A study of these types of fastenings may show some new ideas, although most of them are not at all novel.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

XIX.—HOW TO DESIGN A PAINT (*Continued*).

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 321.)

A LITTLE further illustration of what we mean by mixing pigment and liquid by volume will perhaps be necessary. It is not very easy for us to think of volumes of pigments, since pigments are mostly measured by weight; and we do not at all mean, when we say that the pigment and liquid should be proportioned to each other by volume, that we should use, for example, a gallon of oil and a quart of pigment. Such a proceeding would lead to very disastrous results, for the simple reason that a quart of all pigments is not the same volume of all pigments. This may seem a little paradoxical, but we think the matter will appear clear when it is explained that the space occupied by a quart, for example, of pigment is not all occupied by the particles of pigment, but partly by particles of pigment and partly by air between the particles. We have made a number of experiments on the relative amount of space occupied by the pigment itself and the air in between the particles of pigment, and to our astonishment we find with most ordinarily fine pigments the space occupied by the air is three or four times as great as the space actually occupied by the particles of the pigment. When the paint is mixed the oil or liquid occupies the space formerly occupied by the air, while each particle of the pigment maintains its own identity and occupies a space characteristic of its own size.

Our experiments on the relative proportions of actual space occupied by the solid material and the interspace occupied by air have led to some rather curious information. It is well known that if particles of any solid material are in the form of spheres, the interspace does not vary, although the size of the particles vary. For example, a pound of lead in the form of shot one-quarter inch in diameter, and in the form of shot one-sixteenth inch in diameter, has the same actual volume occupied by the lead and the same interspace in both cases. Not so with pigments, nor, if we may trust our experiments, with any solid material in any other shape which we have experimented with. Our experiments show that the finer the material the greater the amount of interspace for the same amount of space occupied by the material. For example, if we have a pound of carbonate of lime, and grind it moderately fine, there will be a certain volume of space filled by the lime particles and a certain interspace. If the same amount of material is made finer and finer, of course the space occupied by the solid particles of carbonate of lime itself will be the same in all cases; but the interspace increases, and increases rapidly as the material gets finer. This fact makes it clear why we cannot take, for example, a quart of pigment and a gallon of oil for mixed paint, for all pigments are not of the same degree of fineness, and consequently with two different pigments the actual space occupied by the pigment would not be the same if we should take a quart of each. But for the correct mixing of paint we must have the same volumes of pigment. Furthermore it is well known that dry substances measured by volume compact themselves more or less by shaking. Oats and corn are familiar illustrations. The same thing is true of pigments; but unfortunately pigments do not shake down equally well. Some pack a great deal closer than others with the same shaking; so that, in order to mix pigment and liquid by volume, we shall have to get at some method of measuring the pigment different from putting it into any convenient measure. Our law that two or more pigments can be mixed with liquid on the same formula by volume only holds true when equal volumes of all pigments are mixed with equal volumes of oil.

There are several circumstances which affect the proportions of pigment and liquid, and these circumstances lead to practical variations from the law above mentioned, when we come to the practical use of paints. It will be borne in mind that in all this discussion thus far we are speaking about the proportions of pigment and liquid that will give the best paint after it is dried on the surface, reserving for a later point in the article the discussion of how to get a paint which will work satisfactorily under the brush; but it will be perhaps advisable first to discuss these concomitant circumstances a little, and their influence on the paint. We are quite well aware that where it is desired to have paint dry more rapidly, an increase in the amount of liquid is frequently made use of by practical painters, resulting in a thinner coat, and thus varying the proportions of oil and pigment. Also it is well known by those who are familiar with pigments that the same amount of liquid cannot be used with different pigments, due to their nature and to their fineness or coarseness. We are inclined to think, however, there are only two variables which will seriously modify the formula which we propose to give. These are the cost of the paint, and whether the paint is to be used as first, or second and third coat. In regard to these variables, it is quite true that a paint mixed on the formula which we shall give will cost more than a paint mixed with a greater proportion of liquid to the pigment; and if parties desire a cheap paint, a very simple way is to add more liquid to the paint, and thus cause it to cover a great deal more surface. It is perfectly obvious that less weight of material will be put on each square foot or square yard under these conditions, and since paints are usually bought by weight, the paint containing less pigment will be cheaper.

A variation produced with a desire for cheapness is of course legitimate, provided the variation is done with the eyes wide open, and the modification of our formula for this purpose is perfectly legitimate, although, if our experiments are correct, not as durable a job will be obtained.

The second legitimate modification of the formula is, we think, due to whether the paint is used as first, or second and third coat. Our experiments indicate that quite a portion of the liquid of the first coat goes into the wood. This can hardly be obviated by any method with which we are familiar at present. If, now, the proportion of pigment and liquid on the first coat is such as will give the most durable paint, our experience indicates that the paint becomes difficult to spread on account of the absorption of the liquid by the wood, and also there is quite a tendency for the paint to become spotted, due to unequal absorption on different parts of the wooden surface. Some portions take up a great deal more of the liquid than other portions, and these portions being deprived of a greater portion of their liquid, have a different shade from the contiguous

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint; No. XVI, in the May number, on Paint Specifications; No. XVII, in the June number, on the same subject, and No. XVIII, also in June, on the Livering of Paint; No. XIX, in the July number, on How to Design a Paint. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.