

tiles laid flat radiate from the apex of the dome to the foundations. These ribs are joined to the central mid-rib by cement, and all are inclosed by the two shells of the tiles laid on edge. The cohesive strength of tile construction is thus amply demonstrated. Engineers representing a number of structural steel manufacturers intimated before the work was undertaken that it was impossible to build the dome in this way without metal reinforcements of some kind; but the dome has been finished for some months and the heavy skylight placed in position. The lightness of the tiles makes the dome nearly half the weight of another of similar size constructed of metal, while the fireproof quality of the material insures the dome from interior destruction by fire. The tiles having been burned in the making do not warp or shrink after being placed in position, and elaborate decorations can be made directly to them without danger from cracking or warping.

A similar dome of less size and ambition has been built on the new Madison Square Presbyterian Church, which recently has been completed. The same size flat tiles are used there, and the dome is built and surmounted by a small tower. The crushing strength of the tiles is upward of 2,000 pounds to the square inch, and their cohesive strength is dependent chiefly upon the quality of the Portland cement used in building the dome. The major axis of this new dome is only 52 feet, but its shape and artistic appearance from either the inside or outside make it remarkable quite as much as the decorations placed on it by the architect. The dome springs direct from the walls of brick, and it thus completes a remarkable building independent of any iron or steel work.

Within the past few years a number of other similar domes of this same general character have been completed. In the new library building of the University of New York there is one with a major axis of 70 feet, and over the rotunda of the University of Virginia the Guastavino dome of flat fireproof tiles laid edgewise has a diameter of 69 feet. The Hall of Sciences, in Brooklyn, has a dome of flat tiles without any metal supporting work of 60 feet in diameter, and the new Minnesota State Capitol one of similar dimensions. The dome over the Bank of Montreal building is 72 feet in diameter, and is the largest, next to the new one over the rotunda of the New York custom house, yet finished by this new method of cohesive construction.

The construction of such fireproof, non-metal-supported domes represents a special branch of masonry designing which has slowly reached perfection in this country. It is based upon the principles of the early Roman architects who used heavy bricks and stones for their work, but with superior tiles and cement mortar to work with, the modern designers have secured strength and rigidity with materials much lighter and absolutely fireproof in character.

The high degree of skill and mathematical designing required to construct domes, arches, and stairways of tiles by the cohesive system is probably even better illustrated in the two pairs of stairs built in the new custom house facing Bowling Green in New York. These stairs spring from the basement of the building and terminate at the roof. No metal whatever is employed for supporting them. On the contrary, heavy balustrades of metal, and equally heavy marble treads, only add to the dead load carried by the tiles. Rather larger tiles are used for the stairs than for the dome construction, but they are all light and apparently frail for this work. From the basement to the main floor a circular wall of brick masonry is built, and the tiles are attached at one end to this wall; but each semi-circular flight depends for its strength and rigidity upon the cohesive strength of the tiles and the scientific strength of a curve when the load is so distributed that the pressure to the arch is continuous. Above the main floor each flight springs to the floor above without any support other than that derived from the top and bottom. The stairs are formed by a number of thicknesses of flat tiles at the base which gradually diminish toward the middle of the arch, and then thicken again toward the top.

The construction of spiral and semi-circular stairways with hard flat tiles requires independent and careful study of each individual case. No definite rule or principles can be laid down to apply to all cases, but each problem has to be worked out by itself. The combination of the spring of the arch with the continuous curve under each platform to adjust the adjoining flight are questions of mechanical skill. Such stairways of hard, fireproof clay tiles are constructed to carry loads which will suffice for any kind of public buildings, and those recently constructed in the custom house (or rather in the course of construction at this writing) are designed to carry heavy marble treads and ornamental iron and bronze work besides the weight of those who will constantly use them for ascending and descending. The fireproof quality of such stairs is of particular force in view of the modern effort being made to eliminate everything possible from public buildings which will crumble or disinte-

grate when attacked by a hot interior fire. The difficulty of protecting an iron stairway by terra-cotta casing as commonly practised in protecting beams and girders is quite apparent. If left unprotected a sharp interior fire will cause a collapse of the stairs and greatly increase the damage to the building. A tile stairway on the contrary would not be affected by a fire unless the temperature reached 2,000 and more degrees, and a collapse would not follow.

The use of the cohesive tile construction for floors and ceilings is well illustrated in two other notable buildings recently built in New York. The dome ceiling of the new Tiffany building is constructed of hard, flat tiles laid on edge and sprung from rotunda columns and terminating in a large skylight. In these dome ceilings the curve is less than in the domes, and the effect is of a slightly arched ceiling of great beauty. The decorations are sometimes laid directly on the tiles and in other cases ornamental faced tiles are cemented to the hard supporting tiles for interior effect. In the new Gorham building all of the different floors and ceilings are made of hard tiles. A series of arches spring from the steel columns and terminate in points in the ceiling. The compression on the tiles is uniform, so that the load is carried without any undue stress upon any part. The tiles are laid on edge, with several courses forming the arch, breaking joints at each course, and cemented together with the best Portland cement mortar. The decorations are either made directly on these fireproof tiles or ornamental tiles cemented to them. No metal work is employed to support the dome ceilings other than the series of steel columns from which the arches spring. No steel reinforcements or tension rods whatever are employed in the construction. The remarkable lightness of the floors and ceilings built in this way is one of the chief virtues ascribed to the new method of fireproof building. The carrying capacity of a floor built of cohesive tile masonry is certainly sufficient to warrant their construction in some of the finest public and commercial buildings of the country. As an interesting development of the fireproof question cohesive tile construction is without a peer, and its adaptation to new work and fields is a matter that should be of inestimable value to the building trades. In cases where lightness of structure is an important consideration hard flat tiles may prove far more desirable than iron skeleton work, and also where it is desirable to use fireproof clay materials owing to the difficulty of covering the iron work with terra cotta.

INTERNATIONAL MARITIME EXPOSITION COMMEMORATING ANNIVERSARY OF STEAM NAVIGATION IN BORDEAUX, FRANCE.

BY CHARLES A. SIDMAN.

That great interest is being manifested in the International Maritime Exposition which is to be held in Bordeaux in May is evidenced by the great progress that has been made in the construction of the several buildings, and the fact that the contractors promise to have them all ready some time before the opening on May 1.

This exposition is designed to commemorate the centennial anniversary of the successful application of steam to navigation by Robert Fulton. The motive for the celebration of this great event may be found in the fact that in 1803—four years before his success on the Hudson with the "Clermont"—Fulton made his initial trials in steam navigation in France. Fulton's experiments appear to have been at first with a submarine boat, which he christened the "Nautilus," and in which he was submerged for five consecutive hours on one occasion in 1801. This demonstration appears to have been at Brest, in the presence of the French Admiral Villaret, and it is recorded that by the use of torpedoes Fulton managed to blow up a boat in the harbor.

He made a second submarine boat, and gave a demonstration on the river Seine at Paris, on which a commission appointed by Napoleon reported favorably. Nothing, however, came of the submarine boat, and it was subsequently, in 1803, that Fulton treated the Parisians to the spectacle of a small boat propelled by steam on the river Seine with two bateaux tied astern. A chronicler of that time describes it as "un bateau mu par des roues comme un chariot" (a boat moved by wheels like a chariot).

The exposition, as officially stated, is to be international in character, and to illustrate the history of navigation. The world's marvelous progress in the art of shipbuilding and the science of navigation is to be shown by a collection of models of every kind of water craft, ancient and modern. All that pertains to ocean geography and all industrial and artistic products having relation to maritime affairs are to find a prominent place. There is to be a congress of naval architects, with lectures on science, art, industry, commerce, and political and social economy. There will be boat races on the river Garonne, in which the management hopes that crews from the several nations will compete.

The grand palace and the main buildings, covering

an area of about ten acres, are all so connected by arcades that they form practically one great building. The grand palace is to be devoted to the illustration of maritime history, ocean geography, ancient and modern painting, sculpture, architecture, and horticulture. Materials for the construction of boats and ships, diving and life-saving apparatus, fishing appliances, ship's provisions, sea food, and motor machines (land and water) will have considerable space devoted to their exposition. In the place allotted to the navy there is to be a special exhibit of submarine boats, guns, torpedoes, ship's armor and equipment. Aeronautics, electrical apparatus, signals, wireless telegraphy, telephones, pumps, refrigerating apparatus, heating and ventilating appliances, port and harbor works, sea and river sports, art bronzes, lace tissues, linen and tapestry, glassware, china, cutlery, and musical instruments are also to have spaces devoted to them.

This exposition should afford excellent opportunities for American manufacturers to show the superiority of their products and extend their trade. Manufacturers of motor boats, light motors and dynamos, canoes, lifeboats, diving and life-saving appliances, fishing apparatus, optical and nautical instruments, or those who make anything that relates to navigation or ships, will find a good chance here to advertise their goods and increase their business.

An appropriation of \$15,000 was made at the recent session of Congress to enable the government of the United States to be properly represented at the exposition. There will be a pavilion erected especially for the American exhibitors.

The Secretary of the Navy has ordered several of our finest warships to attend, and the members of the American Committee of Honor comprise men well versed in these matters.

It is especially fitting therefore that France in taking the initiative shows once more her thankfulness to the artisans of progress, and her sincere friendship for the United States, in commemorating the century anniversary of Robert Fulton's victory, for it was in France that a great many of his experiments were made.

BURCHELL'S ZEBRA.

One of the larger South African mammals now verging on extinction, if, indeed, it has not already ceased to exist, is the typical race of Burchell's zebra, the *bontequagga* of the Boers, and the *Equus burchelli typicus* of zoologists, writes Mr. Lydekker in Knowledge. This race apparently inhabited the plains to the north of the Vaal River, now forming British Bechuanaland. It is characterized by the complete absence of barring on the legs and of stripes on the lower part of the hindquarters; while between the dark brown body-stripes were faint "shadow-stripes" on the still paler ground-color. The original specimen in the British Museum brought home by the great African traveler, Dr. Burchell, was, unfortunately, destroyed at a time when but little attention was paid to the priceless value of "types," and there is now no example of this race of the species in the national collection. According, however, to a paper published by Mr. R. I. Pocock in the Annals and Magazine of Natural History for 1897, there is, however, one specimen in the museum at Tring, and a second in the Bristol Museum, both of which come very close to the typical form, although neither is exactly similar, and each differs slightly from the other. In these circumstances it is interesting to learn that a specimen exists in the American Museum of Natural History.

THE CURRENT SUPPLEMENT.

The current SUPPLEMENT, No. 1629, opens with an excellent article by the English correspondent of the SCIENTIFIC AMERICAN. This is one of the most important undertakings in connection with the development of transportation facilities in the African continent, and second in magnitude and character to the Cape to Cairo Railroad only. Many illustrations accompany the article. Poulsen's system of radiotelegraphy by continuous electrical oscillations is described. John B. C. Kershaw writes on the development of the electrochemical and electro-metallurgical industries in 1906. A very excellent discussion of the recent accident on the electrified portion of the New York Central Railroad is published, and helpful diagrams are printed, which give one a very clear idea of the cause of the catastrophe. The limits of thermal efficiency in internal-combustion engines are discussed. Dr. D. T. MacDougal presents a thoughtful article on the hybridization of the oaks. Dr. Charles Mercier contributes a very curious paper on the fear of open and closed spaces.

The Jiji Shimpo states that, according to the government's present plans, the efficiency of the Japanese navy in 1915 will be double what it was before the Russo-Japanese war.