the practical part of making reflecting telescopes, and not the theory, I will not offend his patience. To convince any one of the certainty of my assertions, let him polish a metal of $2\frac{1}{2}$ inches diameter, and $9\frac{1}{2}$ inches focus, upon an *elliptical tool*, whose diameters are $2\frac{1}{2}$ and 3 inches; and I can assert, he will always find the metal, when polished, (if it is not too thick,) beyond the parabola, or it will always prove hyperbolic. If he polishes it upon a *circular tool* in the common way, with cross strokes in every direction possible, using first a few round strokes every time he changes his position, he will find it always prove spherical, and consequently *short* of the parabola. A very little experience in these matters, will convince any one of the ease and certainty of giving the great speculum a parabolic figure, by polishing it in a common manner only with cross strokes in every possible direction, upon an *elliptical tool* of the proper dimensions, in which, for common foci and apertures, viz. $2\frac{1}{2}$ to $9\frac{1}{2}$ focus, or 3,8 inches in diameter to 18 inches focus, the diameters should be 10 to 9. The shortest diameter of the ellipse being accurately the same as the diameter of the metal, and the longest diameter of the ellipse to the shortest diameter, as 10 to 9.

[TO BE CONTINUED.]

On the Colours obtained from the Metallic Oxides, and fixed by Fusion on different Vitreous Bodies; abstracted from an essay on that subject. By ALEXANDER BROGNIART, Director of the National Manufactory of Porcelain at Sevres, in France.

THE art of employing metallic oxides for colouring by fusion different vitreous matters, is of very great antiquity: every body knows that the ancients manufactured coloured glass and enamel, and that this art was practised in particular by the Egyptians, the first people who in this manner imitated precious stones.

The practice of this art in modern times has been carried to a high degree of perfection: but the theory has been neglected; it is almost the only one of the chemical arts in which no attempt has yet been made to apply the new principles of that science.

The very numerous works which treat on the method of preparing and applying vitrifiable metallic colours, either contain no theory, and consequently no general principles, or give only explanations founded on hypothesis, often ridiculous, which formerly composed the theory of chemistry.

I have thought it might be of utility to the arts, and that it was the duty of the national manufactory of Sevres, to make known the pretended secret of the composition of those porcelain colours which are unalterable in the fire.

My object is not to give a detailed account of the exact composition of all the vitrifiable colours; such a labour cannot be the subject of a single memoir.

It is well known, that all vitrifiable colours have for their basis

metallic oxides; but all the metallic oxides are not proper for this purpose: besides, as they are not vitrifiable by themselves, they can scarcely ever be employed alone.

Highly volatile oxides, and those which adhere little to the great quantity of oxygen they contain, either cannot be employed in any manner, as the oxide of mercury and that of arsenic, or are employed only as agents. The colour they present cannot be depended on, since they must lose it in the slightest heat, by losing a part of their oxygen: such are the puce coloured and red oxides of lead, the yellow oxide of gold, &c.

Oxides in which the proportions of oxygen are susceptible of varying with too much facility, are rarely employed: the oxide of iron, though black, is never employed for that colour; and the green oxide of copper is, under many circumstances, very uncertain.

I have said, that alone, oxides are not susceptible of fusion: however, as they are destined to be applied in thin strata on vitrifiable substances, they may be attached to them by a violent heat. But, except the oxides of lead and bismuth, they would give only dull colours. The violent heat, often necessary to fix them, would change or totally destroy the colours. A flux then is added to all metallic oxides.

This flux is glass, lead, and silex; glass of borax, or a mixture of both.

Its general effect is, to give splendour to the colours after their fusion; to fix them on the article which is painted, by promoting, more or less, the softening of its surface; to envelop the metallic oxides, and to preserve their colour by sheltering them from the contact of the air: in a word, to facilitate the fusion of the colour at a low temperature not capable of destroying it.

Metallic oxides are employed sometimes directly, and merely mixed with their flux, without being previously fused with it. In many circumstances, oxides are fused previously with their flux, and afterwards ground. In speaking of colours in particular, I shall point out those which experience this kind of fusion.

I shall speak here only of the application of metallic colours to vitreous bodies or to vitreous surfaces.

These bodies may be divided into three classes, very distinct by the nature of the substances which compose them, the effects produced on them by the colours, and the changes they experience. These classes are:

1st. Enamel, soft porcelain, and all crusts, enamels, or glass, that contain lead in a notable quantity.

2nd. Hard porcelain, or porcelain which has a crust of feld-spar.

3d. Glass in the composition of which no lead enters, such as common window glass.

It is well known, that enamel is glass rendered opaque by the oxide of tin, and exceedingly fusible by the oxide of lead. It is the oxide of lead, in particular, contained in it, that gives it properties very different from those of the other excipients of metallic colours. Thus all glass and glazing that contain lead will participate in the

properties of enamel; and what we shall say of one may be applied to the rest with very trifling differences. Such are the white and transparent glazing of stone ware, and the glazing of porcelain called *soft glazing*.

This porcelain, which was the first made in France, and particularly at Sevres, where it was a long time manufactured almost exclusively, has for its base a vitreous frit, rendered almost opaque, and susceptible of being worked with clay, and is glazed with an exceedingly diaphanous glass, into the composition of which there enters a great deal of lead.

The colours employed in it are those which serve for painting in enamel: consequently, whatever changes these colours experience on enamel, they must experience on this kind of porcelain, since the causes of this change, which we shall mention hereafter, are the same.

Enamel or soft porcelain colours require less flux than others, because the glass on which they are applied becomes sufficiently soft to be penetrated by them. This flux may be either glass of lead and pure silex, called *rocaille*, or the same glass mixed with borax.

Montamy asserts, that glass of lead ought to be banished from among the enamel fluxes; and he employs only borax. He then dilutes his colours in a volatile oil.

On the other hand, the painters of the manufactory of Sevres, employ only colours without borax, because they dilute them in gum; and borax does not dilute well in that substance. I have found that both methods are equally good; and it is certain that Montamy was wrong to exclude fluxes of lead, since they are daily employed without any inconvenience, and as they even render the application of colours easier.

I have said that in the baking of these colours, the crust, softened by the fire, suffers itself to be easily penetrated by them. This is the first cause of the change which they experience. By mixing with the crust they become weaker, and the first heat changes a figure which appeared to be finished, into a very light sketch.

The oxide of lead which the crust contains, is a second, but much more powerful cause of the considerable changes which colours experience. The destructive action which that metal exercises chiefly on iron reds, is singularly remarkable. I shall soon give an account of some experiments, which prove it in a very evident manner.

It has been already seen, that the two principal causes of the changes, which colours on enamel and soft porcelain, are susceptible of experiencing, do not depend in any manner on the composition of these colours, but on the nature of the glass to which they are applied. When it is said, that the colours of porcelain change in a considerable degree, it ought to be added, that it is those of soft porcelain; a kind almost neglected.

It follows from what has been said, that painting on soft porcelain has need of being several times retouched, and of several heats, in order that it may be carried to the necessary degree of strength. These paintings have always a certain faintness; but they are con-

stantly more brilliant, and they never are attended with the inconvenience of detaching themselves in scales.

Hard porcelain, according to the division which I have established, is the second sort of excipient of metallic colours. This porcelain, as is well known, has for its basis a very white clay, called *kaolin*, mixed with a siliceous and calcareous flux, and for its covering, feld-spar fused without an atom of lead.

This porcelain, which is that of Saxony, is much newer at Sevres than the soft porcelain. The colours applied to it are of two kinds: the first, destined to represent different objects, are baked in a heat very inferior to that necessary for baking porcelain. They are exceedingly numerous and varied.

The others, destined to be fused in the same heat as that which bakes porcelain, lay themselves flat, and are much less numerous.

The colours of painting are made nearly like those destined for soft porcelain; they only contain more flux. Their flux is composed of glass of lead, called *rocaille*, and borax.

When porcelain is exposed to heat, in order to bake the colours, the covering of feld-spar dilates itself and opens its pores, but does not become soft: as the colours do not penetrate it, they experience none of those changes which they undergo on soft porcelain. It must, however, be said, that they lose a little of their intensity, by acquiring that transparency which is given to them by fusion.

One of the greatest inconveniences of these colours, especially in the manufactory of Sevres, is the facility with which they scale off, when exposed several times in the fire.

This inconvenience is observed more at Sevres than any where else, because it depends on the solidity and infusibility of the porcelain manufactured in that establishment. But these are qualities which make it much longer resist alternations of heat and cold, and which give to its paste a more striking whiteness. Paris porcelain, on the other hand, being more vitreous, more transparent, and bluer, often cracks when boiling liquors are put into it.

To remedy this defect without altering the quality of the paste, I was of opinion, that the crust only ought to be softened, by introducing into it more siliceous or calcareous flux, according to the nature of the feld-spar. This method has succeeded; and for about a year past, the colours might be exposed two or three times to the fire without scaling, if not overcharged with flux, and if not laid on too thick. It has been remarked, that soda and potash introduced into the colours make them scale; they are, therefore, never used as fluxes. It is found that these alkalies, by becoming volatilized, abandon the colour, which when alone, cannot form an adhesion with the crust.

The third sort of excipient of vitrifiable metallic colours, is glass without lead.

The application of these colours to glass, constitutes painting on glass; an art very much practised some centuries ago, and which was supposed to be lost, because out of fashion; but it has too direct a dependence on painting in enamel and porcelain, to be entirely

lost. Besides, a description of it may be found in a very great number of works.

The limits of a memoir will not allow me to enter into historical details respecting the art of painting on glass: a full history of it has been given in the work of Leveil. The matters and fluxes which enter into the composition of the colours employed on glass, are, in general, the same as those applied to porcelain. Neither of them differ but in their proportions; but there are a great number of enamel, or porcelain colours, which cannot be applied to glass, where they are deprived of the white ground which serves to give them relief. When seen by refraction, several of them entirely change their tone, and assume a dirty tint, which can be of no use: we shall make them known when we come to treat of colours in particular. Those which can be employed on this body, change sometimes in baking, and acquire a great transparency. In general, they are not beautiful; but, when placed between the light and the eye, they then seem to answer the only object that can be proposed in painting on glass.

The baking plates of painted glass, presents more difficulties than might be supposed. Care must be taken not to disfigure the piece, or alter the colours: all the works we have read recommend a bed of gypsum. This method has sometimes succeeded; but the glass, for the most part, becomes white and full of cracks. It appears, that glass too alkaline, (and alkalies are the most common in white glass) suffers itself to be attacked when warm, by the sulphuric acid of the sulphate of lime. We were able easily to bake pieces of glass much larger than those before painted, by placing them on very straight plates of earth, or of soft porcelain.

Of Colours in particular.

After collecting the general phenomena exhibited by each class of vitrifiable colours, considered in regard to the body on which they are applied, I must make known the most interesting particular phenomena, exhibited by each principal kind of colours employed on soft porcelain, and glass, in a porcelain furnace.

Of Reds, Purples, and Violets, made from Gold.

Carmine red, is obtained by the purple precipitate of Cassius: it is mixed with about six parts of its flux; and this mixture is employed directly, without being fused. It is then of a dirty violet, but, by baking, it acquires a beautiful red carmine colour: it is, however, exceedingly delicate; a little too much heat and carbonaceous vapours easily spoil it. On this account, it is more beautiful when baked with charcoal than with wood.

This colour, and the purple, which is very little different, as well as all the shades obtained from it, by mixing it with other colours, really change on all porcelain, and in every hand. But it is the only one that changes on hard porcelain. Its place may be supplied by a rose colour from iron, which does not change; so that by suppressing the carmine made with gold, and substituting for it the rose oxide of iron, here alluded to, you may exhibit a palette composed

of colours, none of which change in a remarkable manner. This rose-coloured oxide of iron has been long known; but it was not employed on enamel, because, on that substance it changes too much. As the painters on enamel, however, have become the painters on porcelain, they have preserved their ancient method.

It might be believed, that by first reducing to a vitreous matter the colour called *carmine*, already mixed with its flux, it might be made to assume its last tint. But the heat necessary to fuse this vitreous mass destroys the red colour, as I have experienced. Besides, it is remarked that, to obtain this colour very beautiful, it must be exposed to the fire as few times as possible.

Red, Rose, and Brown Colours extracted from Iron.

These colours are made from red oxide of iron, prepared with nitric acid. These oxides are further calcined, by keeping them exposed to the action of heat. If heated too much, they pass to brown.

Their flux is composed of borax, sand, and minium, in small quantity.

These oxides give rose and red colours, capable of supplying the place of the same colours made with oxide of gold. When properly employed, on hard porcelain, they do not change at all. I have caused roses to be painted with these colours, and found no difference between the baked flower, and that not baked, except what might be expected to result from the brilliancy given to colours by fusion.

These colours may be employed indiscriminately, either previously fused, or not fused.

The composition of them is the same, both for soft porcelain and for glass. They do not change on the latter; but on soft porcelain, they disappear almost entirely, on the first exposure to heat, and to make any thing remain, they must be employed very deep.

This singular effect must be ascribed to the presence of lead in the crust or glazing. I assured myself of this, by a very simple experiment. I placed this colour on window glass, and, having exposed it to a strong baking, it did not change.

Yellows.

Yellows are colours which require a great deal of care in the fabrication, on account of the lead which they contain, and which, approaching sometimes to the metallic state, produces on them black spots.

The yellows for hard and soft porcelain are the same: they are composed of the oxide of lead, white oxide of antimony, and sand.

Oxide of tin is sometimes mixed with them; and when it is required to have them livelier, and nearer the colour *du souci*, red oxide of iron is added, the too great redness of which, is dissipated in the previous fusion to which they are exposed, by the action of the lead contained in this yellow. These colours when once made, never change: they disappear, however, almost entirely when exposed to a porcelain heat.

These yellows cannot be applied to glass: they are too opaque and dirty. That employed by the old painters on glass, has, on the contrary, a beautiful transparency, is exceedingly brilliant, and of a colour which approaches near to that of gold. The processes which they gave, clearly showed that silver formed part of their composition; but, when exactly followed, nothing satisfactory was obtained. C. Miraud, whom I have already had occasion to mention, has found means to make as beautiful paintings on glass as the ancients, by employing muriate of silver, oxide of zinc, white argil, and yellow oxide of iron. These colours are applied on glass merely pounded, and without a flux. The oxide of iron, brings the yellow to that colour, which it ought to have after baking, and contributes with the argil and oxide of zinc, to decompose the muriate of silver, without deoxidating the silver. After the baking, there remains a dust which has not penetrated into the glass, and which is easily removed.

This yellow, when employed thicker, gives darker shades, and produces a russet.

Blues.

It is well known, that these are obtained from the oxide of cobalt. All chemists are acquainted with the preparation of them. Those of Sevres, which are justly esteemed for their beauty, are indebted for it, only to the care employed in manufacturing them, and to the quality of the porcelain, which appears more proper for receiving them, in proportion to the degree of heat it can bear.

The blue of hard porcelain, destined for what is called the ground for a great heat, (*les fonds au grand feu*) is fused with feld-spar; that of soft porcelain has for its flux, silice, potash, and lead: it is not volatilized like the preceding; but the heat it experiences, is very inferior to that of hard porcelain.

These colours, when previously fused, do not change at all in the application.

Blues on glass, exhibit the same phenomena as those on soft porcelain.

Greens.

The greens employed in painting, are made with green oxide of copper, or, sometimes with a mixture of yellow or blue. They must be previously fused with their flux, otherwise they will become black; but after this first fusion they no longer change.

They cannot stand a strong heat, as it would make them disappear entirely. Green grounds for a strong heat are composed with the oxides of cobalt and nickel, but a brownish green only is obtained.

Bluish greens called *celestial blues*, which were formerly colours very much in vogue, can be applied only upon soft porcelain; on hard porcelain they constantly become scaly, because potash enters into their composition.

These greens cannot be applied on glass: they give a dirty colour. To obtain a green on glass, it is necessary to put yellow on one side,

and blue, more or less pale, on the other. This colour may be made also, by a mixture of blue, with yellow oxide of iron. I hope to obtain from oxide of chrome a direct green colour. The trials I have made, give me reason to hope for success. Pure chromate of lead, which I applied to porcelain in a strong heat, gave me a pretty beautiful green, of great intensity and very fixed.

Bistres and Russets.

These are obtained by mixtures in different proportions of manganese, brown oxide of copper, and oxide of iron from ombre earth. They are also previously fused with their flux, so that they do not change in any manner on soft porcelain.

This colour fades very speedily on glass.

Russet grounds in a great heat, known under the name of *tortoise shell grounds*, are made in the same manner. Their flux is feldspar.

Blacks.

Blacks are the colours most difficult to be obtained very beautiful. No metallic oxide, gives alone a beautiful black. Manganese is that which approaches nearest to it. Iron gives an opaque, dull, cloudy black, which changes very easily to red: the colour-makers, therefore, to obtain a black which they could not hope for, from the best theorist, have united several metallic oxides, which separately do not give black, and have obtained a very beautiful colour, which, however, is liable to become scaly and dull.

These oxides are those of manganese, the brown oxides of copper, and a little of the oxide of cobalt. The gray is obtained by suppressing the copper, and increasing the dose of the flux.

Having here made known the principles of the fabrication of each principal colour, it may be readily conceived that by mixing these colours together, all the shades possible may be obtained. It is evident, also, that care in the preparation, choice in the raw materials, and a just proportion of doses, must produce in the results, differences very sensible to an eye accustomed to painting. A mere knowledge of the composition of colours, does not give the talent of executing them well.

In recapitulating the facts above mentioned, to present them under another general point of view, it is seen:

1st. That among colours generally employed on hard porcelain, one only, is susceptible of changing, viz. carmine, and the tints into which it enters: that its place may be supplied by the reds of iron, and that no colour then changes.

2nd. That among the colours for soft porcelain and enamel, several change in a considerable degree. These are principally the reds of gold and iron, the yellows, the greens, the browns. They have not been replaced by others, because this kind of painting has been almost abandoned.

3d. That several of the colours on glass change also by acquiring

complete transparency. These in particular are the yellows and greens.

4th. That it is neither by calcining the colours in a higher degree, nor previously fusing them, as supposed by some, that they are prevented from changing, since these means really alter the changing colours, and produce no effect on the rest. The change which several colours experience on soft porcelain, and on glass, does not then depend on the nature of their composition, but rather on that of the body on which they are applied.

Consequently, by suppressing from the colours of hard porcelain, the carmine of gold, which is not indispensably necessary, we shall have a series of colours which do not change.

On the valuable Properties of the genuine Emery Stone; and on a superior Process of washing over Emery, invented by Mr. JOHN ISAAC HAWKINS.

THE genuine emery stone is brought to us from *Naxos*, one of the islands in the Greek Archipelago. It is found in hard, compact, stony masses, of a bluish purple colour, interspersed with pyrites. These lumps of emery are used in their native state, in Sweden, to shape porphyry into slabs, mortars, &c.; being held firmly against the masses of porphyry, whilst the latter are turned in large lathes, moved by the power of water. They are also used in this country by the glass cutters, to turn their cast iron laps into shape; and the emery made from them is greatly preferable to any other, in its effects upon the articles to be cut or abraded by it, owing to its great hardness. This valuable property of hardness, however, has increased the difficulty of manufacturing emery from it; and, accordingly, substitutes have been found for it, which fall vastly short, indeed, in this desirable quality. We have even been told, that *the clinkers from a smith's forge* are too often made into what is called emery! We would therefore recommend those persons who wish to obtain emery of a superior description, to make it themselves, of the genuine Greek emery stone, by reducing it to powder in a cast iron mortar with an iron pestle; and then, either sifting it to the required degree of coarseness or fineness, with proper wire sieves; or else, by washing it over in water, as usual, bring it to a state of minuter division, and as described in our article "*On Grinding and Polishing Lenses.*" [See p. 596, Vol. IV.]

On Mr. J. I. Hawkins' Improved mode of Washing Emery.

We have lately been favoured, through the kindness of Mr. Hawkins, with an account of his very superior manner of preparing emery for nice purposes. He was induced to effect this, by finding that the emery commonly sold was totally inefficient for the purpose he had in view; namely, grinding two flat surfaces of hard cast-steel accurately; as the workman found that only a few of the coarser parts of