Electrification in Brazil

How the Sao Paulo Railroad Is Following the Example of Its American Namesake

By Robert Carlton Brown

THE recent announcement of the forthcoming electrification of a portion of the lines of the Paulista Railway in the State of Sao Paulo, Brazil, has aroused great interest in railway and electrical circles of South America, the United States and Europe. The electrification was decided upon only after the company had made an exhaustive investigation of its possibilities. Simultaneously with the announcement of the letting of the contract, work on the manufacture of equipment for the great enterprise was begun in the United States.

The initial enterprise on the Paulista Railway will extend over a line forty-four kilometers in length from Jundiahy, the southern terminus of the Paulista Railway, northward to Campinas. The railway is double-tracked over the whole of this distance.

This installation calls for twelve electric locomotives, eight locomotives for freight service and four locomotives for passenger service. The freight locomotives will weigh ninety metric tons each and the passenger locomotives 110. These locomotives will be operated at a tension of 3,000 volts of direct current. They will take their power from two overhead copper trolley wires by means of a pantograph operated by compressed air. These locomotives will each contain four motors connected with the locomotive driving axles by means of double-spring gears and pinions. The locomotives can be controlled by one man with the ease that a street car is operated.

Electric power will be furnished to the railway by the Sao Paulo City power company, which will deliver three-phase, sixty-cycle power at 88,000 volts. It will be distributed along the lines of the Paulista Railway for connection at the various power substations which will be eventually installed. For the operation of the electric locomotives over the initial section, a power substation will be installed midway between Jundiahy and Campinas.

This substation will convert the 88,000-volt alternating current into the 3,000-volt direct current for delivery to the overhead trolley wires. The equipment for this substation, which will have a total capacity of 4,500 kilowatts, will include a system of three motor-generator sets of a capacity of 1,500 kilowatts each. These will consist of 2,300-volt, three-phase, synchronous motors, directly connected to two 1,500-volt generators. These will operate in series and will give the potential strength of 3,000 volts required to operate the locomotives on the line.

There also will be included with each motor-generator set, and mounted on the same shaft with the motors, an exciter which will provide excitation for the two generators. The 88,000-volt current which enters the substation is stepped down to 2,300 volts for connection to the motors by means of transformers. A switchboard with automatic switching equipment and meters also will be provided for measuring the current which enters the station as well as that which is delivered to the trolley system. These automatic switches will be so designed as to provide the maximum protection to all apparatus as well as to the operators against any possible accidents. The lines will be further protected against lightning by means of electrolytic lightning arresters. The trolley wires will be supported by means of the well-known catenary type of overhead suspension, especially developed for high voltage, heavy traffic and high speed service. The steel rails used for the present system of steam locomotive service will be connected by means of copper bonds to establish the return circuit.

Materials for the new work will begin to arrive in Brazil from the United States within a few months and the railway company will immediately begin work on the electrification, assisted by engineers of the electric company. The installation of the power transmission lines and the overhead trolley system will be started first. Work will also be started at once on the first substation and it will be ready to receive the machinery on its arrival. The huge locomotives will be the last of the equipment to arrive. These will be unloaded at the port of Santos. They will be assembled there and will proceed to Jundiahy over the rails of the Sao Paulo Railway. It is expected that the electrified system will be in complete operation by July, 1921.

One feature of the electrification will be that the direct system of current will be used instead of the usual alternating current. The locomotives to be used will be provided with the regenerative braking system, whereby the locomotives and the trains when descending a grade generate power which is returned to the line. The speed of trains descending grade can be very accurately controlled by this system and at the same time power is being generated. Further advantages of this system include elimination of difficulties incident to the use of the airbrakes on heavy freight trains when descending grades; elimination of brake-shoe and wheel wear with resultant reduction in maintenance; reduced wear on tracks, especially on severe curves; and entire absence of grinding of the brakes which is especially disagreeable on a heavy passenger train.

Economy is the big factor in favor of electrification of railways, although there are many other arguments to be advanced in favor of the replacement of steam locomotives by the electrical equipment. The high cost of coal has always been a leading item in the expenses of the railways of Brazil and it is believed by many observers that the coal question will eventually result in the electrification of most of the railway systems of the republic. Electrification is peculiarly practical in Brazil in view of the great abundance of waterfalls. Excellent waterpower is easily available to a large portion of the railway area of the country.

Experts of the electric company who are in Brazil on the Paulista enterprise summarize the advantages of electrification under two leading heads. One of these

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Correspondence

The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

Seeing in the Dark

To the Editor of the SCIENTIFIC AMERICAN:

In the article, "Detecting Men by Their Heat Radiation," in your issue of March 27, 1920, it is stated that my instrument "can detect the difference between the painted and unpainted sides of a steel plate, of which the temperature is slightly higher than the surrounding atmosphere."

The interesting fact is that on *clear nights* the instrument readily detected the difference between the painted and unpainted sides of an invisible steel plate which had the *same* temperature as the surrounding atmosphere. And, furthermore, the side of the plate which was painted black gave an indication similar to that which would have been given by a body considerably warmer than the atmosphere, although there was no question of the fact that the entire plate was at the same temperature as the surrounding atmosphere. This result was in direct contradiction to what had been predicted from previous laboratory tests on a *cold* body, in which the blackened metal gave a considerably *colder* indication than that given by the unblackened part (both parts being of course at the same temperature). An analysis of these laboratory results led to the conclusion that the large cold indication of the blackened surface was, of course, a measure of the true temperature of the metal, while the warmer indication of the bright metal was caused by reflected energy from the walls of the apparatus which were at the higher temperature of the room. This unexpected result seemed entirely to negative my method and I took care that news of it did not get to Washington until I had made some actual field trials. Many authorities held that the radiation from objects such as men would be entirely obscured by the effect of the surrounding atmosphere and the background, and this laboratory test was held to support their view. However field tests showed that I was right and they were wrong, and resulted ultimately in the very successful results alluded to in your article.

I might add that the reason for the cold indication of the bright metal when in the open, on clear nights, was reflection of the intense cold of interstellar space, or stated more correctly, a cooling of the blackened surface of the thermopile by radiation into space. It was this fact that rendered it so easy to detect aircraft on clear nights, as the plane, coming between the instrument and the outer sky, acted as a shutter to stop this radiation into space, and resulted in giving a large warm indication.

San Francisco, Cal. SAMUEL O. HOFFMAN.

Cleaning the Clock

To the Editor of the SCIENTIFIC AMERICAN:

As a reader of your publication for more than thirty years, twenty or more of which have been spent in the repairing of all kinds of time-pieces, I wish to protest against the printing of such ideas as those contained in a recent article on the use of kerosene as a cure for dirty clocks.

The oil used on clocks is as near non-drying as is obtainable but even the best will dry up somewhat after the long time between cleanings. As there is less than two drops on the whole outfit of pivots in the ordinary type of clock it can be easily seen that the supply is small and not renewed from oil-cups as in many other types of machine. Also the clock is more or less open to the air around it which has a great deal of dust floating in it ready to stick to anything fluid like the oil around the pivots. This tends to thicken the oil and to work into pivot-holes, serving as an abrasive to cut the pivots.

The only way to relieve the condition is to take the clock completely to pieces and clean each and every piece; to "peg out" each hole; polish the cut or worn parts and then to assemble the whole for proper oiling on clean metal.

The use of kerosene on a tuft of cotton is as much good in the manner given in your article as it would be in removing carbon from the cylinder of an automobile by placing a cloth wet with the "panacea" on the floor of the garage under the machine.

Newton Center, Mass. F. W. WOOLWAY.

Measuring the Flow of Liquids

To the Editor of the SCIENTIFIC AMERICAN:

In the June 19th issue of the SCIENTIFIC AMERICAN we notice a description of instruments for measuring and recording the flow of liquids, recently brought out by a large British firm.

The description is so exact that we have no difficulty in recognizing this as the device originated by Mr. Lea, mechanical engineer of Manchester, and the only reason of our writing to you is because of the inaccuracy of the statement that this has been recently brought out.

As a matter of fact our clients have been the American manufacturers of this instrument on which they hold several patents on improvements since 1911. We know that several thousand of these are in use in many of the largest plants in this country, Great Britain and other parts of the world.

The device is not new but is a well-established and time-tested device.

Philadelphia, Pa. R. G. E. ULLMAN.

Invention vs. Re-invention

To the Editor of the SCIENTIFIC AMERICAN:

Your article, "A Boat That Pumps Its Way Along," in the issue of the SCIENTIFIC AMERICAN of June 12 and the illustration of the same is certainly another proof, as you say, that "history is forever repeating itself." The principle involved in the propulsion of this boat is identical with that James Rumsey used about twenty years before the "Clermont" went up the Hudson. Of course he had none of the fine mechanism of modern times, but the boat was propelled by taking in water near the front of the boat and expelling it in the rear. Undoubtedly this was the first application of steam to navigation. Recently the state of West Virginia has erected a beautiful monument overlooking the point in the Potomac River at Shepherdstown, West Virginia, where the first demonstration was made by Rumsey December 3, 1787. No one will claim that the old "Constitution" is anything to compare with the modern dreadnought, and, of course, Rumsey's crude beginning is in the widest contrast between the modern floating palace, but honor to whom honor is due.

THOS. C. MILLER.
Shepherdstown State Normal School.

Reducing Trade Routes with Submarine Freighters

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As Mr. Lake sees it, the under-water ship of trade has claims to consideration even beyond its peculiar fitness to navigate ice-strewn waters. He declares his submersible to be safer to run at all times and that it is practically unsinkable except at the will of those aboard. Despite the fanciful character of the project, it should be borne in mind that Mr. Lake has helped materially toward achievements commonly believed Utopian twenty-five years ago; and it is upon these accomplishments that he now confidently bases his contemplated revolution in deep-sea transportation.

The Aquitania as an Oil Burner

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in each watch, and the loss from this cause amounted to 8,000 horse-power every 4 hours. With oil firing there is a constant flow of oil; a constant furnace temperature; and contraction stresses, due to the inrush of cold air through the open fire doors, are avoided. The steam pressure is constant; the average speed is higher; and the life of the boilers is prolonged.

What Is an Asphalt Road?

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The second course or wearing surface consists of a mixture of hot asphalt, dust, and sand, mixed and rolled in the same way. The sand is finely graded so as to give great strength and stability, while the asphalt binds the whole together closely. The combined thickness of the two courses is usually two and a half or three inches.

Another type of pavement which is more and more widely used both for city streets, boulevards and country roads is the asphaltic concrete or Topeka type. This resembles the sheet asphalt type except that it is generally laid in one course two inches thick, and instead of consisting only of asphalt, dust, and sand, also contains a small proportion of small stone.

The most widely used pavement for country roads is the asphaltic macadam pavement. This is simply a broken stone or macadam road in which the stone is bound together with asphalt. The stone is laid in two courses and the asphalt is poured into it from a machine which distributes it under pressure; the asphalt penetrating the stone and binding it all firmly together. This kind of pavement is often referred to for that reason as a penetration macadam road.

Asphalt is produced from asphaltic petroleum. Petroleums differ very greatly in character according to the field where they are produced. The oils found in the Eastern and Middle Western States are known as paraffine petroleums, while those found in Texas, California, Mexico and South America are known as asphaltic petroleums.

Electrification in Brazil

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is that it gives increased track tonnage capacity by reason of heavier trains, higher speeds and reduction in the number of daily train movements. The other is that the cost of electrification in many cases that have been thoroughly investigated has been found to be considerably less than the cost of corresponding improvements with continued steam-engine operation, and that there is also a return upon the additional capital charge incurred for electrification of from 15 to 20 per cent, resulting from the savings in the operating expense over steam operation.

The eventual electrification plans of the Paulista Railway are for the complete electrification of the line from Jundiahy to Sao Carlos do Pinhal, comprising the greater portion of the main trunk line of the company. This is the second largest railway electrification project in the world, being only surpassed in magnitude by the electrification system on the mountain divisions of the Chicago, Milwaukee & St. Paul Railway in the United States. The St. Paul is electrically operated for a distance of 440 miles. The electrified portion of the road crosses the Rocky Mountains at an elevation of 6,350 feet, the Belt Mountains at an elevation of 5,768 feet and the Bitter Root Mountains at 4,200 feet. The road in these regions presents one of the most difficult problems of transcontinental railroading in the world. Practically all of the important features of that gigantic work will be incorporated in the Paulista electrification.

Seeing in the Dark

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however, the Germans were on the run and trench warfare had practically ceased. The menace of airplane raids, on the other hand, was increasing, and it was decided to develop a similar apparatus for ranging on airplanes. Anti-aircraft guns were rather a joke, insofar as actually hitting anything was concerned. The endeavor was to maintain a heavy barrage and keep the enemy high up so that he could not drop his bombs with accuracy. Sound horns were in use to locate invisible airplanes, and could do so with great accuracy, but unfortunately it took the sound 7 or 8 seconds to get down to the ground from the plane and the shell almost as long to get up there. Usually, by the time the shell arrived at the calculated place the plane was somewhere else. The great advantage of getting the range by heat radiation was that the indication traveled to the ground with the speed of light, almost instantly; in other words, there was no time lag.

Some successful tests were made with model airplanes, and the construction of special thermopiles and a special ranging instrument was at once started. The thermopiles for this work had to cover a much larger field than those for trench use, on account of the great speed of the planes. They were built in a form comparable to the cross hair of an ordinary optical instrument, and are probably the most elaborate thermopiles ever constructed.

This instrument was finished about the time of the armistice, and was tried out in January, 1919, at Langley Field, Virginia. No trouble was experienced in picking up planes a mile away, or in keeping the dark image on the thermopile. By keeping the image constantly on the pile, the speed of the plane could be read directly by the instruments already in use for daylight work. As extended night flying with poor landing fields was extremely dangerous no attempt was made to ascertain the maximum distance at which planes could be picked up. To allow for the low elevation of the plane used in the tests, the motor of a small, low-powered plane was throttled down so that it developed only about 50 hp. It was figured that this small amount of energy would be about equivalent to that coming from one of the large bombing planes at the usual great height. One instrument alone gave only the direction of the plane; two were necessary to give, by triangulation, the height.

The ease with which planes can be detected at night is largely due to this very cold indication of the clear sky. Anything coming in between the sky and the thermopile, either a plane or a cloud, acts as a shutter to cut off the radiation from the surface of the thermopile to outer space, and results in a large warm indication.

The fact that clouds lessened the value of this method of detecting planes at night is not of as much consequence as may appear at first sight. For obvious reasons, raids were very seldom attempted on any but clear nights.

It will be noticed that the original prob-

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