THE SCIENTIFIC CITY STREET.

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Electricity, in its modern application, is both solving and creating problems. For example, it affords the only method by which the public streets may be used for rapid intramural travel without diminishing the value of property and imposing serious public burdens, while it intolerably disfigures the same streets, with its unsightly and dangerous aerial conductors and supports, which constitute an æsthetic and material nuisance of great magnitude.

Broadway, New York, is the most notable American example of the injury it inflicts and the benefits it offers. For many years engineers have been employed in devising methods for converting its roadway into a rapid transit subterranean thoroughfare; a multitude of plans have been devised, but all have failed to attract financial support or allay local apprehension and opposition, for the reason that no effectual method of removing the products of combustion by mechanical means could be devised, those adopted elsewhere not being successful, or not adapted to the limited space available. No openings in the roadway would be permitted, and many ineffectual attempts have been made to secure ventilation through what was known as the "area" between the sidewalk and the building; meanwhile the area has disappeared by the widening of the walk and the vault itself has become of great value, so that time has increased and not removed the difficulty. Further, as the products of combustion, smoke, ash, cinder, sulphurous acid gas, are heavier than the atmosphere, and the air of the subway damper and cooler than external air, even the most elaborate and expensive systems of ventilation would have proved inadequate to their complete removal. Electricity, however, dispenses with combustion within the subway, and, therefore, a structure which is constructed with reference to dryness, and the continuous passage of a current of external air, wherein the trains are worked by electricity, is freed at once from all the objections to a subway, is the safest, the most comfortable, convenient way, and provides for the fastest possible city travel.

Meanwhile, a general committee on electrical underground communication was formed, representing twenty-one corporations, and a sub-committee was appointed, under the chairmanship of Dr. Henry Morton, of the Stevens Institute of Technology, to study and report upon the practicability of disposing of all electric wires and conductors underground, the accumulation of poles and wires having become a public nuisance. This committee received its instructions May 7, 1883, and reported March 15th, 1884. The report was long, learned, and elaborate, involving in its preparation an immense amount of labor in examining devices and collecting testimony from all sources. The summary reads as follows:

“No system submitted to or investigated by the committee seems to fulfill all the requirements so satisfactorily as a properly constructed tunnel of sufficient size to admit the passage of workmen and access to the wires within it. Connecting with this tunnel, conduits of sufficient capacity for lateral wires could be constructed as described.* The multiplicity of subterranean structures in this city might tend to operate disadvantageously, if not to prohibit the construction of such a tunnel, unless the same were arranged to accommodate the gas, steam, and other systems, as well as the electric wires. The deteriorating influences of steam and gas would, however, be apt, by destroying or impairing any system of insulation, to render the success and reliability of any system of conduits in the lower portion of the city questionable.”

The first capital requirement of a great thoroughfare is—the accommodation of traffic, sub-divided into several classes. An ideal street should provide a smooth foot-way for the pedestrian, an even and noiseless carriage-way for vehicles, *and both of these ought to be unobstructed by any permanent or immovable thing whatever.* The present surface impediments will be doomed whenever the citizen obtains access to one example of unobstructed street surface. It must also provide for the travel of the hundreds of millions who wish to avail themselves of a more rapid or a cheaper method, and it must do this without appropriating the surface. The “elevated” road is therefore a temporary and clumsy device for accomplishing this end. It provides the facility, safety, rapidity and cheapness required, at an unspeakable

* See p. 17 of that Report.

sacrifice of space, quiet, comfort, convenience, health and comeliness. The tramway is the least objectionable form so far devised to meet a part of this demand, and is capable of very great improvement in respect of speed, steadiness, comfort, convenience and economy when the motor supersedes the horse, and a good pavement permits the use of a slightly grooved rail. There remains the vast mass of rapid, long-distance travel, not now provided for at all, and the rapid short-distance travel which the tramway cannot develop sufficient speed to accommodate on Broadway, or upon any narrow and crowded thoroughfare.

There are, then, two distinct demands which the requirements of modern life make upon the sub-surface street, which it is the object of the "scientific street" to supply. Broadway is taken as the standard, and reference is made to the plate for illustration. The total width of the street (80 feet) is marked "Public Property." The private fee is shown in black, marked house-line, and is beyond this line. The side-walk is called "City Permit," for the reason that while the title is in the public, it is—underground—almost uniformly in the exclusive use of the abutting proprietor in fee, under license or "permit" from the city. The parts marked "area" and "vault," cover 18 feet from house line to curb line (colored yellow). Neither the one nor the other is disturbed by the lines of railway tunnel, or the galleries for pipes and wires.

The roadway between the curbs is 44 feet in width, and this furnishes all the accommodation required for all purposes. It is divided into two sections, the one, centrally placed, affords accommodation for two "way" and two "express" tunnels, within 35 feet, and is called the "permissive section" (colored red). The sections on either side are 4 feet 6 inches (colored blue) and called the "compulsory sections," because the existing impedimenta of the street must be disposed of at that point of access to the abutting houses. By this disposition of the street all requirements are fulfilled. A smooth, noiseless and unobstructed surface is provided for pedestrian and vehicular traffic, express and way trains for rapid transit, permanent housing for sewer, water, gas, steam, pneumatic, electric conductors and pipes, with access throughout for inspection, *and in all cases in immediate contact with the premises where the connections are to be made.* In neither express or way stations is private property taken, nor at any point does the structure abut private premises, even during construction. The section selected for illustration is

north of Dey Street, where the existing obstructions are greatest, including the pneumatic tubes of the Western Union Company, the heavily "packed" pipes of the Steam Heating Company; and where provision for 4000 electric wires is required.

The method of construction is as follows: street excavation is effected in sections, and is governed by the extent and character of the traffic. A uniform platform of concrete, about two feet in thickness, floored by half-inch of Trinidad asphalt, is first laid, extending across the street at the maximum base depth of about 17 feet, forming a foundation for the whole structure. Upon this is erected the external vault wall (A A), securing to the abutting proprietor the permanent use of the whole vault and area undisturbed throughout the standard section. This vault wall is fitted while under construction with suitable connections for gas, steam, electricity, sewer and water at every house. This wall is also the external wall of the galleries, arranged adjacent to either curb (B B). The galleries are sub-divided longitudinally and continuously, by beams riveted to their internal and inserted in their external walls. Access throughout is provided at the termini and stations, and they are calculated for access to, housing and inspection of the tubes, pipes and wires. The electrical conductors are arranged anti-inductively, upon shelves riveted to the roof and gallery beams, as shown at C. There being no permanent floor above the foundation, the pipes in either gallery are accessible from above or below. Street opening for repair, replacement, or connection is thus wholly obviated. The internal frame supporting the galleries is formed by iron columns, placed four feet apart, and coincident with those forming the outer wall of the way railway tunnels. These columns are composed of two angle-irons riveted, and rest upon a continuous granite foundation. The space remaining between the pipe galleries, which in Broadway is thirty-five feet, is disposed in four railway tunnels, for the accommodation of an up way (D) and express (E), and a down (F) way and express (G) train. These tunnels are formed by five rows of columns each composed of four angle-irons, arranged longitudinally four feet apart, resting on a continuous granite base (H), the spaces between the columns at the foundation and the roof being filled by a panel composed of a tough, non-resonant material, secured by clamping-bars to elongated flanges of the columns, free but reinforced top and bottom. This panel fulfills a double function, it completes the tunnel for purposes of ventilation, and

it prevents resonance, which might be caused by the rapid passage of a train through a tunnel with metallic walls. The roof is supported, and the whole structure tied by beams placed four feet from centres (J), which extend across the entire span, bolted at every eight feet to the tunnel columns, the ends being inserted in the vault wall. Upon these beams the steel ten-inch-span buckle-plate roof is laid and bolted; over this is a two-inch skin of Trinidad asphalt, as a protector from chemical contact and dampness, and as a slight cushion. Above this is placed six inches of concrete, which completes the permanent street. This structure as a whole contemplates the minimum of excavation, the maximum of capacity, the greatest number and most equal distribution of points of support, and consequent maximum of firmness and steadiness in use.

The railway tunnels form open cylinders from station to station, and the trains being of approximate cross-section constitute loose pistons always moving in the same direction; the obvious effect is the establishment of a ventilating current, dependent for its force upon the approximation of cross-sections and the speed of the trains; as the products of artificial combustion are excluded from the tunnels the requirements of ventilation are reduced to a minimum, and perfectly performed. The traffic-rails and the electrical conductor-conduit are bolted to the same steel tie (L), which arrangement secures perfect alignment, the tie being permanently set in the concrete foundation. The modern wood pavement now used in London and Paris, should be substituted for the noisy granite. This is constructed upon the correct theory that the surface is not an enduring part of the street, but that it bears the same relation to it that a woollen carpet does to an ordinary floor, that is, that it provides a comparatively temporary, soft and agreeable surface for wear, while it protects the floor itself from destruction. This pavement, like a carpet, is easily and cheaply repaired or renewed, and provides at once a smooth, easily cleaned and noiseless surface for traffic. Stations for way trains are approached from side streets, by entrances placed at the curb lines, the passage being faced with white enamelled brick, while the platform is placed in the space occupied in the standard section by the pipes and wires (they being specially arranged at stations), and a portion of the vaults only, but in no case any part of the area. The express stations are "double decked," and occupy but little space inside the curb

line. There are entrances to stations at twenty two streets, between the Battery and the Hudson River terminus, at Vanderbilt avenue.

The steam plant for generating electricity for the railway service provides ten thousand horse-power, and the passenger capacity of the road will be about equal to that of the entire elevated railway system, as now worked. The railway carriages will be of unbreakable material and of standard gauge, so that they may be worked over the lines of any connecting trunk railways, which may provide an electric-conductor between the traffic rails. The devices of many electrical engineers and inventors will be employed in the complex designs for moving, switching, signaling, braking, lighting and regulating the numerous heavy trains required by these fast services.

Modifications of this specific design will be required under the variety of conditions imposed by varying widths and grades, but I venture to hope that its realization on Broadway will lead to the adoption of the sub-way for rapid travel in cities to the exclusion of any surface structures whatever. Meanwhile, an electric equipment for both elevated and surface roads, which is entirely within the present resources of the art, will diminish their offensiveness as far as is possible in the nature of things.

Note.—In the standard sections the disposition of pipes and wires in the galleries is : water-main, M ; water distribution, N ; sewer, O ; gas-main, P ; gas distribution, Q ; street gas, R ; steam pipes, S ; pneumatic tubes, T.