ber of small holes, *F F*, or a longitudinal knife-edged slot. By this arrangement the ascending volume of water and steam, instead of bubbling up through the body of water, emerges from the openings *F F*, the water, by reason of its greater momentum, impinging upon the surface of the water in the drum while the steam enters the perforated

Fig. 4.

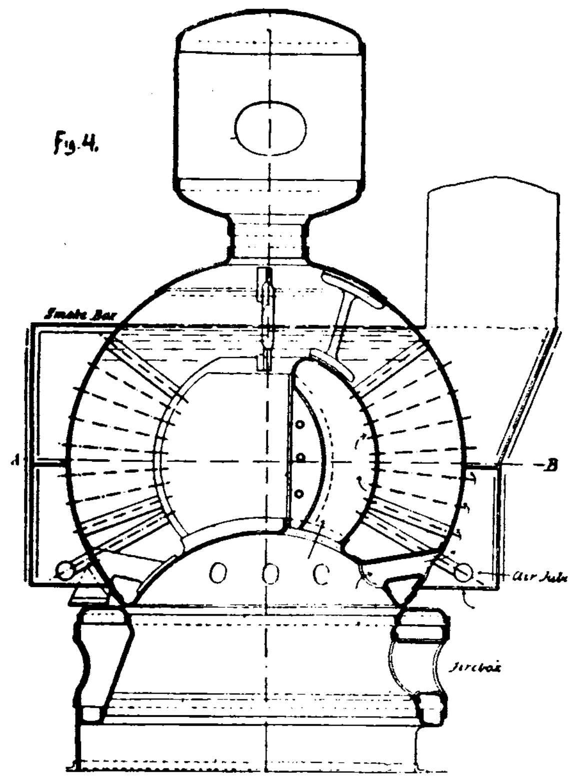
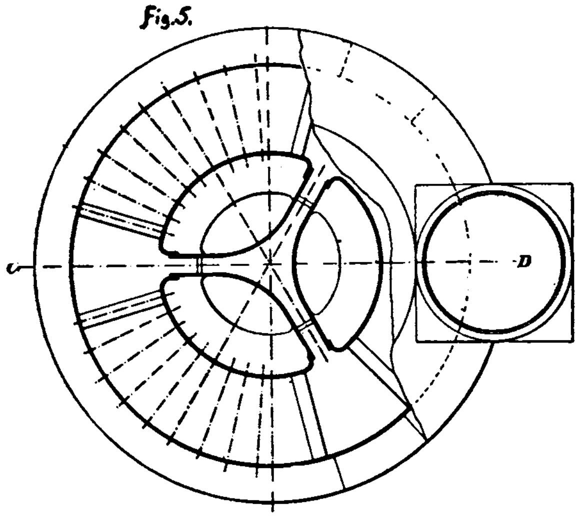


Fig. 5.



collecting pipe *A'*. It is claimed that by this device priming is almost entirely prevented.

The generating tubes *E E* are arranged in the manner shown in figs. 1 and 2, exposing a very large surface to the action of the fire. At their lower ends these tubes are connected with two water drums, *M M*, which are also connected with the steam drum above by the pipes *N N*, fig. 2, thus securing a free and constant circulation. In order to strengthen the steam drum and also to prepare it for the reception of the ends of the tubes *E E*, a strip, *G*, is riveted upon the side along the entire length occupied by the tubes. The joint is made by means of clamps and T-headed bolts *H*, inserted in grooves, as shown on a larger scale in fig. 3. This plan permits the tubes to be removed without difficulty when repairs are needed.

The advantages claimed for this boiler are great evaporative efficiency, freedom from priming, free circulation of water, and facilities for repair or renewal of tubes.

The grate is placed between the two cylinders *M M*, which are protected by fire-brick, as shown in fig. 1, and the entire boiler is surrounded by an iron casing.

In figs. 4 and 5 is shown another new form of high-pressure boiler devised by H. B. Buckland, and recently tested at Shields, England. This boiler, which the inventor calls the "Stanley," is spherical in form, the lower portion being reversed to form the crown of the furnace, the combustion chambers, three in number, taking away direct the greater part of the gaseous products and passing them through the upper tubes into the smoke-boxes, and hence to the funnel. Large lower tubes are also provided in the lower portion of the boiler to take away part of the gases, which are returned through the ordinary tubes into the combustion chamber. The sides of the furnace and bottom are a distinct structure, so that the boiler has practically a dry bottom, the lower water spaces forming a feed-heater, any steam generated passing direct through piping to the steam dome or receiver.

The boiler tested is shown in the engravings, which are taken from *Industries*, fig. 4 being a vertical section and fig. 5 a section on the line *A B*, fig. 4. This boiler is 14 ft. 3½ in. high, 7 ft. 6 in. diameter, or 8 ft. 10¾ in. diameter to the outside of the smoke-boxes. It contains 252 tubes 2¼ in. external diameter, 1 ft. 7½ in. long, 84 tubes being fitted to each of the combustion chambers. To each of the latter there are also fitted three tubes for admission of air, each being fitted with an apparatus for regulating the quantity admitted. The furnace was bricked round, reducing the diameter of the fire-grate to 4 ft. 3 in., equal to an area of 14.18 sq. ft. The chimney, 2 ft. 6 in. in diameter, 26 ft. 4 in. high above the fire-bars, is common to all the combustion chambers. The boiler was submitted to a short test, lasting 1½ hours, simply to show its steaming power, the results being satisfactory and considered better than the ordinary type of marine boiler. It was worked up to 85 lbs. only.

One of these boilers has been put in the steamer *Napier* as an auxiliary boiler, and will be tested in actual service.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

XVIII.—HOW TO DESIGN A PAINT.†

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 254.)

IN the April number we discussed the question of How to Design a Paint, in answer to the question, "What pigment shall be used?" This leaves two other points still to be discussed. These are, first, "What liquid shall be used?" and, second, "What proportions of pigment and liquid give best results?"

First, in regard to the liquid. With the present state of our knowledge it almost goes without saying that the liquid which must be used to hold pigment on a surface is necessarily, largely at least, linseed-oil, since this oil is abundant, is low in price, and has the interesting property when exposed to the air of changing chemically from a more or less greasy liquid to a leathery solid, which serves ad-

* 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.

† Continued from No. XV, in the April number.

mirably as a means of holding pigment on a surface. It is, of course, well known that there are a number of other oils which have this property, notably poppy-seed oil and hempseed oil, which, if our experiments are to be trusted, is often a constituent of the linseed-oil of the market, and also, to a certain extent at least, some of the fish oils. It is hardly necessary to add that the class of oils that is or may be used, as the principal portion of the liquid in paints, is known as the "drying oils." It may be mentioned also that there are a number of oils called "semi-drying oils," the most common of these being, as we understand the matter, cotton-seed oil. None of the drying oils, however, so far as our observations go, except linseed-oil, is sufficiently cheap and abundant to be used with success as the principal portion of the liquid of the paint. A little further on we will speak about linseed-oil substitutes.

Let it be granted, then, that in the present state of our knowledge and of the market, linseed-oil must necessarily constitute the principal portion of the liquid to be used in paint. But raw linseed-oil alone, at least with some pigments, will not make a satisfactory paint, because it dries so slowly. It has been previously stated that raw linseed-oil alone spread on glass requires about four days to dry, and when mixed with many pigments it does not dry much more rapidly than this. With white lead, which is of itself more or less of a dryer, the time is shortened somewhat, and the same thing may also be said, we think, of red lead, and to a certain extent with pigments containing oxide of manganese, such as umber; but in general the pigments themselves do not sufficiently facilitate the drying, so that it would be safe to say a paint might consist of pigment and raw linseed-oil. Accordingly more or less of a material called japan is added to a paint and becomes really a portion of the liquid. Japan, in brief, may be defined as a soap made by combining lead and manganese oxides with linseed-oil or with shellac, or in some cases with other oils, which soap is subsequently dissolved in spirits of turpentine or benzine. In our experience the japans of the market vary a great deal in their capacity to facilitate drying. With some of them the greater the amount of japan present the smaller the time required for drying. With other japans an increase in the amount of japan beyond a certain percentage retards the drying, so that it is very difficult to say how large a percentage of japan should be used in an oil in order to give successful results. We are accustomed with any new japan to mix it with raw linseed-oil in the proportions of 5.00, 10.00, 20.00, 30.00, and 40.00 per cent. of japan in the mixture, and to spread the various mixtures on different pieces of glass, and see which one dries the best. This enables us to use that japan wisely.

We prefer japans which can be used in small amount, and the best japan which we have ever seen gave most rapid drying when used to the extent of about 95.00 per cent. raw linseed-oil and 5.00 per cent. japan. We prefer a japan of this nature, and would likewise think it unadvisable to use a japan which required more than 10.00 per cent., or at the utmost 15.00 per cent. of japan to 85.00 of raw linseed-oil.

It should be stated that many of the japans of the market have kauri or other copal gums in them as constituents. We regard this as a mistake, as the gum occupies space which could be better occupied with other material. If it is desired for any purpose to have special gloss on the paint, a little varnish added to the paint is better than to have this material introduced through the japan.

Thus far, then, the liquid to be used in painting is found to consist of raw linseed-oil, with a sufficient percentage of japan in it to produce satisfactory drying, the japan having all the way from 40.00 to 60.00 per cent. of its weight of spirits of turpentine, so that in reality the liquid used in most painting consists of raw linseed-oil, the soaps which are characteristic of the japan, which likewise dissolve in the oil, and the turpentine introduced with the japan. In addition to this, as will be seen a little later, we are inclined to favor a still further percentage of turpentine as a means of diluting the paint for spreading. The amount of this and the reasons why will be explained further on. The three things mentioned—namely, raw linseed-oil, the lead and manganese soaps introduced with the japan, and turpentine, both as a constituent of the japan and as a means of diluting the paint for spreading, we regard as the best practice, and as legitimate materials to form the liquid part of paint.

The practice of many painters, and especially the practice of paint manufacturers in making many of the cheap ready mixed paints of the market, differs very widely from these three simple constituents. It is not at all uncommon to find in the market paint mixed with so-called linseed-oil substitutes. These substitutes, which we have examined, have been, largely at least, either petroleum product mixed with fish oils or doctored in other ways to make them dry, or rosin oils with a greater or less amount of fish oil, or possibly linseed-oil doctored up in some other way so that it would dry, or rosin oils, or petroleum product with japans. The various mixtures are difficult to separate, and the usual test which we have put the so-called linseed-oil substitutes to is to determine their rate of drying. We have never run across, in our experience, any of these substitutes—with we believe one possible exception—that were not so slow in drying that this feature alone condemned them, and so we have not tried in every case to find out exactly of what the substitute consisted. We have had samples which would not dry in four or five days, where good linseed-oil paint, properly made and applied, would dry in eight hours.

We would not at all like to be regarded as saying that nothing can be found which will take the place of linseed-oil, for to our minds linseed-oil has a good many defects, and we should only be too glad to find some substance which could be used successfully as the liquid part of paints that would be free from these defects, notably the permeability of the dried linseed-oil to water. If some liquid could be found which would dry as rapidly as linseed-oil, that was as durable as dried linseed-oil, and that would make a paint which would absolutely repel water, it certainly would be a great discovery, and would undoubtedly prove of great value to the person who first brought it forward. Thus far in our experience we have never seen such a liquid.

Our experience with fish oils in place of linseed-oil has not been very extended. Usually, so far as our experiments have gone, they dry more slowly, and do not offer much advantage in the way of price over linseed-oil. Furthermore a paint mixed with fish oil is apt to dry spotted and sticky. Quite a notable exception to this general criticism of fish oils is a prepared fish oil, which has recently been brought to our attention. This oil, so far as our knowledge goes, has been treated in such a way that it dries fully as rapidly as linseed-oil, but our experience with it, especially as to its durability and behavior on exposure to the weather, is so meagre that we are hardly willing to do anything more than mention the matter as above. We are constantly on the lookout for any modifications of paint liquid which will produce better results, and only regret that we are compelled to say that thus far we have found nothing to take the place of linseed-oil.

Two points further in regard to paint liquid. We have already mentioned that spirits of turpentine is a legitimate constituent of paint mixed ready for spreading. We are finding, however, that spirits of turpentine in the market is becoming adulterated more or less with petroleum product, and this is leading us to examine all shipments of this material.

The question may be asked, What objection is there to a small amount of petroleum product in a paint, introduced either through the turpentine or, as it is more commonly introduced in the market—namely, as benzine? We are quite well aware that many practical painters, and especially many manufacturers of ready mixed paints use large quantities of benzine, both as a constituent of their japan and to dilute the paint with to prepare it for spreading. We have examined many samples of mixed paint which contained large percentages of petroleum product, introduced either as benzine or as a constituent of the turpentine. So far as the introduction of petroleum product of any kind along with the turpentine is concerned, we will say that, of course, it is a fraud to buy as turpentine a material mixed with petroleum product, but to our minds there is a still more serious objection to the use of turpentine adulterated with petroleum product or benzine in mixed paint. This objection lies in the tendency produced by the petroleum product, either benzine or the ordinary adulterated spirits of turpentine, to cause the paint to peel. We have made positive experiments on this point, and confirm by these experiments what the practical painters with whom we have talked on the matter affirm to be their experience—namely, that a paint containing any considerable amount of any petroleum product, as a constituent of the liquid, peels, and accordingly it will wear worse than if simple raw linseed-oil, japan and turpentine were the liquid constituents. The reason for this is not difficult to find. Very few of the petroleum products of any kind are free from paraffine wax, or non-volatile members of the paraffine series or other non-volatile substances. It follows, therefore, that when the paint dries the volatile part of the benzine or other petroleum product passes away, while the non-volatile part remains and is soaked up into the wood. But this soaking up of an oily, slippery substance like paraffine wax, or the non-volatile substances into the wood prevents the layer of paint from adhering to the wood surface. Our belief in the inferiority of benzine or other petroleum products as a constituent of paint is so strong that we are quite inclined to condemn any paint containing benzine. The non-volatile part of the turpentine, as is well known, is very adhesive and sticky, and helps the oil to hold the paint on the surface. The non-volatile part of any of the petroleum products fills the pores of the wood and prevents the paint from adhering, or, what amounts to the same thing, causes it to peel and scale off much more rapidly. Benzine is a good thing for the paint manufacturer, in that it is very cheap in price, and causes the paint to deteriorate so rapidly that buildings must be repainted every year or two. It is a bad thing for the consumer, who is interested in having a paint as durable as possible.

There is another feature of the use of benzine which should not be forgotten—namely, that in a closed paint shop, having a good many painters, the amount of benzine given off might be large enough to cause danger of an explosive mixture being formed in the shop. It is quite well known that several serious accidents have occurred from trying to clean carpets with benzine, and the same state of affairs might result from the use of a large amount of paint containing benzine in paint shops. Our belief in the inferiority of this material as a constituent of paint is so strong that we recommend that none of it be kept on the Company's property or used in the shops anywhere if its use can be avoided.

This is the place to speak of one point further in regard to paint liquid. We are quite well aware that the relative merits of boiled and raw linseed-oil have been very much discussed, and that there is a very strong prejudice among a large number of painters in favor of boiled oil. We are compelled to confess, however, that all our experiments, and we have made a good many of them, do not lead us to think that boiled oil is anything like as valuable as many master painters claim. We have never seen a sample of boiled oil which would dry as rapidly and as free from "tache" as good raw oil mixed with the proper amount of japan. Adding to this the fact, which is well known by those who are well informed, that quite a large percentage of the boiled oil of the market is not boiled oil at all, but is simply raw oil treated in the barrel with a little japan or oil dryer, we are inclined to think that the value of boiled oil has been over-estimated. We do not ignore the fact that the influence of the heat changes the oil somewhat, but to our minds this change is the very thing which should be avoided. Good raw oil properly dried is, so far as any knowledge which we have been able to get, as durable and as satisfactory in working as any boiled oil ever made. We do not, therefore, favor the use of boiled oil, either in the grinding or mixing of paints.

Let us turn now to the question at the head of this article —namely, what proportions of pigment and liquid shall be used? Upon this point the practice of painters, as well as that of the manufacturers of ready-mixed paints, differs very widely, and we have sometimes been inclined to think that in no one of the three elements that enter into painting is there so much fraud as in the proportions of pigment and liquid. Where the coloring power of the pigment is strong, we have seen paints so diluted that they were practically little more than a wash. Of course those familiar with the characteristics of the trade know that there is a great difference of practice in the kinds of pigment used, and also in the nature of the liquid used; but if we may trust our experience it is also true that there is very great variation, quite to the detriment many times of the buyer, in the proportions of pigment and liquid.

It is not at all easy to give a definite statement in regard to proportions of pigment and liquid, since there are a number of elements which enter into the problem, and a rule which would be applicable to one liquid and one kind of pigment would not be applicable with others. There are also a number of preliminary points which must be considered before we can give definite figures for proportions of pigment and liquid. We will take up these points one by one, and reach definite conclusions on them, and later will give the results of our study in the matter of proportions.

First of all, it should be borne in mind that what follows in regard to proportions applies only to what is known as house painting in distinction from carriage painting. It will be remembered that this distinction has been drawn in previous articles, and in this article we do not profess to give the proportions of pigment and liquid, which should be made use of for successful carriage painting, in which the paint is used almost exclusively for the color and not for protection. This article applies to paints used both for color and for protection.

At the very outset of the discussion we are met by a distinction which must be carefully cleared up before we can do anything definite—namely, does our discussion of proportions apply to the paint mixed ready for spreading, or to the paint after it is dry? It is well known by those who have to do with painting that a coat of paint when freshly applied contains constituents which vaporize, and that consequently a dry coat of paint is not the same in its proportions as a coat of paint freshly applied. It has also been stated already that for paint ready to apply we regard linseed-oil or some equivalent material, japan and turpentine, as legitimate constituents. Of these by far the largest portion remains on the surface, but a good portion of the turpentine and some constituents of the oil pass off during the process of drying. The liquid portion of the paint which remains it is customary to call "binding material," and so far as our experience goes the binding material is always a little less than the liquid in the paint when it is applied. In some cases where very little japan is used the binding material is almost identical in amount with the liquid portion of the paint, since linseed-oil changes very little in weight, due to the drying process. The absorption of oxygen which takes place is about equivalent in amount to the losses of the oil during the drying. On the other hand, if a paint ready for spreading contains any japan, and this japan had in it any turpentine or benzine, the amount of the binding material left on the surface with the pigment would be somewhat less than the amount of the liquid in the paint. Since now all our experiments indicate that the greater the proportion of pigment in the paint the greater the durability, owing to the fact that the pigment apparently protects the oil from decay, we will state that in what follows in regard to proportions between pigment and liquid we refer to that portion of the liquid which stays with the pigment as "binding material." In other words, until we specially say to the contrary in the discussion that follows in regard to mixed paint, when we say pigment and liquid, we mean pigment and binding material. Our formulas for making mixed paint are based on this foundation. The material added for the purpose of making the paint spread well is a separate matter, and will be so treated.

Another preliminary question which it would perhaps be wise to discuss is, when we speak of proportions of pigment and liquid, do we mean proportions by weight or proportions by volume? We are well aware that the trade, and, in fact, practical master painters, are accustomed to mix paints by taking so many pounds of pigment or paste and adding to it so many gallons or quarts or pints, as the case may be, of the liquid. This is all right so far as our knowledge goes, and there is no objection to this way of arriving at the result of getting a paint ready for spreading and a paint which will have great durability after it is dry, but it simplifies the discussion of the question very much, and we think places the matter on a philosophic basis to consider that the question of mixed paint is not by weights, but by volumes. Of course, with a little knowledge of the specific gravity of pigments and liquids, it is easy to pass from the weights to volumes or volumes to weights; or we may use a combination of volumes and weights in our practical formula; but we may as well state that our formulas are founded on proportions by volume. The reason for this is that paint, as we understand it, is a mechanical mixture of pigments with liquids, and when we say mechanical mixture we mean that there is no chemical combination between the pigment and the liquid and no solution of pigment in the liquid. They are simply mixed together, each one maintaining its own identity independent of the other. We are quite well aware that with white lead, red lead, and zinc white, and possibly several other pigments, there is a small amount of chemical action between the pigment and the liquid, but this is so small in amount that it can be allowed for, and does not really seriously interfere with the conception that a paint is a mechanical mixture of pigment and liquid. If we allow, then, that paint is a mechanical mixture, and that the proper proportions of pigment and liquid can best be obtained by volumes, it apparently places the mixing of paint on a philosophic basis, and gives us a chance to obtain some laws which are wide in their application.

How difficult it would be to get any uniform formula on which to proportion the pigment and liquid in paints, if the mixing is done by weights, will become evident from one or two examples. It is well known that seven or eight parts of white lead with two or three parts of boiled linseed-oil by weight make a paint ready for spreading, and which will give very good results in service. If we attempt, however, to use the same formula—namely, seven or eight pounds of P. R. R. standard freight-car color, with two or three pounds of boiled linseed-oil, or raw linseed-oil, containing the proper amount of japan, we get a paint that is so thick that it cannot be spread at all with a brush, and indeed is so stiff a paste that it will hardly run out of the vessel. Clearly no uniform formula can be made use of to proportion pigment and liquid in paints if we attempt to do this by weight. On the other hand, our experiments indicate that proportions by volume apply fairly well to all pigments—that is to say, if all pigments were entirely devoid of chemical action between the pigment and liquid, and if all pigments were equally fine, we are inclined to think the same formula would apply for proportions of pigment and liquid, provided these proportions are decided by volume. We will give the figures of what we regard as the successful proportions by volume a little later.

(TO BE CONTINUED.)

Foreign Naval Notes.

THE Russian torpedo-cruiser *Kasarski* recently made a voyage from Pillau to Sebastopol, steaming in all 4,500 miles in 343 hours, at a mean speed of 12.28 knots. During part of the voyage she met with very heavy weather. This ship was built in Germany by Schichau; she is 190 ft. long, 24 ft. beam and has one triple-expansion engine, working up to 3,300 H.P. With natural draft the boat has a speed of 16 knots and with forced draft 21 knots an hour.

IT is stated that in consequence of troubles and break-downs experienced with the torpedo-chasers—vessels of about 400 tons displacement—in the last manœuvres of the French Navy, the locomotive boilers with which they are fitted will be taken out and replaced by tubulous boilers, probably of the d'Allest type.

EXPERIMENTS conducted on board the Italian armored ships *Castelfiardo* and *Ancona*, to test the suitability of petroleum fuel for use on shipboard, have resulted favorably. The apparatus used is an invention of Captain Cuniberti. It is claimed that petroleum is cheaper than coal, and that a battle-ship can keep the sea three times as long as is possible with coal. As a result of these experiments a course of instruction is to be opened on the *Ancona*, to make known the best method of procedure in firing with liquid fuel.—*Journal of the American Society of Naval Engineers.*

THE new Japanese cruiser *Hashidate Kan* was launched March 24 at the Imperial Dock Yard, Yokosuka. This ship is a fast unarmored cruiser of 4,300 displacement. She is 300 ft. long, 50 ft. beam, and 22 ft. average draft. The engines are of the triple-expansion type, and are expected to give a sea speed of 16 knots. The armament will be heavy for a vessel of this size. Some interest attaches to this ship, as she was built entirely by Japanese mechanics, and is the largest vessel yet built in that country. The steel from which she is constructed was bought in Europe.

Lake Transportation.

THE Sault Ste. Marie Canal officers are about to publish the results obtained from a discussion of the business of the canal during 1890, and it will be shown that the average cost per ton per mile on that part of lake freight that passed through the canal has again been reduced this time to 1.3 mills. Rates are steadily approaching the ocean figure, which is estimated at 1 mill per ton per mile. Following are some comparisons gained through advance information regarding the report:

	Freight tonage, net.	Valuation of freight tonnage.	Average distance carried, miles.	Total cost, water transportation.	Cost per ton-mile.
1887	5,494,649	$79,031,758	811.4	$10,075,153	2.3 mills
1888	6,411,423	82,156,020	806.9	7,883,077	1.5 "
1889	7,516,022	83,732,527	790.4	8,634,246	1.5 "
1890	9,041,213	102,214,949	*707.2	9,472,214	1.3 "

The rates for different kinds of merchandise vary a great deal. In 1890 coal, which is an up freight, was carried for 0.5 mill per mile-ton, while miscellaneous merchandise cost 3.4 mills per mile-ton. Vessels made big profits in 1887, and this accounts for the high rates of freight.

The largest cargo passing the canal in 1890 was 3,021 tons, and was carried by one of the whaleback barges, No. 107.

The greatest number of mile-tons was reported by the steamship *Northern Queen*, one of the Great Northern Railroad boats.

The greatest aggregate number of tons carried through the canal by any vessel during the season was 77,124 tons by the steamship *Manola*, owned by the Minnesota Iron Company. This boat also reported the greatest number of miles run, 49,201 miles. In addition she made one trip to Escanaba, bringing her total season's run up to 50,580 miles in 223 days. It is believed that no boat ever before ran this distance in so short a time.

The total valuation of all vessels using the canal during the last four years is as follows:

1887 .... $19,773,950
1888 21,895,400
1889 26,926,200
1890 29,635,500

This shows that about $10,000,000 worth of vessel property has been added to the Lake Superior fleet within the past four years.—*Cleveland Marine Review.*

Water Power under Varying Heads.

THE Pelton Water-Wheel Company, of San Francisco, has contracted to remove the inward-discharge turbine water-wheels in the Columbian River Paper Mills, at La Camas, Washington, and replace them with Pelton wheels. One of the new wheels, only 5 ft. in diameter, is to develop 300 H.P., or, if required, 430 H.P., under a head of 110 ft. The small diameter is to adapt the speed to that of the main shaft, which runs at 141 revolutions per minute. Another wheel in the same mill is to run at 70 revolutions per minute and develope 50 H.P. Three other wheels are included in the contract. The two first named show the extreme flexibility of the system and its adaptation to all the varying conditions of speed and power and head. This case shows the futility of tendering for pressure turbine wheels in the case of the Niagara Falls plant, where the head is 140 feet.—*Industry, San Francisco.*

* Mean 801.5.