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THE MOTIVE POWER OF THE PHILADELPHIA CABLE RAILWAY.

The present plans of the Philadelphia Traction Company comprise a little over 20 miles of cable road, divided into three districts or routes. Each of the three stations is provided with two engines, which may be used singly or in combination, and six boilers arranged in pairs. The Market Street station, located at 19th Street, operates a line to Front Street and return, a distance of 19,000 feet, and also a line to 42d Street, a distance of 20,000 feet. The Sansom Street station, at 9th Street, works a line to 7th Street, to McKean, to 9th, to Sansom, and to the station, a distance of 19,000 feet; the second line from this station extends to 9th Street, to Spring Garden, to 7th, to Master, to Franklin, to 7th, to Sansom, to station—19,000 feet. From the Columbia Avenue station one line runs to 33d Street, where it connects with an auxiliary cable forming a loop, and designed to accommodate summer travel to the Park and return, a distance of 9,000 feet; the second line leads through Columbia Avenue to Franklin Street, to Master, to 7th, to Columbia Avenue, to station—19,000 feet. It is expected that the speed on all of these lines will be about 7 miles an hour, with the exception of that from the Market Street station to 42d Street, which will be 9 miles, and the loop in the Park, which will be 3½ miles.

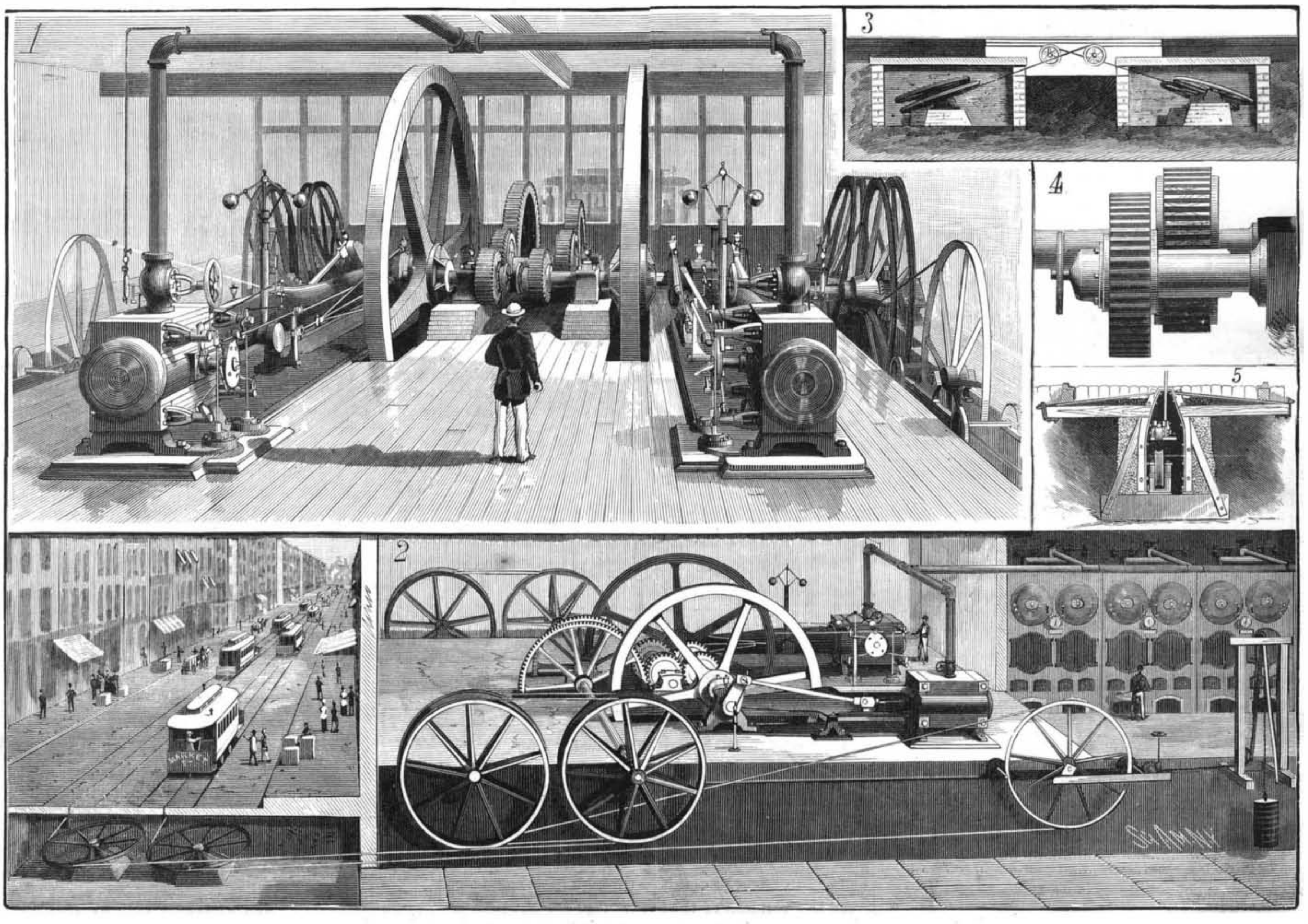
The engines, built by Messrs. Robert Wetherill & Co., of Chester, Pa., are of the Corliss type, and are conspicuous for their symmetry of design and the very apparent rigidity of construction. Many new features have been introduced by the makers, which render certain the action of the valve motion and governing mechanism, which increase the effectiveness and durability, and which combine all the essential elements conducive to the highest economy in the consumption of steam.

The cylinders are 24 by 48 inches; each engine is 260 horse power, making 520 horse power in each station. The valves are given a much larger bearing surface than is generally allowed, thereby allowing the engine to work under high pressure without cutting the valve seats, which are bored out perfectly true with tools specially constructed for this purpose. To insure a quick and quiet closing of the steam ports when the steam valves are liberated by the governor, a form of vacuum pot is used which avoids the inertia of the old style weight dash-pot. These are mounted on a piece projecting from the cylinder stand, and being in sight, above the floor, are in easy reach. In operation, a vacuum is formed in a small cylinder, when its plunger is raised by the opening of the valves; and the instant that detachment is made by the governor, this is exerted to force down the plunger, and reverse the direction of motion of the valves to close the ports. The requisite amount of cushion, obtained by a large chamber above the cylinder, is controlled by a screw covering a passage in communication with this chamber; all shock to the valve gear is thus prevented.

The cylinder heads are made with ground joints, thus doing away with all packing, and the back heads are entirely covered with a cap which presents a surface easily cleaned, and provides a chamber that may be filled with non-conducting material. The piston head is made in one piece, cast hollow and ribbed, giving the necessary strength with one-half the weight of the ordinary piston. The rings are of cast iron cut in segments, and lapping each other to break joints. Steam is not admitted under the rings to set the packing out, the joint against the surface of the cylinder being effected by German silver elliptic springs attached to each segment, and so adjusted that an equal pressure is exerted against the bore of the cylinder. The tightness of these pistons has been frequently tested by running the engine single acting, with back head off, when the packing showed no signs of leaking. The cross head pin is placed in the vertical center line of the shoes, which are adjusted by means of large screws held in position by jam nuts. The pin is lubricated through a curved branch, secured to the center, and provided with a sight feed cup, the oil being carried through the center of the pin and discharged on the top surface by suitable channels. This construction of cross head prevents the rocking of the center of the head up and down at every stroke, as is frequently the case when the pin is located forward of the center of the shoes. The connecting rods are of hammered iron, and in length are 5½ cranks; they are made with square end straps, which present a large bearing surface for brass, making it impossible for the box to get out of position, and heat. The boxes are of bronze metal, and have large wearing surfaces working on steel pins. The frame is heavy and rigid, with broad center support under the forward end of the guides. The castings of the pillow blocks are heavily proportioned, thoroughly ribbed, and provided with removable bearings.

The general arrangement of the gearing and winding drums, built by Messrs. Robt. Wetherill & Co., of Chester, Pa., by which power is transmitted from the engine to the cables will be understood from the engravings, Figs. 1 and 2, which show the engines at the Market Street station. The crank shaft is of hammered iron, is 12 inches in diameter, and mounted upon it, between the main and outboard pillow blocks, is a cast iron flywheel, 18 feet in diameter, and weighing 40,000 pounds. Upon the end of the shaft is a cast iron pinion, 40 inches in diameter, 14 inches face, and formed with thirty teeth. Each of these pinions is so mounted, with a feather, that it may be moved to the extreme outer end of the shaft, when it will be disengaged from

(*Continued on page* 117.)



THE MOTIVE POWER OF THE PHILADELPHIA CABLE RAILWAY.

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a pinion rigidly mounted upon a shaft located parallel with the crank shafts, or up close to the pillow block, when it will engage with the middle pinion. (The engraving, Fig. 1, shows one crank pinion meshing with and the other disengaged from the intermediate pinions.) This movement is accomplished by means of a hand wheel mounted upon a screw threaded rod entering the end of the shaft. The second, or intermediate, shaft is mounted between the two flywheels, and carries two pinions of the same size as those upon the crank shaft; but the teeth of these pinions are made of maple wood, and are so held that they can be easily adjusted to take up wear, and in case of breakage a new tooth can be readily inserted. The main object in making these teeth of wood is to deaden the noise which would result from the use of an intermediate pinion of iron, since all the other pinions and spur wheels are of cast iron with file-trimmed teeth. So far, this method of construction has given the greatest satisfaction, the noise being hardly perceptible, and no wear being as yet apparent.

It will be perceived that either engine may be used to run the intermediate shaft, the position of the shaft pinions determining which shall do the work.

Extending across the rear of the engines is a 12-inch hammered iron shaft formed in two parts, each 12 feet 2 inches long. Upon one shaft is mounted a spur wheel, cast in one piece, 12 feet in diameter, 14 inches face, and having 107 teeth; upon the other is a spur wheel 9½ feet in diameter, 14 inches face, and having 83 teeth. These wheels engage, respectively, with the intermediate pinions. The larger wheel operates the cable running to Front Street at a speed of 7 miles an hour, and the smaller one that running to 42d Street at a speed of 9 miles an hour.

These are the only cables running at different speeds, the engines at the other stations being provided with two of the larger spur wheels. Upon each of the outer ends of these shafts are mounted two sheaves over which the cables pass. From what we have described it will be understood how either engine may be used to operate these shafts; but in order that either line may remain quiet while the other is running, each of the driving shafts is furnished with a crab-clutch coupling. This consists of a sleeve moving upon a feather, and so formed as to mesh with a rigidly mounted piece on the shaft when moved in one direction, and to be fr e when moved in the opposite direction. The weight and close fit, or more properly the stick, of this sleeve on the shaft make it a difficult job to move it, especially after it has remained in one position for some time. To obviate this a disk is rigidly mounted upon a short shaft journaled in a standard placed a little distance from the sleeve, to which it is connected by a rod pivoted at such a distance from the center of the disk that when the latter is turned about half way round, the sleeve will be moved its full distance. The opposite end of the short shaft is squared to receive the end of a lever bar by which the movement is effected.

Just back of the engine room are placed six compound tubular boilers, also built by Messrs. Wetherill & Co., each 48 inches in diameter, 14 feet long, and having forty 4-inch tubes. The grate surface of each is 20 feet; the boilers are arranged in three separate nests.

The two grooved sheaves upon the outer ends of the driving shafts are loosely mounted. An ingenious device for allowing for any inequality in the wear of the two wheels was designed by Mr. A. D. Whitton, chief engineer of the Traction Company. Each sheave carries upon the inner end of its hub a beveled steel wheel, 32 inches in diameter, and having 29 teeth. Between these wheels, and extending across the main shaft at right angles, is a steel shaft 6 inches in diameter, upon each end of which is a loosely mounted beveled pinion, 16 inches in diameter and having 14 teeth. These pinions mesh with the wheels on the sheaves. It will be seen that any difference in the speed of the two sheaves resulting from changes due to wear will be allowed for by this compensating device.

The cable, entering from the street, passes over the first of these sheaves, then around one of a similar pair placed a little distance away, then over the second, then to the other of the second pair, and thence around a sheave mounted on a car running along the pit, and then back to the street. The pit is 140 feet long, and the travel of the car sufficient to take up 280 feet of slack. (The course of the cable while in the building is plainly shown in Fig. 2.) The tension car is 17 feet 3 inches long, and travels upon a horizontal track of 4 feet gauge, laid along the sides of the pit. The rear end of the car is attached to a chain that passes over a pulley on a frame at the rear end of the pit; the end of the chain can be weighted to suit the requirements of the cable.

In a vault under the street, in line with the pit, are placed two sheaves—all the sheaves are 12 feet in diameter—mounted to revolve in such a plane that the incoming and outgoing portions of the cable will be led to their respective tracks. This is shown in Fig. 3.

Each station is furnished with a 10,000-gallon tank, thus making the company independent of the regular city water supply. At the Market Street station is an hydraulic elevator by which the cars may be raised to the second and third floors and stored during the night.

The cables are of steel wire 1¼ inches in diameter. The street tube, designed by A. Bonzano, C.E., in which they run—a cross section of the tube is shown in Fig. 5—was thoroughly described and illustrated in the SCIENTIFIC AMERICAN of June 7, 1884. It is formed of heavy boiler iron provided with vertical angle irons to stiffen it, and braced with angle rods extending from near the top to projections of the base. Upon each side is placed a backing of concrete. Extending along the top is a slot ⅝ of an inch wide through which the grip standard passes. In order to prevent the sides of this slot being forced together by the action of frost, ties 3½ feet long and made of 5 by 7 inch timber extend from the sides of the tube above the concrete backing. The stringers rest upon these ties. Seven-eighth inch tie rods extend from the top of the tube to shoes on the ends of the ties. By moving the nuts on the ends of these rods, the width of the slot can be adjusted. In the lower part of the tube the small pulleys carrying the cable are mounted.

The cables cross each other at five different points. At these places the grip of the car on the under cable is detached, the momentum of the car being depended upon to carry it by the crossing; cars upon the upper cable, of course, pass without freeing the grips. The cables are so deflected by the arrangement of the pulleys as not to interfere with each other. In passing around curves—the standard curve is 35 feet 7¾ inches—the pulleys in the tubes are placed horizontally, and the slot is located so as to form a circle concentric with, but a little larger than, that formed by the outer edges of the pulleys. This permits the grip to pass freely by the pulleys, the cable moving in the circle described by the slot and grip.

The grip—of the Low & Grim's patent, San Francisco, and built by Messrs. Robt. Wetherill & Co., of Chester, Pa.—consists of a wide bar, 7/8 an inch thick, at each side of the lower end of which is a grooved pulley for raising and guiding the cable between the two grooved bars (shown in Fig. 5), placed parallel with the cable, and which constitute the grip proper. The jaws are so placed as to prevent undue wear upon the cable. These jaws are operated to press the cable between them, or to release it from the platform of the car, the gripping being effected through a plate sliding vertically in the center of the grip shank.

Within the stations the plant is in thorough working order, and as but little remains to be done to complete the street portion of the system, it is expected that all the lines will be in operation in a few weeks.

Advice to Young Engineers.

A good many engineers will undoubtedly recognize some of their own early experiences in the engine room when they read the following, from a correspondent in the *American Machinist:*

When business is depressed, the manufacturer thinks he must get along with a young man or boy in the place of a competent man, and the following is the result:

They discharge their engineer, and in his place put a young man who has served a short time as wiper in another place. He can oil and wipe an engine, knows how to pound with a hammer and twist the corner off nuts with a wrench, and that is enough until times are better. No sooner is he in the engine room than he considers himself quite an engineer. Because the engine does not happen to break down the first week, he gets an idea that he is an old hand, and a desire comes over him to see the inside of the engine. So at the first opportunity he pulls it to pieces, placing part of it on the floor, some on the cylinder, and some on the bench, strewing it generally about the engine room; all small nuts, keys, or screws he happens to have he puts in one of his many pockets.

Now, young man, the trouble commences. Objects that were familiar to you look strangely different now, as they lie strewn about the room. But together it must go, so you begin with the steam chest. Where did you put the bolts? Oh! here they are, in this pile by themselves, so they would not get mixed with any of the others. That is nice, no doubt, but when you go to put them in, one goes in with the use of the fingers only, while another requires a long wrench. What is the matter with them? They came out easily. The matter is simply that little pile. Now that you have the bolts all started, you begin at one point and screw them up tight as you go along, so as to know where to leave off. Queer some older head didn't think of the same thing.

Where are the valve rods? In a pile by themselves also. But which is which? I don't know, but will try them and see. This one goes on hard; give me my hammer. Now you exhibit the one thing that you can do and do as well as any one, and that is, pound with a hammer (don't use a block of wood, for in time you would be certain to destroy the block).

One other thing you know ought to be done, and that is each individual piece should be carefully wiped and the waste deposited—well, on the floor is the handiest place. You pick it up and wipe a piece with it, lay it down, roll it over, and step on it until it finally becomes well mixed with grease and grit, but it is waste, and that is enough.

Let's see; how far did I run this nut back on the eccentric rod? Well, two or three times, more or less; it don't make much odds.

You have it together at last. It came apart easy enough, but it went together very hard.

Now is the great moment in your life. You have had an engine apart and put it together all yourself, and are about to start it. Finally you get on steam enough to get it up to speed. What is the result? It pounds, squeaks, groans, and heats. What is the matter? Simply your incompetency.

The bearings are all full of grit from the dirty waste; some parts you oiled and some you didn't. You mixed up the valve rods, keys, and screws. You did not get the nut on the eccentric rod in the right position. In fact, you forgot a thousand and one little attentions necessary to have an engine run properly, which a man who has learned his trade will not forget.

Now, young man, first of all, let well enough alone. Never disturb an engine without occasion demands it, and if so, do it systematically. Have the floor swept clean, and spread some old sacking which is clean. When you take a part off, clean it with clean waste, being careful to keep your waste from all grit. Run your hand over the part to see if the waste has left anything on it, as the hand will readily detect the smallest particle of grit. After you have cleaned a part, lay it back out of the way just as it came off, and all the small stuff with it, just as it belongs.

When you take off the head or steam chest, take the bolts and lay them in a circle or hollow square, with the small ends in, so that you can put them back just as they came out. You will be surprised to see how much faster the work will progress.

When you come to a thing that sticks, find out what causes it, and remedy it. The builders of steam engines do not always do their work well. But whatever you do, don't use a hammer; use wood or lead tools to pound with. If you use blocks, cut them about 5 inches long and 8 inches in diameter, of hard wood, keeping them on hand all the time, replacing them as fast as one gives way, never waiting until needed.

When you put a wrench on a nut, see that it fits it before you begin to pull, or you will soon spoil both wrench and nut. If a nut goes too hard, take it off and clean the thread.

If your oil can gets stopped up, look out for it, as it does no good to stick the snout of a can into an oil hole unless you leave a drop of oil there.

Empty out both your can and filler and wash them out clean, then get a piece of thin cotton cloth and strain the oil; it will not take long, and you will be sure of the can's delivering a drop of oil every time it is required. And, lastly, when your engine runs bad, sit down and try and reason out why it does so. And take a good paper to read.

The Square in Battle.

Lieut.-Gen. Sir Edward Hamley, of the British Army, is strongly opposed to the tactics adopted by the troops of forming squares in battle. He argues that unless the front rank is lying down, a position it could not maintain when the enemy comes close to the sides attacked, it delivers a fire small in proportion to the number of rifles, while the sides not attacked deliver none. Should the square be penetrated, then it becomes a mob, because the recoiling troops are pressed back on the other forces. The troops forming three sides of the square have their backs to the enemy who have succeeded in getting inside, and such of the men as face inward to meet the attack cannot fire on the enemy without also firing into the opposite side of the square. He thinks it desirable to ascertain how far the losses in the late action were caused by the English fire during the *melee*. When the whole brigade is placed in a square, the chances of disaster are immensely increased, as the sides of the square are under different regimental commanders, unaccustomed to act in such close association, while the extent of the space occupied renders it difficult for the brigade commander to convey with sufficient promptitude the orders necessary to insure an *ensemble*, even in movements of a simple kind, and impossible to effect a good formation when engaged with an enemy in a much better formation, such as echelons, or half battalions, or even double companies.

THE completion of the Mackey-Bennett cable makes the total length of submarine cable, according to the *Electrician*, about 68,000 miles. Each cable contains an average of 40 strands of wire, so that altogether there are over 2,500,000 miles of wire used in their construction, or ten times the distance from the earth to the moon. Practically all of this has been laid within the last twenty-five years; the greater part within a decade.