nized in the light of the moon. The telluric bands, which originate in absorption of solar rays during their passage through the earth's atmosphere, will frequently be perceptible, and in this way the prediction of approaching rain is often possible. The bright lines in the spectrum of lightning may sometimes be observed, as well as those that characterize the aurora. By the aid of a spirit lamp, or, better, of a Bunsen burner, the beautiful and varied flame spectra afforded by salts of lithium, strontium, calcium, barium, potassium, and sodium can readily be produced, and, where a small induction coil is available, a whole host of further experiments, as beautiful and varied as they are interesting and instructive, becomes possible. Specially charming are the spectra of such gases as hydrogen, nitrogen, and carbonic oxide, when transmitting the electric discharge. Nor must we overlook the curious absorption bands and lines which appear when the rays from a lamp flame pass through such deeply colored vapors as hyponitrous acid, iodine vapor, etc. The aniline dyes in solution, blood, and other colored liquids give interesting appearances by the same method; nor should different varieties of colored glass be forgotten, especially the various shades of blue.

PETROLEUM AS AN EXPLOSIVE.

By Prof. PETER T. AUSTEN.

WHEN an oil train suffers a collision, it is a common occurrence for the oil to take fire. If the accident happens as the train is passing through a city, much loss of life and property may result. These oil fires are usually explained by the assumption that the ignition of the oil has been caused by a spark struck from impact of metallic surfaces or by live coals from the locomotive.

The amount of oil passing through some cities is immense, and terrible calamities may happen at any time, should the contents of an oil train suddenly flow through the streets of a town in burning streams. Should this occur at night, it is hard to say what nameless horrors might result.

That petroleum evolves inflammable gases at ordinary temperatures is well known. As to its inflammability at low temperatures, however, I have been unable as yet to find any information. As petroleum is a mixture of varying amounts of hydrocarbons, which run from very light and volatile substances to solid and heavy ones, and as certain of these lighter and more volatile hydrocarbons seem to be gases held in solution in the heavier hydrocarbons, and are not liquefied by considerable reduction in the temperature, it is fair to infer that the temperature of the petroleum may be considerably reduced without greatly affecting its power to evolve inflammable gases. To test this, a sample of crude pipe petroleum was placed in a six-ounce flask to the depth of about an inch and allowed to stand in a mixture of ice and salt for about twenty minutes. The temperature of the oil was then found to be 0 degrees F. On applying a small flame to the mouth of the flask, the flask at once became filled with a blue flame. The flask was allowed to cool for about ten minutes, and then shaken and the flame applied. The flash again occurred. The fact is therefore established that at the temperature of 0 degrees F. crude petroleum evolves an inflammable gas. In this respect, then, petroleum is dangerous both in summer and winter.

When the gases from petroleum are mixed with air, the gas having sufficient oxygen mixed with it for its combustion when ignited, burns at once, and, as the heat of combustion expands the gas, air, and products of combustion, an explosion results. Of course the more the petroleum is agitated, the more gas will be evolved from it. Hence the iron tanks in which the petroleum is conveyed on the cars must contain in the parts not filled with oil an inflammable gas, and as this gas will be mixed with more or less air, it will be more or less explosive. If the gas in contact with the petroleum becomes ignited, the petroleum will in most cases take fire unless the body of the liquid is very cold. If it takes fire, the heat of the combustion soon heats the body of the oil, thus causing the whole mass to boil up and evolve large quantities of inflammable gas. It is also possible that the tanks from which the petroleum has been emitted may be filled with an explosive gas. In case the oil tanks are but partly filled with oil, their condition will be more dangerous, as the agitation will liberate more gas. As the temperature increases and the oil in the tanks becomes warmer, both the oil and the gas will expand, and, unless the tanks are absolutely tight, the gas will be forced out by the internal pressure. Should the gas thus issuing become ignited, say by live coals dropped by the locomotive, or hot bearings, the tank may assume a dangerous condition. It seems, therefore, that under certain conditions petroleum may be considered as belonging to the class of explosives that explode on application of heat alone, as gunpowder, for instance.

The behavior of a tank of petroleum under pressure does not seem to have been much studied. It is a well-known fact that if a volume of air be compressed by means of a cylinder and piston, the motion of the piston is converted into heat. The physical apparatus known as the "fire syringe" is an example of this. On the end of a brass piston, working snugly in a brass cylinder closed at one end, is a piece of tinder. On driving the piston in by a powerful and sudden blow, and then withdrawing it, the tinder will be found to be on fire. That is to say, the compression of the air has raised its temperature to a point sufficiently high to ignite the tinder. If the firesyringe is made of glass, as it often is, so as to allow the ignition to be readily seen, it will be noticed that not only is the tinder ignited, but also the oil with which the piston was lubricated. The burning of the oil causes a bright light at the moment of maximum condensation, and proves that the temperature must be at least 300 degrees. Of course, the temperature required for the ignition of the volatile gases of petroleum would be less than would be required to ignite an average lubricating oil.

The amount of heat developed by the compression of a volume of air to one quarter of its volume will be the same as is required to expand one volume to four volumes. Assuming the temperature of the air and vapor over the petroleum to be 0 degrees F., the elevation of temperature on compressing the space to one quarter will be 429 degrees. Taking the temperature to be 70 degrees F., the rise of temperature will be 499 degrees.

It follows, therefore, from the above that if an oil

tank filled partly or entirely with an inflammable mixture of petroleum gas and air be suddenly compressed in such a way as to greatly reduce its volume, the gas, beyond a doubt, will be ignited by the compression, and in all probability will ignite the contents of the tank. Such a compression might result from the oil tank being "telescoped," or falling from a height to the ground below.

If an oil tank almost entirely filled with oil were suddenly compressed, the resistance offered by the liquid would heat the latter sufficiently to cause it to evolve the lighter hydrocarbons which it contains; and even if they were not ignited by flame or spark struck by metallic friction, they might be set free in such amounts as to produce a dangerous pressure within the tank, especially if the tank were in a weakened condition. The sudden stoppage of an oil tank car but partly filled with oil, as would occur in case of a collision, would cause the mass of oil to be hurled with great force against the front end of the tank, and in this way enough heat might be generated to evolve an amount of gas sufficient to cause the tank to become dangerous.

From these considerations it appears that there is no doubt but that petroleum may be considered as capable of ignition by impact, and when once ignited causing an explosion. It is, therefore, a question if petroleum should not be handled with the same or similar precautions that are taken in the transportation of substances explosive by percussion, or impact, as a nitroglycerine, for instance.

Rutgers College and N. J. State Scientific School.
—*Engineering and Mining Journal.*

IMPROVED WASH BOTTLE.

By Prof. GEORGE W. SLATTER.

I HAVE used an improved wash bottle which I think will be found useful to analytical chemists and others for washing precipitates, etc.

The annexed drawing is almost self-explanatory.

After blowing with the mouth as usual until a good pressure has been obtained within the flask, the India rubber tube may be squeezed by the thumb against the neck, and then the mouth may be removed, but the water will continue to stream out of the jet. The tube, B, may be tied to the flask by string, and the neck of the flask wrapped with string or other bad conductor of heat.

When the bottle needs refilling, the India rubber tubing, A, will stretch sufficiently to allow the withdrawal of the cork.—*Chem. News.*

CARBON BISULPHIDE.

By ROWLAND WILLIAMS, F.I.C., F.C.S.

THIS substance occurs naturally in crude benzol and in oil of mustard. It is a heavy, colorless liquid, with very great refractive powers. When perfectly pure, carbon bisulphide has a faint ethereal odor; but the crude article possesses a most disgusting smell. Carbon bisulphide is slightly soluble in water—about one part per thousand. Its vapor is highly inflammable and very poisonous, and when inhaled produces most unpleasant and even dangerous symptoms.

Manufacture.—Carbon bisulphide is made on the commercial scale by passing sulphur vapor over red hot charcoal, which is contained in retorts, as at A, in

GENERAL VIEW OF MANUFACTURING PLANT.

the above illustration. The retorts are made of cast iron, about 1½ in. thick, with an extra thickness at the bottom. They are cylindrical in shape, and measure about 16 in. diameter and 12 ft. in length, and are set in brickwork in a vertical position. Fire clay retorts are not used on account of the extensive wear and tear which would take place. The outlet for the

carbon bisulphide vapor is a cast iron pipe, B, about 6 in. diameter, and is situated close to the top of the retort, A. This pipe is connected with an iron boiler, C, about 12 ft. by 5 ft., by means of ordinary water lutes, D. A portion of the vapor condenses in the boiler, the uncondensed gas passing over through a pipe, E, into another boiler, F, of about the same size. In each of these boilers a layer of water 6 in. deep is kept, in order to prevent evaporation of the condensed carbon bisulphide. The vapor afterward passes through a leaden coil, G, surrounded by cold water, which is placed in a good sized vessel, so as to present ample condensing surface. This coil is connected to an iron receiver, H, in which a layer of water is kept, with an escape pipe, J, at the top for the waste gases, which consist chiefly of sulphureted hydrogen. At the bottom of the last receiver is a pipe, K, connecting H to the rectifying still, through which the liquid bisulphide is run as it accumulates. The rectifier is immersed in a water bath, and on the application of heat the carbon bisulphide vapor passes over and is condensed by means of an ordinary lead coil cooled by water. The free sulphur remains behind, and is employed again. A glance at the accompanying illustration will make the whole process perfectly intelligible to the reader. Only one retort is shown in the figure; but in actual practice two or more are heated by the same fire, so as to economize fuel. The retorts are cased all round with fire bricks, and the flues, L, reach to within about 4 ft. of the top. At the bottom of the retort is an outlet, M, about 8 in. diameter and 2 ft. in length, with a cast iron flange and cover, which reaches outside the brickwork and is employed for cleaning out the retort. This is done once a fortnight. Above this is a cast iron hopper, N, set in the brickwork, which becomes hot enough to liquefy the sulphur. At the bottom of the hopper is a taper hole, 3 in. diameter, in which a plug, O, fits loosely to allow the liquid sulphur to pass into the retort at the bottom. The retort is filled with dry charcoal to about 3 in. from the outlet, B, at the top, and the lid, P, is then securely fastened. Sulphur is next introduced into the bottom of the retort by means of the hopper at the rate of about 5 lb. every half hour. This is continued for about forty-eight hours, when the retort requires refilling with charcoal. The average yield of carbon bisulphide from each ton of sulphur is from 18 cwt. to 19 cwt.; but, of course, a portion of the sulphur is recovered. One of the largest manufacturers of this article informs me that the yield of carbon bisulphide is fully 10 per cent. less in summer than in winter. This loss he accounts for by the higher temperature which prevails during the summer months. Gas coke is, I believe, always employed as fuel in the manufacture of carbon bisulphide. Regulation of the temperature is a very important point. A temperature midway between dull red and bright red heat is considered the best for the purpose.

In three experiments made by Sidot at different temperatures, using 40 grammes sulphur and 10 grammes purified charcoal, the following results were obtained:

1. Dull red heat.....	5	grm. C gave 17 grm. C S ₂
2. Red heat	6.3	" " " 29 " "
3. Bright red heat	7.5	" " " 19 " "

These figures prove conclusively that a moderate red heat gives the largest yield of carbon bisulphide, and this temperature should not be exceeded, otherwise there is a risk of the bisulphide being decomposed, carbon being deposited, and free sulphur distilling over. Even when every possible precaution is taken, a certain amount of dissociation always occurs, from 5 to 10 per cent. of sulphur sometimes passing over with the carbon bisulphide, and imparting a yellow color to the crude compound, which requires to be submitted to a process of rectification.

Purification.—The exact nature of the various impurities which impart the offensive smell to crude carbon bisulphide is not properly known, but the odor is most probably due to the presence of complex sulphur compounds. Many attempts have been made to remove these objectionable impurities; but few, if any, have been absolutely successful. The simplest process of rectification, which removes most of the free sulphur, consists in carefully distilling the crude bisulphide from a water bath. Another plan is to wash the impure carbon bisulphide several times with water in order to extract the sulphureted hydrogen, and then leave it in contact with quicklime for some time. The carbon bisulphide is afterward distilled from the lime, and the distillate collected in a vessel containing clean copper turnings. The objectionable smell is said to be removed by these means. The following are some other methods which have been suggested for purifying crude carbon bisulphide: (1) Treatment with permanganate of potash, to be followed by agitation with mercury and careful distillation; (2) repeated distillations with pure oil, which is said to remove some of the impurities each time; (3) treatment with bleaching powder solution, with subsequent distillation. By repeated distillation and chemical treatment, almost pure carbon bisulphide may be obtained, but at so high a price that it cannot be employed for industrial purposes. Attention is now being paid to this point, with a view to prepare the pure article at a moderate cost, and I understand that one large manufacturer is within reasonable distance of success.

Uses.—Once-distilled carbon bisulphide is generally used for recovering oil and grease from waste materials, on account of its low price. It is very impure, and gives off a most offensive smell; but as the oil extraction process is carried on in closed vessels, the escape of vapor is only trifling, and the workmen are therefore but slightly exposed to the injurious action of the bisulphide. By a second distillation, a much purer quality is obtained, the odor not being quite so offensive; and in this state the carbon bisulphide is used, mixed with a small proportion of chloride of sulphur, by India-rubber manufacturers, in the process of vulcanizing rubber goods. Carbon bisulphide is employed for dissolving oil from seeds, and also for extracting the delicate perfume of certain flowers; but for this latter purpose it must of course be exceedingly pure. On account of its poisonous properties, carbon bisulphide is frequently used as an insecticide, more especially in France as a remedy against the phylloxera, which has such an injurious effect upon the vines. It seems probable that diseases of the potato and other crops might be successfully treated in