I am sure Miss Talbot will give you every facility for studying it, should you so desire."

After receiving this most courteous letter, I at once put myself in communication with Miss Talbot, in due course receiving from her the following communication, dated at Mount Holyoke College, the 10th of November, 1915: "Dear Dr. Shufeldt:

"I am very sorry to have kept you waiting so long for an answer to your letter in regard to *Podokesaurus*, but I am far from well this fall and the trip to New Haven seems to have upset me completely, so that I have been able to do my regular work, only, and have had to let everything else go.

"I am not at all sure that I shall not publish a little note in regard to *Podokesaurus* myself before long, taking issue with both you and Prof. Lull, in regard to different bones, however. This being the case, I hardly want to send you the photographs that I am to have taken soon, nor do I want to give you the results of my study.

"I should be very glad, however, to have a digest of the remarks that Prof. Heilmann has made on the fossil. . . .

"Very sincerely yours,

(Signed) Mignon Talbot."

Before receiving this letter I had had another most instructive one from Dr. Lull, dated at Yale University the 22nd of October, 1915, which ran thus:

Dear Dr. Shufeldt:

"After your letter came, Miss Talbot was in the building and I talked to her of some of the difficulties of interpretation of the beast *Podokesaurus*. She is going to make a very careful examination of the pubis and other bones to see if in her opinion there is any indication of their having shifted. She will also have further photographs

made of that region of the specimen, as all the photographs sent either to you or to Mr. Heilmann were before the ultimate preparation of the specimen, which was done here at Yale. Her opinion and the photographs should be given due weight and that is the only additional information on the specimen we can get. She is also going to photograph that which she considers to be the hand of the animal, which may give further light.

"When I first saw *Podokesaurus* I thought right away that it was a plant-feeding dinosaur, one of the Ornithopoda, and so advised Miss Talbot. Later, however, when we came to study it in more detail, we both came to the conclusion that it was one of the Theropoda, the evidence lying principally in the structure of the pubic and ischial bones, for I do not think the foot or hand would be indicative of the ordinal condition of so small a dinosaur as this, in the absence of the skull. There is no known predentate or ornithopod dinosaur in which there is not a considerable pre-pubis. If any part of the pubic bone tends to abort, it is, so far as my knowledge goes, the post-pubis or the after limb of the pubic structure. All of them show a forward directed pubic bone, just as the carnivores do, the principal distinction being that in the predentates usually the post-pubis, or, as Huene calls it, the pubis, lies parallel with the ischium. I should under no circumstances consider the animal a sauropod dinosaur, your last question being whether it is possible to decide positively whether it belongs among the Theropoda or Sauropoda. My whole conception of the evolution of the Sauropoda from the Theropoda is based upon the gradual increase of size and the necessity of taking to a semi-aquatic habitat for bodily support and the changing of the diet in order to maintain the bulk, characters which are certainly absent from the

creature under consideration. The smallest of the sauropods, which comes from the Potomac, has a length of 10 feet and as yet no Sauropoda are known from Triassic strata.

"With best wishes, very sincerely yours,

(Signed) Richard Lull."

Here the correspondence practically ended, in so far as this subject was concerned; and, personally, I now await what Miss Talbot publishes after she has further developed the skeleton of *Podokesaurus Holyokensis* in the matrix. It may throw further light upon the subject and it may not, for the reason that the opposite pubis may not only not be found, but it, likewise, may be out of place when it is.

Then, too, I anxiously await the next instalment of Dr. Heilmann's valuable work, which will doubtless present his side of the argument far more lucidly than I have been able to do here.

In any event I do not believe for an instant that the pubic bone ever occupied any such position in life as Dr. Lull has given it in his restoration, for reasons that I have attempted to set forth in the present article, and for the added reason that we never meet with bones in any vertebrate skeleton—living or extinct—where an extremity of that bone is *expanded* for the purpose of affording a sufficient area in that a *notch*, such as exists in the proximal end of the pubis of *Podokesaurus*, may exist there. A notch of that kind would not be found there unless it had some *definite use*, and the most natural one would be to either articulate with some juxtaposed bone, or to afford a greater amount of surface for ultimate co-ossification, which latter I take to be the case in *Podokesaurus*, where, in addition, it completes a foramen found in both birds and dinosaurs.

The Future of the Steam Locomotive*

A Consideration of the Factors of the Different Motive Powers Available

By John E. Mulfield

THE principal factors that will enter into the steam railway transportation and motive power situation during the ensuing ten years justify the following conclusions:

1st. As the supply and cost of liquid fuels, when compared with coal, lignite and peat, in the United States and Canada, make their general use for internal combustion types of motive power prohibitive, and as producer gas and storage batteries do not offer any early possibilities, the electric locomotive dependent upon an outside source of power for its propulsion, is the only one that can be considered as being in the same field as the steam locomotive in general railway service.

2nd. The general difficulty incident to adapting electrification to existing steam railway operation will not warrant any considerable change from independently operated steam motive power units because of the prohibitive capital and non-productive cost, unreliability of service, non-adaptability for concentration or distribution of motive power over various parts of the road, inability to utilize full power under a wide range of speed and traction variations, and lack of standardization.

3rd. The future development of the steam locomotive will be along such lines as will produce the maximum hauling capacity per unit of total weight, at the minimum cost per pound of drawbar pull.

4th. The modernized steam locomotive will provide for the transportation department a motive power unit capable of more nearly continuous service, between general repair periods.

5th. New and existing steam locomotives will be equipped to eliminate the production of smoke, soot, cinders, sparks and fire hazard; to utilize the heat now available in exhaust steam and waste gases; to lessen noise; and to reduce the consumption of fuel per unit of work performed.

6th. All steam locomotives will be provided with special and automatic appliances to minimize the liability for accident, eliminate arduous labor, reduce mechanical delay, and overcome the necessity for frequent inspections and adjustments.

7th. Existing steam locomotives having transportation value will be modernized with a view of reducing the cost for operation and enhancing their physical valuation.

8th. The refinements in design, construction and operation that will be effected during the next few years, justifies the prediction that through the combined use of

superheated steam, pulverized fuel, fire-box brick arch, feed water heating and compounding, a horse-power hour will be successfully delivered at the tender drawbar of a steam locomotive of great power for 50 per cent less fuel than is now used by saturated steam motive power.

A century has passed since Trevithick, Hedley and Stephenson produced the general arrangement of boiler, machinery and running gear which still forms the basis of the modern steam locomotive.

Since the construction of George Stephenson's "Rocket," which was equipped with a single pair of driving wheels, the principal development has been an increase in the number and size of coupled driving wheels and a corresponding enlargement of the boiler and machinery, in order to provide means for utilizing a greater percentage of the total locomotive weight for adhesion and tractive power, and thereby enable the increasing of the train load.

During recent years the tendency toward greater speed has resulted in larger driving wheels and the application of various combinations of leading and trailing trucks, such as in the Atlantic, Pacific, Mountain, Prairie, Mikado and Santa Fe types, for the purpose of carrying the loads imposed by larger boiler heating surfaces and grate areas. While this change has usually provided a greater sustained boiler capacity, it has permitted the utilization of the maximum weight available for adhesion for the reason that the bridging effect of a combination of leading and trailing truck wheels will increase rather than decrease the permissible ratio between the weight on driving wheels and the tractive power to an extent that the maximum allowable weight of the locomotive available for the production of drawbar pull cannot be used. As it is clear that the propelling power of a locomotive is dependent on the load carried by the wheels of the driving axles, and that whatever weight not so distributed is non-productive, it is easy to discern that the eight-wheel, mogul, consolidation, six and eight-wheel coupled, decapod and Mallet articulated types of locomotives will produce a greater hauling capacity per pound of either total or adhesive weight than the corresponding Atlantic, Pacific and other trailing truck types of locomotives that have superseded them. As improved means of combustion will eliminate the necessity for grates and ash-pans and enable the location of relatively large driving wheels adjacent to the firebox, the non-trailing truck types of locomotives will no doubt again come into favor.

Next to the adhesive factor, the steam generator is

the all important element and which, in the steam locomotive, is a self-contained part of the motive power unit. In general the maximum power that can be developed by the present day steam locomotive depends upon the maximum rate of fuel consumption which can be maintained per square foot of grate area, the limit being reached when the draft becomes high enough to carry partially consumed fuel out of the stack in the form of smoke, cinders and sparks, which, besides decreasing the effectiveness of the machine, introduces the danger from fire hazard. While the enlargement of grate areas and heating surfaces, improvement in circulation, and the application of firebox brick arch and tubes have materially increased the boiler capacity, the forcing of the combustion of a large amount of fuel per hour on a limited grate area has increased the quantity of fuel used per unit of work performed far beyond what a more effective means of combustion will produce. However, the burning of fuel in a pulverized form in suspension will materially relieve this condition.

Having regard for the utilization of the steam, with the exception of the Mallet articulated type of locomotives, the general practice now is to use single expansion cylinders. As the thermal effectiveness of a steam engine is, in general, increased by carrying out the expansion of the steam in two or more stages in separate cylinders, the use of compound rather than of simple cylinders, especially with the superheated steam that is now available, provides opportunity for further improvement in locomotive capacity, and in fuel and water consumption. Compounding has been largely discontinued during the past fifteen years, due to the mechanical and operating difficulties (largely influenced by the excessive condensation of saturated steam) that resulted from the various designs which were adopted in the United States during the previous ten-year period. The introduction of the Mallet articulated type of locomotive by the Baltimore & Ohio R. R. in 1903, however, resulted in the revival of the compound system, and in combination with superheated steam, the results have been such as will no doubt again bring about the introduction of the compound type of locomotive in other than the articulated designs. The more recent development of intercepting valve mechanisms will largely overcome the mechanical deficiencies in the previous designs of compound cylinders.

Relative to the unbalanced reciprocating parts that go to make up a considerable portion of the weight of a modern steam locomotive, it has developed, by recent research and experimental work, that through improved

*Railway Review.

design and material the weights of these parts, such as piston valves, valve motion gear, piston heads and rods, cross heads and main and side rods and counterbalancing, may be materially reduced, with the resulting considerable decrease in non-spring-borne parts of the running gear and machinery, as well as in wear and tear on motive power and roadway. The further development of the three cylinder compound locomotive offers particular opportunities in this regard.

A comparison of the thermal efficiency of steam and electric motive power shows that under the average working conditions a hand-fire saturated steam locomotive burning coal on grates and an electric locomotive will each deliver about four per cent of the thermal heat value in the coal at the track rails. When the steam locomotive is equipped with superheater, firebox, brick arch and for burning pulverized fuel, this percentage is increased to about six. The added saving that may be effected through the application of feed water heaters and other appliances whereby the heat now in the waste gases and steam that is exhausted to the atmosphere may be made to perform useful work, offers a practicable means for further substantial improvement.

With respect to the electrification of steam railway lines in the United States and Canada, the initial application was in 1895 in the operation of a relatively long tunnel on the Baltimore & Ohio R. R. in the city of Baltimore. Including that and subsequent installations, exclusive of the Chicago, Milwaukee & St. Paul Railway main line electrification, the primary reasons for the introduction of electric service on steam railways to the present time have not been to expedite the movement of traffic or to effect economies in operation, but to provide for:

1st. Smokeless operation through underground terminals and tunnels, eleven installations.

2nd. Utilization of cheap hydro-electric power, three installations.

3rd. Franchise requiring other than steam motive power, two installations.

4th. Relief of terminal passenger station congestion, one installation.

5th. Development of local traffic, one installation.

This total of eighteen installations made by thirteen different steam railway systems during the past twenty years, aggregates about 625 road miles, out of a total of approximately 280,000 road miles in the United States and Canada, and a comparison of the principal detail, such as the current generating, transmitting, distributing and contact systems, voltages, types of locomotives and the like, will show wide variation and is indicative of the present undeveloped state of the art.

While the costs for installation and for maintenance and operation of these electrified sections of steam lines are either unavailable or difficult to obtain, it would probably be conservative to approximate that a unit of passenger or freight hauling power will cost for first installation from five to ten times more for electric than for steam, and for fixed charge maintenance and operation it will cost from two to three times more for the electric than for steam. For example, should the initial cost of a steam locomotive be \$25,000, complete ready for service, an electric locomotive of identical hauling capacity with its necessary propelling auxiliaries will represent a first cost of from \$125,000 to \$250,000.

Where adequate water power can be utilized economically in combination with a load factor of 75 per cent or more to reduce operating costs; where relatively small train loads and rapidity and frequency of service obtain in congested districts of dense passenger traffic; or where the transportation operations are auxiliary to mining or other industrial developments requiring the extensive use of electricity, there may be some justification for the use of electric motive power. However, the disadvantages that will still remain as compared with steam, may be stated as:

1st. The almost prohibitive cost for installation, operation, interest, taxes and depreciation, except where unusually cheap hydro-electric power and a high road factor are obtainable.

2nd. The necessity for incurring large capital investments and discarding existing locomotive, car, track, signaling and supply equipment, and road and terminal facilities.

3rd. Inability to utilize more than an average of from one third to one half of the power generating capacity, due to low load factor, and for maintaining additional emergency power generating equipment.

4th. Non-interchangeability of equipment over other than electrified home districts, due to lack of standardization in current and contact systems.

5th. Liability for dangerous and expensive short circuiting at power stations or on the line, with consequen-

tial fire, suffocation, personal injury and fatalities.

6th. Dependence upon an outside source of power generating, distributing and contact system for operation, resulting in complete stoppage of all locomotives in event of failure.

7th. Interference of storms, snow, sleet and floods with operation.

8th. Necessity for duplicating and patrolling long distance transmission lines to insure against current supply failures.

9th. Electrolysis of water, gas and other metal mains and structures.

10th. Short circuiting and leakage of current, due to defective insulation and bonding, and on account of unfavorable weather.

11th. Liability for "overheating" of motor equipment after short, heavy runs, necessitating "resting" of locomotives at terminals.

12th. Extraordinary expense for upkeep of track and contact line surface alignment.

13th. Delays in changing locomotives at the termini of the electrified and steam zones.

14th. Necessity for a more skilled class of labor for inspection, maintenance and operation.

15th. Increased delay and constructive mileage for motive power and crews.

16th. Inability of the electric locomotive to utilize its rated capacity and effectiveness throughout the same range of speed and tractive power variations as the more flexible steam locomotives.

17th. High initial and consequently greater fixed cost to be added to the operating expense per unit of power developed.

18th. Difficulty in adapting electrification generally to existing steam road practice.

Given a certain trackage equipped with fuel, water and sand supply, turning and slag-pan dumping facilities, a modernized steam locomotive may be successfully operated. However, an electric locomotive in lieu of these facilities would require for its operation one or more fireproof power generating stations; general and auxiliary feeder and distributing systems; general transformer, converter or storage battery sub-stations; overhead or surface contact lines; track rail bonding and insulation; safety cut-out switches; electro-magnetic disturbance neutralizers, and the like, each item of which is made up of innumerable complicated and costly details for installation, maintenance and operation. Therefore, the financing of projects involving the electrification of steam railway lines will be somewhat different until it can be demonstrated that electrification will produce net results that cannot be obtained from steam operation.

The agitation for electrification has stimulated mechanical engineers engaged in designing steam motive power to attack the various problems confronting them along vigorous lines, with the result that while the interchangeable steam locomotive is rapidly becoming a more effective and economical machine under all conditions of weather, speed and train-load, the electric locomotive, from an engineering standpoint, has not yet reached any comparative degree of general standard design, method of operating, reliability or efficiency.

Since the initial application of electricity on the Baltimore & Ohio Railroad, and particularly during the past ten years, a tremendous advance has been made in the perfecting of the steam locomotive through the use of larger single units of power, in the application of special appliances for producing effectiveness and economy and through general and detail improvements in design, material and construction.

Prior to the development of the Mallet and other locomotives of great power having boilers equipped with high steam pressures, superheaters, large grate areas, firebox brick arches, compounding and other capacity-producing devices, the accelerating qualities and the endurance of the electric locomotive at speeds on grades was regarded as an advantage over the saturated steam locomotive, even though its limited steam capacity was no greater handicap in the development of maximum hauling capacity than the overheating of the motors of electric locomotives. However, the past ten years development of the steam locomotive has brought about a material change; for example, the use of superheated, as compared with saturated steam, has not only increased the capacity of locomotive operation approximately 33 1/3 per cent, but it has at the same time enabled a saving of approximately 25 per cent of the fuel and 33 1/3 per cent of the water used per unit of work performed for the reason that in single expansion cylinders an indicated horse-power hour may be produced for from 15 to 20 pounds of superheated steam, as compared with from 26 to 32 pounds of saturated steam, and a horse-power hour may now be delivered at a

tender drawbar, through the complete range of the effective capacity of the locomotive, for approximately three pounds of coal.

In general, therefore, it may be conservatively concluded that the steam locomotive will remain the standard unit of motive power for present and future general railway operation for the reason that its existing merit and the possibilities for improvement fully justify its continued use.

Improving the Physique of Americans*

HUMBOLDT declared that "Whatever virtue men would have appear in society must be taught in the schools." It is upon these nurseries of civilization that we must rely to reawaken the physical conscience and to show to future generations that, by taking thought, they can not only free themselves from disease, but can attain a vigor of intellect and a strength and beauty of body not seen on earth since the days of the ancient Greeks.

The following plan is proposed as a direct and efficient method of teaching the masses what the body beautiful should be, and what steps are necessary to secure this great desideratum.

The number of teachers and experts necessary to carry it out will be no greater than the extra teachers now employed in our public schools to distract the children's minds from the fundamental studies of the curriculum by inculcating in a vague way a smattering of various more or less immaterial subjects. Teachers, parents, and everyone else at this writing, acknowledge that health comes first, and that the whole system of education must be made to conform to this axiom in very deed, even as it now professedly conforms to it in theory.

To begin with, we must fain acknowledge that there is no question that much of the present drive to conserve and improve the health of school children begins too late. It is in the improper treatment of the little children that most of the seeds of future trouble are sown. If small scholars were carefully watched, and each one minutely studied for any congenital defects, as well as for any fault of environment, there might result an enormous saving to the State by reason of the diminution in the numbers of dipsomaniacs, neurasthenics, insane, and incompetent people. Starting the education of numbers of congenitally defective children in our public schools, and pushing them along, until their condition is made worse and harder to remedy, is an error which we are learning to avoid. But we are not so careful to avoid and not so successful in combating injury not alone to the delicate, underdeveloped, and undernourished children, but even to the normally healthy ones, by improper physical conditions in the schools.

The principal reason for this failure, which is so far-reaching, and so general that its importance cannot be overestimated, is that we neglect the physical status of the young scholar until more or less harm has been done. We are trying to make bricks without straw by pushing all the young scholars along the road of education just so many feet every year, all the while neglecting the two essential features, first, whether the child has the normal equipment, physical and mental, for the work, and second, whether the work is in any way injurious to him.

School teachers have a notion that so long as the child keeps up with his grade, and no complaints of ill health are made, he is doing well enough and there is nothing to worry about. There are a great many rules and tables to determine what the mental status of a child should be at a certain age, and for that matter, there are enough rules to show what the average child's physical development should be at a given age. Unfortunately, however, the teachers do not know the latter rules, however well they may be acquainted with the former; nor are there any tests of the physical status of the scholars in the regular school work that are as easily applied and as efficient as the tests of their mental work, always at hand in their marks for their recitations and their periodical examinations.

Consequently the average teacher is not at present capable of judging whether the child is being injured by the school work, or whether the child has the normal physical development for his age. The medical inspector of the school is not engaged to do this essential work, so it is not done.

There is, therefore, not only the danger of a lasting injury to the child by allowing him to live under improper conditions, both in and out of school; there is also the further unfortunate circumstance that his physical development is neglected. From both of these causes the average school child suffers injuries that are most vital, both in their immediate and remote results. "As the twig is bent, the tree is inclined." Our interference with present conditions must not be solely of a negative character; we must take positive steps to assure the best

* An abstract of an article in the *Medical Record*.