worth careful study as a most ingenious piece of mechanism, which possesses many good points. The whole design is neat and substantial, and quite worthy of the high reputation of the Swiss makers.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS.

II. TALLOW.

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

(*Continued from page* 557, *Vol. LXIII.*)

TALLOW is used by railroads principally as a cylinder lubricant. It is also used, to a limited extent, mixed with white lead ground in oil, as a means of protecting the bright work of locomotives and other machinery from corrosion, when from any cause they are taken out of service for a period of time. It is also used somewhat in treating hot boxes on the road, and may be used as a constituent of lubricants. On some railroads tallow-oil is used by preference in place of tallow. The principal use of tallow, however, so far as our knowledge goes, is everywhere as a cylinder lubricant. The amount used for this purpose is so great, that the figures, to one unaccustomed to railroad accounts, seem almost incredible. Any large railroad company may use on its lines, in one year, from 750,000 lbs. to 1,000,000 lbs. of tallow, at a cost of from $60,000 to $80,000, by far the largest portion of this amount being used for cylinder lubrication. It is gratifying to be able to state, that with the introduction of sight-feed cups, the use of tallow as a cylinder lubricant is diminishing largely, and in view of the difficulties which seem to be inseparable from the use of this material, railroad operating officers will certainly welcome the day when its use can be dispensed with entirely.

In order to make clear what follows, it will be necessary to get a full understanding of what tallow is. Speaking chemically, tallow is principally a mixture of three neutral fatty bodies, known as stearin, palmitin, and olein. The stearin is about 61 per cent., the palmitin is about 6 per cent., and the olein is about 33 per cent. of the tallow. The stearin and palmitin are solids at ordinary temperatures, the melting point of stearin being from 123° to 157° Fahrenheit, and of palmitin a little less. Pure olein is a liquid at ordinary temperatures, and becomes hard at something below 40° Fahrenheit. Tallow oil is largely olein mixed, however, with more or less of palmitin and stearin. Each of these three chemical bodies consists of a characteristic acid chemically combined with glycerine, the stearin being stearic acid combined with glycerine, the palmitin, palmitic acid, and the olein, oleic acid combined with glycerine. It is, perhaps, more correct to say that when stearine, palmitin, or olein breaks up, stearic, palmitic, or oleic acid and glycerine are formed, water being absorbed in the process. In other words, stearin is stearic acid combined with glycerine, minus the elements of water, the water separating when the combination takes place. The point which we want to make is that these neutral fatty bodies contain an acid. The glycerine is a small percentage of the total weight of the tallow.

When the fat exists in the animal, at least if the animal is in a healthy condition, the three principal constituents of the tallow are, as stated above, simply neutral fatty bodies, enclosed in little membranous sacs in the fat tissues. In order to secure the tallow, and separate it from the tissues, heat alone is at present made use of—so far as our knowledge goes, at least. It is commonly believed that dilute sulphuric acid is made use of by many country butchers, to help in separating the fat from the tissue, but in our experience we have never seen any evidence that this method was practised. Generally the fat is thrown into either open kettles along with a very small amount of water, and heat applied, or it may be put in a closed vessel, and the heat communicated to the fat by means of steam pipes inside. In either case the same result follows, namely, the membranous tissues are ruptured and shrivel, and allow the melted fat to separate. At the end of the operation both the water added and the water contained in the tissue has disappeared, and the tissue has shriveled to be a very small proportion of the total mass. These shriveled bits of tissues are known commonly as "cracklings." The tallow is separated from the cracklings by straining and pressure, and is usually marketed in barrels containing about 350 to 380 lbs. each. If these operations are performed in the proper way, and under proper conditions, a tallow results which is almost neutral, as will be readily understood, being simply a mixture of the three neutral bodies above mentioned. In practice, however, it is excessively difficult to secure tallow as it was in the animal—a mixture of neutral bodies. Almost all commercial tallow, when examined in the proper way, shows the presence of more or less free acid, and this acid may vary in amount, from possibly 0.50 per cent. up to as high as 5.00 or 6.00 or 10.00 per cent. of the total weight of the tallow.

The acid just referred to is, so far as known, either one of the three acids which are characteristic of stearin, palmitin, and oleine, or mixtures of them. It is difficult to say which one, if either, predominates. We, of course, are speaking in a general way, and ignore the very small amounts of characteristic volatile fat acids which may be in the tallow. The explanation of this free acid in tallow seems to be that from some cause or causes, the glycerine is separated from the neutral bodies of which the tallow is composed. Experiments have been made by determining the amount of free acid under various conditions, and the following causes are believed to be prominent in increasing the amount of free acid in tallow:

First. If the fat is allowed to stand some hours or days before rendering, especially in warm weather, the amount of free acid will be great. This is, perhaps, very easily accounted for by our common knowledge, namely, that after death decomposition immediately sets in, and, so far as known, the first step in the decomposition of tallow is the separation of the fat acid from the glycerine. Whatever the explanation, definite experiments show that if the fat is rendered within, say, three or four hours after the animal is killed, attention being given to the conditions which follow, the amount of free acid may not exceed 0.50 per cent., even in warm weather. Six hours will bring it up to 0.75 per cent., 24 hours to 1.00 or 2.00 per cent., and two or three days may give a tallow containing as high as 5.00 to 8.00 per cent. of free acid.

Second. High heats increase the amount of free acid. It is difficult to say just exactly why, but perhaps the tendency to saponification by means of the water in the tissues is increased by high temperatures, it being well known that the glycerine in fat acids can be completely separated by water if a high temperature and pressure are employed.

Third. The amount of free acid in the tallow is increased when the rendering is done in closed vessels. This has been demonstrated by positive comparative experiments. Tests of tallow rendered in the same apparatus, in the one case the vessel being closed, and in the other the cover being left off, all the other conditions being exactly the same, showed that the tallow rendered in the closed vessel contained the largest amount of free acid. These experiments were made in the steam-jacketed apparatus used in one of the large abattoirs in Philadelphia. This is accounted for in the same way as in the previous case, namely, by the tendency to water saponification in the closed vessel. Those making tallow to be used as a cylinder lubricant, in which the amount of free acid is desired to be as low as possible, will therefore find it greatly to their advantage to render the tallow as soon as possible after the animal is killed, to avoid high heats, and to do the rendering in open vessels. If proper care is exercised in all of these respects, a commercial article can be made which will contain as low as 1.00 per cent. of free acid the year round.

It will be observed that considerable stress has thus far been laid on the question of acid in tallow; the reason for this we will now attempt to make clear.

We are so accustomed to regard fats or greases of any kind as an antidote to corrosion, that it may seem singular to state that tallow under certain conditions may be extremely corrosive to iron. As stated in the first article of this series, one of the first questions investigated in the laboratory at Altoona was to find out why the valves and steam chests corroded so badly. It was not at all uncommon to find a valve, which had been in service not over a year, so eaten through under the valve yoke, that live steam from the steam chest would blow through into the exhaust. Also on removing the steam chest the contact between the steam-chest and the top of the cylinder was frequently found badly corroded, and a collection of blackish material always found. It was first thought that the tallow might contain sulphuric acid, introduced during the rendering, as above described. Careful examination of the black material did not show the presence of sulphates, and consequently this theory had to be abandoned. The steam was next charged with the crime, the well-known corrosion of surface condensers in marine engineering being supposed to be a parallel case. On this supposition, however, it was difficult to see why the corrosion should be so largely confined to the steam chest. The dry-pipes and the branch-pipes had equally the effect of the steam, but in no case was the same characteristic corrosion observed. During all this time the thought was prominent, as above stated, that tallow protected the metal surfaces from corrosion, and accordingly the other hypotheses were exhausted before thinking to take hold of the tallow. This view was strengthened by the fact that the best chemical literature at our disposal did not mention any salts of iron formed by the combination of the fat acids characteristic of tallow with iron. Watt's *Dictionary of Chemistry* gave descriptions of stearates and oleates of copper and other metals, but was silent on the corresponding salts of iron. Accordingly, a definite experiment was made by heating cast-iron borings with samples of stearic, palmitic, and oleic acids, the temperature maintained being that of the ordinary locomotive cylinder. Chemical action began before the temperature of the steam cylinder was reached, and continued in the experiment under consideration, as long as the metal and acid were allowed to remain in contact. The action of the acid on the iron produced a brown-looking stearate, palmitate, or oleate of iron. Corresponding experiments were made with tallow containing various amounts of free acid, and in every case the action of the acid on the iron was evidenced both by the formation of the brown salts above mentioned, and by the loss of weight of the iron borings, when separated from the products of the action. No special study was made of these fat acid salts of iron, the point which we were after, namely, whether the fat acids characteristic of tallow act on iron, being demonstrated. The reason why the products of the action of the tallow on the iron, which are found in the steam chests, are black instead of brown, is apparently due to an admixture of dirt, bits of cinder, etc.

This fact being established, the more important question of providing a remedy came into prominence. Obviously, the most natural remedy that would occur would be simply to neutralize the fat acid of the tallow with some alkali. We found this method already in practice by some of the so-called tallow refiners who were making cylinder tallow for the market. Rather inferior tallow of strong odor, and containing large amounts of free acid, was treated in some of the refineries with caustic soda. The soda and the free acid combined, forming, as is well known, common hard soap, and, of course, if the proportions were right, the amount of free acid in the tallow was entirely neutralized. The resulting cylinder lubricant was therefore a mixture of soap and tallow. This seemed like a very reasonable procedure, and it only remained to prove whether this resulting mixture was injurious to the metal. Positive experiments, quite to our astonishment, showed that the mixture of soap and tallow acted on the iron fully as rapidly, if not more so, than the free acid alone. These experiments were repeated many times, and always with the same result. Very pure tallow, containing almost no free acid, was heated up with iron borings to the proper temperature. If the amount of acid is as small as 0.50 per cent. the action is very slight, apparently due to the fact that there is so small an amount of acid and so large an amount of tallow. On dropping into this mixture a small piece of hard soap the action was increased quite largely, and as the result of all our experimentation, it was concluded that this remedy was worse than the disease. It is, perhaps, difficult to account for this behavior of a mixture of soap and tallow. The most reasonable explanation that we could suggest was that the soda of the soap gives up its acid to the iron, and by so doing is set free in condition to attack some of the tallow, and that this action goes on, of course, as long as either the iron or unsaponified tallow remain.

The experiments in attempting to neutralize the free acid resulted so disastrously that no further experiments were made in this line. It is possible that some base might be found which would not interchange with the iron in the tallow, but we did not carry on any experiments in this line further, except to attempt to combine glycerine with the free acid of the tallow, our reasoning being, that if we could restore the tallow to its neutral condition, by giving it back the glycerine which it had lost, it would be a satisfactory material. These experiments did not result in anything satisfactory, as although the reaction is a possible one, yet the conditions under which glycerine combines with free fat acid are somewhat difficult to control.

The attempts to neutralize the acid not succeeding as a practical measure, it was finally decided to attempt to obtain from the market a tallow containing the least possible amount of free acid, and the conditions leading to the formation of free acid in commercial tallow, as previously described, were somewhat studied. Early in the work on tallow a method of determining the amount of free acid in tallow was found to be a desideratum. The method employed is based on the fact that the free acids of tallow are quite soluble in ordinary alcohol, while the tallow itself is only slightly soluble. After a number of modifications and changes, the method finally adopted is given below, as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Method of Determining Free Acids in Oils and Tallow.

I.—Materials Required.

½ dozen 4-ounce sample bottles.

3 10 cubic centimeter pipettes, or, if desired, a balance weighing milligrams.

1 30 C. C. burette, graduated to tenths [burette-holder if desired], with pinch cock and delivery tube.

2 oz. alcoholic solution of turmeric.

2 qts. 95 per cent. alcohol, to which ½ oz. dry carbonate of soda has been added and thoroughly shaken.

1 qt. caustic potash solution, of such strength that 31½ cubic centimeters exactly neutralizes 5 cubic centimeters of a mixture of sulphuric acid and water, which contains 49 milligrams H_2SO_4 per cubic centimeter.

II.—Operation.

Take about two ounces of the clear alcohol and add a few drops of the turmeric solution, which should color the alcohol red, warm to about 150° Fahrenheit, then add 8.9 grams of the oil to be tested and shake thoroughly. The color of the solution changes to yellow. Fill the burette to the top of the graduation with caustic potash solution, and then run this solution from the burette into the bottle, little at a time, with frequent shaking, until the color changes to red again. The red color must remain after the last thorough shaking. Now read off how many cubic centimeters and tenths of the caustic potash solution have been used, and this figure shows whether the material meets specifications or not.

To determine the free acid in tallow, everything is done exactly as above described, except that the tallow is melted before it is added to the alcohol.

Ten cubic centimeters of extra lard oil, at ordinary temperatures, and the same amount of melted tallow at 100° Fahrenheit, weigh almost exactly 8.9 grams. In ordinary work, therefore, it will probably not be necessary to weigh the oil or tallow. Measurement with a 10-cubic centimeter pipette, will usually be sufficiently accurate, provided the pipette is warmed to about 250° Fahrenheit, and allowed to drain, the last drops being blown out. In case of dispute, however, the balance must be used.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., February 16, 1889.

With regard to above circular it may be explained that the dry carbonate of soda is added to the ordinary commercial alcohol, because almost all commercial alcohol contains small amounts of acid, probably acetic, and, as will be readily understood, this acid would be counted as fat acid in the tallow if it was not neutralized. The addition of the small amount of carbonate of soda obviates this difficulty. The caustic potash solution required can be obtained in the market from any good dealer in chemical supplies. The turmeric solution is simply an indicator, it being well known that when turmeric solution is acid the color is yellow, and when alkaline it changes to a bright red. The use of phenol-phthalein as an indicator, does not give the same results as turmeric, when used with fats which have undergone considerable decomposition. No investigation has been made as to why this is true, nor are we sure which indicator gives the most accurate results.

The method used will doubtless be clearly understood. The fat acid being dissolved in the alcohol, the addition of the caustic potash solution combines with it, forming potash soap, which remains dissolved in the alcohol. When all the acid has been saturated with potash the color of the solution changes to red and the amount of acid is known from the amount of potash solution required. At first we were accustomed to give the results of free acid in percentages by weight, but in view of the fact that there may be any one, or mixtures of three different fat acids present, which acids differ in molecular weight, this method does not give quite accurate results, and was accordingly abandoned. The acceptance or rejection of tallow or oils in which the acid is determined, is now based upon the amount of standard alkali required to neutralize the acid. The limiting figures given in the specifications for tallow below do not differ far from 1.50 per cent. by weight of free acid in the tallow.

As the result of the whole study of this subject, including the method of determining free acid, and the conditions which lead to the formation of free acid in commercial tallow, as already described, specifications were prepared, and an attempt made to secure tallow in accordance with them. As has proven true in almost every case of new specifications issued by the Pennsylvania Railroad Company, during the last 14 years, considerable difficulty was experienced at first in getting material that would fill the requirements. Those who were rendering tallow had not been accustomed to have any careful examination of their product made, and many of them were very careless indeed. During the first six or eight months after the specifications were issued, it was found excessively difficult to get tallow enough, that would fill requirements, to supply the road. Gradually, however, as the manufacturers have learned to treat the material better, and especially to render the tallow quickly after killing the animal, the difficulties have disappeared, and for a long time very few rejections of tallow have taken place. The specifications first issued were revised from time to time as new information was obtained. The copy given below represents the specifications now in force. It is gratifying to be able to state, that although the specifications do not give a tallow for use in steam cylinders which entirely obviates corrosion, as above described, the first issue of tallow specifications was followed by a large diminution in the replacing of valves. After the specifications had been in force nearly two years the different Master Mechanics of the road were requested to state how the valves were behaving compared with the two years previous, without knowing what this information was desired for. In every case the statement came back that there was not as much trouble with corrosion of valves as had previously been experienced. The experience of the past six or eight years has confirmed this view, and it is, perhaps, not too much to say that from being a very annoying source of trouble, the repair of valves has diminished to a very insignificant item.

It is not hoped, however, that the specifications for tallow will ever entirely prevent the difficulty. As long as the tallow contains any free acid there will be some corrosion. Mixing high fire-test petroleum with tallow, as has been done in many cases for cylinder lubricant, is advantageous in diminishing the amount of free acid in the mixture. As already stated, the use of sight-feed lubricators, which use an oil containing very small amounts of any fatty acid, and which diminish largely the amount of lubricant used, will, undoubtedly, sooner or later, make any serious difficulty of valve or steam-chest corrosion a thing of the past. The present tallow specifications are as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Tallow.

Tallow for use in locomotive cylinders should contain the least possible amount of free acid, and should, at the same time, be as free as possible from dirt, *cracklings*, and fiber. In order to secure such tallow the following specifications have been adopted:

1. Tallow which, on inspection, is found to contain dirt or *cracklings* disseminated through it, or in streaks, or which has a layer of dirt or *cracklings* in the bottom of the barrel more than an eighth of an inch thick, will be rejected.

2. Tallow containing more free acid than is neutralized by three cubic centimeters of standard alkali will be rejected. The standard alkali, and directions for determining free acid are given in the circular, "Method of Determining Free Acids in Oils and Tallow," which will be furnished on application.

3. Tallow containing soap, or other substances not properly belonging to tallow, will be rejected.

To persons furnishing tallow, who may not have appliances for determining the amount of free acid in tallow, it may be said, that if the fat is rendered within twelve (12) hours from the time the animal is killed, using a temperature of not more than 225° to 250° Fahrenheit during the rendering, it is believed that the free acid in the tallow will be less than amount specified above. In very warm weather it may be necessary to render the fat in less than twelve (12) hours after the animal is killed.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., January 24, 1883.

The reason for each of the requirements in above specifications are, perhaps, all sufficiently evident from what has preceded. It is often found that tallow received from the country butchers contains rather large amounts of cracklings in a fine state of division. This results from using severe pressure in separating the tallow from the cracklings. Of course this material is inferior, and it is necessary to put a limit on the amount received. The examination of tallow, for soap and other impurities, is usually made by burning off the tallow, the soda of the soap remaining behind. Our experience for several years now indicates that there is very little attempt made in the market at present to remove the free acid by neutralization. The ordinary adulterations of tallow in the market are the addition of makeweights, consisting of soapstone, tripoli, or other substances of similar nature, and the admixture with the tallow of other fatty bodies or oils. In our experience it is very rare that a makeweight of any kind is added. If a barrel of tallow weighs over 380 lbs., exclusive of the barrel, it is a suspicious circumstance. Of course the amount of makeweight, if it is mineral matter, can be determined by burning the tallow and weighing the residue, or if soap is absent, by dissolving out the fat in ether or gasolene and weighing the residue.

Quite early in our work on tallow we found serious adulteration arising from the addition of petroleum products to the tallow. In one case no less than 20 per cent. of the weight of the tallow as received, was simply what is known in the market at present as paraffine oil, and what was known at that time as neutral oil. Nearly half of the oil added to the tallow became a vapor at the temperature of the steam cylinders, and, consequently, was worthless for lubrication. In addition to this, the oil cost in the market at that time three or four cents per pound, while the tallow was being sold at 11 cents per pound. This kind of adulteration is very rarely attempted at present, and is readily detected both by the change of color of the tallow, if any of the cheaper grades of petroleum are used, and by a quantitative saponification by well-known chemical methods, if any white non-saponifiable substance is the adulterant.

A very peculiar treatment of tallow arose in our experience some years ago, consisting in this: On a certain railroad, to which a certain dealer was furnishing tallow, the little bits of the ends of the candles used in car lighting were sold to the dealer. He, very innocently, as is believed, melted up these bits of candles, added them to the tallow, and then sold the tallow to the railroad company, to be used as cylinder lubricant. This, of course, would cause those who are well informed on the subject to smile, since the ordinary car candle is pure and simple stearic acid, as near as it can be obtained pure in a commercial process, and in reality the dealer was adding to the tallow what the chemist had for some time been studying how to exclude from it. An examination made of several samples of this tallow showed free acid as high as 15.00 to 20.00 per cent., which is what we would expect. There was no attempt at concealment in this case; indeed, the practice was well known to the officers of the road, and it could hardly be classed as an adulteration, but as, rather, one of those cases which show the value of a little chemical knowledge in railroad operation. It is hardly necessary to add that the practice was abandoned as soon as the free acid determinations were made.

As stated at the outset, the use of tallow as cylinder lubricant is largely diminishing, and it is probable that within a few years its use will disappear almost entirely. For the benefit of those who are gradually going out of the use of tallow, it may, perhaps, be stated, that if the change is made suddenly from tallow to any of the well-known cylinder lubricants, very serious difficulties are apt to result. The reason for this is that most of the cylinder lubricants of the market consist largely of high fire-test petroleum, which petroleum is a solvent for the binding material of the black substance which, as has been previously described, is contained in the cavities of the valve, and around the edges where the steam chest joins to the cylinder, and also to the steam chest lid. The dissolving out of this substance sets free a large amount of grit and other material which gets between the surfaces and increases the friction enormously. An attempt to use petroleum alone as a cylinder lubricant on engines which had previously been using tallow, might result in breaking the rocker-shafts, and would certainly seriously strain the valve gear. This difficulty can be avoided if the change from tallow to cylinder lubricant is made gradually. Mix with the cylinder lubricant at least one-half extra lard oil for the first month, and gradually diminish the amount of lard oil from month to month. This subject will be referred to again under the head of Cylinder Lubricant.

(TO BE CONTINUED.)

THE NEW TORCY RESERVOIR.

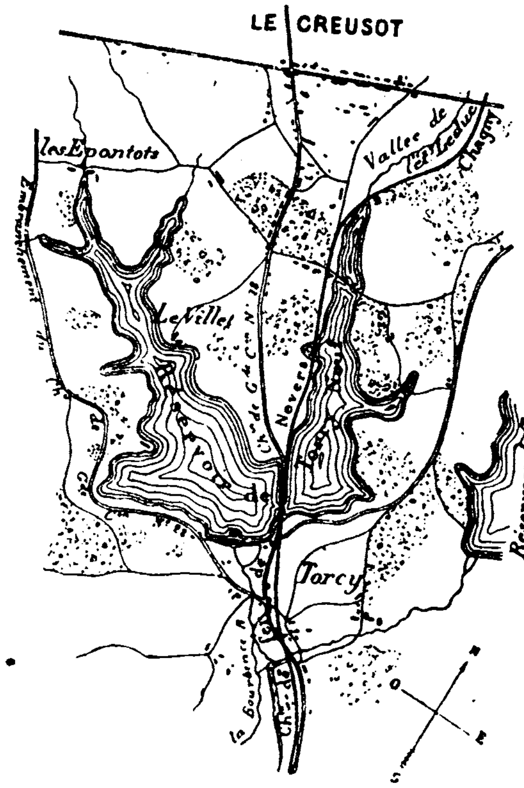
THE great works undertaken in 1881 by the French Government on the Canal du Centre had for their object the enlargement of the cross-section of the canal and the lengthening of the locks. As a consequence it became necessary to increase the supply of water for the canal, and for that purpose a new reservoir has been constructed at Torcy, in the neighborhood of the great steel works of Creusot. This work was begun in the year 1883 and was finally completed and the reservoir filled in July, 1888. To distinguish it from the old reservoir near by, it is called the New Torcy Reservoir. It is situated a little over three miles from the main line of the canal, and the dam is near the village of Torcy. In the accompanying illustrations, fig. 1 is a map showing the position and plan of the reservoir.

The bottom of the reservoir is principally red sandstone, a rock which underlies much of the ground in the vicinity. The surface overflowed is about 412 acres; the reservoir itself is 9.32 miles in circumference; the greatest depth 47½ ft., and the storage capacity 309,600,000 cub. ft. With this assistance the supply of water for the summit level of the canal will be about doubled in the dryest season.

At one end of the dam a channel 39.3 ft. wide is provided for overflowing water. At the end of the dam also a watchman's house and storehouse are erected.

The dam itself, which at both ends is strongly anchored to the hill-side, is built of well-mixed clay and sand well rammed together, the mixture being about 66 per cent. of sand and 34 per cent. of clay. Its total length is 1,432 ft.; width at the top, 8.04 ft.; at the bottom, in the deepest part, 173.5 ft.; the greatest height is 43.5 ft., and the cubic contents of the dam are about 168,700 cub. yds. The slope of the dam on the water side is faced with masonry work 1.64 ft. thick, which is built upon a bed of broken stone and concrete and which rise, as shown in fig. 2, at an angle of 45° in steps 4.92 ft. in height broken by flat berms or treads 2.95 ft. in width. The outer side of the dam, which is built with a slope of 1 : 2.73, is not faced, but to a height of some 16.5 ft. from the bottom is

Fig. 1.



planted with acacias. The top of the dam, which is 5.9 ft. above the highest level of the water, is faced with stone, which is a continuation of the masonry work on the inner side, and across the top runs a wall 3.94 ft. in height.

On the water side, for the whole length of the dam, runs a bed of masonry about 5 ft. in depth upon which the bottom of the facing masonry rests, and which is carried 3.28 ft. below the surface of the ground. Before building this masonry, or beginning the construction of the dam, the ground was carefully cleared off to the rock, and in addition two trenches 3.28 ft. in depth were carried the whole length of the dam in order to provide a better connection between the ground and the dam itself.

The clay for the dam was laid in layers 4 in. thick, and then rolled down hard with steam and horse rollers. In building it was found that with a steam roller weighing about 5 tons, about 650 cub. yds. could be rolled in a day's work. The cost of putting in place and rolling down the material for the dam was 3.35 cents per cubic yard.

The bottom of the waste canal is 2.3 ft. below the usual level of the water. This canal is closed by wooden gates, which open automatically when the water rises above a certain level. The out-take, or channel, through which the water is drawn from the reservoir, is through a water tower, which is built up from the base of the dam on the water side, and which is also used as an overflow or outlet for