Steam Road Electrifications

The Author Discusses Mountain-Grade Service and Shows That with the Electric Locomotive the Ruling Grade Need No Longer Be a Limiting Factor to Transportation Capacities

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The electrification of our steam railways has been the goal toward which the efforts of electric railway engineers have been directed for many years. Certain installations such as terminal and tunnel electrifications are thoroughly justified and will take place for reasons other than adequate return upon the capital invested. With a better understanding of the electric locomotive and its operating possibilities, its fitness as a superior type of motive power for main-line electrification has become apparent. This fact, together with certain fundamental conditions which have developed during the past few years, has made it possible to consider immediate electrification of certain portions of our main steam roads where the local conditions are especially favorable to electrification and where the limitations of the steam engine are most apparent.

As a result of several years of operation of electric locomotives, sufficient figures are at hand to indicate within reasonable limits their probable cost of operation and maintenance. After making due allowance for the different conditions obtaining, there seems every reason to believe that the electric locomotive can successfully replace the heaviest type of steam engine on the mountain-grade divisions of our main steam roads, provided the daily tonnage is sufficiently heavy to justify the first cost of electrification. These proposed electrifications show a saving over present steam operation sufficiently large to attract the capital investment required, and therefore come outside the scope of the so-called "enforced electrifications" demanded by local sentiment or for reasons of expediency.

There are certain fundamental causes underlying the fact that mountain-grade electrifications can in many instances be considered immediately, and these may be classed under the following three general headings:

1. Electric power situation.
2. Preparedness of the manufacturing companies.
3. Superiority of the electric over the steam locomotive.

ELECTRIC POWER SITUATION

The past few years have witnessed the formation of large power interests in both the West and the East, and these installations have reached such a magnitude and the high-tension distribution systems now cover such a large territory and are fed from so many sources of supply as to guarantee to prospective railroad purchasers a reliable and cheap source of power. The very mountain-grade divisions that are so troublesome to the operators of steam engines are frequently the centers of large hydraulic installations, so that the abundant supply of power in the mountains finds a ready local market in the railroads. The reliability of such electric power supply is indicated by the operation of the Great Falls installation of the Butte Electric & Power Company, which showed a total of seventeen minutes' delay during its first year of operation and a still better record the second year.

Except under very favorable conditions, it does not appear economical to install and operate a power station devoted solely to supplying electric locomotive load alone, owing to the high fixed charges required to furnish power with a ragged load curve and also maintain sufficient reserve apparatus to guarantee continuity of service. Such loads, however, can be absorbed by large power developments at a cost for power which may in many locations make electrification attractive, because such power systems can take full advantage of the diversity factor of railway, lighting and miscellaneous power load. Not the least of the contributing causes justifying immediate electrification in certain localities is therefore the fact that power can be purchased by the railroad companies at reasonable rates, thus eliminating the necessity of any additional outlay for power house and transmission lines, a condition most attractive when financing constitutes the greatest obstacle toward electrifying certain engine divisions.

ELECTRIC LOCOMOTIVE AND STEAM LOCOMOTIVE DESIGN

It is to be expected that the electric locomotive will be improved from time to time with the advance of the art, and the present preparedness of the manufacturing companies to build electric locomotives of any capacity demanded is based upon the experience gained in the manufacture of many such machines. Compared to the steam engine, the electric locomotive is comparatively new, and the belief is held by some that the purchase of to-day will be rendered obsolete by the improvements of to-morrow. It is difficult, however, to anticipate material improvement in the operating results of such machines, for example, as the locomotives operating over the New York Central electric zone. These machines, purchased at a reasonable price, operating at over 92 per cent efficiency from third-rail to rim of drivers, maintained in original operating condition at a total cost of approximately 3 cents per mile run and requiring inspection only after 1200 miles operation, leave small opportunity to effect any but minor future improvements.

The steam engine, on the other hand, is open to fundamental improvements in future designs that may readily make present machines economically obsolete. The change from simple to compound, coal to oil as fuel, the adoption of the superheater, feed-water heater, etc., may make for a fuel economy considerably greater than that open to future improvements in electric locomotives. The use of mechanical stokers may also be justified by reason of the increased engine output so obtained, provided such increased capacity is not purchased at a too great sacrifice in fuel economy.

In other words, the modern steam engine itself is much more liable to future fundamental changes in design than the electric locomotive, owing to the fact that the latter is already advanced to a high state of development not possible with the more complex steam engines comprising both motive power and steam generating plant. Any fear, therefore, that the electric locomotive constructed to-day will be discarded to-morrow by reason of having become obsolete is based upon a lack of understanding of the inherent qualities of such a type of motive power, as such replacement, if made, will be for reasons other than that of locomotive efficiency.

The main reason for electrification, however, rests in the superiority of the electric over the steam locomotive as a type of railway motive power and its better adaptability to the rigorous requirements of heavy mountain-grade railroading. The electric locomotive possesses certain inherent characteristics not equally shared by the steam locomotive, which offer the opportunity of introducing improved methods of operation and effecting economies in the handling of mountain-grade traffic which will have far-reaching effect.

POWER OF STEAM ENGINE LIMITED

The steam engine is a complete power house on wheels and depends upon the mechanical activity and skill of the fireman as regards its horse-power or service capacity output. Its available tractive effort is a function of the weight upon the drivers, diameter of cylinder and steam pressure, all of which may be thoroughly in keeping with the local conditions obtaining in the class of service to which the engine is assigned. The speed at which this tractive effort is delivered, however, depends upon the rate at which a fireman can throw coal and also upon his skill and the efficiency of the boiler. As the result of the continually increasing demand for heavier trains operating at higher speeds in order to take care of the volume of daily tonnage on a single track and meet the schedule competition of possible parallel lines, it has been necessary to develop steam engines having a continually greater weight upon the drivers. With weight per driving axle of nearly 60,000 lb. it is probable that the limit has been reached with present weight and composition of track rails and bridge construction. A further limit has been reached in the four driving axles comprising the 16-ft. rigid wheelbase of a simple engine; hence the development of the Mallet type of engine comprising two articulated trucks of either three or four driving axles each. All this development of the running gear of the engine has been accompanied by an increase in the diameter of cylinder to keep pace with the additional tractive effort demanded, until up to 90,000 lb. may be delivered from a single Mallet engine during the starting or accelerating period of the run.

The steam engine, however, is still fired by hand where coal is used as fuel, and the limit of continued effort of one fireman is still at the rate of not exceeding 5000 lb. of coal thrown per hour. The use of two firemen alternating in short shifts of say twenty minutes may result in throwing a somewhat greater quantity of coal beneath the boiler than indicated above, but at best the steam engine has reached limits in its horse-power output by reason of the amount of coal which can be fed to the grates. The introduction of the mechanical stoker may effect a considerable increase in the amount of coal fired, but such improvements have yet to show that the increased locomotive output so obtained is not purchased at a decreased coal efficiency that largely impairs the gain effected. Oil is used as fuel in favorable localities with resulting marked increase in the service capacity and hence speed of the locomotive on mountain grades. With the continually increasing demand for oil products, it is probable that the economic operating zone for this kind of fuel will become very restricted; in fact, a return to coal has already been made on certain single engine divisions owing to recent advances in the price of fuel oil.

While the weight upon the drivers and tractive effort of steam engines has therefore kept pace more or less with the requirements of mountain-grade railroading, the increased tractive effort so provided has been purchased at the expense of speed. The simple engine of four driving axles and a total of 200,000 lb. on drivers may haul its rated tonnage on the maximum grade at 12 m.p.h., while the Mallet engine with its greater weight on drivers and increased tractive effort available will haul a correspondingly greater rated tonnage at speeds, however, not greatly exceeding 7 to 8 m.p.h. If greater speeds are required upon ruling grades, the demand can be met with the Mallet engine only by hauling less than its rated load or by providing more engines per train.

It is just in this connection that the electric locomotive offers all the advantages of the high tractive effort demanded without being penalized by the correspondingly reduced speed of its steam competitor. Just what this may mean in the operation of a mountain-grade division is best appreciated by a brief analysis of the inherent characteristics of modern steam engines and the type of electric locomotive just completed for operation upon the Butte, Anaconda & Pacific Railway. These figures are shown in Table I.

Both the Mallet and the electric locomotives have been built in units larger than listed in this table, but for general conditions the size quoted may be taken as typical for both.

LOCOMOTIVE PERFORMANCE

While fuel economy is not the most important consideration, there is generally a certain saving to be effected in this item by the substitution of the electric for the steam locomotive. The cost of coal and its quality, as well as the cost of electric power, will vary so greatly in different localities that no comparison is of any more than general interest. The coal consumption of a steam engine is, however, of the greatest interest from the standpoint of indicating its service capacity. In order not to confuse the issue being discussed, the data shown in Table II have been tabulated, based upon the coal burned by the steam engine itself, while working at full output, although of greater interest are the total amount and cost of coal purchased, including the wastage and cost of handling between purchase point and engine tender.

TABLE I, SHOWING GENERAL CHARACTERISTICS OF SIMPLE MALLET COMPOUND AND RECENT ELECTRIC LOCOMOTIVE.

	Simple.	Mallet Compound.	Electric
Number of driving axles	4	6	8
Weight on drivers	200,000 lb.	300,000 lb.	300,000 lb.
Total weight locomotive and tender	400,000 lb.	530,000 lb.	300,000 lb.
Weight per driving axle	50,000 lb.	50,000 lb.	37,500 lb.
Length of engine and tender	70 ft.	85 ft.	75 ft.
Length rigid wheel base.	16 ft.	10 ft.	9 ft.
Diameter drivers	57 in.	57 in.	46 in.
Cylinder, diameter	23 x 28	21 x 32, 33 x 32	....
Rated tractive power	44,000 lb.	66,000 lb.	66,000 lb.
Coefficient of adhesion	22 per cent.	22 per cent.	22 per cent.

The tonnage rating of a locomotive is based upon its performance on ruling grade, and in many instances the ruling grade may extend over a considerable distance, thus calling for the continued development of maximum output and demanding the best efforts of the fireman. While delivering the large tractive effort required on ruling grade, the steam engine must necessarily operate at a considerable proportion of its full stroke, a fact that should not be lost sight of in determining its coal and water economy, and hence horse-power output, as derived from the amount of coal that can be fired per hour.

TABLE II, SHOWING TYPICAL STEAM ENGINE PERFORMANCE.

	Simple.	Mallet Compound.
Steam consumption per i.h.p. on ruling grade	30 lb.	23 lb.
Mechanical efficiency	85 per cent.	85 per cent.
Steam per hp at rim of drivers	35.5 lb.	27 lb.
Evaporation per pound of coal*	5—8	5—8
Coal per hp-hour at rim of drivers	7.06 4.42	5.4 3.38
Hp available at rim of drivers at coal rate of 5000 lb. per hour	709 1130	926 1480
Tractive effort on basis of rated tonnage	36,000 lb.	54,000 lb.
Coefficient of adhesion	18 per cent.	18 per cent.
Speed at rated tractive effort	7.35 m.p.h. 11.7 m.p.h.	6.39 m.p.h. 10.20 m.p.h.

*Evaporation will depend upon the heat units per pound of coal ranging from 10,000 b.t.u. for Western lignite to nearly 15,000 b.t.u. with Eastern bituminous. This points out that the limitations in locomotive output and speed, as determined by the amount of coal which a fireman can throw per hour, are more keenly felt on the Western mountain grades where inferior coal must be used.

SLOW SPEED OF STEAM LOCOMOTIVE ON RULING GRADES

A careful study of Table II is most instructive, as it points out one of the great weaknesses of the coal-burning, hand-fired steam engine, and that is its low speed when operating on ruling grade. The values of steam consumption and evaporation taken are fully representative of good performance, but it must be also admitted that considerable latitude should be allowed in such values as pounds of coal burned per horse-power hour output at driver rims on account of the boiler condition and the efficiency of the crew. Hence the average performance of all the engines assigned to one grade division may quite possibly fall below the figures quoted above.

The table shows why the heavier Mallet must necessarily haul its larger rated tonnage at a lower speed than the simple engine. There are admitted large economies resulting from the movement of heavy unbroken trains over a mountain-grade division; hence the usefulness of the Mallet. But the question of operating speed must not be lost sight of, and with a congested single track a possible marked increase in speed may eliminate the necessity of constructing a second track with the large capital outlay which this would entail in the mountain districts.

Turning again to what relief from these conditions is offered by the electric locomotive, there is presented a machine entirely separate from its power supply and comprising electric motors, running gear and superstructure, all suitably proportioned to best advantage. The motor armatures may be mounted direct on the axles, as in the New York Central design, or may transmit their power through twin gearing, as is the case with the Great Northern, Detroit tunnel and Baltimore & Ohio tunnel locomotives, or may even connect with side rods or combination of gear and side rods. The several types of gearing present a radical difference in appearance but a comparatively small fundamental difference in actual efficiency from electrical to mechanical power.

The main point to be considered at this time is that, however different in type of construction, the electric locomotive, as such, is a highly efficient machine, can be maintained at a lower cost and is capable of giving a sustained output greatly exceeding that of a steam engine. With good-quality bituminous coal, the steam engine may operate its rated tonnage calling for a tractive effort corresponding to 18 per cent coefficient of adhesion of its drivers, at a sustained speed of not over 12 and 10 m.p.h. respectively, for hand-fired simple and Mallet engines. With Western lignite the speed may fall as low as 8 and 6 m.p.h. for the two types of engines working under the same maximum conditions.

The electric locomotive, however, having access to unlimited power, is restricted in its tractive effort only by the weight upon its drivers and has no reasonable speed limits other than those imposed by the curvature of the track. Moreover, several locomotive units may be coupled together and operated as a single locomotive under the control of one operator. The ability of the electric locomotive to furnish both large tractive effort and high speed is best brought out by the comparison shown in Table III

Table III, Showing Comparative Hauling Capacity Steam and Electric Locomotives.

	Simple.	Mallet Compound.	Electric.
Total weight, including tender	400,000 lb.	530,000 lb.	300,000 lb.
Weight on drivers	200,000 lb.	300,000 lb.	300,000
Cofficient of adhesion at rated tonnage	18 per cent.	18 per cent.	18 per cent.
Tractive effort at rated tonnage	36,000 lb.	54,000 lb.	54,000 lb.
Tractive effort 2 per cent grade	40 lb.	40 lb.	40 lb.
Train and curve resistance	7 lb.	7 lb.	7 lb.
Total resistance	47 lb.	47 lb.	47 lb.
Rated tonnage, total	776 tons	1,150 tons	1,150 tons
Rated tonnage, trailing	576 tons	885 tons	1,000 tons
Per cent of electric trailing, tons	57.6	88.5	100
Speed at rated tonnage*	7.35 m.p.h.	6.38 m.p.h.	14 m.p.h.

*Speed based upon using Western lignite at approximately 10,000 b.t.u.

applying to the locomotive constants given. A typical ruling 2 per cent grade division is taken as representing general mountain-grade conditions.

A study of steam engine practice discloses the fact that engines receive a tonnage rating on ruling grade that will require a tractive effort of approximately 18 per cent coefficient of adhesion of their drivers.

SERVICE CAPACITY

The hauling capacity of the electric locomotive having the same weight upon its drivers is shown as being but 13 per cent greater than that of the Mallet, but the speed at which this tonnage is hauled is over double that possible with the steam engines. The "service capacity," or the product of trailing tonnage and speed upon ruling grade, is therefore a truer measure of the comparative performance of the several locomotives and is given in Table IV.

Table IV, Showing Comparative Service Capacity of Steam and Electric Locomotives.

	Simple.	Mallet.	Electric.
Trailing tons, 2 per cent grade	576	886	1,000
Speed	7.35 m.p.h.	6.38 m.p.h.	14 m.p.h.
Speed multiplied by trailing tons	4,235	5,660	14,000
Per cent of electric "service capacity"	30.2	40.5	100

This table shows that the electric locomotive "service capacity," or its ability to move tonnage per hour, is three times that of the simple and two and one-half times that of the Mallet engine, while its total weight is less than either.

As compared with hand-fired coal-burning steam engines of either the simple or Mallet types, the electric locomotive may be looked upon to furnish the much-needed increased capacity of motive power for mountain-grade divisions. Such grade divisions are not only a heavy expense in operation but introduce a very slow schedule in a trunk-line service, besides greatly congesting the traffic on a single track, when steam engines are depended upon. Many divisions comprise ruling gradients of such a nature as to require the breaking up of through trains or at least a partial rearrangement of the train tonnage delivered by the adjoining low-grade division. The delay thus introduced, together with the lost time incident to steam engine haulage on a heavy grade, amounts to a considerable total.

ELAPSED TIME

A mountain division of 220 miles, comprising ruling gradients of 2 per cent, showed the results published in Table V of elapsed time under existing steam engine conditions compared with the time that could have been made with suitable electric locomotive equipment.

Table V, Showing Elapsed Time with Steam Engine on Given Run and That Possible with Electric Locomotive on Same Run.

	Steam, Hours.	Electric, Hours.
Actual running time	15.15	13.02
Taking water	.90	.....
Cutting in and out helpers	1.00	.50
Testing air brakes	.20	.20
Changing engines and rearranging tonnage	1.40	.....
Total elapsed time	18.65	13.72

The run of 220 miles shown in Table V comprised two steam engine divisions, entailing the necessary delay in changing engines, while the schedule of the electric locomotive is based upon its making the through run of 220 miles, changing crews, however, at the division point.

The electric locomotive run is further based upon making a maximum speed of not over 35 m.p.h. on level track, the speed attained in the steam engine run, but, however, making a much higher speed on the ruling grades than the 10 m.p.h. reached with the steam engine. The delay due to taking on water is best appreciated by having knowledge that the water supply in the tender is sufficient to last only from one to one and one-half hours of continuous running at maximum output corresponding to a possible distance covered of from 10 to 15 miles. With a complement of three steam engines per train, taking water involves a delay of from twenty to thirty minutes, all of which time is saved with electric locomotive operation. Aside from the economies resulting from replacing the steam with the electric locomotive, the providing of increased hauling capacity at increased speed comprises operating advantages that will be fully appreciated in these days of track congestion and competition.

COAL CONSUMPTION

In previous tables values of from 3.38 lb. to 7.06 lb. of coal per horse-power hour at the driver rims have been quoted. Such figures, however, apply only to the coal used while the steam engine is working at full output.

In addition, there is much coal burned from which no return in mileage is made. Commencing with firing up and ending a run with fire banked, coal is continuously being burned during the time that the train is in motion as well as when standing still.

Some idea of the coal wastage inherent to steam engine operation is gained by study of Table VI, which has been compiled from observed operating conditions.

Table VI, Showing Coal Records of Simple Engine.

Firing up preparatory to run	1000 lb.
Standing on sidings	500 to 1000 lb. per hour
Coasting down grades	950 lb. per hour
Fire banked in roundhouse	150 lb. per hour

The steam engine is actually working but a small part of the twenty-four hours, and to the coal consumed during working periods must be added that burned in making up fire, coasting down grade, standing on sidings, banking fire, etc. A series of readings extending over a period of thirty days and covering two engine divisions of a Western mountain road where lignite coal of less than 11,000 b.t.u. was used showed that nearly 12 lb. of coal was purchased for each useful horse-power hour expended at the driver rims.

In some instances nearly 10 per cent of the tonnage moved over the division consists in the coal required to move the trains.

The price of such coal may vary from $1.50 to $3 per ton upon the tender, and in this item of fuel the electric locomotive holds promise of material saving. While this article is largely devoted to a consideration of the Western mountain-grade problem, there is an even greater saving in fuel to be attained in operating electric yard locomotives. The average demand for power is less than 100 kw in yard shifting service, as given by Mr. Murray, while the coal consumption per horse-power hour of steam yard engines is even greater than the figures given above for road engines on grade divisions.

OTHER OPERATING ADVANTAGES

Electrification promises much in the way of increased hauling capacity, higher speed on ruling grades and relief from track congestion. Other operating advantages result with the use of the electric locomotive. In certain railway systems it is the practice to pool the engines, while in others best results appear to be obtained when an engine is assigned to its own crew. The greater reliability, ruggedness and uniform operation of electric locomotives make it entirely feasible to pool them and secure the benefits of a lesser outlay without risking any marked increase in the cost of locomotive maintenance. Moreover, it is entirely possible to operate an electric locomotive continuously during the twenty-four hours with no reference to coaling or watering stations or roundhouse and no delays incurred thereby or in cleaning fires and washing out boilers. The freedom of action which the electric locomotive enjoys should prove a valuable asset in the operation of a complete engine division. Many other advantages are offered such as electric braking on down grades, thus relieving the brakeshoes and wheels and eliminating possible delay and derailments due to overheating these parts. Freedom from cinders may be a consideration in passenger train operation, but is also of value as reducing the fire risk.

Few comparisons of steam and electric operation are made upon the same basis of schedule and train tonnage moved, showing in itself that electrification is primarily considered from the standpoint of improvement in the service that can be accomplished by steam. It is difficult, therefore, to express any economic value of motive power substitution, as such benefits as, for instance, decreased running time are difficult to put into figures. Such direct savings as are evident, however, indicate a very attractive return upon the capital investment required after paying all the increased fixed charges incurred. In fact, perhaps one of the most effective causes contributing toward the present electrification movement lies in the acceptance of existing proofs that the electric locomotive can be economically as well as reliably operated.

BUTTE, ANACONDA & PACIFIC LOCOMOTIVES

The foregoing data apply to the electric locomotive as such, with no particular reference to any one type of construction. Characteristics of the Butte, Anaconda & Pacific locomotive have been quoted as being typical of the performance required for mountain-grade service. This installation will be in operation in the very near future and test data made available. The Butte, Anaconda & Pacific locomotive is of interest in this article in that it is the most powerful machine thus far constructed for its weight, comprising an eight-motor equipment capable of giving a sustained output of 2200 hp in continuous operation with 75 deg. C. rise, and the complete locomotive weighing 150 tons, all on drivers. When it is realized that this large sustained output is delivered at a speed of approximately 15 m.p.h., the fitness of this locomotive for heavy grade haulage will be admitted.

The Butte, Anaconda & Pacific motors are connected to the driving axles through twin gearing, following the construction of the Cascade, B. & O. and Detroit tunnel locomotives, as affording the greatest possibilities of large horse-power output at low operating speed. The locomotive motors differ from any now in operation in this country only in the voltage, which is 2400 volts d. c. between trolley and rail. The rugged qualities of the direct-current motor are fully known, and the greater radius of action secured by the use of 2400 volts is made apparent by the statement that the 26 miles between Butte and Anaconda will be fed from two substations located at either end, with trains of 3400 tons trailing against a gradient of 0.3 per cent operating at a speed of 14 m.p.h. The Butte, Anaconda & Pacific Railway comprises approximately 114 miles of track, of which 90 miles are being electrified at present.

ELECTRIFICATION OF TERMINALS AND OF MOUNTAIN GRADES

The causes underlying the movement toward terminal electrification in our large cities are so apparent and well founded that this important class of work has received but passing mention in this article. The installation of electric locomotives to operate through tunnels is also a matter beyond question, and this fact is not lost sight of in future plans for mountain-grade divisions, as in some favored localities a very few miles of tunnel can replace many miles of surface grade, with its attendant higher elevation, high cost of maintenance and operation. The fact, however, that is just being appreciated is the value of the electric locomotive characteristics when applied to the haulage of the heaviest trains at the highest speeds feasible on mountain-grade divisions.

The introduction of the electric locomotive robs the dreaded "ruling grade" of half its terrors, as the heaviest trains can be moved up such grades at double the present operating speeds with steam engines and can be safely controlled down grade with electric brakes without having recourse to air brakes except as an emergency resort.

Moreover, the operating advantages which the electric locomotive introduces can be secured with adequate return upon the capital investment called for. In these conditions and in the availability of cheap power, with the present state of development of electric locomotives and auxiliary apparatus, we find the main causes underlying the present earnest movement toward the electrification of mountain-grade divisions.

The Development of the Electric Railway Motor

The Electric Railway Motor Has Now Reached the "Age of Economy"—Dangers in Too Great Reduction in Car Weights Are Cited—Possibilities in Field Control Are Discussed

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The evolution of the modern railway motor began in the early eighties and is practically all confined to a period of thirty years, which may be divided into about five stages as follows:

First—The period embracing the experiments of the early inventors such as Field, Hopkinson, Henry, Daft, Edison, Van Depoele, Farmer, Bentley, Knight and Sprague.

Second—The period covering the exploitation of the double reduction motor between the years 1886 and 1891.

Third—The period from 1891 to 1907, covering the development of the single reduction motor of the straight series type.

Fourth—The period from 1907 to 1911, covering the development of the commutating-pole motor.

Fifth—The period beginning 1911, which is not yet completed, covering the age of economy in operation.

Of the first and second stages it is unnecessary to say anything at this time as they are a matter of history which is already well written in numerous articles in the STREET RAILWAY JOURNAL and elsewhere.

The third stage has not been so completely described. It begins with the introduction of the first really successful single reduction motor—the Westinghouse No. 3—and covers the entire range of motors built by the Westinghouse Electric & Manufacturing Company down to the No. 101-B-2, the motors built by the General Electric Company from the S.R.G. to the G.E.-80, and the various motors built by the Short Company, the Walker Company, the Lorain Company, the Stanley Company and the Allis-Chalmers Company. Some of these companies, such as the Short, Walker and Lorain companies, were strong competitors in the early days and made some very good motors. For one reason or another the companies abandoned the manufacture of electric railway motors. However, the good points of the motors were largely retained and transmitted to the later designs. The motors at the end of the third stage may be said to have embodied in them practically all of the improvements which were developed prior to that time. The Westinghouse No. 101-B-2 motor, for instance, had the following features, many of which are now common to all railway motors:

1. Inclosed type with cast-steel frames.
2. Four laminated radial pole pieces bolted into the frame.
3. Mummified strap-wound field coils insulated with asbestos paper between adjacent turns, the entire coil impregnated in a vacuum.
4. Large armature shafts carried in bearing housings extending inside of the armature at the pinion end and inside the commutator at the front end.
5. Bearings well lubricated by the use of oil-soaked waste.
6. Separate oil well for gaging depth of oil and for receiving fresh oil.
7. Efficient oil throwers as a protection against the oil reaching the interior of the motor.
8. Spring packing of field coils to counteract the effect of shrinking insulation, and thus prevent loosening.
9. Improved methods of holding motor leads to prevent vibration and breaking.
10. Two-point suspension of gear cases.
11. Commutator cover with simple and reliable cam-locking device.
12. Slotted drum-wound armature.
13. Ventilated armature.
14. Form-wound armature coils assembled in sets of three coils each.
15. Armature core and commutator assembled on spider.
16. Armature bands laid in grooves in the armature core.
17. Coils protected by asbestos hoods on the commutator end.
18. High-grade insulation.
19. Commutators with mica extending beyond the copper, both on the inside of the commutator and at the end next to the windings to prevent short-circuits.
20. Improved brush holders with insulation consisting of high-grade insulating tubes protected by brass shells where clamped and by porcelain sleeves to give creepage surface.
21. Brush holders with adjustable tension and frictionless springs.
22. High-grade carbon brushes.
23. Many other small details which contribute to the success of the motor but can scarcely be enumerated.

Each one of the features mentioned has its own history which, if completely written, might cover a good many pages. It is, however, not necessary to give this in detail, and only a few comments will be made.

It is, of course, understood that these special features above given did not all originate with the No. 101-B-2 motor. They were carefully selected after a study of the previous types in service and were based upon the comments and suggestions of a great many operating men. The earlier railway motors were almost entirely the product of the manufacturers' designers. It was natural that this should be so since there was so little actual experience in operating motors and so few people in the business who actually knew anything about them. Even after there were thousands of equipments in service, it was rather difficult to get concrete suggestions from operating men for improving the design of motors. At the time the No. 101-B-2 motor was designed, however, a systematic effort was made to make the operating men thoroughly understand that the motor designers were in earnest in asking for their opinion and advice, and the result was that a great many valuable suggestions were obtained and some of the most valuable features in the modern motors were due to suggestions from operating men. The close touch between the operating men and the designers, which has been brought about through association largely in the American Electric Railway Engineering Association, has been of incalculable value in the design of railway motors.

INCLOSED TYPE OF MOTOR AND LAMINATED POLES

The inclosed type of motor resulted from the large amount of trouble experienced from mud and water splashing into the early types and causing them to break down their insulation. The No. 3 Westinghouse motor had the lower half of the frame inclosed, but the top half was more or less open over the commutator. The General Electric W.P. motor went still further and had the motor completely inclosed. The use of the four radial poles followed the attempt to get the most compact as well as the lightest design for street car motors. The Westinghouse No. 3 was the first commercial motor with this feature. It had the four radial poles and four equal field coils.

Laminated pole pieces were introduced to decrease the loss from eddy currents in the pole faces, which, with the high inductions introduced with the slotted armature and small air gaps, greatly increased the total loss in the motor.

The earliest motor having laminated poles was the Westinghouse No. 38-B. The poles were cast into the steel frame. The writer well remembers testing the first No. 38 with solid steel poles and finding such an astonishing loss in the pole face that laminated poles were at once decided upon. The pole pieces were bolted in on later motors, but whether first by the Lorain Company or the General Electric Company, the writer is unable to say. This was done in order to make the motor more compact and to utilize all of the space to the best advantage. It has ever since been standard practice. The induction in the air gap and the pole face is considerably less than the economical induction for working in sheet steel, so that it was quite possible to reduce the section back of the pole face and use the projecting tips to hold the field coils in position. Later the Westinghouse generator practice of saturating the pole tips by cutting off alternate pole tips from the punchings was introduced. This is still used to some extent.

MUMMIFIED STRAP-WOUND FIELD COILS

The use of mummified strap-wound field coils with asbestos insulation has become practically universal, and the use of round wire is permitted only on the smallest sizes of motors where the section is so small that no gain is secured by the use of the flat copper ribbon. This type of field coil has been a wonderful improvement over the earlier types. Insulated as it is with heat-proof insulation in the interior of the coil, it is able to withstand a much higher temperature, and the external insulation which is so completely filled with varnish, etc., makes it practically waterproof as well. The G.E.-57 motor and some others had field coils of copper ribbon insulated with asbestos between turns. They were, however, wound in metal bobbin shells or spools and could not be wound tight enough to prevent chafing of insulation and grounding. The mummified construction adopted for the No. 101-B-2 motor eliminated this trouble and made a solid coil which when used with the spring packing is held perfectly tight. The use of springs back of the field coils to insure their being held firmly at all times has been a great addition to the motors. It prevents the breaking of leads and chafing of insulation which would result in grounded field coils.

LUBRICATION

Probably no improvement has been more marked and has done more to keep the motor cars out of the repair shop than the introduction of the type of bearing housing and the method of lubrication used with the No. 101-B motor. With the old grease lubrication, it was no uncommon thing for armature bearing shells to be replaced after 3000 miles of service. The life of the bearing on the No. 101-B-2 motor may be almost anything up to 300,000 or 400,000 miles. This extraordinary result is due to the excellent design of the bearing, which has the waste packed against the shaft on the low-pressure side, with pressure of a column of waste over it, and the oil fed from below, coming from the well, which may be gaged at any time to see that the oil is kept at the economical level. This type of bearing is now universally adopted. It is scarcely necessary even to add oil to the bearings more than once a month, so that not only is the cost of lubrication reduced to a negligible quantity but the cost of maintaining the bearings and the loss due to the armature getting down on the pole pieces, which was a fruitful source of expense with the old bearings, have been practically eliminated.

OTHER ARMATURE IMPROVEMENTS

The modern armature is a very different piece of apparatus from that of twenty or twenty-five years ago. Then the armatures were either hand-wound, as in the W.P. and S.R.G., or the coils were wound on a form and driven down on the ends of the armature with a mallet in the process of winding them, as in the Westinghouse No. 3. The evolution from that type to the one used at present has been gradual. The early motors, like the No. 3, had only one armature coil per slot; the Westinghouse No. 12-A had two coils per slot; the No. 38-B had three coils per slot. The No. 12-A introduced the barrel-shaped armature winding with the ends left open to provide circulation of air through the coils. The G.E.-57 had form-wound coils with sloping ends bound firmly on a coil. The modern type has the coils projecting straight out banded to the coil support and completely covered with canvas or asbestos cloth caps.

The asbestos hoods on the front end of the armature windings were introduced to prevent the damage incident to flashing which may occur from any reason and is liable to set fire to a canvas covering.

The modern brush holders are a great improvement over the earlier form, not only in accuracy of adjustment but in simplicity of the insulation, substantial design and the use of adjustable frictionless springs. Sluggish brush holders and inaccurate adjustments used to be fruitful sources of bad commutation and flashing, but they have been almost entirely eliminated.

Another scheme that was introduced with the No. 12-A and the No. 38-B motors was the use of longitudinal holes through the armature core that served the double purpose of paths for circulation of air and of saturating the iron beneath the armature slots, which thereby improved commutation. The saturation has been largely abandoned on later motors, but the air ducts are continued.

Introduced with the No. 101-B for small motors was the armature spider, which carries not only the armature core but the commutator and thus permits the easiest possible renewal of bent or broken armature shafts. It also stiffens up the shaft in the spider and gives a much larger diameter for carrying the armature punchings and thus holds them tighter. There is less liability of relative motion between armature core and commutatior, as both are keyed to comparatively large diameters on the same spider.

COMMUTATING-POLE MOTORS

Coming at a time when the straight series motor had thus reached its high state of perfection, it is little wonder that the commutating-pole motor introduced in 1907-08 was an immediate and unqualified success. It had the benefit of all of the experience gained in the design and operation of the earlier motors, and added to that the use of the commutating pole, which eliminated the last serious objection to the direct-current street car motor, namely, the troubles incident to the commutation of the current. It is probable that no class of apparatus ever designed had a greater measure of success than the commutating-pole railway motors introduced at this time. However, the commutating pole was not the only new feature. The close association of the designers with the operating force and the intensive study of the subject led to still further minor improvements in the motors, and some very valuable features were introduced. Among them was the two-turn strap-wound coil with the Westinghouse No. 310 motor, which was a triumph in the art of armature winding. The method of forming the coils used in this motor obviates all of the difficulties which had previously been experienced with that type of coil. It permits of increased efficiency, larger capacity, better insulation and more substantial construction than with the ordinary wire winding.

The high-grade carbon brushes which came into extensive use about the same time, added to the undercutting of the mica on the commutator surface and the sparkless commutation due to the commutating pole, have practically eliminated wear on the commutator and greatly increased the life of the brushes. The amount of carbon and copper dust originating in the motor, which would tend to reduce the efficiency of the insulating surfaces, is, therefore, very small. This feature is of the utmost importance in the motor to be used on high-voltage circuits and greatly increases its reliability. Without it the high-voltage motor would have been a difficult if not a commercially impossible problem. With it the motor operates better on 1500-volt circuits than the old motor did on 600 volts.

THE AGE OF ECONOMY

The first interruption to the course of the commutating-pole motors came with the fifth stage in the history of the railway motor, namely, the age of economy.

One of the most notable signs of the times in the last two or three years has been the demand for economy and efficiency in every field of human endeavor. This has been due in great part to the training of the thousands of engineers who have been working in every possible way to increase the outputs of factories, mills and mines, to reduce operating expenses for a given output, to reduce the losses in generating plants, to increase the efficiency of transmission lines by the use of higher voltages, and so on through the entire field, trying in every way to reduce costs and increase dividends. This craze for efficiency—for such it has become in some quarters—reached the electric railways two or three years ago when someone called emphatic attention to the fact that it costs good money to carry around dead weight on street cars. This cost is variously estimated at from 2 cents to 10 cents per pound—a favorite figure being 5 cents per pound per annum. The exact amount, of course, depends on the cost of power at the car, the mileage and the class of service in which each car is engaged. Undoubtedly there are some classes of city service where the cost of hauling 1 lb. for a year is as much as 5 cents and possibly more.

REDUCTION IN CAR WEIGHT

Of course, this was not a particularly new idea, as it had been preached in some places for a good many years; but, be that as it may, it was brought out strongly at a very opportune moment—at a time when all parts of a car equipment had reached their maximum weights as a result of the demand for safety and reliability. It cannot be denied that there was reason for the complaint about excess weights, for the reduction in weight consequent upon the demand of operators for light-weight cars was prompt, and the reduction was so large as to leave no room for doubt that the previous weights had been excessive. However, as is usually the case, the reduction in weight has been carried to such an extreme in some cases that it has increased rather than decreased the cost of operation. It is always a question where to stop in such changes, and it is always a mistake to have only one idea in mind, especially if this idea consists simply of the possible fact that it costs 5 cents per pound per annum to haul the weight around on the cars.

Other things being equal, a reduction in the weight of a street car will effect a proportional reduction in the power required to move it. However, one should always be certain that the reduction in weight is not accomplished at the price of decreased operating efficiency or of increased cost of maintenance. Either of these can easily far more than offset any saving effected by decreased weights.

The prime idea should be a broader one. The reduction in cost of operation is the most comprehensive idea, but the demand for a reduction in the energy required to move the cars is a far safer and saner idea to inculcate in the minds of the operating men than the sole idea of the reduction of weight to save money. It should be understood that the lightest equipment is not necessarily the one which will have the lowest energy consumption per car mile.*

OTHER METHODS OF IMPROVING OPERATING EFFICIENCY

Ample proofs have been offered to show that the energy consumption can be greatly decreased by other methods than by decreasing the weight of equipment. This is especially the case where a decrease in the weight of the railway motor means an increase in the speed and consequently gives a lower efficiency in operation. A light-weight, high-speed motor may have a very good efficiency when operating at full voltage, better possibly than that of a heavier motor which runs at 20 per cent lower armature speed. In service, however, it is very frequently the case, and is nearly always the case in city service, that the motor with the lower speed will give a higher operating efficiency. This is due to the fact that the motor with higher speed will necessarily have a much greater resistance loss in accelerating, which is far more than enough to offset the power saved by reducing the weight.

In general, it is dangerous to make radical reductions in the weight of railway motors. It must be remembered that the motors built ten years ago were lighter in weight than the standard motors of to-day, but they were not nearly so reliable. For instance, a reduction in the size of armature shafts, which have been brought to their present generous proportions by years of hard experience, even though accompanied by the use of heat-treated material, is dangerous. Heat-treated materials have not yet reached the stage where they can be considered as standard, and until the methods of heat-treating of steel are much better understood by the general run of manufacturers and it is possible to obtain more uniform results by such treatment, we believe it will be better to make shafts strong enough to stand the service required of them without a resort to heat treatment. An extremely careful redesign of railway motors is, of course, producing some reduction in weight, but a radical reduction is sure to be followed by increased cost of maintenance, which will render the equipments less reliable and will more than offset any saving that can be made on account of the reduced weight.

The use of a coasting-time clock and of similar devices has drawn attention to the tremendous waste of power due to inefficient handling of equipment. It is said that the coasting-time clock, by putting a premium on rapid acceleration and on the maximum amount of coasting, has resulted in a saving of power consumption in some places of 20 per cent to 25 per cent or even higher. For the benefit of those who are seeking to reduce weights it is well to call attention to the fact that efficient handling of the cars may in some cases result in so much less heating in the motors as to permit the use of a smaller size of motor, which will thus effect a reduction in weight without a decrease in the mechanical strength of the motor.

Another scheme for reducing the weight of the equipment is by the use of ventilated motors. For some years back the use of forced ventilation has been common on locomotive motors and some motors for car service as well; notably, the motors on the Long Island Railroad have been operated for several years with forced ventilation secured by the use of small motor-driven blowers. The circulation of the external air through the internal parts of the motor is very effective in carrying off heat and will very largely increase the continuous capacity of the motor. This same result may be brought about by the use of perforated covers on the motor or of a fan on the armature shaft arranged so as to draw air through all parts of the motor. Either method is very effective and is quite satisfactory where the dust and dirt do not offer a serious obstacle. In cases where the danger from dust and moisture is serious, the air should simply be circulated about inside of the motor with no connection to the outside air, as has been the practice for many years. Any method that will cause the air to circulate inside the motor is helpful, because it brings the heat to the surface much more quickly than if the air were to remain stagnant in the motor.

FIELD CONTROL

Undoubtedly the most positive power saver which has been introduced with the interpole motors in the last two years has been the use of field control for the motors. This, as is well known, is simply a revival of the old-time control system, which was used in some of the earliest railway motors. The Sprague double-reduction motor made

* Under the subject of "Economies in Railway Operation," F. E. Wynne has very ably discussed this matter in a paper presented before the Baltimore Section of the A. I. E. E. last spring and published in the *Electric Journal*, October, 1912. He shows clearly the effect of higher armature speed, corresponding to small gear reduction, on power consumption in city service. He also takes up the methods for securing the greatest efficiency in operation.

the most extensive use of this, since the control was entirely by commutating the field and employed no external resistance at all. It was used to a greater or less degree in the early double-reduction motors and in one or two or the single-reduction motors. However, the commutation with slotted armatures was not good enough, and the selection of equipments and operation of motors were not well enough understood at that time to make the system a success. It was dropped nearly twenty years ago and was not revived to any great extent until it was applied on the locomotives of the New York, New Haven & Hartford Railroad, which were supplied in 1906 and 1907. These were single-phase motors of the series compensated type and permitted a wide range of variation in the field strength without impairing the commutation. The system in this instance worked with marked success. Its later application to the commutating-pole motors on the giant Pennsylvania locomotives used for the New York terminal was also an entire success, so that the engineers of the company which had furnished both of these types of locomotives were satisfied that this system of control could be used safely with any size of motor. The trial equipment placed in service on the Metropolitan Street Railway in New York City nearly two years ago met with just as great success as that of the locomotives, and the decrease in the energy consumption of this car equipment over the standard type of equipment in use was quite remarkable. A motor of very slow speed was used, and the resistance was normally cut out of circuit before the car reached a speed of 8 m.p.h. Higher speeds were obtained by weakening the fields of the motors. The maximum speed obtained was hardly as high as that of the standard equipment so that a part of the saving of power is due to the lower speed, but the larger part of it is undoubtedly due to the use of field control.

The table given in Mr. Wynne's paper before referred to shows that the energy consumption of the standard equipments of double 60-hp motors was 152.26 watt hours per ton mile, while that of the equipment of double 40-hp field control motors was 124.41, or a total reduction of over 16 per cent in energy consumption per ton mile. This, added to the fact that the equipment weighs considerably less, effected a total saving of over 20 per cent in the energy consumption. There is no doubt that similar savings can be effected in other places.

When we consider what a large part of the work done by the railway motor in city service, consisting chiefly in storing energy in the moving car, is done at speeds under 10 m.p.h., and we realize that most of this work with ordinary control is done with resistance in series, we can begin to understand how very important it is to cut the resistance out at the lowest possible speed. The standard type low-speed motor operates efficiently in the slow service, but the maximum speed is too low to maintain most schedules. Field control both cuts out resistances at the minimum speed and gives the maximum speed desired. It is almost ideal.

Practically the entire advantage of the use of field control in city service is in securing a lower energy consumption. On interurban railways, however, there are additional reasons for using it. The energy consumption is, of course, reduced a certain amount for each acceleration, the peaks on the line are decreased, and the maximum demand from substations is correspondingly reduced, but possibly the most important advantage for interurban work lies in the fact that the field control equipment is suitable for both limited and local service. There are a great many instances where cars equipped with standard motors have been geared for the high speed required for limited service and are operated in both limited and local service. The high-speed gearing renders the cars unfit for local service, since either the acceleration will be very poor and the schedule extremely low or the motors will be badly overworked. As it is the almost universal custom of railways to maintain the fastest possible schedules at any cost, the natural result of this is that motors have been generally overloaded where used for both classes of service. The use of field control enables the motor to be equipped with a comparatively large gear reduction which fits it for the local service, while the operation with the short field enables the car to attain the high maximum speed which is necessary for the limited service. It has been demonstrated that the motor with field control has great advantages on locomotives, on street cars and on interurban cars. The question may be asked: Is there a twilight zone where it is not good? The opinion of the writer is that its advantages should bring it into use in every known class of railway service. Its advantages are positive. Its disadvantages are almost negative. It requires one extra motor lead and a slightly more expensive and complicated control equipment.

We believe that in most classes of service the use of properly designed field control equipment will effect a saving of not less than 10 per cent in the total power consumption required for operating the cars. When it is considered what a vast amount of power this would save in the course of a year if all the railway motors were operated in this way, one feels justified in believing that it will be only a very short time before every one will demand field control equipments. Already many inquiries have come from roads operating large equipments to know if field control can be applied to their existing motors. In most cases, in city service, it is impossible to do this and effect any considerable economy. This is especially the case where the motors are already provided with the maximum gear reduction.

ADAPTATION OF FIELD CONTROL TO EXISTING MOTORS

In such a case the possibility for saving is very limited since the standard motors are usually worked at a fairly high induction at normal accelerating loads and the induction can be increased very little by the addition of extra turns on the field coil. There will, therefore, be very little decrease in the accelerating current and a correspondingly small decrease in speed. Consequently, the saving in rheostatic losses would be very small and not enough to pay for a change in the equipments. The use of fewer turns on the field for obtaining higher speed would be of no advantage whatever where the equipment is already geared for speed as high as is required. To get the advantage from field control in slow city service, *motors must be wound for slower armature speed than is ordinarily used for standard motors.* This will in most cases require new armature windings. Where interpole motors are now used with large pinions the advantages of field control can be secured in most cases by an increase of the gear reduction, a change in the field winding and by making the necessary changes in the control equipment. These changes in most cases cost so much as to be prohibitive unless made at a time when gears are to be changed and motors overhauled. It should be kept in mind, however, when new equipments are bought and when all the advantages may be secured at a minimum cost.

Field control with non-commutating-pole motors cannot be recommended, as it will result in most cases in trouble with commutation.

Any well-designed commutating-pole railway motor may be adapted for field control by a proper arrangement of its field windings. To get the full benefits, however, the gears must be properly selected. For interurban work the benefits of field control may be secured by the use of standard high-speed armatures with a larger gear reduction than usual. In most cases, also, sufficient space is available to permit the extra field winding to be used. Special armatures for use with field control are necessary only for cases where the slowest speeds and the maximum gear ratio are required.

It will usually be found that where a motor of a given size is used in city service with the maximum gear reduction and the usual series parallel control a slower-speed armature may be used with the same motor frame and will make the same schedule with a lower energy consumption when field control is employed. The motor will have a lower horse-power rating, but the current used will be correspondingly less, and, consequently, the motor will have no more loss in it than with the motor of higher speed with a larger rating. In other words, the use of field control permits the use of a motor of a smaller rating for a given service. Where the maximum gear ratio is used in both cases, the same size of frame must be used. However, where the gear reduction can be increased for the field control motor it will frequently be found that a smaller size of motor can be used at a lower first cost and with less weight to be carried around. A double saving will thus be effected.

The question frequently arises as to what range of speed may be covered by field control. For car equipments it is usually from 15 per cent to 25 per cent, which may be secured by cutting out 20 per cent to 40 per cent of the field turns. This amount may usually be secured by one step on the controller. On the Pennsylvania locomotives the field turns are reduced 50 per cent in three steps on the controller. It will generally be found most economical to have the speed of the motor with the short field 20 per cent to 25 per cent higher than with the long field. This will reduce rheostatic losses at least one-half and will give the simplest arrangement of control. The limit to the amount of variation in speed which is possible by a variation of the field of the commutating-pole motor depends to a large extent on the number of commutator bars. If the average voltage between bars is low, the field may be weakened very greatly without materially affecting the commutation, but where the number of bars is small, so that the average voltage is relatively high, a small change in the field strength may result in an increased distortion of the field, and this will cause a corresponding increase in the maximum voltage between bars and will result in flashing over.

Why do we not use a shunt on the motor field instead of having two separate windings? Simply because a shunt on the field makes the magnetism sluggish and renders the motor liable to flash over in case of sudden applications of current resulting from a jumping trolley or contact shoe. It is always preferable to cut out a certain portion of the field and have neither short-circuited turns nor a non-inductive shunt around the field or any part of it, and though it costs more to do it in that way, it should always be done in railway work.

A number of the possible economies in the operation of railway equipments are dependent to a large extent on the control. Fortunately, the development of controllers has kept pace with that of motors, so we can at once secure the benefits that have been pointed out—at least in new equipments.

It has been stated that the use of the coasting-time clocks put a premium on rapid acceleration. To get the best results, therefore, the rate of acceleration should be fixed beyond the control of the motorman. Various schemes have been devised for checking the speed of operating the hand controller, but undoubtedly the best arrangement is a purely automatic control with the steps dependent on the current in the motor. Multiple-unit control has now reached the point where an automatic field control equipment is in operation that will permit the control to be stopped on any notch and requires only five or six train-line wires and an extremely small number of interlocks. Space will not permit a description of this control, and it is mentioned only to show that the advantages secured by the offer of a bonus for the maximum amount of coasting can be secured without risk of injury to equipment and discomfort to passengers due to bad acceleration. The control is so simple that anyone can take care of it. It has also the advantage of being very light.

PRESENT OUTLOOK

The outlook is extremely hopeful. There never was a time in the history of electric railroading when developments came more rapidly than at present. It has been rather disconcerting to the railway manager to find improvements coming so fast that he cannot keep absolutely up to date unless he buys new equipments every year. Fortunately, however, one does not have to be up to the minute in railroading. The more modern of the old equipments are giving as good service as the new ones can do. The only thing is that they are not quite so economical in energy consumption. The advantages of the most modern equipment should be secured in new equipments, so that in time they will be universally obtained, but the old equipments should be worn out in service.

THE TREND OF PUBLIC UTILITY REGULATION

In an article in the *New York Commercial* for Dec. 14 H. M. Byllesby has reviewed the conditions which are now confronting the public as well as the public service corporations. Mr. Byllesby's statements are in part as follows.

"A community which by accident, design or misfortune is poorly served by any of the so-called public service corporations is a community which necessarily is behindhand in its material development. A community suffering from faulty equipment or management of the public service corporations likewise endures a consequent loss of material advancement with attendant inconvenience and dissatisfaction. No one questions the occurrence from time to time of mistakes, errors, hardships and frauds in the past on the parts of both parties to these enterprises, viz., the projectors and owners of the enterprises and the citizens, communities, governments and municipalities served. The net result, however, has been a service on the part of all such corporations in the United States of America which has not its equal in the world.

"Up to a comparatively recent period the public service official was justified in extending the operations under his charge on the general doctrine of averages—that if a given extension proved unprofitable for the time being or permanently, it would be compensated for by the greater profit to be reached from some other contemporaneous, subsequent or existing branch of or extension to the service. Under this condition of affairs enterprise was fostered and development went forward actuated by the hope of a reward beyond the ordinary fixed small return of the absolutely settled and non-hazardous enterprise.

"To-day throughout the country the unmistakable tendency by Interstate Commerce Commissions, Public Utility Commissions, and by the law-making and legal administering bodies, to hamper and curtail and paternalize the conduct of all of these corporations to a point which is rapidly destroying the enterprise of the individual officers and employees of such corporations is putting a period to the further investment of capital for the extension and enlargement of such enterprises. The result of this policy, if carried along the lines of its present extreme tendencies, will be simply a stop to the further energetic development of these enterprises, and will destroy the individual initiative of these corporations. This policy, if persisted in along the program of the political agitators of the present time, leads inevitably and logically to federal and municipal ownership.

"A new situation and new conditions are now confronting the public and these corporations. It is a time for the underlying common sense of our people to take these questions out of the hands of the muck-raker and the professional politician and to put them before the great tribunal of common sense and love of justice of the American people. These questions are of such deep and far-reaching importance that they should be placed in the hands of entirely non-political tribunals."