The road now has 32 locomotives, and the trains are made up of 7 cars, carrying 336 passengers. The weight of the train, without locomotive, is 105 tons, the latter weighing 42 tons. The average speed is 14 miles per hour, with stops of 20 seconds at the stations; a maximum speed of 30 miles is allowed. The trains follow each other at intervals of 2½ minutes, and this is reduced to 2 minutes at times of greatest traffic.

The profile of the road presents the peculiarity that each station occupies a level between two grades, ascending and descending, of 3 per cent. This gives a diminution of speed upon arriving, and on the other hand makes it easier to start the motors on leaving the station; this arrangement gives a considerable economy of current. The central station is located at Shepherd's Bush, and supplies three-phase current at a tension of 5,000 volts; this is transformed in four sub-stations to continuous current at 500 volts for the motors. The locomotives have two trucks, each of which is provided with two motors. The current is taken by rubbing contacts upon the central rail. The annual expenses of operation are estimated at $660,000, this being made on a basis of 2½ minute intervals for the trains.

## SMELTING PROCESS FOR ZINC ORES,

The zinc industry has been brought prominently before the public by the promotion of many companies to operate the rich mines of the Joplin district of Missouri and Arkansas, a profitable state of affairs having resulted from the ore producers' combining and dictating prices to the smelters. It happens that the Joplin mines produce over 60 per cent of the world's output of zinc ores which can be reduced economically by present methods. From the standpoint of scientific smelting, zinc occupies a most unsatisfactory position. The reduction of its ores is accomplished by processes "just as clumsy as they were when Paracelsus described them more than three hundred years ago." Arthur Winslow states in an article upon the lead and zinc industry of Missouri, that in making zinc upon a large scale about 25 to 30 per cent of the metal is lost, and that it takes 3 tons of ore averaging from 45 to 50 per cent of zinc, 6 tons of coal, and 700 pounds of refractory materials to yield 1 ton of zinc. The present methods require rich ores which are first roasted to transform their zinc compounds into oxide. The calcined ore is mixed with coal and loaded in small charges into clay retorts which are placed, many at a time, in a special furnace. Upon heating, the zinc is produced and volatilized, the vapors being led to condensing apparatus by suitable connections with the retorts. This laboratory method has to be employed because the temperature of reduction of zinc oxide and the boiling-point of zinc at atmospheric pressure differ by but a few degrees. Many endeavors to produce zinc, like iron, lead, and copper, in a blast-furnace have failed, the metal being vaporized and lost with the gases as zinc dust, a mixture of zinc oxide and finely divided zinc.

There exist throughout the West unlimited deposits of sulphureted zinc-lead ores, carrying generally a small amount of silver. They are cheap but refractory. An easily available ore of this nature contains 20 per cent lead, 30 per cent zinc, and 40 ounces of silver per ton. At the present day these ores are utilized by the lead smelters. In the ordinary way of lead smelting rich ores are required. These being rare and the competition keen, the smelter has to purchase them at prices not only leaving no profit but mostly entailing actual loss. To counterbalance this loss there is included in the furnace charges as much of the cheap, refactory ores as can safely be added. Yet, in the present method of smelting, not only is the whole of the zinc lost, but its very presence causes great losses of lead, silver, and gold, partly due to the formation of flue dust and partly by the production of a viscous slag rich in zinc. In purchasing these ores the smelter does not pay for the zinc and deducts, moreover, 50 cents per ton from the price established by the amount of lead and precious metals for each per cent of zinc above 10. As the zinc passing into the slag renders them very viscous, the smelter can only add as much as is compatible with economy. It is not good practice to have more than 7 per cent of zinc in the slag. On this basis the quantity of zinc lost in slag in the United States amounts to more than its total annual production.

Dr. Emil E. Lungwitz, a mining engineer of considerable experience, has invented a process for the smelting of these refractory ores and the recovery of practically all the contained metals. It merits attention because it rests upon a sound, scientific foundation, and the facts involved have been established by careful experiments made in the laboratory of the Royal Polytechnic School of Berlin by Dr. Lungwitz and Dr. R. C. Schüpphaus. The process is based upon the fact that the boiling point of a liquid is an increasing function of the pressure. Dr. Karl Barus has determined the most reliable figures with regard to zinc, and states that in the neighborhood of atmospheric pressure, the temperature increment of the boiling point of zinc amounts to 1·5° C, for each additional centimeter of

mercury pressure. Briefly, Dr. Lungwitz proposes to smelt zinc ores in a blast furnace under pressure sufficient to keep the zinc liquid at the temperature of the furnace and to withdraw it in such a manner that it will have a temperature below its boiling point under atmospheric pressure when it reaches the receiving vessels. The objection occurs at once that bulky constructions like blast furnaces do not lend themselves to designs involving high internal pressures. Dr. Lungwitz, however, is convinced that a pressure of three atmospheres is amply sufficient. The facts to support this are: The temperature of reduction of zinc oxide by carbon is 910° C., and the boiling point of zinc under one atmosphere is 930° C. Dr. Barus estimates the boiling point of zinc under five atmospheres pressure to be 1,500° C., a temperature known to be entirely out of the question for the melting of either lead or zinc ores or a mixture of both. The temperature of a slag formed in a lead stack was found by Malvern Iles to be 1,034° C. The melting point of diabase is not higher than 1,170° C., according to Dr. Barus, and no blast furnace could ever be run on a slag of similar composition. In the experiments of Dr. Lungwitz and Dr. Schüpphaus, a crucible supported and surrounded by fireclay bricks was placed in a strong cast-iron vessel provided with a bolted cover. The high temperatures needed were obtained by heating to incandescence by an electric current a platinum wire strung up and down through perforated rims on the inside of the fireclay cylinder into which the crucible fitted. Temperature measurements were made with a Le Chatelier thermo-couple carried in a porcelain tube dipping down into the top of the crucible. Pressures were obtained by forcing air in by a small compressor. A gage and safety valve were also attached. There were obtained in this apparatus ingots of zinc at the bottom of the crucible when a mixture of pure zinc oxide and carbon was heated under a gage pressure of 45 pounds per square inch to 1,150° C., a temperature some 200° C. above the ordinary boiling point of zinc.

Conditions are yet more favorable in smelting the sulphureted zinc lead ores. Taking the temperature of lead furnace at 1,056° C., the tension of zinc vapor for that temperature is under two atmospheres, as given by the figures of Dr. Barus. In addition, lead and zinc alloy with avidity at red heat and the osmotic pressure exerted under these conditions will aid to prevent the ebullition of the zinc. The separation of these metals is most easily effected by cooling, for at temperatures in the neighborhood of the melting point of zinc (415° C.), lead combines with but a few tenths of one per cent of zinc, no matter how carefully the mixture is stirred. These facts show the feasibility of Dr. Lungwitz's process and prove that the conditions of operation will lie entirely within practical bounds.

There have been experiences in smelting work which show that the accidental establishment of these conditions has led to the delivery of zinc in small quantities, when zinciferous ores have been made use of. The Rammelsberg smelters, in the Hartz Mountains, sold, forty years ago, zinc that had been tapped from lead blast furnaces, the quantity obtained at each tapping varying from 0·5 to 5 pounds. Then an improvement called the zinc shelf was introduced to condense the zinc vapors, and what was obtained was found very rich in lead and was produced under the conditions of a reducing atmosphere, at a low temperature as compared with modern practice, and under a slight excess of pressure. The New Jersey Zinc and Iron Company utilize a zinciferous iron ore by first vaporizing and oxidizing the zinc and then smelting the residues from iron. These residues contain at least 3 per cent zinc, and it frequently happens that when the furnace cools off considerably and the pressure of the blast rises, establishing conditions favorable to the formation of liquid zinc, quantities of from 400 to 500 pounds of metallic zinc have been tapped together with the iron. These and similar observations were investigated carefully by Dr. Lungwitz, and he concludes: "From these actually observed cases of 'condensation of zinc in blast furnaces, under widely differing conditions, we may conclude that the forces favorable to the liquefaction of the zinc are pressure in the furnace and chemical affinity."

Dr. Lungwitz has proved his case up to the point of actual trial in a large furnace. This will be done before the year is out. It is expected that no flue-dust will be formed during the trial, by reason of the high-pressure blast which will be employed.

An interesting chemical point in connection with the experiments of Dr. Lungwitz and Dr. Schüpphaus in their laboratory furnace was the formation on different occasions of a powder of a canary-yellow hue which contained by chemical analysis more zinc than belongs to ZnO. Pursuing the idea that this yellow compound might be a low oxide of zinc, they made the following experiments, each yielding a body permanently yellow. Zinc oxide was heated in an atmosphere of pure nitrogen; zinc oxide was heated in vacuo; zinc oxide mixed with zinc dust was heated under pressure. The investigators concluded: "These experiments render it highly probable that zinc oxide on heating loses part of its oxygen and that the new

compound is stable if it is cooled in the absence of oxygen." The matter is being thoroughly investigated by Prof. v. Knorre, of the Berlin Polytechnic School.

## A NEW TELE-PHOTO LENS.

Although the tele-photo lens has been before photographers for about ten years it has not come into anything like general use or acquired the popularity that it deserves. Two causes have contributed to this: the general belief, derived from its name, that it is only adapted to photography at long distances, and the fact that with the tele attachment, very much longer exposures are necessary than with the normal lens without it.

All this is now likely to be changed and the tele-photo lens given a fresh start, T. R. Dallmeyer having patented an arrangement in which the complete enlarging system may be as fast as the ordinary lens alone, and the users of hand and other small cameras may avoid the usual "exaggerated perspective" by getting at a greater distance from the foregrounds, and at the same time secure any desired size of image.

The new tele attachment consists of two lenses, a positive and a negative, one in each end of a sliding tube, and placed in front of the ordinary lens, generally screwed into the place of the hood. The outer or positive lens is of the highest possible intensity, that is, of as large a diameter and short focus as may be convenient; the inner or negative should be of shorter focus than the ordinary lens, and its power should be at least equal to the sum of both.

When the lenses of the tele attachment are at their normal distance apart, that is at a distance equal to the difference of their focal lengths, parallel rays incident on the outer or convergent lens are sent converging to the inner, the diverging, and by it transmitted parallel to the ordinary lens. If this has been focused for parallel rays, as is the case with so-called ''fixed focus'' cameras, the image of the complete system will be formed at its focal plane, just where it would be without the tele attachment, but with considerable magnification.

Placed more closely together, the converging rays from the positive lens are, by the negative, transmitted to the ordinary lens at an increased degree of divergence, forming a larger image, larger in proportion to the decrease of the distance, but coming to a focus at varying distances beyond its focal plane.

When the elements of the tele arrangement are separated to distances beyond their normal, their action is reversed; rays reach the ordinary lens in a convergent form and come to a focus within its focal plane; but the intensity is considerably increased, that is, the system now is faster than the ordinary lens without the tele arrangement.

In connection with this, it may be interesting to know that not to Barlow, in 1834, as is generally supposed, are we indebted for the original tele-photo lens, but to R. P. F. Joannis Zahn, in 1686. Dr. Von Rohr tells The British Journal of Photography that he recently unearthed a book by that old scientist, in which he describes and illustrates "A special combination of a concave and convex lens for producing a larger image," and drawing and description are as applicable to the modern tele-photographic lens as though they had been made yesterday; the only difference being that his lenses were not corrected, while those of the modern instrument are.

## THE LATEST DEVELOPER.

A new developer has lately appeared which is said to give good results and the equal, if not superior, to hydroquinone. The body which has received the name of adurol is a derivative of hydroquinone, and seems to have all the good properties of that developer, without its defects. It requires but a small quantity of alkali, and the potassium carbonate may thus be replaced by sodium carbonate, which is less corrosive, while the use of caustic alkali becomes necessary. In spite of the small quantity of alkali, the image comes up more quickly than with hydroquinone, and it is also to be remarked that low temperatures have no appreciable influence in retarding the development of the image or details. The principal quality of adurol is its great developing power, which is not equaled by hydroquinone even with the use of caustic soda; it has the valuable property of working up to the end of the development without causing fog upon the plate, which renders it superior to many other developers in this respect. The image appears normally in about 20 seconds and the development is regular and uniform; after about 4 minutes it has gained the desired intensity. The reduction of silver takes place not only in the strongly exposed parts, but in the details, which come up regularly as the development proceeds; in this way the final results is a plate which presents a harmonious appearance, rather soft than hard in quality. It is apparent that audriol may be used with shorter exposures then when hydrochinon is used, and may thus be of value for exposures by dim light, for rapid instantaneous work, X-ray exposures, etc. Bromide of potassium is an excellent retarder for this developer, but it may be used in smaller proportion than usual.