TELPHERAGE.

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Definition. Telpherage is derived from two Greek words "τελε" and "φερω." "Tele" means far, and "ferro" means to bear or to carry. Therefore, telpherage means far-carrying. The same word "tele" appears in telegraph and telephone. The word was originally invented by the late Professor Fleeming Jenkin, who was the early spirit of telpherage, and but for his untimely death, telpherage would be even more extensively used. Like many other words, its meaning has varied. In the beginning it meant, practically, aerial electrical transportation, but now it has been brought back to its original meaning, which is the transportation of material to a distance by electricity, overhead, or sometimes on the surface, or even underground. In the latter case, it is termed "tubular despatch." Therefore, telpherage may be concisely defined as the electrical transportation of material. The method of applying it is an engineering problem and must depend upon local conditions, and even to-day the term "telpherage engineering" is becoming a common expression. It will be noticed that the word "automatic" is left out in these definitions. The reason for this is that it is a commercial question, and in cases where a man is required to attend to certain portions of the work, it is often cheaper for the man to go with the load than to use automatic devices. As to whether it is better to make an installation automatic or otherwise, depends entirely upon the comparative cost of the two methods of operation. In this connection it may be said that with telpherage plants the word "telpherman" is now often used.

FIG. 1. Side bearing telfers with permanently attached trailer. Track solid rail. Telfer controlled from either end. Length 1,200 feet. Four curves one "S" curve. Grade 12 per cent. Maximum total 4,000 lbs. Speed on level 10 miles per hour. Speed on grade 5 miles per hour. Horse power—5 horse power. Capacity, 100 tons per day per telfer.

History. The early history of telpherage closely resembles that of the electric railway. Before the successful pioneers in electric street railway traction had finally accomplished satisfactory results, many men had experimented, and it is well known that, some forty years ago, an electric railway was operated, having a speed of several miles per hour. It seems that it is necessary, with all successful applications of power to the transportation problem, that much preliminary work, seemingly unproductive, must be done. It often happens, as in the case of early telpherage, that the time was not ripe for its commercial adaptation. In the history of telpherage in England, a telpherage line was installed, using what was then called the series system, whereby it was necessary to use a telpher with a number of trailers. One section was positive and the next negative, the current passing from one section of the track to

FIG. 2. Track of above showing "S" curve.

the other through the motor, thereby completing the circuit. In passing over the insulator between the positive and the negative sections, there necessarily occurred considerable sparking, which greatly increased the cost of maintenance. It was also necessary always to have trains of certain lengths. There were many other disadvantages, such as having to use a track made of round bar rail and the difficulty of manufacturing reliable electric motors. If it was desired to install a telpherage plant, it was always necessary to put in an engine, boiler and dynamo. In comparison with its early history, telpherage to-day possesses the advantage that every factory, where there is need for tel-

pherage, either has its own electrical plant, or the power may be rented from existing central stations or even street railway stations. There are also to-day for aerial transportation most excellent cables made especially for telpherage work, and likewise, where it is more desirable to use than solid rail cable, special shapes have been devised which give most excellent results. Motors, controllers and carriers of great reliability are now manufactured following the methods developed by the best railroad practice.

Before it was decided to enter into the present commercial adaptation of telpherage, an engineer visited all the electrical manufacturing plants and electrical installations in Europe, and found that nothing was being done in the transportation of material electrically. In the United States many experiments had been made, but the inventors were always seeking the unobtainable. Upon careful research, it was found that there were 450 patents directly applying to telpherage and several hundred more which pertained indirectly to this subject. Most of these original inventors, were, however, too ambitious, and there was hardly any limit to the number of miles per minute which was to be achieved by the new and wonderful agent, electricity. Not only material was to be transported, but also passengers, and beautiful cars of mahogany were built and put in experimental operation. Cigar-shaped carriers were devised, some of which made a speed of two miles per minute or more, and when it was impossible to attain a greater speed there was great discouragement. There are no authentic examples of much more than experimental work, namely, merely conveying material between two points, generally in a straight line, placed in some vacant lot or loft, and there seemed to be a desire to force the method of transportation according to certain preconceived ideas, rather than to pay the necessary attention to its commercial adaptation.

Construction. On account of various advantages in regard to the distribution of material—such as depositing at an elevation—most of the telpherage plants thus far installed, have been overhead. As engineers, you will be most interested in hearing what has been accomplished; the descriptions are, therefore, confined to overhead work. Under the head of construction, it may be stated that the track is made of cable, especially drawn, either of standard wire or lock coil type, which latter has a strength approximating 95 per cent. that of the solid bar, or else solid rail, either of flat, girder or bulb type.

FIG. 3. SUPPORTING POLE, DOUBLE LINE. One of the simplest methods of pole construction for double lines. Especially recommended for long lines and where trees are available.

FIG. 4. OTHER FORMS OF POLE CONSTRUCTION, SHOWING SINGLE AND DOUBLE LINES. The track cables are supported by another cable, which is called the suspension cable. It would be impossible with long spans to stretch a cable so that under load there would not be considerable deflection. This deflection or sag is taken up by the suspension cable. Not only can we make the track cable horizontal, but even higher in the center than at the terminals.

The cable tracks are supported every hundred feet, provided it is convenient to erect poles or structures. Where there are deep ravines or between upper stories of factories, the span is made to correspond with the distance, and may be made of any reasonable length. In addition to the track cable, upon which the telpher runs, there is also what is known as the suspension cable. As is well known, it would be impossible to prevent considerable sag in the track cable and therefore the track cable is suspended from this suspension cable by means of hangers. The number of these hangers depends upon the length of the span. It will be easily seen that it is possible to have the

FIG. 5. Cable construction, Pittsburgh, Pa., line 97 feet from the ground, illustrating suspension cable, track cable and hangers.

center of the span higher than the ends, by merely raising the suspension cable and the hanger. This obviates one of the early difficulties met in the use of cable for telerage, as there is now no objectionable deflection in the cable when the telpher approaches a bracket. There are several methods of connecting the track and suspension cables by means of the hangers. The sizes of the cable, hangers and brackets vary, depending upon the weight which comes upon each individual span. The support is either simple poles with a bracket, or what is known as the "A" construction or ordinary cross bents. Cable con-

struction costs less than solid rail, except where there are many switches, in which cases the prices of solid rail and cable approach each other. In general, cable lines is recommended for straight lines, except where the weight is excessive.

In solid rail construction, the supports are ordinarily placed sixteen to twenty feet apart; longer spans are used if it is not convenient to erect supports. On long spans, the track consists of a girder rail with the track rail above it. It is not possible to give any general rule, as to what kind of track it is advisable to use, as this is a factor of the length of the spans and the

FIG. 6. Examples of cable construction with telfer, electric hoist and bucket, Elizabethport, N. J.

weight. The weights conveyed thus far by telpherage vary from 125 to 10,000 lbs. and the cost varies accordingly. It will be readily understood that when the weights are greater, the supports must be nearer together, and the cables or girders heavier. Running parallel to the track rail, either above or at the side, depending upon the amount of head room, are stretched one or more trolley wires; one wire, if the track is used as a return. If, however, it is desired not to use the track as a return, or to use alternating current, two trolley wires are employed. There are many other details of construction, but the photographs and outline drawings will serve to illustrate better than any description.

FIG. 7. Solid rail combined with cable construction. Capacity, 150,000 lbs. of ashes in ten hours. At present, handling the ash output of 23 boilers with other refuse. Average power consumed about one horse power. Located in New York City.

Telphers. According to the construction, telphers are divided into three distinct classes, center bearing, side bearing and alternate bearing. The center bearing has two motors, one on each side of the track; the side bearing has both motors on the same side, and the alternate has one motor upon one side of the track and the other motor upon the other side, but not upon the same shaft. Illustrations of each kind (Figs. 8, 9, 10, 11 and 12) are shown, also the same in operation. All the weight, in the side-bearing telpher, is utilized for traction, and the load is suspended

FIG. 8. CENTER-BEARING TELPHER.

FIG. 9. TELPHER WITH SOLENOID SPEED REGULATOR FOR GRADES AND REVERSING SWITCH.

FIG. 10. FRONT VIEW. SIDE BEARING. DOUBLE TROLLEY.

FIG. 11. SINGLE TROLLEY. SIDE BEARING.

FIG. 12. Side bearing telfer in operation. Illustrating method of suspension, also the carrier, section insulator, hanger, suspension and track cables with trolley wire.

beneath the driving wheels. Sometimes two telfers are connected up together in a single truck, this giving what is called a double telfer; or a trailing wheel is used after a double telfer, in order to distribute the weight over a greater portion of the track. This is necessary when the weight of the load to be carried is great. Fig. 13 shows quite fully this weight distribution. In all telferage work, gears are rarely used except for very heavy work or on steep grades. The frames of the later telfers are made in one casting, and the driving wheels are of steel, this having been determined to be the best material.

Motors. The motors are waterproof and dustproof and are compound wound for automatic work. When a telferman goes with the telfer, the series winding is employed. There is also used a special series coil to give greater torque when starting. The telfer is placed above the track, thereby keep-

FIG. 13. The double telfer; maximum traction; capacity, four tons of coal, or 95 cubic feet; speed, 800 to 1,200 feet per minute. Side-dumping bucket operated by telferman; controlled from either end. Telfers can be operated separately.

Three of these double telfers have a capacity of 250 tons of coal per hour over 2,000 feet of track. Labor, power and maintenance less than one cent per ton.

ing the motors from injury, while there is also no danger of their coming in contact with the carriers or being otherwise injured.

Hoists. The hoist is suspended below the telfer, or sometimes from a trailer drawn by the telfer. Special attention has been paid in the later designs of hoists to use as little head room as possible. It was deemed best at first to combine the telfer and hoist, but there were so many cases where it was necessary to use the telfer alone without the hoist, and also where it was advisable to put the hoist on the trailer instead of on the telfer, that experience has shown that it is better to make the telfer and hoist two separate pieces

of apparatus. Greater simplicity has also been obtained, and a correspondingly lower maintenance reached. There are many other interesting details concerning hoists, as to the speed, lift and construction, which it is necessary to omit here.

Brakes. Two distinct types of brake are used on telfers, either hand brakes or solenoid brakes, both of which are arranged to apply pressure to the wheels or to grip the track. In regard to the solenoid brake, it is only necessary to explain that it works automatically, the solenoid being placed in series with the armature. A spring normally holds the brake on the

FIG. 14. ELECTRIC HOIST SUSPENDED FROM TELFER.

wheel or the track. If, however, from any cause, the amount of current passing through the solenoid is reduced, whether by means of external resistance or by reason of the additional counter-electromotive force generated by the armature, due to running at a high speed, the solenoid becomes weakened and the brake is applied. An air cushion is arranged so that the brakes will be applied gradually.

Trailers. It is often advisable, where a large amount of material is to be carried, especially over one track, to use trailers. These consist generally of a two-wheeled truck, below which is suspended a bucket or other suitable form of carrier, or even the hoist, as the case may require. It is customary where a large amount of material is to be carried, to arrange a long train carrying as much as ten tons. The order of procession is, first, a telpher with four or five trailers, then another telpher and four or five trailers, and a telpher at each

FIG. 15. ELECTRIC HOIST AND TRAILER.

end. The placing of these telfers at intervals greatly adds to the traction, while the distribution of weight over the whole span, or over two or three spans, enables much lighter construction to be used for greater capacity.

Layouts. Much engineering skill is required to lay out or plan the telpher lines for any proposed work in order to decide whether the line should be single or double, and the weight to be carried by each unit. The installations should be so

planned that the expense will be reduced to a minimum, and further, that the track will not interfere with existing machinery or buildings, taking care to avoid an excessive number of curves and switches, as these add more or less to the expense, particularly to the cost of erection. It is necessary therefore, for the selling engineer to be thoroughly trained in this part of the work, or else have the necessary engineering knowledge derived from some other similar business. It may readily be understood that it is impossible to give general prices for telferage work. Complete specification blanks, with many necessary questions, are, therefore, provided, and the replies to these questions, together with a blue print showing a plan and elevation, are generally sufficient for the company to give a complete estimate for any proposed installation.

Method of Operation. It is difficult to treat in a general way of the method of operation. In automatic lines it is necessary to provide appliances whereby it is impossible for an unskilled operator to injure the telfer. In order, therefore, to provide for contingencies, a "dead section" is placed at each end of the line, the middle of the line being generally left alive. Upon closing a spring switch, the dead section is energized so long as the operator keeps his hand on the switch, which is usually only a few seconds, during which time the telfer passes to that portion of the line which is always alive. When it reaches the other end, it comes upon the dead section and then either slows down of its own accord, or else a mechanical or solenoid brake is applied. The telfer then passes under the reversing arrangement and it is therefore reversed, either with no current in the line or else with a high resistance. If the telfer is at the further end of the line, the operator at the near end, by closing a switch, can bring it back to him. The dead sections at the end of the line, which have current only so long as the hand is held upon the spring switch, render the line as safe as possible against the telfer coming in contact with the terminal posts. An automatic block system prevents collision of telfers.

Curves. The curves are solid rail and likewise the trolley track, where there is a curve, especially when it has a short radius. Wherever it is necessary to pass around a curve, to take turnouts or crossovers, a resistance is inserted in the trolley circuit, whereby the telfer automatically reduces its speed while it is traversing the curve or turnout or approaching a crossover switch. As soon as it reaches the other side of the

curve it receives full voltage and continues at its normal speed. In regular service the speed varies from 300 or 800 feet per minute, up to 20 miles per hour, or even more, when required. The slower speeds are used when the lines are short and where there are many curves, particularly for factory and foundry

FIG. 16. TELPHER WITH AUTOMATIC DUMPING BUCKET TRAVERSING A CURVE. This shows a telferage plant located at Buffalo, N. Y. This installation is interesting on account of its automatic features. The bucket is loaded at the cars and the load is transported by electricity to the end of the line, where the bucket automatically dumps its load. The telfer reverses itself and returns with the empty bucket to the cars for another load. The telfer may be operated by unskilled labor with the minimum of expense for power, maintenance and first cost. Power is less than one horse. The material which is dumped into a hopper is then elevated to the upper story. This line consists of a straight section and a right angle curve. A portion is cable, and the curve and the track in the building are solid rail. The line is supported, as will be observed from the photograph, from ordinary telegraph poles, and is an excellent example of simple construction.

work. For lines running across the country a speed in excess of 20 miles per hour can be obtained, but with the higher speeds the cost of the construction increases, certain special devices being necessary. Even for installations which are termed "cross country work," 15 to 20 miles per hour has been found amply sufficient.

As to what the ultimate capacity on grades may be, this has not been fully determined. Experimentally more than 20 per cent has been reached. In actual practice the greatest grade equipped has been 12 per cent., and thus far there seems to be ample traction.

THEORETICAL HORSE POWER NECESSARY TO PROPEL 1,000 POUNDS
AT VARIOUS SPEEDS AND UP VARIOUS GRADES AT SAME SPEEDS.

SPEED IN MILES PER HOUR.															
Grades in per cent.															
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	
0	.027	.053	.080	.107	.133	.160	.187	.213	.240	.267	.320	.400	.533	.667	
1	.053	.107	.160	.213	.267	.320	.373	.427	.480	.533	.610	.800	1.07	1.33	
2	.080	.160	.240	.320	.400	.480	.560	.640	.720	.800	.960	1.20	1.60	2.00	
3	.106	.213	.320	.427	.533	.640	.747	.853	.960	1.07	1.28	1.60	2.13	2.67	
4	.133	.267	.400	.533	.667	.800	.933	1.07	1.20	1.33	1.60	2.00	2.67	3.33	
5	.160	.320	.480	.640	.800	.960	1.12	1.28	1.44	1.60	1.92	2.40	3.20	4.00	
6	.186	.373	.560	.747	.933	1.12	1.30	1.49	1.68	1.87	2.24	2.85	3.73	4.67	
7	.215	.427	.640	.853	1.07	1.28	1.49	1.71	1.92	2.14	2.56	3.20	4.27	5.33	
8	.241	.480	.720	.960	1.20	1.44	1.68	1.92	2.16	2.40	2.88	3.60	4.80	6.00	
9	.267	.533	.800	1.07	1.33	1.60	1.87	2.13	2.40	2.67	3.20	4.00	5.33	6.67	
10	.293	.586	.880	1.17	1.47	1.76	2.05	2.34	2.64	3.03	3.52	4.40	5.36	7.33	
11	.320	.640	.960	1.28	1.60	1.92	2.24	2.55	2.88	3.20	3.84	4.80	6.40	8.00	
12	.346	.693	1.040	1.38	1.73	2.08	2.43	2.77	3.12	3.46	4.16	5.20	6.93	8.67	

Although the amount of power may be easily figured out, it is somewhat in the nature of a surprise when we consider that to carry half a ton on a level track at a speed of six miles per hour, much less than a horse power is required, including all losses. This is a revelation to most manufacturers. The absence of gearing, the motors being attached directly to the driving wheels, gives the highest efficiency possible, as well as freedom from noise.

The actual power consumed, according to the table given above, at six miles per hour for 1,000 pounds on a level is only .16 h. p. It is, therefore, seen that ample allowance is made for losses and extra weights not provided for in the load, such as down-comes, buckets or carriers. The power required increases greatly with the grades and when this reaches certain limits it is deemed advisable to use gears in order to reduce weight of motors.

Maintenance. Although telpherage has not as yet been in operation for a sufficient number of years to determine exactly what the maintenance will be, yet, at the same time, in lines that have been operated for a year and a half, the maintenance has been exceedingly small. As stated above, the driving wheels being of steel, none of them has thus far shown any signs of wear, and trailer wheels are of the same material and type

as those which have been used on mechanical cable lines for ten years and are still in good serviceable condition. The motors, on account of their elevated position, have shown a better maintenance than stationary motors of the same type. This may possibly result from the extra care taken in their construction. In regard to the track, this has also shown most excellent results, also due to the fact that it is above grit and dirt and crossing teams and, when well painted, has shown little signs of wear or depreciation. Wherever a change is made from cable to solid rail, or where cable passes over hangers or brackets, it is pro-

FIG. 17. Plan and elevation of another form of double telpher with four-ton coal bucket, bottom dumping, cab for telpherman. The side elevation shows method of attachment to side of building and loading chute.

tected by what are called "shields," these being arranged so that they may be readily replaced. The cable is also protected at the hanger and brackets by steel shields.

Capacity. An important feature in telpherage is the capacity of the line. In general, I can say that there is no other form of conveyor known which shows such flexibility. This is due to the use of electricity, and the features which apply to the street railway, apply also to telpherage. There are two factors of special importance in relation to the capacity of the line:

first, the speed, and second, the number of telfers and trailers. The line may be laid out with one telfer and a few trailers. More telfers or trailers may be added, and, if upon a single line, coupled in long trains. If it is desired still further to increase the capacity, the line may be made double, while if de-

FIG. 18. In sewer or trench excavation the method of operation it as follows: The bucket has attached to it a trailer wheel. The buckets and wheel are lowered into the excavation, and the bucket, when filled, is raised by the electric hoist so that the wheel of the trailer engages the gravity rail. The load then passes by gravity to the place desired and is automatically dumped. This may be along the line of excavation, for refilling the trench, or to the right or left, for unloading into carts, or in connection with the telfer to any desired distance. The telfer has the flexibility of a trolley car. This method is a combination of telfer and gravity lines, and the amount of work that can be accomplished by it with the minimum of labor is remarkable.

sired, the carriers may also be made continuous so as to take boxes and barrels or other freight as fast as they can be delivered to the carriers of the telfers and trailers.

The flexibility of telferage in regard to capacity is wonderful, and is a most important feature. In fact, it may be said that there is practically no limit to flexibility. In one plant, about to be installed, the proposed capacity is 250 tons per

hour, over a distance of one-half a mile, the material to be distributed over an area of about an acre. Any one who is familiar with conveying will note that there is no other system that can do this so economically, and in a way so thoroughly satisfactory as telferage.

The nature of installation varies with the amount of material to be carried, so that if the amount to be carried is small, the expenditure need not be great. Figs. 17, 18 and 19 show various applications.

Applications of Telferage. There are few factories where the installation of an overhead telferage system would not prove a valuable investment. The question is often asked: Is telferage suited for carrying specific articles? And the reply may

FIG. 19. Excavating and leveling in preparing roadbeds for railroads. The function of the telfer is to transport the hoist, bucket and load. The hoist does the excavating and elevating. The hoist automatically brakes itself either upon the girder rail or grips the cable as soon as there is any longitudinal strain. Used also for scooping and transporting earth, sand, ashes or coal.

be made that it is adapted to the conveying of the products of almost every kind of manufacturing.

In these days of consolidation of companies, factories cover immense areas. The individual buildings are frequently large enough in themselves to utilize a telfer line. In many cases, on account of fire risks or of convenience in manufacturing, the buildings are widely separated from each other, and yet constant communication is necessary. Overhead telferage, therefore, in manufacturing establishments is used for carrying the raw material, implements and finished products from one part of the grounds to another, from one building to another, or, even from one part of a building to another part, moving raw material from

cars or vessels to the works and then taking the finished products to the railway station, or the wharf, for shipment; and for conveying refuse away from the factory. In this connection we might mention the conveying of ashes or slag to the dump heap.

Telpherage may also be extensively used for handling coal. It serves to reduce greatly the cost of transportation on plantations and farms and may be economically used for handling coffee, sugar cane, tobacco, fruits and hay and other like products.

In general, it may be said, that wherever material is to be carried to a distance, there is no power so flexible, so economical in first cost of installation, costing so little for power or the expense of maintenance, and with such great capacity as telpherage. It may, therefore, be designated a material transportation by an immaterial fluid, and may well be called one of the most important of the many adaptations of electricity.

If time, floor space, or labor is being consumed in the conveying of any kind of material in any plant, plantation or mine, each can be saved by the installation of telpherage. Any condition at any manufacturing establishment which presents a requirement for hauling by man or team, whether in transmission of product during the various stages of manufacture, the movement of materials by which the product is to be treated or the handling of fuel, and ashes or other waste, is a logical opening for the installation of telpherage.

When you install telpherage you employ a machine to do the work of men. Machinery is the most powerful factor for economy in production. Telpherage is almost human in its operation, works any number of hours per day and never tires. In many cases you start the telpher, it conveys, automatically leaves its load at the destination and returns for another load. Telpherage conveys 50 lbs. or 50,000 lbs. solids or liquids.

Much more can be said about telpherage, but the above will give a general idea of its work. Many plants have been installed and many more are being installed daily, and in many instances duplicate orders are being received from former customers.