mend the award of the John Scott Legacy Medal and Premium.

CARL HERING, *Chairman*, RICHARD W. DAVIDS,
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WM. McDEVITT,

Adopted, February 4, 1891.

S. L. WIEGAND,

Chairman of the Committee on Science and the Arts.

THE SYSTEM OF HOUSE AND UNDERGROUND
WIRING OF THE INTERIOR CONDUIT AND
INSULATION COMPANY.

BY E. H. JOHNSON, New York.

[A Paper read before the Franklin Institute, December 17, 1890.]

JOSEPH M. WILSON, president, in the chair.

MR. JOHNSON—MR. PRESIDENT AND MEMBERS OF THE
INSTITUTE:

Having been identified with the new industry of incandescent electric lighting, and more particularly with the practical work of distributing the electric current therefor, since its inception, I have been made aware of the requirements of the problems of safety, convenience and economy in a pronounced way, and in the system which I am honored in being requested to bring to your attention to-night, I claim to have fully incorporated these essential factors.

Briefly described, the system is nothing more or less than a well worked-out scheme of supplanting or supplementing the former practice of attaching the insulation to the wire itself, by a system of insulated raceways, into which to draw the wires, and which supplies in itself a degree of high and durable insulation not attainable by the old methods, while supplying in addition the highly important (I might almost say imperative) adjuncts of accessibility.

In the matter of safety, I have only to call your attention to the fact that it is practically impossible to main-

tain a flame within the circumscribed limits of a tube scarcely greater in diameter than the material ignited within it; such an enclosure becomes a snuffer, and this quality of suffocating combustion is independent of the inflammability of the material of which the snuffer may be composed. No elaborate description of the system is required. The sample of wiring which stands before you tells its own story on the instant, and the experiments which my assistant and associate inventor, Mr. Greenfield, will now make, will demonstrate its utility better than any verbal explanation. Before proceeding to such demonstration, however, I will make mention of one or two points which an experience of a year in promoting this system has developed.

(1) You will readily perceive that if this means of insulating wires for interior or underground purposes should in practice prove all-sufficient, the very large interests now invested in the wire-insulating industries would imagine itself seriously jeopardized, and the new method would encounter the open and severe attack of such interest. This attack has been made, and while I have not claimed for the system that it is a complete substitute for all other insulations, I have, by virtue of the very efforts that have been made to depreciate it, been led to develop it on lines which will speedily enable it to fulfil such conditions absolutely.

In illustration, certain rubber insulation interests in the city of Boston, undertook to prove to interested authorities that the tube would burn, not by virtue of heat emanating from the wires within it, but by fires originating from other and external causes; and this demonstration was made quietly and without my knowledge. Upon learning the facts, I at once called attention to the fact that no claim of non-combustibility had ever been made for it. That such was, in fact, not an essential requisite, nevertheless, I then undertook to provide a special tube which might be employed in certain cases where this feature was important. A sample of this tube will be shown you to-night.

(2) It has been alleged also that this tube disintegrates

in time in the presence of moisture. This criticism was very properly made against the first tube we placed on the market, but when the new tube completely met it, the criticism was not abandoned but was kept alive by the exhibitions of the early samples. When, however, in the course of time, I made this contention untenable, it was narrowed down to the statement that the tube would disintegrate in cement. Upon investigation I found this to be true and endeavored at once to correct it if possible. I am glad to say that this most difficult of all problems has now been satisfactorily solved.

(3) It has been asserted that its cost, in consequence of its not being a complete substitute for other insulation, is simply an additional charge on an installation and one that brings no sufficient compensations. To this I reply that the cost of an installation by this method need be no greater than that of any other method approved by the better class of underwriter inspectors. Not so great, in fact, as some methods. The difficulty is that too much work is done, where reliance is placed wholly on the insulation of the wire itself. In fact, notwithstanding the universal knowledge that no insulated wire exists which does not need to be physically protected, many installations are thus made to-day and pass the inspectors, where owners and architects, however, take an intelligent interest in the subject and insist upon superior work. This system can be and is installed at prices that compete with others.

Furthermore, the details of its application are being cheapened and improved every day, and it is probably not even now too much to claim for the system that its opponents have caused it to be developed to a degree that will justify the contention that their wires may be safely employed in it and thus the tables be turned; that is to say, it may be installed more cheaply than any other, because the costly insulation of wires by its use are dispensed with.

I venture, in conclusion, to submit a statement and description of a new underground conduit system, which is more or less the outgrowth of the interior conduit system just described, and is the result of a series of costly and

elaborate experiments to determine the practical requirements of underground electric conductors. The system is not unlike the interior system, in that it consists of a series of highly insulating, water-proof tubes, which form individual channels or raceways for the reception of whatsoever electrical conductors may be employed, thus providing for the drawing in, or withdrawal of, conductors at any time, rendering them as accessible for renewal and repairs as if placed on the surface itself.

In its physical characteristics it differs from the ordinary iron, wood, cement and other conduits, in that while they only contemplate ducts of uniform and large diameter, each accommodating a considerable number of wires, these conduits provide an individual duct of suitable dimensions for each and every wire or cable employed. In the important element of insulation, however, it differs radically. All conduits hitherto employed practically ignore the problem of insulation, thus compelling the use of costly and cumbersome insulations upon the wires themselves, whereas this system provides in the conduit itself without special investment therefor an insulation ample for all purposes. The extra charge, direct and indirect, incurred for the necessarily expensive insulations and metallic protections of such insulated cables and for handling their greater bulk and weight, will, in any plant of material size, amount to a sum more than sufficient to pay the entire cost of this conduit system.

This conduit may consist of any desired number of individual tubes or ducts, continuous from one man-hole to another, no joints or couplings being employed to unite the several sections of the individual ducts, and thus a fruitful cause of leakage and consequent deterioration is eliminated. The method of converting the tube sections into continuous unbroken and unjointed ducts constitutes one of the important elements of our system.

The general method is as follows :

A series of tubes of any given number, length and diameter is racked in a suitable frame so as to be held at a uniform distance apart. The segregated bundle thus

formed is then pushed into a cast-iron pipe of a diameter slightly greater than that of the bundle of tubes, but of exactly the same length. A jig is then attached to the end to secure a uniform terminal location of the ducts, and the whole is then immersed in a bath of special insulating compound maintained at a high temperature. When withdrawn from this bath, only that portion of the compound which has entered the interior of the tubes is allowed to escape, all that portion which has filled the waste interstices is imprisoned, and subsequently becomes solidified, thus presenting a substantial body composed only of a high insulating material, throughout which are the clear, straight and smooth duct interiors; these completed sectional bodies are for convenience of handling manufactured in ten-foot lengths, and in this form are ready for laying. Realizing, however, that all attempts at hermetically uniting the multiple ducts of such sectional systems have proven utter and disastrous failures, we have evolved a method of laying these conduits, which converts these sectional units into continuous ducts having practically no junctions, certainly none of inclusive cross section, or contiguous coincidence. The manner in which this is effected is as follows:

In addition to the consolidated section above described, we employ individual tubes the length of which is the same as the consolidated ducts, the external diameter of which, however, is slightly less than the internal diameter of the consolidated ducts and the internal diameter of which is just what is called for by the requirements of the service for which they are intended. These individual tubes are coated at the moment of laying with an insulating compound or cement, and are then telescoped into the consolidated ducts to the depth of just one-half their length in each section. The abutting ends of the exterior or consolidated tubes of contiguous sections are, of course, mid-way of the general containing pipes, each and every duct thus telescopically formed of the two complete tubes and cemented with a superior insulating compound, becomes, therefore, to all intents and purposes as perfect in its continuity as if manufactured at the factory in one unbroken

length. The general containing pipes are united by a special sleeve or coupling box, which is thoroughly filled with insulating compound and further sealed by the insertion of a sheet-lead gasket between the sleeve or box and the abutting ends of the pipe.

From man-hole to man-hole, we thus provide a system which in its outer material form and appearance is identical with that method, which fifty years of practical experience has evolved as best practice in the distribution of water, gas, steam, etc. Cast iron having become the accepted economical and durable channel for the distribution of energy in all its other forms, why not for the distribution of electricity? The answer to this question has hitherto been found in the absence of suitable provision for the continuity of insulation in each and every one of the separate ducts demanded by the peculiar requirements of electrical distribution, viz: That the aggregate volume traversing a given channel must consist of separately maintained minor units or volumes, each of which possesses some special characteristic of pressure or other function differentiating it from its neighbor. This problem of absolutely reliable insulating continuity is now solved for the first time by our telescopically continuous insulated ducts.

Man-holes.—Having applied to electrical channel distribution the best practice evolved by other and older industries, and having only supplemented these with new devices where the special requirements of electric distribution demanded, we have proceeded to analyze the terminal requirements of electrical conductors and, as far as possible, have endeavored to apply thereto that method of practice which experience has demonstrated to be most effective. The "man-hole" is practically a creation of the electrical industry; we are therefore limited in any consideration of its problems to electrical practices; fortunately, however, the man-hole is an indispensable adjunct of all electrical systems, hence, by virtue of the extraordinary development of the electrical industry, we become possessed of a vast deal of practical experience from which to obtain useful data. An examination of these data develops the fact that the

demand is for a man-hole which may be left open with impunity. This means simply that the conductors passing through it and the ducts entering it must be considered, in so far as their treatment is concerned, as though permanently terminating in a cesspool. We have attacked the problem from this point of view.

The man-hole as we have finally designed it is simply a construction of brick and carefully cemented to protect it as far as possible from the exudations of the soil, for the sake of cleanliness. The section of the general containing pipe entering the man-hole is expanded in a funnel form to about double its normal diameter, for the purpose of separating, and, therefore, providing a greater space around the duct ends for more perfect manipulation. The end of this funnel is provided with an iron head, on the face of which are short pipe projections corresponding to the number of ducts, and into each of which a duct end terminates. These iron nipples are threaded on the outside for the reception of a metallic cap or coupling. When the conductor has been drawn into the duct a section of lead pipe with an insulated lining is pushed over the end of the conductors, and a short distance into the duct itself; a coupling is then screwed onto the cap and over the lead-encased conductor and so firmly screwed home as practically to consolidate the lead sheathing and iron nipples, and thus hermetically seal the end of the duct. The corresponding end of the conductor on the opposite side of the man-hole having been treated in the same way, it now only remains to join the broken sections of the conductors and their lead sheathing, hang the completed conductor upon its proper rack at the side of the man-hole, and proceed to treat each of the other conductors in a like manner. When all are so treated, and any unoccupied ducts securely sealed, the man-hole itself may be left open with impunity.

It will be observed that since each and every conductor is treated at the man-hole as flexible cable, and hung upon a rack at its side, the centre of the man-hole remains unobstructed, and perfect freedom is afforded the workmen who may need to get at any particular conductor for purpose of testing, repairs or lateral tapping.

Lamp-posts, feeder-posts, or other branch taps are provided, and are so constructed as to be nothing more or less than minor extensions of the system in its every feature. They are iron pipes filled with our insulating compound and jointed to the conduit proper by suitably constructed elbow extensions, thus providing for the drawing in of the conductors from the nearest man-hole to the top or extreme terminal of the post or other branch.

In conclusion, I may say that we feel free to express our conviction that in point of first cost, durability, flexibility, insulation, cleanliness, economy of maintenance, economy of space and general adaptability, no other combination of underground conduit and conductors can even approximately equal this system.

I thank you, Mr. President and gentlemen, for your courteous attention.

THE CONTINUOUS GIRDER—VARIABLE MOMENT OF INERTIA—FIXED POINTS—GRAPHIC METHOD.

BY C. H. LINDENBERGER.

Those who are familiar with graphic methods would scarcely like to lose the sense of assured satisfaction that comes from proving the agreement of a graphic calculation with an analytical one, even though the latter may not be so very difficult. This is the case in the majority of instances, but there is this advantage that an increased difficulty in the analytical calculation seldom means a corresponding difficulty in the graphical method. Hence a graphic theory is always valuable as a means of solution.

The theory of solution by "fixed points," so far as it relates to "constant moment of inertia," has been dealt with in this journal for December, 1888, and November, 1889. It remains to extend it to "variable moment of inertia," and, to make the theory general, to extend it to the case in which the coefficients of the unknown quantities are different in each equation.