market are obtained and made into tools, and their value is determined by actual use in the machine shops of the navy yard. A dynamometer is used to determine the power expended, while the losses in weight of the tool and of the metal cut by it are carefully determined and compared. Finally, a careful chemical analysis of the tools is made; and the comparison of their constitution with the data, derived, as described, will indicate what a good steel really is. It was stated that no comparisons by name—which might well be deemed "odious" by the less fortunate makers—will be made in the report. It is intended that the work of the board shall be entirely impersonal, and that its results shall do as much good and as little harm as possible.

General Sooy Smith, chairman of committees on girders and columns, gave the board an outline of the results obtained during a very valuable series of experiments, recently carried on at the shops of the Cincinnati Southern Railroad, to determine the strength of compression members of structures, and stated that other equally important investigations were to be made for the board at an early date. Incidentally, the effect of cold in altering the resisting power of the metal, a subject which has been discussed at length in the columns of the SCIENTIFIC AMERICAN, had received some further elucidation, both at Cincinnati and at Washington.

Mr. A. L. Holley, the well known pioneer in the introduction of the Bessemer process in the United States, and who is chairman of the committees on chemical research and on modern steel processes, stated that a chemist—Mr. Andrew Blair, of St. Louis, Mo.—had been appointed under authority of the board, that a laboratory had been fitted up at the Watertown Arsenal, and that the chemist had been for some time engaged in the analysis of irons and steels sent in for test, and on metallic alloys tested by the committee on alloys. Promise was given of securing much information that may prove of exceptional interest and value. Coincident chemical analysis and mechanical testing have never before been systematically attempted on such a scale, and this one peculiarity in the method of investigation followed by the Board is likely to make its work one of vastly greater value and of more permanent usefulness than any similar investigation ever attempted. In this matter the work of this Board is unique. Mr. Holley's committees are gradually collecting a very complete assortment of metals, and the work of testing can be commenced immediately upon the completion of the machine and the appropriation of the required funds. A Pittsburgh firm is preparing a set of several series of steels, each of which series is peculiar in its gradation of some one element. It is expected that by testing these series, the precise effect of each of the more important elements present in steel may be traced with accuracy. Nothing like this has been attempted before, except in the determination of the effect of varying proportions of carbon in researches by Professors Leeds and Thurston, recently, at the Stevens Institute of Technology.

Professor Thurston, chairman of the committees on abrasion and wear, on metallic alloys, and on the effects of temperature, reported a large amount of work accomplished. A specially devised apparatus for determining the effect of variations of temperature on the quality of material had been designed and partly constructed, and this research had been planned. Another season will probably see the work done. The work of the committee on abrasion and wear will be commenced immediately upon the completion of preparations now being made under the direction of the chairman of the committee. Meantime, a series of experiments on the value of the various standard kinds of unguents in the prevention of abrasion and wear of the metals is in progress, under the eye of the chairman, in the laboratory for technical research of the Stevens Institute of Technology.

The work of the committee on alloys is reported to be well advanced. A large amount of valuable information and a very extensive collection of important data are recorded; and the time of the Board was largely occupied in the examination of the results of a long series of experiments on bronzes, for the publication of which all engineers and mechanics will look with interest. No investigation so complete, so extended, or so accurate has ever been undertaken previously. Every grade of bronze, from the copper to the tin end of the series, has been examined. The transverse, tensile, compressive, and torsional resistance, the elasticity and the modulus of elasticity, the changes of chemical composition due to fusion and to liquation or separation, the density, co-efficient of expansion, state of crystallization, character of fracture, mechanical condition of aggregation, and, in fact, all that the engineer wishes to know, are to be determined; and Professor Thurston is directed by this committee to make the research so thorough that, if possible, the necessity of its repetition at any time in the future may be avoided.

There are many other matters in hand, which the Board are expected to make useful to the country and to the engineering profession; but we have no space to consider them here. Some of this work will be described at greater length hereafter, and we shall endeavor to keep our readers informed of the progress made by the Board, whenever the publication of their work may enable us to do so. When the extent and importance of this national work is fully comprehended, we shall expect to see that the assistance, which the circulars issued by the several committees ask of other members of the engineering profession, is rendered gladly and effectively. The members of the Board state that, with the exception of that given by a few of the most distinguished and public-spirited engineers and manufacturers, but little valuable aid has been given them in their investigations, although they have received encouragement from all sides by the generally awakened interest in the subject. Some very interesting and valuable material has been sent from Europe, where great interest is, evidently, felt in this subject. MM. Tresca, Launhardt, Millar, Thompson, and other equally distinguished men have shown such practical appreciation of the work.

[For the Scientific American.]

ARTIFICIAL ICE MANUFACTURE.

BY P. H. VANDER WEYDE.

The ice crop has failed this winter, and ice will be consequently dear during the next season; it will therefore be interesting to investigate how far artificial ice, of which so much has been said in late years, can supply this want, and form, besides, a lucrative business for those who feel disposed to commence it. In order to understand the following descriptions, it must be remembered that the thermometer alone cannot be relied on for measuring definite quantities of heat, as the amount of heat which will raise the thermometer 10° will depend largely on the quality and quantity of the matter to be tested, in which the thermometer is suspended. When, for instance, one thermometer is suspended in a pint of water, and another in a pint of mercury, it will be found that it will take nearly 2½ times as much heat to raise the temperature of the water than to do the same with the mercury; but mercury is 13½ times heavier than water —1 pint of water weighing about 1 lb., and 1 pint of mercury weighing 13½ lbs—so that it takes 2¼ times more heat to heat 1 lb. water than 13½ lbs. mercury, and 2¼ × 13½ = 30 times more to heat 1 lb. water than to do the same with 1 lb. mercury. This number 30, divided into 1, adopted to denote the specific heat of water, gives 0·033, and this is called the specific heat of mercury, and so the specific heat of iron is found to be 0·11, of copper 0·095, of lead, 0 03, etc. So much for the influence of the quality of the matter, but the quantity still more affects the amount of heat required: for to heat a gallon of water will evidently take 8 times as much heat as is required to heat a pint. And as these differences in the required amounts of heat cannot be indicated by degrees on the thermometer alone, it is necessary to establish a standard or unit of heat which actually indicates its amount; and it has therefore been agreed upon to accept an amount of heat sufficient to raise the temperature of 1 lb. of water 1° Fah. as the unit of heat, by which all other amounts can be measured and compared.

It is obvious, from the specific heat of iron, copper, mercury, and lead, given above, that 1 unit of heat will cause a rise in temperature of 1° Fah. in 1 lb. water, in 9 lbs. iron, in 10½ lbs. copper, in 30 lbs. mercury, and in 33 lbs. lead: which numbers correspond to 1 divided by the fractions respectively denoting the specific heat of the different metals.

Of more importance than the specific heat is the latent heat, that is, the heat which bodies absorb when changing from the solid to the liquid state, and which they again give out when returning from the liquid to the solid condition. So ice when melting, on changing into water, will absorb heat, and cause it apparently to disappear; and this to such an extent that 1 lb. of ice of 32° Fah. will require 1 lb. of water of 174° to melt it, when the result will be 2 lbs. of water of 32°. It is then seen that the ice has absorbed 142 units of heat to change it into water of 32°. These 142 units are called the latent heat of water; and in the process of congelation they have to be extracted. On this principle is ordinarily based the method of making artificial ice. The practice of this manufacture, however, involves another principle, that of the latent heat of vapors. When water is changed into steam, it again absorbs heat; and when 1 lb. boiling water is evaporated and converted into steam of the same temperature, 212° Fah., it absorbs as much heat as would be sufficient to raise 5⅓ lbs. water from 32° to 212°, that is, 5⅓ × (212 —32) = 5⅓ × 180 = 960 units of heat. This is the latent heat of steam, and is given out again when steam condenses into water: hence the effectiveness of steam for heating buildings by the condensation of steam, in pipes and other contrivances.

MAKING ICE BY EVAPORATION IN VACUO.

On this principle is founded one method of making ice, namely, the forced rapid evaporation of water by means of a vacuum. In an old experiment in the physical lecture room, a small quantity of water is placed on a watch glass, under the bell jar of a good air pump; a vacuum is rapidly made, and the water will at first commence to boil, and the vapor evolved will absorb so much heat from the water that at last it will freeze, and form a small piece of ice. As the latent heat of the steam or watery vapor is 960 units, 6¾ times as much as the 142 units of latent heat absorbed from the water to freeze it, it will require the evaporation of about $\frac{1}{6}$ of the water to freeze the remaining $\frac{5}{6}$. In order to aid the air pump in the rapid removal of the watery vapor arising, it is well to place also under the bell jar a cup of strong sulphuric acid, which has great affinity for watery vapor and absorbs it, causing the experiment to succeed in less time, and also with a less perfect air pump. This method of ice-making is now in operation, on a small but practical scale, in the leading restaurants in the principal cities of the European continent. A strong glass bottle is about ¾ filled with water, and its neck is connected with the pipe of a good air pump, worked either by hand or by power. Between the bottle and the pump is a reservoir containing sulphuric acid, over which passes the air and watery vapor which the pump draws from the contents of the bottle; the sulphuric acid absorbs the vapor, and experience shows that, conformably to the theory above stated, when about $\frac{1}{6}$ of the water has been removed by evaporation, the rest will rapidly freeze to a solid mass. Then the bottle is detached and placed on the table of the guest; where, if necessary, some water may be added, which it will then soon cool to about 32°. If no sulphuric acid is used, it is hard work to freeze a pint of water with such a machine, requiring, as it does, the continuous labor of a man for about half an hour, and also the condition that extraneous heat is carefully excluded by covering the bottle with non-conducting material, the absence of which would lead to a loss of the cold produced. The amount of labor required is perfectly in accordance with the theory of the mechanical equivalent of heat, which is that 1 unit corresponds with 776 foot pounds; and as from every pound of ice-cold water 142 units have to be extracted to transform it into ice, the abstraction will be equal to 142 × 776, or 110,192 foot pounds. As the power of a man is about 4,000 foot pounds per minute, it will take $\frac{110192}{4000}$, or 27 minutes' work, equal to 4,000 foot pounds each, to effect this abstraction. If the work is done by machinery, we find, in the same way, that a horse power, equivalent to 33,000 foot pounds per minute, will abstract 110,192 units in $\frac{110192}{33000}$ or nearly 3 minutes, that is, it will freeze 1 lb. of water every 3 minutes, or 20 lbs. per hour; and as in a good steam engine a horse power can be obtained at the expense of 2 lbs. coal per hour, we see that 2 lbs. coal will be sufficient to produce 20 lbs. of ice, or 1 tun of coal 10 tuns of ice. If, however, we use as an aid the intense affinity of sulphuric acid for watery vapor, we may surpass this estimate; but it must be considered that ice is usually wanted in warm climates or during hot seasons, and the loss of cold from, or rather the incursion of external heat to, the different parts of the apparatus is so considerable that it is necessary to use all possible precautions, and to employ all known means, if we expect to attain the theoretical maximum of 1 tun of coal producing 10 tuns of ice.

We have seen that it lately has been claimed that, with one of the modern ice machines, 1 tun of coal would produce 20 tuns of ice; but this is an estimate in which the loss of power involved in changing heat into motion by the intervention of the steam engine had been overlooked or intentionally neglected; and we are satisfied, as well by practical experience as by the theory above stated, that the ratio of obtaining 10 tuns of ice by the combustion of 1 tun of coal will be the maximum to be hoped for as long as we have to use the present form of steam engines; and more can only be hoped for when we shall have found how to obtain a horse power out of 1 lb. of coal or less per hour.

SCIENTIFIC AND PRACTICAL INFORMATION.

POISONING FROM PARIS GREEN.

A correspondent of the *Medical and Surgical Reporter*, Dr F. Horner, of Virginia, wrote recently that a case of poisoning from the effects of Paris green, arsenite of copper, occurred during the late summer, near Winchester, Virginia. Four members of the Van Meter family died, with symptoms of arsenical poisoning, after eating apples gathered from the ground of an orchard which was planted with potatoes, on which had been sprinkled Paris green in powder, and in the midst of which had fallen the apples subsequently gathered for domestic purposes. No example has been reported of this substance causing death by transmission through absorption by the plant.

RUSTING OF IRON.

It has usually been supposed that the rusting of iron depends principally upon moisture and oxygen. It would appear, however, from the late Dr. Calvert's experiments, that carbonic acid is the principal agent, and without this the other agencies have very little effect. Iron does not rust at all in dry oxygen, and but little in moist oxygen, while it rusts very rapidly in a mixture of moist carbonic acid and oxygen. If a piece of bright iron be placed in water saturated with oxygen, it rusts very little; but if carbonic acid be present, oxidation goes on so fast that a dark precipitate is produced in a very short time. It is said that bright iron placed in a solution of caustic alkali does not rust at all. The inference to be derived is that, by the exclusion of moist carbonic acid from contact with iron, rust can be very readily prevented

REFINING GLASS.

M. E. Frémy states that the difficult portion of the manufacture of glass is the process of refining, the object of which is to render the mass homogeneous, and expel as far as possible the bubbles of gas which are produced in abundance at the moment when the glass is formed. The nature of this gas is not exactly known, but it is evidently due to the action of reducing agents upon the sulphate of soda found in excess in the glass. This excess of sulphate of soda is destroyed by various methods, but chiefly by the use of sticks. At the instant when the sulphate of soda is thus submitted to the action of an organic body, the formation of sulphide is proved by the yellow coloration which the glass assumes, but which disappears afterwards from the action of oxygen. It is curious to point out here a certain analogy between refining glass and refining copper. In the former case, the excess of the sulphate of soda, which is the agent of vitrification, is destroyed by wood. In refining copper, oxygen is the agent of purification for the metal: but the excess of this gas forms protoxide of copper, which dissolves in the metal, and renders it brittle. The refining of copper, like that of glass, is therefore completed by making use of wood, which decomposes the oxide of copper, and restores to the metal all the useful properties which the oxygen had caused it to lose.

W. C. D. says: "I have a copy of *Wrinkles and Recipes*; and if I could not procure another, $25 would not purchase mine."