alumina in the form of ammonia alum, together with 100 mgms. of phosphorus pentoxide in the form of sodium phosphate and the mixture treated as were those containing iron. The two precipitates of aluminum oxide finally obtained, weighed respectively 28.9 and 29.3 mgms., showing a large minus error. Another set containing 400 mgms. of lime was run through. The same precipitation of calcium molybdate was found to occur. The weights of alumina obtained were but 19.8 and 20.6 mgms. respectively, showing a much larger minus error.

From the above surprisingly bad results it is shown conclusively that the molybdate method for iron oxide and alumina, at least in this form is not at all trustworthy. Yet I have myself at times, and so have others, obtained good results by its use where these results were checked against those made by some of the standard methods used in delicate work.

SOME PRACTICAL POINTS IN THE MANUFACTURE OF NITROGLYCEROL.[1]

BY J. E. BLOMÉN, PH.D.

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FROM the very beginning of the commercial manufacture of nitroglycerol the aim of the inventors and manufacturers has been to eliminate the dangers of the operation to the highest possible extent and they have been so successful in this that very few, if any of the many accidents on record can be traced back to the apparatus. The problem is simple enough as the reaction is easily controlled. The indications of approaching danger are clear and the means to avoid it are easily kept at hand. From the old wooden boxes worked by hand with a paddle-wheel to the present elaborate apparatus, the principle is the same—to secure an even and low temperature through the mass of the mixture of acids and nitroglycerol.

It has long been considered that the safest way of stirring is with compressed air, but this can hardly be taken as an axiom. The water, which is formed during the reaction, is of the same temperature as the mixture and does not tend to elevate the temperature, but the moisture brought in with the air certainly does

[1] Read at the Boston Meeting, December 27, 1894.

raise the temperature as soon as it comes in contact with the acid. To prove this point air of the temperature of 82° F. was passed for five hours through a mixture of nitroglycerol acids (three-fifths sulphuric acid to two-fifths nitric acid) of 86° for five hours. After thirty minutes the temperature had risen to 92°, after one hour to 93½°, after two hours to 94°, after three hours to 94¾°, after four hours to 95½°, and after five hours to 95¾°, the temperature of the air remaining constant and the barometric pressure being 762 mm. during the entire experiment.

The apparatus is necessarily far away from the air-compressor and the air therefor has to be carried in pipes for a considerable distance. If then, as frequently happens, the moisture of the air (when not used for stirring) is condensed a considerable quantity of water is forced into the said mixture at one time and it becomes difficult to control the apparatus. Besides a stoppage in the pipe-line may take place at any time—for instance from a bad leakage, from an ice-plug or other substances in a pipe-section, or something may suddenly happen to the air-compressor. For these reasons it is doubtful if this system has any advantage over a stirrer or serpentine screw operated by an engine close at hand and which can be supervised by the operator. The latter way is besides decidedly the more economical as the moisture in the air (most of which comes in at the beginning of the operation) tends to dilute the acid mixture at the time when it is most important that the latter should be as strong as possible and the continuous forcing of warm air through nitric acid cannot but weaken this to a considerable extent.

It is true that when air is used the cooling surface can be better distributed by means of a number of smaller coils through the whole apparatus, but quite sufficient cooling surface is obtained by one big coil (embracing the serpentine screw or paddle-stirrer) when the mixture of the nitroglycerol acids is continually thrown against this and the sides of the apparatus cooled off by a water-jacket.

The question of how big a charge should be used at one time has been a matter of considerable controversy between expert nitroglycerol manufacturers. Of course it would be of the greatest advantage and convenience to use an apparatus big enough

to make one day's output of nitroglycerol in one operation, but this is hardly practical. It seems to be the experience of manufacturing chemists that very few chemical reactions can be effected with advantage on a very large scale; the nearer the operations come to the laboratory conditions the better is the result. This maxim is particularly true in this case. The dilution of the acids by the water formed is considerable — $C_3H_5-O_3H_3+3(H-O-NO_2)=C_3H_5-O_3-(NO_2)_3+3H_2O$ — and the acid mixture is consequently rapidly weakened. This cannot but have a serious effect on the reaction and if a very big charge is operated the acid mixture necessarily becomes uneconomical in composition. If air is used for stirring, of course, that will also weaken the mixture the longer it is used. Furthermore the acids will always find some little nook or corner of the apparatus—be this of lead or iron—that is weak and in a short time it will act upon it so that the apparatus must be repaired or renewed, and if it then is very big, the trouble and cost this will cause is obvious. Besides, if a charge should need to be drowned, as will happen, the loss is heavy.

On the other hand a charge should not be made too small, because it would take too much time and labor to cool off the acid mixture and rearrange the operation. A convenient charge to operate is one that will take one drum of the acid at a time. One drum holds about (or can by contract be made to hold exactly) 1,500 pounds of mixed acids. Experience has shown that the best composition of acids is three-fifths of the strongest sulphuric acid to two-fifths of the strongest possible nitric acid and 1,500 pounds of this mixture will nearly fill an ordinary iron drum. It has further been proved that it takes a little more than seven pounds of this mixture to each pound of glycerol to obtain a good yield of nitroglycerol. If therefore the apparatus is constructed for a charge of one drum (1,500 pounds) mixed acids and 210 pounds glycerol, it seems to meet the requirements of both practical and theoretical conditions. Of course, the size of the apparatus has to be such as not to allow any undue pressure to be exerted on the charge by confining the mixture and not so large as to allow a play of waste acid fumes to attack a large surface on the top portion of the apparatus.

Of late some so-called continuous apparatus have been proposed. I have never seen one in operation and cannot judge of their practicability. Knowing, however, how difficult it is to get the acid mixture uniform (on account of stratification of the acids), I doubt if they prove economical. If the jets of glycerol and acid mixture meet it is of the utmost importance that the latter should be of uniform composition and the difficulty of getting it so is within the experience of every manufacturer of nitroglycerol. If the acid is not continually stirred it will lack uniformity, and give a low yield, the temperature will fluctuate to a great extent and the danger of the manipulation will be greatly increased. Besides a small jet is easily stopped up and then in a few seconds the point of safety is overstepped.

SEPARATORS.

Formerly, when the cost of the nitroglycerol was of less importance; the nuisance of strongly acidulated water was not considered; and the yield was not all important; the charge was always drowned immediately after it was made. Now it is necessary to recover the "spent" acids, both for the reason of economy and so as to avoid the accumulation of acids, which otherwise would destroy whole tracts of land. On a small scale, when the apparatus only has to be used two or three times a day, it can also be used as a separator, but usually this is not the case, and such a number of separators has to be used as will permit the first one being emptied while the last one is being charged. For this reason the size of a separator ought to be such that it will hold exactly one charge of the converter.

The forms of separators have varied from that of a square box to that of a cylinder and a funnel. As they are generally made of heavy lead it is of advantage to present as few seams and corners as possible, and for this reason they should be made round so that only one seam is necessary. The funnel-shaped undoubtedly possesses several advantages, such as easy separation, but it takes too much space and must be made too deep to be convenient, if the nitroglycerol is to be skimmed off. An ordinary wooden tub, lined with heavy lead (ten pounds to the square foot), which at the bottom has an inclination of about six inches, or is drawn to a funnel-shape, answers the purpose very well.

The faucets of the separators, as well as of the apparatus, ought to be of earthenware, perfectly ground and well greased with vaseline, but the place to put them is hard to determine. The separation line of the nitroglycerol from the acids, varies considerably, partly on account of the difference in yield and partly because the amount of acid used frequently varies from three to four inches.

If the upper funnel be too high up it frequently happens that several inches of nitroglycerol remain and have to be dipped, and if it be too low the amount of acid drawn off would be a source of danger in the wash-house. If the charge is not too big the "dipping off" is accomplished in a short time and the constant stirring of the dipping pan (an enameled iron casserole) in the nitroglycerol helps the separation considerably. It is, however, necessary to have an experienced man in the separating room as the greatest loss is here, if the skimming is not conducted with the most scrupulous care. In most cases it is preferable to dip besides having faucets as every one of them, being brittle as they are, considerably increase the danger from breaking. The separation ought to be accomplished in an hour and a half. If it is not, the glycerol used has been inferior or the operation in the apparatus has been faulty. If the glycerol contains calcium or other alkaline salts and fatty acids there will be found a great number of worm-like particles floating up and down, mechanically carrying nitroglycerol to the acids and *vice versa*, and the charge had better be drowned. The last two inches in the separator should be drowned as it always contains enough acid to considerably raise the temperature of the first wash-water and here is where the funnel, the spout, or the inclined bottom is of advantage as it only allows a narrow separating belt. If the charge is run down in the separator at 17° to 19° C., it scarcely, if ever happens that the temperature rises again to any dangerous degree. It is indeed very rare that it happens that the temperature varies to a dangerous degree in the separators, but it is of the utmost importance to guard against such an occurrence and it ought to be made compulsory for the man in charge to note down the temperature registered at the thermometers in each separator every fifteen minutes, and any neglect

or omission in this respect should be followed by immediate dismissal, as it possibly endangers the life of every one connected with the manufacture.

Before the charge is allowed to leave the separator-house it should be immersed in, and for a few minutes stirred, with cold water, both for the reason of security and economy; of security, because the nitroglycerol mixed with even a small quantity of acid is liable to explode in the pipes in case a friction should take place, or some water be present to raise the temperature of the adherent acid and of economy, because the first wash-water will invariably carry along some nitroglycerol, which ought to go to the drowning tank where it will settle at the bottom of the tank.

WASH-HOUSE.

When it is considered how very important a thorough washing of the nitroglycerol is, what danger a poorly or insufficiently washed nitroglycerol is in the process of manufacture, and that it is an ever-increasing source of danger the longer it is stored, the question of a proper wash-house is one of great importance. As to the form of wash-tubs, the conical one is undoubtedly the best. This form admits the broadest possible surface of contact, it prevents any water coming with the nitroglycerol when it is drawn off, and affords a good opportunity for skimming or drawing off the wash-water. The size need not be larger than to easily accommodate one-half of the charge, because the man who washes has plenty of time to do this when the charges are settling. The wash-tubs as well as the faucets can be of wood (preferably cedar), which should be free from knot-holes, as so little acid comes along when a charge is well separated and has had a preliminary washing in the separator-house that it cannot attack the wood. When a charge is let down the water ought to be let down slowly and from a coil at the side of the wash-tub so as to give it an opportunity to bubble through the nitroglycerol.

If compressed air is to be had, that is, of course, the preferable stirrer, otherwise wooden stirrers can well be used. To prevent waste the wash-water, when drawn off, ought to be allowed to stand in a big tank as it always carries some nitroglycerol along, which will be deposited at the bottom of the tank and should be

taken out at least once a week. The amount of water to be used depends, of course, upon the size of the charge, but twice the volume of the nitroglycerol is certainly enough under all circumstances. If the charge has been well separated and a preliminary washing has been given it one washing will be enough. The last trace of acid should now be taken out. For this purpose a weak alkali solution is used. It is a convenient arrangement to have this solution in a tub set up somewhat higher than the wash-tub and let it run in by gravity, preferably through the coil which is used for the wash-water. If the water in this tub is kept at 30° to 35° C. and the water at this temperature is nearly saturated with sal-soda or if about five pounds of soda-ash are used to about fifty gallons of water the solution is of proper strength. Of this solution I have found that it takes about two pails to remove the last traces of acid in about 460 pounds of nitroglycerol. After the soda solution is drawn off the nitroglycerol should have one thorough washing with water and then it ought to be ready for use. To ascertain this, however, each and every charge should be tested. This of course can be done with any one of the ordinary indicators and the choice of one depends upon the intelligence and education of the man in charge of the washing. For any ordinary workman I would recommend the use of very carefully prepared litmus paper. This is more easily handled than most indicators and is quite sensitive. It must be kept in well-corked bottles and out of the acid fumes. The liquid indicators generally require more skill than the man in charge can be depended on to exercise. Two like strips of litmus paper should be used at one time, one dipped in a little distilled water (which the steam on hand always can furnish) and the other in the nitroglycerol and then be compared. When the wash-water tank is cleaned it will be found that a spongy, dark-gray substance has accumulated. This consists chiefly of salts from alkalies and fatty acids, and holds mechanically a good deal of nitroglycerol. To get this out a felt filter can be used, and by letting it stand long enough in this a good deal of nitroglycerol is obtained.

It is difficult to give a rule for the size of the drowning-tank. This depends upon the size of the converter and the charge used;

the amount and composition of the acid mixture; the size of the separators and somewhat on the temperature of the water available. It must be large enough to allow one full charge to be drowned without the least danger. It would seem as if the larger the tank the greater the safety, but that is not so. If the tank is very big the very large amount of water it holds exerts a pressure, which is likely to spring either the bottom staves or the sides, or the faucets, and if this is done and the acidulated nitroglycerol comes in a crevice not reached by the water, it immediately attacks the wood, generating a heat which sets the nitroglycerol afire and the danger is considerable. It is hard to empty and clean a very large tank; such a tank will last a shorter time than a smaller one, and when it is to be replaced the cost is considerable and the time required, during which the manufacture must cease, is long. On the other hand, if the tank is too small, it is dangerous to drown a full charge; the water in the tank is always strongly acidulated from the last inches of the separators, which must be drowned and is consequently hard to dispose of and constant and tedious cleanings must be made. With these points in view it seems to me to be the best arrangement to have two medium-sized tanks for drowning-tubs connected in such a way that they are in constant communication but will allow each one to be disconnected from the other and connected with the apparatus, separators, and wash-house separately. The size of each one need then only be such that one alone will be enough for an emergency during the short time required to repair the other.

To ascertain the cost of the powder, to be able to check the carefulness of the men, and to rightly regulate the daily output it is of importance that the yield of nitroglycerol and the amount on hand can be easily ascertained at any time. I have found it convenient for this purpose to have the storage tank placed on a large platform scale, where it can be weighed at any time. It is weighed, the amount of nitroglycerol taken out since the last weighing is calculated from the formulas of the powder produced; the weight of tank and nitroglycerol at previous weighing deducted; and this amount divided by the number of charges run down; an average yield will thus be had. The storage tank

—to fit the platform scale—should be a square lead-lined box, and of such a size that it will hold enough nitroglycerol for the manufacture of high-grade dynamite even if three charges should be delayed in converter, separators, or wash-house.

I have found it most convenient to draw the nitroglycerol from the storage tank by means of a rubber hose long enough to reach the top of the tank when raised. If this hose be fastened by a clamp to the upper part of the tank it will not be necessary to have a faucet which must be turned every time a bucket is drawn and which is likely to give rise to considerable friction. By bending the hose sharply between both hands the nitroglycerol will be shut off until the end of the hose reaches the bucket, placed on a small platform scale some distance away, when it can be let down carefully in any desired stream simply by relieving the pressure. The mouth of the hose should, of course, be carefully wiped off before being put back into position.

The problem of conveying the nitroglycerol in the most careful manner from one house to another and from the storage-tank to the mixing-house is one that is astonishingly neglected in most powder works and yet it is one of the utmost importance. It is imperative that no communication by hose, pipes, or trays should exist between the buildings except during the time actually taken to run a charge from one to the other. In case of explosion or fire in one of the buildings the whole factory is doomed to destruction if connections exist between the buildings, but if the connections are cut off the plant can, without difficulty, be so constructed as to make one building independent of the other, as Professor Munroe's valuable experiments have clearly shown, that nitroglycerol is less liable to sympathetic explosion than was generally considered. The converter should be in direct communication with the drowning-tank, and not be allowed, as is so very frequently the case, to communicate with this by the way of the separating-house. This connection may be permanent as the danger of explosion in the drowning-tank is small, but for the sake of additional safety, may be broken near the apparatus. The connection between the apparatus and the separating-house may be made either of lead pipes or rubber hose, but in both cases it should be broken off at an equal distance

from both buildings, a space of at least twelve feet allowed between the ends of the pipes or hose, connection being made between the ends only when a charge is let down and disconnected as soon as the charge is down, and the upper end should terminate in a small lead-lined box to receive drippings. The same conditions should be observed between the separating-house and wash-house, and between the wash-house and storage-tank, and any failure to immediately disconnect the line after use should be severely reprimanded and repetition followed by dismissal. The connecting and disconnecting can be very easily accomplished by a piece of rubber hose and two short glass tubes.

To convey the nitroglycerol from the storage-tank to the mixing-houses pails are almost invariably used. These pails were formerly either of lead or of leather but indurated fiber buckets may be used, if precaution is taken to tare the buckets at least once a week since they are affected to a certain extent by the nitroglycerol.

It is necessary that the nitroglycerol plant with the storage-tank be kept at a considerable distance from the mixing or dynamite manufacturing plant and consequently these buckets have to be carried a long way. The rule not to have any connections between the houses is still more forcible when the connection between the storage-tank and the mixing-houses is considered; no pipe line between the plants should be admissible. In most cases the men have to carry these buckets by hand and a close supervision should be kept to ascertain that the men are careful in doing this, especially in slippery weather. Acting on the suggestion of Professor Munroe some three years ago Messrs. Roebling & Sons built a trolley system to carry the nitroglycerol from the storage-tank to five different mixing-houses at the Forcite Powder Manufacturing Co.'s plant, in Hopatcong, N. J., and this plant worked perfectly satisfactory.

In the construction of a nitroglycerol plant it has always been maintained that it should be so located that the nitroglycerol may run down by gravitation from the converter to the storage-tank. It is well and good if this can be done without inconvenience but it is in no way any absolute necessity, as it can easily

be arranged to press the nitroglycerol from one building to another with compressed air without any great cost and with perfect safety. The mixed acids should, if possible, be cooled off for some time in a place higher than the top of the converter, and if the time it takes to run a charge is allowed for in cooling the acids for the subsequent charge they will not need to be cooled off in the converter, which would otherwise delay the running, considerably. As the glycerol almost invariably has to be warmed before using to assure an even flow and as this operation can easily be done in the converter-house, it is necessary to afterwards press up the glycerol required to a receiver above the apparatus.

The safe distance between the buildings depends partly upon the nature of the ground, partly upon the amount kept in a building at one time, and partly upon the construction of the buildings themselves. The drowning-tank should be as near the converting-house and the separating-house as possible and so low as to assure the rapid discharge of a charge. If the ground is hard the shock of an explosion is more easily carried from one building to another than if it is soft or marshy and the buildings have then to be further apart. If the nature of the ground allows a natural protection of one house from another, or if artificial banks can be built between and at some distance from the houses the latter can, of course, be closer than when unprotected. The buildings ought to be constructed in the lightest possible manner so as to afford little resistance to an explosion, which would otherwise be too powerful. All the buildings must be ceiled and in every way so protected as to assure as even a temperature as possible, but the foundation, the framework, the roof, etc., can be of a very light material. In the separating-house, as well as in the wash-house it is to be recommended that the floor be lined with lead, as this materially assists in keeping the house scrupulously clean and prevents any acidulated nitroglycerol from creeping in between joints, a thing that must be carefully avoided.

To obtain a good yield of nitroglycerol, that is, to make powder economically, the materials selected must be of the best quality or rather of the most suitable quality for the purpose.

To obtain and maintain this there is only one way open to the manufacture; *viz.*, to let a chemist of experience and standing draw up specifications for the acid mixture and the glycerol and to employ a chemist to see that the specifications are rigidly enforced. Some of the more prominent powder works in this country have now such specifications drawn and it would be of great benefit to the trade in general if they should be published so as to lay down a normal rule for the contractors. In this connection I wish to state that whenever it is practicable it is, without doubt, the most economical and best plan for dynamite works to make their own nitric acid. The iron drums, in which the acid mixture comes, are not affected by sulphuric acid but no one ever claimed that they are not affected by nitric acid, and it is hard to see why this should not be the case even when the nitric acid is mixed up with the sulphuric as it can hardly be claimed that the sulphuric acid is a preventive against such attack. It is so frequently lost sight of by manufacturers that the sulphuric and nitric acids are simply a mechanical mixture in which each one retains its peculiar chemical properties, and not a compound different from anything else. This mixture stratifies by standing, the nitric acid corrodes the drums, which are consequently weakened, and, worst of all, it may not be uniform in composition. The contractors frequently mix the acid in tanks in sufficient quantity to fill two or three car-loads. This mixture, which is drawn from the tanks to the drums, must, by necessity, be lacking in uniformity as the specific gravity of the sulphuric acid is so much higher than that of the nitric. It has come within my experience that when the supply of acid mixture was delivered at the beginning of the month instead of being distributed in weekly deliverances, the acid mixture in the drums which have been lying for four weeks has been very much inferior to that which was used in the beginning of the month and that consequently a bad yield resulted. If there were no other reason existing than that of getting a uniform mixture of acids it would be sufficient to advocate the erection of a nitric acid plant, but besides that it is decidedly more economical to have such a plant and it makes the manufacturer more independent both of contractors and of freight service.

To test the stratification of the acid mixture some glass jars four feet high and four inches in diameter were filled with an acid mixture of sixty-five per cent. sulphuric acid to thirty-five per cent. nitric acid and the mixture allowed to stand undisturbed for some time. In four days the color of the upper four to five inches had changed from a pale yellow to a brown color. After six days standing a sample taken six inches from the top had the composition of thirty-eight per cent. nitric acid and sixty-one per cent. sulphuric acid, and after twelve days an analysis gave thirty-nine per cent. nitric acid and 58.4 per cent. sulphuric acid. A sample taken at the bottom of a jar after six days standing gave sixty-eight per cent. of sulphuric acid and thirty-two per cent. of nitric acid, and after twelve days such a sample gave seventy per cent. of sulphuric acid and 29.3 per cent. of nitric acid. These figures represent the average of a number of analyses.

What is to be done with the spent acids and where to run the acidulated water from the drowning-tank and the wash-house are questions which well deserve attention. There exist at present three ways of using the "waste" acids each one of which has some merits. In Europe these acids are most frequently used for the manufacture of fertilizers. Where other fertilizing materials are scarce and insoluble phosphates are plentiful it is natural that the use of this acid for the conversion to soluble phosphate should flourish. The most usual way to utilize the "spent" acid in the United States has hitherto been to "regain" it. The ordinary way of doing this has been to pass the acid mixture through towers filled with coke or bricks where it is met by a jet of steam, which carries the nitric acid through the top of the tower and to receivers, leaving the sulphuric acid to run down to the bottom. The waste of this process is obvious. The sulphuric acid is diluted to such a degree as to make it almost valueless, and the nitric acid rarely acquires a strength of more than 32° to 34° B. The acids in the waste acid mixture has still considerable strength, and to dilute them in order to "regain" them is uneconomical. The third way is to use the mixture direct for the production of nitric acid. It contains nitric acid of the strongest kind, as all the water formed during the reaction has

been taken up by the sulphuric acid, and the sulphuric acid itself has not been diluted to such a degree that it is unsuited for nitric acid manufacture. If the mixed acids, therefore, be added to a charge of sodium nitrate and strong sulphuric acid, almost all of the nitric acid will be recovered. The objection always raised to this plan is that the mixture may contain some traces of nitroglycerol, which would endanger the process. In answer to this it can be said, first, that very little nitroglycerol need be present if the separation has been carefully conducted, and if the acid has been allowed to stand (preferably cooled) for some time before using; secondly, that the very small amount remaining can be exploded by detonating a strong cap in the vessel in which it is stored before using; and thirdly, that even if present in a considerable degree in the retort it would all be decomposed there by the sulphides formed, which are the best decomposers of nitroglycerol known. This way of utilizing the "waste" acid is one of the most economical that can be devised. Unfortunately, however, it only applies to factories having nitric acid works of their own. If the waste acid is kept in iron vessels with free access of air, the vessel will soon be attacked, but if the air is excluded it is not affected. I was brought to this conclusion by observing acid drums a few years ago and to ascertain how far this was true the following experiment was carried on: A small iron still, previously weighed and heated with an iron coil was filled to two-thirds with "waste" acids and connected with a vacuum pump. The acids were now boiled down to about one-half of the still by steam-heat in vacuo. The acid was tested and it was found that the sulphuric acid was of sufficient strength for immediate use and the nitric acid was as strong as before using, but about twenty-four per cent. of the original acid was gone. By adding strong nitric acid to this mixture in such amount as to re-establish the proportion between sulphuric and nitric acids the acid may be directly used again. The still had, after repeated use, lost almost nothing in weight, showing that it was not affected by the acids under this condition. Continued experiments in this direction may give a solution to the problem of how to economically use the waste acids in works which have no nitric acid plant. To pay freight for a strong

nitric acid, use part of it, dilute the rest, and pay another freight back to the factory from where it came, as is done where regaining works are used is certainly not economy.

The acidulated water from the drowning-tanks, wash-house, etc., is frequently a source of great annoyance to the nitroglycerol manufacturers. It cannot be let down into running water as it will soon pollute this; it cannot be run into the field as it will soon destroy all vegetation and cause complaint from all sources. If a deep ravine, separated by considerable earth banks from water supplies is to be found on the ground it may be run into that. The ravine, however, ought to be thoroughly cleaned from leaves, etc., and the bottom scraped so as to enable the soil to absorb the water quickly. If limestone of any kind is to be had on the grounds or near by it is certainly the best way to blast a big excavation, fill it with the limestone, and let the wash-water run into this. The limestone will purify the water from adherent nitric and sulphuric acids and affords a good drain for the water.

How far the risks of the dangerous manufacture of nitroglycerol can be minimized may be judged by the fact that since 1871 no accident of any kind, explosion, or fire has taken place at Winterwiken, Stockholm, Sweden. What is of the utmost importance is to have well-constructed plants, good supervision, and a good chemical knowledge.

COLUMBIAN UNIVERSITY,
December, 1894.

METHODS FOR THE EXAMINATION OF GLYCEROL FOR USE IN THE NITROGLYCEROL MANUFACTURE.[1]

BY G. E. BARTON.

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THE most commonly accepted methods for the examination of glycerol are described by Allen in his Commercial Organic Analysis, Vol. II.

His requirements are very severe, in fact, too severe it seems to me in some respects. For example, he requires entire freedom from chlorides and iron. Most of the glycerol offered to the

[1] Read at the Boston Meeting, December 28, 1894.