# General Electric Company
Schenectady, N.Y.

RAILWAY DEPARTMENT

*July, 1906*


*Bulletin No. 4454*

## THE GE-90 RAILWAY MOTOR

The following description and illustrations will give a general idea of the construction of the GE-90 Form A motor.

### MAGNET FRAME

The frame is of cast steel, octagonal in shape, and is made up of bowl-shaped top and bottom halves, machined along the edges, and bolted together with four bolts. The two bolts on the suspension side are hinged so that by the removal of the back bolts the lower half may be swung down into a pit for inspection or cleaning.

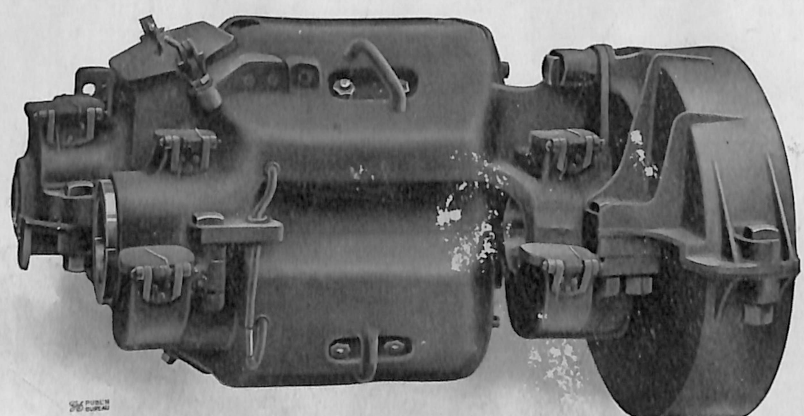
The opening over the commutator is closed by a malleable iron cover having a felt gasket which bears on a machined seat on the frame and is held in place by a readily adjustable cam-locking device. On both ends of the motor smaller holes, fitted with malleable iron covers and gaskets, are provided for inspection or ventilation whenever the service conditions will permit.

The four field coils are held by laminated pole pieces bolted in place with through bolts with nuts on the outside of the frame.

Bails are cast on both upper and lower frame for handling the motor.

### BEARINGS

All the bearings are designed for oil and waste lubrication, as this system has met with great success for railway motors ever since its original introduction by the General Electric Company.



GE-90-A RAILWAY MOTOR, BACK

The armature and axle bearings are outside of the frame proper, the supporting brackets being cast integral with the top magnet frame. The linings are held rigidly in the supporting brackets by means of caps which are bolted tight against them.

The armature shaft linings are bronze sleeves finished all over and lined with a thin layer of Babbitt metal which is securely anchored and soldered in place. The Babbitt furnishes an ideal bearing surface and is so thin that it will not allow the armature to rub on the poles in case it is melted out by overheating.

In both axle and armature bearings the oily waste used for lubrication is packed in oil wells and bears on the shaft through an opening in the low pressure side of the bearing linings.

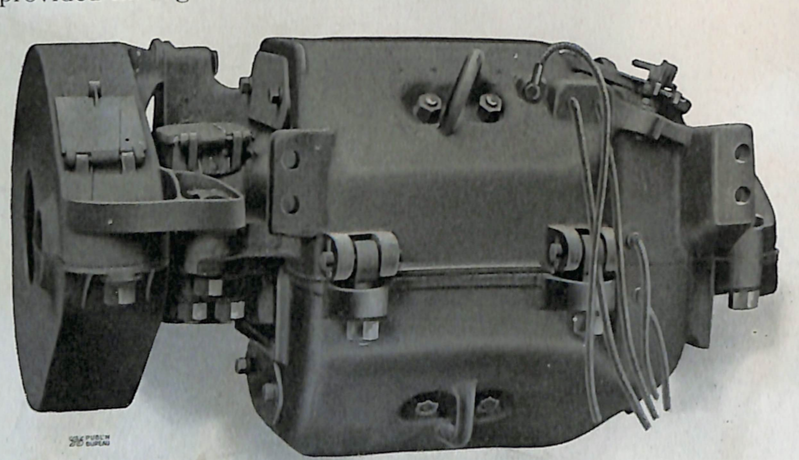
The oil wells for the armature bearings are cast in the upper magnet frame, and a large hole is provided through which the waste is packed around the bearing. Oil is supplied through a smaller hole leading to the bottom of the oil well, thus insuring a more uniform feed and reducing the quantity of oil to a minimum. This arrangement also largely reduces the danger of dirt getting into the bearings, since it is unnecessary to open the lid over the bearing when fresh oil is required.

The oil wells for the axle bearings are cast in the axle caps, though there are smaller auxiliary wells cored in the upper magnet frame just above the bearings to permit the use of an oil cup if desired. Oil cups can also be used on the armature shaft bearings.

Waste oil from the armature shaft bearings is prevented from entering the interior of the motor by deflectors, which throw it into grooves cast in the frame, from which it is then conducted away.

This form of bearing is fully equal in simplicity and reliability to standard M. C. B. journal bearings. The method of lubrication and treatment is practically the same, and the boxes are reached through large hand holes protected by swing covers with felt gaskets resting on machined seats. These covers are held in place by strong springs.

The amount of oil required for the bearings is exceedingly small. Wide experience indicates that no other type of bearing equal to this has ever been placed on a railway motor.



GE-90-A RAILWAY MOTOR, FRONT

The GE-90 motor is constructed with very liberal wearing surfaces, as may be seen from the following dimensions: The armature shaft bearing is $2\frac{3}{4}''$ in diameter and $7\frac{1}{2}''$ long at the commutator end, $3\frac{1}{4}''$ in diameter and $8\frac{1}{4}''$ long at the pinion end. The lining on the commutator end is unsplit, but on the pinion end is split to permit of its removal without disturbing the pinion. The axle-bearing linings are $9''$ long and a maximum axle of $5''$ diameter may be used.

## FIELD COILS

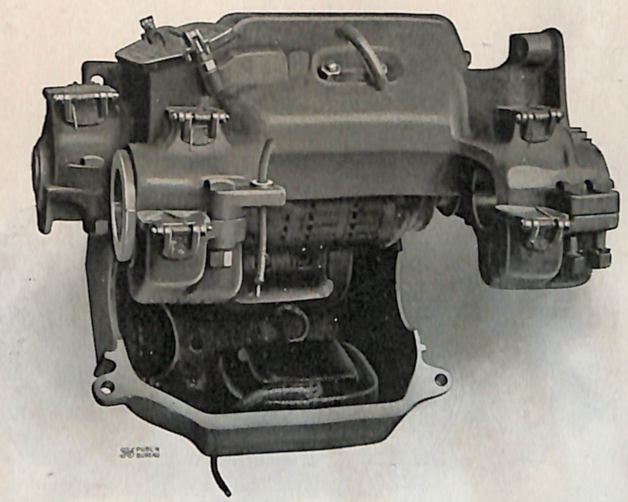
The mummified type of field coil is used. The coils are wound with asbestos and cotton-covered wire, and when completed are treated in an insulating compound by a vacuum process to protect them against moisture and vibration of the windings. After being treated, they are further insulated with wrappings of special insulating fabrics and then taped. The finished coil is solid and compact, and is well adapted to dissipate heat and withstand moisture.

For the support of the coils and protection against chafing, strong spool flanges of pressed sheet steel bear against the laminated pole pieces and securely clamp the coils in place when the pole pieces are bolted in.



## ARMATURE

The armature core is built up of soft iron laminæ interspaced with air ducts, which provide excellent ventilation.



GE-90-A RAILWAY MOTOR WITH FRAME LOWERED FOR INSPECTION

The armature has five coils per slot. The coils are wound on forms in groups of five, with insulation between adjacent coils, and the poly-coil is pressed to shape in a steam mold. The coils are then covered with insulating fabrics of high insulating qualities, and as a final protection, principally against mechanical injury, are taped and then filled with an insulating compound.

The windings are specially well protected from dust, oil, and mechanical injury. The pinion end core head extends under the end windings with a flange reaching up past the ends of the coils. The windings at both ends are covered with a strong canvas dressing securely bound in place. In accordance with a long established practice of the General Electric Company, binding bands are not allowed to project above the armature core, and the ends of the band wires are secured by means independent of the solder.

## COMMUTATOR

Conforming to the General Electric Company's standard practice, the commutator segments are made of hard drawn copper, insulated throughout with the best grade of mica. The cone micas are built up and pressed hard and compact in steam molds. The mica between the segments is made of a softer quality to make it wear down evenly with the copper. Great care is taken in the construction of the commutator. The cone surfaces are carefully machined and cleaned from burrs and sharp edges to prevent short circuits between the segments, and creepage distances are made long to prevent grounding.

The excellent commutating qualities of the motor, together with the good construction and liberal wearing depth of the commutator, insure a long life to the segments.

To prevent breakage and to keep the commutator true, the shell and cap are made of steel in strong sections. The segments are clamped up tight by the cap, which is pressed home in a hydraulic press before tightening up the commutator nut.

## BRUSH-HOLDERS

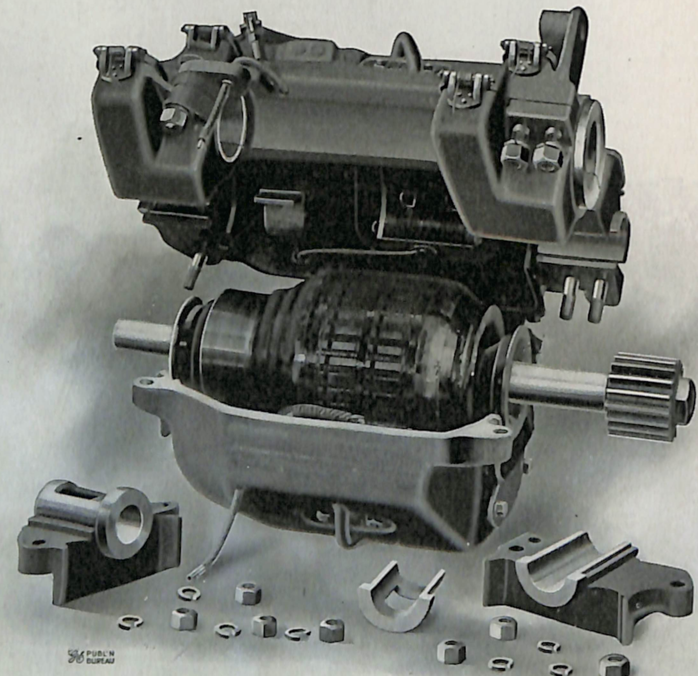
There are two brush-holders which are made of cast bronze and have two carbon brushes per holder. The brushes slide in finished ways and are pressed against the commutator by independent fingers, which give a practically uniform pressure throughout the working range of the brushes. Each brush has a cross section of $1\frac{7}{8}'' \times \frac{1}{16}''$.

The springs which actuate the fingers are designed to bear only slightly on the pins on which the fingers pivot, thus lessening any tendency of the fingers to stick on the pin and reducing the wear to a minimum.

## VENTILATION

Particular attention has been given to ventilation in the construction of the GE-90 motor. Free circulation of air between the interior and exterior of the motor can be obtained — as already described under the heading "Magnet Frame" — by the removal of the malleable iron covers whenever service conditions will permit.

The armature is constructed so as to draw a large volume of air into the interior of the



GE-90-A RAILWAY MOTOR SHOWING ARMATURE AND BEARINGS

There is a pigtail or shunt between the fingers and the brush-holder body to prevent current passing through the springs or pivot-ing pins.

The brush-holders are adjustable to allow for wear of the commutator. They are clamped to a treated hardwood yoke which is bolted to the top of the magnet frame and can be removed through the opening in the frame over the commutator.

All leads from the motor to the car are brought out through rubber-bushed holes in the magnet frame.

core when running, which is expelled through ducts opening along the exterior.

The good ventilation and small electrical and mechanical losses of the motor keep it cool, and greatly add to its capacity in service. The ventilation is secured without sacrificing in any way the proper protection of the armature windings, which is a strong point in the construction of the motor.

## GEAR, PINION, AND GEAR CASE

The gear is made of a superior grade of cast steel and the pinion from a special stock



of forged steel, extra hammered to improve the quality of the metal. The gears have a 5″ face and the teeth are accurately cut to a 3″ pitch.

The gear case is of malleable iron and embodies our latest ideas in design to prevent breakage.

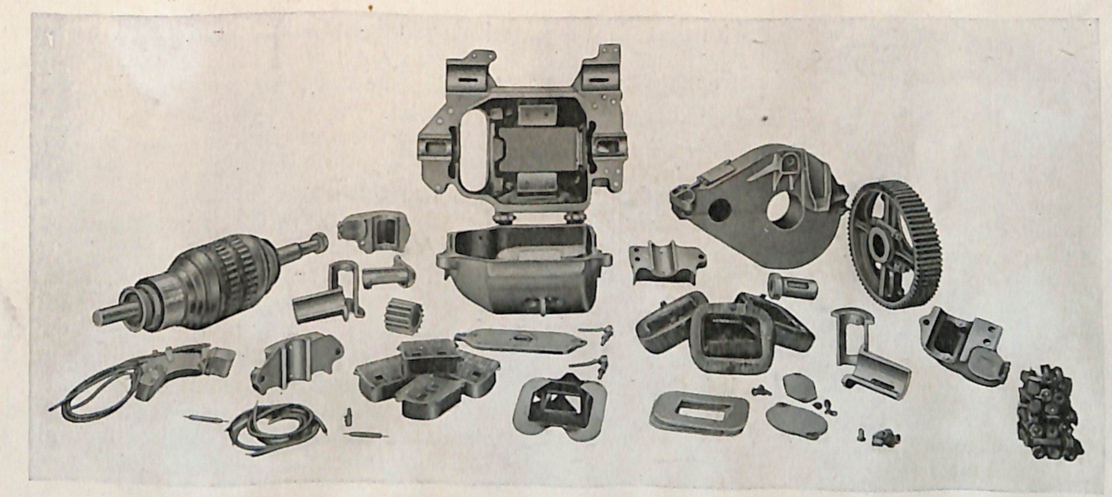
The case is suspended at three points from the top half of the magnet frame to reduce vibration. Strengthening ribs radiate from the points where the case is attached to the motor frame, to prevent the case from cracking. The surfaces in contact between

## WEIGHTS AND DIMENSIONS

The general dimensions and weights of the GE-90-A and GE-90-B motors will be found on the motor suspension diagrams Nos. 14254 and 14265, and the weights of equipment on page 8.

## ADVANTAGES

The GE-90 motor, as a type, possesses a number of advantages, some of which may be briefly summarized as follows:



PARTS OF GE-90-A RAILWAY MOTOR

the case and frame are made large to prevent undue wear.

The three-point suspension has proved so successful a feature in the operation of General Electric motors that it is considered a salient point in their design.

## SUSPENSION

Lugs are cast on the upper half of the motor frame, to which a suspension bar for either yoke or nose suspension is bolted.

For inspection and repairs the lower half of the Form A motor frame can be swung down on the hinge bolts into a pit without disturbing the upper half.

If desired a Form B motor can be furnished with magnet frame opening upward to allow for inspection and cleaning.

The bearings have shown great superiority in the method of lubrication as affecting their life, cost of maintenance, and cost of lubrication. The armature is easily removed and the pinion end lining can be taken off without disturbing the pinion.

The gear case has three points of suspension, thus reducing the vibration and consequent danger of breaking the case.

The various parts of the motor are made exceptionally strong and substantial. The large bearing surfaces, size of bearings, width of gear face, size of bolts, etc., and small details of construction should be noted.

We would also call attention to the following points of this motor, which will commend it to all practical users of this class of apparatus:

Good commutation and high efficiency.
Low iron and copper losses.

High free running efficiency and good ventilation.
Superior brush-holder design and construction.
A large commutator with deep segments.
The highest class of insulation thoroughly protected from mechanical injury.

## RATING

The GE-90 motor is rated at 50 h. p., which is based on a temperature rise by thermometer of not more than 75° C. above the surrounding air after one hour's run at 500 volts at rated load, the temperature of the surrounding air not exceeding 25° C. Its capacity for continuous service is high, owing to its electrical efficiency and good ventilation.

This method of rating has been in use for a number of years, and while not necessarily giving an exact measure of the capacity of a motor to perform all classes of service, is convenient and well understood, and conveys a sufficiently close idea of the relative sizes of motors for general use.

A test is made on the motors at rated load, and all motors are also thoroughly tested for commutation, bearings, brush-holders, etc.

The predetermination of the capacity of a motor to perform a given service is a problem, the solution of which necessitates a complete knowledge of the mechanical, electrical, and thermal characteristics of the motor. Knowing these characteristics, it is possible to calculate the losses in a motor performing any specified service. The only way of determining how hot a motor will run is by reference to actual tests of the motor under the same or similar service conditions.

The heating of a given motor in service manifestly depends entirely on the character of the service, and consequently no reliable estimate can be made of the necessary capacity or characteristics of the motor for successful operation, without a complete knowledge of the operating conditions. The weight of car or train, schedule speed, location, number and duration of stops, profile and plan of road, and voltage are necessary for a complete and careful analysis of the problem.

In order to obtain full information on these questions, the General Electric Company, besides carefully testing each type of motor for efficiency, $I^2R$, core and friction losses, speed and commutation, etc., at various voltages and amperes, also makes exhaustive tests to determine the capacity of the motor for heat dissipation under operating conditions. For this purpose motors are put into actual service on the Company's experimental track (more than two miles in length), and are run day after day under a wide range of known service conditions, careful temperature measurements being taken until sufficient data are obtained to show what temperature different parts of the motor will reach, not only with various total losses, but also with different distributions of these losses.

From the data obtained in the above tests, which cover all the characteristics of a given type of motor, the company's engineers possess all the information required to determine with practical certainty the adaptability of the motor to handle any specified service, and the problem has become not a matter of guesswork but of calculation.

As the power required to operate an equipment affects not only the heating of the motors, but also the total amount and cost of power for operating the road, careful calculations are made to determine the most suitable characteristics of a motor for a given service and the most economical gear ratio to use. The possibilities of saving power by the careful design and proper selection of the gear ratio are much greater than ordinarily appreciated.

A table which is based on tests, such as have been described above, will be found on page 9, showing schedule speeds for various gear ratios with varying number of stops per mile and different weights per motor. This table has been prepared to enable customers to determine quickly and with considerable accuracy the capacity of the GE-90 motor to handle cars or trains under ordinary service conditions, and it will also be found useful for laying out operating schedules.

As the reputation of the General Electric Company's motors and the interests of its customers are affected by the proper selection of motors for any given service, the General Electric Company desires to aid and coöperate with its customers in selecting motors best adapted for their service. For this purpose customers are furnished with blank service data sheets to fill out, so as to show the character of the service which it is desired to operate. The General Electric Company's great experience enables it to render valuable assistance in this class of work, and long experience has shown that coöperation is mutually beneficial.

The blank form shown on page 10 will be gladly furnished to prospective customers.



Speed torque and efficiency curves for the GE-90 motor, with various gear ratios corresponding to the gear ratios given in the table, will be found on pages 11 to 14. These curves are convenient for general reference.

The diagrams of the motor on pages 15 and 16, which show the external dimensions and axle preparation for both forms A and B, will enable truck builders and car manufacturers to adapt their trucks and cars for the proper reception of the motor.

The table on page 9, giving the estimated schedule speeds in miles per hour for the GE-90 motor, is calculated on the basis of a 500 volt line pressure at the motors.

The duration of each stop has been taken as 10 seconds.

The maximum temperature rise of the motors above the surrounding air has been taken as not more than 65° C. with the motors closed, this temperature being based on the operation of motors under average normal conditions. Though the temperature rise will not usually exceed the estimate of 65° C., it should be noted that this temperature rise cannot be guaranteed, as motor temperatures can depend on the manner in which motor-men handle the equipments.

As a lower schedule and less heating is obtained by running motors in series than by running them in multiple, and since there may be services for which it is advisable to use series running in cities and multiple running outside, it sometimes happens that a heavier car than is indicated in the table can be handled by a given equipment, or that a higher speed gearing can be used for a given weight of car. Further, motors with high speed gears and multiple running may be able to handle heavier cars than indicated on the table, in city service where the stops are frequent, without the temperature rise exceeding 65° C., provided a sufficiently large part of the whole run is suburban or interurban, where but few stops are made. If it is of importance to take advantage of these points, full information should be furnished to the General Electric Company for complete analysis.

When applying the tables to services requiring two or more different schedules, such as a city service with many stops per mile combined with a suburban or interurban service with but few stops per mile, the schedule for each class of service should be taken separately and a resulting schedule for the combined service obtained.

The schedule speeds given in the table are based on the operation of motors under favorable conditions, and are 10% below the theoretical schedule speeds, in order to allow for the normal delays due to curves, grades, slow-downs, etc.; in other words, it is assumed that the delays due to these causes will equal six minutes in every hour. If this allowance is considered insufficient, due to special local conditions, the schedule should be reduced 1.84% for each additional minute of delay. The improper handling of the cars or excessive track or car friction may also reduce the schedule, and this will also be the case if, in addition to the regular stops, there is an unusual number of slow-downs, curves, or grades. If curves and grades are numerous or excessive, or the conditions are special or abnormal and an extensive analysis is necessary, complete information should be furnished to the General Electric Company before deciding on the motor equipment to be used.

The schedule speeds given in the table should be decreased by the percentages given below for any voltages below 500. For each 1% reduction in the voltage there will be approximately the following reduction in the schedule:

| | |
|---|---|
| 1 stop per mile........ | .5% |
| 3 stops " " ........ | .2% |
| 7 " " " ........ | .1% |

Where the voltage is greater than 500, the schedule may be increased by approximately the same per cent as it is decreased for a reduction of voltage. It should, however, be borne in mind that there will be an increase in temperature at the higher voltages and schedules. Nevertheless, as there will be somewhat less heating of the motors at a lower voltage and schedule, it is permissible to increase the schedule on parts of the line by increasing the voltage, provided there is a corresponding decrease in the voltage on the other portions.

As the number of stops per mile increases, the schedules that can be made with the same car weights, but with different speed gears, become more nearly equal.

When the same schedule is made with different speed gears, the heating of the motors is less with the low speed than with the high speed gear.

Under ordinary service conditions the watt-hours per ton mile for a given schedule are less with a low than with a high speed gear. Therefore, in order to operate with the lowest power consumption and also with the minimum heating of the motors, the lowest speed gear, that is, the highest gear ratio which will make the required schedule, is generally best suited for the given service.

The maximum speeds given in the table are approximately free running speeds on the level under favorable conditions. Excessive track or car friction or head winds will affect the speed.

The tractive effort is taken at 20 lb. to 35 lb. per ton, depending on the speed and weight of the car. An examination of the motor curves will show the tractive effort assumed for the various speeds.

In determining "TONS PER MOTOR" the total weight of the car or train, including the load, motors, controllers, rheostats, etc., divided by the number of motors, should be taken.

In ordinary service the average and not the maximum load should be taken. The average passenger load may be represented by the seating capacity, and the average weight per passenger can be assumed to be 140 lb. If the motors operate with maximum load for a large part of the time, the maximum and not the average load should be taken.

The tables do not apply when the motors are used for electric brakes, as the heating of the motors is increased thereby.

## APPROXIMATE WEIGHT IN POUNDS

| | |
|---|---|
| Motor complete with pinion, gear, and gear case | 2,875 |
| Double motor equipment, complete, with two K-11 controllers | 6,765 |
| Double motor equipment, complete, with Sprague General Electric type M control and two C-38 master controllers | 7,672 |
| Four-motor equipment, complete, with two K-14 controllers | 13,750 |
| Four-motor equipment, complete, with Sprague General Electric type M control and two C-38 master controllers | 14,171 |

## GEAR RATIOS

### CHARACTERISTIC CURVES, ETC.

Gear ratios with characteristic letters and numerals corresponding with two-turn armatures and 90.5 turn fields are as follows:

| Pinion | Gear | Gear Ratio | Classification | Characteristic No. |
|---|---|---|---|---|
| 17 | 69 | 4.06 | GE 90-A-1 | 133 |
| 19 | 67 | 3.53 | GE 90-A-2 | 134 |
| 22 | 64 | 2.91 | GE 90-A-3 | 135 |
| 15 | 71 | 4.73 | GE 90-A-4 | 136 |



## SCHEDULE SPEED — GE-90 MOTOR

### Arm. 2 Turns — Field 90.5 Turns — 500 Volts — 33″ Wheels

**READ BULLETIN CAREFULLY BEFORE APPLYING TABLES**

TONS PER MOTOR

| Stops per Mile | Gear Ratio | 5.5 | 6 | 6.5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/4 | 4.73 | 24.8 | 24.4 | 24 | 23.6 | 22.8 | 22 1 | 21.4 | 20.8 | 19.8 | 18.8 |
| 1/4 | 4.06 | 25.7 | 25.3 | 25 | 24.7 | 24.2 | 23.5 | 23 | 22.5 | 21.5 | 20.5 |
| 1/4 | 3.53 | 27.3 | 27.0 | 26.7 | 26.4 | 26 | 25.6 | 25.2 | 24.9 | | |
| 1/4 | 2.91 | 29.0 | 28.3 | 27.4 | 26.6 | 26.3 | 26.0 | | | | |
| 1/2 | 4.73 | 23 | 22.7 | 22.3 | 21.9 | 21.3 | 20.6 | 20 | 19.4 | 18.9 | 18.3 |
| 1/2 | 4.06 | 24.4 | 24.1 | 23.7 | 23.4 | 22.8 | 22.2 | 21.6 | 21 | 20.2 | |
| 1/2 | 3.53 | 25.3 | 25 | 24.6 | 24.3 | 23.6 | 22.9 | 22.2 | 21.5 | | |
| 1/2 | 2.91 | 27.1 | 26.9 | 26.3 | 25.7 | 25 | 24.3 | | | | |
| 1 | 4.73 | 20 | 19.7 | 19.3 | 19.1 | 18.6 | 18 | 17.7 | 17.2 | 16.9 | 16.5 |
| 1 | 4.06 | 21.2 | 20.9 | 20.7 | 20.5 | 20.1 | 19.5 | 19.0 | 18.6 | 18.1 | |
| 1 | 3.53 | 22.4 | 21.6 | 21.5 | 21.3 | 20.7 | 20.5 | 20.2 | | | |
| 1 | 2.91 | 23.5 | 23 | 22.6 | 22.2 | 21.6 | | | | | |
| 2 | 4.73 | 16.1 | 15.9 | 15.7 | 15.5 | 15.1 | 14.8 | 14.5 | 14.2 | 13.9 | 13.5 |
| 2 | 4.06 | 16.9 | 16.7 | 16.4 | 16.2 | 15.8 | 15.4 | 15 | 14.6 | | |
| 2 | 3.53 | 17.3 | 17.2 | 17 | 16.8 | 16.5 | | | | | |
| 2 | 2.91 | 18.0 | 17.7 | | | | | | | | |
| 3 | 4.73 | 13.9 | 13.8 | 13.7 | 13.5 | 13.2 | 13 | 12.7 | 12.4 | 12.1 | |
| 3 | 4.06 | 14.4 | 14.2 | 14.1 | 13 9 | 13.6 | 13.2 | | | | |
| 3 | 3.53 | 14.8 | 14.6 | 14.4 | 14.2 | 13.9 | | | | | |
| 3 | 2.91 | 15.0 | 14.9 | | | | | | | | |
| 4 | 4.73 | 12.5 | 12.3 | 12.2 | 12.1 | 11.8 | 11.6 | 11.3 | 11.1 | | |
| 4 | 4.06 | 12.7 | 12.6 | 12.4 | 12.3 | 12 | 11.7 | | | | |
| 4 | 3.53 | 13 | 12.8 | 12.6 | 12.4 | 12.2 | | | | | |
| 4 | 2.91 | 13.1 | 13 | | | | | | | | |
| 5 | 4.73 | 11.3 | 11.2 | 11.1 | 11 | 10.8 | 10 5 | 10.3 | 10.1 | | |
| 5 | 4.06 | 11.5 | 11.4 | 11.3 | 11.2 | 10.9 | 10.7 | | | | |
| 5 | 3.53 | 11.7 | 11.5 | 11.3 | 11.1 | 10.9 | | | | | |
| 5 | 2.91 | 11.8 | 11.7 | | | | | | | | |
| 6 | 4.73 | 10.25 | 10.15 | 10.05 | 10 | 9.8 | 9.6 | 9.45 | 9.3 | | |
| 6 | 4.06 | 10.45 | 10.35 | 10.25 | 10.15 | 10 | 9.8 | | | | |
| 6 | 3.53 | 10.5 | 10.35 | 10.30 | 10.15 | 10 | | | | | |
| 6 | 2.91 | 10.55 | | | | | | | | | |
| 7 | 4.73 | 9.36 | 9.36 | 9.36 | 9.36 | 9.2 | 9 | 8.87 | 8.8 | | |
| 7 | 4.06 | 9.63 | 9.63 | 9.6 | 9.5 | 9.3 | 9.1 | | | | |
| 7 | 3.53 | 9.81 | 9.77 | 9.68 | 9.54 | 9.36 | | | | | |
| 7 | 2.91 | 9.9 | | | | | | | | | |
| 8 | 4.73 | 8.73 | 8.73 | 8.73 | 8.73 | 8.55 | 8 38 | 8.20 | 8.05 | | |
| 8 | 4.06 | 9.00 | 9.00 | 8.9 | 8.8 | 8.6 | 8.41 | | | | |
| 8 | 3.53 | 9.27 | 9.09 | 8.98 | 8.86 | 8.65 | | | | | |
| * Max Speed Quadruple Equipment | 4.73 | 30 | 29.5 | 29 | 28 | 27.5 | 26.5 | 25.5 | 25 | 24 | |
| | 4.06 | 32 | 31.5 | 31 | 30.5 | 29.5 | 29 | 28 | 27 | 26.5 | |
| | 3.53 | 33.5 | 32.5 | 32 | 31.5 | 30.5 | 29.5 | 29 | 28 | 27 | |
| | 2.91 | 36 | 35.5 | 35 | 34.5 | 33.5 | 32.5 | 31.5 | 30.5 | 29.5 | |

* Maximum speed double motor equipment 5 to 10% slower for same tons per motor.

## DATA FOR GENERAL ELECTRIC COMPANY FOR RAILWAY EQUIPMENTS

on the .................................................................................. Railway

MOTOR CARS: (OPEN OR CLOSED) ............................ No. of motors per car ............................

Weight of empty cars and trucks *not* including electrical equipment ......................... tons (2000 lbs.)

Length of car over all, .................... Length of car body, .................... Seating capacity, ....................

Capacity with standing load, ......................... If open car give number of benches, ....................

Have cars single or double trucks? .......................... Diameter of car wheels is ...................... inches

TRAIL CARS: (OPEN OR CLOSED) ..................................

Weight of empty cars and trucks .................. tons (2000 lbs.) Length of car over all, ....................

Length of car body, ................. Seating capacity, ................ Capacity with standing load, ..................

No. of trail cars handled by motor car, .......... Hours during which trail cars are operated, ..........

LINE POTENTIAL: Maximum voltage is .......... Minimum voltage is .......... Average voltage is ..........

TIME: (excluding layovers) required to make round trip ............ minutes. Length round trip ............... miles.

DISTANCE: round trip in city service ............ miles. Suburban ............. miles. Interurban .......... miles.

STOPS: Average number on round trip in city service is ........... Suburban is ........... Interurban is ...........

(It is assumed that the average duration of stops will be 10 seconds each.)

LAYOVERS: (if any,) number and duration ..........................................................................

..........................................................................................................................

GRADES: Underscore grades which cars both ascend and descend in round trip.

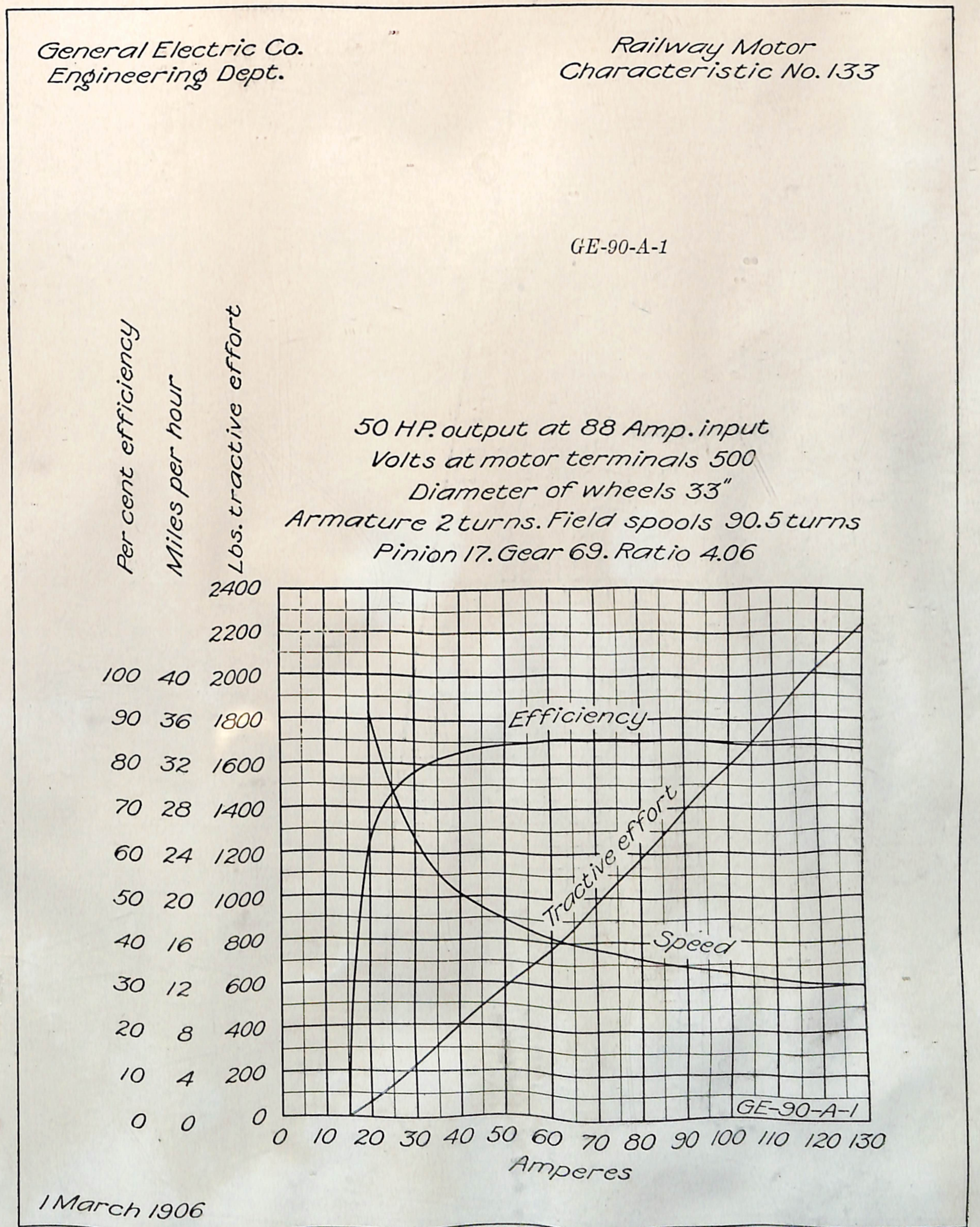
| Length in ft. | % | Length in ft. | % | Length in ft. | % | Length in ft. | % | Length in ft. | % |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

REMARKS (Pertaining to character of service not covered above, particularly with reference to curves and slowdowns.)

Dated ...................................... 19.......... Signed ..........................................................

By ..........................................................



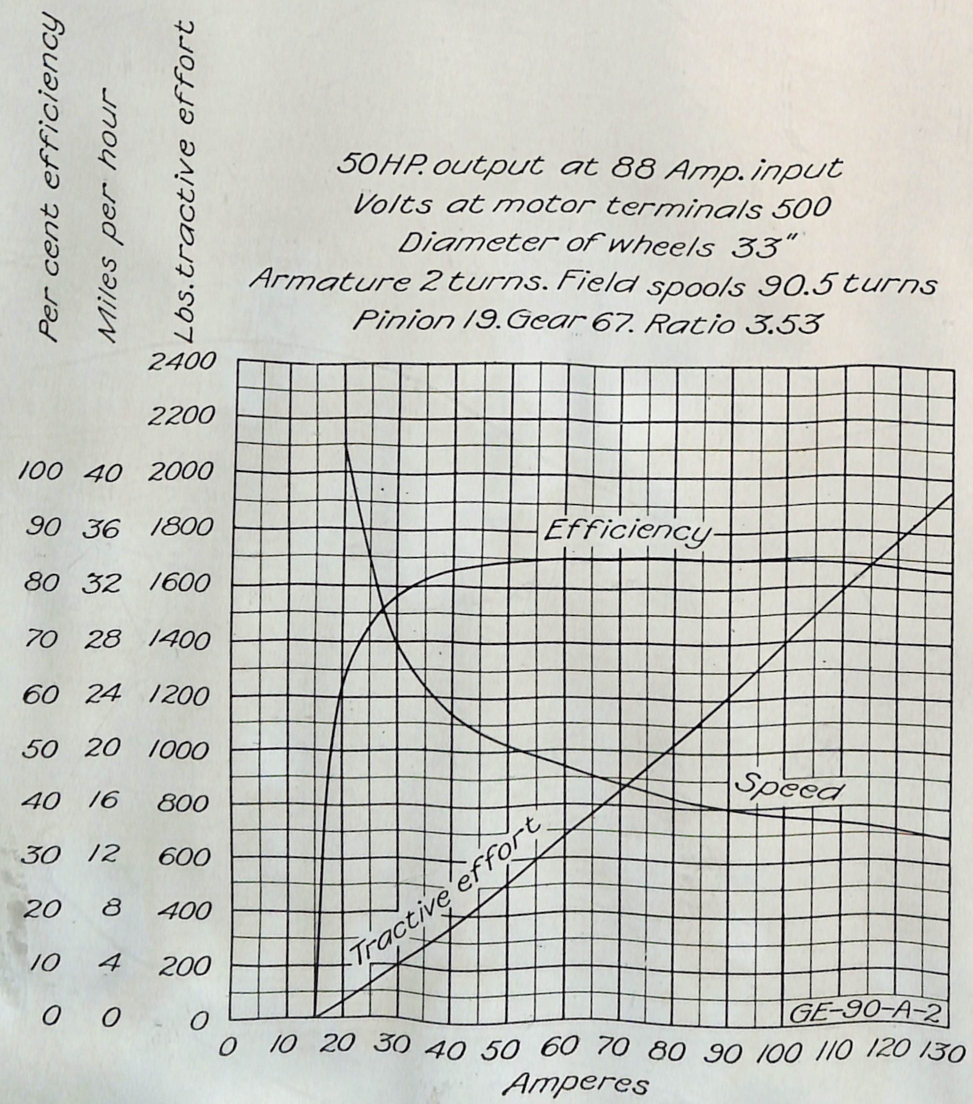


General Electric Co.
Engineering Dept

Railway Motor
Characteristic No.134

GE-90-A-2

50 H.P. output at 88 Amp. input
Volts at motor terminals 500
Diameter of wheels 33"
Armature 2 turns. Field spools 90.5 turns
Pinion 19. Gear 67. Ratio 3.53




1 March 1906

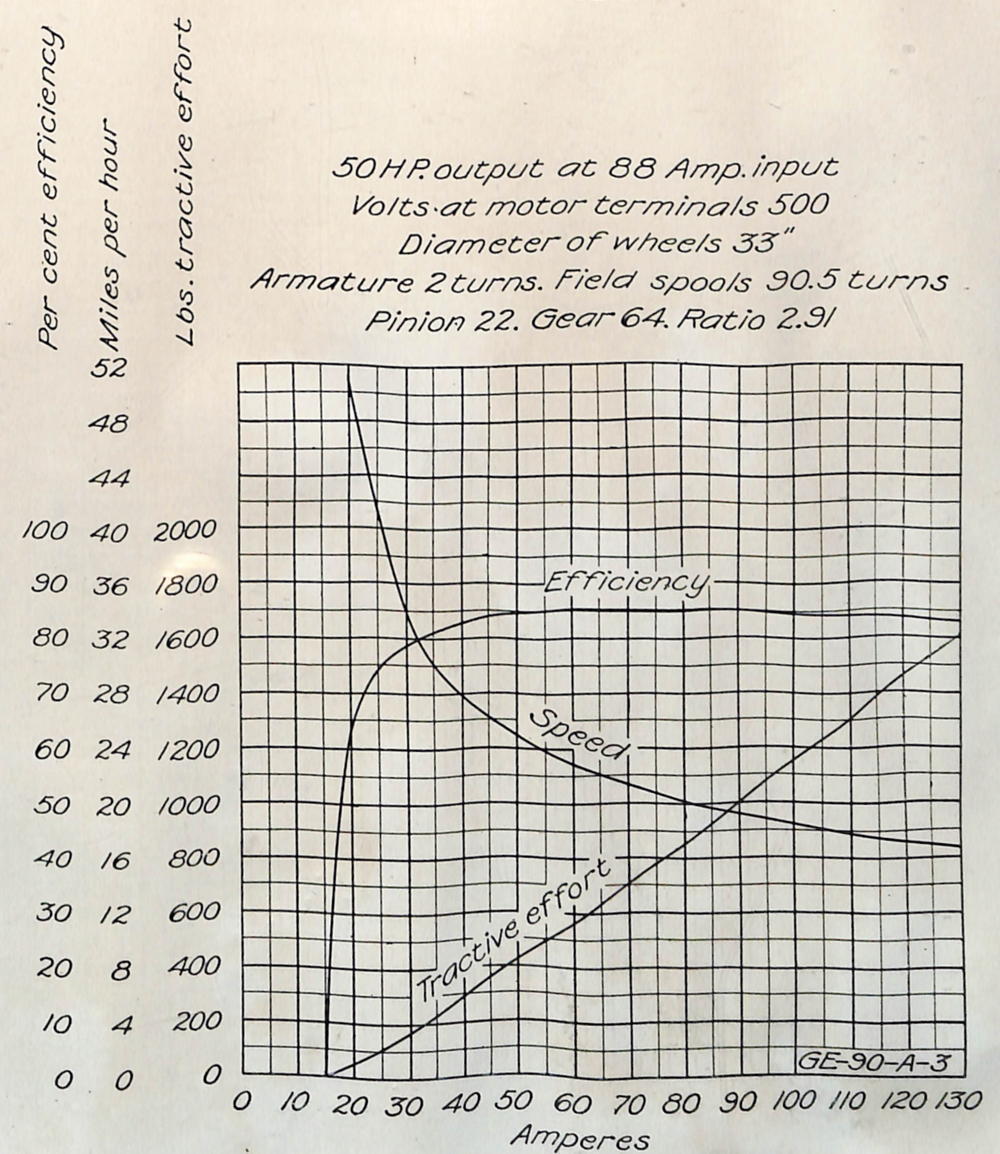


General Electric Co.
Engineering Dept.

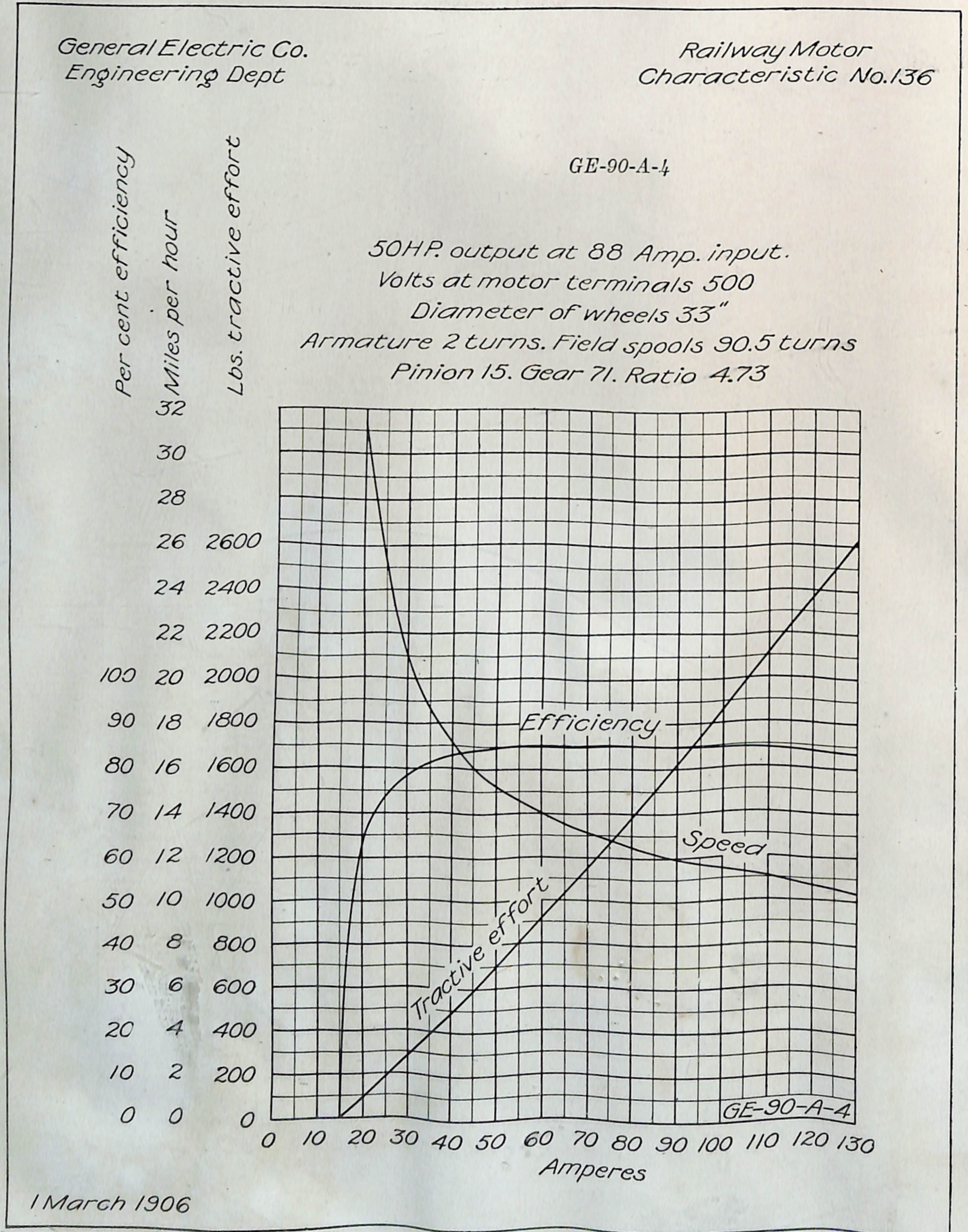
Railway Motor
Characteristic No.135

GE-90-A-3

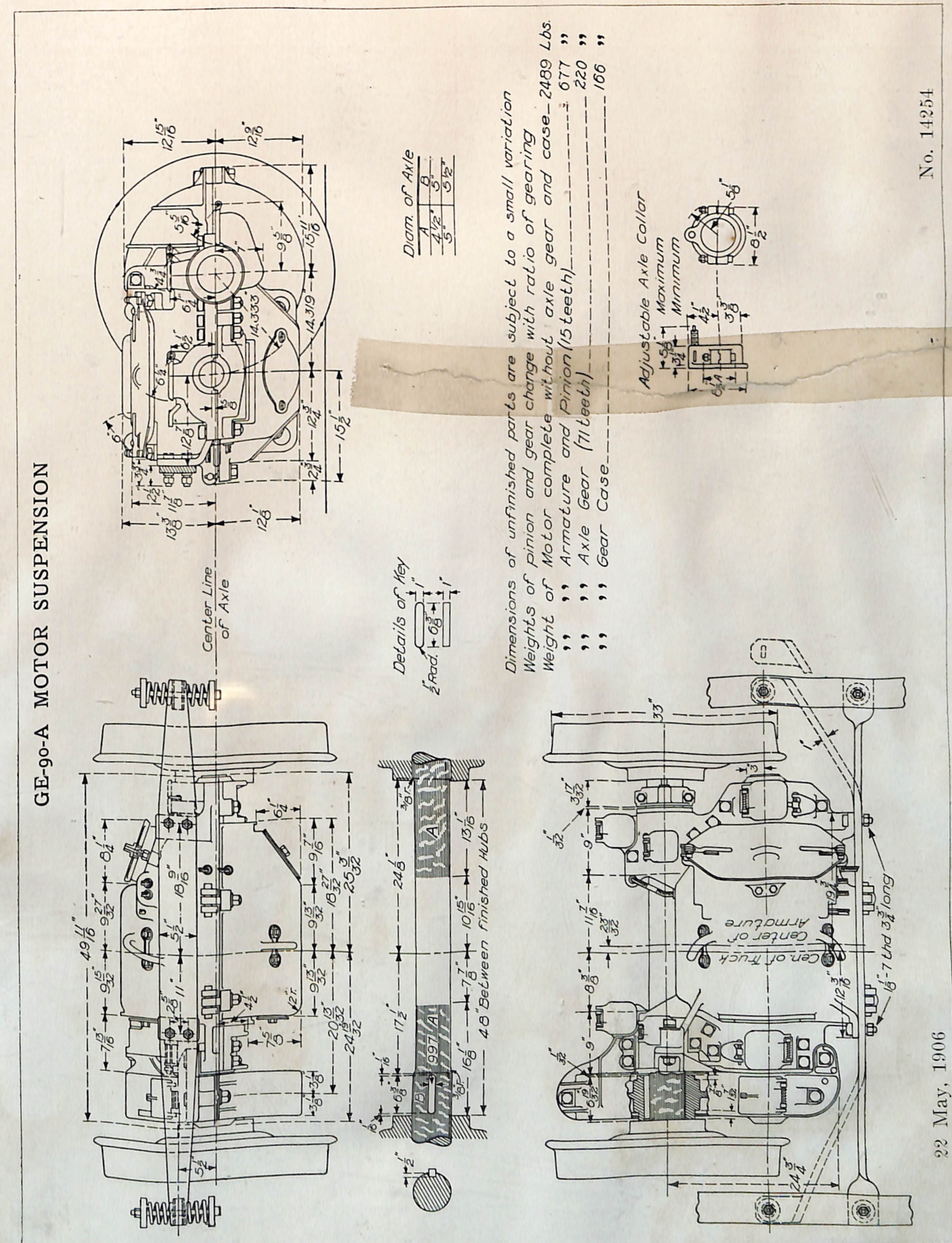
50 H.P. output at 88 Amp. input
Volts at motor terminals 500
Diameter of wheels 33"
Armature 2 turns. Field spools 90.5 turns
Pinion 22. Gear 64. Ratio 2.91



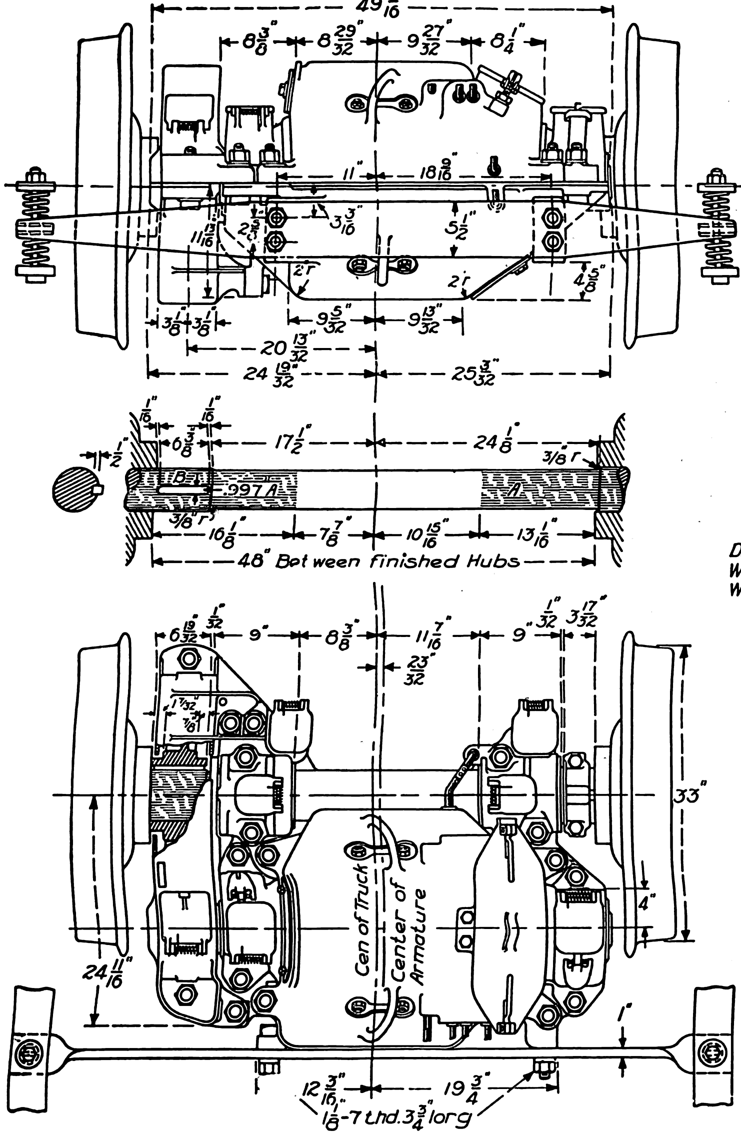

1 March 1906

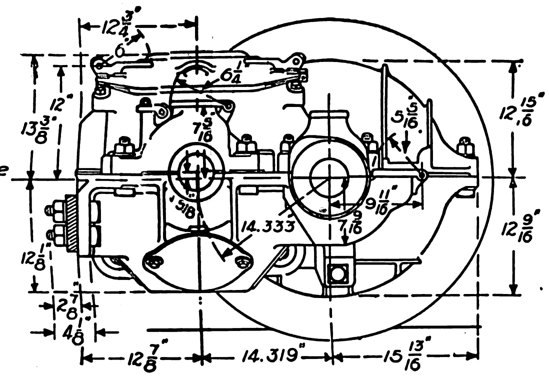

General Electric Co.
Engineering Dept
Railway Motor
Characteristic No.136
GE-90-A-4
50H.P. output at 88 Amp. input.
Volts at motor terminals 500
Diameter of wheels 33"
Armature 2 turns. Field spools 90.5 turns
Pinion 15. Gear 71. Ratio 4.73
Per cent efficiency
Miles per hour
Lbs. tractive effort
Efficiency
Speed
Tractive effort
Amperes
GE-90-A-4
1 March 1906

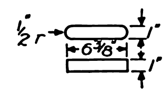



GE-90-A MOTOR SUSPENSION
No. 14254
Diam. of Axle
Details of Key
Center Line of Axle
Dimensions of unfinished parts are subject to a small variation
Weights of pinion and gear change with ratio of gearing
Weight of Motor complete without axle gear and case 2489 Lbs.
" " Armature and Pinion (15 teeth) 677 "
" " Axle Gear (71 teeth) 220 "
" " Gear Case 166 "
Adjustable Axle Collar
Maximum
Minimum
49 Between Finished Hubs
Center of Armature
Cen. of Truck
22 May, 1906

# GE-90-B MOTOR SUSPENSION



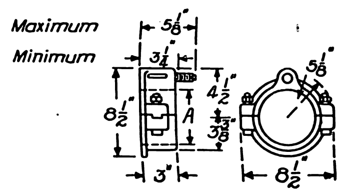

Diam. of Axle

| A | B |
|---|---|
| 4" | 4" |
| 4 1/2 | 5" |
| 5" | 5 1/2" |

*Dimensions of unfinished parts are subject to a small variation*
*Weights of pinion and gear change with ratio of gearing*

| | |
|---|---|
| Weight of Motor complete without axle gear and case | 2533 Lbs. |
| " " Armature and Pinion (15 teeth) | 677 " |
| " " Axle Gear (71 teeth) | 220 " |
| " " Gear Case | 200 " |

*Adjustable Axle Collar*




29 June, 1906 No. 14265