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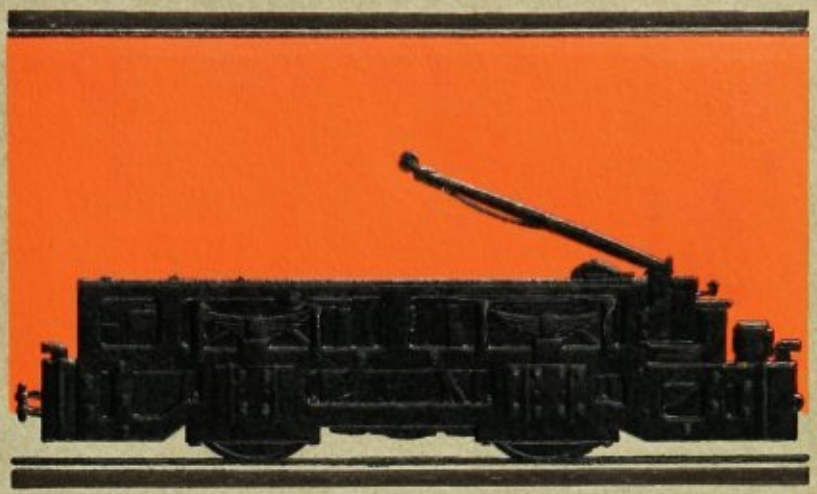

MINE *and* INDUSTRIAL LOCOMOTIVES

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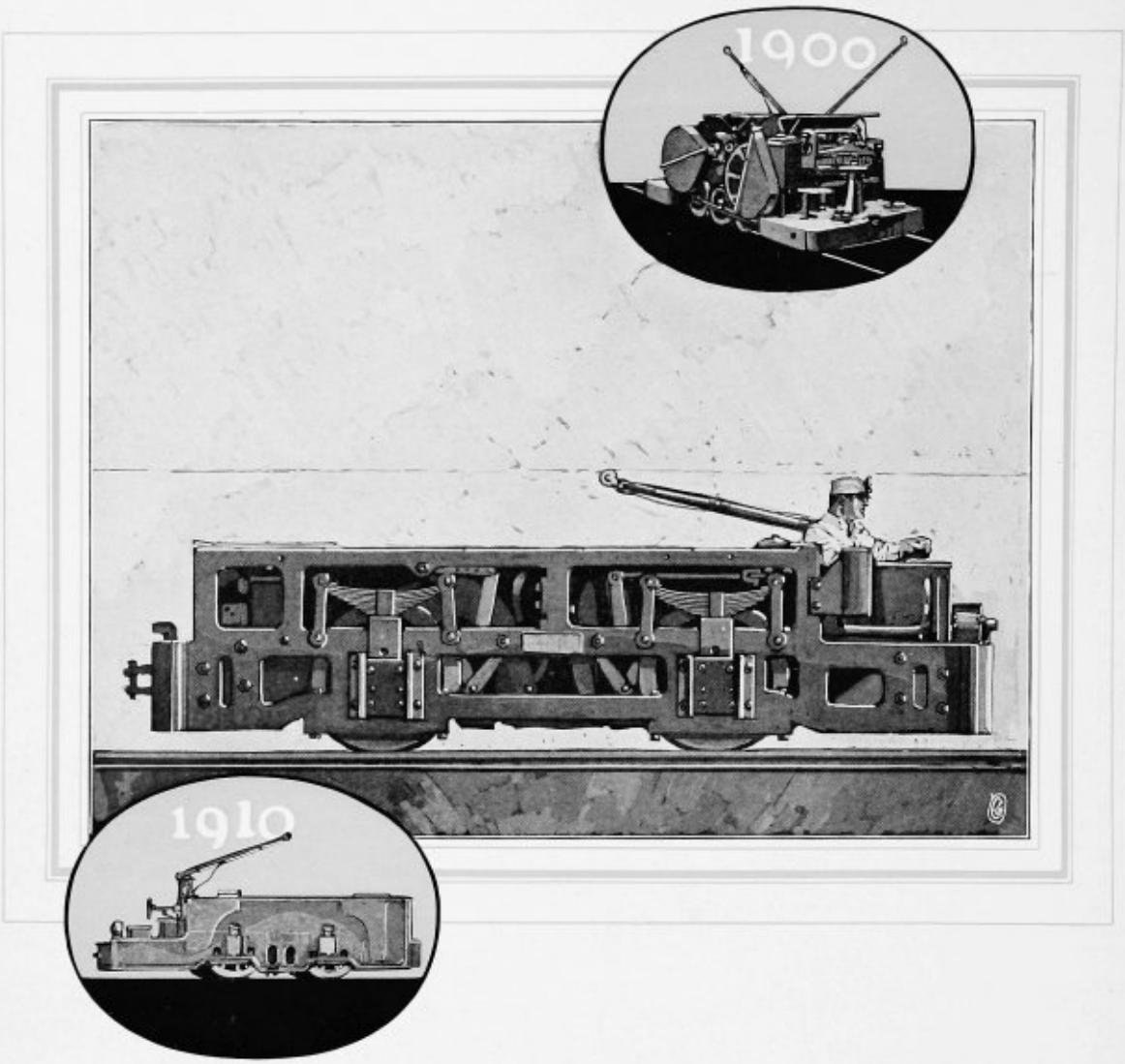
WESTINGHOUSE ELECTRIC

MINE *and* INDUSTRIAL LOCOMOTIVES



DURING the past twenty years the advancement in design and efficiency of mine and industrial locomotives has been phenomenal. The three illustrations shown on this page bear ample testimony of this remarkable development. The upper and lower illustrations show the types of locomotives in use during 1900 and 1910 respectively, whereas the center illustration represents the modern type of electric mine locomotive.

MINE *and* INDUSTRIAL LOCOMOTIVES

CIRCULAR 1648

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.
EAST PITTSBURGH, PA.
BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA.

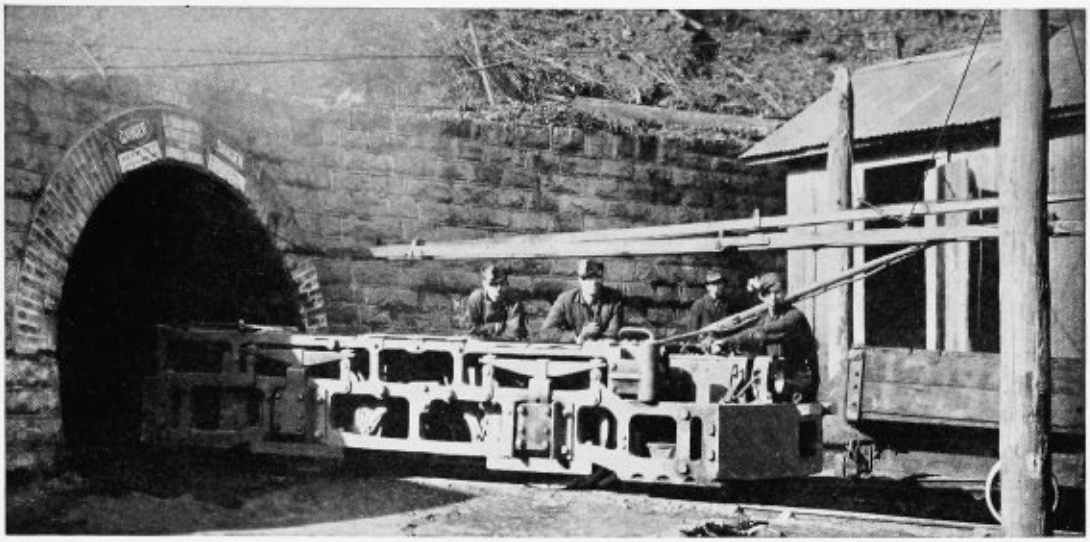
FOREWORD

DURING the last decade many factors have influenced the increasing demand for electrical haulage equipment for mines. The necessity for reduced mining costs, the striving for increased tonnage, the improvements in electric motors and locomotives, the increase in number and capacity of power lines, and a better understanding of the advantages and savings obtainable by the use of electric power, all are partly responsible for the general adoption of electric mine locomotives for underground haulage.

Not only in the earliest days, but throughout the entire development, Westinghouse and Baldwin engineers have joined forces to bring out the best locomotives, both electrically and mechanically, that sound engineering could devise. New features advantageous to the user from the standpoint of simplicity, accessibility, and maintenance have been introduced as changes in operating practice and conditions have been made.

During the thirty years that the Westinghouse and Baldwin Companies have been associated in the design of electric locomotives they have met and solved the requirements of the service found under a wide variety of conditions and for all sizes of installations. These two companies build a complete line of all types and sizes of mine and industrial locomotives, and are, therefore, in position to recommend and to supply the proper locomotive for any particular condition. To maintain this preeminent position in the field of design and application, a large force of experienced engineers are continually engaged in working out the various haulage problems presented. These engineers are available to assist purchasers in choosing suitable equipment for their particular requirements.

The purpose of this book is to put clearly before you the many points of excellence which are incorporated in the well balanced design of Westinghouse-Baldwin mine locomotives and industrial locomotives. We believe them to be the last word in modern construction and so well founded on sound engineering principles that they will endure for many years. We feel it is to your best interest to know these facts and principles.



FUNDAMENTAL REQUIREMENTS OF GOOD DESIGN

THE successful solution of mine or industrial haulage problems depends to a large extent upon securing haulage units which will operate continuously and economically. Units of proper design and type, which are long-lived and comparatively free from weaknesses which cause delay or require excessive renewal of wearing parts, are essential to a well-planned system.

To secure these desirable characteristics, certain fundamentals must be included in any locomotive design. Chief of these are:

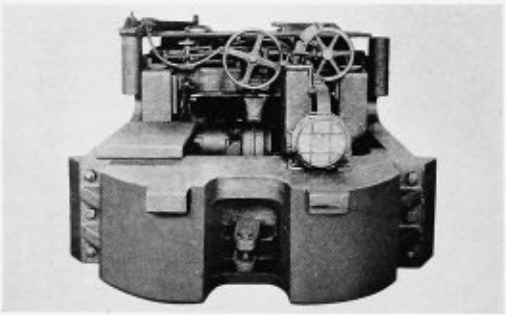
1. Strength of mechanical construction
2. Accessibility for inspection and repairs
3. Ample motor capacity
4. Simplicity of control
5. Proper ventilation
6. Correct location of equipment units
7. Substantial wearing parts
8. Good tracking and riding qualities
9. Standardized design
10. An efficient cable reel

STRENGTH OF MECHANICAL CONSTRUCTION

The Barsteel frame construction which is typical of all Westinghouse-Baldwin locomotives assures mechanical strength, accessibility to, and proper ventilation of, electrical parts. The truss-like structure is made of the necessary cross section to give it transverse stiffness and permits concentration of strength at those points where weakness is most liable to develop. In view of the possibility of accident in underground mine service, these frames are usually made of a thickness comparable with main line locomotives of twenty times their weight. Their strength is proved by the fact that of the thousands of Barsteel locomotives in service and the numerous wrecks with which they have met in service, broken frames are practically unknown. This proves that the locomotive's backbone is substantial.

ACCESSIBILITY AND VENTILATION

The grid-like construction in addition to giving the locomotive remarkable strength provides openings which insure ample ventilation of the electrical equipment, as well as space to get at the interior of the locomotive to inspect all parts, lubricate them or renew them when necessary. In this way all parts may be kept in working condition, and occasionally serious trouble forestalled.



The fan shown in the center forces air through the motors and increases their continuous capacity

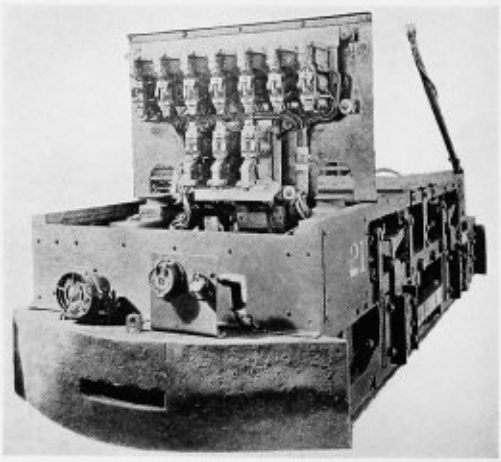
AMPLE MOTOR CAPACITY

Ample motor capacity means equipment that can pull loads within the adhesion limits set by the locomotive weight not only for a short time, but also capacity which will allow a comfortable margin of safety against over-heating when used strenuously all day. The Westinghouse 900-line of mine motors, was designed to have high continuous rating rather than high hour rating. The ability of the motors to perform the service required of the locomotive without overheating depends on their continuous capacity at the average voltage applied to them. As a large part of the work is done with resistance in series with the motors, especially in gathering work, the average voltage applied to the motors is 50 to 80% of the line voltage. It is obvious that the ability of the motors to operate continuously on such voltage, and to do their work properly under these conditions, is most important. It is the real measure of their success in service. Motors are, however, given a nominal or one-hour rating at normal voltage in accordance with the A. I. E. E. rules. The higher the ratio of continuous capacity in amperes to the hour rating in amperes, the better is the motor able to withstand, without injury, the demands made upon it. In Westinghouse motors this ratio is between 35 and 50% depending on the size and design of the motor. In mines where the haulage equipment is so scheduled that it must keep moving continuously or where there are just enough locomotives to move the tonnage, this characteristic of Westinghouse equipment will be found exceedingly valuable.

The hour rating depends principally on the thermal capacity, while the continuous capacity depends on ventilation and the relation of copper and iron losses. Higher continuous capacity may be secured to meet the severe conditions of long hauls over heavy grades by increasing the ventilation. This is accomplished by the use of ventilated housings and a fan, which draws air in at the commutator end and forces it out at the pinion end. Still higher continuous rating is obtained by forced ventilation, which means forcing air through the motor by using an external blower fan. In this manner, motors of lower hour rating may be designed to have a high continuous capacity, and, therefore, they have the ability to do more work than other motors of a much higher hour rating. It is, therefore, not enough to compare motors on an hour rating basis. It is very necessary that the motor with the high hour rating have also a sufficient or comparable continuous capacity.

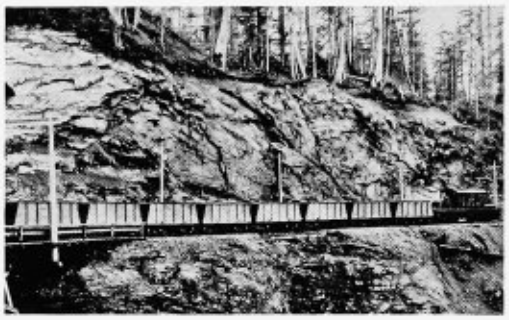
SIMPLICITY OF CONTROL

A simple controller built to withstand the service to which it is subjected, and whose wearing parts are easily renewed is most advisable. As nearly all locomotives for mining work are built for low height, standard controllers of the series and parallel type embodying these characteristics are used on Westinghouse-Baldwin locomotives. The controller must have capacity to function properly and still be small in size, the latter being so necessary that the power economy and smoother acceleration obtainable with series-parallel controller must be sacrificed



The locomotive cover at the rear is lifted to show the mounting, location and accessibility of the magnetic switches

In far-off Alaska where continuity of service is a paramount requirement, this 20-ton Barsteel haulage locomotive is operating

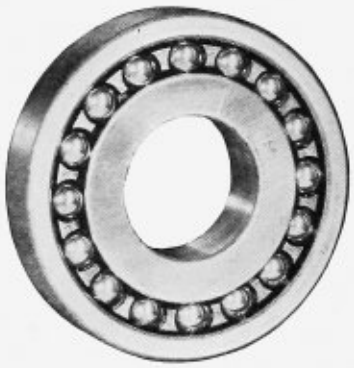


This 42-ton Barsteel locomotive is shown hauling copper from a Canadian mine to the smelter. It is used also to haul blister copper from the smelter to the wharf

This old type Westinghouse-Baldwin haulage locomotive has been in continuous operation in Canada since 1900 and is still giving good service

This locomotive hauls ten 25-ton ore cars through a 6600-ft. tunnel to the crushing plant of a large Arizona copper company

on account of space limitations. On the larger locomotives and in tandem units, magnetically operated unit switches controlled by a small



Oversize armature bearings used to assure minimum wear

master controller are supplied. These insure more safety and space for the motorman, as the heavy current-carrying circuits are removed and the small master controller replaces the larger drum controller in the cab end. Where the locomotive is equipped with air brakes, electro-pneumatically operated unit switches such as the type HL control are used.

Though it is not generally recommended as advisable, dynamic braking control can be furnished where service conditions are suitable. When used, it is particularly desirable to use motors of a high continuous capacity, as they are in service a greater proportion of the time than when braking is done mechanically. Gearing and resistance life may also be expected to decrease.

LOCATION OF EQUIPMENT UNITS

A feature of design not often carefully considered is the arrangement of the equipment in the controller end of the locomotive. In Barsteel locomotives the equipment is so grouped around the motorman's pit as to provide as much open space as possible, thus giving the operator an opportunity to crouch low when passing through entries where the headroom is restricted, and to get out quickly and easily in case of collision. The illustrations show how the motorman may easily reach the different parts when seated.

An alternate arrangement may be furnished which allows the motorman to couple cars and sand the tracks without removing his hand from the controller. In this manner the motorman may operate the brake or the sander or couple cars with one hand, while inching the locomotive along using that hand on the controller which is accustomed to the work. He need not change hands at all. With this arrangement the controller has its back to the front cross tie and the brake wheel extends beyond the controller. An offset brake shaft at slight additional cost can be furnished to provide a convenient arrangement on the wider gauges.

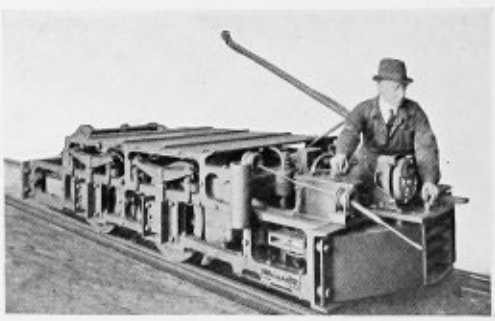
All the auxiliary equipment such as fuse boxes, headlight switches, etc. are placed in easily accessible positions, but where they are most protected from rough handling and from falling rock or coal.

SUBSTANTIAL WEARING PARTS

All wearing parts of Barsteel locomotives are designed to have long life, to be accessible for inspection and lubrication, and to be easily and quickly renewed. These parts include the following:

Solid heat-treated forged steel gears and pinions
Steel insert brake shoes
Oversize armature ball bearings
Bronze motor axle bearings
Brass wearing plate on journal box lid
Ample size journal brasses
Porcelain guides for cable on cable reel
Treated steel guide tongue on cable reel

The illustrations on page 38 show the ease with which the wearing parts may be renewed, and the small number of simple tools that are required for the work.



Equipment is so arranged in the operator's pit as to be within comfortable reach. The illustration shows how easily the locomotive can be inched and coupled

GOOD TRACKING AND RIDING QUALITIES

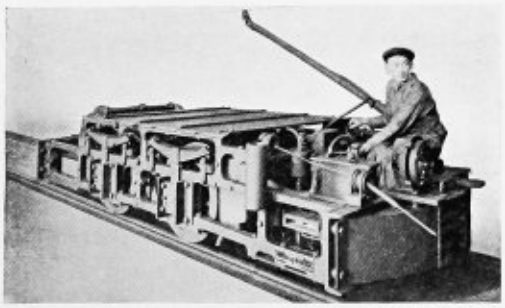
To successfully handle tonnage over the usual mine track, a locomotive must possess ability to stay on the track when passing over inequalities and obstructions in the roadbed, and do this without trying the nerves of the operator. This quality of buoyancy, smooth running, and quick response to changes in the roadbed without teetering on the one hand or heavy sluggishness on the other hand is a real test of a well-designed locomotive. It is obtained by special care in selecting proper contour of wheel tread and flange, non-binding gib ways, resilient springs, as well as by proper distribution of weight between the axles, and proper length of wheel base in relation to gauge of track and drawbar height. This feature is one for which experience alone is a faithful guide and is not found in many makes of locomotives.

Good tracking and riding qualities not only save time, increase tonnage, save wear and tear on track and roadbed, but also lower the upkeep on the locomotive itself.

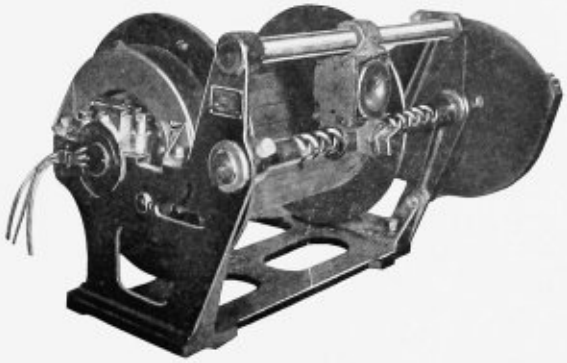
STANDARDIZED DESIGNS

A first consideration in the designing of a locomotive is to have it suitable in all respects for the required service. This is kept constantly in mind in designing and building Barsteel locomotives. Various designs have been prepared to meet the most exacting requirements of mining work, and in most cases a standard locomotive is available which will operate successfully under specified conditions.

The Barsteel locomotives have been standardized as to construction, dimensions and equipment so that purchasers may adopt these locomotives as their standard with the assurance that they have been tested and proved under exacting conditions in many districts. They may also continue to purchase their requirements and secure duplicate units with the improvements or without them, at their option.



The operator is here shown sanding and braking at the same time, the control of each being conveniently placed



The YR-2 horizontal motor-driven cable reel keeps the cable off the roadbed and prevents it from being snarled or torn

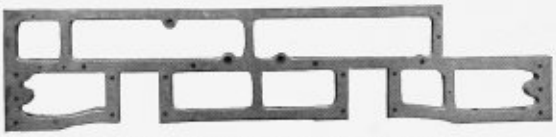
Certain of the more popular combinations of weight and gauge are carried regularly in stock from which immediate shipment can be made. It is greatly to the purchaser's advantage to choose a stock design, for on these he obtains all the latest improvements, the benefit of quantity production and he can secure complete locomotives or renewal parts as needed.

The service of the two companies extends to all parts of the world so that those concerns having properties in different parts of this continent, or in foreign countries, by choosing a standardized design may know that locomotives of uniform quality and duplicate construction are being supplied.

It is well to remember these advantages when opening new mines or re-equipping old ones, so that the equipment in all properties may be uniform. Contractors who find the use of electric locomotives economical in construction work, such as tunnels, power sites, etc. will learn that it pays to buy standardized stock equipments, not only for the short delivery at time of purchase, but also for the reason that when the contract is completed this type will be more readily salable and have a higher second-hand value.

AN EFFICIENT CABLE REEL

A necessary requirement of a gathering locomotive is a cable reel which will handle the con-



This illustration shows how the open Barsteel construction gives both strength and accessibility

ductor cable in a satisfactory manner when entering and leaving rooms. The Westinghouse YR-2 horizontal motor-driven reel is such a reel. It is a self-contained unit, the horizontal insulated drum and spooling device being driven through gearing by a special shunt-wound motor mounted within the drum itself. The spooling device guides the cable on to the drum in even layers and the motor maintains an even tension on the cable; the former prevents snarling, chafing and tearing of the cable, the latter keeps it off the roadbed and away from the locomotive wheels, thereby greatly increasing its life.

The design of the reel permits its being mounted at the end rather than on top of the locomotive. Therefore, it does not interfere with easy access to other electrical or mechanical parts. In this position it is also entirely accessible for inspection and lubrication and all parts may be renewed or overhauled, without removing the reel from the locomotive. All moving parts are thoroughly protected, the motor being inside the drum and the gears enclosed in grease-tight dust-proof gear cases, while the guide tongue is protected from falling rock or coal by the heavy guide bar above it. All parts are designed for exceptionally long life and low upkeep expense. Available records give assurance of the unusual life of the cable when used with this reel.

OTHER BASES OF EXCELLENCE

As it is commonly recognized that a two-motor drive locomotive is far superior to a single-motor drive, either when the latter is driving one axle or both, Westinghouse-Baldwin have consistently recommended and supplied the two-motor drive for all classes of mine and industrial haulage. The outstanding advantages of the two-motor drive are:

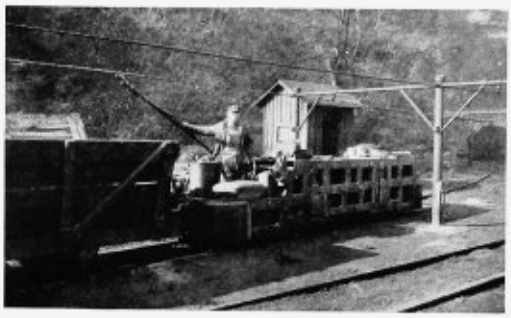
1. More nearly equal distribution of weight
2. Better utilization of available tractive effort
3. Elimination of chains, side rods or other methods of tying both axles together
4. Independent operation of either motor possible in an emergency
5. Greater rheostatic efficiency

The following paragraphs cover briefly those superior and exclusive features common to all types of Westinghouse-Baldwin locomotives, and point out in a general way the reasons for the excellence of these locomotives.

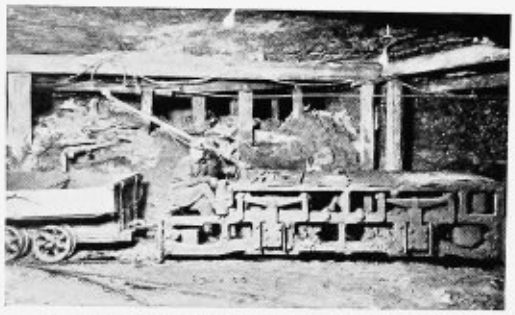
Barsteel Frame:—Chief among these is the Barsteel frame, of which brief mention has already been made and a brief description given. However, in view of the highly important part the locomotive frames play in the success of the locomotive from operating and maintenance standpoints, a more detailed description is given. It is of great importance that the frame be made of the best material, carefully inspected and tested. Barsteel frames are made to rigid specifications which insure a uniform product of the requisite strength and toughness. They are thoroughly annealed in furnaces which are fired by oil sprayed from each end. From 18 to 30 hours are required to anneal, the time being dependent upon the carbon content of the steel. The required temperature is 1650 degrees Fahrenheit, at which the frames are held from 10 to 14 hours. They are then allowed to cool slowly for 12 to 15 hours before the covers of the annealing furnace are removed. The frames are cast with a test piece at each end; and after the annealing process is finished, these test pieces are removed and inspected. This test specimen must bend cold through 90 degrees, around a 1-in. pin, without cracking on the outside of the bent portion and must conform to the following minimum requirements as to tensile properties:

Tensile strength, lbs. per sq. in.	70,000
Yield point % tensile strength	45
Elongation in 2 ins., %	18
Reduction of area, %	25
Phosphorus and sulphur content, not exceeding, %	.05

Bumper:—The standard bumper used is of the built-up type, the bumper proper consisting of either a steel channel or flanged plates, with bumping blocks bolted on. These blocks are of wood, faced with steel plate. A four-pocket iron draw casting is bolted to the center of the bumper. Other types of draw castings can of

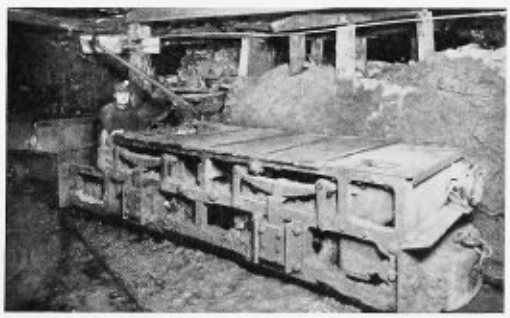


The maintenance expense of this 20-ton haulage locomotive operating in a West Virginia coal mine has been carefully watched and found to be extremely low



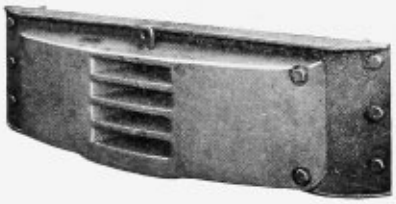
A 13-ton Barsteel locomotive in a wet mine in western Kentucky. The electrical equipment and brake rigging must be reliable to withstand these conditions

All-day service hauling heavy trips like this requires motor equipment with high continuous capacity. Locomotive in use at a West Virginia coal mine



Another view of conditions as sometimes found underground. The open frame and ample clearance make rerailing much easier if necessary

course be used if desired. Wrought iron climbing guards are bolted to the top of the bumper on either side of the draw casting. The bumper is secured to the bar frames by means of angle irons. Where it is necessary to gain

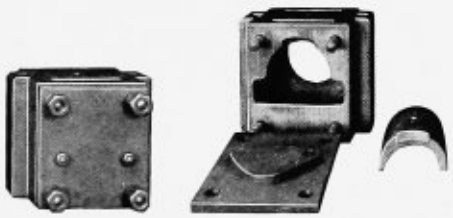


A standard built-up bumper permits easy coupling at various drawbar heights

weight, a one-piece cast-iron bumper is used instead of the built-up form. This bumper has the draw pockets, bumping blocks, and climbing guards cast integral with it, and is also provided with heavy flanges for bolting it to the frames.

Axles:—All axles are made of high grade forged axle steel, a distinct improvement over the cold rolled, low carbon steel as used in the past. Axle steel permits a higher grade of finish for the driver journals, motor axle bearings and press fits for wheels and gears.

Journal Box:—The standard journal box used on outside frame locomotives is of cast iron, and of a design known as the thrust type. The entire box is made in one piece and the end thrust of the axle is taken by the box lid. To prevent wear of the lid a brass wearing piece is held on its inner face by countersunk-head bolts



Closed journal box shown at the left. The few easily removable parts are shown at the right

so that the plate can be easily replaced when worn. This wearing plate limits the lateral motion of the axle; and not only prevents the wear of the wheel hubs, but assists in insuring correct mesh of gears and pinions.

Leaf Springs:—The frames of Barsteel locomotives are suspended on leaf springs, placed directly over the journal boxes. These springs have a sufficient degree of elasticity to insure good riding qualities, and are proving more satisfactory in service than the coil springs

Typical leaf spring showing spring clip and the slots at the ends which hold the hangers

formerly used. Special attention has been given the design of the spring clips and hangers with the result that it is impossible for the clips to jump out of place; furthermore, provisions are made for a spring of maximum width, a most important consideration in securing a reliable and resilient product.

On four-wheel locomotives the springs are independent, no equalization being necessary or desirable. The springs have sufficient flexibility to permit the wheels to adjust themselves to inequalities of the track, and they are so liberally designed that excess movement of the journal boxes with resulting weight transfers will not overly stress them.

On six-wheel locomotives, two pairs of wheels are equalized together on each side of the locomotive, and the third pair is cross-equalized, thus providing the equivalent of a three-point suspension system.

Brake:—The locking screw type of brake is generally used, and, having stood the test of

Skeleton view of brake rigging shows the direct positive action of brakes. Adjustment to offset wear on shoes is made by changing the leverage

many years' service, is recommended as preferable to all others. Its operation is simple but very effective, giving a braking power equal to 100% of the weight of the locomotive with a pull of 100 pounds at the rim of the brake wheel. This is more than sufficient to skid the wheels.

The illustration shows that the brake-shaft is horizontal while the wheel is in a vertical position. This is the preferable arrangement as it allows a maximum amount of room in the cab or operator's pit. Note the provisions for adjustment.

The brake-shoes used are designed and constructed on the same lines as the MCB type. The shoe face wears down evenly and all shoes are interchangeable, no rights or lefts being used.

Solid gears will outwear the wheels. The axles are high grade steel which assures a tight wheel and gear fit

Gears:—The gearing may well be considered one of the most vital parts of the locomotive. On all Westinghouse-Baldwin locomotives, the BP grade drop-forged steel pinions are standard. This grade of pinion has proved its superiority for light and heavy traction railway service after many years of successful application. They are secured to the motor shaft by shrink-fit and key, and in addition a lock washer and nut are applied to insure the correct lateral position.

Solid BP grade steel gears are applied with press fit on the axle. The solid gear is better than the split gear because all bolts and keys are eliminated. The solid gear has other advantages over the split gear as follows:

(a) It will outlast several cast-iron wheels and has a life greater than that of rolled steel wheels.

(b) It can be more accurately machined and assembled on the axle.

(c) The omission of the key results in a stronger gear and a stronger axle.

Wheelbase:—Barsteel locomotives are built with wheelbase as long as is consistent with the curves to be traversed and with as short an overhang on each end as possible. With a given amount of equipment to be placed on the locomotive, a short wheelbase necessitates a relatively long overhang and this has two serious disadvantages in curving:

(a) The displacement of the two ends of the locomotive from the outer rail is excessive; and, if the curve is in a narrow entry, the locomotive is liable to scrape the side walls and timbers.

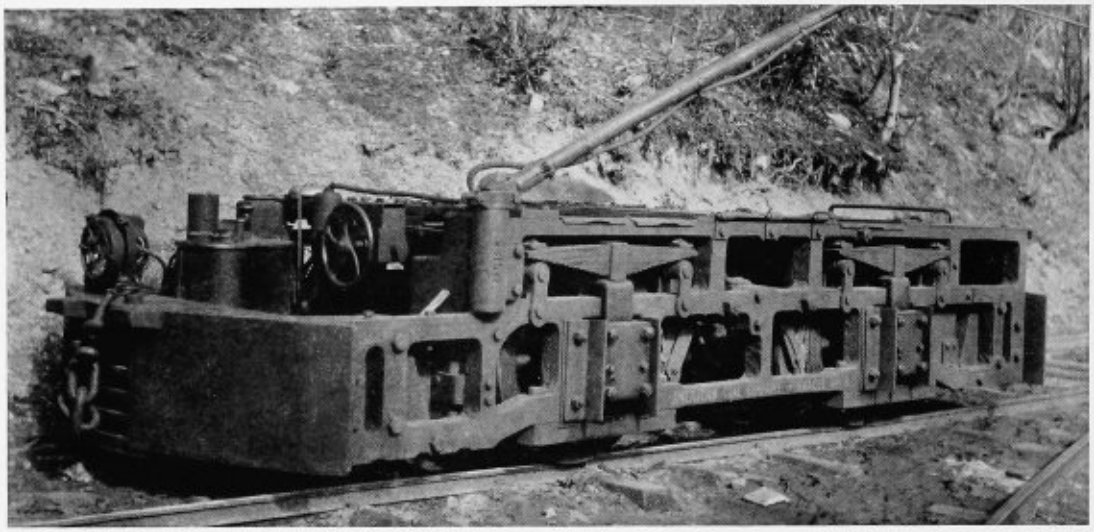
(b) As the overhang on the cars is comparatively short, the coupling between the locomotive and the first car is placed at such an angle with the track that derailments are liable to occur.

A short wheelbase and long overhang tend to promote teetering and this is aggravated if heavy weights are placed near the ends of the locomotive. Nosing is also more liable to occur if the wheelbase is short as compared to the gauge for the resistance to movement in a horizontal plane is thereby reduced. Ordinarily the wheelbase should not be less than 75% of the gauge, and should preferably be equal to or greater than the gauge.

In all cases, regardless of the type of locomotive, it is important to keep the overhung weight as near the axles as the design will permit.

Clearance:—Westinghouse-Baldwin engineers have long realized the great importance of liberal clearance under gear cases. The necessary clearance is determined by several items, such as, the amount of coal, slate, rock, etc. allowed to accumulate and remain on the roadbed; and the nature of the rails, frogs, crossovers, switches, etc. In Barsteel locomotives sufficient clearance is provided to give satisfactory operation under average mine conditions without excessive damage to the gear cases and gearing. Proper clearance inside the gear case to the tips of the gear teeth is provided so that the best lubrication can be secured with minimum gear lubrication. This insures maximum life for the gears.

Details:—Other features, small in themselves, common to all Westinghouse-Baldwin locomotives, but important to the operator and indicative of the careful thought which has been put into the design are described in the following sections.



DETAILED DESCRIPTION OF STANDARD DESIGNS

Descriptions of the detailed construction of standard locomotives are given in the following pages:

TROLLEY TYPE HAULAGE LOCOMOTIVE

Frames:—The locomotive side frames are Barsteel. The side and end frames are held securely together and in perfect alignment by accurately fitted machined joints and by turned bolts driven into reamed holes.

The Barsteel frames are of maximum strength, especially above the journal boxes, and afford accessibility for inspection, lubrication, and adjustment in addition to free ventilation of the electrical equipment.

In case of derailment this construction has the further advantage of affording numerous openings in which a jack may be placed, thereby reducing the time and labor necessary to replace the locomotive on the rails.

Wheels and Axles:—The wheels which may be either cast iron with chilled treads, steel tires, or of rolled steel are pressed on high grade forged steel axles.

Gears:—Single-reduction gearing enclosed in split, dust-proof gear cases is provided. The gears and pinions are made of heat-treated steel, with machine-cut teeth.

Journal Boxes:—The journal boxes are of cast iron and on locomotives with outside frames are so constructed that the end thrust of the axle is taken by a brass wearing plate on the inside of the box lid. This feature prevents wear of the wheel hubs.

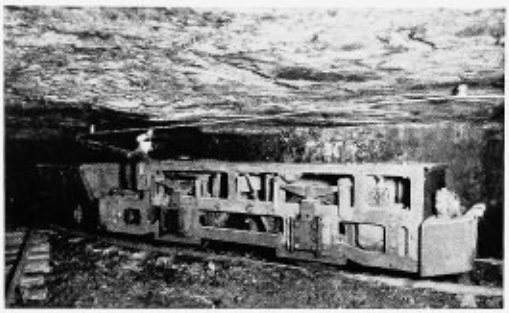
Springs:—The weight of the locomotive is supported by semi-elliptic leaf springs placed directly over the journal boxes. These springs inherently allow a greater vertical movement than do coil springs, insuring an exceptionally easy riding and good tracking locomotive. They are carefully treated during manufacture to insure maximum life and resiliency.

Brakes:—Automatically locking screw brakes having sufficient power to lock the wheels are furnished.

The brake shoes provided are MCB design with special steel inserts to retard wear. They are easily detached from the brake head and are hung independently to insure full bearing on the wheel tread and plumb hanging of the shoes.

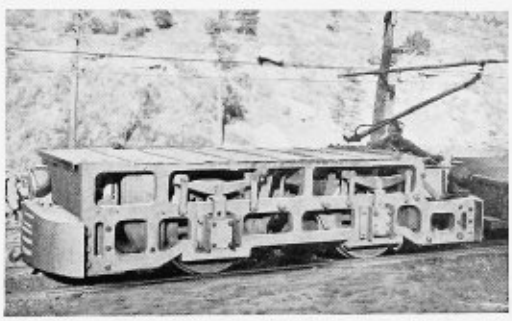
The brake rigging does not interfere with the inspection or overhaul of the other parts of the locomotive.

This locomotive operating in a Canadian copper mine is equipped with a special trolley which can follow a trolley wire located on either side of the track



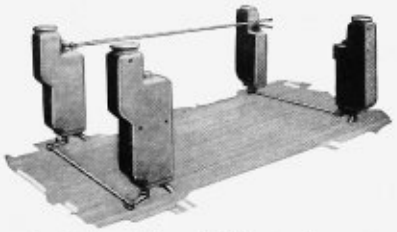
15-ton Barsteel locomotive in a western Kentucky coal mine. The massive construction of this type of locomotive gives strength without sacrificing accessibility

A low-design locomotive pulling a trip out of a drift mine in West Virginia. Note that the journal gibs protect the nuts on the journal boxes



A 15-ton haulage locomotive in a New Mexico coal mine. On such locomotives, journals are easily removed due to the frame construction being outside the wheels

Sanders:—Two sand boxes of liberal capacity are supplied on each end of the locomotive. These are piped so that sand may be applied



A typical sand box and rigging equipment which shows a part of the control of the sand valves and the large capacity sand boxes

directly in front of the leading wheels in either direction of operation. The operating handles are placed within convenient reach of the motorman.

Bumpers:—The bumpers furnished are of the styles previously described on page 10.

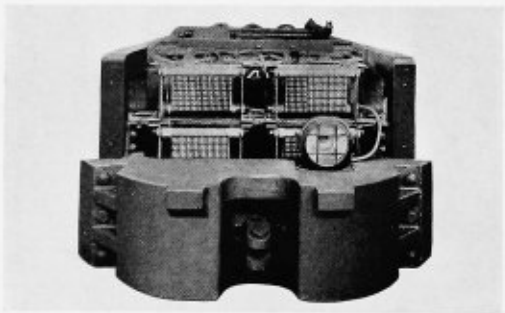
Covers:—Drip-proof sectionalized sheet-steel covers are securely latched to the frames, thus protecting the electrical equipment from falling coal, slate, or water.

ELECTRICAL EQUIPMENT

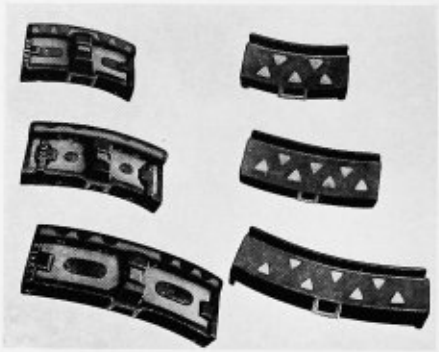
Motors:—Two motors of the "900" series are furnished. This series was designed specifically for mine locomotives, and possesses all the improvements that have been found desirable in motors for such use.

The principal features of these motors are:

1. Excellent commutation due largely to the use of interpoles.
2. Cast-steel frame split diagonally into two parts, the upper half being removable without disturbing the suspension or axle brackets.
3. Ball type armature bearings.
4. Form-wound armature coils, oil and moisture-proof, thoroughly insulated to insure long life without deterioration.
5. Heavily taped and impregnated field coils, protected from vibration by heavy cushion springs between the coil and motor frame.
6. Rugged and substantial brush holders easily adjusted to compensate for commutator wear.
7. An unusually high continuous rating compared with the one-hour rating. This superior and exclusive feature is of great importance because it insures continuous maximum production per locomotive without danger of overheating.



Cover and end plate removed to show four resistors at the rear end of the locomotive. The alloy grids are flexible and made to withstand vibration



These steel-insert brake shoes of the MCB type prevent the shoes and wheels from wearing unevenly

Controllers:—Unless otherwise indicated in the specifications, the locomotive is provided with a drum controller designed and connected so that operation may be obtained in either direction with the motors in series or in parallel.

Magnetic blowouts insure immediate rupture of the arcs formed when the circuit is opened between the main drum and contact fingers. This lessens the burning of contact tips, greatly prolongs the contact life, and reduces cost and labor of maintenance.

The main and reverse handles are interlocked in the usual manner.

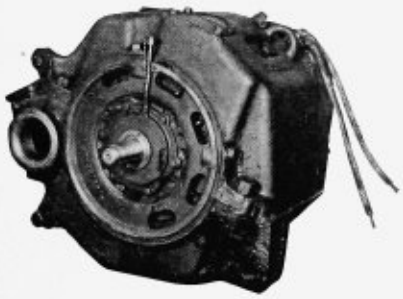
Resistors:—Resistor frames made up of three-point suspension cast grids are supplied. These grids are made of a nickel-iron alloy, the composition of which combines minimum weight and bulk with maximum strength and durability.

Trolley:—A mine trolley is mounted in a socket at the controller end of the locomotive. The pole head and harp are made of malleable iron which gives much longer wear than ordinary material. The pole is of selected first quality ash.

Protective Devices:—Overload protection is provided by a copper ribbon fuse mounted in a magnetic type of fuse box. These fuse boxes are of particularly strong and substantial construction, and may readily be opened for insertion of the fuse.

For locomotives operating above ground, protection from lightning is provided by a multipath arrester.

Wiring:—Wherever possible, the cables are bunched and encased in a heavy canvas hose for protection.



Standard mine motor showing heavy split frame and axle bearings. The ventilated housings give high continuous ratings

Headlights:—Two Westinghouse-Cutter headlights are furnished, one on each end of the locomotive. These headlights are built especially for mine locomotive service. The lamp is of the concentrated filament type mounted at the focus of a parabolic reflector and is spring supported for protection against vibration. This insures the longest possible lamp life.

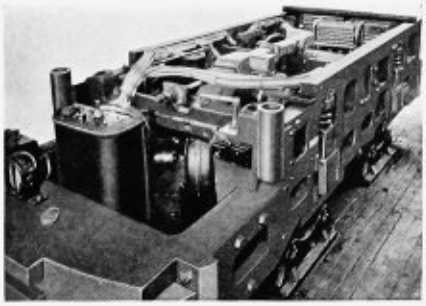
ACCESSORIES

Gong:—A hand-operated gong located within easy reach of the motorman is furnished.

Tools:—A tool box and tools including a monkey wrench, socket wrench, pinch bar, automatic lowering ratchet type jack and oil can are provided.

TROLLEY TYPE GATHERING LOCOMOTIVES

Gathering locomotives are identical in construction with the haulage locomotives previously described, except that the frame is of slightly different shape to provide space for the gathering reel without increasing the locomotive height.

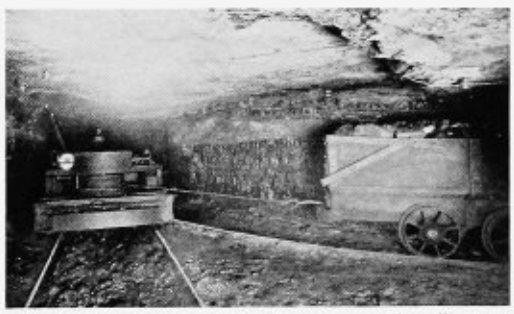


Locomotive cover removed to show arrangement of equipment and wiring. This view shows also the air conduit for forced ventilation

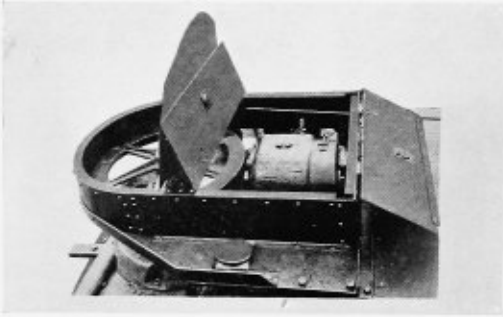
Either a conductor cable reel or a traction or crab reel may be located at the end of the locomotive opposite the controller end.

Traction Reel:—The locomotive equipped with a traction reel may be considered as a portable hoist. The motor power for the reel is furnished by a 7½-hp. or a 15-hp. type K series-wound motor, controlled by a small rheostatic drum controller. The reel drum is equipped with 350 ft. of ⅜-in. steel cable, and is driven by the motor through a bevel gear. When in operation, the locomotive stays on the cross-entry track with the brakes set, and the cable is taken into the room by a trip rider who hooks the cable to a loaded car. The reel motor is then started, and the car drawn out on to the cross-entry track.

This type of locomotive can be used where the headroom is too low for the conductor cable reel locomotive, and where the track in the room is so light or so poorly laid that nothing heavier



Gathering locomotive with traction reel pulling loaded car from room to cross entry, motor operated drum reeling in the steel cable



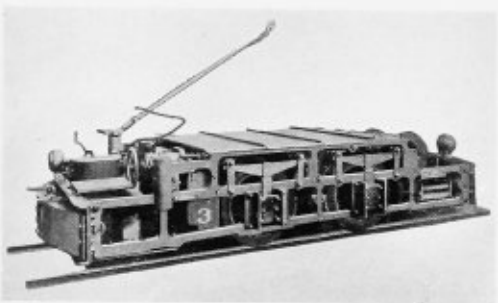
Cover removed to show motor and drive of the traction reel. The motor is a standard crane motor

than loaded cars can be supported. It can haul loaded cars up very steep grades and is useful in handling flat cars that are loaded with rails or props, or cars which for any reason cannot be coupled to other types of locomotives. Its limitation is that it cannot, of course, push empty cars up grade into rooms not equipped with a trolley wire.

The Westinghouse-Baldwin traction reel is of the vertical type, very simple in construction, uses only a single-reduction gear and has no clutch or other complications in the mechanism. The type K motor used has been giving satisfaction for years in the most severe kind of service. It is totally enclosed and fully protected from dust and moisture, but all parts are easily accessible. Standard practice is to guide the cable over the front, or controller end of the locomotive, but arrangement for guiding it over the back end can be made if desired.

CONDUCTOR CABLE REEL MOTOR-DRIVEN

It is generally conceded that the Westinghouse type YR-2 conductor cable reel is so far the most satisfactory motor-driven reel developed by any manufacturer, and its record in actual service amply supports this. Moreover, the principle of spooling electric cable horizontally is undoubtedly correct and economical.



Standard type of gathering locomotive with motor-driven conductor cable reel

This reel is an insulated horizontal drum driven through gearing by a separate shunt-wound motor mounted within the drum. The special shunt-wound motor maintains a constant pull on the cable at all locomotive speeds whether reeling in or reeling out. Even tension keeps the cable off the tracks and from under the locomotive wheels, and obviously prolongs the life of the cable.

This motor is connected to the line through a canopy switch, snap switch, fuse and permanent resistance. The resistance is of such capacity that the reel motor may be left across the line. However, as the resistance consumes power, it is advisable to open the circuit when the reel is not required.

The design of the reel permits its being mounted at the end of the locomotive so that it

View of cable guide mechanism. A guide tongue fitting in the lead-screw at the bottom causes the guide to travel to and fro as the screw rotates

does not interfere with easy access to the other electrical or mechanical parts; and yet, all parts of the reel itself are readily accessible for inspection, and the motor armature may be removed for inspection without taking the reel off the locomotive.

The spooling device consists of a bracket, which shuttles back and forth between a guide bar and lead-screw parallel to the drum. The bracket holds a doughnut-shaped porcelain block through which the cable is guided. The lead-screw is a double-threaded shaft rotated by gearing arranged to feed either single or double conductor cable at the proper speed. A guide tongue attached to the spooling bracket travels in the grooves of the lead-screw and is automatically reversed at each end, thus guiding the cable on to the drum in even layers.

By spooling in this way on to a horizontal drum, snarling, tearing, and chafing of the cable

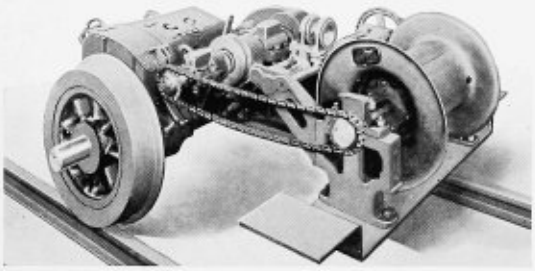
are prevented, thereby avoiding the short circuits and burning so prominent in other winding schemes. By virtue of this feature and the savings effected by maintaining even cable tension, cable maintenance is reduced one half.

The single-conductor cable is used when the track in the rooms is made of steel and the joints so bonded that they afford a return circuit. The double-conductor cable is used when the tracks are not bonded.

In either case, where the single or double-conductor cable is used, the current for the main motor is taken from the reel motor collector ring, by a brush and holder, then carried through leads to the controller and locomotive motors.

CONDUCTOR CABLE REEL MECHANICALLY DRIVEN

The mechanically driven reel is similar to the YR-2 but is driven directly from the locomotive axle or indirectly by means of a countershaft interposed between the axle and the reel, and not by an independent motor. When driven direct from the axle, the driving chain is always running while the locomotive is in motion. When driven from the countershaft, the driving chain is running only when the reel is winding up the cable. When desired, the reel is put into operation by means of a friction clutch applied by the motorman. With this clutch is also combined a brake to keep the cable taut when being paid out. This brake is released automatically when the friction clutch is applied.



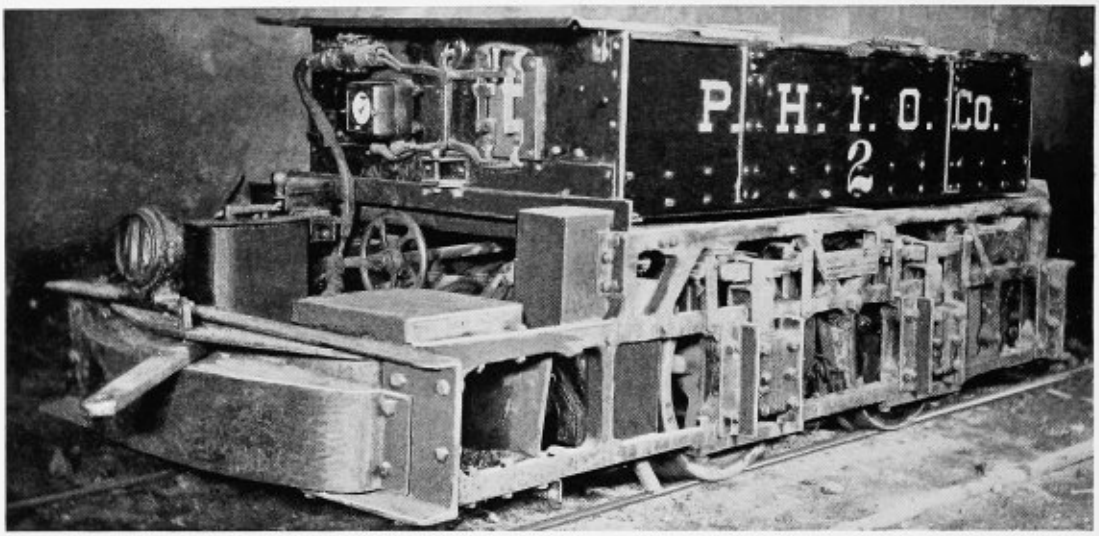
Mechanical cable reel, countershaft driven, showing arrangement of drive, clutch, guide and drum

The motor-driven reel is generally superior to the mechanically operated reel, especially when the locomotive must gather on a grade of 4% or greater. With the motor-driven reel there is no danger of the cable becoming slack and being run over by the locomotive should it skid down grade with wheels locked by the brake shoes on return to the heading.

Rear view of standard gathering locomotive equipped with wire rope reel

With both the conductor cable reels described the standard arrangement is to guide the cable over the front end; however, it can be arranged for guiding over the rear end if desired.

Generally speaking, gathering locomotives may be designed low enough for all ordinary conditions. In some extreme cases, however, it is necessary to locate the trolley pole socket below the top of the frame, to keep within the height limit. This location can usually be avoided; but, when absolutely necessary, it requires only the lifting of the trolley pole from its socket to swing it over the top of the locomotive.



STORAGE BATTERY LOCOMOTIVES

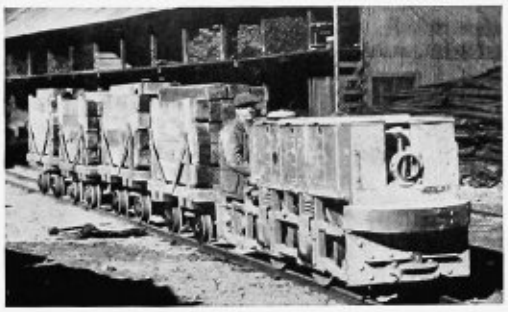
THE storage battery mining type locomotive is particularly adaptable to gathering service and underground haulage in coal mines where there are difficulties in erecting and maintaining trolley wires and in bonding the rails, or where wooden rails are used. It is also suited to roustabout haulage when mines are first opened. In metal mines where the grades favor the load and small cars are used, the smallest standard battery locomotive usually will handle the tonnage and in addition will have the advantage of safety, low installation and power cost.

The salient advantages of the Westinghouse-Baldwin locomotive of this type include accessibility, simplicity, efficiency of operation, and general ruggedness of design. The mining type conforms to the principles established by years of experience in the successful application of mining locomotives of the trolley type and the construction follows that type as closely as possible. Mechanically, the storage battery locomotive has the same features of construction previously described for the trolley type, but modified to suit the service. The Barsteel frame has additional advantages in storage battery locomotives for it affords ventilation of the battery; and accessibility to the motors, brake shoes and resistance without removing the battery box. This is not possible with solid frame construction.

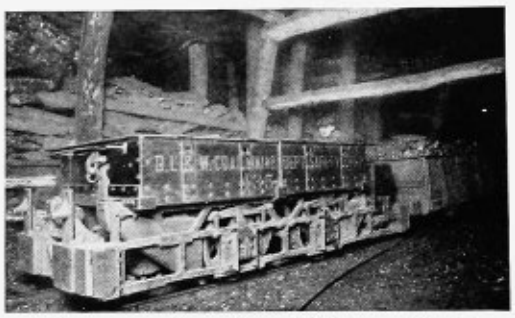
Either the lead-acid or the Edison type of battery can be furnished in sizes necessitated by the particular service requirements. Where the battery is mounted on top of the side frames, the battery container or compartment is made of sheet steel, the cover being in sections for ease in handling, and is made water-proof by means of special interlocking flanges. For convenient lifting, these compartments are equipped with suitable lugs; when two or more section compartments are furnished, each section is provided with such lugs. The standard crate consists of a single section provided with rollers, permitting easy removal without any form of hoist or crane if a suitable platform be provided. When the battery is mounted between the side frames, the steel crate is omitted as the battery consists of several sections.

The mechanical construction of the motors for these locomotives is of the same general design as the 900-line motors used in the trolley type locomotives. They are very rugged and compact and have an unusually high efficiency throughout their entire range of operation. As the standard battery voltage used is 80 volts, commutating poles are not included in the design of the storage battery locomotive motors as perfect commutation and increased efficiency can be obtained without their use.

Since the power available for operating a

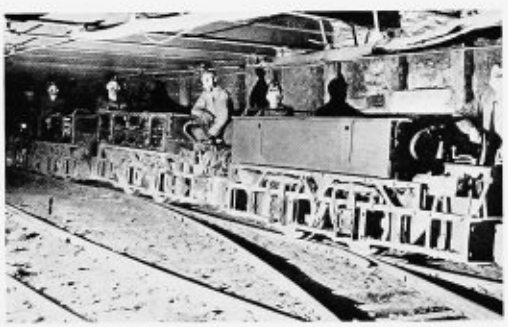


Barsteel storage battery locomotive, hauling mine timbers at a large Arizona copper mine. The location of the battery, together with the open frame construction, allows inspection without the necessity of removing the battery

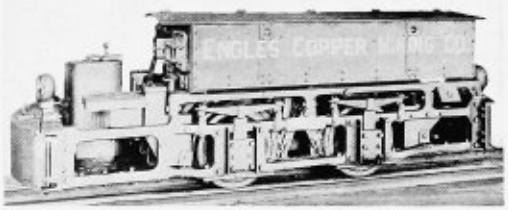


A large storage battery locomotive in an anthracite coal mine. Notice the large sand boxes and climbing guards

A Barsteel A6-2 storage battery locomotive in an iron mine in northern New York. This locomotive permits the battery compartment to be rolled off for charging



A group of locomotives in an Illinois coal mine. These locomotives are especially economical in power consumption for gathering work



A modern type of storage battery locomotive built for a California copper company. The battery circuit control is mounted directly on the front of the battery box and is protected from dripping water or falling rock by the extension of the cover

storage battery locomotive is contained in the batteries carried on the locomotive, it is highly important that the power wasted be kept to the absolute minimum. To accomplish this, the Westinghouse Control scheme was devised, which, by ingenious combinations of series and parallel groupings of the motors and motor fields, gives five speeds forward and reverse without any waste of the battery power in resistance. This method of control gives high torque or tractive effort with minimum current demand during acceleration and other periods. It has been found that this feature, particularly where locomotives are used for gathering work in coal mines, requires 15 to 30 % less energy from the battery than that used by other control schemes and other designs of locomotives. This allows either the use of a smaller battery or the hauling of more cars per day. In either case, there is a lower investment for a given output.

The controller is provided with two handles, a main handle for speed control and a reverse handle for reversing the motor equipment. Interlocks are arranged so that the reverse handle cannot be operated unless the main handle is in the "off" position, and also that the main handle cannot be operated unless the reverse handle is fully set in either the forward or reverse position.

Provision is made to protect the contacts where necessary with magnetic blowouts for disrupting the arc formed when the circuit is interrupted. Suitable arc shields for properly confining this arcing separate the contacts. These may be swung clear to facilitate inspection. All wearing parts are renewable and easy of access.

The controller is provided with a metallic return circuit, which reduces to a minimum the liability of a short circuit on the battery resulting from a ground.

The grid resistors and protective devices used are of the same general design as used on trolley type locomotives previously described.

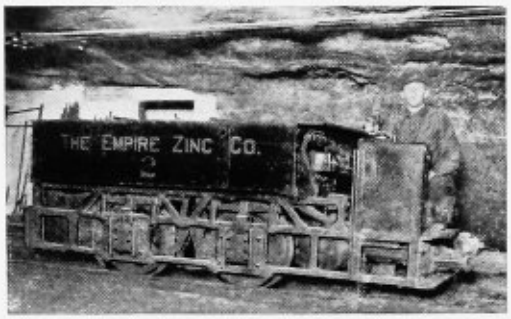
For control of the battery circuit, charging, etc., there is mounted directly upon the end of the battery compartment, adjacent to the locomotive operator, a main battery knife switch, a Sangamo locomotive-type amperehour meter, and a charging receptacle and plug. The receptacle and plug are arranged with an additional connection to automatically terminate the battery charge upon its completion.

Although certain standards of manufacture and design have been set for this type of locomotive, modifications can be made to suit very special requirements, such as low height, short wheelbase, narrow gauge, and unusually large battery capacity. This flexibility of design is a highly desirable feature considering the large variety of applications to which the storage battery type of locomotive is suited.

One of the most common modifications of the standard storage battery locomotive design requested, is that for low height. Our engineers, realizing the tendency of coal mining to the working of thinner veins, have designed such locomotives to as low a height as 30 in., still maintaining sufficient space for adequate battery capacity and still retaining all the features which have made the Westinghouse-Baldwin locomotive preeminent.

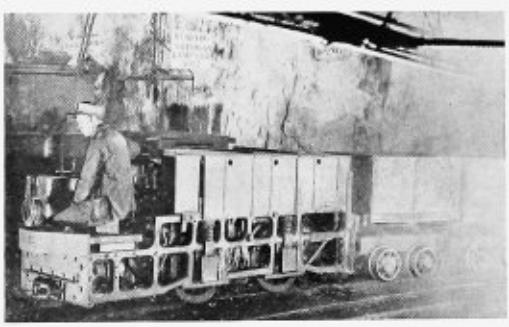
As previously mentioned, the storage battery locomotive may be equipped with a cab or canopy, making it suitable for haulage work above ground, such as yard switching service, general trucking work in and around industrial plants, ash and waste haulage and almost an infinite variety of other uses. This cab may be of the end type or of the center type, as shown in the illustrations. The end type of cab is customary on locomotives smaller than 10 tons; and for locomotives over that weight, center or end type is optional. In either case they are of weather-proof riveted sheet steel.

Standard storage battery locomotive equipped with special bumpers. These bumpers were made necessary by the special mine cars in use at this Utah copper mine

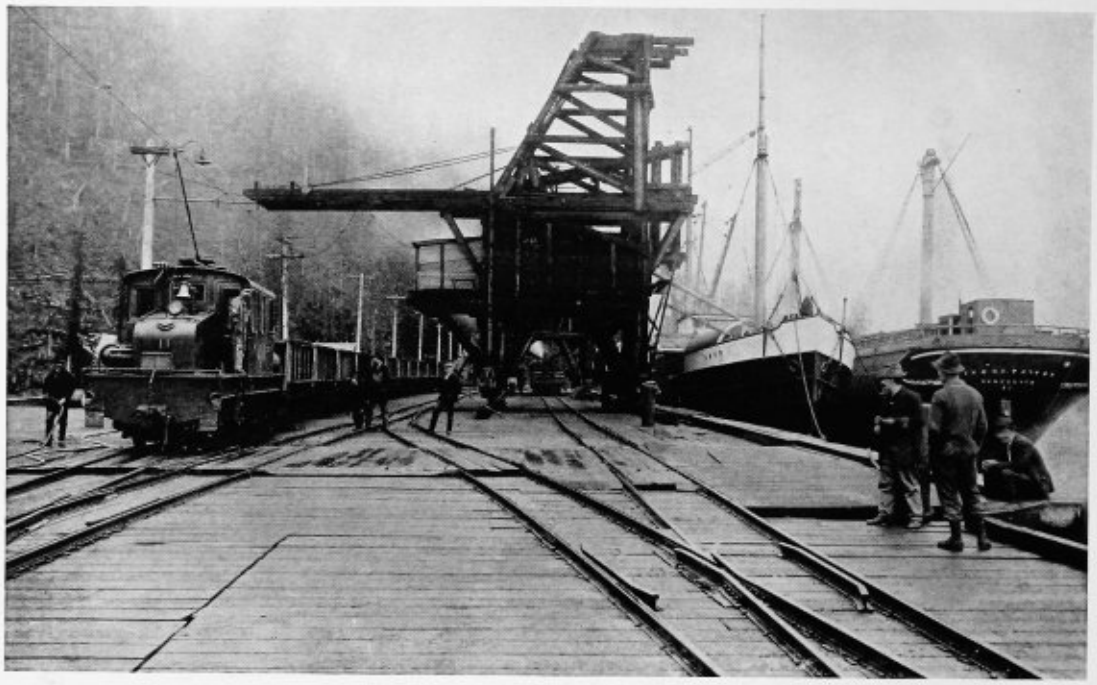


Storage battery locomotive in underground service in a Colorado zinc mine

A storage battery locomotive equipped with end cab used for surface haulage at a quarry in Missouri. The cab is of plate steel with ample door and window space



Locomotive underground in an Arizona copper mine. The battery box is sectionalized to facilitate handling underground



SPECIAL DESIGNS FOR SPECIFIC SERVICES

THE flexibility of the general design of the electric locomotive makes it adaptable to a wide range of special applications to many of which it has already proved indispensable.

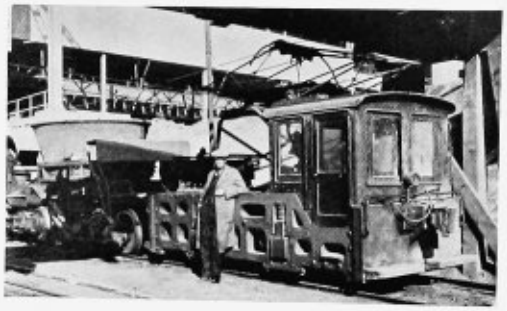
LOW HEIGHT COMBINATION LOCOMOTIVES

For certain mining or industrial applications, a locomotive combining the advantages of the trolley type and the storage battery type has proved its popularity. This locomotive can be furnished for practically any gauge, weight, and battery capacity desired. As the name indicates, it is a combination of both types, the main difference being in the controller. The controller makes provision for instantaneous switching from trolley to battery operation or vice versa. In case low voltage motors are used, operating in series only, the controller automatically provides protection against paralleling the motors when operating from the trolley. Provisions for charging the battery from the trolley may or may not be furnished, depending on the service.

TANDEM AND THREE-MOTOR LOCOMOTIVES

The need often arises, particularly in coal mining service, for a larger locomotive or for a locomotive having a greater draw bar pull than can be obtained with a single unit equipped with two motors of the maximum size which can be applied to the road gauge. In such cases, either a tandem unit consisting of two standard units operating as one locomotive or a locomotive equipped with three motors is recommended.

The tandem locomotive may be furnished in either the permanent or separate tandem arrangement. In the permanent tandem, the two units are permanently coupled together electrically and mechanically. Provisions for electric and brake control are provided for only on the primary or operating unit. Under certain operating conditions this is a disadvantage because the weight of the complete unit is not required at all times. For this reason the separate tandem is more popular. This type also has much wider range of utility since the units may be separated and operated individu-

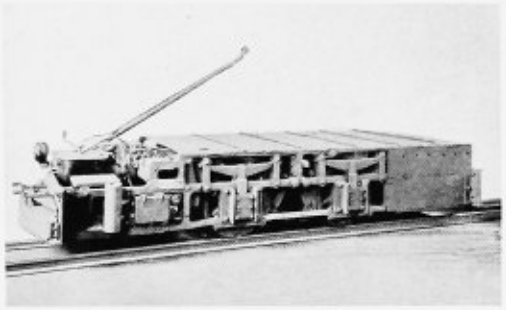


A smelter locomotive, with end cab and air brakes, used in handling slag cars and concentrate at an Arizona copper smelter. Similar locomotives are in service at all large smelters in the West

42-ton 4-motor haulage locomotive equipped with air brakes and HL control. This locomotive is used for hauling ore from the mine to the smelter at a Canadian copper mine

One of six 8-ton locomotives, equipped with motor-driven cable reel, being used in construction work on a dam for a large power project in Alabama. Power is supplied by third rail

Special tandem unit consisting of two 3-motor locomotives with magnetic control built for a West Virginia coal company to meet the requirement of a heavy locomotive used on narrow gauge



Low height combination locomotive used in thin seam coal mines. This type is advantageous where gathering is done over a considerable area from scattered rooms

ally. Both primary and secondary units are equipped complete with controller, brakes, etc. The electrical connection between the two units is made by substantial and easily removable jumpers. The brake rigging is connected or disconnected by means of a few bolts.

Either the drum type or the electro-magnetic type of control can be applied to these locomotives, the magnetic being preferable because, for a very slightly higher cost, it makes the units exact duplicates of each other, provides a smaller controller which is more easily operated, simplifies the jumper connections and permits locating the heavy current-carrying parts away from the vicinity of the motorman. Moreover, either unit can be used as a primary unit.

Where the service is such that a tandem unit has no particular advantages to recommend it, and where the greater weight or drawbar pull is at all times necessary, the three-motor locomotive has the advantage of lower first cost. A locomotive of this type is similar in all respects to the standard two-motor locomotive, except that there are three pairs of wheels with a driving motor on each axle. No flanges are used on the middle pair of wheels, thereby greatly reducing curve friction and preventing any tendency of derailment when rounding curves.

Standard 3-motor locomotive for heavy duty where track or gauge is too small to use 2-motor locomotive. Note that the springs are cross equalized

"MIDGET" TYPE STORAGE BATTERY LOCOMOTIVES

One of the latest additions to the Westinghouse-Baldwin line of locomotives for special applications is the "Midget" type storage battery locomotive. This design was created to fill the demand in the metal mining industry for a small locomotive. Its particular field of application is in those mines where enough haulage is necessary to justify a locomotive, but where there is not sufficient work on any one level to keep a

Special locomotive for an Indiana steel company used in yard haulage and inside buildings. Note the special double third rail shoe construction for rails located along the walls of buildings

locomotive continuously busy throughout the whole shift, and where it is not desirable to resort to animal or man power for tramming cars. This locomotive is, therefore, so arranged that it can readily be hoisted or lowered from level to level on any standard hoisting cage. It is made up of two units; the driving unit carrying the motor, controller, etc., and the trailing unit carrying the battery. It has a rated drawbar pull of 400 pounds at 3 miles per hour, and a starting drawbar pull of 500 pounds, sufficient for all ordinary requirements.

As far as possible the general design is the same as the standard mining locomotives, including the Barsteel frame, single-reduction low-speed motor, leaf-type springs, etc. The tender may be equipped with either the lead-acid or Edison type of storage battery as desired.

INDUSTRIAL TROLLEY TYPE LOCOMOTIVES

No catalog would be complete without mention of the almost infinite variety of uses to which the

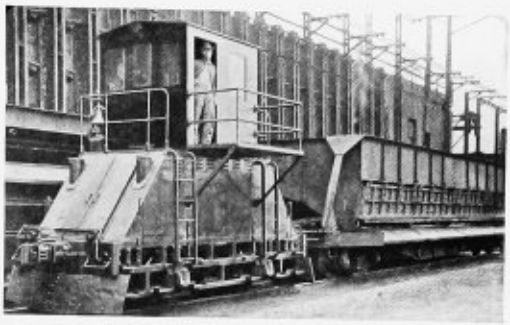
industrial type trolley locomotive is applicable. Where outdoor service is required, some form of protection must be provided for the motorman, and this is admirably taken care of by the heavy sheet steel, wind and rain-proof cab as applied to Westinghouse-Baldwin locomotives. Furthermore, where climatic conditions make them necessary, electric cab heaters can be furnished. This allows all-day operation of the locomotives in zero weather with no discomfort to the motorman. The illustrations indicate the wide applications of these locomotives and the many industries in which their economy is appreciated.

QUENCHER LOCOMOTIVES

The quencher locomotive is a noteworthy example of a special application having been developed for by-product coke plants. The operating requirements of such a locomotive are most exacting. This service demands of a locomotive the ability to perform a predetermined schedule with faithfulness and clocklike precision. The Westinghouse-Baldwin Companies have produced a quencher locomotive which does keep the coke plant pulse throbbing.

The work done consists of pushing one or more quencher cars under the doors of the coke ovens where they receive the discharge of the white hot coke—thence to the quenching station where the coke is deluged with water, and thence to the coke wharfs where the cooling is completed. In addition, opening and closing the doors of the quencher car are done by compressed air supplied and controlled from the locomotive. It is obvious that the locomotive is the key to continuous operation of the plant, and that all parts must be absolutely reliable. For this reason, the compressor equipment is furnished in two units, either of which has sufficient capacity to furnish the necessary air for operating the quencher car doors, locomotive brakes, and control switches.

The locomotives built for this service are virtually heat and water-proof, using standard mine type motors, electro-pneumatic control and having a high steel cab with windows on all sides which permit the operator to see signals above the clouds of smoke and steam which arise from the quencher car.



Quencher locomotive in operation at an Alabama by-product coke plant. The air compressor equipment is in duplicate so as to give continuity of service in case of accident

PUSH POLE LOCOMOTIVES

Another eminently successful application of the electric locomotive is pushing and spotting railroad cars in yard and dock service. It will be noted from the illustration that the essential features of locomotives of this type are end steel cab, long wheelbase, and two air-operated pusher arms with which one or more standard freight cars may be pushed on an adjacent track on either side. These locomotives usually weigh about 25 tons and are equipped with straight or automatic air brakes, air also being used for the lowering and raising of the pusher arm. Electro-pneumatic control is frequently used and though it has many advantages to recommend it, electromagnetic or hand control can be furnished if desired.

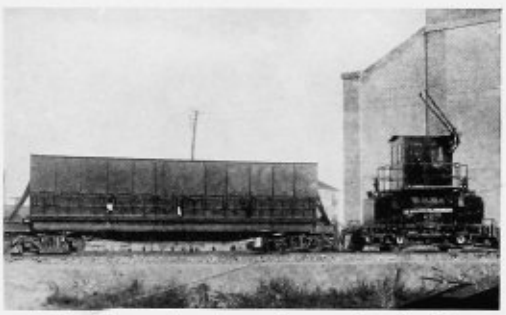
The installation of these locomotives in the service indicated has invariably resulted in the handling of more cars in a given time, quicker and more accurate spotting of cars, relief from yard congestion, and less expense for engine crew wages.

25-ton push-pole locomotive with air operated arms in use on lake ore docks. The use of these locomotives invariably results in relief from yard congestion and a saving in engine crew wages

Special platform type locomotive with center cab, built for a Pennsylvania steel company. This locomotive is used for hauling ingots and semi-finished steel between departments

25-ton haulage locomotive pulling ore cars from underground tunnel to the mill of an Arizona copper company

An industrial storage-battery locomotive used in yard haulage at the plant of a large Washington lumber company. There is no fire hazard with this type of locomotive



A Barsteel quencher locomotive operating in a by-product coke plant in Spain. The high cab and double air compressor capacity distinguish this type of locomotive

DETERMINING THE PROPER LOCOMOTIVE FOR THE SERVICE

TO correctly choose a locomotive suited to a particular mine or industrial service, the following data should be available, for each item is a factor in the problem:

Weight of empty car
Weight of loaded car
Number of cars per trip, (average and maximum)
Average length of round trip
Number of trips per day
Hours worked per day
Maximum grade and its length in favor of or against load
Average grade in favor of or against load
Gauge of track
Minimum curvature of track
Weight of rail
Power available
Limiting dimensions

The locomotive weight required by the worst grade conditions should first be determined. This may be found by the formula:

$$W = \frac{L\,(R + G + C)}{20P - (G + C)}$$

where W is the required weight of the locomotive in tons

L is the weight of the trailing load in tons.
R is the frictional resistance of the load in pounds per ton.
G is the grade resistance in pounds per ton.
C is the curve resistance in pounds per ton.
P is percentage of adhesion.

R is determined by the type and weight of car, the kind of bearings, and the condition of track. Where test values of the particular car are not available, it is customary to assume 30 pounds per ton for mine cars up to 3 tons capacity; 15 to 20 pounds per ton for larger mine cars; and 7 to 10 pounds per ton for standard freight cars. G is 20 times the per cent grade. C is .5 to 1 pound per ton per degree of curvature depending on the wheelbase of the car. Curve resistance may usually be neglected in mine applications as the curve is usually much shorter than the train. The value of P is 20 for cast-iron wheels and 25 for steel-tread wheels.

Where the grade is in favor of the load, the locomotive weight required to hold the train on the down grade may be the determining factor. In this case the curve resistance is neglected. The formula then becomes

$$W = \frac{L\,(G - R)}{20P - G}$$

As a matter of safety for braking, P should be taken at 18 for cast-iron wheels and 20 for steel.

Where grades are light, the weight of locomotive required to accelerate the train may be the determining factor. This is obtained from the formula,

$$W = \frac{L\,(R + G + C + A)}{20P - (G + C + A)}$$

where A is accelerating resistance. This is usually taken as 100 pounds per ton for acceleration at the rate of 1 mile per hour per second, and the rate of acceleration required in mining service is .1 to .2 miles per hour per second, making A equal 10 to 20. The value of P during acceleration may be taken as 25 for cast-iron wheels or 30 for steel-tread wheels. It will be seen that, where G is large with respect to A, the increase in allowable adhesion during acceleration will more than compensate for the inclusion of A in the formula so that acceleration need be considered only where grades are light.

The weight of the locomotive should be checked with the weight of the rail and, if greater than shown in the table on page 32, a three-axle or a tandem locomotive should be applied. The table shows the maximum weight of two-axle locomotives recommended for various weights of rails.

When the weight of the locomotive has been determined, the motor capacity should be checked against the service. In gathering service it is very difficult to figure accurately the required motor capacity, but experience has shown that the motors on Westinghouse-Baldwin trolley type gathering locomotives have ample capacity for any gathering service. In haulage service it is desirable to check the root-mean-square current as determined from the operating schedule against the continuous rating of the motors.

The ability of the motor equipment to perform the service required of the locomotive, without overheating, really depends on the continuous

capacity of the motors at the average voltage applied to the motors. This average is 50 to 80% of the line voltage since the motors are connected across the line without resistance in series a part of the time only. Since mine motors are rated on a nominal basis of one hour at normal voltage, the continuous rating must be secured to specify the adequate motor capacity.

It is the usual practice to equip locomotives with motors large enough so that the hour-rating will not be exceeded at the rated drawbar pull of the locomotive.

$$HP = \frac{TE \times MPH}{375}$$

where HP is the horsepower at the wheel and TE is tractive effort in pounds at the wheel. TE = DBP + locomotive friction, (which is assumed at 1% or 20 T pounds), where T is the locomotive weight in tons. TE = DBP + 20 T, or since DBP with steel tread wheels is 25% of the locomotive weight or 500 T (pounds), TE = 520 T (pounds). Since mine motors are rated at the armature shaft, in order to get the motor horsepower required, add the gear loss to obtain the horsepower at the wheel. Assuming a gear loss of 5% and substituting

$$HP = \frac{520T \times MPH}{.95 \times 375} \text{ or}$$

$$\frac{HP}{T} = 1.46\ MPH \text{ or}$$

$$HP \text{ per ton per } MPH = 1.46$$

If the horsepower per ton per MPH is 1.5, the hour-rating of the motor will not be exceeded at the rated drawbar pull of the locomotive. Since the maximum adhesion on starting is approximately 33%, the maximum drawbar pull which the locomotive can exert will be approximately 33% above the rated drawbar pull. This corresponds to an increase of 25 % in motor current above that at the rated drawbar pull. Since modern mine motors will stand overloads of 100% or more during acceleration without injury, the horsepower per MPH might be considerably below 1.5 without affecting the ability of the motors to slip the wheels without injuring the motor. However, with a low ratio of continuous capacity to hour-rating, it is desirable to have the horsepower per ton per MPH 1.5 to insure a motor with sufficient continuous capacity for the service, which a mine locomotive is to be called upon to perform.

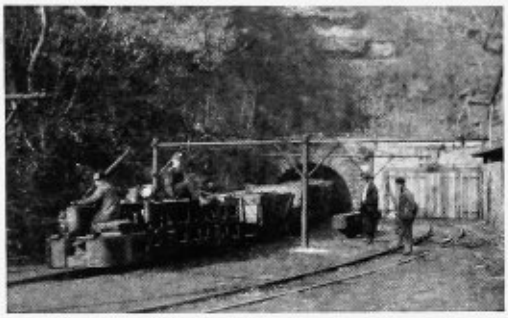
Westinghouse "900" motors were designed to have high continuous ratings, rather than high hour-ratings. As previously stated, the motors on gathering locomotives have ample capacity for any gathering service. The standard motor equipment on haulage locomotives has sufficient continuous capacity to perform practically any service required of a locomotive of the weight involved. Where exceptionally severe service conditions indicate that additional capacity is required, this can be obtained by the use of ventilated housings on the motor, or forced ventilation on the locomotive. This method of increasing the capacity is preferable to increasing the size of the motor.

In storage battery locomotive applications it will usually be found that the battery capacity rather than the weight is the determining factor. More accurate data as to service is required to select a battery for a battery locomotive than to select the proper equipment for a trolley locomotive. The battery capacity can be roughly determined from the formula:

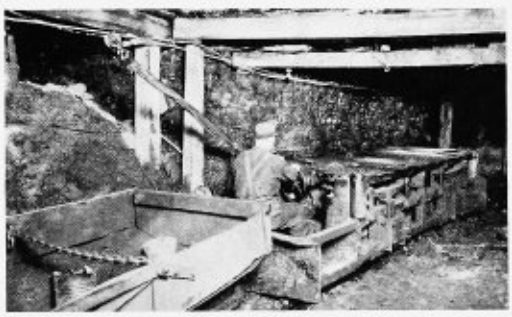
Watthours = tractive effort $\times$ .72 $\times$ distance, where distance is given in thousands of feet. The tractive effort required on the various sections of the run should be figured separately and the watthours added. The sum will determine the capacity of battery required. A more accurate check can of course be made by the use of motor curves, but the formula gives a first approximation and is usually as accurate as the data on which it is based. The weight of the locomotive required to mount a battery of the proper capacity is usually greater than that required from the standpoint of adhesion.

Storage battery locomotives are rated at 1000, 2000 and 3000 pounds drawbar pull for the 6000, 8000 and 10,000-pound chasses respectively at a speed of 3½ miles per hour. The motors have a one-hour rating equal to, or greater than, the nominal rating of the locomotive. While the horsepower per ton per MPH is less than on trolley locomotives, the motors will slip the wheels without injury to the motor. The motors have a very high continuous capacity with respect to the hour-rating and the motor capacity is greater than the battery capacity, so there is very little danger of overheating the motors in any service that the battery can perform.

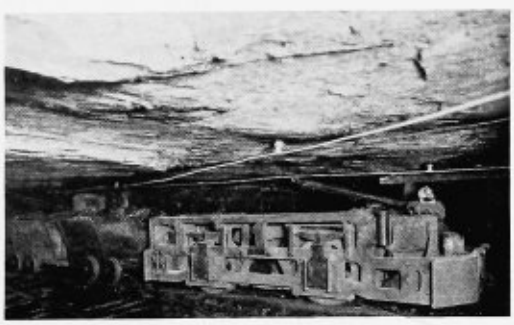
A 15-ton Barsteel locomotive hauling coal out of a drift mine in New Mexico. A feature of this type of locomotive is its low maintenance



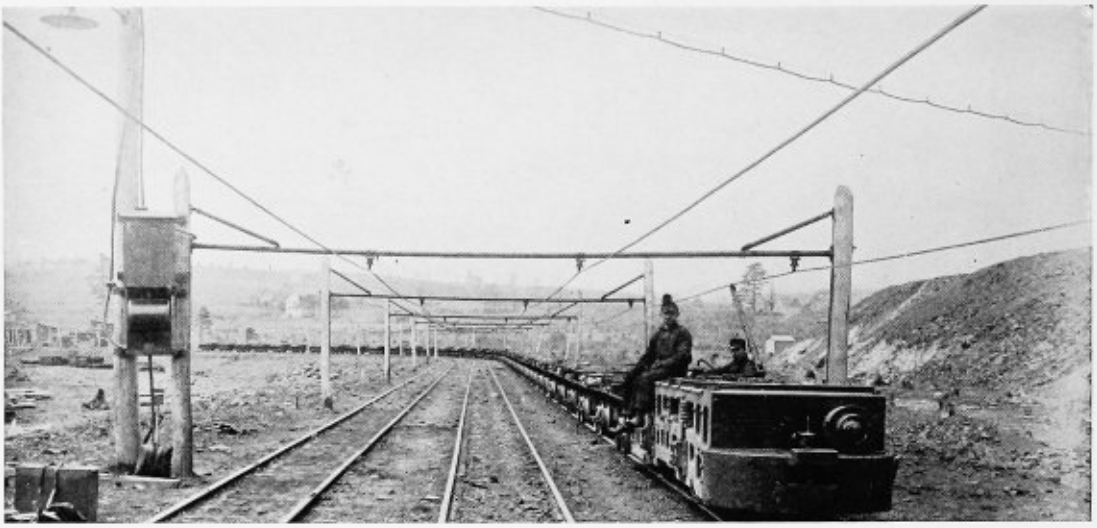
A 20-ton locomotive operating in a drift mine in Virginia. The trolley wire installation is a feature in this mine as can be seen by the overhead construction



The wet and muddy condition of this mine is typical of the kind of service to which some mine locomotives are subjected



A 15-ton haulage locomotive in a western Kentucky coal mine. This illustration shows the solid construction of Barsteel locomotives



RECOMMENDATIONS FOR NEW OR RECONSTRUCTED INSTALLATIONS

IN conformity with the most recent recommendations of the American Mining Congress, all coal-mining operators and industrial plant managers are urged to install in all new work, where possible, a track gauge of 42 in. and curves having a minimum radius of 28 ft. Recognition of these recommendations will, for obvious reasons, react to the mutual benefit of both purchaser and manufacturer.

Recommendations for rail installations for various sizes of locomotives are as follows:

Weight of Locomotive in Tons	Weight of rails in pounds per yard
4 to 6	16
6 to 8	20
8 to 10	25
10 to 13	30
13 to 15	40
15 to 20	50

The trolley wire installed should be of 0000 grooved copper wire, except that in entries where a single gathering locomotive is used 00 wire may be installed. In addition to the trolley wire, a feeder is usually required along the main haulage way. The size of feeder will depend on the length of haul and the load, or current. It should be large enough so that the voltage drop, including the drop in the rail return is below 20%.

The method of supporting the trolley wire is, of course, determined by the mine roof, or other overhead construction which must be used for such support. In the case of a mine where the roof is poor, and cross timbers are used, the trolley suspension may be fastened to the cross timbers. Where there is a good rock or slate roof, expansion bolts can be driven in to support the suspension. Where the roof is considerably higher than desirable, iron pipes may be driven into the roof and the suspension mounted on the lower end. Feeder wire may be suspended in the same manner.

The Pennsylvania Bituminous Mine Law of 1911 requires an automatic line section switch, or section insulators with a line switch in each branch line, so that the power may be cut off in any section.

In service outside the mine, or in general industrial service, the trolley is usually supported from bracket arms or from cross bands of wire, pipe, or timbers, the feeder being carried on insulators on the supporting poles.

Most installations of trolley type locomotives consist of a single trolley wire with ground return in which case the rails are, of course, used as the return circuit. It is, therefore, important to have the rails well bonded to keep the voltage drop to a minimum. The question of the selection of the type of bond, and the method of

The overhead construction of this Virginia mine is thoroughly modern and consists entirely of Westinghouse equipment

its application is worthy of serious consideration.

There are three principal types of bond in use, viz., the tubular pin, the compression pin, and the welded bond.

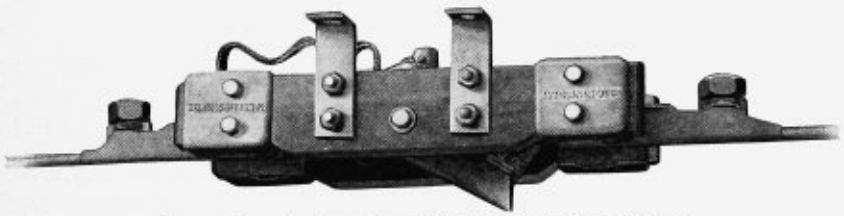
For temporary track work the tubular pin bond has the advantage that it can be removed and used over again. It does not, however, make as good a joint or maintain as good a contact as other types.

Where properly applied and expanded with a compressor, the compression pin bond makes a very good joint, and a more permanent one than the tubular pin type.

The welded bond is the most permanent type; and, when properly installed, will remain in good condition indefinitely. With proper equipment it is very easily and quickly applied, and the slight extra cost is more than compensated for by the improved voltage conditions. Experience has well established the fact that electric welded bonds are the most satisfactory because actual tests show the percentage of defective bonds to be negligible.

Welding can be accomplished by the resistance method if the trolley is the negative side of the line. While standard practice requires that the trolley be positive, it is usually possible to reverse the polarity during welding operation, but this change, of course, has no effect on the motors in the mine. However, where it is not possible or desirable to change polarity, a motor-generator welding outfit, mounted on a mine car will give very satisfactory service.

When considering welded bonds, we invite your attention to Westinghouse equipment for electric welding.



Automatic section insulator and line section switch combined. Trolley wheel of inbound locomotive closes the switch and opens it upon its return

CHARGING EQUIPMENT FOR STORAGE BATTERY MINE LOCOMOTIVES

BOTH Edison and lead-acid type batteries find an extensive field of application in the mining industry with the result that charging equipment for these batteries forms an important part of the operating equipment of mines using storage battery locomotives.

Several methods of charging these batteries are in common use, but experience has shown that for best results Edison batteries should be charged by the constant-current method and lead batteries by the modified constant-potential method.

Due to the fact that locomotives usually are operated in widely separated sections or on different levels of the mine, it is common practice to buy charging equipment with each locomotive, charging either directly from a 250–275 volt direct-current line or from a motor generator.

Westinghouse-Baldwin storage battery mine locomotives are equipped with 80-cell Edison batteries, varying in capacity from the A-4 to the A-12 and the G-7 to the G-18; or 48 cells of lead battery, ranging in size from 7 to 33 plates. Two types of equipment are available for charging locomotive batteries. One type requires an attendant to adjust the charging current from time to time; the other automatically completes the charge, disconnects the battery from the line or motor generator, and shuts down the motor generator after completion of the charge.

Before a suitable selection of charging equipment can be made, and before calculating the capacity of the motor generator required for charging purposes, it is necessary to know whether or not a boosting charge for any period of time is desired; what method of charge is to be employed; the number of cells in each battery; the number of batteries to be charged simultaneously; and the time available for charging.

For automatically charging from 60 to 80 cells of Edison battery in series, by the constant-current method, the Westinghouse Company builds a line of induction motor generators having differentially wound, inherently regulating, constant-current generators, for any capacity of battery listed. These sets will give a single battery a proper charge in a satisfactory and very convenient manner. Motors for these sets, operating at 1750 RPM, may be obtained for 220 or 440 volts, 2 or 3 phase; and for 550 volts, 3 phase, 60 cycle.

KD-1 PANELS

For the control of the differential generators or for an incoming 125-volt direct-current line, there is a KD-1 line of switchboard panels, which are automatic in their operation and which provide overload, low-voltage and reverse-current protection. They are also designed for shutting down the set or disconnecting the battery from the line at the completion of charge. These panels are fully described and illustrated in our Annual Supply Catalog.

For charging lead batteries from either shunt or compound-wound generators by the modified constant potential method, the panels are the same as those used with Edison batteries except no rheostat face plate is necessary, as the charging resistance is fixed. When used with a D.C. generator, the voltage of the machine may be adjusted so that even a fixed resistance will not be required unless the generator is supplying a load which will not permit of voltage variation by the field rheostat. All automatic features are embodied in these panels, regardless of whether power is supplied by a motor generator or an incoming line.

SAFETY-FIRST PANELS

The safety-first panels, known as the type SF, have been designed for charging single batteries from a generator or incoming direct-current line. They meet the demand for a panel providing not only protection against accidental contact with live parts but also protection of the equipment from dripping water and falling dirt from the mine roof. The mechanical features of this type of panel include:

(1) Live parts totally enclosed in a steel cabinet having an expanded-metal door, which permits of visual inspection of parts without opening the cabinet door.

(2) Charging resistor and field rheostat, totally enclosed by grill work.

(3) Meters mounted on a panel directly above the cabinet. This permits the operator to read both current and voltage directly. The generator field rheostat hand wheel is also mounted on this meter panel.

(4) A sheet-metal covering over the entire equipment for protection against dirt and dripping water.

(5) Complete unit mounted on iron framework, making it compact and portable.

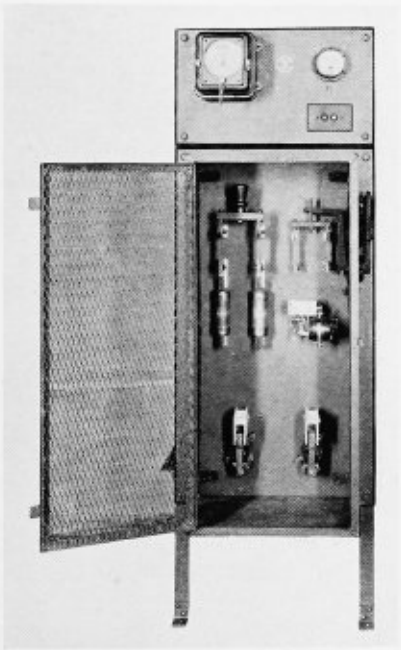
(6) Charge started by merely pressing push button mounted on meter panel.

Electrically, these panels have the same features as the KD-1 line, and provision is made for disconnecting the battery from the generator or line, or the motor generator from the line at the completion of the charge.

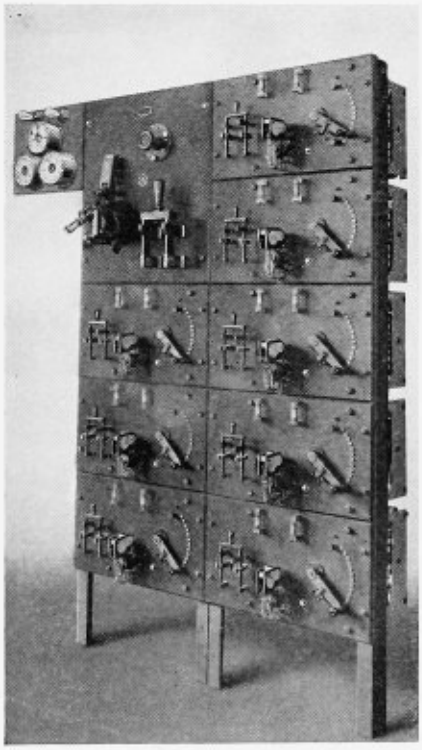
SD PANELS

The SD line of panels has been designed to take care of charging several batteries at one time. They can be supplied for either automatic or non-automatic operation depending upon the desire of the user. The non-automatic panels, which cost considerably less than the panels providing the automatic features, are fully described in our Annual Supply Catalog.

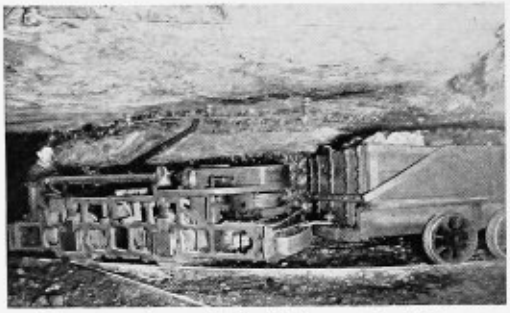
Where conditions in a mine are such that all locomotives can be brought to one point for charging, these panels find their particular field of application. It is possible to add charging sections from time to time, as more battery locomotives are installed, which makes the equipment very flexible. The panels are also very compact, since it is usually possible to mount the necessary charging resistors directly on the rear of the panel.



Safety-first panel with push button control for starting; charging is automatically stopped when completed

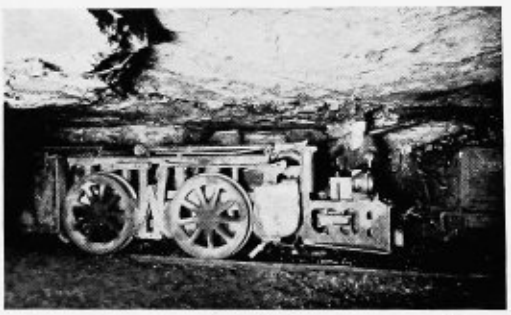


Several batteries can be charged at the same time with this type SD charging panel

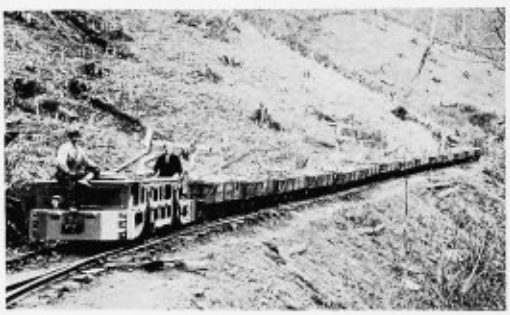


A 6-ton traction reel gathering locomotive is shown leaving the room neck with a loaded car in a West Virginia coal mine

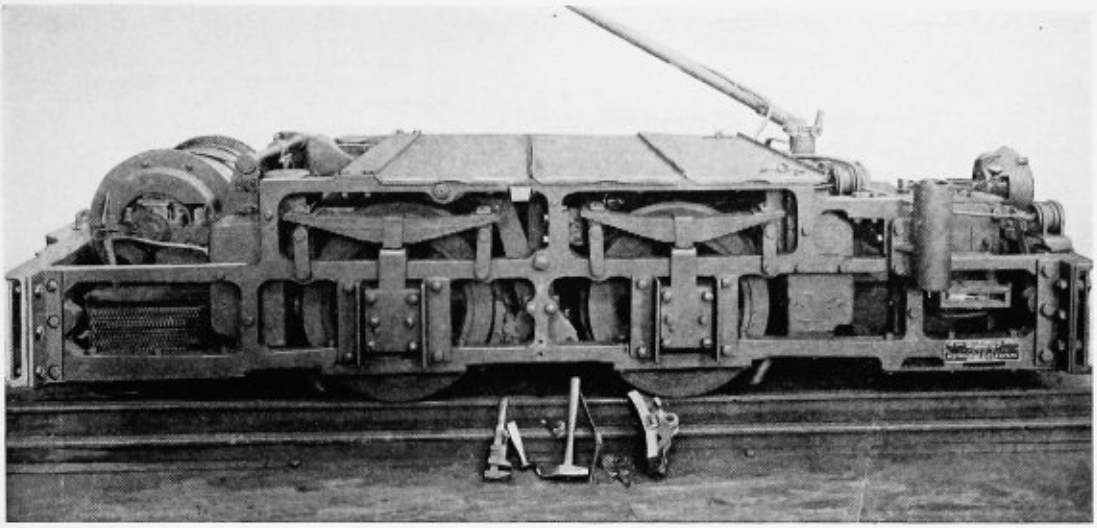
A 6-ton locomotive hauling cars in an anthracite mine in eastern Pennsylvania. The locomotive is equipped with a standard Westinghouse spring-supported headlight



Inside-frame locomotives of this type are generally used in narrow-entry mines. This locomotive, hauling coal in a West Virginia mine, is equipped with 2 trolley poles and especially large sand boxes



This locomotive has been in continuous operation for 14 years, hauling heavy loads up steep grades. Forced ventilation which increases the continuous capacity of the motors is particularly desirable here



MAINTENANCE AND RENEWAL PARTS INFORMATION

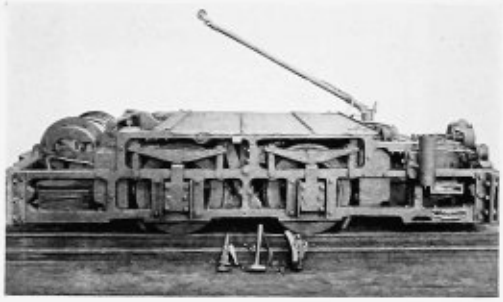
WESTINGHOUSE-BALDWIN locomotives have incorporated in their design all possible features tending to facilitate proper maintenance with the least effort on the part of the purchaser. From the standpoint of continuous operation this is of the first importance, but proper maintenance of the locomotive after it is placed in service is nearly as important, and this must necessarily be the purchaser's responsibility. The Westinghouse Company has issued instruction books 5183 and 5144 giving instructions for the care and operation of the storage battery and trolley locomotives respectively. Every motorman should read one or both of these instruction books in order to know the manufacturer's recommendations regarding proper maintenance.

To make necessary renewals of worn parts with a minimum loss of time, certain parts of the locomotive which are subject to wear and renewal should be carried in stock; the amount or extent of the stock depends upon the number of locomotives of the same type in use, the distance of the purchaser from the market or base of supply and the machine shop facilities and equipment available. The following lists cover

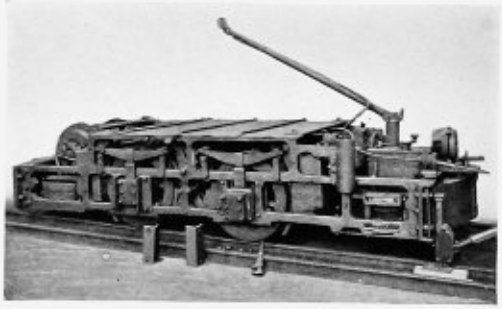
Armature coil

Main field coil

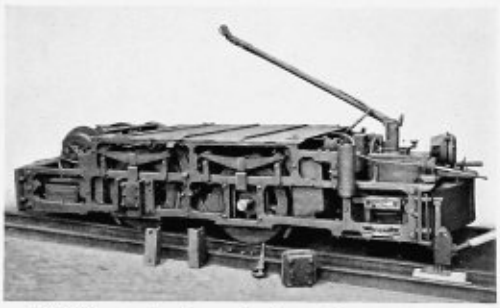
Commutating field coil



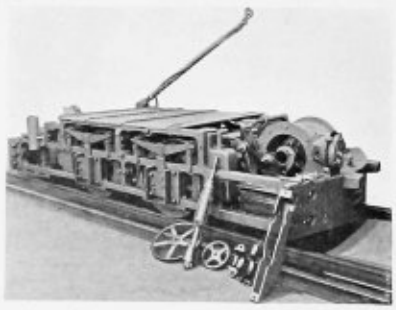
This illustration shows how easily a brake shoe may be removed and the few tools required



A jack and a monkey-wrench are the only tools required to remove the journal boxes



This illustration shows the journal boxes removed



In order to dismantle the drum reel, only a few parts need be removed; it is not necessary to remove the reel from the locomotive

the recommendations of the Westinghouse-Baldwin engineers for a supply of renewal parts under ordinary conditions:

RECOMMENDED RENEWAL PARTS TO CARRY IN STOCK

ELECTRICAL

(Per Locomotive)

1 Set armature coils
1 Main field coil
1 Commutating field coil
1 Set axle bearings
1 Set armature bearings
½ Set controller fingers
1 Set main drum contacts
1 Set brushes per motor

Where there are several locomotives with the same motor equipment, an armature complete with housings will greatly reduce delay in case of any armature trouble.

MECHANICAL

Gears and pinions
Driver journal boxes
Driver journal brasses
Brake shoes
Driver springs
Brake beam nut
Pair of wheels and gear on axle
Motor suspension springs
End thrust wearing plates for journal box covers

HEADLIGHTS

Lamps
Headlight glass
Headlight resistance
Headlight switch

TROLLEY

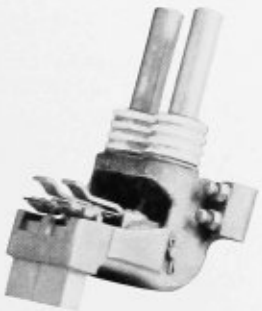
Poles
Stationary contact block and protection cap
Movable contact block
Trolley wheel
Trolley harp
Trolley wheel axle pin
Contact spring and washer
Pole head and swivel stud

GATHERING REEL

Armature pinion
Countershaft pinions
Armature bearings
Guide porcelains
Guide tongues
Lead screw
Cable
1 Set brushes

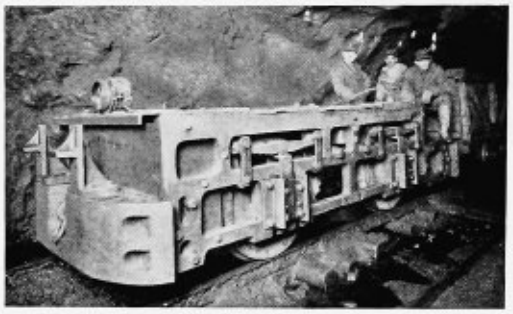
RENEWAL PARTS FOR MINING MOTORS

The Westinghouse mine motor parts tabulated are subject to wear or deterioration and must be renewed from time to time, even though these parts are designed to give maximum life and accessibility. Part catalogs are furnished with the locomotives which give information for ordering renewal parts.

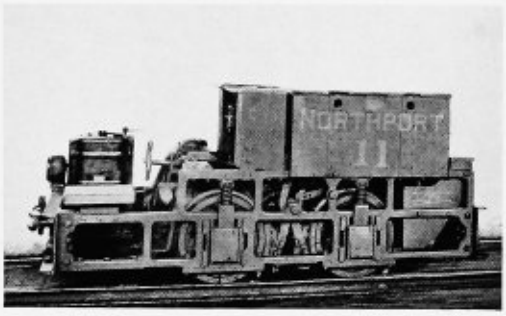


Standard brushholder

Axle bearing

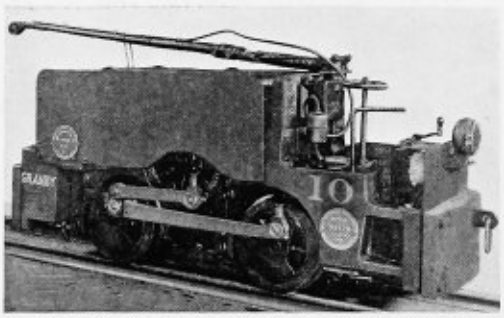


An 8-ton Westinghouse-Baldwin locomotive operating in an anthracite coal mine

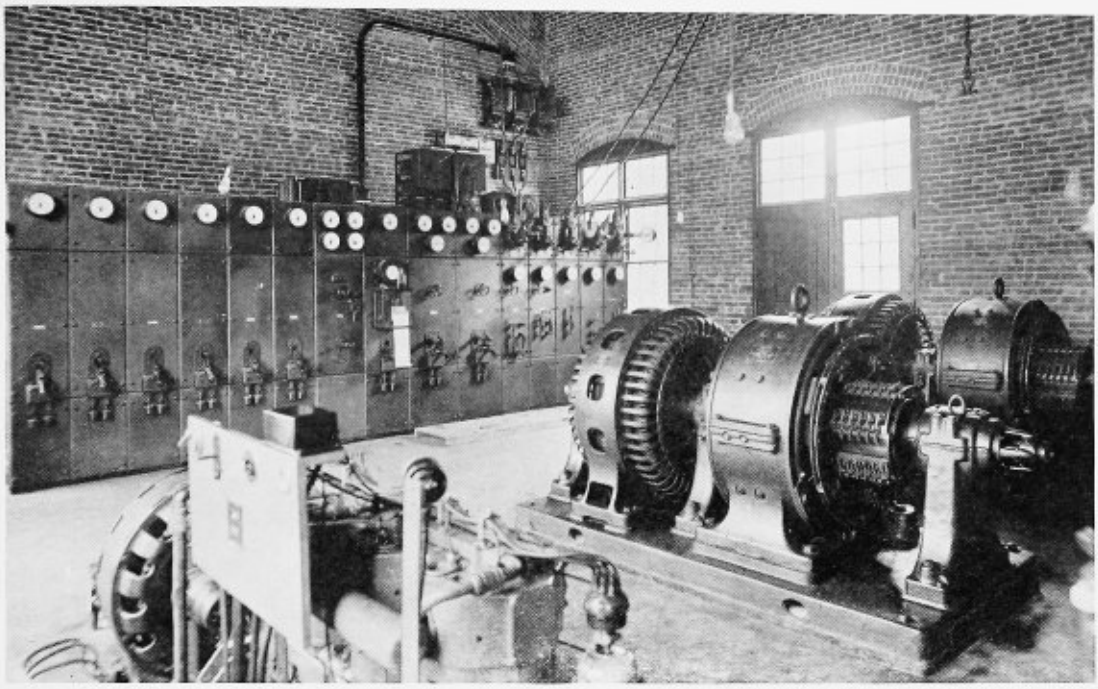


A special light-weight storage-battery locomotive for metal-mine service

Standard storage battery locomotive operating in a northern Michigan copper mine



This early design of mine locomotive has what is known as the "Hockey Stick" drive



AUXILIARY EQUIPMENT

MINE SUB-STATION EQUIPMENT

THE Westinghouse Company has designed a complete line of synchronous motor generators and synchronous converters for mining sub-stations.

To meet mining conditions, generating equipment must have sufficient capacity to meet the momentary and sustained peak loads characteristic of this service. The synchronous motors are designed to operate at 80% leading power factor and both units of the motor generator are designed to carry 1½ times full load current for two hours after carrying full load continuously for 24 hours. The synchronous converters are also designed to meet the exacting conditions of mining service and carry the same overload guarantees. Both the motor generators and synchronous converters are furnished with pedestal type bearings.

Switchboards for control of the generating equipment are a necessary part of the sub-station units. These switchboards may be either the hand or automatically operated type.

The present day tendency is toward the automatic type of control. There are a number of reasons for this, among which are:

1. It eliminates the cost of one operator per shift.
2. It assures the minimum interruption to the service with the maximum protection of equipment.
3. It gives more adequate protection to the equipment than does a manually operated sub-station, thereby lessening the liability of an expensive shut-down for repairs.
4. It makes practicable the location of the sub-station near the center of the load, which is not feasible in the case of a manually operated sub-station. This location not only means a saving in feeder copper, but usually results in better voltage regulation with a consequent increase in mine output.

The Westinghouse automatic switching equipments are not only highly reliable but are also

simple and compact. These equipments duplicate mechanically all hand operations without the ever-present danger of damaging the equipment. In addition to this there are unusually complete protective devices furnished to safeguard the apparatus from injury wherever faults arise inside or outside the sub-station, and at the same time assure the least interruption to the service, consistent with adequate protection.

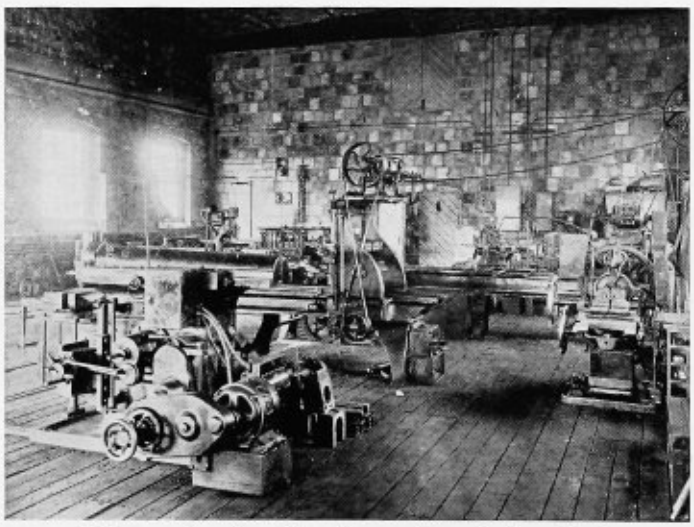
REPAIR SHOP EQUIPMENT

The locomotive barn where locomotives are kept at night, either inside or outside the mine, should have a pit and be equipped with a chain block or small crane. It may often be combined to advantage with a machine shop and electrical repair shop. They should all be well lighted and kept clean.

The tool equipment necessary will depend on the size of the mine and the extent of the repairs attempted, but should at least include a general utility lathe, drill press, forge, anvil, pinion puller, ball-bearing puller, wrenches and other necessary small tools. Necessary space and bins should be provided for a stock of renewal parts. It is also generally advisable to have a wheel lathe and press.

If armatures are rewound in the electrical shop, there should be an oven for drying and baking the armature after it has been rewound and dipped in the black flexible insulating compound. A valuable addition is an armature testing equipment to test for open and short circuits in the rewound armature. An insulation testing set is also desirable.

To properly maintain apparatus, to make minor repairs, and to do emergency work of a more serious nature, this much equipment is certainly essential. For large mines, and for complete insurance against delays due to breakdowns, more extensive equipment is needed.



Modern repair and machine shop at a Pennsylvania coal mine

SERVICE AVAILABLE

THE Westinghouse Company maintains throughout the United States large warehouses for apparatus. These warehouses are also well stocked with renewal parts for the various types of mine and industrial locomotives. These stocks are of great value to the purchaser when the necessity arises for replacing wearing parts because such service saves time and may prevent serious loss of production.

As previously mentioned, a force of engineers, experts in various locomotive applications, is employed by the Westinghouse Company and by the Baldwin Locomotive Works. When the user contemplates purchasing apparatus from the Company, the services of these men are available to assist in selecting the correct apparatus for his particular application.

It is the policy of the Westinghouse Company to sell the purchaser only such locomotives or auxiliary apparatus, as they believe will give satisfaction. Owing to the variety of types and designs manufactured, the judgment of the engineers is in no way restricted, and they, therefore, are able to select the equipment which represents the best practice for the particular application under consideration.

The Company's Works at East Pittsburgh, Pa.

WESTINGHOUSE PRODUCTS

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

For Industrial Use

Instruments

Motors and controllers for every application, the more important of which are: Machine shops, woodworking plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.

Welding outfits

Gears

Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.

Lighting systems

Safety switches

For Power Plants and Transmission Lines

Circuit-breakers and switches
Condensers
Controllers
Control switches
Frequency changers
Fuses and fuse blocks
Generators
Insulating material
Instruments
Lamps, incandescent and arc
Lightning arresters
Line material
Locomotives
Meters
Motors
Motor generators
Portable power stands, 110 volts
Rectifiers
Regulators
Relays
Solder and soldering fluids
Stokers
Sub-stations, portable and automatic
Switchboards
Synchronous converters
Transformers
Turbine-generators

For Transportation

Locomotives
Railway equipment
Marine equipment

For Mines

Automatic starters and controllers
Battery charging equipment
Lamps
Locomotives
Motors for hoists, pumps, and tipples or breakers
Motor generators
Portable sub-stations
Switchboards
Synchronous converters
Transformers
Line material
Ventilating outfits
Welding outfits

For Farms

Fans
Household appliances
Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit-cleaning machines and sorting machines.
Generators for light, power and heating apparatus.
Portable power stands, 32 volts
Radio apparatus
Transformers

For Office and Store

Electric radiators
Fans
Arc lamps
Incandescent lamps
Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.
Ventilating outfits

For Electric and Gasoline Automobiles and the Garage

Battery charging outfits
Charging plugs and receptacles
Lamps
Instruments
Motors and controllers
Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.
Solder and soldering fluids
Starting, lighting and ignition systems, embracing: Starting motors, generators, ignition units, lamps, headlights, switches, etc.
Tire vulcanizers

For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.
Automatic electric ranges
Fans
Incandescent lamps
Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players.
Sew-motors

Westinghouse Electric & Manufacturing Co.

EAST PITTSBURGH, PA.

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ALBANY, N. Y., Journal Building.
ATLANTA, GA., Candler Bldg., 127 Peachtree St.
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BOSTON, MASS., Rice Building, 10 High St.
BUFFALO, N. Y., Ellicott Square Bldg., Ellicott Square.
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CHARLOTTE, N. C., Commercial Bank Bldg., Rooms 409-10-11.
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The Hawaiian Electric Company, Ltd., Honolulu, T.H.—Agent.

*Government business exclusively.

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CANADIAN COMPANY

CANADIAN WESTINGHOUSE COMPANY, LTD., Hamilton, Ontario

Westinghouse Electric International Company

165 BROADWAY, NEW YORK, U. S. A.

MAIN WORKS: East Pittsburgh, Pa. **EUROPEAN OFFICE: No. 2 Norfolk Street, Strand, London**

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