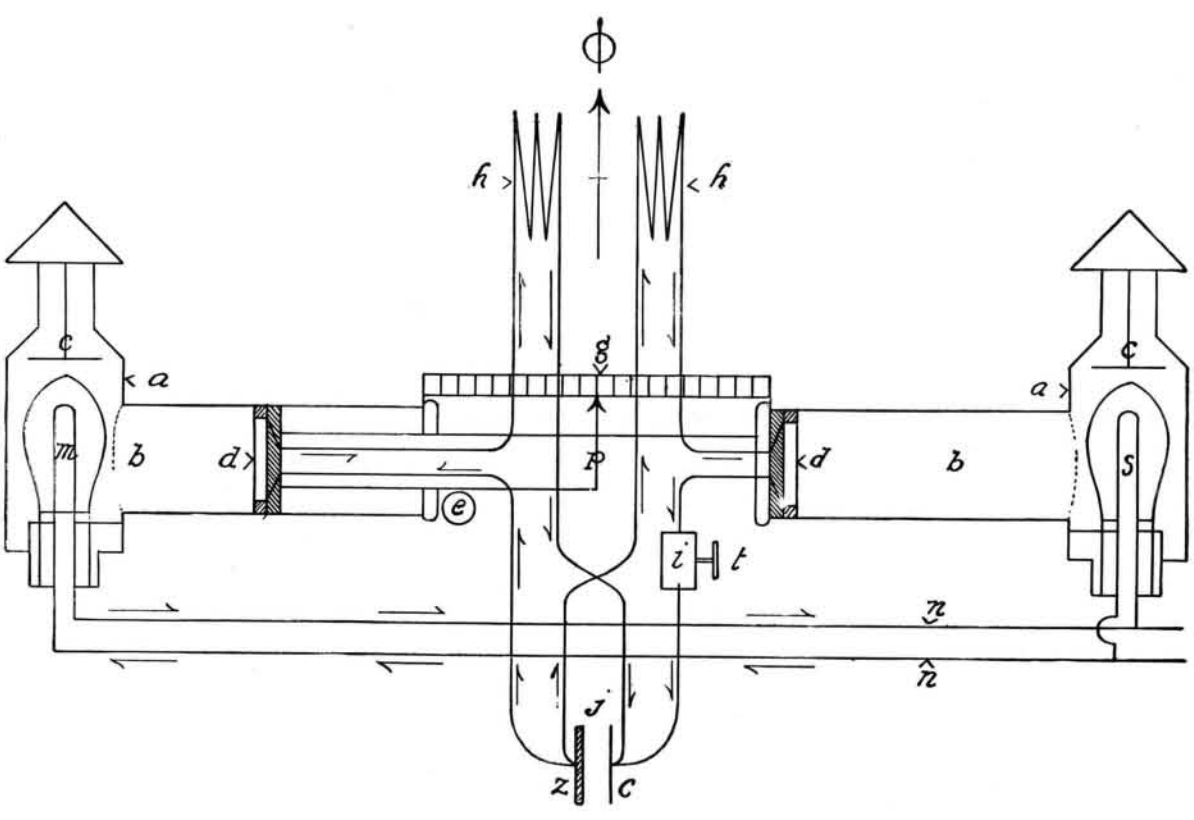
A NEW PHOTOMETER.

On account of the difficulty of eliminating the personal equation, photometric work has always been attended with a great deal of uncertainty, and an instrument for the measurement of light, whose accuracy does not depend upon the sense of sight, has long been needed, but since the days of gas lighting, and more especially of electric lighting, a reliable instrument has become an absolute necessity. Various ways have been suggested for avoiding the uncertainty of the ordinary photometric methods, but the best device for the purpose that has come to our notice is the invention of Mr. S. F. Van Choate, of Boston, which he has given to the world without price or the expectation of reward.

In this instrument—which is shown in the annexed diagram—a selenium cell is employed to receive the light beam, and to thus vary the electric current which is made use of to give the visual indications. The instrument is in the nature of a balance connected with a differential galvanometer, the standard light being arranged to affect one side of the balance, and the light of unknown strength being placed upon the opposite side of the instrument. The tubes, *b*, of two lanterns, *a*, are preferably arranged axially in line. In the right hand lantern is placed the light, *s*, to be tested, above which is suspended a disk, *c*, for preventing the escape of light. In the other lantern is placed the standard lamp, *m*, and in the tube, *b*, upon the same side of the apparatus is fixed an adjustable selenium cell, *d*, which is moved along the length of the tube, *b*, by the pinion, *e*. To the selenium cell, *d*, is attached an index, *p*, which slides in front of the scale, *g*. If the standard lamp and the lamp to be tested are electric lamps, they are connected up in an electric circuit in the usual way.

In the upper portion of the diagram is shown a differential galvanometer which is connected with a battery, *j*. The right hand coil of the differential galvanometer is connected by one of its terminals with the zinc plate, *z*, of the battery, while the remaining terminal of the coil is connected with the selenium cell, *d*, which in turn is connected through the rheostat, *i*, with the carbon plates, *c*, of the battery. In a similar manner one terminal of the left hand coil of the galvanometer is connected with the carbon plate, *c*, and the remaining terminal is connected with the adjustable selenium cell, *d*, from which a wire extends to the zinc plate, *z*, of the battery. The two branches of the battery circuit are placed in electrical balance by means of the rheostat, *i*. The selenium cells, *d*, being alike, if the lamps, *s*, *m*, are equal, the distance between the selenium cells, *d*, and their respective lamps will be the same. If, however, the lamp to be tested is inferior to the standard lamp, the selenium cell, *d*, which faces the standard lamp, will be moved until the galvanometer indicates equilibrium. The difference in the distance between the selenium cells and the lamps, as indicated on the scale, will give the basis for the calculation of the relative intensities of the light from the two lamps, calculations being made according to the law of inverse squares.

This instrument can be used in measuring the intensity of light from other sources by simply adapting the lanterns to the kind of light used for standard and for testing.



VAN CHOATE'S ELECTRIC PHOTOMETER.

Casson's Steel Process.

In the manufacture of steel and ingot iron some attention is just now being paid to Casson's new process, as carried on at his extensive works in Staffordshire, England, the purpose in view being to so carburize the molten metal that the amount of carbon resulting may be more or less accurately determined. This is accomplished by introducing carbon, in the form of charcoal, into the casting ladle, and then tapping the metal direct from the converter or furnace into the ladle, after adding any desired quantity of ferro-manganese or other material; in this way, as is found, a high percentage of carbon can be readily introduced into the metal, and a high grade of steel produced. In practice, that is, to produce a high grade of steel capable of standing from 26 to 34 tons tensile strain, the use is called for of about 5 lb. of finely ground charcoal per ton of metal, the usual percentage of ferro-manganese being also somewhat increased. Other forms of carbon than wood charcoal may also, it is stated, be employed, so long as they do not contain such a high percentage of sulphur or other ingredients as would be injurious to the resultant steel.

The Great Chicago-Mississippi Waterway.

Chicago has surprised the world in many wonderful undertakings of late, and not least among them is the proposed waterway from that city to the Mississippi River, upon which contracts for one section, involving $10,696,755, were let a short time ago. In letting these contracts the drainage board in charge of the great sewer, as it is now commonly called, has shown considerable boldness. As it is claimed that this waterway will serve the twofold purpose of diluting Chicago sewage and for future commerce between the lakes and the Mississippi, some details regarding the plans upon which work has been begun will probably be of interest at this time. The canal will have a width at bottom of 160 feet and a uniform depth of 19 feet, a gradient of 5 inches to the mile, and a capacity of 600,000 cubic feet per minute. The Suez canal has a bottom width of 72 feet, just sufficient for one large steamer. It is, in fact, a "single track" canal with turn-outs; the Chicago canal will be "double track." The Suez canal has a top width of 197 feet, the depth in center being 26 feet, or 7 feet more than that of the Chicago canal. The superior dimensions of the Chicago canal were not so much demanded in the interests of navigation as in that of sewage disposal, the law demanding as it does a water supply for diluting Chicago's present and future excreta to the enormous amount of 600,000 cubic feet per minute. The position of the present work is neither the beginning nor the end of the programme of the sanitary commission. It is a stretch of 14 miles of heavy cutting across what is called the Chicago divide, or "height of land." It commences at a village called Willow Springs, 20 miles from Chicago Court House, close to the present Illinois and Michigan canal, and runs in a southwesterly direction to Lockport, a town three miles from Joliet. The total length of cutting will be 14 miles, the maximum depth in rock about 35 feet, and in clay about the same.

Difficulties to be met with in this project are, of course, very numerous. It will involve a most prodigious expenditure, and notwithstanding the claims of its promoters that it is intended as a highway of commerce, all attempts to secure appropriations from the general government will be stubbornly fought. The local government engineer, Captain Marshall, has already opposed the application of Chicago for government grants in aid of the enterprise, considering as he does that to do so would be to apply federal money to municipal purposes. Careful study has shown that no positive detriment would result to lake shipping on account of the abstraction of so large an amount of water from Lake Michigan, but the great cost of securing an entrance to the city of Chicago and the lake, and the effect of such entrance on the transportation problem, are all-important questions. The present harbor entrance, narrow and with low banks, has been a barrier to rapid transit on account of the swing bridges, which obstruct also the navigation. The programme of the sanitary board includes the entire filling up of this present harbor entrance, the creation of industrial properties on its site, and the facilitation of rapid transit across the new cuts by means of tunnels. Seeing that every street must have its tunnel, which will have to be about 1,500 feet long, including approaches, in order to make one crossing of the same capacity as a present street, the cost will be about $1,500 per lineal foot, or $2,250,000 per street. This work alone would run into a big sum of money, and it is evident on every hand that in the matter of sewage disposal Chicago has an important subject to deal with.—*Marine Review.*

The Discouragement of Industry.

Judging from the inflammatory editorials, personal attacks, and sensational reports in certain public journals, one of the last things that a man ought to aim at in this land is success and eminence in his business, especially if it be one requiring the investment of a large amount of capital and the employment of a large number of operatives.

Men of large means in such positions at once become the target for sensational journals, who offer absurd suggestions, assail them with personal abuse, or attack them as "robber barons," "purse-proud millionaires," "aristocrats," and the like. Yet these very men have built up great industries, increased the wealth of the community, given employment to thousands, and been liberal in their charities and public gifts.

All that they have done, however, in this direction is forgotten, because while benefiting others they have enriched themselves. They have sinned in being successful, while others with less talent, genius, and brains have failed or plodded on in hopeless mediocrity.

One of the worst features of the disturbance at Homestead has been the pandering to a morbid desire to assail capital, because it is capital, by the sensational press. Indeed, we may say this is not the chief reason; it is well known that the popular side of a question is with the laboring class. There are many employed by one employer. Hence the publishers, seeing a profit in increased daily sales of paper, throw right and principle to the winds, print the most absurd statements to please the excited mass, and do not hesitate to attack in the vilest and most outrageous manner men who have by their exertions added to the wealth of the country and increased its industrial capital and facilities.

Andrew Carnegie, who has created by his active brain a business which employs four or five thousand men, who has given away for the public good gifts to the amount of hundreds of thousands of dollars, has a difference with some 300 out of the 5,000 men with regard to what he considers the value of their services. That value is not to be gauged by the amount of money he is worth, but by the market price of labor. Mr. Carnegie gets no more than the market price for his iron, and if he is to pay more than proper cost of production in wages, he must stop his works, throw thousands of men out of employment, and live on the income of his savings.

If the workman refuses to accept, of course Mr. Carnegie must do the best he can to supply his place at the rate he offers, and one has a perfect right to do so throughout the civilized world. Yet while this question is in abeyance and he is striving to protect his property from illegal occupation and injury, he is held up as a tyrant and an oppressor of the poor, is depicted in public journals as stabbing the workingman with a bloody knife on one hand and giving money to foreign charities on the other.—*Com. Bulletin.*

Tools of the Pyramid Builders.

A two years' study at Gizeh has convinced Mr. Flinders Petrie that the Egyptian stone workers of 4,000 years ago had a surprising acquaintance with what have been considered modern tools. Among the many tools used by the pyramid builders were both solid and tubular drills and straight and circular saws. The drills, like those of to-day, were set with jewels (probably corundum, as the diamond was very scarce), and even lathe tools had such cutting edges. So remarkable was the quality of the tubular drills and the skill of the workmen that the cutting marks in hard granite give no indication of wear of the tool, while a cut of a tenth of an inch was made in the hardest rock at each revolution, and a hole through both the hardest and softest material was bored perfectly smooth and uniform throughout. Of the material and method of making the tools nothing is known.

HIGH-SERVICE WATER TOWER, BROOKLYN.

(*Continued from first page.*)

feet above the street level, the tower extending 58 feet above the top of the tank or water reservoir it contains. The manner in which the reservoir is supported in the tower is shown by the sectional view on this page. The height of the tank is 75 feet, with an inside diameter of 16 feet. It is built up of fifteen rings of boiler iron of varying thickness, the two rings nearest the bottom being half an inch thick, the two next above $\frac{7}{16}$ of an inch, then three rings of $\frac{3}{8}$ of an inch each, three of $\frac{5}{16}$, and five of $\frac{1}{4}$ of a inch each. The iron is of a high grade, and has a tensile strength of 52,000 to 55,000 pounds. The tank is supported upon a flooring of steel girders resting upon masonry piers, the bottom of the tank being 34 feet 7 inches above the foundation.

The flow of water to and from the tank is indicated by the arrows, and the inlet and outlet pipes are each 20 inches in diameter. A short section of pipe connects these pipes, so that water may be pumped directly into the service main without being passed into the reservoir if desired. Within the reservoir is arranged an overflow pipe, adapted to discharge into the old reservoir. The top of the overflow pipe is 12 inches below the top of the reservoir, and in it are arranged four reducing disks or diaphragms, to break the force of the fall of the water in the pipe. The pipe is 10 inches in diameter, and the reducing disks have each a central opening of 6 inches. Fig. 2 shows one of these disks in position, Figs. 2, 3 and 4 also showing the manner of supporting and holding the overflow pipe in place. A spiral staircase, 2 feet 10 inches wide, leads around the tank to an outlook room above, in the top portion of the tower, from which a view of wide extent is afforded.

The pumping plant is to consist of two Davidson high-service pumps, each capable of pumping one and a half million gallons a day. It is expected that the entire cost of this improvement will be about $100,000.

The beautiful memorial arch which forms so prominent a feature of the picture is now very near completion. It has been erected by the city "To the Defenders of the Union, 1861-1865," as indicated by an inscription upon an entablature below the frieze, and is built of light granite. It is 80 feet long, 71 feet high, and 45 feet wide. The top will be reached by stairs in each abutment.

Locomotive Performances.

Almost every one is familiar with the remarkable run recently made by a Schenectady locomotive hauling a special train on the New York Central Railroad, when the distance of 439½ miles from New York to Buffalo was made at an average speed of nearly 60 miles per hour, and which was the precursor of the Empire State express, which makes the regular run at an average speed of over 52 miles per hour.

More recently we have accounts of an interesting record made by a well known writer on two runs between New York and Albany, on which a large number of indicator cards were taken. The weight of the train was about 270 tons. The steam pressure varied from 160 to 170 pounds. From an inspection of about a dozen cards, the indicated horse power varied from 551 horse power at 44 miles to 1,120 horse power at 78·9 miles. At 60 miles per hour the train resistance is stated to have been 15 pounds per ton and at 70 miles 17·10 pounds per ton. About seven pounds of water were evaporated per pound of coal.

A remarkable statement concerning this performance was made by Mr. Sinclair, which, while almost incredible, will, if borne out by an analysis of facts, prove to be something of a surprise to those who make their prophecies of the electric economies by comparative statements.

In the description of these tests it is stated that the whole trip shows an indicated horse power per hour for an average expenditure of only about 3½ pounds of coal per hour. This is far better than many stationary engines.

On the New Jersey Central road one schedule time is 86¼ miles in 89 minutes, which is made where there are a number of necessary slackings. On May 13 the time was taken of the speed of a Baldwin compound locomotive for a considerable period of time on one of the regular runs. Ten continuous miles were made in 452½ seconds, and five were made in 222 seconds. The fastest time taken was 44 seconds and the slowest noted was 47.

On February 26 a similar compound passenger locomotive running on the same road broke all steam records by running a mile in 39¼ seconds, or at the rate of nearly 92 miles per hour.

At this speed the indicator cards showed 930 horse power, and the drivers, which are 78 inches in diameter, were making 395 revolutions per minute.

In making these very high-speed runs there is not much attempt at maximum economy of coal consumption, the necessity being to generate steam as fast as required by the cylinder, but, on taking an average of five trips, I find that there was evaporated 7·19 pounds of water per pound of coal used and 9·41 pounds of water evaporated per pound of coal consumed. The total weight of the train varied from 213 to 241 tons.

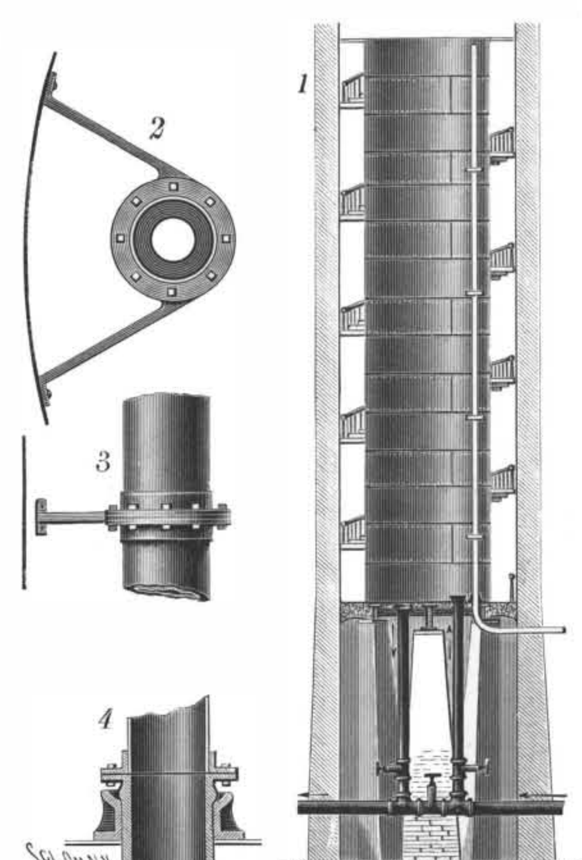
Some time ago I made a very careful analysis of the work done in the elevated roads in New York City, with a view of determining the coal consumption and the duty performed by the locomotives. At the time this investigation was made, now nearly seven years ago, there were in use on the Third Avenue division 63 trains at one time, running at very close intervals. The weight of the train was from 80 to 90 tons; the speed was often as high as 20 to 25 miles an hour; stops were made every third of a mile; in short, the duty demanded of the engines was exceedingly severe.

The maximum indicated horse power of the locomotives was found to average about 163 horse power, although on occasions these locomotives have been worked up to 185 horse power. Work was divided approximately as follows:

Acceleration in starting, 59 per cent; lifting, 24·3 per cent; and traction, 16·7 per cent. The average horse power exerted was 70·3 horse power, considerably less than one-half of the maximum.

The work on the line was so distributed that there was an almost constant total duty of about 4,500 horse power. The locomotives were on duty twenty hours, but used steam only six hours, and including all losses when standing still and the amount of steam used in braking, there was a horse power developed for about 6·2 pounds of coal per hour.

I believe that these figures are entirely reliable, and they show a remarkable performance when we consider the class of duty.



HIGH-SERVICE WATER TOWER—SECTION.

There are, generally speaking, three distinct elements constituting the resistance of train movement on a level, and they have a most important bearing when we consider the operation of long or short trains, and at high speeds. One of these elements is the friction of the train in its bearings; with good rolling stock this is about 8 pounds per ton. For all reasonable speeds it is probably fairly constant, provided the lubrication is good. Another element is that of air resistance, which varies with the shape of the forward end of the train, the condition of the air, the direction of the wind, and the velocity of movement. The third I may call the train-lifting or rail-bending effort, which depends upon the weight and swiftness of the train and solidity of the roadbed.

Dr. Dudley stated that on the New York Central system he found that trains of about 250 tons, when running at a speed of a mile a minute, had a resistance of from 10 to 12 pounds per ton, but that on short trains of two or three cars the resistance sometimes ran as high as 35 or 40 pounds per ton.

This is probably due not to any change in the friction of the bearings, but to the fact that the air resistance enters as a much higher component of the total.

It at once emphasizes the fact that the operation of short trains at high speeds must, no matter how good the track or how favorable all other circumstances, be with a train resistance higher than required by long and well-vestibuled trains.

Mr. Dudley further stated, in speaking of the influence of stiff rails, that the difference in power required on the Chicago Limited when running on an 80 and a 65 pound rail was from 75 to 100 horse power per mile, that is, somewhere between 10 to 12 per cent of the power actually developed, and he estimates that with a 105 pound rail, which is nearly twice as stiff as the 80 pound rail, there would probably be saved another hundred horse power per mile, making a total saving of a quarter by less than doubling the weight of the rail. In his opinion it is perfectly safe to run a steam engine 120 miles an hour on this heavy rail.

Almost all the locomotive work of the United States has been done up to the present with simple engines. Their weight and capacity has been increased, their steam pressure raised until the standard is now about 140 pounds. Within recent years, however, the compound locomotive has come into use, and there is a comparatively large number of them in daily service. The steam pressure has gone up to 180 pounds as a standard, working sometimes as high as 200 pounds, but these are by no means the limits of steam pressure.

On the Paris, Lyons, and Mediterranean Railway the standard for steam pressure for compound locomotives is 250 pounds. The compound locomotive has still its battle to fight, but I think he would be a rash man who would say that the days of still higher steam pressure are not to come and that the triple expansion locomotive will never exist.—*Frank J. Sprague.*

Paving Estimates.

Estimates per square yard for the different kinds of paving for Pacific Avenue, in Tacoma, are as follows:

WOOD.

Size of blocks, nine inches long, three inches wide and six inches deep. If concrete is used for foundation it would be six inches thick, and in the proportion of one part of cement to four parts of sand and six parts broken rock. Estimate for one square yard of wood blocks:

Concrete, six inches thick, at $9 per cubic yard	$1.50
Sand, one inch thick, at $1 per cubic yard	3
Six inch block, fifty-four feet B. M., at $10 per M	54
Labor, 2 cents per square foot	18
Total cost	$2.25

BRICK ON CONCRETE, PER SQUARE YARD.

Concrete, six inches thick, at $9 per cubic yard	$1.50
Sand, one inch thick, at $1	3
Brick on edge (8x5x4), eighty-one brick per square yard, at $14	1.13
Labor, 2 cents per square foot	18
Total cost	$2.84

DOUBLE BRICK PAVEMENT, PER SQUARE YARD.

Gravel, eight inches thick, at $1 per cubic yard	$0.22
Brick, laid flat, forty-one brick, at $14	57
Sand, two inches thick, at $1 per cubic yard	6
Brick on edge, eighty-one brick, at $14	1.13
Labor, per square yard	25
Total cost	$2.23

BITUMINOUS ROCK.

Concrete	$1.54
Bitumen laid in place	1.20
Total cost	$2.74

Florida Moss.

The valuable moss of Florida, says Mr. Harry Bomford, abounds in the hammocks and back lands. It is gathered chiefly by negroes. In its natural state it hangs in festoons from the limbs of trees in strands from one to five feet in length. The moss is gathered by pulling it from the trees with long poles, or by cutting the trees down and then removing it. The moss is buried in the earth for about a month, after which it is dug up and is dried and shaken and sold to the local moss dealers for $1 per hundred pounds. It is then run through a machine called a gin, which is nothing more than a cylinder covered with three-inch spikes revolving between a roll of similar stationary spikes. The action of these spikes is to knock out some of the dirt and trash, but it does not complete the job. It is then shaken over a rack formed of parallel bars, after which it is pressed into bales of about 200 pounds each. Some of the moss mills do all this work by hand, except the ginning. The moss, after having gone through the above process, brings from $2.50 to $3 per hundred pounds.

If, instead of allowing it to remain in the earth for one month, it is left there for three months, the entire bark of the moss is pulled off and there remains a beautiful black fiber almost exactly like hair. The hair moss brings from $5 to $7 per hundred pounds.

Mr. Bomford suggests the treatment of this moss as a good field for invention. He thinks a machine could be made which would take off the bark, leaving the fiber, without the necessity of burying the moss for so long a time in the earth.

Universal Cement.

250·0 sugar placed in a flask are dissolved in 750·0 water by aid of a water bath, 65·0 slaked lime added and the mixture warmed for three days at 70-75° C., agitating repeatedly. After cooling, the supernatant liquid is poured off clear; 200·0 are diluted with 200·0 water and 550·0 finest glue allowed to swell in it for three hours, when it is heated until perfect solution takes place; after restoring the original weight by adding water, 50·0 acetic acid (96 per cent) and 1·0 pure carbolic acid finish the preparation.