when in the molten state it is cast into shells or run into cold water where it is granulated, by chilling, in the form of pebbles or pellets. TNT may, therefore, appear in granulated crystalline form, in pebbled or pelleted form, or in blocks or other cast forms. As offered by the Department of the Interior for use in blasting it is in the granulated crystalline form. Naturally, as produced on a large scale, TNT is not chemically pure, though the admixed substances are principally other nitrotoluenes which do not materially affect the explosive quality of the product though they do change its appearance and other physical characteristics. Thus the War Department secured and has alloted to the Department of the Interior for industrial use three grades of TNT as follows: Grade 1 having a setting point (S.P.) of 80°C. (176°F.); Grade 2, (S.P.) 79.5°C. (175.1°F.); and Grade 3, (S.P.) 76°C. (168.8°F.), the setting point of the molten TNT being employed by the Ordnance Corps, U.S.A., as the criterion of purity, because it is more readily observed with accuracy than the melting point of the solid. This Grade 1 appears as a dry granular crystalline powder, having a slight yellow color, and so fine that it will pass through a 30-mesh sieve. Because of its dryness it readily gives off dust; Grade 2 is a granular crystalline powder resembling light brown sugar, with a reddish tinge in color, and so fine that it will pass through a 12-mesh sieve. It is less dry and, therefore, less free-running and dusty than No. 1, and Grade 3 as a dry crystalline granular powder having a pale sulphur-yellow color, and so fine that it will pass through a 12-mesh sieve. It is not dusty, has the consistency of brown sugar, looks as if it were slightly moist, or greasy, and shows a tendency to cake, and is less free-running than No. 2.

### Solubility and Hygroscopicity

TNT is almost insoluble in water. According to Marshall, water at 15°C. (59°F.) dissolves 0.021 per cent. of it, and at 100°C. (212°F.) 0.164 per cent. That is, 100,000 parts of water at 15°C. dissolve 21 parts of TNT, and at 100°C., 164 parts. The solubility of the different grades mentioned above is of the same order as this. In fact, the lower grades, and especially Grade 3, have a greasy feel and appearance and are, to a degree, water repellant. The proved solubility of TNT shows that it cannot be deliquescent ,or more than slightly, if at all, hygroscopic. Investigation at the Bureau of Mines Experiment Station has shown that it absorbs moisture when exposed to the atmosphere to about the same extent as powdered glass. This is for all practical purposes an entirely negligible quantity.

### Packages

Military TNT, as offered for use in industrial operations, is packed in the granular crystalline form, in boxes made of white pine, ⅝-inches thick. The boxes are lock-cornered construction, and lined with paraffined paper. Most of the boxes of TNT received at the Explosive Experiment Station of the bureau were 22⅜ by 15¼ by 13 inches outside dimensions, and occupy a volume of 4,436 cubic inches (2.57 cubic feet). The boxes contained 100 pounds of TNT, and their gross weight averaged 113 pounds. It is possible that the boxes supplied by other manufacturers differ in dimensions and weight from these. The tops and bottoms are fastened on with nails. In opening the boxes, if force is necessary, the covers should be pryed off with wooden wedges. Grades 2 and 3 tend to cake during storage, and the lumps must be broken up to render the explosive "free running," so that it may be made into cartridges or loaded directly into bore holes. They may be so broken by pressing them with a wooden paddle or striking them light blows with a wooden mallet on a wooden surface.

### Poisoning

TNT has a faint smell and a bitter taste. It produces brown stains on the skin which are difficult of removal. It is toxic and may produce poisoning by being inhaled as dust, or taken into the mouth, or by absorption through the skin but, unlike nitroglycerine, which produces severe headaches if but even a minute quantity touches the skin, rather long contact with TNT is required before its toxic effects become of moment. Nevertheless, those engaged in handling it, crushing the lumps and loading it into cartridges should avoid getting it into the nose and mouth, and clean their hands thoroughly before eating.

### Detonation

TNT is more difficult to detonate with certainty than nitro-glycerine, dynamite, or the explosives ordinarily used in engineering operations, in mining and in quarrying. TNT charges require a No. 8 detonator (blasting cap) or electric detonator, while dynamite and the other high explosives ordinarily used in industrial operations require but a No. 6 detonator. Objection has been raised to the use of TNT on the ground of the increased cost consequent on the use of this stronger detonator. From inspection of current price lists it appears that No. 8 detonators cost nine-tenths of a cent more apiece than No. 6 detonators, and that No. 8 electric detonators cost 1.7 cents more apiece than No. 6 electric detonators.

### Sensitiveness

As shown by tests with the pendulum friction device, all the three grades of TNT are less sensitive to friction than 40% straight dynamite, gelatin dynamite or picric acid, and as shown by tests with the large impact machine, all are sensitive to percussion than 40% straight dynamite, amonia dynamite and nitrostarch powders. It may be set on fire, when it will burn, but this burning may change to a detonation. Hence TNT must be protected from fire and causes of fire, such as sparks, flame, heated bodies, friction, percussion and the like, as all explosives should be at all times.

### Gaseous Products of Detonation

In tests made at the Pittsburg Experiment Station by detonating TNT, Grade 1, and collecting the gases, it was found that 454 grams (one pound) of the explosive gave 506.5 liters of gases having the following compositions:—

TABLE I.—GASES FROM DETONATION OF GRADE 1, TNT.

| | Per cent. by volume. | Volume in liters. |
|---|---|---|
| Carbon dioxide | 4.9 | 24.8 |
| Oxygen | 2.5 | 12.7 |
| Carbon monoxide | 46.6 | 236.0 |
| Hydrogen | 24.6 | 124.6 |
| Methane | 2.6 | 13.2 |
| Nitrogen | 18.8 | 95.2 |
| | 100.0 | 506.5 |

from which it appears that there was produced 46.6%, or 236 liters of a poisonous gas (CO), and 73.8%, or 373.8 liters of combustible gases (CO, H and $CH_4$). The tests of other grades of TNT gave similar, though not identical results, but all indicate it to be unsafe to use TNT in close places, such as underground workings and particularly coal mines. These results emphasize the importance of remaining away from the face of the blast after the explosion, until assured that the gases produced have been blown or have diffused away from the interstices of the debris. The safe waiting time will, of course, vary with the quantity of explosive fired, the location, such as a pocket, or valley, or plain, and the atmospheric conditions, particularly that of the force and direction of the wind. These precautions are such as should be taken with all explosives.

### Relative Efficiency

In determining the relative efficiencies of explosives in use, the Bureau of Mines has long employed the "unit deflective charge," and the "rate of detonation" as criteria. The unit deflective charge is ascertained by exploding a known weight of the explosive in the ballistic pendulum and this term "unit deflective charge" is defined as "that weight of an explosive which will swing the ballistic pendulum the same distance as one-half pound of 40% straight nitro-