

as stated in the Government Report dated Mar. 1 last, the consistent earning power of the various hydro-electric organisations, coupled with the fact that the output of new stations is absorbed almost as soon as it comes on the market, has created a favourable impression in capitalist circles and established a public confidence which is demonstrating itself in the inception of wider and more expansive undertakings. Of the 265,837 h.p. installed during 1926, more than 219,000 h.p. was destined for public distribution through the medium of central electric stations. Pulp and paper mill organisations installed 44,760 h.p. during the year, mainly connected to electric generators, and they will purchase a considerable portion of the additional installation of the central electric stations. Installations other than for central electric station purposes and in pulp and paper mills, totalled only 2072 h.p., of which 2000 h.p. was for electro-chemical reduction.

The uses to which the existing installations throughout Canada are put, indeed, continue to

follow on general lines the apportionment in the foregoing paragraph. Preponderant, and of growing importance, is the distribution of hydro-electricity through the medium of central electric stations, which account for fully 80 or 81 per cent. of the total. Next comes the pulp and paper mill industry, absorbing about $11\frac{1}{2}$ per cent. of the total power, apart from the large purchases which the mills make from the central stations themselves. General industrial enterprises, such as electro-chemical reduction, lumber manufacturing, flour milling, grain grinding, water pumping, etc., account for the balance of $7\frac{1}{2}$ per cent.

The table above from the Government report is of interest in showing these allocations, and also the total hydraulic installation per thousand of the population, a feature which bears on the capacity for industrial output of the workers of the Dominion. The high average of 485 h.p. per 1000 population enables Canada to assume a position of importance among the nations of the world in *per capita* utilisation of water power.

Some Colouring Agents in Glasses and Glazes.¹

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BEFORE dealing with the colours and effects produced by ferric oxide in glasses and glazes, let me direct attention first to the different shades of colour which can be seen in varieties of the oxide itself. These range from a reddish yellow through brick reds, bright reds, to a rich brown red and almost to a black. Some specimens also have almost a bronze-like appearance. The range of colours produced when ferric oxide is used as a colouring agent for glasses and glazes is practically as great. It is doubtful if the colours produced by ferric oxide are due to compounds of this oxide with the other constituents of the glass. Without going into elaborate detail it is somewhat difficult to give adequate support to this statement. Perhaps the simplest way of dealing with it is to take the behaviour of ferric oxide in lead glasses, frequently described as flint glasses. There are light flints and dense flints. In the light flints there is always a notable quantity of an alkali such as potash or soda along with the lead oxide. In the dense flints the proportion of alkali is decreased and the proportion of lead oxide is increased.

Now, taking three such glasses as examples, having specific gravities of 3.2, 3.8, and 4.8, it is possible to add a known, but small, quantity of ferric oxide to the first glass and still to produce a glass having no detectable yellow colour to the eye. The same amount of iron added to the second glass will give a noticeable yellow colour, and added to the third glass will give a marked yellow colour. The glass of specific gravity 3.2 contains a notable proportion of alkali, and there is reason to believe that this either promotes the formation of a compound of ferric oxide with the alkali or the

formation of a double silicate, either sodium ferric silicate or potassium ferric silicate; such compounds appear to be colourless. If the quantity of iron be increased, then a colour can be produced in the light flint, and, by increasing the percentage of ferric oxide to 5 per cent., a fairly strong yellow colour is produced. With 10 per cent. of ferric oxide in the same glass the colour is a deep brownish red when looking through a thickness of about 3 mm. With 20 per cent. of ferric oxide an even richer red colour can be seen when looking through a thickness of $\frac{1}{2}$ mm.; but in thicknesses of 1 mm. or more the glass is practically opaque. When the percentage of iron is raised much higher, some ferric oxide crystallises out from the glass on cooling, and with 40 per cent. of ferric oxide the small crystals dispersed through the glass can be seen with a hand lens. With the denser flints, containing a lower percentage of alkali, colours similar to those described above are produced with much smaller proportions of ferric oxide.

A reasonable explanation of this would be on the same lines as the suggestions made in dealing with cuprous oxide and metallic copper, namely, that the light yellow colour is due to a small amount of free ferric oxide dispersed in the glass as extremely fine particles; the transparent deep yellows and brownish reds would represent a greater concentration of ferric oxide similarly dispersed, possibly also, as the percentage of ferric oxide gets higher, as somewhat larger particles. In the 20 per cent. glass mentioned the particles are still too small to be seen, but in specimens of lead glass containing nearly 30 per cent. of ferric oxide, fine clouds of almost irresolvable particles can be seen in the microscope.

Leaving the subject of lead glasses coloured with

¹ Continued from p. 266.

ferric oxide, I would first mention the behaviour of ferric oxide in a glass containing a large proportion of phosphoric acid, an acid which in glasses may be described as a much stronger acid than silica. Ferric phosphate is a definite compound and is colourless; in this phosphoric acid glass, quite a notable proportion of ferric iron may be present without showing any colour. Evidence that the iron is in the ferric state is obtained by heating the glass in a highly reducing atmosphere; this reduces the ferric iron to the ferrous state, and the glass is found to have developed a marked indigo blue colour, due, possibly, to ferrous phosphate, or to ferrous phosphate along with a very small proportion of unreduced ferric phosphate.

In such glasses as ordinary sodium calcium silicates, it is rather difficult to obtain light pure yellow colours with ferric oxide. Much use has been made of ferric oxide in producing glazes which are of a deep colour: practically black in moderately thick layers, though of a fine golden brown in thinner layers. These glazes are frequently described as felspathic glazes, and their composition may be given as sodium or potassium calcium aluminium silicates. To get the deep colour of these glazes, amounts of ferric oxide of the order of about 12 per cent. are required. If the percentage of ferric oxide is raised to about 15-20 per cent. some of the ferric oxide separates out on cooling and, according to the concentration of the ferric oxide, so may be seen a fine brown red colour on the surface of the glazes or bronze-like spangles of ferric oxide, or rosettes, or tree-like crystals, or even more massive crystals which to the eye look black. The Chinese made much use of this behaviour of ferric oxide. As the result of a close microscopic study of certain Chinese glazes owing their colour to ferric oxide, which I undertook in collaboration with Mr. A. L. Hetherington, he was able to explain how the varied and beautiful effects seen on certain specimens of Chinese porcelain could be obtained, and to show many similar glazes produced in the laboratory to support the explanation put forward.

Ferroso-ferric oxide, magnetic oxide of iron, gives in certain glasses neutral tints of various depths, but with high concentration of this oxide a black glass can be obtained. If the concentration of the ferroso-ferric oxide be high enough, some of this oxide will come out on cooling so as to be dispersed through the glass in very minute aggregations, which are, however, presumably crystalline, since the resulting glass is appreciably magnetic. The above remarks refer to glasses containing the whole of the iron in the ferroso-ferric form. If a ferrous iron glass or glaze contains some ferric iron, the green colour due to the ferrous iron will be modified and various olive green tints can be obtained. There are many such coloured glazes in which the iron is principally in the ferrous state, but there is sufficient of the ferric iron present to produce the olive green tint. In a similar way small quantities of ferrous iron in a glass which contains appreciable quantities of ferric iron will

modify the yellow or brown colours due to the ferric iron and give somewhat dusky hues.

Before leaving the subject of iron I am tempted to hazard a guess at the nature of the colouring matter in lapis lazuli. In almost all the specimens which I have seen, here and there crystals of iron pyrites (ferric sulphide) can be seen. An examination of these specimens under the microscope reminds me very strongly, except for the difference of colour, of the appearances of many of the glazes very deeply coloured with ferric oxide, in which also crystals of ferric oxide can be seen. The colouring of lapis lazuli is very intense, so much so that very thin portions of it make equally thin portions of the deepest blue glass obtainable look almost white by comparison. Let me for a moment direct attention to a simple experiment with solutions. If to an aqueous solution of ferric chloride, as free as possible from free hydrochloric acid, there be added quickly an aqueous solution of hydrogen sulphide, there is the production of a transient intense lapis lazuli colour. It has been suggested that this colour is due to the formation of a ferric sulphide which, in the solution, rapidly breaks down to a ferrous salt with the separation of free sulphur. My guess in respect of lapis lazuli is that the beautiful blue colour is due to minute particles of ferric sulphide, altogether too small to be seen by the microscope, dispersed through the mineral. Different concentrations of the dispersed ferric sulphide would account for the various lighter blues, full blues, and dark, almost black, blues which can be seen in specimens of lapis lazuli. I hope to be able to find a specimen of lapis lazuli of the very blackest blue colour obtainable and to examine it critically by the microscope; I also hope to be able to test the suggestion made by synthetic experiments.

In the process of making artificial ultramarine by heating together clay, sodium carbonate, sulphur, and charcoal, or some other substance rich in carbon, it has been stated, I believe, by a number of experimenters, that small amounts of iron must be present in the materials. I need scarcely mention that almost every clay contains small, but appreciable, quantities of iron.

A few points about the third colouring agent already referred to may now be described. It is quite a common thing to see glass in windows which by long exposure to sunlight has developed colour ranging from a pink, through various depths of rose-violet almost to a marked blue-violet. Some window glasses also become coloured with a brownish-yellow tint by long exposure to sunlight, but the colour is not usually noticeable. In a glass sphere taken from a sunshine recorder, kindly lent me by Dr. G. C. Simpson, the originally colourless or slightly green glass has become a pronounced yellow-brown; the colour of this sphere is very marked in comparison with the usual colourless sphere.

The colour developed in a glass by exposure to sunlight is partly determined by the composition of the glass. Similar discoloration can also be produced in glasses by exposing them to ultra-

violet rays of shorter wave-length than those present in sunlight, to X-rays and to the radiations from radium, but the colour developed by these agencies is not, in every instance, the same as that which can be produced in the same glass by exposure to sunlight. There can be little doubt that the radiations are the cause of the colour, though what is the nature of the material which is separated out by the action of the radiations and produces the colour is not fully known. In purple window glass, manganese has been frequently mentioned as the colouring material, it being sometimes assumed that under the influence of the radiations the colourless manganous oxide in the glass becomes oxidised to a purple manganese peroxide. In a similar way it has been suggested that the brown colour such as is seen in the sunshine sphere is to be explained by the oxidation of the ferrous iron to the ferric state. There are certain difficulties in accepting these explanations of the colours. The colourless sunshine sphere mentioned above was, a few weeks ago, a much darker yellow-brown than its companion which shows the marked brownish-yellow colour. Both spheres were colourless when new, and the present colourless one has been rendered so by heating it to a temperature of 500° C. All the varieties of coloured glass with which I have been able to experiment, and which owe their colour to the action of radiations, can similarly be decolorised by heating to an appropriate temperature; but of all the glasses I have tried which have been purposely coloured by ferric oxide, or by manganese dioxide, I know of no example which can be decolorised by heating, even if it is heated up to a temperature sufficiently high to re-melt it. This is not to say that these observations refute the suggestions of the nature of the colour mentioned above, but they certainly introduce difficulties which it would take too long to elaborate on this occasion.

Just as glasses can become discoloured by radiations, so have many minerals apparently been similarly affected, and in all examples which I have tried, and in which the colours were produced presumably by radiations, the colouring could be discharged by heat. Highly coloured fluor spar is a typical example; purple amethyst, smoky quartz, rose quartz, yellow quartz, and various coloured zircons, known in the gem trade as jargons, are others. All of these can be decolorised when heated to an appropriate temperature. A fine purple amethyst, for example, became clear colourless quartz at a temperature of about 400° C. A rather browner purple amethyst lost its purple at the same temperature, but had a yellow colour left, which was discharged, however, at 700° C., and the resulting quartz was white but not clear; it was opalescent.

In all the cases mentioned above it is found that when the colour of the glass or mineral is discharged by heat, the apparently colourless material shows a marked absorption in some part or other of the ultra-violet spectrum.

In the instances of glasses and fluor spar it is generally found that the decolorised specimens

exhibit marked fluorescence under the influence of ultra-violet light. I have not seen examples of crystalline quartz which show similar fluorescence, but if the decolorised amethyst be fused, the vitreous silica so obtained shows marked fluorescence. Either the decolorised amethystine quartz or the same substance fused can be coloured again by exposure to radiations, the colour being developed most readily by exposure to the gamma-rays of radium. It is not possible, with pure crystalline quartz, which shows the highest transparency to ultra-violet radiations, to produce any coloration by submitting it to the action of the gamma-rays from radium over a period sufficient to produce marked coloration in the decolorised amethyst or in decolorised rose, yellow, or smoky quartz. Similarly, I have not found it possible with fluor spar of the highest transparency to ultra-violet light to colour it by gamma-rays, but there are many specimens of fluor spar colourless to the eye which fluoresce in the ultra-violet light, and these can be coloured by exposure to the gamma-rays from radium.

From all the observations it certainly seems that the substances I have mentioned owe their colour to the action of radiations, and become coloured only when they contain a small quantity of a suitable impurity. There is no conclusive evidence of the exact nature of the material which, separated out by the action of the radiations, imparts colour to the glass or mineral. Finely dispersed metal such as calcium has been thought possible as accounting for the colouring of glass, fluor spar, and Iceland spar, but glasses which contain no calcium become coloured by radiations, and it is not impossible to imagine finely dispersed potassium or sodium as the colouring material. Silicon itself has been suggested as producing the colour of some quartz, and so has titanium, and so has carbon. It is difficult to see why silicon, which is made to go back as silica by heating, should render the quartz opaque to some ultra-violet radiations. There is no suggestion which has been made which is not open to some objection or other.

In the production of these colours, there appears to be some analogy with the ordinary changes which are observed in silver salts on exposure to light. A pure silver halide (chloride, bromide, iodide) is apparently unaffected by light. That the well-known action of light on these compounds as they are generally prepared is ascribable to the presence of small quantities of some other material or materials is generally accepted; but no one would suggest with our present knowledge that the dark material which develops in the silver salt when exposed to radiation consists of the impurity. The darkening is ascribed to decomposition of the silver salt, which decomposition is rendered possible by the presence of the impurity.

Taking into account all the observations which have been made on the effect of exposing various glasses and minerals to radiations and to cathode discharge, it would appear not unlikely that the colours produced in these experiments are

ascribable to the separation from the material of one or other of its constituents by the action of the radiation, which separation is only possible provided there is present in the material a suitable impurity; but change the line of argument a little, and there are facts which would appear strongly to support the view that it is the impurity itself,

in many instances, which becomes separated out in a fine state of division by the radiations and imparts the colour to the glass or mineral. We do not know. There is a mass of evidence to be considered, but much more experimental work is needed before that evidence can be dealt with and properly assessed.

Hæmolysis.

THE discussion at the recent meeting of the British Medical Association in Edinburgh, opened by Dr. Eric Ponder, afforded much information as to the nature of hæmolysis, and was particularly fruitful in clearing up the apparently contradictory data concerning the structure of the erythrocyte or red blood corpuscle.

On one hand, it has been held that the red blood corpuscle, although to all appearance homogeneous, in reality consists of an external envelope of colourless material which forms a thin film enclosing the dissolved coloured material or hæmoglobin. Thus this envelope would be controlled by the laws of osmotic pressure. When water reaches the corpuscle it passes through the film and swells the corpuscle, causing it to become globular; eventually the envelope will burst or become sufficiently distended to allow the fluid to escape through its pores, the envelope being left. The loss of water from the cell causes shrinking and corrugation of the surface, the wrinkled or crenated form being produced. On the other hand, it has been supposed that the corpuscle is formed of a homogeneous porous material, in the pores of which the hæmoglobin is contained.

A few years ago a reversal effect was described by Brinkman, but the reaction is only apparent. After hæmolysing the cells, the solution was centrifuged and the supernatant fluid subjected to cataphoresis. This treatment resulted in the appearance of the ghosts at one pole and of the hæmoglobin at the other; on mixing the ghosts and hæmoglobin together the cells were apparently re-formed, but on analysis only 50 per cent. of the hæmoglobin could be accounted for. Further, it can be shown that the isoelectric point of the normal cell and that of hæmoglobin are different, whereas the isoelectric point of the re-formed cell and hæmoglobin are the same, which is evidence that in this phenomena the cell is not re-formed as was originally thought, but that the hæmoglobin is merely adsorbed on to the surface of the ghost.

The further evidence advanced by Brinkman, that section of the red cell does not result in the exudation of fluid, is by no means contradictory to the theory of the envelope-like structure of the cell, for indeed, as Schafer pointed out, it is possible to cut a soap bubble in a similar manner, the razor reuniting the edges of the cut membrane.

The changes in size and shape which the cell undergoes both in hypotonic solutions and in solutions containing hæmolysins afford considerable evidence that the red cell of mammals is a balloon-like structure possessed of an envelope of consider-

able strength. The work of Seifriz offers direct information. This observer has actually micro-dissected the human red cell, stretched its envelope, and observed the escape of fluid containing hæmoglobin from the cell. The membrane is probably similar to that suggested by Beehold, namely, that it has a protein frame-work in the interstices of which lipoids are contained. It is probably inaccurate to describe the lipoids as a constituent of the cell membrane; for recent work goes to show that the lipoids are mainly if not entirely within the cell. Mellanby, in the discussion, raised the objection that the cell membrane could scarcely be of a protein and lipid structure, as the enzymes lipase and trypsin are without hæmolytic action upon the red cell. In this instance the specificity of enzyme action must be remembered; and, further, Ponder has shown that certain proteolytic enzymes of bacterial origin are capable of producing hæmolysis.

The ingenious method devised by Mellanby has afforded a means of making rapid and accurate observations on hæmolysis. A beam of light passes through a system of lenses, the emerging parallel rays being incident upon one of the parallel faces of the glass cell containing the suspension of corpuscles. The beam of light, after passing through the suspension, falls upon a selenium cell which is connected in circuit with a galvanometer. Variations in the intensity of light passing through the suspension of corpuscles produce variation in the deflexion of the galvanometer. The galvanometer scale is calibrated so that the readings may be made direct in terms of hæmolysis. To keep the experimental conditions constant, the parallel-faced dish is surrounded by a water bath, the temperature of which is kept constant by an electric thermo-regulator.

Using this method, Ponder has shown that a large number of lysins fall into what might be called the class of simple hæmolysins. With this class of lysins, hæmolysis results in the using up of the lysin due to its union with some protein component of the cell envelope, the reaction being of the first order. Among this simple class of hæmolysins are the majority of the hæmolytic glucosides, the soaps, salts, and acids allied to the bile salts; while recently McLachlan and Ponder have shown that the majority of the lysins of bacterial origin fall into this class. It is very interesting to note that two of these bacterial lysins, namely, that of *B. histolyticus* and that of *Streptococcus pyogenes*, are definitely known to be proteolytic.