new industry, although blast furnace gases may have a future. Taking the above figures as basis of the calculation, the author finds that in Norway 1 kilogramme of nitrogen in the form of NO_2 costs only 0.15 M. (1.8d.), while in the form of sodium nitrate or nitric acid it costs from 1.15 M. to 1.90 M.

Prof. Frank, of Charlottenburg, was to have read the last paper upon this subject, dealing with the Frank and Caro method of fixing atmospheric nitrogen by means of calcium carbide. Prof. Frank, however, did not attend the meeting, and below we give an abstract of the paper he delivered on the same subject at Rome, a fortnight earlier. Calcium carbide is formed in the usual manner by heating lime and coke in the electric furnace, and over this product, while still hot, nitrogen obtained by the fractional distillation of liquid air is passed. This gas is absorbed by the heated calcium carbide with formation of a compound having the formula CaCN_2 , and known as calcium cyanamide, or "Kalkstickstoff." This product contains nitrogen in a form which renders it available for other chemical reactions, and it can be used directly upon the soil as a chemical manure, or as the raw material of several secondary manufactures. Among these latter, the production of pure ammonia, pure nitric acid, ammonia salts, cyanamide, dicyandiamide, urea, indigo, and a new compound for hardening steel, "Ferro-dür," may be named. Dicyandiamide has been used in the manufacture of powders for rifles and cannons with good effects, since it reduces the combustion temperature, and, therefore, the wear and tear on the rifling of the gun.

As regards the industrial development of the Frank and Caro process, three works have been planned for operation on a large scale in connection with water-power developments in Italy, and the first of these, located in Plain d'Orte, is already in operation. Other works are to be erected in France, Spain, Switzerland, and Norway at an early date. As regards yield, the best results obtained so far represented the fixation of 330 kilogrammes of nitrogen with the expenditure of one E.H.P. year; but it is hoped, as more experience is gained in the practical working of the process, that this yield, equal to 43 per cent of the maximum possible, will be greatly increased.—Engineer.

THE PROGRESS AND LOGICAL DESIGN OF REINFORCED CONCRETE.*

By ROSS F. TUCKER, M.Am.Soc.C.E.

Those who are under the impression that the present popularity of reinforced concrete is largely a fad may be interested to note the progress of this type of construction since its inception in 1885, in terms of the production of Portland cement in the United States. In 1882 the output of Portland cement was 82,000 barrels. At this time, reinforced concrete was unknown, and the value of Portland cement concrete as a structural material was not dreamed of. Natural and Rosendale cement had the field practically to themselves and concrete, where it was used at all, was confined almost wholly to foundation and underground work. A glance at the accompanying illustration, Fig. 1, will show at once the enormous stride that the industry has made in a short quarter of a century. In Fig. 1 is shown the production of Portland cement in the United States at intervals of five years from 1880 to the present time. At the side is shown the development of the concrete industry in the same periods of time.

In 1885, Ernest L. Ransome, then of San Francisco, invented the twisted bar and demonstrated the principle underlying all reinforced structures whereby it is possible to incorporate steel bars in a mass of concrete in such a manner as to enable the concrete to withstand transverse loads. It will be noted by reference to the figure that at this time the production of Portland cement in the United States was 150,000 barrels. From 1885 to 1890, Ransome was engaged in ap-

* Read before the quarterly meeting of the Association of American Portland Cement Manufacturers.

FIG. 2.—INTERIOR OF MUSEUM BUILDING, STANFORD UNIVERSITY. 45-FOOT SPANS

(Withstood earthquake perfectly.)

FIG. 3.—GIRLS' DORMITORY (ROBLE HALL) STANFORD UNIVERSITY.

plying his discoveries to works of the most elaborate and extensive character. When we take into consideration that, at that time, the subject of reinforced concrete was in a most elementary experimental stage, and that there were no accurate formulae or known

architects and engineers, while interested in the possibilities of reinforced concrete, were loth to give up the steel skeleton and adopt a type of construction with which they were so entirely unfamiliar. The lesson, nevertheless, had its effect. About this time came the introduction of expanded metal and the mesh systems of concrete construction, which enabled the architects to retain their steel structures and use concrete for the filling and arch work between beams in place of brick work and terra cotta. These methods enabled the architects to use concrete in a conservative manner and to become acquainted with its structural properties without abandoning the steel frame which constituted the main structural basis of their design. In this period, from 1890 to 1895, the production of Portland cement progressed from 300,000 barrels to 900,000 barrels, and the lessons learned from the use of concrete in this respect led to its adoption in a large number of projects originally planned for other material.

From this time on the use of concrete grew very fast. In 1897 and 1898 there came a great shortage in structural steel. Deliveries were so uncertain and remote that engineers the country over were at their wits' end to find ways and means for fulfilling their designs, and they turned at once to reinforced concrete to help them out of their dilemma. European systems of reinforced concrete were introduced and engineers generally began to study the subject from a scientific standpoint, with the result that by 1900 the steel concrete structure was recognized generally as a structural possibility and its adoption was considered for every conceivable kind of problem. At this period, the production of Portland cement in this country had reached 8,400,000 barrels per annum. In the succeeding five years, however, the popularity of concrete and the confidence of the building public in its properties were demonstrated in a most astonishing manner, for the production of Portland cement sprang from 8,400,000 barrels in 1900 to 36,000,000 barrels in 1905.

Any one considering the progress of the industry, as noted, can hardly say that the reinforced structure is a fad, although it is to be admitted that concrete has been applied to many purposes for which it is not at all suitable. It is a fact now beyond dispute that the steel concrete structure has passed the experimental stage and has been adopted throughout the land as a building element of the greatest value. It is true, however, that much has yet to be done in the education of the architect and engineer and in the use of concrete in a logical manner and for its real value. Owing to the comparative youth of this type of building, architects and engineers generally have not as yet given any great attention to the development of design essentially suitable to reinforced concrete. It is the general practice to design in brick, stone, and steel and then to call upon a reinforced concrete engineer to reproduce a structure in reinforced concrete. This is an imperfect and unscientific method and unfair to the development of the true value of the concrete structure. The average architect and engineer is, as yet, too unfamiliar with the characteristics of concrete to design a structure solely from

FIG. 1.—SHOWING PROGRESS OF REINFORCED CONCRETE IN TERMS OF THE PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES.

valuations for determining concrete design, and that the appliances for making and handling concrete were of a primitive kind, we can appreciate the difficulties with which he had to contend, and can bestow the greater credit and honor upon him for the courage and splendid mechanical and engineering ability which he displayed in undertaking the construction of steel concrete buildings of such magnitude in a country subject to earthquakes. Among the structures above referred to are the Museum Building (interior shown in Fig. 2), and Girls' Dormitory (Fig. 3), at Stanford University; the interior of Academy of Sciences (Fig. 4), the building for the Pacific Borax Company, and the Tubbs Cordage Works, and the value of his discoveries has been further accentuated by the fact that during the recent great earthquake in California all of the above structures, comparatively crude as they were in design, came through the ordeal practically unscathed, where buildings of brick and stone in their immediate vicinity were entirely wrecked. In 1890 Ransome determined to introduce his ideas throughout the country, and for a considerable time thereafter, the writer was engaged in lecturing before technical societies and architects and engineers generally on the subject of reinforced concrete and the possibilities of that type of structure. While these ideas were all of great interest to the technical public, they were so new to the building world at large that it was only here and there that they gained a foothold. The steel frame structure by this time had been brought to a high degree of development and

FIG. 4.—INTERIOR OF ACADEMY OF SCIENCES, SAN FRANCISCO.

(Withstood fire and earthquake.)

that point of view. He thinks in terms of brick and steel, designs in brick and steel, and then attempts to adapt concrete to his structure. The architect who would design intelligently for reinforced concrete must think in terms of reinforced concrete, but up to the

cation of the danger to which the steel structure is subjected, through inadequate fireproofing, attention is called to Fig. 6, showing the condition of steel columns on the third floor of the Bullock & Jones Building in San Francisco. These columns were protected

the concrete of our day will endure far beyond the life of any natural stone and it is not too much to hope and predict that when our architects have become acquainted with the true characteristics of this wonderful material, they will create a new architecture more original and more truly American than any we have attained thus far. The future is replete with possibilities. We have learned thoroughly how to make concrete strong, let us learn how to make concrete beautiful.

[Concluded from SUPPLEMENT No. 1607, page 25751.]

SOME FUNDAMENTAL CHARACTERISTICS OF MERCURY VAPOR APPARATUS.*

By PERCY H. THOMAS.

MERCURY VAPOR LAMP.

As a lamp, the mercury vapor apparatus has a number of interesting characteristics. Its great efficiency, which in long tubes reaches one-third watt per candle-power (exclusive of resistance losses), is obtained only when run under the most favorable conditions; for example, only with the proper vapor pressure, current, and tube diameter. Mercury vapor is a much more efficient material for light production than most other gases and vapors whether used alone or mixed. The addition of atmospheric air, for example, to mercury vapor, even in very small quantities, increases the voltage on the tube very much; thus increasing the energy supplied.

The spectrum of mercury vapor is, furthermore, one of the most complete and usable gas spectra; it contains a variety of colors in substantially equal proportions, chiefly an orange-yellow, a yellow, a blue and a violet, with a smaller amount of a green-blue. The only portion of the spectrum not pretty well represented is the red, which generally speaking is the least desirable color. The mercury spectrum has proved to be excellent physiologically, and extremely well adapted to most mechanical processes. It is possible, of course, by the addition of other gases to add red to the spectrum, which may then be quite prominent, especially if means are taken to condense a portion of the mercury vapor. In general, however, these combinations of gases are more or less likely to deterioration and alteration, and have a considerably lower efficiency than pure mercury vapor. For most purposes the color would not be more desirable with the addition of red.

Light Efficiency.—The efficiency of mercury vapor as a source of light follows a number of laws. (1) The watts per candle-power vary with the pressure of the vapor, having a minimum at a certain pressure. (2) It is nearly independent of the current strength within certain limits, in this case it being assumed that the pressure, temperature, etc., are constant. (3) Superheating the tube, and consequently that portion of the vapor emitting light, seems to have little effect.

It can be shown by the normal lamp voltage characteristic curve that the relation between the current and voltage of the operating lamp, that the most efficient light giving point is at, or nearly at, the point of lowest voltage on this characteristic. This is fortunate, since for purposes of regulation this is a most desirable point to operate the lamp. Above this most efficient point the pressure of the mercury vapor increases rapidly, and while also increasing the candle-power it increases the voltage in the tube in still higher proportion. Below this point the voltage on the

FIG. 5.—TYPICAL DESIGN OF STEEL CONCRETE WAREHOUSE.

present time, the condition is similar to requiring a carpenter to think in the metric system when he has been all his life accustomed to figure in feet and inches. He must stop and translate and is unable to bring his mind to an adequate appreciation of his dimensions until he has so translated them. Reinforced concrete is a structural method possessing peculiar characteristics which are essentially its own, and any design which is to be carried out in this material should be adapted to its characteristics and qualifications. For instance, many have an idea that the cost of cement and the labor involved in the handling of concrete are the particular elements of cost in a concrete structure, whereas, as a matter of fact, the determining factor in the cost of concrete of whatever nature is the cost of the wood work and centering required for the carrying out of the design. The initial cost of a yard of concrete may be \$5, but that same yard of concrete may be made to cost \$40 by the addition thereto of elaborate forms necessary for the placing of the concrete in the position required in the design. On every structure projected for brick and steel, and afterward converted into concrete, the cost of concrete will vary for every yard from \$5 to \$40, depending upon the position in which it is placed and the elaboration of the forms necessary for the fulfilling of the design. It is, therefore, apparent that the greatest economy in the use of reinforced concrete is to be attained by keeping this fact in mind and designing the structure accordingly. The essence of economy in concrete work is the simplicity and duplication of forms, and this of itself demands the elimination of projecting members such as cornices, belt courses, and offsets to the largest possible extent. The reinforced concrete building must be essentially a plain building and its architectural effect must be developed by the study of the relation of the openings to the masses, together with the assistance of such color scheme as may be applied by the insertion in the face of the structure of tile or mosaic work in color masses suitable to the problem.

The above ideas are fairly well demonstrated in Fig. 5. It will be noted that the structure is of the skeleton type with the rectangle between the horizontal and vertical members filled in with block work or brick work, independent of the structure itself. Belt courses, cornices, and offsets are eliminated in a very large degree and shadow effects are obtained from projections of a simple character. Window openings are small and are protected by fire shutters, thereby rendering the building practically proof against the ingress of fire from neighboring buildings. Experience has demonstrated that fire is not to be feared so much from within as from without, and the essential to good design of a fireproof character is that the building may be inclosed from top to bottom. As an indi-

in an inadequate manner with terra cotta, but the sweep of the fire through the building destroyed the covering and exposed the steel work in such a way as to buckle the flange plates and subject the building to very great loss. It is absolutely certain that had these columns been covered with concrete of the same thickness, nothing of this sort would have happened.

Many of the monuments of Rome, that have endured for more than 2,000 years, were built of a concrete far inferior to that which we use to-day—so inferior, in fact, and so different in method and material as to be hardly entitled to the name of concrete, as we know

FIG. 6.—INTERIOR OF BULLOCK & JONES BUILDING, SAN FRANCISCO, SHOWING CONDITION OF STEEL COLUMNS.

il. at all. Still these monuments, stripped of their facings of mosaic, tile, and stone by the ravages of time and conquest, still endure. What, then, may we expect of the great structures which we are building under the eye of modern science? It is certain that

lamp rises, probably partly on account of traces of residual gas not exhausted in the pumping, which causes a great dropping off of the quantity of light and the efficiency. These residual gases are here more

*Journal of Electricity, Power and Gas.