150,000
Ozone.....	—30,000	200,000
Molecular Hydrogen.....	0	90,000

According to this table, while the figures pertaining to reactions between atoms are vastly superior to those pertaining to molecular formation, which we have been accustomed to find in the thermo-chemical tables, they are still infinitely too small to meet the exigencies of our problem. Of all chemical systems imaginable, one consisting of free atoms of hydrogen seems to contain the most latent energy, 45,000 calories per gramme as compared with 1,500 calories for nitroglycerine. The potential energy of such a system will exceed that of the system of carbon and oxygen already mentioned by little more than twenty times. But estimating as the length of duration of the solar radiations a period of one billion years—which is without doubt a minimum—it would be necessary, for the support of that radiation, that the potential energy in one gramme of the sun's matter should be two billion calories, close to fifty thousand times that contained in a gramme of atomic hydrogen. The discrepancy is too painful; we may state without reserve that no manifestation of chemical affinity of any sort actually known involves an emission of energy even remotely approaching the required magnitude.

We find ourselves as a consequence reduced to penetrating the domain of hypothesis in the search of a purely chemical theory. And there, in default of an explanation founded upon precise data, the considerations here adduced furnish us at least with a basis of orientation. This consists in supposing, as is alike possible and probable, that the atom is not the last step in the process of molecular dissociation. The quantities of energy put to work by this dissociation are naturally the stronger, the greater the temperature at which it is effected—just as the heats of reactions between atoms are greater than those characterizing action between molecules, which alone are susceptible to our usual processes of direct measurement. It is possible thus to imagine, for two simple bodies X and Y, and starting from the respective elements of dissociation of their molecules (from their proto-atoms, as we may call them)

a complete series of endothermic reactions leading to the substances X, Y, and finally to the compound XY.



The interior of the sun, if it consists of these proto-atoms, would afford a reservoir of energy accumulated in chemical form and disengaged gradually at the necessary rate. From the quantitative view, it would be necessary, we recall here, that the thermal value of reactions from proto-atomic bases be fifty thousand times greater than that of any known chemical reaction. It would be necessary that a gramme of matter, in the proto-atomic state, contain a reserve of energy of billions of calories. Such figures, which would have appeared inadmissible a few years ago by reason of their magnitude, create less consternation now that we know the fabulous amounts of energy set free during the atomic disintegration of the radio-active elements. Under this last form, it seems indeed that chemical phenomena might be able to participate to no mean degree in the maintenance of the solar radiation.

The Process of Wine "Chaptalization"

THE process of neutralizing the acid in wine by the addition of calcium carbonate has long been known in France by the term chaptalization. The term as well as the custom has made its way in Germany because of its convenience, and both name and practice have been legally authorized. The poor harvests of recent years have led to the extension of the practice, so that a German chemist, Dr. Theodore Paul, has considered it advisable to make a thorough study of the chemical reactions involved in the process, with a view of replacing previous empirical methods by those of scientific exactitude. He reports the result of his studies in *Die Umschau*.

The process consists in the addition to must or young wine of pure precipitated calcium carbonate; marble dust is also used in France. It has heretofore been supposed that because of this addition an equivalent neutralization of the wine took place, by means of the transformation of a corresponding portion of the free and half combined acids into calcium salts, the carbon dioxide formed at the same time escaping. Dr. Paul, finds the process to be more complex in its reactions, saying:

There is, in fact, in this neutralization a retrogression of the titratable acid corresponding in degree to the amount of calcium carbonate added. As demonstrated however by the researches previously undertaken by Th. Paul and Ad. Gunther, the degree of acidity of the wine is identical with the concentration of the therein contained hydrogen ions, and is dependent upon the equilibrium of the salts and acids contained in the wine.

Consequently the "de-acidification" of the wine with calcium carbonate is no simple neutralization process, but is the result of a series of chemical processes and alterations of equilibrium. To obtain a clear knowledge of this matter was the object of the present very extensive investigations, wherein I had the grateful aid of my assistant, Dr. Heinrich Zirkel. It was first determined that the precipitate formed in the wine after the adding of calcium carbonate consists essentially of neutral calcium acetate. Hence the study of this salt was the starting point of the research.

The next step was the experimental study of the chemical equilibrium between acetic acid and calcium carbonate in aqueous solution and in weak alcoholic-aqueous solution, and the application to the wine of the knowledge thus gained. In spite of the manifold variety of the chemical processes involved, the chemical equilibria can quite readily be represented schematically and can also generally be controlled by calculation.

The experiments show, among other things, that in the neutralization of an acetic acid solution with calcium carbonate the degree of acidity diminishes at the beginning with much more rapidity than it does later. This is due to the formation of primary and of secondary acetic acid ions, which remain in the solution until the formation of the precipitate of calcium tartrate, and exert their retarding influence on the dissociation of the acetic acid.

The titrimetric acid content of the solution on the other hand diminishes steadily and in direct proportion to the increase of calcium tartrate, as was theoretically predictable, and could be proved by continued titrations.

Finally there was undertaken a gradual neutralization of wines of pure nature, in accordance with these investigations. Here likewise there was exhibited a similar accelerated decrease in acidity at the beginning, having an unmistakable connection with the formation of the precipitate. The same thing was observed in gross by Von der Heide and Baragiola.

In consequence of the alcohol content, which diminishes the solubility of the calcium tartrate, this separation out begins earlier, and on this account the retardation of the hydrogen dissociation in the wine is not so noticeable at first, and the fall of the acidity curve is not so steep a descent as in the aqueous acetic acid solution.

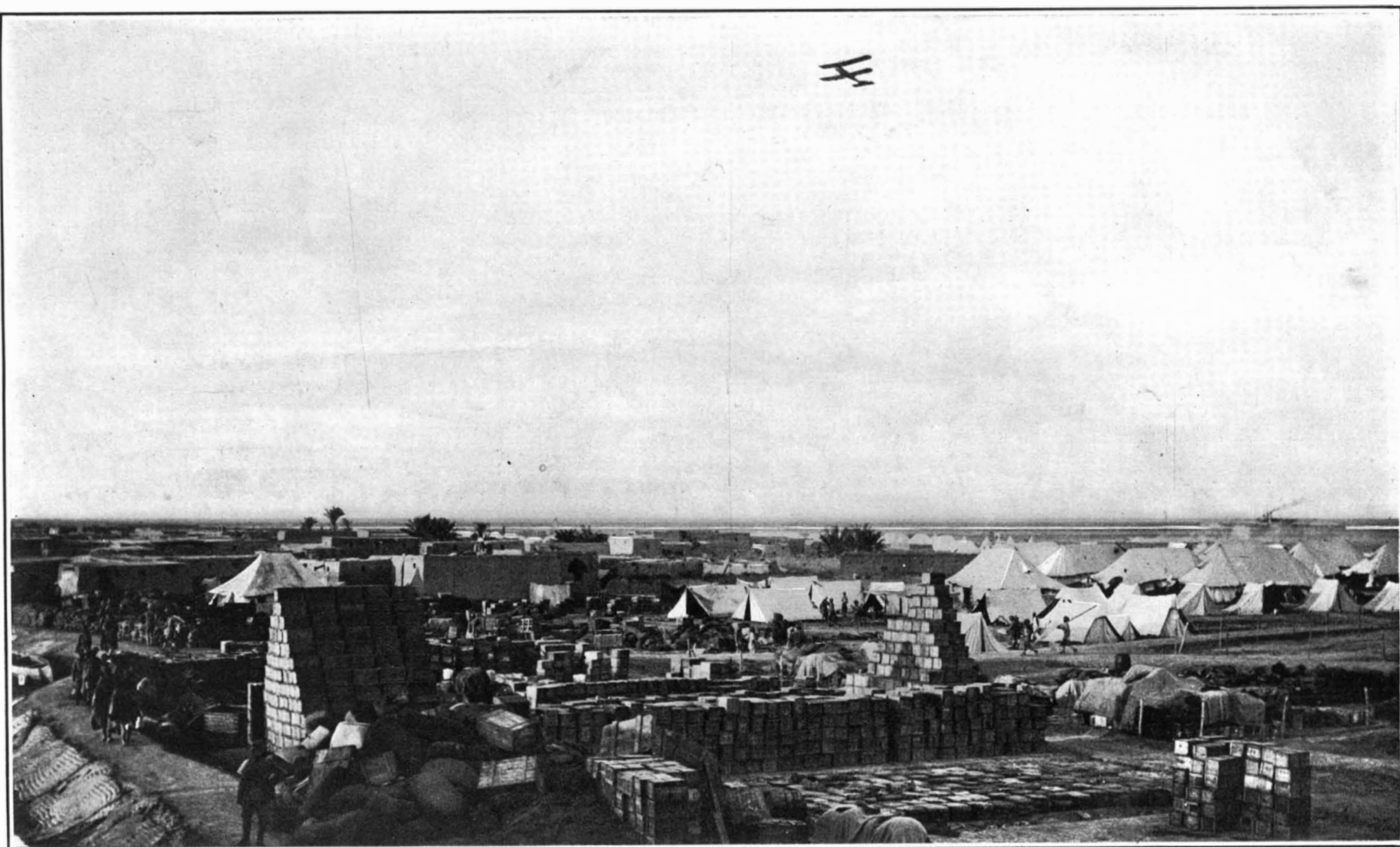


Photo Central News Service

Aeroplane carrying food arriving at the British encampment at Kut-el-Amara.

A New Use for Aeroplanes

Feeding a Beleaguered Army in Mesopotamia

New uses for aeroplanes are developing constantly, and in their day the aviators are called on to play many parts. When the flying craft first gave indications of being practical, enthusiastic designers made a multitude of optimistic claims for them that at the least sounded decidedly extravagant, but it is only fair to say that many of these claims are being justified, although it is plainly apparent that the art of building and operating flying machines can hardly be considered to have passed its initial stage of development.

At first, in the work of war, the aeroplane was employed only for scouting, or purposes of reconnoitering, but the dropping of missiles and bombs on troops and trenches of the enemy soon followed, thus converting it into a means of offense. The rapid transmission of messages and the location of batteries, with the signaling of positions and sighting instructions to their own artillery, were some of the other directions in which the aviator was employed. To counteract these activities the opposite forces soon introduced the fighting air craft, which were large enough and powerful enough to carry a rapid fire gun, together with its operator, as well as the pilot of the machine. And thus were successively developed several different classes of machines, each specially adapted to the particular work for which it was required.

More recently another use was found for the aeroplane, when, as a forlorn hope, it was called on to carry provisions to a beleaguered and starving force of British soldiers at Kut-el-Amara, in Mesopotamia. Surrounded by the Turks, and entirely cut off from supplies, the small company of men, under General Townshend, which had progressed thus far up the valley of the Tigris, found itself in dire straits in spite of every effort to reinforce or to relieve it, for the other British forces that were operating in this region were entirely inadequate to force a way through the opposing Turkish lines; and a light draught steamboat, that successfully evaded the Turkish pickets, stuck fast on the sand banks of the shallow river shortly after and was captured. As a last resort aeroplanes were requisitioned to carry food to the garrison at Kut, which enabled it to hold out a month longer than would have otherwise been possible. The illustration on the cover page shows a portion of an

aeroplane about to start on one of its expeditions of relief, and it will be noted how sacks of provisions were stowed on the lower wings, ready to be dropped on arrival at its destination. It is evident that the machine shown was of sufficient power to carry a passenger, in addition to the operator, but even without this second man it is doubtful if the amount carried on a single trip could have been of any great aid to the number of men in the invested force, which was obliged to subsist on its own horses for the last two weeks before surrender. Still the effort was meritorious, and gives a broader view of the future possibilities of aircraft.

It is difficult to estimate the load carried by the craft shown in the cover illustration, but it will be noted that it is large enough to carry two passengers. If it is designed merely for observation purposes it is not likely that it would lift a load of much over nine hundred pounds including the operator. If it is one of the latter types of fighting machines it might be equal to a useful load of twelve or thirteen hundred pounds, including the operator. With such a machine no very great amount of assistance could have been afforded to the forces at Kut; and here is where a Zeppelin would have been of great service. Some of the recent German fighting aeroplanes carry two or three rapid fire guns, and a crew of five or six men, while Russia has an immense flyer that carries a crew of fifteen, but neither of these machines could probably have carried more than a ton of supplies at a trip on an occasion such as the above, and the only real weight carrier is still the Zeppelin type, which the Allies so far practically have neglected to provide themselves with. A naval type Zeppelin is capable of carrying about a ton and a half load, in addition to its crew, machine guns and supplies, and can make voyages of twenty or more hours (as compared with eight hours for an aeroplane)

Commercial Advantages of Tank Tests With Ship Models

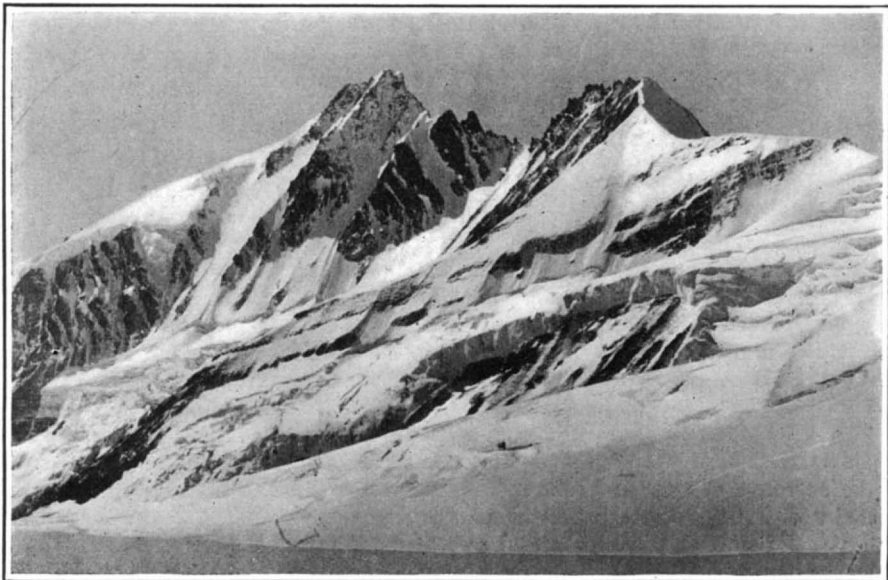
AN enumeration of the immediate commercial advantages that accrue from experimental tank tests of ship models was given in a paper by Mr. G. S. Ba-

ker, the superintendent of the National Physical Laboratory Tank, before the Liverpool Engineering Society.

He remarked that the cost of overcoming ship resistance forms one of the largest items on the balance-sheet of any vessel in the Mercantile Marine. In arriving at an estimate of the power that will be required the designer makes use of existing data derived either from existing ships or from model experiments, or, better still, from a combination of both. The data must be to hand in a standard tabular or diagrammatic form, and with their help it is often possible to make a reasonable estimate, sufficiently accurate for preliminary purposes, even for quite large departures in dimensions and type, from any existing ship. An unnecessarily high estimate of power means an unnecessarily high outlay on the engines and their upkeep, and a reduced cargo capacity for the life of the vessel.

The routine testing of models is a proper thing from the designer's point of view, as it prevents any error in shape and is an advantage to the owner, as he can rest assured that his coal bill is a minimum if the ship is properly handled. From progressive trials, if they are carefully conducted and properly analyzed, the efficiency of the ship and propeller can be approximately determined, but their complete analysis is impossible without tank experiments.

The designing office may use a tank to its own advantage in many ways. For instance, a good collection of data from model screw experiments is now in existence, which can be used for rapidly determining the proportions of propellers for any vessel. A closely connected question is the shape of the struts or webbing supporting the shafts, and a study of the data published by various tanks should enable any bad result from incorrect setting to be avoided. From time to time a builder finds himself wanting information on such items as the setting of bilge keels on the hull for least resistance, the testing of their capacity to extinguish rolling, the determination of the profile of wave against the side of ship in order that paddle wheels may be set at the proper immersion, and the reduction of speed due to shallow water, and often the experimental tank is the only place where it is possible to decide such points.



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The Tatra range in the Carpathians.



War News Exchange Service

Austrian cavalry wearing white cloaks in the snowy mountains.

The Carpathians*

Strategic Importance and General Character of the Range

THE Carpathians may be likened to a great curved wall extending 1,450 kilometers from Presburg to the Iron Gates of the Danube; the topography of the range appears, at first glance, to be complicated, but, as with many other mountain chains, when the early formative movements by which these successive ranges were produced are examined the reasons for the contour and arrangement of strata grow clear. An interesting sketch of the geological structure and strategic value of these mountains has lately appeared in *La Revue des Sciences*, written by a member of the Institute of France, Monsieur L. de Launey, who is also the author of a sketch of the mountainous structure of the Balkans.

The Carpathians, says M. de Launay, curves around Hungary like a reversed upper half of an S, and comes back to the Danube in order to form the lower half of the S in the Balkans. In calling them a wall the word is properly applied only to the central range of the Carpathians, the Eastern Beskids. To the east and west this wall is flanked by two enormous bastions composed of innumerable interesting peaks, the Transylvanian chain and the branch called the Tatra mountains. At the eastern end is found the totally different system of the Transylvanian Alps, while at the west the Western Beskids, another branch of the Carpathians, is separated from the old mountain system of Bohemia and the Sudetic Alps by the basin of the Oder which gives Vienna direct communication with Cracow and Breslau.

On account of this structure the main military efforts were directed to the central and less strongly defended section. In tracing the outline of the late Russian front it is evident that the extreme bastions of the range were never reached, notwithstanding momentary incursions into Bukowina, incursions intended to exert a political pressure on Romania. To the northwest the great curve described by the Russian front hardly went beyond a line running from Wieliczka, near Cracow, to Neu-Sandec and Bartfeld. In the direction of Transylvania there were merely incursions of Cossacks towards Maramaros-Sziget. In the central region, however, there was severe fighting at the Dukla pass, on the line from Lupkow to Mezö-Laborc, at the Uszok Pass, near Lamoczne and Wyszok, or in the triangle Stanislaw-Nadworna-Kolomea.

Early in March the Russian front was a fluctuating line running from Zakliczyn, southwest of Tarnow, to Dukla, Baligrod, Uszok, Koziova, Stanislaw, Kolomea, Czernowitz. By looking at the accompanying geological outline it is seen that the two ends of the Rus-

sian line started from the plain covered by glacial deposits, and that it was entirely contained within the zone of the tertiary and cretaceous groups of special facies which compose almost the whole of the Wooded Carpathians and which is called Flysch, being a thick series of sandstones, marls and shales. There is no ridge of crystalline rocks here, neither granite, gneiss, nor volcanic rocks. If the reader will look again at the diagram a little more to the south-east, below this border of folded Flysch strata, he will find the crystalline and primary ridges of the Tatra mountains corresponding to those of Transylvania, and still farther below a line of volcanic rocks that dominate the Hungarian Plain. The northern slope of the Carpathians then occupied by the Russians is the folded slope containing rich deposits of salt and petroleum; the inner zone towards Hungary is the zone of dislocations and outbursts, outlined by extinct volcanoes.

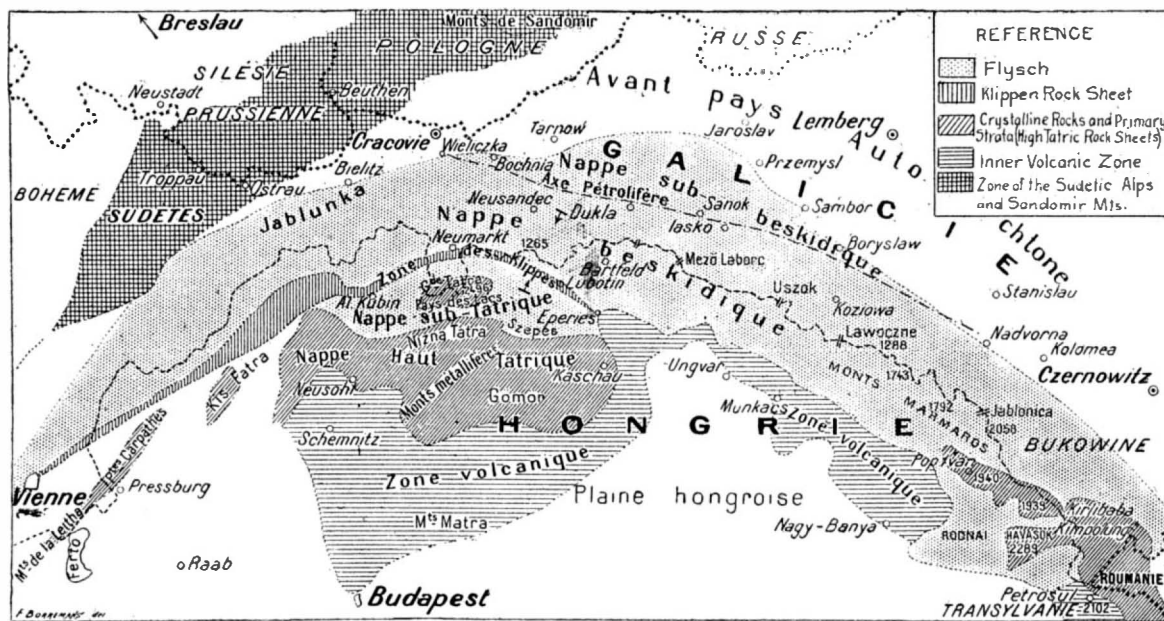
"When in the tertiary period," continues our author,

rection between the three primary ridges of the Russian Peneplain of Bohemia, and of the Agram range, overflowed the continuation of the hercynian Sudetics and the carboniferous silesian, with a further deviation towards the southwest that led then towards the Alps."

In this thrust towards the north above the foreland of Russia and Galicia, the Carpathian strata, like the Alpine, have been thrown in disorder upon one another in overlapping and successive rock-sheets from south to north, just as if the rows of slate or tile of a roof were pushed from the bottom upwards. The Carpathian strata are no more indigenous than those of Switzerland. They come from the south, from the Dinaric system, and lie abnormally in an order that does not correspond to the primitive stratification. At times glimpses may be caught of their paradoxical substratum, from which results a curious phenomenon that has long puzzled geographers and geologists, the exotic rocks called the Klippen.

In his geological discussion M. de Launay limits himself to the Carpathians proper, the Wooded Carpathians and the Tatra mountains, omitting the Transylvanian Alps which form the Roumanian Carpathians, and the Sudetic Alps that belong to an entirely different system. The ranges chosen for investigation extend in the arc of a circle from Presburg to Kimpolung and include, from west to east, the little Carpathians or Kis Karpatok, the White Carpathians, the Western Beskids, the Tatra mountains, the Eastern Beskids, and the Maramaros mountains.

Leaving aside the Tatras which have their own characteristics, the Carpathians give evidence of a folded



Geological outline of the Carpathian mountains.

"the progress of terrestrial contraction caused the folded strata of the entire Mediterranean zone to thrust forward northwards upon the hercynian ranges previously formed, it led in Eastern Europe to a marked drawing together of the Rhodope mountains (continued to the northwest by the Agram range), and the Russian peneplain which, forming a front analogous to that of the Russian invasion, followed the middle courses of the Vistula, the San, and the Pruth. If this drawing together had been continued without outside interference, the result would have been a chain of regularly folded mountains like the Atlas mountains, the Caucasus, or even the central part of the Carpathians. But the solid substratum of the Roumanian Plain, which pushed forward then like a wedge between Podolia and Macedonia, determined the double curve of a reversed S. In the northwest, at the same time, the tertiary Carpathians forced back in the other di-

chain of recent era showing the ordinary dissymmetry, owing to which the gentle decline is on the exterior or convex slope, the abrupt decline on the interior or concave slope where the final result of complex phenomena has the appearance of a vast sinking in. The true mountain range of which the approximate axis is indicated by the frontier line between Galicia and Hungary is uniformly composed of monotonous strata called Carpathian sandstones, corresponding to the characteristic facies of the Flysch. Bertrand once compared this external appearance to that of a coal-measure; it consists of a thick alternating series of sandstones and schists, all alike and all evidently deposited at the same time in the shallow waters of a drying furrow. Although the vegetable deposits of coal-lands are not found here, yet there is a large amount of debris of scattered plants, fucoids, which as a rule cannot be determined. The Flysch deposits have

long been confounded with one another, as fossils are rare and the era, consequently, cannot always be exactly settled. It has, however, been gradually decided that this continuous series was, according to the district, spread over almost the entire epoch included between the beginning of the lower cretaceous and the end of the oligocene. The general aspect of the Carpathians is the result. With a few exceptions which relate to the picturesque parts of the region, as the districts of the Hungarian lakes, of the Tatra range, the peak called Pop-Ivan, etc., the easily disintegrated and crumbling Flysch rocks are found everywhere; these form the gradual slopes on which have sprung up the thick forests.

Directly north of the Flysch region commences the great plain covered with glacial formations, on the edge of which lie numerous cities, as: Ostrau, Cracow, Tarnow, Rzeszow, Przemyśl, Sambor, Drohobycz, Stanislaw, Kolomea, Czernowitz, all connected by a railway that follows the curve of the mountain. Geologically this plain is the indigenous mass, anterior to the Carpathian foldings of the tertiary era, and smoothed down during the succession of ages; against this mass at a later day the folded chain pushed in, pouring over it. In looking north, the primary rocks are seen in the direction of the Sandomir mountains, or on the Dneister; elsewhere is found the horizontal miocene which fills the depression of the Pruth basin. Towards the south, where the outline of the region commences to be uneven, the geological character of the strata abruptly changes and the Flysch reappears.

There is found almost at once in the lower part of the chain a saliferous and petroferous axis that is entirely included in the most advanced, the most northerly thrust of the Carpathians, the subbeskid rock-sheet.

The rest of the folded range of Flysch deposits, which is found farther south, constitutes what is called the Beskid zone. The greater part of it consists of Magura sandstone formed during the oligocene epoch. Elongated and parallel zones representing various cretaceous stages are interspersed, however, especially towards the east beyond the San and Przemyśl and towards the south-west in the mountains west of Vienna called Wiener Wald.

The outline map shows the region just described as a great crescent, the chord of which running from Vienna to Kimpolung, is about 700 kilometers, while the average breadth varies from 70 to 100 kilometers. This crescent, like the arch of a bridge, is buttressed at its two ends by two more southerly pillars formed by ridges of gneiss, which are: on the west the Semmering; on the east the Rodnai Havasok or Gyergyoi Hegys, south of Czernowitz. The Flysch deposits in the axial part, from Cracow to Przemyśl, belong almost entirely to the oligocene epoch; at the two ends towards Vienna and Kimpolung they are almost exclusively cretaceous.

All the summits and passes of the central zone are in this Flysch region that forms a dome-shaped tract of overlapping rock-sheets, of which the most advanced northerly thrust is at Przemyśl. The railway from Bielitz to Neu-Sandec, Sanok, and Sambor runs along a first terrace. Then steeper slopes commence: in the west these rise in the Babia gora to a height of 1,725 meters, and in the east in the Czrona hora to 2,058 meters. A few passes where the land sinks to 500 milometers, as the Dukla pass, permit the construction of eight transverse roads running from the line Ostrau-Presburg to that of Czernowitz-Klausenburg. It was along these transverse roads that the battles of this region were fought.

The inner part of the range has a much more complicated appearance, especially in a curious circular space with a radius of 100 kilometers, the center of which is formed by the Hungarian Ore mountains. These mountains show on a geological map towards the south a volcanic line that is more than semi-circular and at the north the curved line of the lower cretaceous Klippen.

The Klippen or zone of the Piénines (from Mt. Piénin) extending from Brancs, north of Vienna, by way of Also-Kubin to Neumarkt (Nowy targ) and Lubotin, form one of the most curious and most debated phenomena of the Carpathians.

They are a series of isolated crags on a strip about 5 kilometers wide, and are geologically the scattered representatives of heteroclitic strata. Set upon a cretaceous schistose segment these rocks consist of a compact limestone, sometimes neojurassic, sometimes eocene, which should be below the schistose base instead of above it. There are about 5,000 of the Klippen; some are so small that a single quarry exhausts them, others are 16 kilometers long by 2 to 3 kilometers wide. Each forms an independent structure of disor-

dered stratification, which may be vertical or even inverted, and with frequent indications of lamination. All this in a zone where the horizontal middle miocene (Vindobonian) rests on dislocated oligocene.

"Various explanations have been offered," continues the author; "it has been suggested that the Klippen are harder, more resistant cores around which the folds broke, and which subsequently lost their more friable gangue. Another theory is that they are the projections of a post-neocomian range, divided into an archipelago of little islands since the middle cretaceous period. Lastly, they are now regarded, following M. Lugeon's theory, as the outcroppings of deep deposits of southern origin appearing at the surface. This makes the Klippen a sort of frontal moraine that has been thrust forward and that in bending has been broken into pieces.

"The inner part of the Klippen zone contains a last stratum of Flysch, this being the subatric deposit on which rests the High Tatra chain with its granites, gneiss and trias, a chain with peaks rising to 2,500 meters and even to 2,663 meters, yet not considered to be deep rooted. These high peaks, the finest scenery of the Carpathians, the sharpest declivities and the beautiful little lakes called the 'eyes of the sea,' are all found in the southern part of the Great High Tatra.

"Next come the Ore mountains, an archæan and triassic nucleus in the counties of Gömör and Szepes, and the long volcanic curves that dominates the Hungarian Plain. The altitude of these volcanic peaks is generally low, excepting Kelemen Hegys or Pietrosz that is 2,305 meters high. These Hungarian volcanoes, extinct since the close of the pliocene epoch, extend a considerable distance along the interior of the Carpathian chain from the Schemnitz range north of Budapest to Transylvania, and from there, always on the same slope, to Serbia and Bulgaria towards Sophia, Philippopolis and Bourgas. The chain is winding; the signs of eruption are always on the same slope, although this is first the interior and concave side and then the exterior and convex side. Consequently it is not the form of the curve that has caused the dislocation but the position relative to the foreland (Russian peneplain or Roumanian Plain). Undoubtedly during this pressure which pushed forward the rock-sheets piled one above another there remained behind a zone containing districts suitable for volcanic outbreaks."

The eruptive rocks are as interesting practically as theoretically, for they make Hungary the only European and even the only Eurasian country, that can be compared to western America for its metallic outcroppings united to volcanic eruptions that are old enough to be deeply cut into by erosion. In this region are the noted mines of Schemnitz, Kremnitz, Nagybanja, Abrudbanya, etc., complex mines in which gold and silver are associated with the baser metals, lead, zinc, copper and iron.

The Hungarian eruptive series commences in the eocene period with labradorites and andesites generally green in color, and often rich in the quartz called propylites. It is continued by oligocene trachytes, miocene andesites, then a very acid series of rhyolites, liparites and obsidians with which opals are associated, and it terminates with some basalts subsequent to the sarmatian epoch and antedating the pleistocene, therefore long before the volcanoes of Central France. The special types of minerals that form the wealth in mines of this country are probably due to the fact that these are old volcanoes, as are those of the Rocky mountains, and of the mountains of Mexico.

The curved line of volcanoes that goes as far as Budapest and Grosswarden or Arad runs directly along the great alluvial plain, the immense basin in which recent materials, spread out on a horizontal surface, have been piled up. There are found along with the volcanic rocks large districts occupied by miocene strata, with which are connected the salt deposits of the Schlier stage. (Maros, Ujvar, Matamaros, etc.); these districts lie north of Mt. Matra and especially in the region of the Maros, between the ore-bearing mountains of Transylvania and the Carpathians properly so-called.

It may be recalled that in the Carpathian curve, as it passes along in Transylvania, there is a crystalline range enclosed towards the east and south in the Maros flexure by a zone of Flysch and Klippen series. This range is, therefore, similar to what is called the High Tatra zone, the High Tatra and the Ore mountains of Hungary, a zone also enclosed in Flysch and Klippen series. Both of these ranges have been subjected to numerous volcanic intrusions, with which are combined the outcroppings of metals that make these two similar regions the great mining districts of Hungary, Schem-

nitz, corresponding to Abrud Banya or to Zalathua.

Taken altogether the Carpathians are a region of rock-sheets of which the successive layers, overlapping like scales, have all been pushed from south to north, descending or rising in a series of undulations like those of waves. The group surrounding the High Tatra dips to the north. Those north of this as far as the foreland have, on the contrary, a southern dip, so that they have had to rise again on oblique planes propped at the north against the autochthonous foreland. Finally the last rock-sheet forms an anticlinal fold, against the Russian peneplain, that is the zone of the petroleum deposits.

In inspecting the various rock-sheets from top to bottom or from north to south in the order traversed by a boring, there is found first at the north the subbeskid zone, the most characteristic horizon of which is the Tongrian series of menilitic schists that at times contain a large number of fish. Its structure is well known on account of the deep and numerous borings made in searching for petroleum. Says Suess: "There is a mass of upper cretaceous there with a southerly dip, and, following a thrust-plane inclined at 45 degrees towards the south, pushed upon a series of more northerly miocene beds that is folded itself and that dips decidedly towards the south in raising itself upon the thick oligocene Dobrotow beds (sandstones and schists) and upon the saliferous miocene clay that lies above them by means of a second abnormal and less inclined plane of contact.

So there are in this one zone three successive overlapping rock-sheets formed by beds as recent as they are northerly. These three rock-sheets have been pushed and raised, starting from the south, along oblique planes of movement which converge towards the south. Consequently, the middle sheet should have a southern end shaped like a wedge. As to the northern rock-sheet, in approaching the foreland it has taken the anticlinal position already mentioned while folding with a regularity surprising in so violent a movement. It is in this anticlinal followed by no synclinal that the petroleum with ozocerite are found. The position recalls the Swiss molasse with its anticlinal form.

"The succeeding or Beskid zone," says the author further, "like the helvetian rock-sheet of the Alps, of which it is the immediate continuation, is formed largely by the oligocene sandstones of the Magura. There is found from south to north in the normal order: tertiary beds lying upon upper cretaceous, then on lower cretaceous, this latter itself lying abnormally on the tertiary of the subbeskid zone just described. Along with the lower cretaceous there is found in this zone remnants of the jurassic and carboniferous epochs, sandstone and granite, such as the great coal-measure of Hustopetsch.

"The third zone is that already described of the Klippen or the Piénines. The beds represented there run from the triassic epoch to the neocomian or lower cretaceous; they lie in discontinuous overlapping rock-sheets generally stretching in the direction of the folding, but at times they are crumbled and crushed at some particular point as Jarembina in the county of Szepes. Here also the general dip is towards the south. Their origin is southward in the region of the Dinaric Alps."

The subatric rock-sheet that comes next apparently surrounds the crystalline range of the High Tatra, and the range has been compared to an island encircled by its deposits. In reality the rock-sheet dominates the range.

On the northern slope of the High Tatra there is seen in reaching the zone of the Klippen, first a succession of beds alpine in character with numerous gaps and some sublittoral indications, the whole dipping towards the north; then, above and topographically lower, a second alpine series much more complete and with a more decided northerly dip, now explained by a thrust from the south which pushed all this autonomous sheet above the crystalline range of the Tatra, that had itself been pushed up as already mentioned. The dip is towards the north, thus the reverse of that mentioned above. This subatric rock-sheet represents the Austro-alpine rock-sheet, of which it even shows in the Little Carpathians the augitic melaphyres.

Turning south it would be natural to find, as in the Alps, an element that is almost totally lacking here, that is, the primitive strata brought to light and often recrystallized by the regional metamorphism of depth. The only Carpathian district that resembles an interior crystalline zone is the district of the Ore mountains and of Nizna or Alacsony Tatra, south of the High Tatra, between Neusohl and Kaschau, where crystallophyllitic strata are seen of the devonian and carboniferous epochs. On the northern edge of this paleozoic strip triassic and jurassic strata are found with

alpine facies. The strata with which traces of the cretaceous are blended are folded towards the north.

The spurs of the Nizna Tatra and, perhaps, also the analogous offshoots of the High Tatras, with their granite and their primary strata flanked by triassic and jurassic beds, seem to be continued in the west toward the Kis Fatra, the Little Carpathians (Kis Karpatok) that terminate at Presburg, and the Leitha mountains on the other bank of the Danube; in this way they connect with the Semmering and the Eastern Alps. A relatively continuous zone may be seen there which runs to the interior of the subalpine zone and the Klippen; it is called the high tatic rock-sheet, and is the equivalent of the lepontine rock-sheet or that of the Tauern. Tectonically deeper than the preceding one it generally dominates it orographically and forms the most elevated summits of the Carpathians. The regions where it is found recall a great anticlinal arch in which the superposed and folded beds no longer form stratigraphic levels but rock-sheets pushed up and forward and piled one upon the other. It should be said that this region seems to have been raised subsequent to the foldings by simple vertical faulting.

The Hungarian Plain farther to the south is entirely concealed by the alluvial deposits and it is difficult to tell how far it is necessary to go to find the primitive roots of the sheets just mentioned.

In the Carpathians as in all other folded tertiary

chains, the first folds probably go very far back. When mountain chains are differentiated by age, this merely gives the limit in time up to which their movements were continued, while in previous periods they may all have been influenced equally, the attention in such case being focussed only upon the last stage of the work.

The hercynian movements also played their part here. The existence through the whole length of the Carpathians of the Flysch zone of sandstones, marls, and schists shows that from the beginning of the cretaceous epoch a furrow had begun to form which was progressively deepened as the products obtained from the destruction of its borders were heaped there under the form of these sandy deposits.

Local discordances have been noticed which seem to correspond to accentuations of the movements before the upper cretaceous, and between the eocene and oligocene. The essential phase of the movement appeared, as in the Alps, at the end of the oligocene epoch.

Thus it has been shown that the rocks of the more southern Dinaric system advance towards the north in undulations probably caused by the action of substratum, and in a manner similar to the movement of waves in overflowing reefs. The overlapping sheets have been piled up in the Carpathians, where they are found in inverse order to that described: the high tatic zone, the deepest and most crystalline, although

the most projecting, forms the Ore mountains and reappears in a great gash in the subalpine Flysch of the High Tatras, the rock-sheet of the subalpine Flysch superposed on the High Tatras (that apparently in an opening dominates it), dips towards the north; lastly, the Beskid rock-sheet (helvetian) and the subbeskid rock-sheet (Swiss molasse) form a last anticlinal against the autochthonous foreland.

So far, undoubtedly, the displacements were almost horizontal and of an undulating form. The true formative movement from which came the mountainous appearance of to-day, appeared later as vertical faultings that are always the close of formative movements after folding, as the history of the Central Plateau of France shows. The result of these faultings, that must have produced certain high parts of the chain, as the Tatras and the Fatra Krivan, was that the Hungarian Plain, which remained almost unmoved, looks like a great depression in which the rivers then accumulated heaps of debris like embankments until all was level. Instead, however, of being depressed, it is more probable that the Hungarian Plain was raised, since its level to-day is some hundred meters above the sea, and it has simply been probably raised less than the zone of the rock-sheets.

At the same time there were eruptions until the end of the pliocene epoch, one of the results being to give the inner Carpathian curve, where the wreckage covers everything, a factitious similarity.

The Manufacture of Porcelain

IN EARLY days almost nothing was accurately known of the manufacture of porcelain. European potters had never made ware with such admirable qualities as that which was brought by the traders from China, and their attempts to imitate Chinese porcelain were not very successful. The first synthetical experiments were based on the hypothesis that Chinese porcelain was a devitrified glass, or a glass opacified by the addition of clay; afterward Böttger, a pupil of Walther von Tschirnhaus, who had had a great deal of experience in the manufacture of crucibles for his alchemical work, made a vitreous body which had some of the qualities of porcelain, but an objectionable color. The ware was very vitreous and no glaze was used; Böttger seems to have tried to get the bright glossy surface by polishing the body. Böttger then found a deposit of white clay at Aue, near Schneeberg, and, by using that in place of the crucible clay, he was able to produce fair imitations of the body of Chinese porcelain, and a works was started near Meissen in which extreme precautions were taken to preserve the secret. This porcelain was the type now known as hard or feldspathic porcelain. A generalized hard porcelain body has the composition:

Clay.....	50
Felspar.....	25
Quartz.....	25

The discovery of china clay at St. Yrieix, in France, enabled the French potters to take up the manufacture of this same type of porcelain, but in France a totally different type of porcelain was in use. It was called soft porcelain. The composition of soft porcelain can be generalized into the recipe:

Calcareous clay.....	30
Glassy frit.....	30
Quartz.....	40

Soft porcelain lent itself peculiarly well to the production of beautiful pottery, but the cost of manufacture was too great to enable it to compete successfully with the bone china and hard porcelain; as a result, the soft porcelain industry is virtually dead. Artificial teeth, however, are made from a variety of soft porcelain.

Cookworthy of Plymouth discovered that the Cornish stone and china clay of Cornwall could be employed for making a porcelain body, and works were started at Plymouth. The English hard porcelain, while preserving a special character of its own, belonged to the same general type as the German and Chinese. The manufacture of this hard porcelain in England does not appear to have been very successful, and was soon abandoned. A third type of porcelain developed in England, the English porcelain, or bone china. The body of this can be generalized in the recipe:

Bone ash.....	50
Clay.....	25
Cornish stone.....	25

We have considered only the body of the various porcelains. The composition and character of the various glazes are of equal importance. Shortly, hard porcelain, which matures at the glaze temperature—which is very high—has a hard glaze of the nature of felspar; soft porcelain had a lead glaze which matured at a comparatively low temperature. The manufacture of pottery is very

largely dependent upon a multitude of conditions, each one of which might appear to be of little intrinsic importance. Successful potting involves close attention to detail, and this probably more than in any other industry.

There is a marked difference in the behavior of these three types of ware in the firing. In all types of pottery there is a range of temperature or margin of safety outside which the fireman must not go. If the temperature be above these limits the ware is liable to be spoiled; and if below, the ware is insufficiently fired. With hard porcelain there is a particularly wide margin of safety; with soft porcelain the margin of safety is so narrow and the resulting losses so great that the manufacture had to be abandoned as commercially impracticable. With English bone china, too, there is a comparatively narrow margin of safety, which is necessarily attended by proportionate difficulties.

Hard porcelain, unlike soft porcelain and bone china, is first baked at a comparatively low temperature, and the glaze and body are subsequently fired together at the higher temperature. The preliminary baking is not a critical operation, and it can virtually be done by the waste heat of ovens firing at the higher temperature. With soft porcelain and bone china two critical firings are needed; with hard porcelain there is one. The first or biscuit fire with soft porcelain and bone china is much the hotter; the second or glaze fire is not so hot.

Hard or feldspathic porcelain and bone china virtually command the world's porcelain market. Both forms are porcelain, and both are colloquially called china, although the latter term is more commonly applied to the English porcelain as distinct from the Continental. It appears that in quality—presumably æsthetic—British porcelain reigns supreme; but in certain special lines—chemical, electrical, and possibly hotel ware—the Continental porcelain has important advantages which render it advisable to start seriously making it in England. Just as the manufacture of the British type of porcelain has not been particularly successful outside this country, so the manufacture of Continental porcelain has not been successful here. The two types have developed on different lines, and certain radical differences obtain, so that certain conditions necessary for success in the one lead to failure in the other. The cessation of German supplies of chemical ware has led manufacturers to make fairly good imitations of hard porcelain by modifying parian, insulator, and mortar bodies, but these temporary imitations are not so satisfactory as the true hard porcelain. The problem must be solved by our taking up the manufacture of true hard porcelain, and not frittering away valuable time on imitations which past experience has proved to be less suitable for the work. The manufacture should offer no insuperable difficulties to our men once their skill is deflected and adapted to suit the special conditions required for the new type of ware. The subject wants tackling boldly and confidently on a large scale with British raw materials. If much raw material has to be purchased abroad the cost of production will rise accordingly.

This seems a very good opportunity for State assistance, since at present it is to the interest of no individual manufacturer to assist in the development of the new type of ware. It is therefore pleasing to learn that the Committee of the Privy Council for Scientific and Industrial Research has made a substantial grant toward the capital

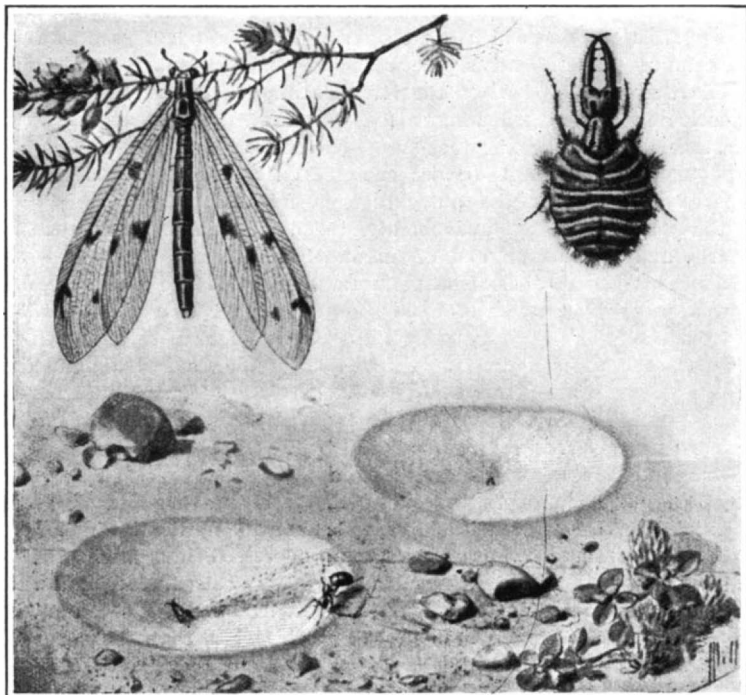
outlay for an experimental factory where the conditions necessary for the successful manufacture of hard porcelain can be studied on a large enough scale to reproduce manufacturing conditions. Once the necessary conditions have been established, the manufacture of hard porcelain will probably interest a great many potters, and this idea has probably led the Pottery Manufacturers' Association to bear a proportionate part of the estimated cost of maintenance. Instead of working slavishly on Continental lines it will probably be far more rational to introduce as few radical changes as possible, so that the supreme skill and traditional experience of our craftsmen may be utilized to its maximum. In this way it is quite likely that a new kind of hard porcelain will be evolved, which will unite the good qualities of the Continental with those of the British porcelain.—B. M. and J. W. M. in Nature.

A Cheap Astronomical Clock

I HAVE been looking out for twenty years for a cheap clock with a 24-hour dial, but in vain. Some years ago I bought a workman's watch with large dial (2¼ inches). I inquired at the shop whether this could be fitted with a 24-hour dial. The shopman said: "Oh, yes! but I shall have to send it to Switzerland to be done." He sent it. In a short time it came back again very neatly transformed, the figures (Arabic) alternately in black and red. The extra cost for the alteration came to about seven and sixpence, the total cost being about 28 shillings. For sidereal time I have used it ever since; it ticks away merrily on my desk as I write this. For more than twelve years it has kept correct sidereal time, and apart from winding has not been touched since the day I bought it.

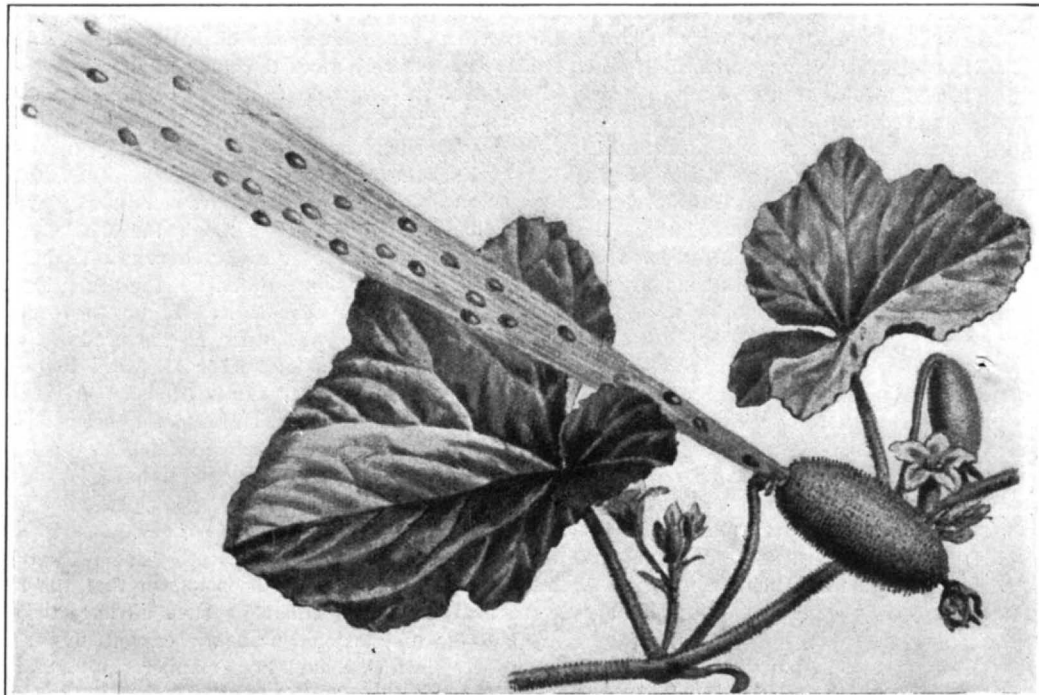
What hundreds of students are wanting is a cheap house clock, but with the 24-hour dial, it matters but little about keeping exact time; for many purposes, it would even be near enough if within ten minutes. A glance at such a clock and at a star map would in a moment indicate what constellations were about the meridian, and how long before such and such a star was in transit. For purposes where accuracy was required, even a common clock of this sort, if put to the correct time, say, at 7 P. M., would be near enough for most purposes for the rest of that evening.—Frederick G. Taylor, in The English Mechanic.

By a curious coincidence the route on which steam locomotives were first used in the history of railways in England is also the railway route on which electric locomotives will first be used for regular mineral trains. The North-Eastern Railway Company has made provisions for the electrification of their line from Shildon to Newport, a distance of about nineteen miles, embracing a part of the original Stockton and Darlington Railway. The system is overhead conductors with direct-current at a pressure of 1,500 volts. The locomotives are the biggest electric locomotives yet seen in this country. Each weighs 74 tons and is designed to haul a train weighing 1,400 tons at a normal speed of 25 miles an hour on the level. There are four motors per locomotive, each of 275 brake horse-power and each driving one axle.—The Practical Engineer.



Larvae of *Myrmeleon formicarius*, that captures its prey by throwing a shower of sand.

Above, at left, is the beautiful insect that develops from the larva.



The wild cucumber (*Echium*) ejects its seeds violently to a distance of one or two meters when the ripe fruit falls from its stem which is so curved at the point of attachment that the base of the fruit points upward.

Living Artillery

Means of Offense and Defense Which Nature Has Furnished to Animals Insects and Plants

THE countless and varied machines and devices which mankind has elaborated for purposes of defense and offense in the lordly game of war may all be found on careful examination to have their prototypes in the world of animals. Knives, daggers and swords are obviously mere elaborations of claws, teeth and horns. Again, all those ingenious methods of hiding from the enemy, either in order to get away from him or to approach him unobserved in order to preclude flight, are but modifications of the protective coloring of animals. In this category we may include the gray paint of battleships, the white uniforms now used by German troops on the snowy steppes of Russia, and the transparent wings of the new French aeroplanes.

Even projectiles, which at first blush would seem a device peculiar to man alone, because of his hands, with their ability to grasp and throw external objects, are, in fact, employed by many animals, and even by a number of plants. It is true that such plants and animals usually make use as a rule of products of their own organism for their projectiles. Yet there are exceptions to this rule, such as the monkeys, who try to beat off assailants by throwing coconuts at them; the elephants, whose trunks are almost as "handy" as real hands, and are capable of directing streams of water at an enemy; the curious little Javanese fish, which "shoots" its prey by a well-directed jet of water, and the ant-lion, which similarly brings its victims within reach by throwing sand on them with its shovel-like head.

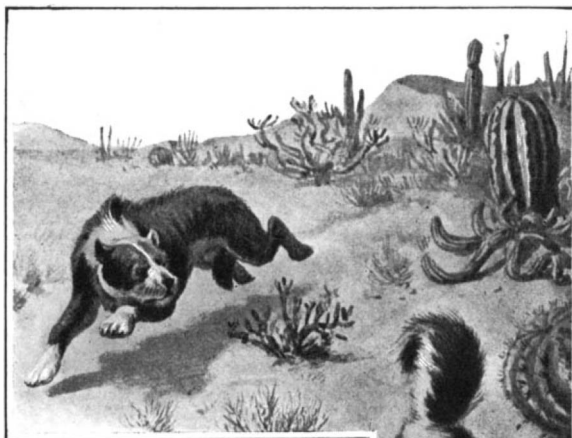
In those animals which produce their own projectiles the latter usually consist of poisonous, irritating or offensive secretions capable of being shot out with considerable force, and of causing pain, nausea, or embarrassment to the foe. Among these are included the skunk, the llama, various poisonous snakes, certain birds, toads, and frogs, and a larger variety of insects and their larvae.

This very timely subject has recently attracted the attention of two well-known European writers on scientific subjects, both members of belligerent nations—Mr. Henri Coupini, of France, and Dr. O. Damm, whose somewhat startling name is familiar and respected in Germany. We are indebted for the curious information given below to articles recently published by these gentlemen in *La Nature* (Paris) and in *Prometheus* (Berlin), respectively.

The most offensive of all such animals among animals is undoubtedly the ordinary skunk (*Mephitis varians*) of North America. This beautiful little animal, whose fur has become so valuable of recent years that attempts are now made with some success to rear it in a state of quasi-domestication, secretes a powerfully malodorous fluid in certain glands which open in the lower intestine and are known as anal glands. Unhappy the meddlesome dog whose sensitive nostrils are assailed by this fearful and unbearable stench, while

as for unwitting men who have been tempted to follow some pretty black-and-white kitten-like creature in the woods, they find too late that all the perfume of Arabia cannot sweeten either their clothes or their persons. In fact, the scent is exceedingly persistent as well as nauseously repellent, and it is said that clothes which have been touched by it must be buried in the earth for days or weeks before being again wearable. The behavior of the animal makes it the more dangerous, since it is said to walk slowly away when followed without exhibiting any sign of fear. But when the follower has approached near enough it suddenly lifts its tail and launches its odious and odorous secretion with deadly effect. The distance to which the fluid can be ejected is variously estimated at from 2 to 6 yards.

The South American llama has the highly unpleasant habit of unexpectedly "spitting" at unsuspecting visi-



Mephitis varians (skunk) defending itself by ejecting a noxious fluid.

tors or at enemies. While the saliva mixed with food thus violently ejected into the face and eyes of the unwelcome visitor is not harmful, it is disgusting and surprising. Some water fowl have manners as bad as those of the llama, since they spew forth at the invader of their nests the foul-smelling contents of their crops. This is particularly true of the stormy petrel and the albatross, those birds of bad or good omen to the sailor. Other sea birds are said to drop excrement on an enemy approaching from below. Most dangerous of all the "spitters," of course, are certain snakes, who eject poison from glands in the mouth. It was formerly doubted that such was the fact, but careful investigation has recently established its truth. This was proved by Jameson in the case of the Egyp-

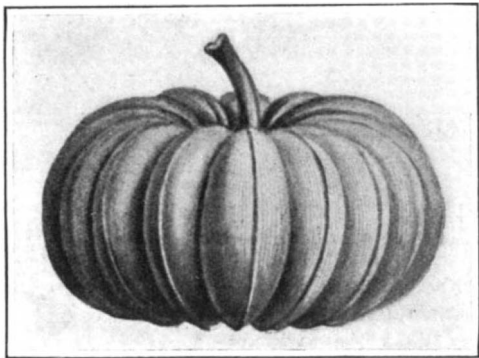
tian hooded snake (*Naja haje*) and of the *Spedon haemachetes*, and by Hobley of the *Naja nigricollis*. All three snakes shoot out a stream of colorless, poisonous fluid at enemies who attack them and then hastily decamp. Apparently they suck in air beforehand in order to enable them to eject the poison spray, which is said to cause severe inflammation of the mucous membrane, especially that of the eyes.

The hedgehog (*Hystrix cristata*) has long been credited with the power of shooting its spines at an enemy. This, however, is now proved to be fabulous. However, they are easily detached, as many an investigating dog has discovered to his sorrow. Modern investigation likewise discredits the belief that toads can eject poison from the glands on the back to a considerable distance. However, both frogs and toads have the offensive custom of expelling urine at an invader. Sometimes there is quite a large quantity of the fluid, and it is said to be expelled even to such a distance as 20 centimeters.

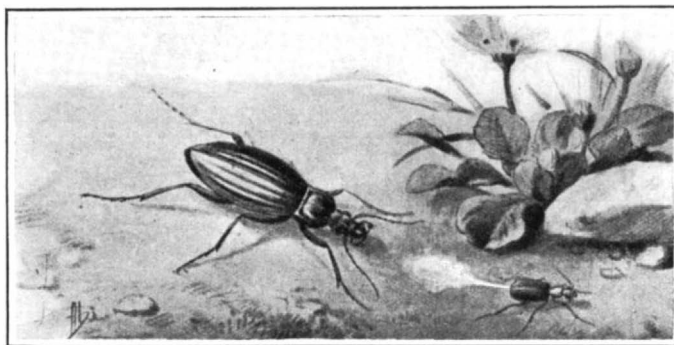
We have referred above to the shooting fish or marksman fish (*Toxotes jaculator*) of Java. This fish, which is only about 20 centimeters long (about 8 inches), is often used as an ornament for a house aquarium, for the sake of its interesting accomplishment. In its native streams it finds its prey in flies or other insects hovering near the banks. It fills its mouth with water, which is then ejected by a sudden contraction of the gills with great precision in the direction of the coveted prey. Struck by the sudden douche the latter is helpless as a small boy under the jet of a fire-hose. It falls into the water and is quickly snapped up by the expert sharpshooter, which is said to be capable of striking its victim at a distance of 1 to 1½ meters (3 to 5 feet).

Besides this cold-blooded sharpshooter we may find a prototype of the trench fighter in the animal world. This curious insect, the ant-lion—known to American children as the "doodle-bug"—is the fat and greedy larva of a graceful and lovely long-winged insect somewhat like the dragon-fly in appearance, whose entomological name is the *Myrmeleon formicarius*. The larva is 8 to 10 millimeters in length (3/10 to 4/10 inch). It digs a small funnel-shaped cavity in the sand, burying itself at the apex, with only its head emerging. Here it indulges in the pastime of watchful waiting until some hasty and incautious ant or other tiny insect passes too near the edge of the cavity and begins to slip down its treacherous slope. Instantly the lurking brigand below begins to throw a shower of grains of sand at its predestined victim, preventing it from climbing out, and confusing or blinding it so that it falls within reach of the powerful curved mandibles of the lurking lion below, which then draws it down to suck out its juices at its leisure. The broad head of the ant-lion is provided with a cavity which enables it to be used like a shovel.

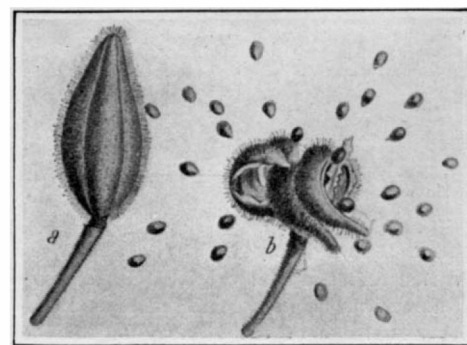
Other insects or their larvae have the power of



The sand box (*Hura crepitans*) bursts open with a loud noise when ripe and projects its seed quite a distance.



Brachinus crepitans, the bombardier chafer, that ejects a drop of liquid having a strong acid reaction that explodes like a bomb when pursued.



Fruit of the balsam that scatters its seeds by a sudden twisting action when it ripens and splits open.

emitting jets of offensive or irritating liquid. Thus the fat, flesh-colored or brownish caterpillar of the willow-butterfly (*Cossus ligniperda*) when threatened by an enemy sends out from its mouth a spray of greenish fluid to a distance of 50 to 60 centimeters (20 to 24 inches). This "juice" is strongly irritant and of such peculiarly penetrating odor that a person familiar with the smell can detect it at a considerable distance even when the creature is merely feeding quietly in the wood. Other larvae, including that of the black water-chaffer (*Hydrophilus*), various species of the "death" chafers (e. g., *Blaps mortisaga*), and of several of the *Silphiidae*, eject the secretion of the anal glands to quite a distance when irritated.

There are many examples, also, among mature insects of the ejection of an offensive fluid to repel or frighten intruders. Ants, for example, not only bite or sting, but actually spray an acid at their foes. Says Dr. Damm: "If one knocks on the hill of the red woods ant (*Formica rufa*), the animals rush forth like men from houses at the thrill of an earthquake. Then one sees the running creatures suddenly halt and curve the abdomen upward. Directly one perceives hundred of tiny jets of liquid rise in the air to a height of 20 to 30 centimeters (8 to 11 inches). These consist of poisonous antacid (formic acid) whose purpose is to drive the disturber away."

Even more curious is the power possessed by many grasshoppers to spurt blood from the joints of their limbs when in danger. In the Algerian species, *Engaster gayoni*, Vosseler observed colorless blood exuding from an opening on the upper side of the leg. A special muscle opens this aperture at the moment of danger. The author observed that such grasshoppers were, in fact, avoided by reptiles.

Another insect capable of making himself as disagreeable in his way and for his size as the skunk itself is the "bombardier" chafer, or *Brachinus crepitans*, a tiny creature scarcely a centimeter in length (4 inches). When alarmed it violently ejects from the anal glands a drop of liquid. "The ejected drop explodes like a bomb and has an extraordinarily alarming effect on the pursuer. In the older zoological books the theory was advanced that these drops contained liquid phosphorus hydride (P_2H_4), which is spontaneously inflammable; it was even declared that a faint flash was always to be seen. But later investigations do not support this theory. The secretion has an acid reaction, and its odor resembles that of nitric acid. On the human skin it causes itching and burning and leaves yellow or brown specks. Bombardier liquids are also produced by various of the *Paussidae* among the chafers; according to the investigations of Loman and Escherich, they contain free iodine." The above quotation is from Dr. Damm. Mr. Coupin also speaks at some length of the bombardier and other *Brachines*, of which there are several species, and relates a personal experience with one which he was pursuing, saying: "It shot into my eye a jet of corrosive liquid so powerful that the resultant pain persisted for several days and finally caused part of the skin of my eyelids to peel off."

A highly novel expedient for discouraging intrusion is the peculiar facility of the *Holothuria*, cucumber-shaped relatives of the star-fish and sea-urchin, for hurling a large part of their own intestines at the intruder. The intestine splits at the rectum wall and also shortly below the gullet. Then, by a violent muscular contraction, the separated intestine is flung through the rectal aperture. Truly a desperate means of defense. It reminds one of Samson pulling down the pillars of the temple to his own destruction as well as that of his foes. However, these little sea creatures are more fortunate, for they calmly set to work to grow new "insides," and accomplish the feat in a comparatively short time. According to Semper, the *Holothuria scabra* renews its intestine in 9 days, but Noll declares

that an animal which has almost completely disemboweled itself in this manner may need as much as 70 days for complete recuperation.

Strangest of all animal projectiles, perhaps, is the arrow to be found at certain seasons in the lung-breathing land snails, to which the ordinary vineyard snail belongs. We quote from Dr. Damm's account as follows: "In this instance the apparatus serves the purposes of procreation. These creatures have a sac-shaped, thick-walled internal organ on the right side of the neck, not far from the great antenna, containing a hard, pointed, calcified (*verkalkten*), arrow-shaped body. This body is the shot. The functioning of the apparatus has recently been described in detail by Meisenheimer:

"In the months of May and June one often finds mature animals exhibiting a singular behavior. They creep about as if seeking something. When two such creatures meet they rear themselves up against each other and lay the soles of their feet together. Then the broad soles glide back and forth against each other and the animals stroke and lick each other in lively manner. After a time one animal begins to act in a very different manner from the other. It expands the fore part of the head powerfully and then shoots the arrow-shaped body at its partner. The arrow usually penetrates the edges of the foot sole, rarely piercing the inner part of the sole, and since it is possessed of a not inconsiderable length and often bores clear in, the injuries caused by it are not only very painful, but may be directly dangerous. The arrow acts as a stimulus organ. It introduces the amative life of the snail, and on this account the zoologists have named it the love-arrow. The shooting of the arrow is accomplished by means of muscles which are placed on the ground and in the lower portions of the wall of the arrow-sac. They are capable of contracting with extreme rapidity. We have here, therefore, a sort of cross-bow."

This completes the list of the animals who avail themselves of projectiles of which Dr. Damm writes. Mr. Coupin, however, gives a brief list of plant projectiles, with some interesting pictures which we reproduce from *La Nature*. The object of the plant is usually the projection of its seeds to points of vantage from which to begin the struggle for existence on their own account. Sometimes, however, pollen is thus projected to a distance in order to secure cross-fertilization.

As shown in the illustration, the fruit of the wild cucumber or *Ecbalium* is "supported by a peduncle recurved in the form of a bishop's cross in such sort that the point of attachment is turned upward. When ripe the fruit detaches itself from its support and through the gaping aperture thus produced it projects with very great force the seeds which it contains in the midst of a mucilaginous liquid to a distance of 1 or 2 meters (a yard or two). This vegetable 'cracheur' is exploited by children, who direct the jet at the face of a comrade by way of a pleasantry."

More familiar in this country is the common balsam of our gardens. Its curious fruit, shown in the illustration, is doubtless known to most of our readers. When ripe it splits according to the five longitudinal lines, and the five valves thus separated twist suddenly upon themselves, thus launching in every direction the seeds which are slightly attached to them.

"Shortly before maturity is reached the slightest touch causes the rupture to take place immediately; it is for this reason that the expressive name of 'Impatient touch-me-not' is often given to the balsam—a name which the botanists have translated into Latin: *Impatiens noli-tangen*. All the other species of balsam act in the same manner.

"Not less singular is the 'sand-box' (*Hura crepitans*), a large tree of America, whose extremely hard fruit looks like a tomato. At maturity this fruit opens suddenly with a noise loud as a pistol shot, and projecting

its valves and seeds to a distance. To preserve the fruit of the sand-box (*sablier*) in collections it is necessary to encompass it with several windings of iron wire, and disastrous instances are quoted where the force of the fruit was sufficient to break these bonds and smash the glass frames that contained it."

As a final instance of vegetable projectiles, Mr. Coupin refers to the parietary, a modest plant growing on ruined walls. If the stamens of the freshly opened blossoms be touched with a pin they immediately rebound like wire springs, scattering to the winds a light cloud of pollen, destined to fecundate the ovules of more distant flowers.

The Great Canadian Reflector

VERY satisfactory progress is being made on the great 72-inch reflecting telescope which is being constructed for the Canadian government, and is now approaching the final stages of erection and adjusting.

The mounting has been completed by the Warner & Swasey Company of Cleveland, Ohio, and has been temporarily erected at their factory. Exhaustive tests have shown that the operating mechanism works perfectly. The entire mounting weighs about 120,000 pounds, of which the moving parts weigh upward of 80,000 pounds, and yet it moves with the greatest smoothness and ease. The worm wheel for driving the telescope weighs more than 4,000 pounds, and yet it may be turned readily on its axis with the finger. By means of seven electric motors and conveniently situated stationary and portable switchboards, the instrument can be set, driven, and guided with the utmost facility. Indeed, the immense machine can be operated and handled with greater ease than many small telescopes. The mounting will be taken down and shipped to the observatory as soon as the erection of its dome is sufficiently advanced.

The optical portions of the telescope are being made by the John A. Brashear Company of Pittsburgh, Pa. The principal part, namely, the great mirror, 73 inches in diameter, is also well advanced. It has been brought to the spherical form, and will be given the paraboloidal form and finally polished as soon as the firm has completed a large plane mirror which is required for testing it. The smaller optical parts are all completed, and have been attached to the mounting. It is hoped that the mirror will be ready as soon as the mounting is erected and in condition to receive it.

The pier to support the telescope was completed last autumn. It is made of reinforced concrete, and is of massive construction. The walls of the surrounding circular steel building, 66 feet in diameter, were erected during the winter, and the dome, constructed by the Warner & Swasey Company, which will rest and revolve upon these walls, arrived in Victoria, B. C., about the end of March, and is now being put in place. The shutter opening is 15 feet in width. The dome has been very carefully designed to work in conjunction with the telescope, and it is confidently believed that it will be the most complete and convenient of any in the world.

One of the observer's residences has been erected, but none of the other buildings required have yet been begun. It is hoped, however, that everything will be ready to begin regular observing with the magnificent equipment next spring, by which time the preliminary experimental work of adjusting will be completed.—*Nature*.

Paper Scarce in England

WHILE paper is getting scarce in this country it is still more so in England, and many schemes are being devised for securing supplies for new material. One of these is the employment of the Boy Scouts in collecting old paper of every kind, which is sold for the benefit of the National Relief Fund; but probably the most prolific source of material is in the continental publications and printed matter of all kinds, mostly intended for America, which the English government is confiscating from neutral ships, and converting to its own uses.

Hay Fever*

Its Cause, Treatment and Prevention

By W. Scheppegegrell, A.M., M.D., Pres. American Hay-Fever-Prevention

UNTIL recently, hay-fever was considered a disease of varied and doubtful origin, but whose reappearance was as certain as the proverbial tax-collector. A more exact knowledge of the etiology of this disease, however, has shown not only that it is not inevitable, but, in view of the simplicity of its prevention, is a disease whose continued existence would be a reflection on preventive medicine.

The development of pollinosis at the exact time of the blooming of certain plants, and its disappearance with these flowers, eventually led to the conclusion that a relationship existed between hay-fever and the blooming of these plants. This was corroborated by the fact that susceptible persons develop a paroxysm by simply approaching such plants at a time when their pollen is being dispersed by the wind. It was also found that this pollen, applied to the nostrils of susceptible subjects, could produce a hay-fever reaction at any season of the year.

The class of plants whose pollen may cause hay-fever are wind-pollinated, that is, the process of fertilization is effected by the pollen being borne by the wind, instead of this being done by contact or by insects. This explains the presence of such pollen in the air. In some cases the pollen is present in enormous quantities, as for instance in the ragweeds, in which it has been estimated that only one in a hundred million pollen is actually used in fertilizing the pistillate flower.

The plants that are responsible for hay-fever are practically all common weeds, such as the rag-weeds, cockle bur, yellow dock, etc., which are also a source of expense and labor to the farmer. Their characteristics are as follows: They are wind-pollinated, without attractive color or fragrance, very numerous, and with abundant pollen. The lack of color or scent is due to the fact that these plants are wind-pollinated, the qualities mentioned being intended to attract insects for fertilization.

The most common weeds that cause hay-fever are the rag-weeds (*Ambrosia artemisiifolia* and *trifida*), which are the causes of most cases of Fall hay-fever. The marsh elder (*Iva ciliata*) is also a cause of Fall hay-fever and frequently prolongs the attack. The early cases are due to the yellow dock (*Rumex crispus*), and the mid-Summer cases to the careless weed (*Amaranthus spinosus*), cockle-bur (*Xanthium canadense*), and other wind-pollinated weeds. In early Summer, many cases are due to the various grasses, all of which are wind-pollinated.

The reaction of pollinosis is divided into the direct and indirect stage. The former is influenced by the physical conformation of the pollen. In plants, in which the pollen is covered with spiculæ, such as the Ambrosias, Partheniums, Dracopis, etc., the direct reaction may develop immediately and is usually prolonged. In those in which the pollens are smooth, such as the Rumex, Amaranthus, grasses, etc., the reaction is deferred several minutes and is milder in character.

The indirect reaction of pollinosis is partly due to the effects of the primary irritation and partly to the absorption of the protein contents of the pollen, and the toxin formed by the proteolytic action of the cells. The immunity of the patient depends upon his resistance to the initial irritation and the completeness with which the liberated toxins are neutralized. The character of this process establishes the degree of susceptibility of the patient and forms an important factor in what is called "predisposition." This is probably also affected to some extent by certain general conditions but the influence of these has not been clearly established.

Immunity and predisposition in pollinosis are relative terms. The person who is immune and the one which is affected may both breathe the same pollen-infected air, the former without apparent discomfort and the latter developing an attack. In each case, the pollen enters the nasal cavities, but in the immune, the clinical symptoms are not presented.

This result is due to the fact that all cells possess to some extent a proteolytic power which acts as a defense against the invasion of foreign proteins, provided certain limits are not exceeded. In addition to this, the entrance of foreign proteins by parenteral channels results in the development of antibodies, which are

ferments which also protect the host within certain limits. The extent to which these processes neutralize the absorbed toxins, and the degree to which he can resist the initial irritation, establishes the degree of immunity of the patient.

Local conditions, such as abnormalities of the nasal passages, also act as a predisposing cause, but much less so than is generally supposed. Operations to correct such defects have given satisfactory results as regards hay-fever in less than 25 per cent of the cases, and are not to be recommended unless also indicated for other reasons.

The increased susceptibility of hay-fever after an initial attack, is due to the anaphylactic condition produced by the absorption of the pollen protein by parenteral channels. The antibodies resulting from this reaction are probably of the anaphylactic type, and this explains the reduced resistance to further infection.

Anti-anaphylaxis, eventually resulting in a reactive condition of immunity, also develops in pollinosis, but is usually delayed for quite a long period, and is indicated by gradual decrease of the paroxysms. This should not be confused with the disappearance of the attacks due to diminution of the supply of pollen resulting from a change of residence or the eradication of the pollinating weeds.

The effects of hay-fever are due not only to the absorbed pollen proteins but also to the action of microorganisms resulting from the lowered resistance of the nasal mucous membrane, and from the inflammatory reactions associated with these processes. In the treatment, these various conditions should be considered.

The important factor in the treatment is the removal of the exciting cause. In many cases the pollinating weeds are in the neighborhood of the patient's residence, and the cutting of these will frequently give marked relief. My first prescription to such patients is "Have the weeds and grass in your neighborhood cut and keep away from other weeds." The result of this advice depends upon the extent to which the pollinating weeds and grasses can be cut or destroyed, but the results compare favorably with the published reports of therapeutic methods.

A method which has given relief in almost every case, is the removal of the patient during the hay-fever period from the infected locality. This does not necessitate an expensive trip to the mountains or seaside, which frequently fails to give relief on account of the presence of hay-fever pollens in the air at these places. A temporary visit to a more central part of the city will be sufficient, provided the areas with pollinating weeds or grasses are at a sufficient distance ($\frac{1}{2}$ mile or more). The new locality should, however, be carefully inspected, as a small lot with high weeds in the same square may be more irritating than a whole acre of weeds at a greater distance.

For several years attempts have been made to increase the resistance of the patient to pollen by the injection of the pollen extracts. In all the early attempts, mixed pollens were used without regard to the special susceptibility of the patient, which is probably one of the causes of their failure. In such cases, only the pollen should be used to which the patient reacts, as evidenced by the nasal, conjunctival, or skin reaction. The injection of the wrong extract may cause the patient to become sensitive to the pollen from which the extract is prepared.

The pollen extract is prepared by dissolving one centigram of the specified pollen in ten c.c. of 5 per cent salt solution to which 10 per cent alcohol has been added and which is preserved in an aseptic condition. When used, this should be diluted to about 5 per cent, the strength to be determined by the conjunctival reaction, this being indicated by a hyperemia produced by the extract. The subcutaneous injection of the extract should be repeated at intervals of three to five days. The object of the injection is to increase the patient's resistance to the pollen toxin (anti-anaphylaxis) so that the inhaled pollen protein will no longer produce an attack.

Instead of the conjunctival reaction, the skin reaction is frequently used. This is effected by making a number of light scratches on the skin and rubbing in a drop of the pollen extract to be tested. A positive reaction is indicated by reddening and edema of the

area surrounding the abraded surface and accompanied by itching.

In cases in which the pollen therapy does not give satisfactory results, autogenous vaccines may also be used. These are prepared from the bacteria found in the nasal secretion of the patient. Both of these methods have given fairly satisfactory results, whose permanency, however, still remains to be established.

Relief has also been reported from the use of calcium chloride, which already has been successfully used in asthma, the dose being 3 grams daily. It is supposed to act as a sedative to the nervous system.

Mercury has also been used in hay-fever, and Barton L. Wright of the United States Navy reports several successful cases. He prefers the succinimide of mercury, 1/5 grain in distilled water, this being injected deeply into the gluteal muscles. He believes that the effects are due to the fact that patients after a mercuric treatment have a peculiar power of resistance to infection of every kind.

In regard to treatment, however, it must be admitted that thus far none except the elimination of the pollinating weeds has given very satisfactory results. The above methods are described as the most promising thus far. Further investigations along these lines it is hoped will eventually give sufficient data to indicate the most advisable method of treating this disease.

As hay-fever has been shown to be a distinctly preventable disease, it is clearly our duty to use every effort to eradicate the cause. The investigations which we have conducted for several years indicate that the large majority of the plants whose pollen give rise to hay-fever are worthless weeds which are alike an expense to the farmer and a menace to health.

In a work of such an extensive character, however, as the eradication of hay-fever weeds, we must have general co-operation in order to be successful. It is, therefore, necessary to educate the public in the relationship of such weeds to hay-fever and the relief that sufferers from this disease are entitled to by removing the cause. Health is one of man's most important assets, and every one has a right to demand that this does not suffer on account of the neglect of his neighbor. If the hay-fever weeds are allowed to infest his neighbor's premises or vacant lots and infect the air he breathes with noxious pollen, he is evidently entitled to relief.

In the medical profession, the relationship of pollen to hay-fever has been so firmly established that it is now technically referred to as "pollinosis." In the recent meeting of the Louisiana State Medical Society, in which I spoke of the etiology of hay-fever, there was not a dissenting opinion expressed regarding the relationship of these pollens to hay-fever.

An important item in the eradication of hay-fever weeds is the distance at which pollen may produce an attack of hay-fever. It has been shown by means of glass slides exposed to the wind that some pollens may travel a great distance, even several miles. We have found, however, that pollen scatters rapidly as it is carried by the wind from the parent weed, the decrease being estimated to be inversely as the square of the distance. On this account, pollen is not often a source of hay-fever at a distance of over a half mile, and even a much shorter distance is often sufficient to give relief. According to the above rule, a patient at 1,000 feet, or about three ordinary city blocks, would inhale only 1/100 part of the pollen to which he would be exposed at 100 feet.

Immunity to hay-fever does not mean that the patient is not inhaling pollen, but that the amount is not greater than he can neutralize. In an atmosphere in which there is abundance of pollen, it is evident that all persons breathing this air must inhale about an equal number, but only those suffer in whom the amount of pollen inhaled is in excess of their neutralizing power. There are probably few who cannot inhale a certain number of pollen grains without disturbance, hence the importance of keeping this number as low as possible.

As an evidence of the importance of eliminating the pollen in the immediate vicinity of the patient, I have observed great relief to patients when the hay-fever weeds in lots adjoining their residences were cut down, although considerable pollen was still in the air from weeds at a greater distance.

*Medical Record.

The increased susceptibility of a hay-fever patient after an incipient attack has already been referred to. We have had patients living at a distance of a quarter of a mile from a large area of hay-fever weeds, who were entirely free for weeks until their susceptibility was increased by an attack from close proximity to these weeds. The amount of pollen at a distance which had not before been a source of irritation was now sufficient to continue the attacks.

In order to be effective, the efforts against hay-fever weeds should be reinforced by proper legislation. There will always be persons who respect their neighbors' rights, in health as well as in other matters, only when compelled by the majesty of the law. When education

has reached a sufficient stage, therefore, suitable laws should be enacted to obtain permanent results against hay-fever.

In New Orleans, where success against hay-fever is already quite apparent, the education of the public in the relationship of certain weeds to hay-fever was carried out by means of articles in the medical and lay press and in lectures before various societies. As a result of this, when an effective anti-hay-fever-weed law was submitted by the American Hay-Fever-Prevention Association to the city council it was passed without a dissenting vote. It is now being enforced, and the results, which have already been demonstrated, have in the reduction of the number of hay-fever

cases thus far (July 1) has surpassed all anticipations.

It is important in enacting such an ordinance that the provisions should not be too drastic or it will be difficult to enforce. The height of grass and weeds should be limited to 1 foot on lots, sidewalks, and roads operating through a public franchise. On the other hand, no preliminary notification should be allowed, as this greatly increases the expense of inspection and reporting, and lowers the efficiency of the ordinance.

As the relation of weeds to hay-fever becomes more generally recognized, adequate anti-weed laws will be introduced in all the towns and cities. Their proper observance will give results in hay-fever that will fully justify the expense of their enforcement.

Malt Extract in the Laundry

A Useful Compound That Renders Starch Soluble

By A. F. Musgrave

MALT extract is just being introduced in American laundries, although it has been a standard washroom supply in England and on the continent of Europe for many years. Abroad it is known by several trade names, such as clenbumel, brimal and farinol, while in this country it is best known commercially, to the laundry trade, as balmal. For many years previous to its introduction into laundry work, it was widely used by the manufacturers of cotton goods as an assistant in the preparation of sizing pastes. Its function in that case was to convert the starch into a soluble form, and it is in this same manner that the product is of such value in the laundry.

Malt extract in appearance is a thick, yellowish liquid, which has a sweet odor and taste. It is perfectly soluble in water, but its efficiency is very much impaired by alkalies. Chemically speaking, malt extract is composed of unorganized ferments, of which many varieties are known to science. The particular ferments are called by different names, although the whole class is named enzymes. A brief definition of the word will show at once the great value of these products in the laundry.

Enzymes are chemical compounds (unorganized ferments) which have the property, when certain substances are brought into contact with small quantities of them, of causing the substances to dissolve or decompose, in most cases with the addition of the elements of water. There are several different enzymes, the name diastase being given to the enzyme which is present in malt. The constitution of the several enzymes and the manner in which they work is little understood as yet.

A brief survey of the manufacture of alcohol will show the manner in which enzymes perform their functions. Some starchy product, such as potatoes, is made into a paste with water and subjected to the action of steam for a few minutes, in order to break down the starch granules. An addition of sprouting barley is then made. The starch from the potatoes is acted on by the enzyme, diastase, which is present in sprouting barley, the result being the formation of maltose, a sugar which is soluble in water. The sugar is then fermented to alcohol by the addition of yeast. Yeast contains another ferment, or enzyme, which acts on the sugar to form alcohol. This article does not deal with the manufacture of alcohol, but I have just cited the above matter in order to show better the manner in which malt extract works.

Every laundry owner knows, or should know, that starch is insoluble in water. It even is insoluble in boiling water, as it only makes a paste in it, but does not really dissolve. The laundry is under the necessity of washing and cleaning fabrics which have been cleaned and heavily starched many times before. As starch is insoluble in water, it seems as though it would be impossible to remove the old starch in the regular laundering process. This is found to be the case, when reliance is placed on the use of hot water to remove old starch.

At the same time, we know that it is impossible to clean thoroughly a fabric which contains a large amount of starch that is insoluble and firmly fixed in the pores of the fabric. Formerly it was necessary for the laundries to use excessive amounts of alkalies and to subject the goods to long rubbing or pounding in order to remove the old starch and the dirt which was mechanically adhering to it. It is needless to say that caustic alkalies are harmful to fibers, whether of wool or cotton, the action in the case of wool fiber being a destructive one, while in the case of cotton fiber it tends to shrink the garment. The effect of hot alkaline baths on colored goods is also well known and the combination of the

long pounding and the strongly alkaline baths has no doubt contributed a great deal to the bad names which the steam laundries have had in the past.

Most laundry owners, and also their washmen, cannot understand how a product which is not a detergent, in the ordinarily accepted meaning of the term, not an alkali, and not a bleach, can be of assistance in the washing of clothes. Malt extract is none of the above; in fact, it is so harmless that it can be taken internally. It is often used in medicine. The *National Dispensary* says: "Barley malt is especially adapted as an aid to the digestion of starchy foods by converting them into soluble dextrine or glucose." Both dextrine and glucose are soluble in water and it is therefore in the same manner that malt extract is of value in the laundry, namely, that it converts the insoluble starch into a soluble compound which is easily washed out of the fabric.

It is easy to understand that the dirt in a heavily-starched fabric, such as a collar, will not enter into the pores of the fibers, owing to their being already filled with starch. The dirt, therefore, remains on the outside, or surface, of the fabric, being held on mechanically by the starch. Where dirty starched goods are pounded or run for some time in hot alkaline baths, a certain portion of the starch will become loosened up, but a part of the dirt will be driven into the pores of the fabric, where it naturally will be much harder to remove. It is also known that certain forms of dirt partake of the nature of dyes, in that they are more permanently fixed on the fabric by the use of hot alkaline baths. The impurities which become affixed in this manner are all the more difficult to remove, and frequently necessitate the use of strong bleach. The use of strong bleach invariably means that the life of the fabric is shortened.

By the use of malt extract, the laundry can get away from the excessive use of alkali and the long pounding which was formerly necessary. The washman may even remove any amount of starch, from any fabric, no matter how delicate in structure or color, without detriment to fiber or dye, the necessary process being only a short immersion in a bath of it.

Let us leave aside the question of dirt and consider the re-starching of the goods after they are cleaned. Starch, in order to become firmly and evenly fastened, requires a perfectly clean surface, and that means that the old starch must be perfectly removed before new starch can be satisfactorily applied. It is well known that starch, under long and continued beating, will frequently turn yellow. What better reason can be advanced for some of the yellow troubles than that they are caused by repeated pressings over old starch which has never been perfectly removed. It is also well known that breaks in collars are the result of old starch in the goods, and which, during the washing of the collars, exerts a strong frictional action.

It is not only on collars that malt extract may be used to good advantage. Lace curtains, before being washed, should always be given a bath of malt extract, in order to remove the dressing. It is well known that lace curtains which have been hanging in the sun for some time are somewhat tendered and will stand very little working. A hard process with heat, alkalies and rubbing would not be allowable in this case, owing to the damage which would be done to the goods. The difficulty easily is overcome by treating the goods in a bath of malt extract, which removes the starch and also the greater part of the dirt.

New flannels are also treated with malt extract to good advantage. Laundry felts are also cleaned in this manner. In fact, it converts starch, whether on fibers or raw, into a soluble compound. Many food

stains that seem to resist the laundering process are stains of a starchy character and frequently are removed in a malt extract bath.

Looking back to the definition of an enzyme, which I will repeat, in order to save time, it reads as follows: "Enzymes are chemical compounds (unorganized ferments) which have the property, when certain substances are brought in contact with small quantities of them, of causing the substances to decompose." It is the phrase, "with small quantities of them," which I wish to emphasize at this time. This phrase, translated to common laundry talk, means that only 4 ounces of malt extract are needed in order to remove thoroughly the old starch from 100 shirts or the equivalent amount of other goods. It is thus seen that the amount of extract needed is very small, but the question is: "Will it pay for itself by a shortening of the process or a saving of other supplies?" The answer is most emphatically, yes. By comparing the following process with an average old method, we find a saving in time and soap.

GENERAL METHOD FOR ONE HUNDRED SHIRTS.

1. Wet out for 5 minutes with cold water.
2. To fresh water at 130 deg. Fahr. add 4 ounces of malt extract; run 10 minutes.
3. Hot rinse, to remove the soluble products of starch.
4. Soap and bleach 30 minutes.
5. Three 5-minute rinses.
6. Blue as usual.

Every laundry owner can compare this method with the method which he is using to-day, without malt extract, and the advantage generally will be found to be in favor of the process here given. Even if the saving in time and supplies is small, there are still the questions of color and the proper preservation of the goods, and these are a factor which no laundry owner can afford to neglect.

Another point which favors the use of malt extract is the washing of goods in hard water. The washing process as ordinarily carried out in hard water will result in the precipitation of more or less insoluble lime soap in the fabric. Any process which will eliminate one soap bath will naturally prevent the formation of just that much insoluble soap. Malt extract is not affected by hard water.—*National Laundry Journal*.

"World's Biggest Ship."

THE correspondent of the *Berlingske Tidende* has had an interview with Herr Ballin, general manager of the Hamburg-America Line, who says that his company is building the "Bismarck," 56,000 tons, the world's greatest steamer, a turbine ship; the "Tirpitz," 30,000 tons, and three other vessels of 22,000 tons each. At the Vulcan Wharf, Bremen, there are building nine vessels, four of them having a carrying capacity of 18,000 tons; being the world's greatest freight steamers; and at the wharf, Flensburg, two steamers of 13,000 tons, and three larger passenger freight steamers are being constructed; while, at Geestemünde two freight steamers of 17,000 tons each, for traffic through the Panama Canal, have been placed under construction. The Hamburger South America Line is building the "Cap Polonio," a sister ship to the auxiliary cruiser "Cap Trafalgar." The Norddeutscher-Lloyd is building two fast sailing steamers, the "Columbus" and "Hindenburg," 35,000 tons; the "München" and "Zeppelin," 16,000 tons each; and twelve vessels of 12,000 tons each. The Africa Line is constructing six, the Hansa Line eight, and the Cosmos Line ten, from 9,000 to 13,000 tons.—*London Daily Telegraph*.

Paper for Artistic Printing

Material of Individual Character for Reproducing Engravings and Etchings

By Dard Hunter

For the printing of intaglio plates, such as etchings, steel engravings and photogravures, the paper has always been a very important factor. This would also apply to the printing of fine books, wood-cuts and all relief printing where an artistic result is desired. To get the quality of paper suitable for certain printing often becomes quite a difficult task.

Paper is divided into two general classes: hand-made and machine-made. In either class there are a great many varieties of paper for different purposes. Hand-made sheets have always been regarded as the only suitable surface for fine prints and books. However, it is possible to print almost as well on machine-made paper as on that made by hand. The quality desired by the artist is, therefore, not so much in the actual printing quality as in the appearance, color and "feel" of the paper. For instance, an etching printed on a piece of good machine-made rag paper, while the lines may be well defined, the print is apt to appear dull and hard. The same copper-plate may be printed on a sheet of hand-made and the etched lines may be printed no better than on the machine-made sheet, but the picture will appear more "full" and have more life and tone.

The machine-made thing, no matter what it may be, is always more perfect than that made by hand. Paper made on a machine is, even in thickness; the weight is uniform and the sheets are clear when held to the light. Hand-made paper is uneven, varying from one side of the sheet to the other; the edges are ragged and altogether the paper produced in a hand-mold is imperfect as compared to that made on a machine. However, the hand-made possesses a character and individuality that the machine cannot be made to imitate. It is this peculiar quality, that only the hand-made thing can have, that is so much desired by the artist and printer of fine works.

For etching the paper is always wetted, the sheets being soaked in water and the surface moisture eliminated by lightly pressing between blotters. In letterpress printing (printing from type, wood-blocks, etc.) where hand-made paper is used, it should also be printed damp to get the best results. Now-a-days paper is almost entirely printed dry—the modern press not being suited to wet printing. If the printer wishes to use hand-made paper he should be consistent and use a hand-press. With a press of this type the sheets can be worked damp and more artistic printing may be had. Of course, this would apply only to the very finest kind of book making.

The material used in machine-made paper can be just as good as that employed in the making of paper by hand. Most of the so-called hand-made imported to this country from Europe is made of no better material than that used in making wrapping paper. There are machines used in Europe (the writer knows of none in this country) which imitate hand-made paper imperfectly, but it sometimes becomes difficult for the printer to distinguish. As a rule, the English hand-made can be relied upon, but it is naturally expensive. In France, Holland and Germany there are many machines that make imitation hand-made but the material used is generally good. Most of the hand-made from Italy (America gets a good portion of it) is made from very poor material—straw, old rope, inferior rags and even wood pulp go to make up this cheaply sold paper.

In the photographs are seen specimens of paper showing the characteristics of deckles. In *A* the sheet is an old American (about 1700), with very irregular deckles. This crudeness was caused by an ill-fitting deckle. The deckle being a wooden frame that fits over the fold on which the paper is formed. This deckle, or frame (from *deckel*, the German word meaning cover) determines the size of the paper being made. The wet pulp going against it causes the ragged edges on the four sides of the sheet. In such an extreme deckle as the one shown, the wet pulp has run under the frame and not stopped abruptly at its edges. These very pronounced deckles are much admired by the etcher and printer of artistic plates. In *B* is seen a sheet from the writer's mill. In this case the wooden deckle fits snugly—the ragged edges being caused by the length of the fibers. When the deckle or frame was lifted from the mold these long fibers came up with it, and when the wet sheet, or "water-leaf," was laid on a felt for pressing, the fibers flattened out and formed

the rough edges. In *C* the sheet is hand-made, but from very short fibers, the deckle being well fitted, making quite straight edges. In *D* is shown an imitation hand-made. This is from a French sheet. The deckles were made by a tearing wire which pressed the wet pulp into sheets with edges resembling those

made by the deckle of a hand-mold. In *E* the sheet is machine-made, the deckle being made by the deckle straps of an ordinary paper-machine. These deckles can only appear on two edges of a sheet, due to the continuous web in which the paper is made. For printing etchings the artist would undoubtedly choose the first two papers as being the most desirable from an artistic view-point.

Generally, the printer and engraver, in selecting paper for their prints, investigate the paper very little more than as to the weight, surface and color. Even in printing the finest books and prints the printer does not ascertain whether the paper is of lasting quality or not. Practically all modern paper is bleached. As this process is comparatively a recent invention (1774) bleached paper has never had a time test. In all probabilities, paper that contains bleach, either hand or machine made, will crumble to dust in a few hundred years. The writer has seen hand-made paper, supposedly good, that contained bleach, broken in two, a ream at a time, over a wooden rail.

The ideal paper for etchings and engravings is made from unbleached cotton with about one-fifth linen, mixed in the pulp state. The rags not being bleached, in the process of making the paper, not only assure the printer of lasting quality but the sheets have a fine cream color. This tone makes a much finer background for a print than the chalky white of bleached paper. The rags should be well boiled and washed in pure water for at least ten hours—the longer the better. The fibers should be drawn out in the beating process and not quickly cut. This takes time, but the quality of the paper is compensation enough.

Animal sizing only should be used on fine printing papers. The sizing should be uniform but not too heavy. No sizing of any kind should be used in the beater as this hardens the sheets throughout. Drawing paper is sized in the beater so the sheets can be used for deep erasures. The best size is made from scraps of hides and parchment. This is boiled down to gelatine and clarified so that it will not discolor the paper when used. The thick gelatine is then thinned with hot water and the sheets immersed in the liquid. The sheets are then hung up to dry in a loft kept at about the same temperature as the drying room for the paper—about seventy or eighty degrees. After sizing, the paper should "season" before being printed upon.

It is too often the case that the artist and printer look only to the surface and color of the paper on which they print their books, etchings and engravings. If the artist wishes his work to be handed down through the ages, the paper on which he prints must be well considered.

An Old Biological Theory Attacked

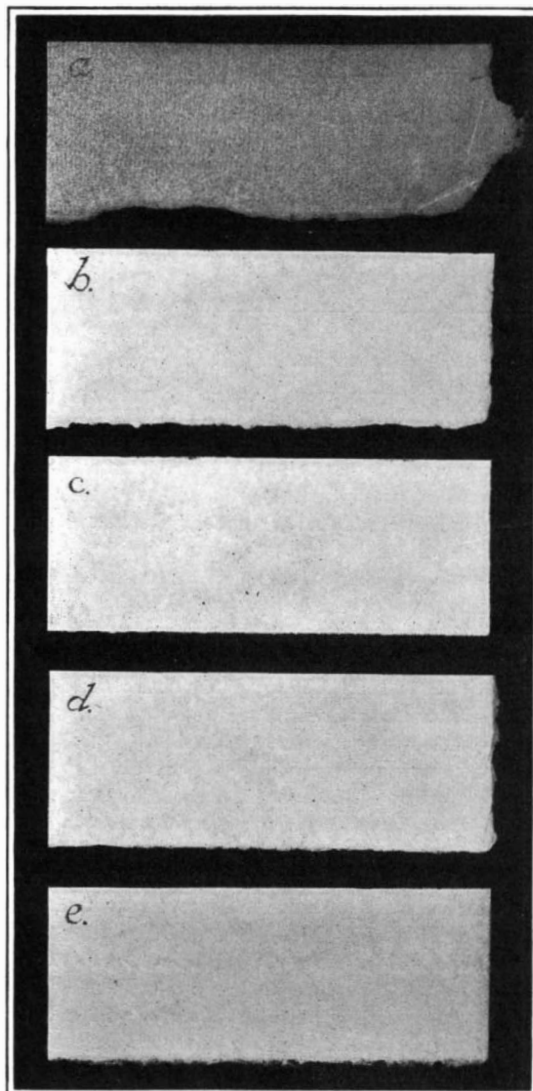
THE notion that the living substance of plant and animal cells is composed of albumen has never been demonstrated experimentally; but, at first a mere hypothesis, it has gradually been formulated with more and more definiteness, with less and less reserve, until it has finally come to be accepted dogma, unquestioned by the orthodox biologist.

This theory has recently been called into question by a German botanist, who has endeavored to show that the albumen bodies found in all cells are not the fundamental cellular substance, but represent merely a reserve supply of nutritive matter. His suggestion demands attention by virtue of the very fact, which he clearly points out, that the older hypothesis has never been properly demonstrated. He cites several authorities to establish that albumen may be entirely lacking in living substance. He describes his own experiments, indicating that certain types of organisms can survive for long periods of time a temperature above the coagulating point of albumen.

One apparently serious objection to this view of the albumen bodies is that after a plant has been starved to death, individual cells are frequently found containing these bodies. Against this objection it is urged that in such event enough cells will be found which consumed their entire supply of albumen, and died for want of more, to account for the death of the plant itself before all of the cells have exhausted their supply of reserve matter.



The mill where the author makes artistic paper by hand.



Various kinds of deckle edges.

The halftone reproduction gives no idea of the artistic texture of these samples.

A New Roentgen Tube

No one can fail to understand the extreme importance of the Roentgen ray in surgery, and especially in surgery of the sort called for by the war. *Die Umschau* recently described a new type of tube for the generation of these rays, which is a pronounced improvement over any hitherto shown.

To understand its operation we must glance at the ordinary apparatus for discharge of these rays. These are given off by the metal surface of the anti-cathode, under the influence of a bombardment of cathode rays, thrown out from the negative pole of a Crookes tube, when that tube is discharged by a high-tension current. The more nearly perfect the vacuum in the tube, the higher tension required for the discharge, and the "stronger," or more penetrating, the resulting Roentgen rays.

"Strong" tubes, giving strong rays are used for taking shadowgraphs of the denser, bony parts of the body; weaker ones, for the less dense tissues. In order to be equipped to meet any case that might arise, the surgeon must keep on hand an array of tubes of different strengths. Nor is that the only disadvantage of the tubes in ordinary use. For any given tube a certain fixed current is proper; and if a stronger (or weaker) current should by accident be used, air passes out (or in) through the walls of the tube and strengthens (or weakens) the vacuum, and hence the tube. To be sure, the original degree of hardness can be restored, but only by a long and complicated process.

The Lilienfeld tube is free from these disadvantages. The vacuum is practically perfect; so it can be used without special preparation. Its operation involves rather more complicated theory than does that of the ordinary tube, but no more care or attention is demanded of the operator.

The anti-cathode, which also serves as positive pole, projects from the top. The long narrow central tube contains the Roentgen cathode, bored from end to end parallel to the axis of the tube. Between the negative pole, situated in the obliquely projecting tube below, and the anti-cathode, a high tension is maintained. The discharge of cathode rays is not induced by this current, but takes place in the filament in the lower bulb, which is made incandescent by an auxiliary current. These rays are driven violently upward through the boring by a high-tension current arranged for the purpose; and their passage making the upper part of the tube conductive, a strong Roentgen discharge then takes place. This accelerates the cathode rays even more, and they fall upon the surface of the anti-cathode with great force, causing the latter to give off the desired Roentgen rays.

If the current in the auxiliary circuit is increased, more cathode rays will be thrown out by the filament, the tube will conduct better, and the Roentgen rays will be stronger. So that by manipulation of a resistance switch in the auxiliary circuit, Roentgen rays of any desired strengths may be instantaneously produced, one after another, and employed successively in photographing regions of varying permeability.

The extremely high vacuum excludes the possibility of accidental strengthening of the rays through loss of air from the tube. Again, in the new model the primary high tension current does not itself have to make this vacuum conductive, since the filament sends its cathode rays through the entire tube. And on account of the small bore, these fall upon the anti-cathode in a very close, dense bundle, and produce there a tiny bright spot, from which the Roentgen rays are given off sideways, to the left. The close approach of this source of the rays to a single point insures a sharp and finely differentiated negative. In the old apparatus, on the other hand, some of the cathode rays fell upon the glass walls of the tube, heating them to incandescence, so that there was a certain loss of power. Furthermore, the life of the rays is considerably greater in this new device than in the old, making possible longer exposures and photographing of regions heretofore impermeable.

Most notable among the advantages of this new apparatus is the way in which it reduces Roentgen photography to a mechanical operation. By mere adjustment of an indicator on a scale the current is so regulated as to give a sheaf of Roentgen rays of proper strength for any desired purpose.

The Efficient Use of Gas in the Home*

By W. H. Forbes

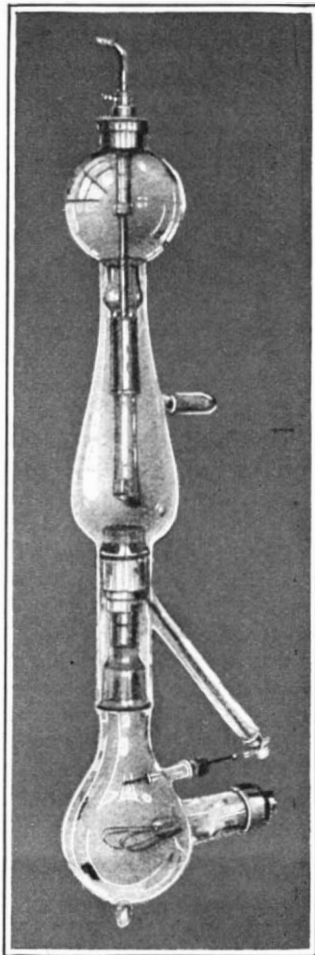
AMONG other matters, such as affect the use or abuse of gas in the home, Mr. Forbes brings to the fore some points regarding the "Safe Use of Gas." These points were brought out as follows:

Explosive Mixtures.—Gas explosions are so rare that it seems almost unnecessary to mention the subject.

They can generally be traced to some carelessness or negligence and they may be eliminated by the exercise of a little thought and care.

Gas cannot be ignited or exploded until it mixes with oxygen. One volume of gas to thirteen volumes of air is about the minimum amount of gas necessary for an explosion, and one volume of gas to three volumes of air is about the minimum amount of air necessary for an explosion. These figures are approximate and will vary some with the kind and quality of gas.

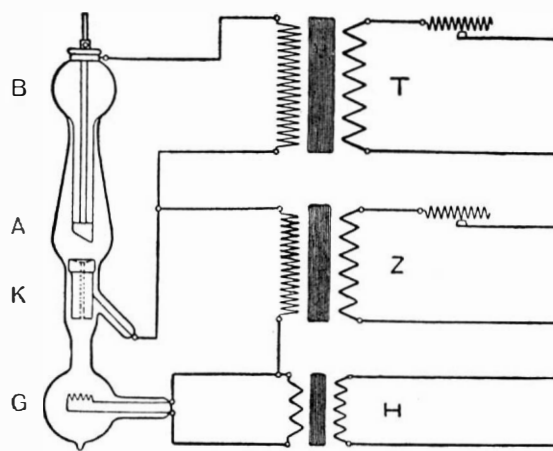
There are 788 foot pounds of energy in one British



The Lilienfeld X-ray tube.

thermal unit. With an explosion of one foot of 600 B. T. U. gas there would be 466,800 foot pounds of energy—enough to raise 4,688 pounds 100 feet.

Gas Ovens.—All gas ovens are provided with some means of admitting secondary air to the place of combustion, there being generally an opening in the bottom of stove below the burner. There is also some means provided for the escape of the products of combustion, generally an opening at the top and back of the oven, which is called the vent. As the products of combus-



Section of the Lilienfeld tube.

A, Combined anticathode and anode.
B, Roentgen cathode.
K, Cathode for discharge of cathode rays.
G, Transformer for main circuit.
T, Transformer for high tension.
H, Transformer for cathode G.

tion leave the oven through the vent, fresh air is admitted below the burner. If the vent is obstructed, thus preventing the products of combustion from escaping, the gas will burn only as long as the oxygen within the oven lasts, after which the flame will die and the oven will soon become filled with unburned gas, which, when the oven door is opened, may be ignited by a top burner if one is in use at the time.

It is easy to determine whether or not the oven is

venting properly. If the vent is not connected with a flue, pass the hand over the vent a few minutes after the oven is lighted. If there is a current of warm air leaving the oven freely, the vent is clear. If the vent is connected with a flue, the flue pipe should become quite warm a few minutes after the oven is lighted.

An oven vent should not be obstructed in any way except when it is connected with a flue having a strong natural draft. In such cases the flue may draw so much cold air through the oven that it would be impossible to maintain a baking temperature. This condition may be prevented by placing a damper in the flue pipe.

Some Causes of Vent Obstructions.—When gas oven vents are connected to flues previously used for coal stoves, the soot may fall down the flue and close the vent.

Cases have been known where mice have gnawed the asbestos linings and placed small pieces of asbestos in the vent in such a manner as to completely close it.

Cleaning cloths have been found in oven vents because they were conveniently near, the cloths thereby being out of sight and out of the way.

At times obstructions are placed in oven vents to prevent what is believed to be "a needless waste of heat." This practice is not consistent, either with economy or with safety.

Cooking utensils are sometimes placed on oven vents because it is convenient; and dishes are often put there to keep the foods which they contain at a certain degree of warmth.

Oven linings sometimes rust and pieces of rust fall to the bottom, thus covering the holes intended for the admission of secondary air. This condition has the same effect on combustion as an obstructed vent.

All the above conditions are dangerous and uneconomical. Dangerous, as they may cause an accumulation of unburned gas. Uneconomical, as they limit the supply of oxygen and thus prevent perfect combustion.

Lighting Oven Burners.—Always open the oven door before lighting the oven burner and never allow gas to accumulate before applying the match. Have the match ready before turning on the gas. Be sure the entire burner is lighted before closing the door.

It is often difficult to regulate an oven burner so that it ignites readily and yet admits enough primary air to support perfect combustion. By wrapping a cloth around the air regulator and thus preventing the admission of part of the primary air, the burner may be lighted much more readily. The cloth being removed as soon as the burner is ignited.

Gas Leaks.—Furnace gas, poor combustion, sewer gas and fumes from chemicals are often mistaken for and reported to gas companies as gas leaks. If an odor is noticed only when the range is in use, it is generally a poorly regulated burner or a poorly ventilated oven.

The gas meter should be placed where it is easily and quickly accessible and nothing should be stored near which could possibly harm it or cause it to leak. Although meters are well constructed, many of them are made of tin and sudden jars or vibrations may cause them to leak. No unnecessary weight or stress should be put on gas pipes or meters.

Each consumer should know where the meter is and how to close the meter cock. In case of a serious leak, any open flame which may ignite the gas should be extinguished, the doors and windows should be opened to allow free ventilation; and if possible, the gas should be shut off at the meter. Gas is generally at a comparatively low pressure and almost any adhesive substance will stop a small leak temporarily. Never look for a gas leak with a match or other open flame. Make a strong suds of soap and warm water and apply this to the pipe joints where the leak is supposed to be. Small leaks, which could not be found with a match, can be located in this way.

Do not allow telephone wire or other electrical devices to be grounded to gas pipes on the house side of meter. If this is permitted the meter must act as a conductor and in case one of the meter connections becomes loose there will be a gas leak at the point where there may be an electric spark. It is much more preferable to connect the ground wire to a water pipe.

Miscellaneous.—Gas stoves are often installed with a stop in the supply pipe and carelessness in the use of this cock is often responsible for accidents. One should always be sure that all burner valves are closed before again opening the cock, as a child may have opened a burner valve while the cock was closed.

Many small appliances are connected with flexible hose. Pressure should never be left on the hose when the appliance is not in use.

When automatic water heaters and other large or automatic gas appliances are installed, special instructions should be given regarding their operation.

*The Gas Industry

Ore Flotation*

A Discussion of the Principles Underlying An Important Process as Yet But Partially Developed

By Prof. Wilder D. Bancroft

WHEN discussing the theory of ore flotation, people are apt to lay great stress upon surface tension in general and upon contact angles in particular. While this is entirely legitimate, it seems undesirable, because we cannot measure a contact angle with any accuracy and because the actual existence of a contact angle is a matter of doubt.¹ The problem of ore flotation is a very simple one or a very complex one, depending on our point of view. It has been customary to consider it as a very difficult problem, but the other attitude rather appeals to me. There is nothing strange to us in the fact that water wets glass and that mercury does not. We also know that water does not wet greasy glass readily. If one wishes to say that these facts are mysterious, I concede it willingly, because everything becomes mysterious if one follows it back far enough. All I claim is that this is no more mysterious than anything else, and that if we start with these bits of every-day knowledge as given, there are no other serious difficulties in connection with ore flotation. Ore flotation is not a unique phenomenon, it is merely a special case under the broad heading of emulsions.

If a liquid wets a solid, it is absorbed by the solid, forming a liquid film on the surface of the latter and displacing the air film that was there. If a liquid is not absorbed by the solid, it does not wet the solid. The formation of a liquid film over the surface of a wetted solid accounts for the experimental fact that the rise of a liquid in a capillary tube is independent of the nature of the walls of the tube. This has always seemed a very improbable state of things, and one that could be justified only by the fact that it was so. It becomes quite simple, however, the moment we consider that the rising liquid does not come in contact with the walls of the capillary tube at all. We are really dealing with the rise of liquid in a liquid tube, and it makes no difference what material is used to support the walls of the liquid tube. That this is the real explanation may be seen from the fact that concordant results are not obtained when a liquid is allowed to rise in a dry tube. To get good results it is important to immerse the tube in the liquid and then to raise the tube.

Since the wetting of a solid is a case of selective adsorption, we should expect that one liquid would wet a given solid more readily than another liquid does, and consequently that the first liquid would displace the second from contact with the solid. No systematic study of this phenomenon seems to have been made, but we know that alcohol will displace oil in contact with metal² and that water will displace kerosene in contact with quartz.³ If we shake a finely divided solid with water and a liquid which is not completely miscible with water, an oil for instance, we can distinguish three cases. The solid is wetted entirely by water, in which case it stays in the water phase and settles to the bottom of it. The solid is wetted entirely by this oil, in which case it stays in the oil phase and sinks to the bottom of it. The solid is wetted simultaneously by oil and water, in which case it passes into the interface separating the two liquids. If the oil is less dense than the water, as is usually the case, it is a little difficult to distinguish between the last two cases. If the non-aqueous liquid is denser than water, chloroform or carbon tetrachloride for instance, it is difficult to distinguish between the first and third cases. The particles will float if the mean density of solid plus adherent oil film is less than that of the water. They may also float if the action of gravity is not sufficient to overcome the surface tension of the water and thus to pull them through the surface. The maximum weight of substances which can be floated can be calculated from the surface tension under ideal conditions. This calculation applies only when the solid passes into the upper liquid, and does not hold for the case where the solid passes into the interface.

Since we are dealing with selective adsorption, we should expect to find that certain substances would float readily, some others less well, and still others not at all, both the nature of the solid and of the liquid having an effect. This is the case experimentally. Hofmann found that lead iodide, silver iodide, mercuric iodide, mercuric sulphide, and mercuric oxide were floated by

ether, butyl alcohol, benzene, kerosene, and amyl alcohol. Copper sulphide, lead sulphide and calcium carbonate were floated only partially by ether, but completely by the other liquids; while zinc sulphide and tin sulphide did not float readily in ether or butyl alcohol, and calcium sulphate was not floated by any of the liquids.

An interesting experiment, which has been done in my laboratory,⁴ is to shake copper powder or aluminium powder with kerosene and water. The metallic powder goes into the kerosene and into the interface, producing an effect of molten copper or molten aluminium, as the case may be. When the bottle is allowed to stand after having been shaken, the metallic powder in the interface creeps up the side of the bottle above the surface of the liquid, rising higher if a little alcohol has been added. I have seen an apparently coherent metallic film rise 2 or 3 inches above the surface of the upper liquid phase. If too much copper or aluminium be added, the kerosene cannot hold all of it up and a portion falls to the bottom of the flask, carrying crops of kerosene with it. If the mixture be poured out on a piece of wood, the copper spreads over the surface of the wood just as it did over the surface of the glass. This experiment illustrates the principle involved in all bronzing liquids. A bronzing liquid consists of a volatile liquid which will hold up the metal, and some substance which will keep the metallic powder from rubbing off too readily after it has been applied. The aluminium and copper powders on the market are coated with stearin. This makes them difficult to wet with water, but special experiments have shown that the behavior of copper or aluminium with kerosene is qualitatively the same whether the stearin coating is removed with ether or not.

Similar results can be obtained with colloidal solutions. Isobutyl alcohol⁵ was added to a colloidal gold solution obtained by reducing gold chloride with carbon monoxide. When the two liquids are shaken, the gold forms a thin film at the interface. This film is violet blue to blue green by transmitted light and golden by reflected light. A thin water film forms between the isobutyl alcohol and the glass, and the gold concentrates in the dineric interface thus formed, making the alcohol appear uniformly gold-plated. With ether the gold film rises high above the level of the two liquids. With carbon bisulphide the adherent film of gold appears blue. When the carbon bisulphide is broken into drops by shaking, each drop appears blue. When a blue gold was obtained by reducing gold chloride with phosphorus dissolved in ether, the gold went into the dineric interface. When a brownish-red gold was obtained in this way, it remained in the water phase and showed no tendency to pass into the interface. This difference is undoubtedly due to an adsorption of something at the surface of the gold, because Reinders found that 0.005 per cent gum arabic prevents colloidal gold from passing into the ether-water interface. With carbon tetrachloride, carbon sulphide, or benzene, the gold goes into the interface as before, but the gum arabic prevents its changing from red to blue.

Colloidal arsenic sulphide goes into the dineric interface with amyl alcohol or isobutyl alcohol, but stays in the water phase when carbon tetrachloride, benzene or ether is the second liquid. India ink goes completely into the interface with amyl alcohol, carbon tetrachloride, or benzene; it goes partly into the interface with isobutyl alcohol, and stays entirely in the water phase when ether is the second liquid.

Winkelblech⁶ has shown that mere traces of gelatine in water can be detected by shaking with organic liquids, the gelatine concentrating at the interface to form a film. "A heavy precipitate was obtained when 10 cubic centimeters of a solution containing 0.234 grammes gelatine per liter was shaken with benzene. Precipitates were also obtained when the gelatine solution was diluted tenfold, twentyfold and even fortyfold, provided 10 cubic centimeters solution were taken for the test. At the highest dilution the concentration of the gelatine was 0.06 grammes per liter, and were consequently 0.06 miligrammes in the 10 cubic centimeters taken for the test. This seemed to be about the limit at which a precipitation could be detected definitely. . . . Some other colloids behave like the glue colloid (glutin), and

can be shaken out of their solutions. Other hydrocarbons are also effective, so that the phenomenon seems to be a general one. Precipitation was obtained with albumin, water-soluble starch and soap, as well as with resin dissolved in very dilute caustic soda. The colloids grouped as mucin can be precipitated from urine and the proteins from beer. It is worth noting that tannin can be precipitated, but not gallic acid.

"The hydrocarbons which can be used are: kerosene, liquid paraffin, benzene, chloroform, and carbon bisulphide (in addition to benzene). The result varies from case to case. With the hydrocarbons which are lighter than water, the precipitate floats on the water; with the denser hydrocarbon the precipitate is below the water layer. The emulsions which form seem to have very nearly the same density as the organic liquid used. It is not possible to get the precipitation with all liquids which are non-miscible or slightly miscible with water. Experiments with ether were entirely unsuccessful.

"As a complement to the action of hydrocarbons on aqueous colloidal solutions it was found that fats dissolved in hydrocarbons or similar liquids can be precipitated in the surface film by shaking with water. Precipitations were obtained with butter, olive oil, lanolin, and vaseline. It was also found that the emulsions of heavy hydrocarbons or carbon bisulphide with the fats of low specific gravity also accumulate below the water layer, only a small portion being carried to the surface by adhering air bubbles. When water is used for shaking out, the precipitation is very slight. With a slightly alkaline solution such as dilute lime water, heavy voluminous precipitates were obtained while a transparent layer of fat is obtained when a slightly acid solution is used. With concentrated alkali or acid solutions, viscous emulsions are obtained which hold fast considerable amounts of solution."

Winkelblech patented the use of such organic liquids as kerosene for clearing sewage by shaking out the colloidal oxidizable matter. The method was not a success commercially, because less than 40 per cent of the oxidizable matter was removed.⁷

Briggs⁸ has shown that sodium oleate is removed from solutions of different strengths during the process of emulsifying benzene, and that the amount of this removal depends upon the strength of the soap solution and the specific surface of the benzene phase. Rayleigh⁹ has observed an interesting case in which dust goes into the water layer. "In the course of some experiments last year, in illustration of Sir George Stokes' theory of ternary mixtures, I had prepared an association¹⁰ of water, alcohol, and ether, in which the quantity of alcohol was so adjusted that the tendency to divide into two parts was almost lost. As it was, division took place after shaking into two nearly equal parts; and these parts were of almost identical composition. On placing the bottle containing the liquids in the concentrated light from an arc lamp, I was struck with the contrast between the appearance of the two parts. The lower, more aqueous, layer was charged with motes, while the upper, more ethereal, layer was almost perfectly free from them. Some years ago I had attempted the elimination of motes by repeated distillation of liquid in vacuum, conducted without actual ebullition, but I had never witnessed as the result of this process anything so clear as the ethereal mixture above described.

"The observation with the ternary association, which happened to be the first examined, is interesting, because the approximate equality of the liquids suggests that the explanation has nothing directly to do with gravitation. But the presence of the alcohol is not necessary. Ether and water alone shaken together exhibit the same phenomenon. It would appear that when the two liquids are mixed together in a finely divided condition, the motes attach themselves by preference to the more aqueous one and thus when separation into two distinct layers follows, the motes are all to be found below."¹¹ . . .

¹ Blitz and Kröhnke, *Zeit. angew. Chem.* 20, 883 (1907).

² *Jour. Phys. Chem.* 19, 210 (1915).

³ *Scientific Papers*, 3, 569 (1902).

¹⁰ *Association* is here employed as a general term denoting the juxtaposition of two or more fluids. Whether the result is a *mixture* depends upon circumstances.

¹¹ The clearness of the upper layer, after a mixture of ether and alcohol has been shaken up with dust, had already been observed and explained, much as above, by Barus, *Amer. Jour. Sci.* (3) 37, 122 (1889).

* A paper read at the joint meeting of the New York sections of the American Institute of Mining Engineers and the American Electrochemical Society on May 12th, 1916.

¹ Rayleigh, *Scientific Papers*, 3, 354 (192).

² Pockels, *Wied. Ann.* 67, 669 (1899).

³ Cf. Hofmann, *Zeit. Phys. Chem.* 83, 385 (1913).

⁴ Bancroft, *Trans. Am. Electrochem. Soc.* 23, 294 (1913).

⁵ Reinders, *Zeit. Kolloidchemie*, 13, 235 (1913).

⁶ *Zeit. angew. Chem.* 19, 1953 (1906).

"I have lately endeavored to obtain some confirmation of the views above expressed by the use of other liquids. It would evidently be satisfactory to exhibit the selection of motes by the upper, instead of by the lower, layer. Experiments with bisulphide of carbon and water, and also associations of these two bodies with alcohol, which acts as a solvent to both, gave no definite result, perhaps in consequence of a tendency to the formation of a solid pellicle at the common surfaces. But with chloroform and water, and with associations of chloroform, water and acetic acid (acting as a common solvent) the experiment succeeded. The motes were always collected in the *upper*, more aqueous, layer, even when the composition of the two layers into which the liquid separated was so nearly the same that a few additional drops of acetic acid sufficed to prevent separation altogether."

The reverse case appears to occur with white lead. J. Cruickshank Smith¹² says: "During recent years the practice has been adopted, largely among white-lead corrodors who grind their own white lead in oil, of doing away with the final drying of the white lead pulp as it comes from the washing process, and grinding or beating up the pulp (exhausted of water until the proportion of the latter does not exceed about 20 per cent) with a suitable quantity of refined linseed oil. This process depends on the greater surface attraction which white lead particles offer to linseed oil than to water. It enables considerable economies to be effected in the manufacture of ground white lead, and it eliminates risk of lead poisoning during one of the most dangerous parts of the white lead manufacturing process." Not enough oil is added to float the white lead, and consequently the white lead carries the oil down with it,¹³ leaving the water as upper phase.

That the adhesion between the solid and the liquid may be very marked is shown by the behavior of the so-called water wings. These consist of a closely woven fabric readily permeable to air when dry. When thoroughly wetted, the film of water is strong enough to permit of the wings being blown up enough to float a person with ease. Though I know of no direct experiments on the subject, it seems probable that the gas pressure in some sandstone anticlines may result from the oil being displaced by water, which would wet the porous rock more readily than does the oil.

In many of the cases where oil flotation has been employed we have a sulphide ore, which is much more readily wetted by oil than by water, in presence of a siliceous gangue, which is much more readily wetted by water than by oil. Consequently the gangue tends to stay in the water phase while the ore is carried up by the oil. The use of an acid solution is natural, because oil absorbs hydroxyl ions,¹⁴ and these latter cut down the adsorption of the solid. Nagel¹⁵ found that when precipitated chromic oxide is shaken with water and benzene, it goes into the dineric interface, but is precipitated from it by addition of caustic alkali. Zinc sulphide is also precipitated from the dineric interface of kerosene and water by addition of alkali. I am aware that modern flotation practice is tending to the use of neutral or slightly alkaline solutions, but in such cases air plays an important part, and the use of mixed oils may introduce a new set of factors. It must also be remembered that acid in ore flotation does not act because of a replaceable hydrogen atom, but by cutting down the concentration and consequently the adsorption of hydroxyl ions. If calcium ions, for instance, cut down the adsorption of hydroxyl ions sufficiently, calcium hydroxide would behave like an acid, so far as ore flotation is concerned, though it would be alkaline to litmus paper. Somewhat similar cases are known. Under electrical stress albumin moves to the cathode in acid solutions, and also in calcium chloride solutions. The effect is not a question of acidity. The direction in which the albumin moves depends upon the charge of the ion adsorbed in excess. The hydrogen cation and the calcium cation are each adsorbed more than the chlorine anion, and consequently the albumin moves to the cathode in these two solutions. I do not know whether anything of this sort is a factor in modern flotation practice.

Since no systematic experiments have been made to determine the exact effect of temperature, we do not know to what extent the apparent advantages of a heated solution are due to a relative change in the selective adsorption, to a change in the relative densities of the two liquids, or to a change in the viscosities. It seems probable that all three changes are factors, but that the change in the selective adsorption is the important one. Of course the absolute adsorption must decrease with rising temperature, but the selective adsorption may,

and probably does, increase with rising temperature. At still higher temperatures the decrease in absolute adsorption becomes too serious and there is therefore a maximum temperature which is not necessarily the same under varying conditions.

We now have to consider the part played by air in flotation. Since the density of air is low, it is clear that a film of adsorbed air or an attached bubble of air will be very effective in floating a solid particle. If we like, we may consider air as an extreme case of a second liquid phase, in which case we may have the solid remaining in the air phase under suitable conditions, concentrating in the interface, or remaining in the water phase. If a piece of metal covered with an air film be laid very carefully on the surface of water, the water may wet it so slowly that the metal will float if it is not too heavy. If the surface of a copper wire be converted to sulphide, it will float more readily because the adsorption of air is more marked. If we have a stearin surface, as in the case of copper powder or aluminium powder, the water has still less tendency to wet the solid, and it becomes quite difficult to cause the commercial copper powder or aluminium powder to sink in water. This difference in readiness to wet is made use of in the film flotation processes of Wood and McQuisten.

The concentration of the solid at the interface occurs when a skin forms over the surface of boiled milk or of cocoa or of a peptone solution. I do not know of any case of ore flotation analogous to this, but doubtless one could be devised if anybody was interested in it. In the case of soap solutions we have a partial concentration in the surface, but the bulk of the soap remains distributed through the water phase. The soap, however, adsorbs so much air that boiling-point determinations on concentrated solutions are worthless.¹⁶

The selective adsorption of gases and vapors by solids is a matter of common knowledge.¹⁷ The film of condensed gas shows itself in the abnormal mobility of very fine powders, in the fact that two pieces of a broken object will not reunite when pressed together, in a resistance to the passage of an electric spark between solid terminals, and in the behavior of the crystal detector and the coherer as used in wireless telegraphy. All liquids show selective adsorption of gases and vapors. The most striking way in which this shows itself is in the form of the splashes when a drop of water, 5 millimeters in diameter, falls on a sheet of water from a height of less than 1 meter. It is this film of adsorbed gas which tends to prevent the coalescence of two soap-bubbles or two impinging jets of water when there is no electrical stress.

Since water removes air more or less quickly from practically all minerals, selective flotation from already wetted ore is practically impossible, and one must have recourse to the combined effect of oil and air. It so happens that in acid or neutral solutions air seems to be adsorbed by organic liquids much more readily than by water.¹⁸ Into 100 cubic centimeters approximately normal caustic potash solution 0.5 cubic centimeter chloroform was dropped from a 5 cubic centimeter pipette. The chloroform did not seem to spread out on the surface before sinking so much as it did with water. The globules sank to the bottom and flattened out; they were distinctly not very mobile, and seemed to sink to the bottom of the vessel. When the chloroform was dropped into the water it broke up into a number of drops which did not agglomerate so easily as in the water solution. In fact, quite a little shaking was necessary in order to make them coalesce. At first no air bubbles could be detected, but after standing for five minutes a very small bubble appeared on the chloroform. Sulphuric acid was then added until the solution became acid. The flattened drop of chloroform at once assumed the shape of a round ball and became mobile. An air bubble also appeared in the center of the drop.

"Into 100 cubic centimeters approximately normal sulphuric acid solution 0.5 cubic centimeter chloroform was dropped as before. The chloroform spread all over the surface and then sank through the solution in small drops, forming round globules with air bubbles clinging to each. It was hard to get rid of the bubbles on the chloroform drops by shaking; as soon as one was driven off, another bubble appeared exactly in the center of the drop. When the bubbles were dislodged from the drops, they rose to the surface carrying with them some chloroform, a part of which remained on the surface until it evaporated, while the rest sank back to the bottom of the solution. The globules were very mobile and coalesced readily. Caustic potash was added to the solution, making it alkaline. The chloroform globule flattened immediately and the air bubble in

the center disappeared. In still another experiment an acid solution was made alkaline, then acid and then alkaline again. The result confirmed Wilson's experiments,¹⁹ for the drop of chloroform was always flat in the alkaline solution and always round in the acid solution. There is scarcely any difference to be noted between the shape of the drop in acid solution and in pure water. The same results were obtained when NaOH and HCl were substituted for KOH and H₂SO₄.

"In one experiment in a nitric acid solution the temperature was raised to about 40 deg. Cent. Bubbles seemed to shoot from all parts of the solution to the chloroform drop. When they had formed a large bubble in the center of the chloroform, the air bubble rose to the surface as in the other cases."

Of course, it does not follow that the relative adsorption of gas is always greater for oil in acid solution, but merely that this seems to be true in the cases hitherto studied. It is purely an empirical observation. Another interesting fact is the difficulty that is experienced in getting air bubbles to attach themselves in some cases to the oil films surrounding the solid particles. Some people have even claimed that nascent gas is essential, but this is absurd. If the air bubble comes in contact with the oil it will adhere; but it is not easy to bring about this contact. It can be done by vigorous agitation or by causing dissolved gas to come out of solution, but the essential thing is merely to bring the gas in actual contact with the oil.

A large air bubble will have a relatively great lifting power, but it will also tear loose very readily from an oiled particle. We shall get better results if we produce a froth consisting of bubbles of air in oil. Under ideal conditions the film around the bubbles will consist of particles coated with oil. We cannot get a froth with a pure liquid and air. There must be present a third substance in colloidal solution which will tend to form an emulsion of air in the liquid in question, for a froth is essentially a very concentrated emulsion of air in liquid. If the colloidal material is not present in the liquid, it must be added. It has often been overlooked that what is needed for ore flotation is a froth of air in oil. People have said to themselves that froth is what is needed and have added saponine and other things with disastrous results. Saponine produces a froth, but it is a froth of air in water and therefore plays havoc with flotation. The things which have proved successful are substances like sodium resinate so called, which produces a froth of air in water in an alkaline solution but one of air in oil in an acid solution, because free rosin forms a colloidal solution in oil but not in water. Mr. Van Arsdale has worded the matter in what seems a different way by saying that the substance added must tend to emulsify water in oil and not oil in water. This is very nearly the same thing, because substances which form colloidal solutions in oil and not in water tend to emulsify water in oil.²⁰ I have preferred to consider the oil-air interface and Mr. Van Arsdale the oil-water interface, but the two points of view lead to the same conclusion in almost all cases.

So far, we have been considering the case where we have a fair amount of oil. If we cut the amount of oil down almost to a vanishing quantity another factor comes in, namely, air flotation. When sufficient quantities of oil are used, the air floats the oil and the oil floats the ore. The ore is inclosed in a drop of oil having the properties of matter in mass and sinks to the bottom of the drop of oil, distorting it to a greater or lesser extent. If the amount of oil is decreased sufficiently, we no longer have an oil drop surrounding the particle of ore, but an oiled particle, the lower part of which is, or may be, in contact with water, while the upper part is in contact with air. We are therefore getting air effect in addition to the oil effect. I do not know the relative importance of these two effects, but it has been claimed—and disputed—that the modified air flotation is of much greater value than the other. In the Wood and the McQuisten processes there is no doubt but that the separation would be more effective if it were possible to cover the ore particles with a thin film of stearin, leaving the gangue particles uncoated. It is very difficult to wet the stearin-coated commercial copper and aluminium powders, and it is therefore very difficult to make them sink under water. In the modern processes of ore flotation using very little oil per ton, we get a thin coating on the ore analogous to the stearin coating on the copper or the aluminium powder. It is possible that the air film may surround the oiled particle completely so that the oil does not come in actual contact with the water. In that case we are back to a straight air flotation of oiled particles. This point calls for further study, because, if established, it would have a very important bearing on the future development of the subject.

¹² The Manufacture of Paint, 92 (1915).

¹³ My attention was first called to this by Mr. T. R. Briggs.

¹⁴ Twomey, *Jour. Phys. Chem.* 19, 360 (1915).

¹⁵ *Jour. Phys. Chem.* 19, 570 (1915).

¹⁶ McBain and Taylor, *Zeit. phys. Chem.* 76, 182 (1911).

¹⁷ Bancroft, *Jour. Phys. Chem.* 20, 1 (1916).

¹⁸ Twomey, *Jour. Phys. Chem.* 19, 360 (1915).

¹⁹ Wilson, *Jour. Chem. Soc.* i, 174 (1848).

²⁰ Bancroft, *Jour. Phys. Chem.* 17, 515 (1913).

It is under these circumstances that addition of more oil causes the ore to cement together and sink. The reason for this will perhaps be seen more easily if we consider the analogy of sand and water. When enough water is mixed with sand, we get a quicksand over which it is unsafe to walk. With only a little water we get a plastic mass over which it is a pleasure to walk and out of which children can make forts, pies, etc. When the sand dries out more, air gets in between the grains, and the walking becomes hard, though the sand is by no means dry from a chemical point of view. When the amount of oil round the ore particles is sufficiently small, the air gets in and makes a froth possible. With more oil we get a plastic mass; with still more we get the bulk oil process.

Anderson²¹ classifies flotation oils as "frothing" and "collecting" oils.²² There is at times some difficulty in grasping the distinction between frothers and collectors as such, for one oil in itself may, and often does, possess both frothing and collecting properties. The action of a frothing oil is such as to produce froth in greater or less amount, dependent on the frothing power of the oil. A collecting oil has a collecting power for sulphides in preponderance over its frothing action, being therefore, so to speak, a poor frother; a collecting oil may have simply a collecting action and little or no frothing action. As stated in the foregoing, some oils combine both the properties of frothing and collecting in variable degrees of each.

"The most successful frothing oils include the pine oils, cresylic acid and turpentine and other pyroligneous products from the distillation of wood—notably methyl alcohol.²³ The coal tar phenols and their near derivatives, and almost all of the so-called essential oils are good frothers. The essential oil of eucalyptus finds favor, particularly in Australian practice, on account of relatively low cost and immediate supply. Castor oil, to which reference has already been made, when mixed 1:4 with kerosene has found application. The more volatile products of petroleum, including kerosene and gasoline [?] have been successful frothing oils."

"So-called mineral oils and tar oils do not generally form a good flotation froth, but have a marked selective action on the sulphide minerals. Among the mineral oils are included the following: asphaltum base, crude petroleum, refined oil, gasoline, burning oil, creosol, and coal-tar creosotes."

"It is found that thick oils tend to form viscous, coherent flotation concentrates, while thin oils form less coherent masses. The action of coal tar in stiffening a weak, ephemeral froth is indicative of the former. In general the essential oils give a coherent froth and satisfactory extraction; oils like oleic acid or candle-maker's red oil, petroleum, and lubricating and engine oils have a strong tendency to produce heavy, thick granules which will not float. Oleic acid has a well-marked power to float silicates."

If a pure liquid does not form a froth with air, it follows that no oils can be frothing oils except in so far as they contain suitable colloidal material suspended in them. In some cases the colloidal material is rosin; in other cases it is for the organic chemist to decide just what the special substance is. Since the good effect of the frothing oils is due to the colloidal substance, it is a question of cost whether it is more advantageous to mix a frothing oil with a collecting oil or to add the constituent which makes the former a frothing oil.

Since we are dealing with selective adsorption, we should expect to find that some oils would be better than others for certain purposes.

Anderson²⁴ states that "oils derived from the destructive distillation of wood, such as wood creosotes, pyroligneous acid, and the like, are found to give the best recovery on galena and zinciferous material; coal-tar products are better adapted to the successful flotation of copper-bearing minerals." There are no independent data from which this result could have been predicted.

Since flotation is due to selective adsorption, any thing which will change the latter will change the degree and nature of flotation as far as the oil-water flotation is concerned. Adding a third liquid which is miscible with the other two, will tend to make the oil and water layers more nearly alike in composition and therefore in properties. This gives us a possibility of varying the selective adsorption within certain limits and its possibilities should be determined, even though there may be no economic advantages. Now that we are a little more clear as to the cause of frothing, it becomes possible to study new frothing agents more successfully, and it is possible that some

of these might have distinct collecting powers of their own. In some experiments recently made at Cornell by Mr. Briggs, it has been found that addition of salt made it easier to shake out colloidal ferric oxide with benzene. The reason for this seems to be that the salt makes the colloidal solution less stable. Any substance which prevents peptization in the water phase or promotes it in the oil phase will tend to increase the flotation. I do not yet know to what extent this is applicable to ore flotation; but Anderson²⁵ reports that experiments performed on a 60-mesh product from the Joplin district containing a pyrite and galena in a calcareous gangue showed: that potassium bichromate will deaden galena and permit the flotation of the pyrite; that sodium, potassium, and ferric sulphates promoted the production of clear concentrates; and that ferrous sulphate and cupric sulphate were very harmful to the successful flotation of this particular product, flotation being practically impossible in their presence. Anderson, of course, ventures no opinion as to why these salts act in this way; but it ought not to be difficult to work out an hypothesis if some data were forthcoming. The inadequacy of the present data is made clear by the statement of R. H. Richards that in the case of a certain Tennessee zinc ore the addition of a small amount of copper sulphate was necessary in order to bring about successful flotation. We have not yet made any experiments on the factors affecting the air flotation when the oil is reduced to a minimum, so I will not discuss that point at all.

There seems to be no reason to suppose that ore flotation has yet gone beyond the first stages of its development, and certainly a clear knowledge of the general theory should help in promoting the development.

How Heavy Firing Affects Animals

SOME curious and interesting observations upon the psychological effect produced on animals by the detonations of big guns have been recently made by a German veterinary surgeon named Reuter and are published in *Umschau* (Frankfort). The animals considered are the horses and dogs used for military purposes and the game in the area of warfare. It was noticed soon after the beginning of the war that the latter began to migrate into Luxemburg, Switzerland, and the portions of France and Belgium not the seat of hostilities. The first to flee was the "black game" (a term which includes the wild boar, the badger, and the bear), whose senses are specially acute. Then the roebuck and the red deer followed; but, strange to say, the hare, whose timidity is proverbial, continued to occupy its usual territory. The larger birds likewise, such as the grouse, the pheasant, the sea-eagle, and the wild duck, were driven away by the heavy firing. Strange to say, the wolf, which is famous in German folk-lore as follower on the heels of Mars, and which was expected to regain lost ground in the present war, has shown itself very gun-shy. Another curious fact noted by Mr. Reuter is that the song-birds, such as the lark, the thrush, and the finch, have not been driven away by the thunder of the cannon, and continue to hold their nests and sing their songs in their accustomed haunts. Other birds which remain unfrightened are various kinds of owls, falcons, sparrow-hawks, crows, etc.

Another interesting observation is that animals vary in sensitiveness of temperament just as do individuals and races. For example:

"The Canidae (dogs, wolves, jacals, and foxes), with their highly developed nervous systems, possess a high degree of sensitiveness. Only the intelligent and long-trained house-dog shows itself more resistant to the shock of detonations. In the same way, among horses the thoroughbred and the half-bred are more sensitive than the cold-blooded. Animals which are by nature easily excited, and also those in whom there are already signs of some malady of the nervous system (as neurasthenia or hyperæsthesia) are less resistant. The German war-horses, though assembled from the most various sources and for the most part untrained, have shown themselves capable of becoming more quickly injured to the noises of battle than are, for example, the celebrated Russian horses.

"The psychological effect of heavy firing, occasioned by the suddenness, the fright, the strength of air-pressure, and the detonation, may be furthered by a sort of predisposition or preformation without actual disease in the organism of the animal. Then, too, the power of resistance may be weakened by over-exertion, long-continued marches, unaccustomed food, hunger, improper handling, and possibly by the vision of the explosion itself . . . with its stones and bits of shell hurtling through the air, causing even the animal soul to be oppressed with horror."

²⁵ *Met. and Chem. Eng.* 14, 137 (1916).

Mr. Reuter makes the point that even when animals have been hardened by custom to be resistant, this resistance may be slowly worn down by too long a stay amid such scenes of nerve-weakening shock; so that the strongest will-power and the most resistant organism will break down in the end. For this reason recuperation stations, or "convalescent homes," have been established in the garrisons for used-up war-horses and Red Cross dogs; in Jena, for example, one such has been prepared by the "League of Humanitarians" to give such nerve-worn animals a chance to recover strength and serviceableness.—*Translated from The English Mechanic.*

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²¹ *Met. and Chem. Eng.* 14, 136 (1916).

²² Van Arsdale calls them "foamers" and "oilers."

²³ This must be an error. W. D. B.

²⁴ *Met. and Chem. Eng.* 14, 136 (1916).