Railway Shop Up To Date

Chapter X

POWER PLANT

THE power plant of the modern railway shop has been developed into one of its most important features. Until about fifteen years ago power for a railway shop was generated in several boiler and engine rooms situated at different points about the shop plant. At some shops a single boiler house provided steam for several engines situated at different points. The latter were usually located in annexes to the principal shop buildings and belted to line shafts At a number of shops built within a later period this same practice was followed in providing for the distribution of power. It is only within comparatively recent years that a single power house has been installed as the center of generation and distribution of all power for a railway shop plant.

The introduction of electrical equipment into railway shop operation has brought about the concentration of all power, generating apparatus in a single building. It is now the universal practice to generate power at one central point and distribute electrical power to the various points of consumption. A plant capable of developing all power necessary for the operation of the entire shop is located as near as possible to the theoretical center of distribution. All power for driving machines and for providing artificial light, is led from this central plant to the various buildings by electric current.

The railway shop power plant of to-day exemplifies a state of development representative of the best engineering skill and experience. The character of the building in which the power generating apparatus is housed indicates careful design, and illustrates a practical provision for the peculiar requirements which the plant must meet. The details of the steam, mechanical and electrical apparatus are worked out to advantage and it may be said that the building with its equipment and machinery is but a complete machine for the generation of power and for the delivery of power to the transmission lines.

LOCATION.

The location of the power house should be as near as possible to the center of distribution, determined by the power consumption of the machinery in the various shop buildings. The point of greatest consumption is the locomotive machine shop and next in order is the planing mill.

The refuse produced by the planing mill is commonly delivered to the power house where it is used as fuel for at least a portion of the boiler equipment. In view of the large bulk of the shavings, etc., its economical delivery represents a considerable factor in expense. By situating the power house near the planing mill, refuse from the lumber passing through the machines is delivered by a system of air ducts direct from the floor of the mill to a vault in the power house and from the vault the shavings are led to the grates beneath the boilers as required.

BUILDING.

It is generally considered that architectural embellishment is out of place in connection with any of the buildings of a railway shop plant. The power house is made to conform to the general architectural scheme of the other buildings, yet it is usually more attractive and pleasing in its appearance. Being a comparatively small building and at the same time a very prominent one, additional care in improving its appearance does not seem out of place.

The power house is usually a rectangular building, and almost square. The material is generally the same as that of the other buildings of the plant and is most commonly brick. The power house at the Elizabethport shops of the Central Railroad of New Jersey is of concrete and in keeping with the other shop buildings at that point.

The building is usually divided longitudinally by a wall extending the full length. Occasionally this dividing wall is built transversely. This provides separate rooms for the boilers and engines.

The roof is generally supported by steel trusses, resting on the side walls, which are sometimes reinforced by pilasters, but the trusses are occasionally supported by independent steel columns tied to the walls for stability.

The roof usually slopes outward from the dividing wall to the exterior side walls. This is reversed at the Milwaukee power house of the C., M. & St. P. Railway where the roof slopes inward toward the dividing wall.

The modern power house is well lighted, a large proportion of the walls being given to the windows. Ventilation is provided for by a monitor over the roof of each room.

The height of floor above grade varies and seems to follow no general rule. The more common arrangement is with the floor of the boiler room on a level with the ground and the floor of the engine room several feet higher. In some cases both are on the ground level and occasionally both floors are on the same level and elevated above the ground.

It is now very common practice to provide a basement beneath the engine room to accommodate auxiliary apparatus, exhaust piping, etc., and in a few instances live steam pipes are carried in the basement.

The provision of a basement beneath the boiler room depends on the arrangement of the coal and ash handling equipment. In some plants each is delivered to a conveyor system beneath the floor and sometimes a commodious tunnel is provided for this purpose.

The dimensions of power houses naturally vary at different points and it is interesting to note the sizes of several prominent ones. The power house at Topeka, A., T. & S. F., Ry., is 176 feet by 57 feet 4½ inches; at Du Bois, B., R. & P. Ry., 90 feet by 60 feet; at Angus, C. P. Ry., 160 feet by 100 feet; at Danville, C. & E. I. R. R., 100 feet by 90 feet; at Milwaukee, C., M. & St. P. Ry., 100 feet by 97 feet; at Silvis, C., R. I. & P. Ry., 154 feet 6 inches by 104 feet 11 inches; at Elizabethport, C. R. R. of N. J., 118 feet by 101 feet; at Collinwood, L. S. & M. S. Ry., 132 feet by 85 feet; at South Louisville, L. & N. R. R., 141 feet 4 inches by 110 feet; at Reading, P. & R. R. R., 175 feet by 112 feet; at McKees Rocks, P. & L. E. R. R., 100 feet by 75 feet.

While the rule is not followed without exception, the boiler room is usually of the same dimensions as the engine room, the interior of the building being divided equally by a longitudinal wall. At Topeka, the building is divided by a transverse wall and the building is long and narrow as compared with other power houses. This is probably due to the rather limited space which could be allotted to the power house.

The longitudinal division is considered more satisfactory as providing for a shorter distance between boilers and engines and thus requiring shorter piping connections.

The modern engine room is universally served by an overhead traveling crane serving the entire floor and operated by hand from below. The crane is usually of about 7½ or 10 tons capacity, though in rare cases this has been increased to 20 tons.

Feed water pumps, heaters, fire pumps, and other auxiliaries are frequently provided for in the basement beneath the engine room, thus removing them from plain sight and at the same time locating them where they will be free from the dust and dirt of the boiler room.

COAL AND ASH HANDLING EQUIPMENT.

Coal and ash handling equipment vary in degrees of development in the railway shop power plant. At many prominent shops, however, very complete automatic systems of handling coal and ash are in service and no manual handling of coal is necessary from the time it leaves the car on which it is delivered until reaching the grates.

The method by which fuel is handled from the car to the grates is a very essential factor in the operation of the power plant. Owing to the comparatively cheap cost of fuel to a railroad company and the small expense for delivery, the price of fuel delivered to the outside of the power house is not great. This, however, does not represent the entire cost of the fuel. The final cost includes all the expense of handling coal between the delivering cars and the grates, in addition to the expense of removing and disposing of a proportionate amount of ashes. Therefore the more economical the method of handling coal after it leaves the car the cheaper the cost of fuel. As the amount of coal used is from ten to twenty times the weight of the ashes to be removed, it is more economical to provide for handling the coal cheaply. Nevertheless the amount of ash to be disposed of is an item sufficiently large to justify economical methods of handling it as well. Those plants having complete automatic systems for handling coal, usually handle ash with the same apparatus, using separate hoppers for its temporary storage.

At those power plants containing the most modern equipment, mechanical stokers are generally employed to reduce the fire room force, and it is desirable to chute coal down from storage bins overhead to the stoker hoppers. Even with hand firing, it is more desirable to chute the coal in a similar manner, rather than to have it shoveled into cars or wheel barrows and dumped in front of the boilers or shoveled from the cars direct to the grate.

The chutes or spouts by which coal passes down from the storage hoppers overhead should be designed to avoid clogging Coal, like gravel, has a tendency to form arches between the walls of the chute through which it is passing and when this occurs it is necessary to clear the chute by poking the coal from time to time. Square chutes are less liable to become clogged than round ones, and the larger the pipe, the less the liability to clog.

The most common system for the delivery of coal to overhead storage hoppers is the bucket conveyor system. It is possible to provide for horizontal and vertical runs for the conveyor system and this system lends itself most readily to railroad shop power plant conditions.

A feature of this system which is likely to produce a failure is the high fibre stress to which the pins are subjected. Continued care is necessary to guard against the pins being cut to a dangerous degree within a comparatively short time. For this reason automatic clutches have been recommended to hold the conveyors in case of an accident or failure.

By the conveyor system, coal is dumped from cars standing on a track adjacent to the power house, into a receiving pit. From this it is led by a gravity feed conveyor to a crusher. Coal from the crusher either falls directly into the buckets of the conveyor system, or falls into a hopper and then to the buckets. An endless chain bucket conveyor then hoists the coal to the upper portion of the building and dumps it into storage bins located above the boilers, from which it is led by chutes to the stoker hoppers.

A few concrete examples will best serve to illustrate the methods of handling coal and ash in the railway shop power houses of to-day.

COAL AND ASH HANDLING EQUIPMENT AT DANVILLE, C. & E. I. RY.

At the Danville shops of the Chicago & Eastern Illinois Railroad, the floor of the boiler room is on the ground level and along one wall of this room the coal bunkers are arranged. As originally constructed the bunkers were of such height that coal could be shoveled by hand from cars standing on the track alongside. Provision has been made for the arrangement of tracks over the bunkers in order to dump coal directly from hopper cars.

The bottoms of the bunkers are hopper shaped and the delivery of coal from them is controlled by gates operated by a shaft and hand wheel, the latter being arranged in the boiler room within reach of the fireman. Coal from the bunkers is delivered into hand cars which may be drawn forward to positions accessible to the firing doors. From the cars coal is fed directly to the grates by hand.

Ash is handled by a telpher system. Directly in front of the ash doors is a trench of such width as to accommodate a specially designed bucket. When this bucket is lowered into the trench ashes are drawn from the ash pits to the bucket. When filled the bucket is drawn up by a motor and conveyed along an overhead track through a door in the wall of the boiler room and dumped directly into a car placed on a switch track near the boiler room, to receive ashes.

COAL AND ASH HANDLING EQUIPMENT AT COLLINWOOD, L. S. & M. S. RY.

At Collinwood, on the Lake Shore & Michigan Southern Railway, the automatic system of handling coal and ash is very complete and the labor necessary in the boiler room is reduced to a minimum. The coal storage pockets and ash bins are of steel and concrete, built permanently into the upper portion of the boiler room. The coal pockets are supported upon 21 inch built up plate girders, 18 feet 6 inches long, which extend from steel posts set in the wall of the boiler room to similar steel posts located between the boiler settings. Upon these girders rest special triangular shaped plates arranged to support the sloping portions of the base of the bin, these portions being built up of 9 inch 18 lb. I beams laid longitudinally and filled in between with concrete. The ends of the trough shaped bottom of the bunkers are so constructed as to slope from the edge of the stoker feed holes to the end walls, preventing the accumulation of coal at the ends. These end portions are of similar construction as that described for the sloping base. The side and end walls of the pockets are built up of 8 inch 18 lb. I beams with solid concrete filling between them.

The ash bin is similar in construction to that of the coal pockets, with the exception of being smaller and of different shape. The entire base slopes in one direction, at an angle of 45°, toward the outer wall of the boiler room. The lower end of the base terminates in a chute extending through the wall and having a 24 inch clearance. The outer end of the chute terminates in a lip hinged to the wall and so counter-weighted as to swing up and down easily. When raised up, the lip acts as a door to close the chute, and when down, as a trough for delivery to a car placed on an adjacent track.

Coal is delivered to the power house by dumping direct from the car into a pit located outside of one corner of the boiler room. This pit is directly underneath the side track which extends along the side of the boiler room and from this pit coal enters the conveyor system. The pit contains a receiving hopper of ¼ inch steel plate, which receives coal as it is dumped from the car and directs it into a short auxiliary open feed conveyor, carrying it to the crusher and main conveyor within the boiler room basement. The open feed conveyor discharges the coal into a hopper feeding into the coal crusher and the crusher breaks it up, if necessary, to the size required for the stokers. After leaving the crusher the coal drops into a hopper below, from which it is fed into the main bucket conveyor system for delivery to the coal pockets above.

The open feed conveyor feeds into the crusher's hopper in regular quantities, avoiding clogging or overloading the crusher. The crusher is of a very heavy pattern, 24 inches by 24 inches in size, with a solid tooth roll. Both the crusher and the apron feed conveyor are run by a 22 horse-power electric motor. The main conveyor is of the pivoted bucket type, consisting of malleable iron buckets, 18 inches by 24 inches in size, pivoted to two strands of 24 inch pitch chain, which is fitted with self oiling flanged rollers for running on the conveyor track. The buckets have overlapping ends, thus forming a continuous trough, which does not open anywhere in transit except when on vertical section of conveyor track or when passing the dumping carriage, and thus does not require a feeder hopper. The dumper carriage is a tripping mechanism arranged below the conveyor track over the coal pockets, which will dump the pockets as they pass. The dumper carriage may be placed at any location over the pockets for dumping and filling the section desired, its position being adjustable from the boiler room floor.

This main conveyor provides for the removal of ashes from the furnaces. Ash pits of bowl shape are located in the boiler foundations below the stokers from which the ashes may be scraped into the conveyor passing in front. By properly adjusting the dumper carriage over the ash bin above, the conveyor buckets dump their contents into the bin, where the ash is ready to be loaded into cars outside.

The main bucket conveyor is operated by a 7½ horse-power electric motor, through a special set of equalizing gears transmitting an even motion. The conveyor travels on a track of 16 lb. T rails.

Ash is dumped from the bins to cars standing on the same track on which loaded coal cars are received for delivery to the power house. Thus the same cars may be used for the removal of ashes and no additional switching is required.

COAL AND ASH HANDLING EQUIPMENT AT MCKEES ROCKS, P. & L. E. R. R.

The system by which coal and ash are handled at McKees Rocks, P. & L. E. R. R., is to a certain extent similar to that described for Collinwood. Coal is delivered to the power house in cars over a spur track leading past one corner of the boiler room. This track passes over a receiving hopper, into which the coal may be dumped directly from hopper cars. The coal thence passes through a proper grating and is hoisted by an endless chain bucket conveyor to the top of the building. Here it is dumped upon a horizontal conveyor, which deposits it at the points desired in the coal storage bins located in the upper part of the boiler room and arranged to feed into the stoker hoppers directly by chutes. The hoisting mechanism is operated by a 10 horse power electric motor located in the basement and the horizontal conveyor is operated by a 7½ horse power motor. The actual power required by the two conveyors when running is about 7½ and 4 horse power respectively. The capacity of this hoisting and conveying equipment is 40 tons per hour, the total storage capacity of the coal bunkers being 200 tons.

Ashes are handled by the same hoisting conveyors as those used for coal delivery, an ash receiving and storage pocket having been arranged upon an elevated structure above the coal receiving track. When a car load of coal has been dumped into the receiving pocket below, the car may be used for removing the ashes without further switching Ashes are dumped directly from the bin to the car.

Ashes are handled from the ash pits beneath the boilers by special wheel barrows and then dumped into the hoisting conveyor, which may be arranged to deliver at the top into the ash hopper side.

The ash bin is of concrete upon steel frame work, with the lowest point of the hopper 16 feet above rail level. The coal hoppers, six in number, are of similar construction, with their outlets 12 feet above the boiler room floor. The coal outlets are controlled by special gate valves operated from the floor by chains passing over the wheels. Coal is distributed to the various pockets by the horizontal conveyor, which may be arranged to dump at any point. A protection for the top of the hoisting conveyor is provided for by a small enclosure above the roof.

COAL AND ASH HANDLING EQUIPMENT AT READING, P. & R. R. R.

At the Reading power house of the Philadelphia & Reading Railroad, coal is stored in a series of elevated hopper bins, of 300 tons capacity, located above the fire room, from which it is delivered direct to the stokers by chutes. The bins are of built up steel construction and are supported partially from the side wall and partially from the roof trusses, which are extra heavy in order to provide additional strength for this purpose. By this construction the fire room is free from obstructions. Coal is delivered into the bins by a conveyor system, having a capacity of 100 tons per hour, which carries it from a receiving pit under a delivery track at one side of the building and distributes it, in connection with a scraper conveyor above the pockets, into any desired bin. The coal used is buckwheat grade, containing about 20 per cent of ash.

The ash conveyor system is entirely separate from the system handling coal. It consists of a scraper line leading through an ash tunnel under the ash dumping portions of the grate and it delivers underground into a separate ash storage building outside of the boiler room. In this ash building another elevator conveyor raises the ashes to elevated bins, from which the ashes are dumped into cars for removal. The ash storage building includes a number of interesting features. The bin floor slopes at an angle of about 45° toward the dumping side and it is lined with 1 inch glass plate. This produces an absolutely non-corrosive surface, upon which the ashes slide with great freedom.

COAL AND ASH HANDLING EQUIPMENT AT SILVIS, C., R. I. & P. RY.

The arrangement of the coal and ash conveying machinery at the Silvis power house of the Chicago, Rock Island & Pacific Railway, is simple and direct. Coal is delivered directly from hopper cars to a hopper just above the steam driven coal crusher and after passing through the crusher is conveyed to overhead storage hoppers by an endless chain bucket conveyor system, which has a capacity of 50 tons of coal per hour. Each boiler has a storage bin of 32 tons capacity.

The conveyor also carries ashes from the ash pits to a hopper located in a wing and over the coal hopper, so that the hopper car when it has been emptied of its load of coal may be filled with ashes. The steam engine which drives the conveyor is situated in the upper portion of the building above the level of the coal pockets. Steam is used in preference to electricity as a motive power for the crusher and conveyor, as it was believed by the designers of this plant that occasions may arise when it is desired to handle coal or ashes when the generators are not running and also because in case of stalling the motor would be liable to injury while the engine would simply slow down and stop.

COAL AND ASH HANDLING EQUIPMENT AT SOUTH LOUISVILLE, L. & N. R. R.

In principle, the coal and ash conveyor system installed in the power house of the Louisville & Nashville Railroad at South Louisville is similar to those already described. Coal is delivered from a track at one side of the building and ash is dumped by gravity from elevated bins into cars on the same track. Coal and ash are elevated by an endless chain bucket conveyor system.

Coal is fed to the stokers from overhead storage pockets, of steel and concrete construction, which have a capacity of 1,000 tons, sufficient to operate the plant for at least three weeks. From the cars coal is shoveled into curved chutes, which conduct it to a crusher and feeding device, after which it passes to the conveyor. The coal crusher is operated by a 20 horse power motor. The conveyor travels at the rate of 40 feet per minute, delivering 40 tons of coal per hour.

BOILERS.

There are many different makes of boilers installed in railway shop power houses. As a type, however, the water tube boiler is used with but few exceptions in representative power houses. The horizontal water tube boiler is used so extensively that it may be said almost to cover the field. At Reading on the Philadelphia & Reading Railroad, at Sayre on the Lehigh Valley Railroad, and at Grand Rapids on the Pere Marquette Railroad, vertical water tube boilers are in service, and at Topeka on the Atchison, Topeka & Santa Fe Railway, fire tube boilers of the locomotive type have been installed.

The increasing use of water tube boilers arises largely from the fact that this type permits steam to be raised very rapidly in response to sudden demands, owing to the smaller quantity of water contained in proportion to the heating surface and due to the better circulation. While no boiler is absolutely safe from explosions, such accidents seldom occur in water tube boilers, though the tubes burst occasionally. The water tube boiler requires a firing aisle of sufficient width to allow the removal and insertion of tubes without obstruction.

BOILER PRESSURE.

A review of a large number of representative railway power plants would lead to the conclusion that 150 lbs. pressure is considered the most satisfactory for this class of work. Frequently one boiler is installed having a capacity of 250 or 300 lbs. pressure, for use in testing locomotives and provided with reducing valves for use with other boilers. They are usually arranged in batteries of two boilers in each with intervening spaces for access. As originally constructed, space is usually left for the future installation of at least one additional battery of boilers. The boilers are arranged in a single row. The horse power of each boiler varies at different plants from 200 to 500.

Due to the comparatively low cost of fuel to the railroad companies incentives to fuel economy have not been so great as in commercial power stations. At the same time the single central power house has illustrated that the boiler room offers a great opportunity to reduce operating expenses. The result is that the boiler room of the new central power house compares favorably in equipment with the boiler room of manufacturing concerns.

STOKERS.

While there are still many stationary boiler plants which are fired by hand, mechanical stokers are now generally used in the larger central power stations. This system not only reduces labor in the boiler room, but prevents cold air from impinging on the hot tubes and plates of the boiler and causing leaks.

There are a number of mechanical stokers on the market, which are divided naturally into two classes, the underfeed and the overfeed. The overfeed, almost exclusively is used in railway shop power stations, and generally with natural draft. The underfeed cannot be used without forced draft.

The type of mechanical stoker which seems to have received the greatest favor in railway shop power stations is the traveling chain grate stoker. This consists of a wide band or chain, made up of short link like sections of grate bars pivoted after the fashion of a sprocket chain. The chain is endless and travels around two drums in the firebox, being so driven that the upper side moves backward from the boiler front toward the arch. Coal is fed evenly on the moving chain as it recedes by a feeding hopper in front of the boiler, the hopper being supplied directly by coal chutes leading from storage pockets above. The fuel burns as it travels with the grate, the speed of travel being so adjusted that when the rear drum is passed, the coal is entirely consumed, leaving ashes only to be dumped off at the end. With this system, it is therefore not necessary to open the door to clear the grates or "bar" the fire.

The stokers are driven by small vertical steam engines geared to drive the drums very slowly through ratchet mechanisms. It is appropriate to say that steam engines are usually considered preferable to electric motors for this service, inasmuch as they may be run when getting up steam or at any time that steam is on, and are not dependent on the dynamos being in operation. The entire chain grate mechanisms are mounted in frames with wheels running on tracks embedded in the boiler room floor, in order that the stokers may be easily withdrawn from the boiler settings for inspection or repairs.

Where a planing mill is operated in connection with the shop plant, it is customary to fire some of the boilers by hand and so dispose of shavings, sawdust and other wooden refuse. For instance, at Angus, of the seven boilers installed, three are equipped with mechanical stokers and four are arranged for hand firing and to receive shavings, etc., from an extensive shavings exhaust system from the planing mill and cabinet shop. At Collinwood one boiler is fitted with stationary grates instead of a stoker in order to burn shavings and refuse. At South Louisville two of the boilers having chain grates are equipped to burn shavings and two boilers are hand fired to use the same kind of fuel.

CHIMNEYS.

Tall chimneys for draft production continue to be built in connection with railroad shop power stations. While a few power houses are equipped with mechanical draft, notably Silvis, C., R. I & P. Ry.; Jackson, M. C. Ry., and Angus, C. P. Ry., the larger number depend on draft obtained by tall chimneys. Except for some of the short stacks used in connection with mechanical draft equipment, steel chimneys have not been installed. The chimneys are built of common brick or radial brick, usually the latter. A common form is a chimney with a square base built of common brick, with the upper portion circular in form and built of radial brick. The brick in the circular portion of the chimney is often of specially baked clay. While not confined to these limits the heights of chimneys at a number of prominent shops vary from 120 feet to about 185 feet.

The chimney of the power plant of the Louisville & Nashville Railroad, at South Louisville, is of careful design and worthy of mention. It is 182 feet high, with a flue 9 feet 6 inches in diameter. For a height of 60 feet the wall is 40 inches thick, and the cross-section of the chimney is square. Above this height the cross-section is circular. The wall is built in sections 16 feet 5 inches in length. The thickness of the wall of each succeeding section is made smaller, until for the top section it is only 8⅝ inches thick. The chimney is topped with a cast-iron cap. The lining of the chimney is of fire brick carried on bracket projections, making it possible to renew any section of the lining without dsturbing the rest and allowing for expansion in various parts. The chimney is built of perforated radial bricks, made from specially selected clay and burned in a high temperature to render them dense and impervious to moisture. Opposite to the opening for the flue is a balance opening of the same shape and size in order that the settlement on the two sides will be equal and therefore prevent cracking or a tendency of the chimney to cant to one side. The balance opening is closed on the outside by a dummy wall.

MECHANICAL DRAFT.

Comparatively few power stations operated in connection with railway shop plants are equipped with apparatus for providing mechanical draft. With natural draft it is rarely possible to burn more than 40 lbs. of coal per square foot of grate area per hour, while with forced or induced draft the amount of coal burned may be as high as desired. Among the advantages to be obtained with mechanical draft may be mentioned reduced size of chimney, smaller boiler plant, control of draft in a manner that may be regulated to suit requirements, use of low-grade fuel. The disadvantages of the mechanical draft system lie in the addition of the mechanical equipment which must be maintained, and in the expense of operation of the apparatus.

As the combustion of fuel depends upon the intensity of draft available, the draft is an important factor, for the operation of the power plant is dependent upon the combustion of fuel. The intensity of the draft required depends upon the quality of fuel used and upon the quantity to be burned per square foot of grate area per hour. Therefore insufficient draft is a cause of serious trouble. By means of a strong draft it is possible to force boilers in case of overload, and sufficiently strong draft is equivalent to a certain amount of additional boiler heating surfac. With a strong draft the use of cheap, low-grade fuel is successful.

Mechanical draft as applied to railway shop power station service is usually induced draft and is produced by fans. The fans deliver smoke and gases through short steel stacks varying in height from about 48 feet to 70 feet, and the mechanical apparatus is depended upon entirely for the draft produced. The mechanical draft is under complete control at all times and may be regulated to suit the load carried. The apparatus is usually installed in duplicate, and while each fan is capable of disposing of all smoke and gases from the entire boiler installation, one fan is held in reserve in order to shut down one engine and fan in case of necessary repairs.

DRAFT SYSTEM AT READING, P. & R. R. R.

At the Reading shop power house of the Philadelphia & Reading Railroad, natural draft is provided by a brick stack 125 feet high with an inside diameter of 10 feet. The chimney draft is supplemented by a fan on the forced draft system, the requirements calling for both an air pressure below the grate and an exhaust above. The undergrate forced draft is furnished by a 10-foot blower fan delivering through an underground flue in front of the boilers. Dampers are provided at each boiler to regulate the air pressure as well as to regulate the effect of the natural draft.

The reason for providing both natural and forced draft is that both were required with the stoker as installed in order to obtain the desired working efficiency of 10.5 lbs. of water evaporated per pound of combustible.

DRAFT SYSTEM AT SILVIS, C., R. I. & P. RY.

The more common system, where mechanical apparatus is installed, is induced draft produced by fans. The induced draft apparatus at the Silvis plant of the Chicago, Rock Island & Pacific Railway consists of two exhaust fans 12 feet in diameter and 6 feet wide driven by 12 by 12-inch horizontal single cylinder engines. The speed of the engines is regulated by regulating valves. Either of these fans is of sufficient capacity to handle all the gases from the complete boiler equipment, and dampers are provided to cut off whichever fan is not in use. The stack is of steel, 60 feet high and 7 feet 8 inches inside diameter.

DRAFT SYSTEM AT ANGUS, C. P. RY.

Induced draft in the boiler plant of the Angus shops of the Canadian Pacific Railway is produced by two 10-foot fans, operated in connection with a steel stack 70 feet high and 8 feet in diameter. Each fan is connected with all of the boilers and runs at about 200 revolutions per minute.

DRAFT SYSTEM AT JACKSON, M. C. RY.

The boiler plant of the Michigan Central shops at Jackson, Mich., is operated with induced draft. The apparatus consists of two 7-foot blast fans operated in connection with a steel stack 48 feet high and 60 inches diameter. Each fan is direct connected to a vertical steam engine having a cylinder 8 inches in diameter and 6-inch stroke. The fans are arranged one above the other for economy of space, the upper fan and its engine being supported upon a steel platform of I beams, 9 feet 4 inches above the floor. The blast wheel of each fan is mounted directly upon an extension of the engine's shaft. The blast wheel is 84 inches in diameter, with a face 42 inches wide. Each fan has a delivery outlet 48½ by 42 inches. Either fan is capable of handling the gases from all of the boilers.

ECONOMIZERS.

The boiler plants operated in connection with mechanical draft appliances have usually been equipped with economizers. However, comparatively few economizers have been installed in railway shop power houses, and the extent to which they have been omitted would lead to the conclusion that they have been so far looked upon as refinements somewhat beyond immediate needs, in view of the comparatively low cost of fuel.

Economizers introduce considerable friction in the flue system in addition to the loss of draft caused by the heat abstracted from the waste gases, the drop varying from 0.20 to 1.00 inch of water, according to the length of the economizer, its area and the number of elbows it causes in the gas passage. The straight passage economizers cause less friction than those with staggered tubes, but the staggered tubes should be more efficient as heat absorbers.

PIPING.

With the development of the central power plant, the piping represents a marked improvement. This is noticeable not only in the material provided and in the improved construction of joints, but also in the arrangement of easy bends of large radius to provide for expansion and to eliminate the obstruction due to elbows and short curves, as well as in the convenient disposition of the pipes. By dividing power houses longitudinally with a single wall separating the boiler and engine rooms, and by locating boilers and engines with a comparatively short distance between them, the length of piping is reduced.

The main steam header is supported back of the boilers on specially designed suspensions or supports. The header is usually 10 or 12 inches in diameter and of the same diameter throughout its length. Steam is led from each boiler to the header through a pipe having an easy bend of large radius. Connections to the engines are led from the header to the engine throttles in easy curves. Separators are placed in the steam pipes leading to the engines either just above the headers or above the engine throttles. The pipes are connected to the headers on top in order that no water of condensation will be entrained in the pipes and provision is made for draining the header.

Steam pipes are either carried through the partition wall and direct to the engine throttles or are carried through the basement. There is a tendency in power house practice to dispense with all piping above the floor, in which case the pipes are carried in the basement beneath the engine room floor. This arrangement not only removes an unsightly obstruction from the engine room but places the pipes in position where they are easy of access.

ENGINE EQUIPMENT.

As the development of the central power plant in railroad shop practice is a result of a demand for the generation of power at one point, with electrical distribution to the various points of consumption, it naturally follows that the engine equipment of such stations is selected for driving electrical generating machines. For this work, horizontal, cross-compound, non-condensing engines are usually employed, though tandem-compound and vertical engines are installed in some railway power plants, and the condensing engines in the power house of the C. M. & St. P. at Milwaukee are exceptional.

It has not been considered that the advantages in the line of economy gained by triple or quadruple expansion engines pay for the added complications introduced. Such engines show up to their best advantage only under practically constant load, and in an electrical generating plant the load is very variable. The engines are usually non-condensing, as the exhaust steam is used for heating the shop buildings, and the cost of fuel is such that condensers seem to be a refinement beyond present-day requirements.

Each engine is direct connected to an electrical generator, and in the central power plant a belt-driven dynamo is a rarity. The speed of the dynamo is then dependent upon the speed of the engine, and as the larger engines operate at a comparatively low speed, the smaller unit is more economical and satisfactory. Of the information at hand the engine of largest capacity installed in a railway shop power plant is one of 900 horsepower at the West Albany plant of the New York Central Lines.

It is usual to install two or more main units for the maintenance of power for the operation of the plant under the usual conditions of service, while a smaller unit is installed for supplying power for lights at night and for light power at such times as it may be unnecessary to operate the larger machines.

STEAM TURBINES.

Thus far there are very few examples of the installation of steam turbines, or rather, turbo-generators in railway shops. In 1903 three units of 300-h. p. each direct connected to two generators were adopted in the Aguas Calientes shops of the Mexican Central. This year the new El Paso shops of the El Paso & Southwestern Ry. have been equipped with three turbo-generator sets, each consisting of a 150-h. p. De Laval steam turbine, direct connected to two 50-k. w. 250-volt generators. The new shops of the Big Four at Indianapolis are to be equipped with Curtis turbo-generators, and the new shops of the D., L. & W. R. R., now under construction at Scranton, Pa., will be provided with turbo-generators.

The steam turbine is a splendid power generator, and under conditions favoring its use probably excels steam reciprocating engines in several respects. However, it is well recognized that under less than its full load its economy falls off more rapidly than the reciprocating engine. Also it is imperative that it should be operated condensing, and in many railway shops it is preferable to use the exhaust steam for heating the buildings. Again, the cost of providing water for condensing purposes often renders it more desirable to operate non-condensing. Tribe says that 20-foot lift and 500 feet of pipe should be regarded as the limit distance through which condensing water should be drawn by the vacuum of the condenser. This explains the very general use of compound non-condensing engines in most railway shops.

GAS ENGINES.

There is no information at hand of railway shops where the gas engine has been introduced to supply the power. The increasing use in other fields of the gas engine in connection with gas producer plants of either the suction or pressure type, however, causes one to be safe in thinking that the great economy of such plants will cause them to be considered for railway shop use before long.

ELECTRICAL CURRENT.

The various installations which have been placed in the most prominent railway shop plants put in operation within comparatively recent years are not sufficiently alike to lead to a conclusion as to the electrical system considered most satisfactory under conditions peculiar to railway shop work. The arrangement looked upon with greatest favor is the installation of alternating current circuits for the operation of all constant speed motors, for instance, those driving wood-working machines and groups of metal-working machines, as well as for lighting, and direct current circuits for driving individual variable speed motors attached to large metal-working machines and motors for traveling cranes and transfer tables.

There is an opinion more or less widely circulated that individual driving of metal-working machines has been carried to too great an extent, and that better results would be obtained with fewer machines direct connected.

In a number of instances railway shop power stations provide power for lights not only throughout the immediate shop plant, but also to passenger stations, freight yards, etc The distances over which this power must be transmitted are frequently great, and alternating current is eminently the most satisfactory, as this current is particularly adapted for long-distance transmission, due to its high voltage.

Owing to the different methods of distribution in service in various shops, it is instructive to note the individual methods of distributing electrical power at several prominent shops.

DISTRIBUTION OF ELECTRICAL POWER AT COLLINWOOD, L. S. & M. S. RY.

The general electrical distribution of the Collinwood shops of the L. S. & M. S. Ry. is a two-wire system operating at 240 volts, and in addition to this is a four-wire multiple voltage system for use in obtaining variable speeds at the motors of the motor driven mechanical tools in the locomotive shop. The distances from the power house to the various points of power consumption are not great. The point of consumption located at the greatest distance is the roundhouse, where power is used for operating the turntable and which is lighted electrically. The roundhouse is about three thousand feet from the power house.

The distribution of power at the McKees Rocks shops of the P. & L. E. R. R. is by the same system as that at Collinwood.

DISTRIBUTION OF ELECTRICAL POWER AT DANVILLE, C. & E. I. RY.

At Danville, on the C. & E. I., the distribution of electrical power is by a 250-volt direct current system using the two-wire system of distribution for motors and the three-wire system for lighting. The average distance of transmission is not over 800 feet.

DISTRIBUTION OF ELECTRICAL POWER AT SILVIS C., R. I. & P. RY.

Direct current transmission is used at the Silvis shops of the C., R. I. & P. Ry. For power delivered to cranes, heating fans and constant speed machine motors, distribution is by the two-wire system at 230 volts. For variable speed machine motors and for lighting, distribution is by three-wire 230-115 volt lines.

DISTRIBUTION OF ELECTRICAL POWER AT ANGUS, C. P. RY.

At the Angus shops of the Canadian Pacific Railway both alternating and direct current systems are used. The direct current system is used only for the transfer table, traveling cranes and for a few individually driven machine tools requiring variable speed motors. The alternating current is 3-phase, 60-cycle and 600-550 volts. The direct current is at 275-250 volts.

DISTRIBUTION OF ELECTRICAL POWER AT JACKSON, M. C. RY.

During the year 1903 a modern power plant was completed at the Jackson, Mich., shops of the Michigan Central Railway. This provided for the electrical distribution of power from a single point and replaced four separate isolated power plants of boilers and engines which were scattered around adjoining various shop buildings. This plant also provided power for lights at several points removed some distance from the shop.

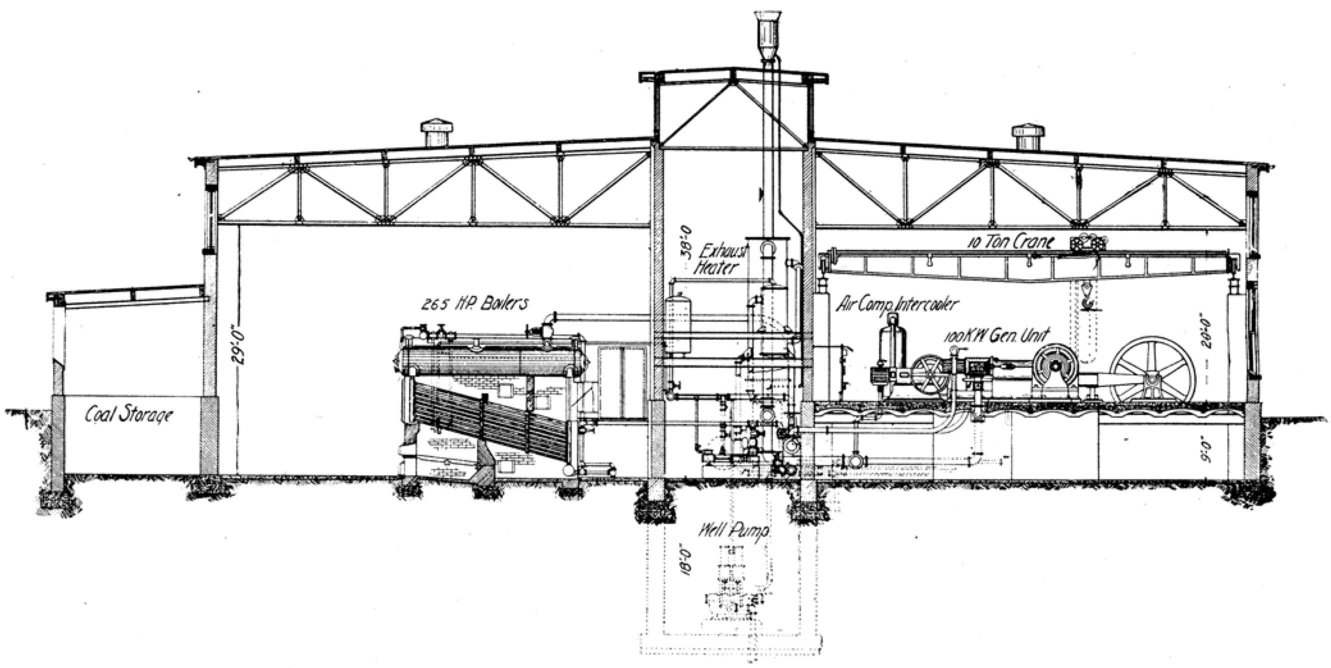
The alternating current system alone has been installed and provides power for all machine tools, cranes and lights. This is the alternating current, 3-phase, 60-cycle system operating at 480 volts.

DISTRIBUTION OF ELECTRICAL POWER AT WEST ALBANY, N. Y. C. LINES.

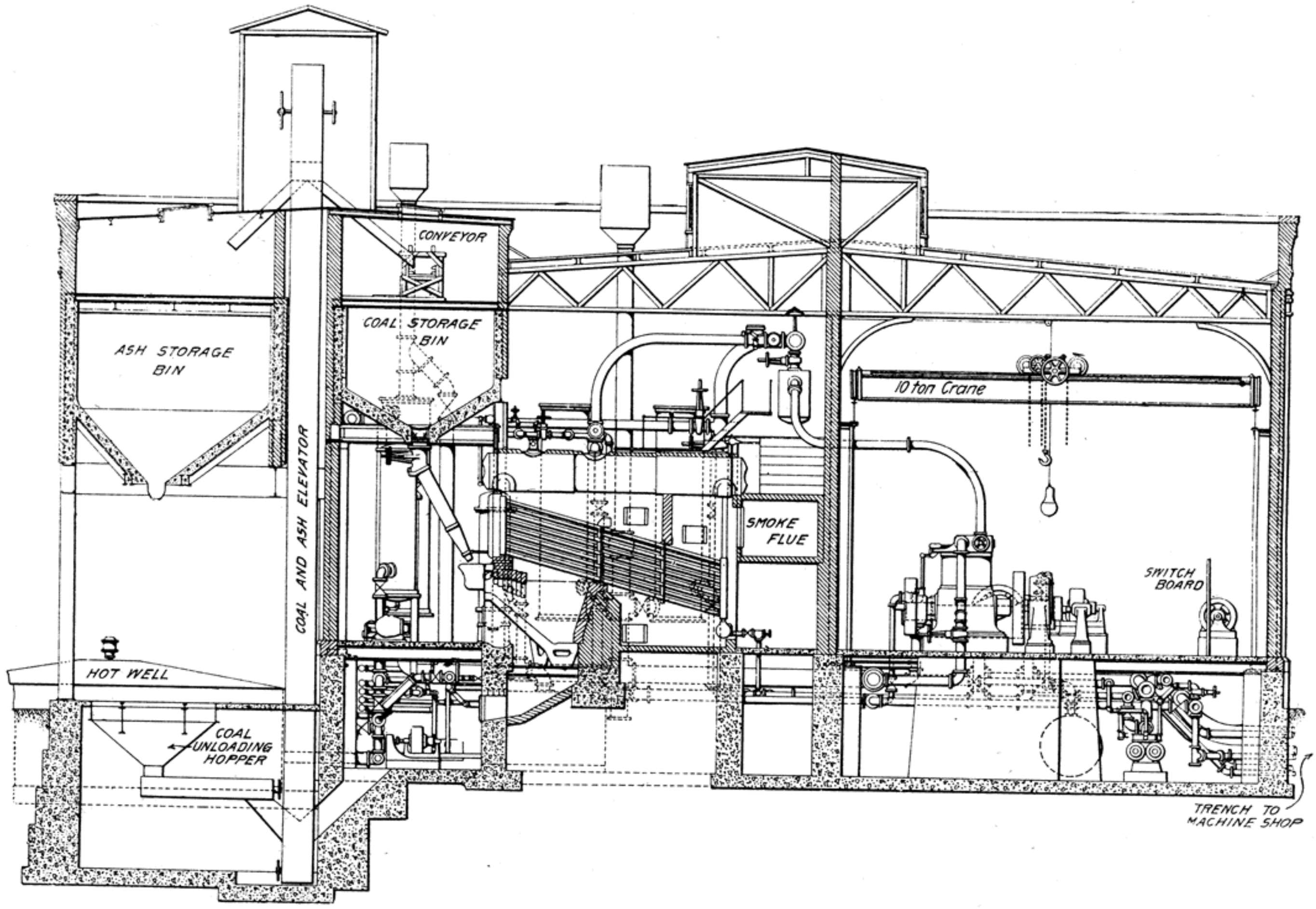
At the West Albany power plant of the New York Central Lines alternating current generators supply 3-phase current at 60-cycle per second at 480 volts for light and power. As the main power circuits are all alternating, direct current is supplied for the cranes by a motor generator set. The set consists of a 60-cycle, 3-phase alternating motor of 900 revolutions per minute and 480 volts, and a multipolar 250-volt direct current generator.

Data of Representative Power Houses

Road	Location	Size Bldg.	No. of Boilers	H. P. each Boiler	Total Boiler H. P.	Steam Press.	Type Boilers	Air Comp. cu. ft.	Type of Engine	No. of Engines	H. P. Each Engine	Total Engine H. P.	K-W. Each Gen.	Total K. W.	Current	Volts
A. T. & S. F.	Topeka	176x56-9	7	200	1400	150 250	Fire Tube Locomotive	3500	Horiz. Cross Comp.	4	325 120	1095	200 75	675	D C	230
B. R. & P.	DuBois	92-9x63	5	200	1000	150	Horizontal Water Tube	1300	Vert. Cross Comp.	4	200 100	600	125 75 65	390	D C A C	220 2200
C. P.	Angus	216x103	12	416	4868	150	Horizontal Water Tube	6000	Horiz. Cross Comp. and Simple	6	750 375 300	3675	500 250 200	2450	A C D C	600 550 275 250
C. & E. I.	Danville	100x90	7	264 300	1956	125	Horizontal Water Tube	2000	Simple	3	750 300 150	1200	500 200 100	800	D C	250
C. M. & St. P.	Milwaukee	100x97	4	300	1200	150	Horizontal Water Tube	1200	Horiz. Cross Comp.	3	330 160	820	200 100	500	D C	250
C. R. I. & P.	Silvis	154-2x104-7	6	300	1800	150	Horizontal Water Tube	3000	Cross Comp.	2	667 333	1000	500 250	750	D C	250
L. S. & M. S.	Collinwood	135-6x88-6	6	300	1800	150	Horizontal Water Tube	3000	Horiz., Vert., Cross Comp. and Simple	4	650 480 150	1930	400 300 75	1175	D C	250
L. & N.	S. Louisville	141-4x110	8	305	2440	180	Water Tube Vertical (Curved)	3400	Horiz. Cross Comp.	3	550	1650	350	1050	D C	240 to 250
M. C.	Jackson	93-7x98-6	4	264	1056	150	Horizontal Water Tube	1750	Tandem Compound	4	100 250	850	200 60	660	A C	480
N. Y. C.	W. Albany	113-4x92-8	4	500	2000	200	Horizontal Water Tube	....	Horiz. Cross Comp.	2	900	800	600	1200	A C	480
P. & R.	Reading	175x112	8	250	2000	150	Vertical Water Tube	1500	Tan. Comp. and C. C.	4	300 600	2100	200 400	1400	A C D C	480 125
P. & L. E.	McKees Rocks	102x81	6	264	1584	150	Horizontal Water Tube	2000	Vert. Cross Comp.	5	250 410	1410	150 250	850	D C	240
St. L. I. M. & S.	Baring Cross	131x78-9	5	250 550	1550	150	Horizontal Water Tube	3000	Tand. Comp. Vert. Comp. Simple	4	75 160 175 290	700	50 100	450	D C	220
C. R. R. of N. J.	Elizabethport	118x101	3	500	1500	120	Horizontal Water Tube	2800	Simple	5	175	875	100	300	D C	240
Big 4	Indianapolis	116-10x129-8	6	400	2400	5-165 1-225	Water Tube	2000	Turbines	3	670	2010	500	1500	A C	440



CROSS SECTION OF POWER HOUSE AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



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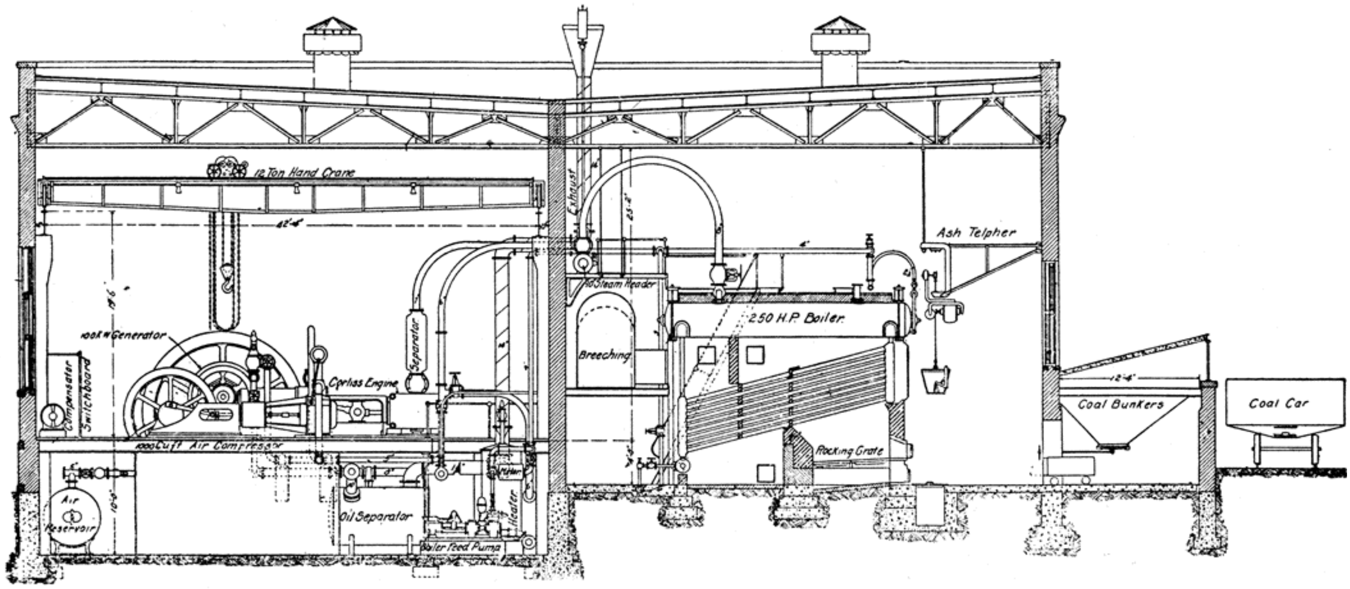

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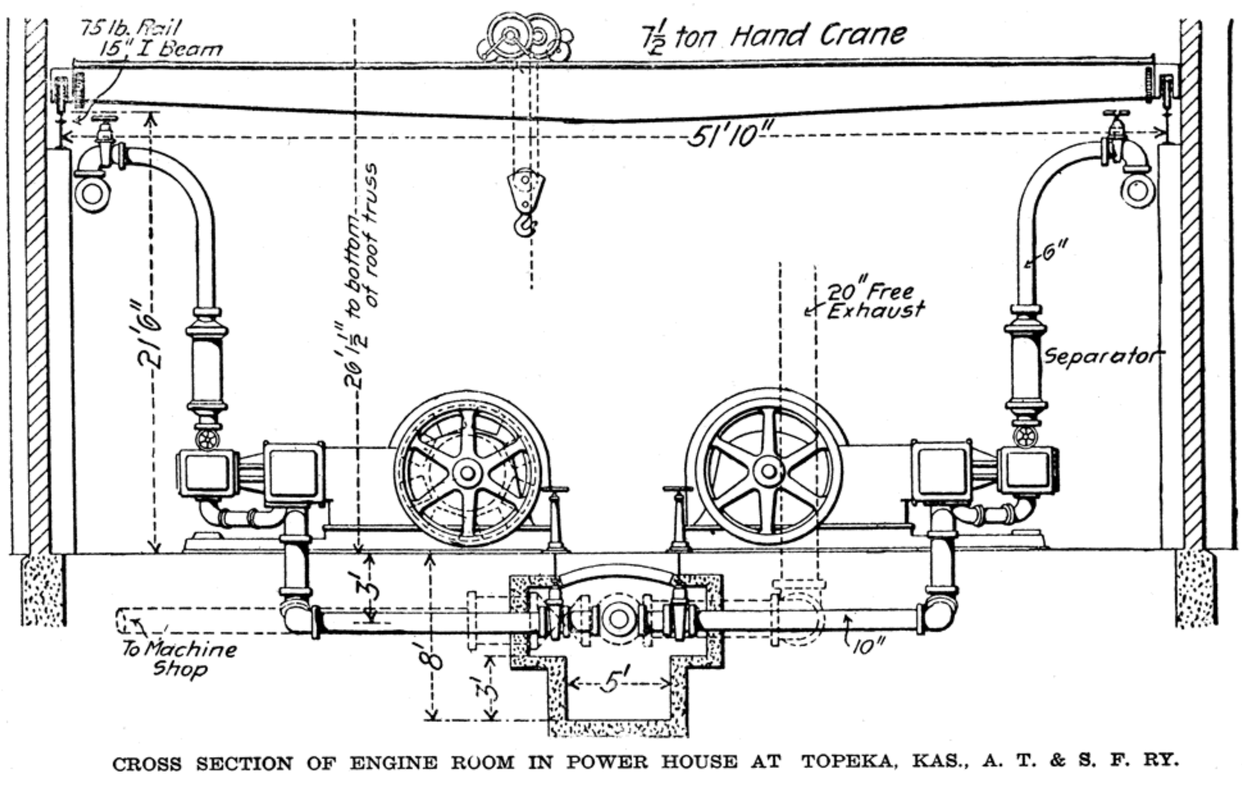

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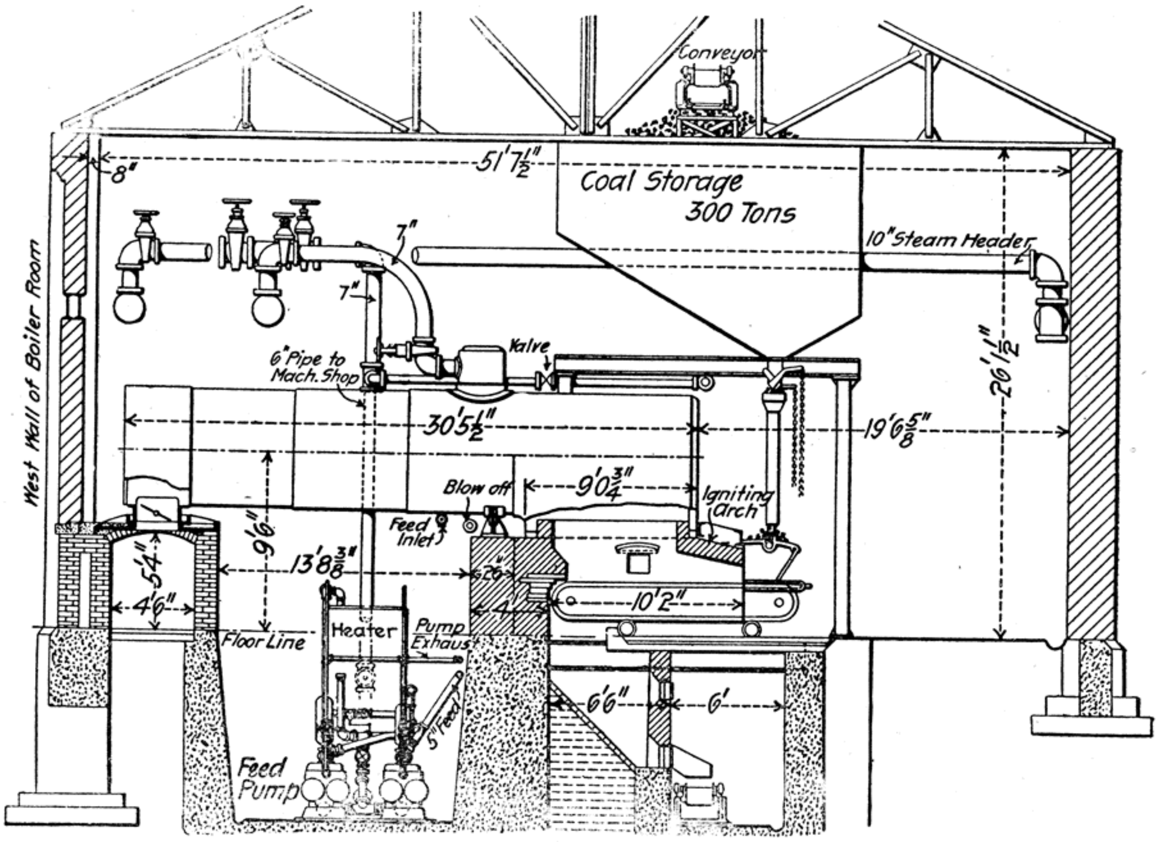

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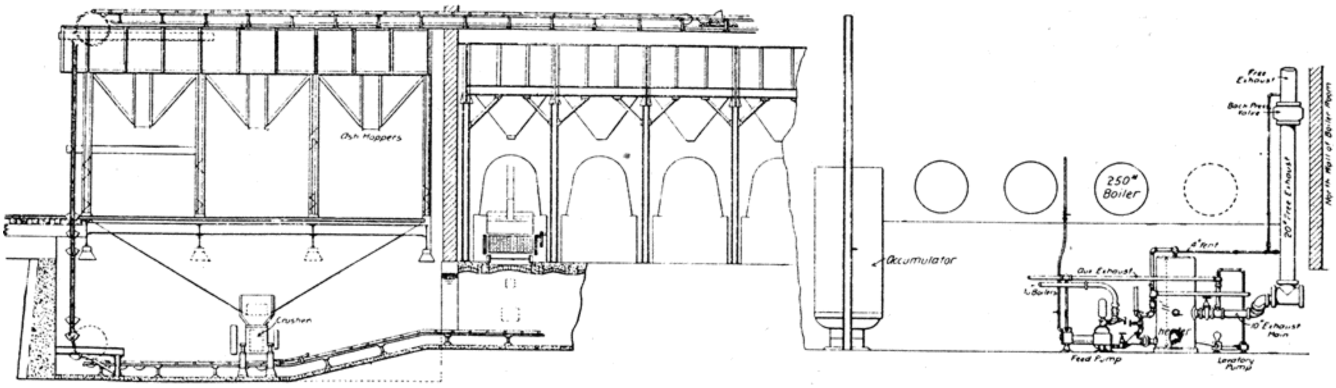
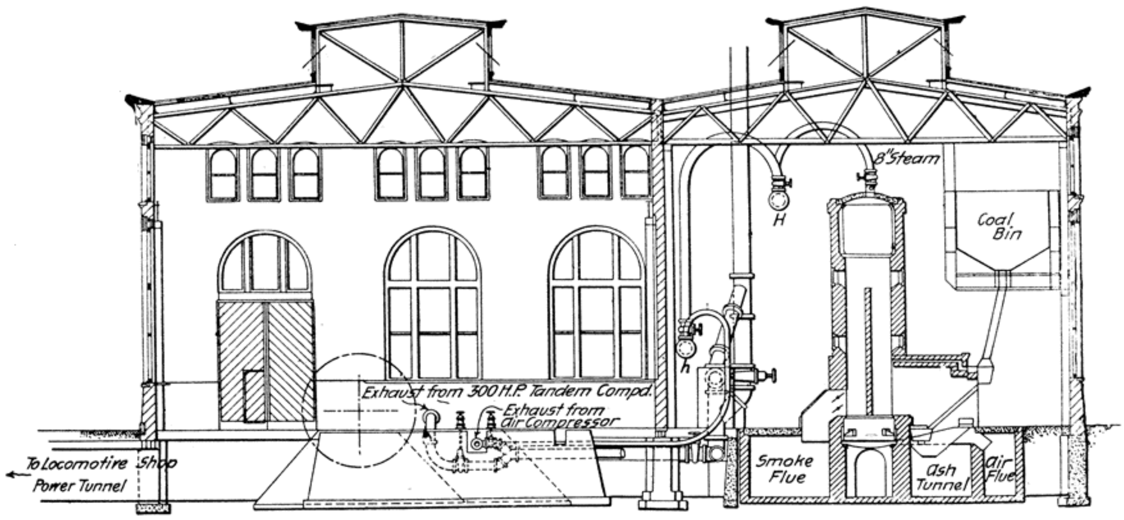


LONGITUDINAL SECTION OF BOILER ROOM AND COAL HOPPER PIT AT TOPEKA, KAS., A. T. & S. F. RY.



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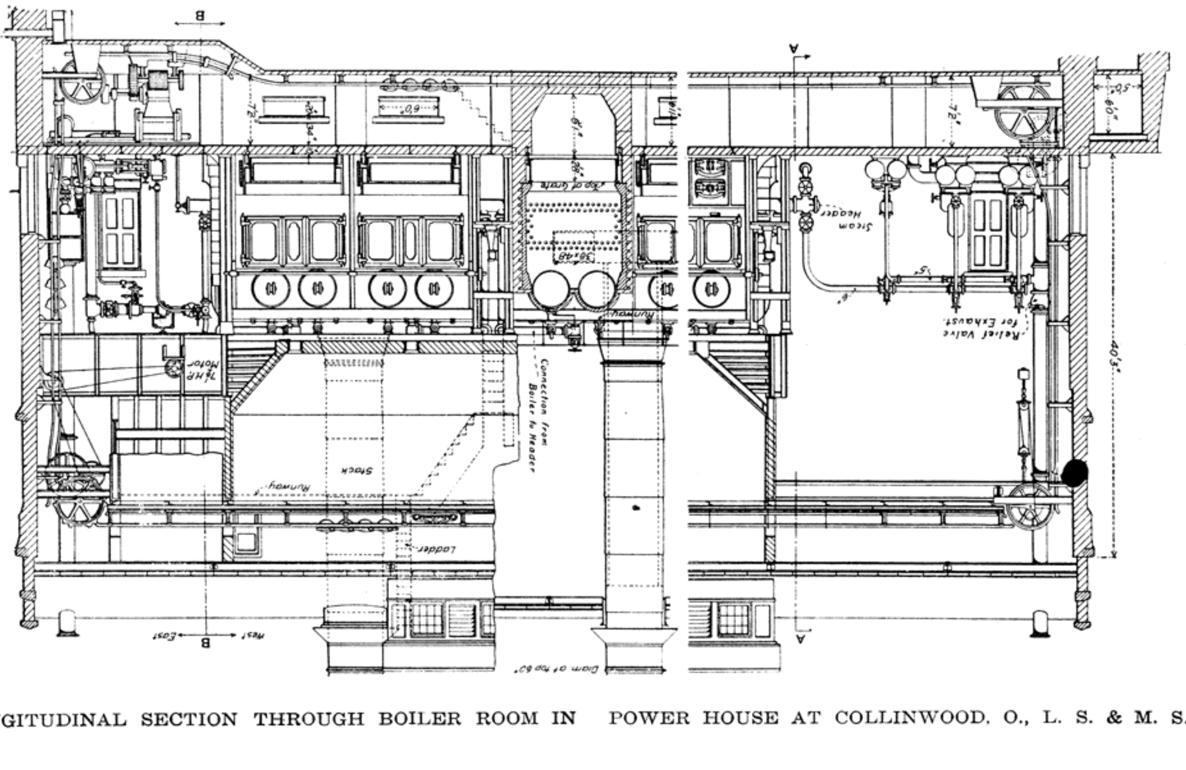
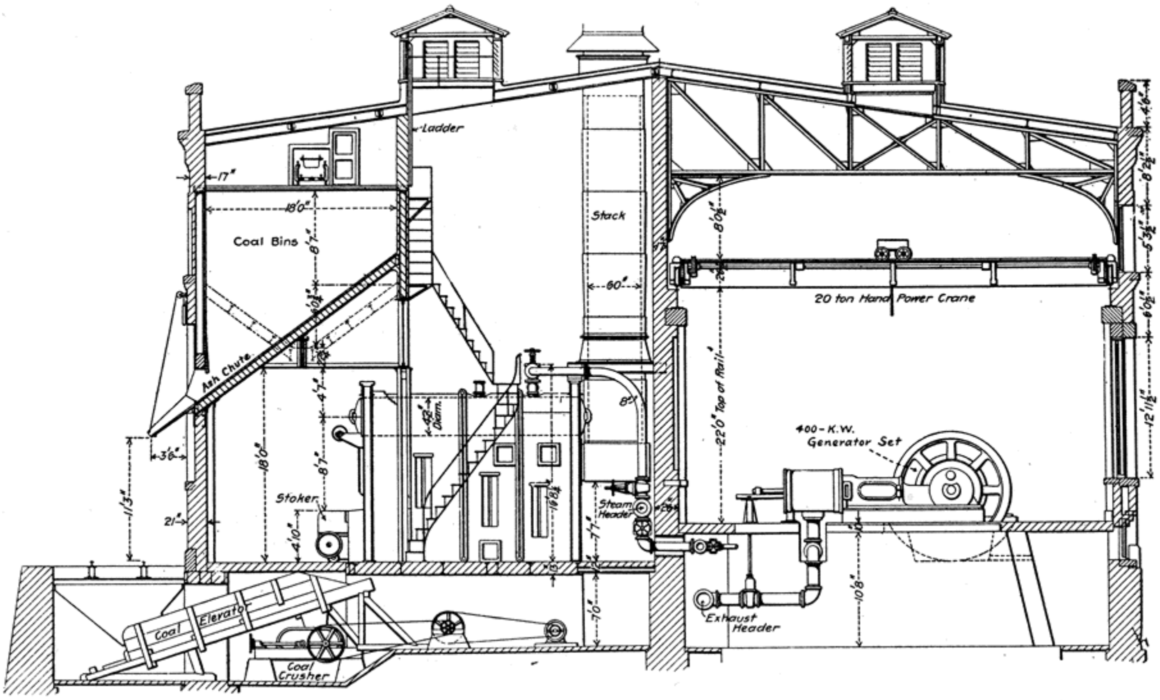


LONGITUDINAL SECTION THROUGH BOILER ROOM IN POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



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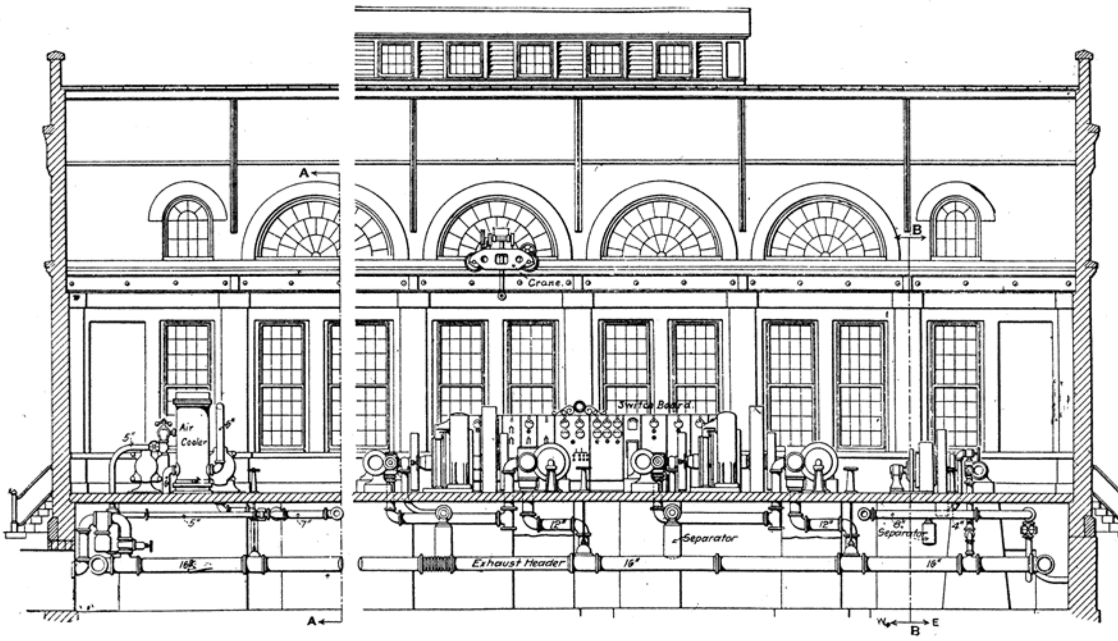
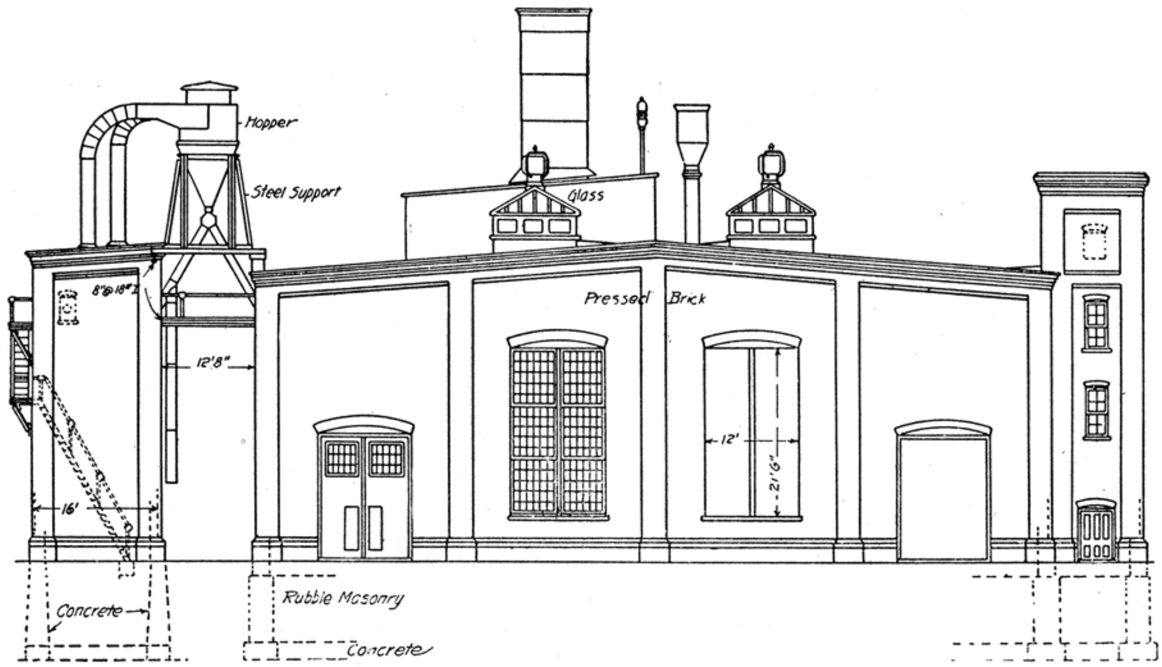
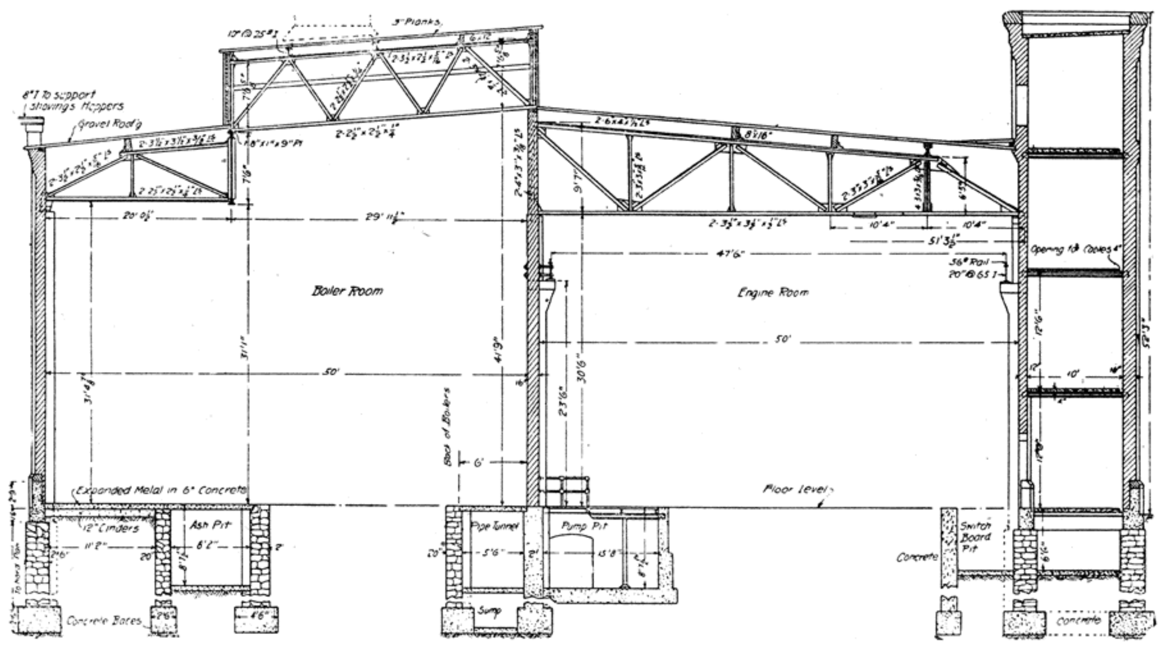


PARTIAL LONGITUDINAL SECTION OF POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



ELEVATION OF POWER HOUSE AT ANGUS (MONTREAL), C. P. RY.



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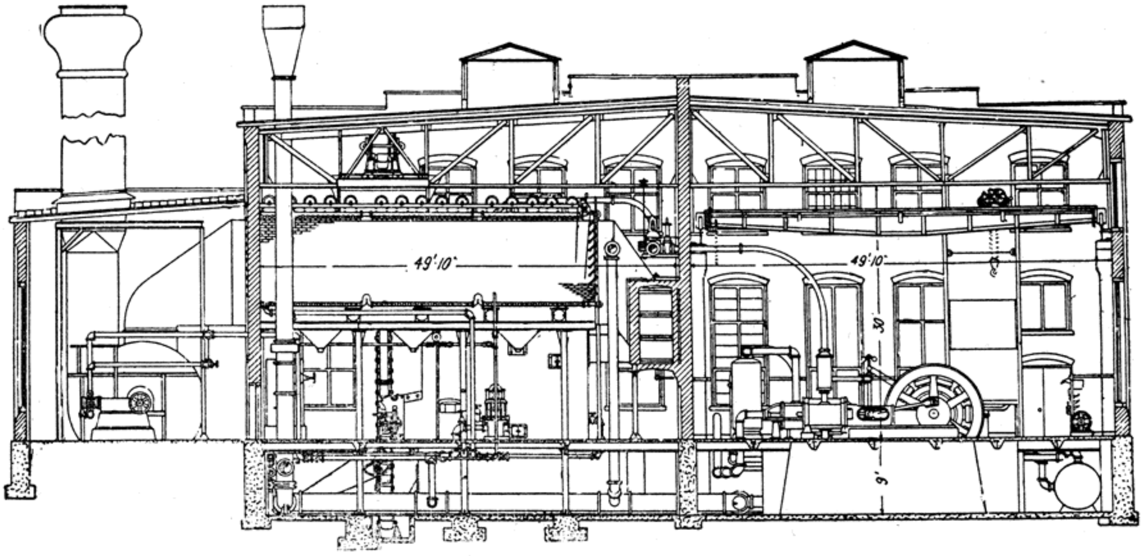
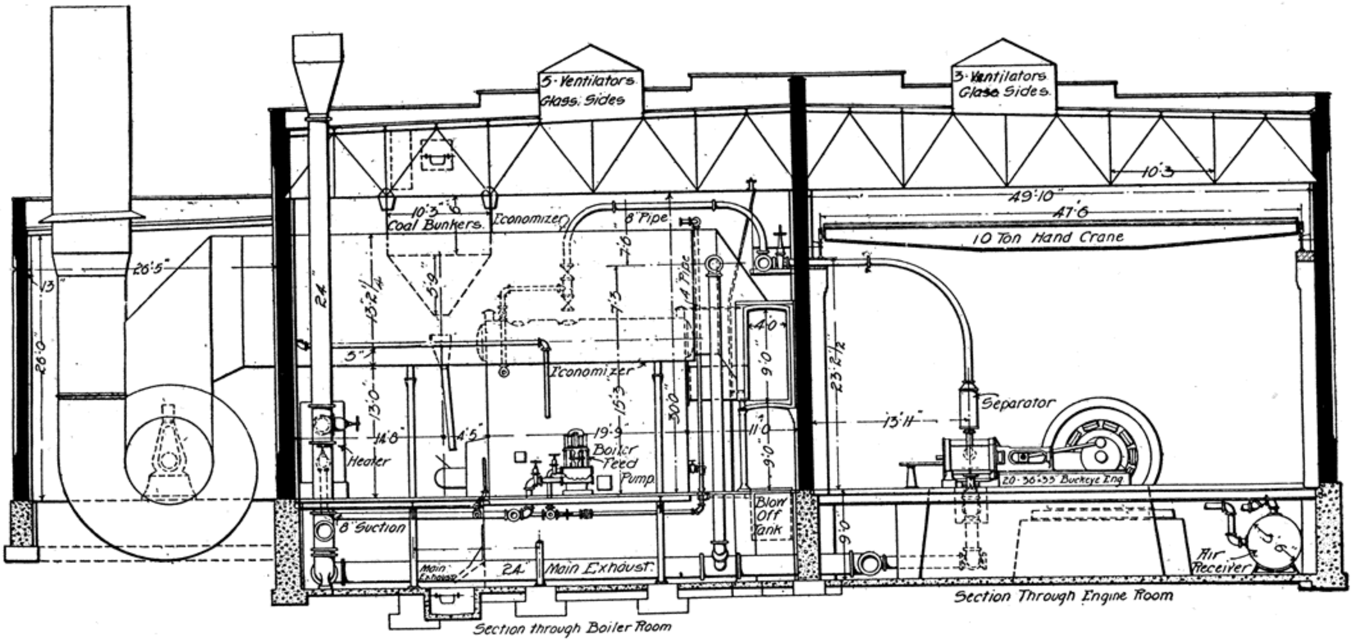


CROSS SECTION OF POWER HOUSE AT SILVIS, ILL., C. R. I. & P. RY.



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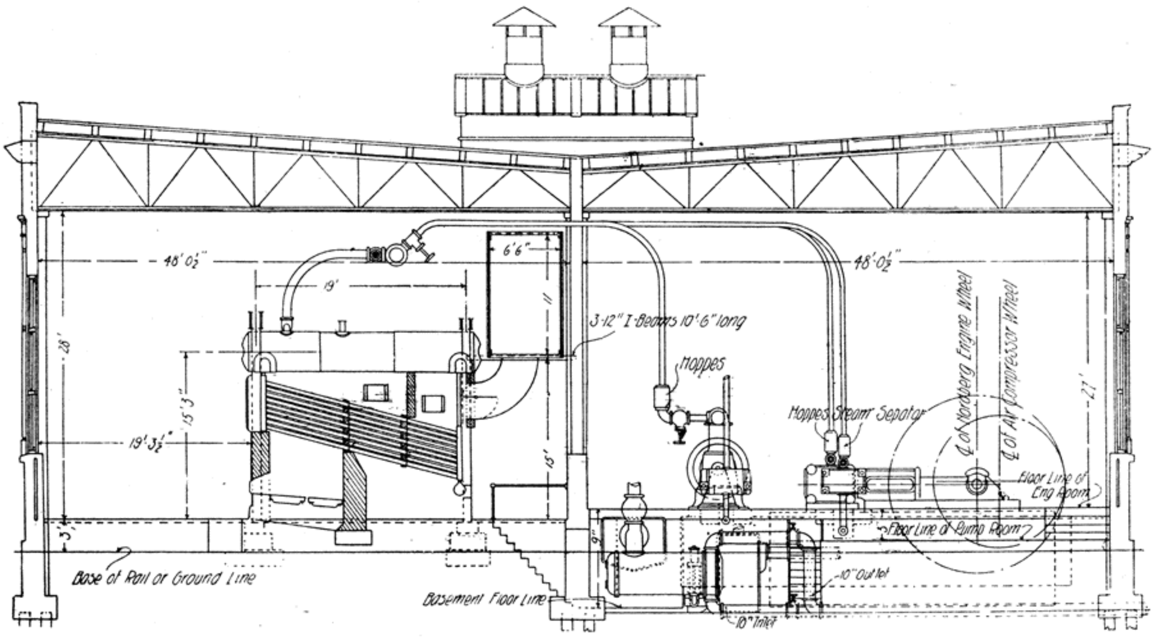

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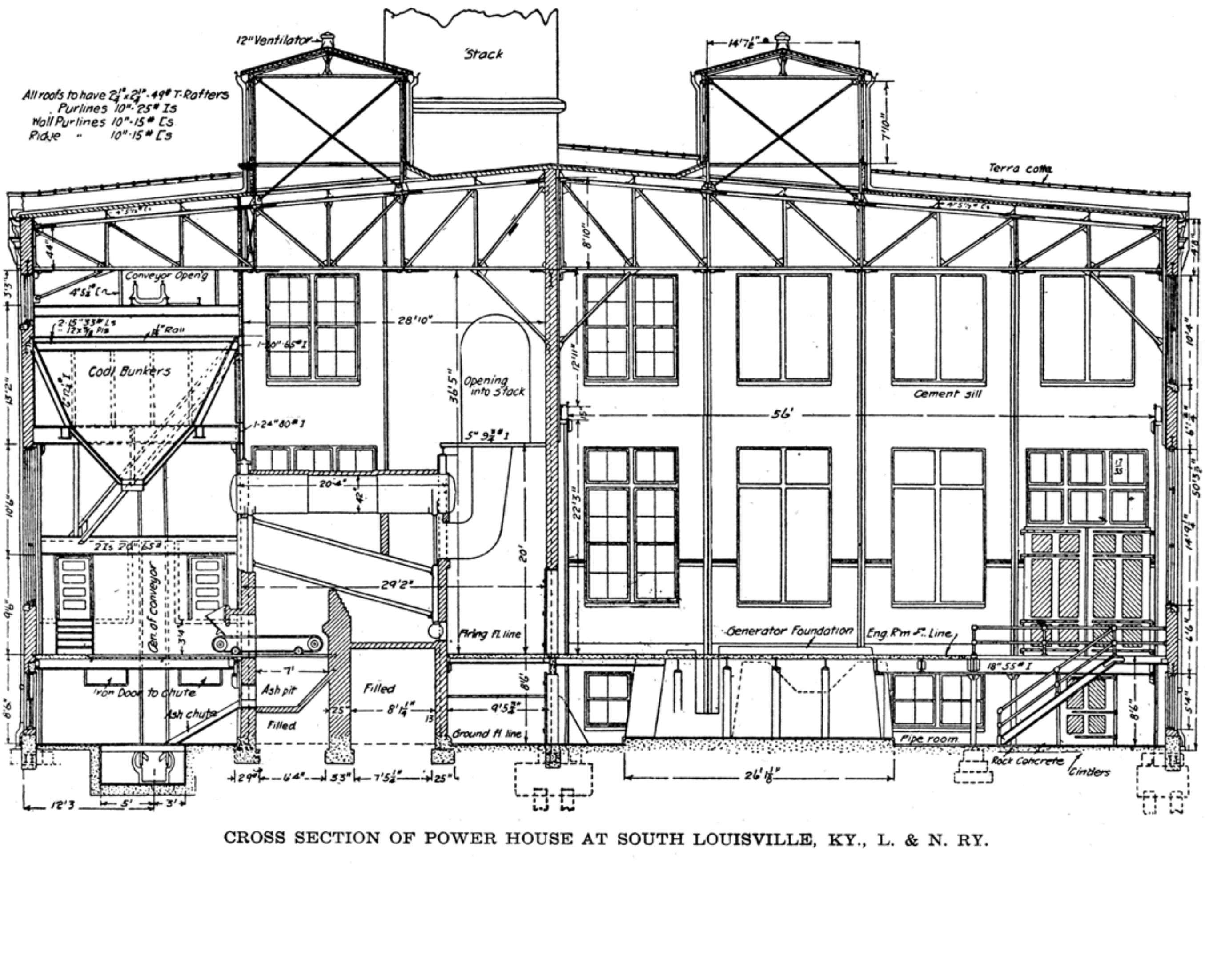

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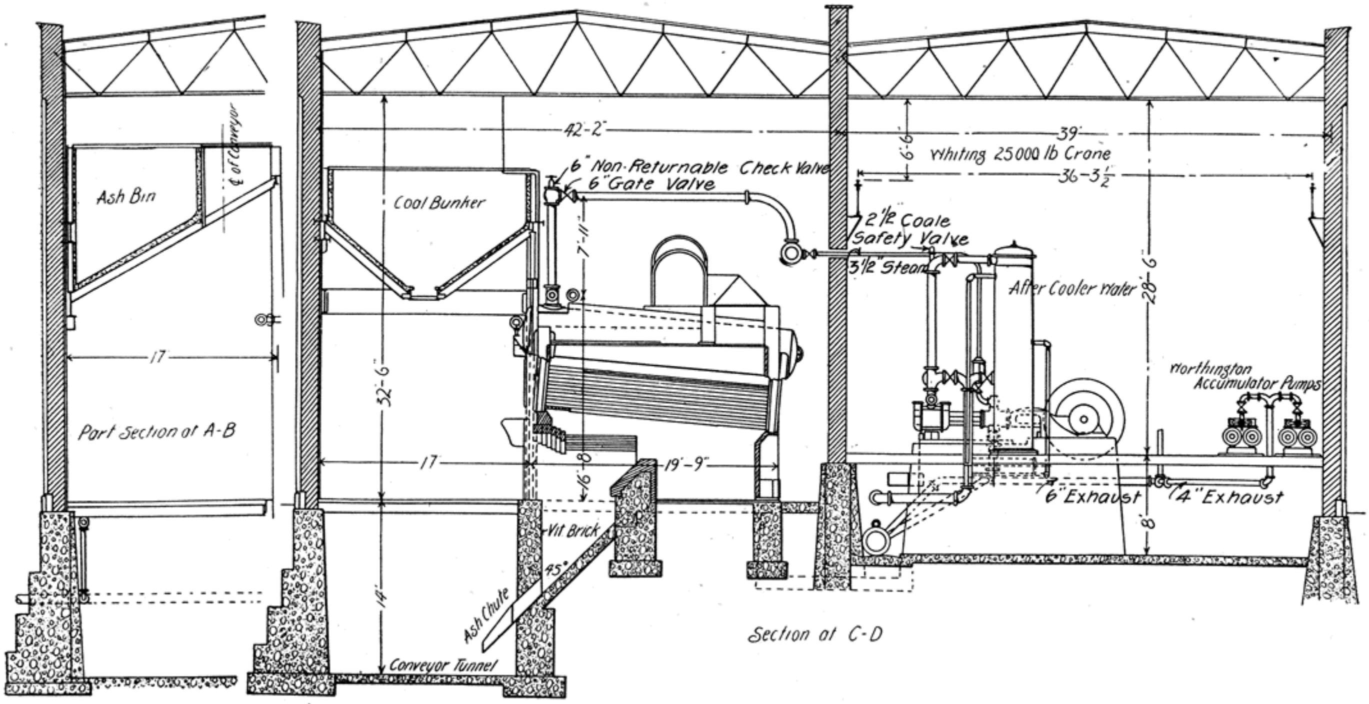

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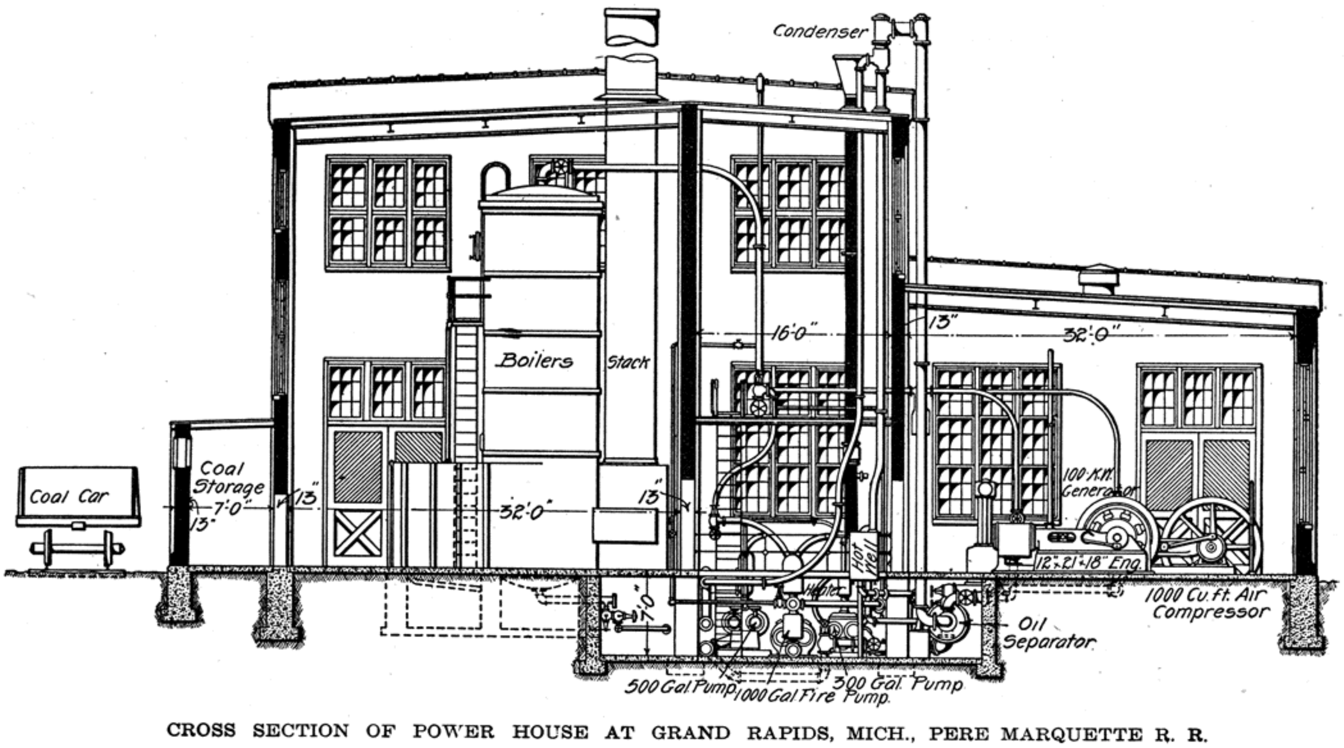

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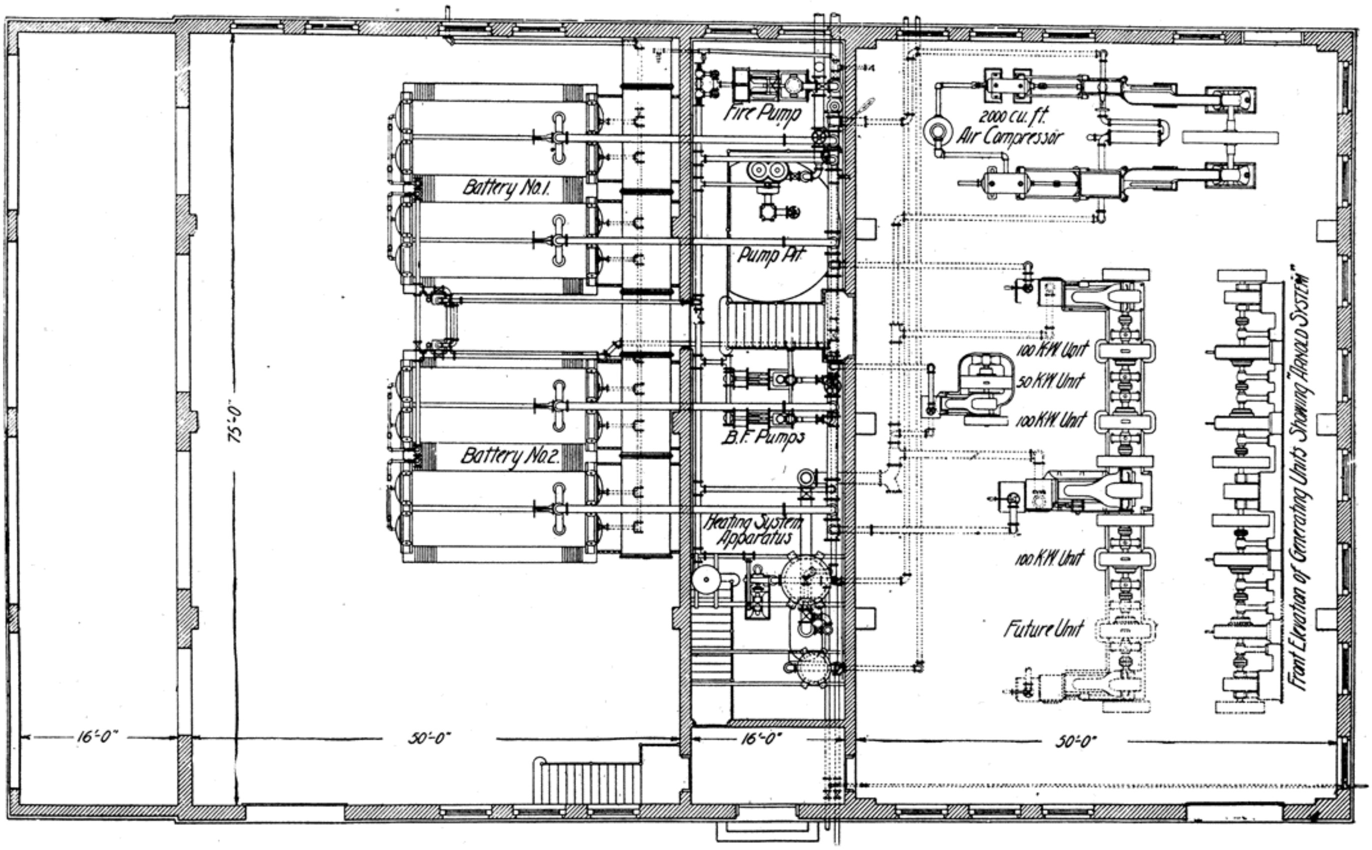
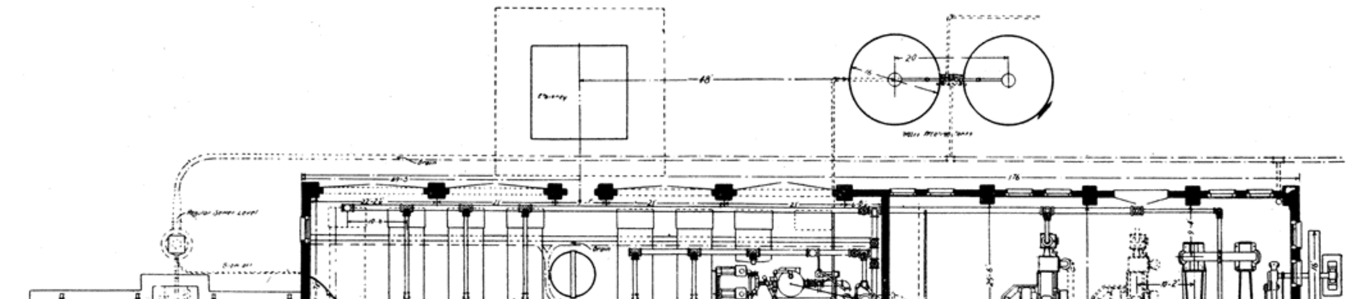


PLAN OF POWER HOUSE AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



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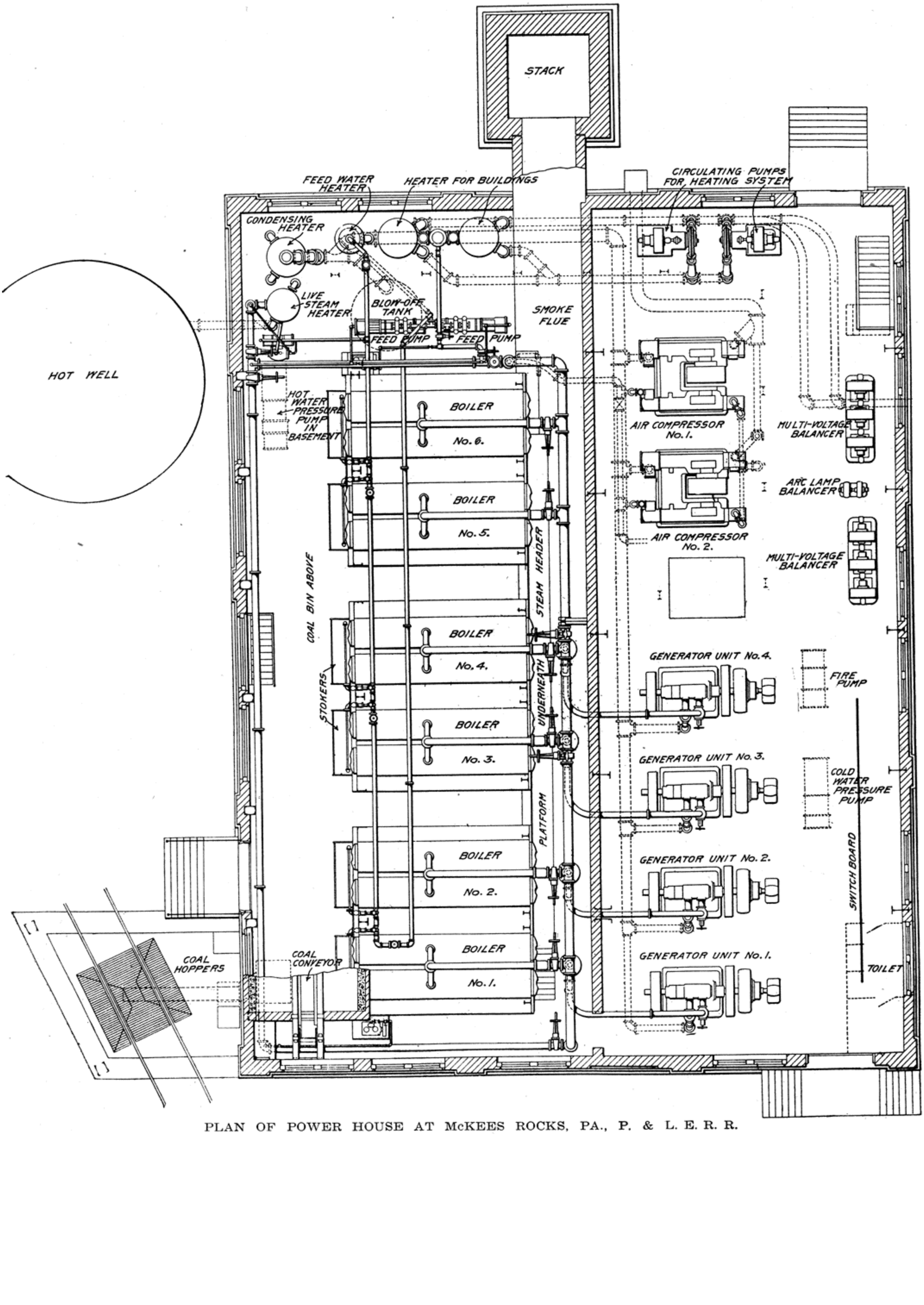
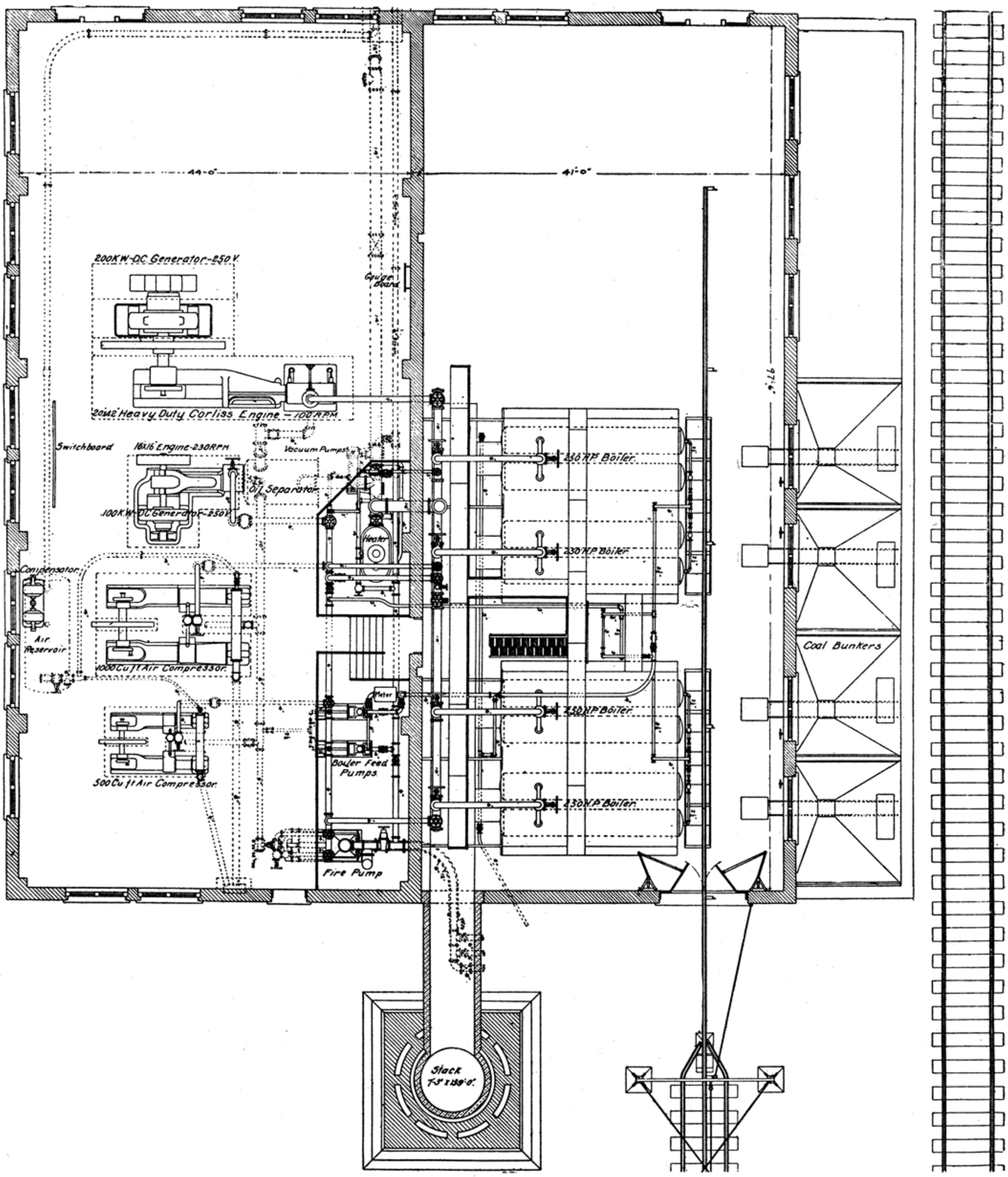


PLAN OF POWER HOUSE AT McKEES ROCKS, PA., P. & L. E. R. R.



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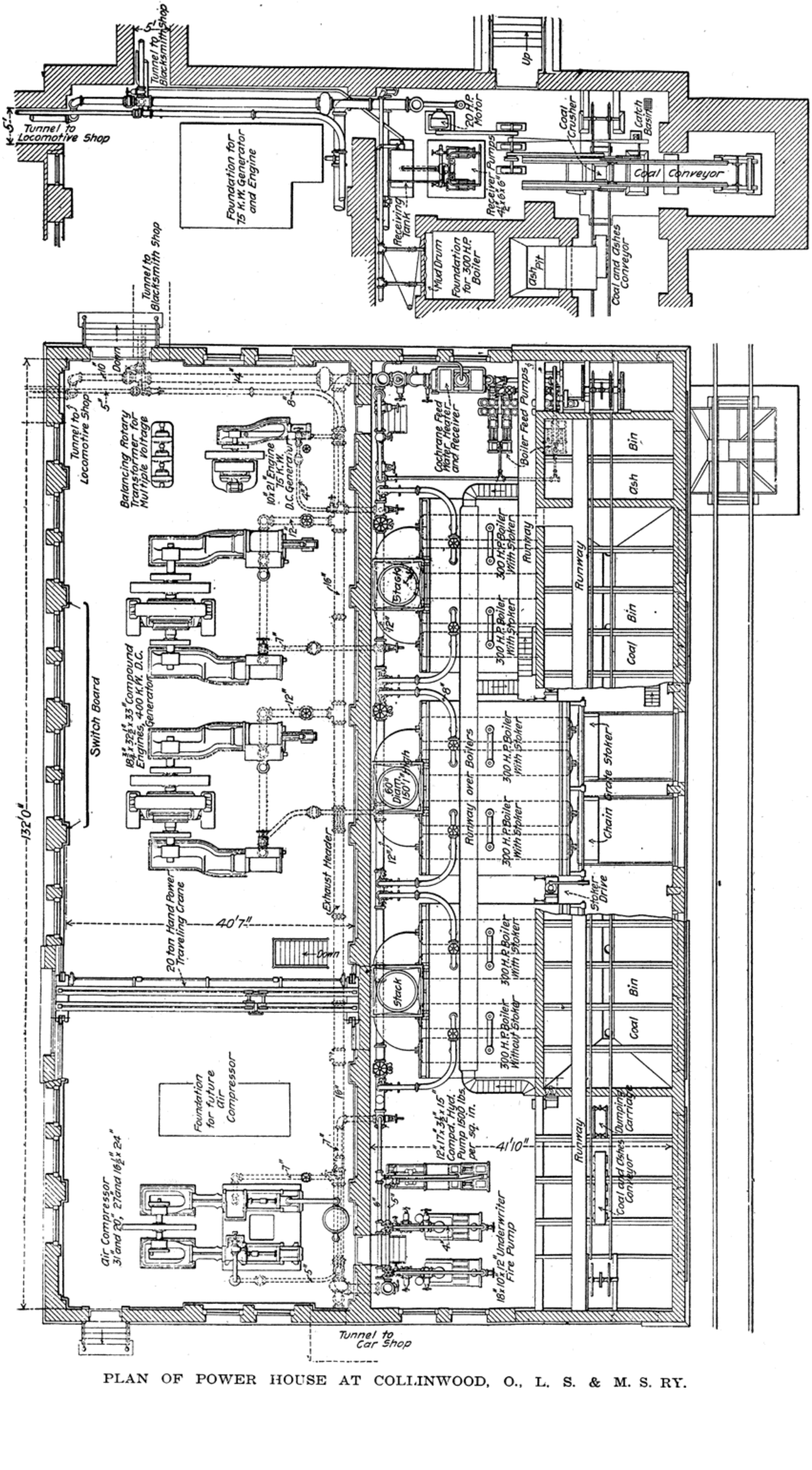

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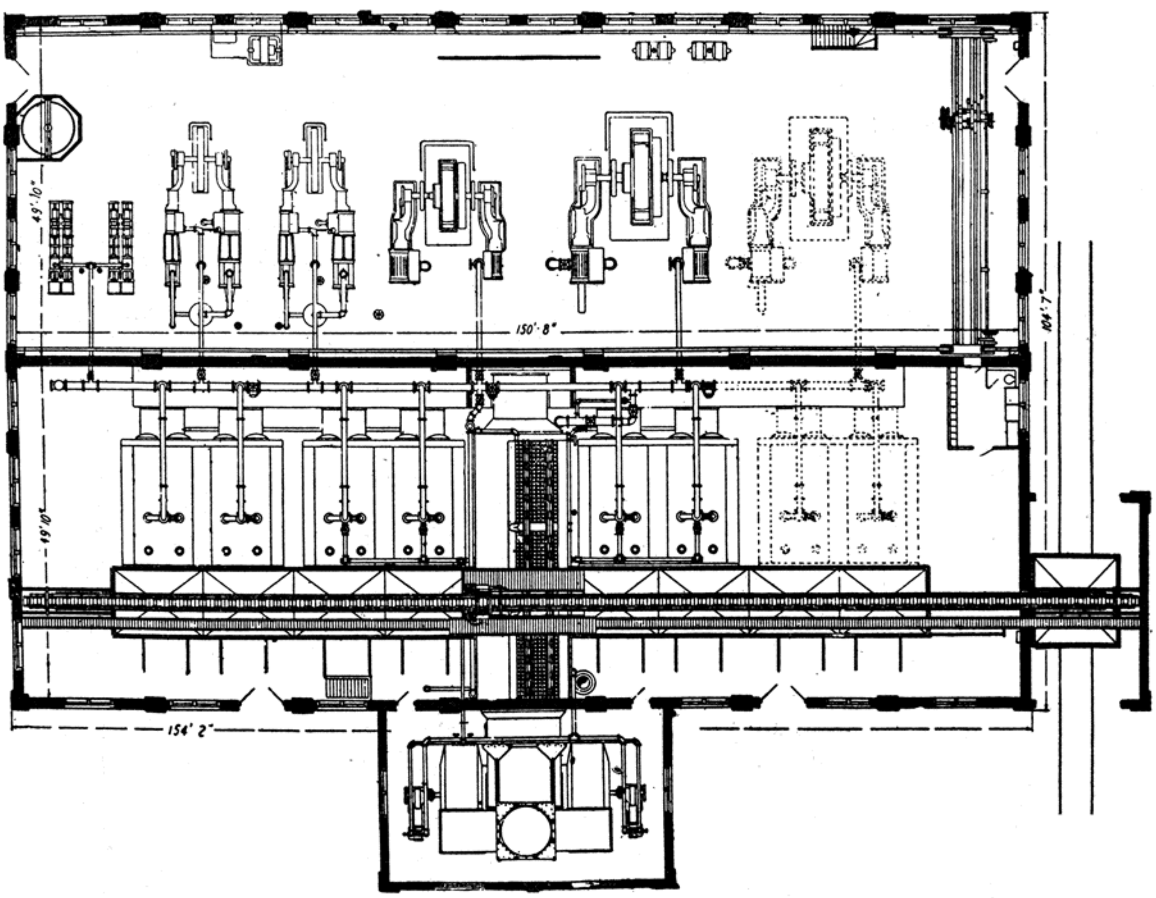

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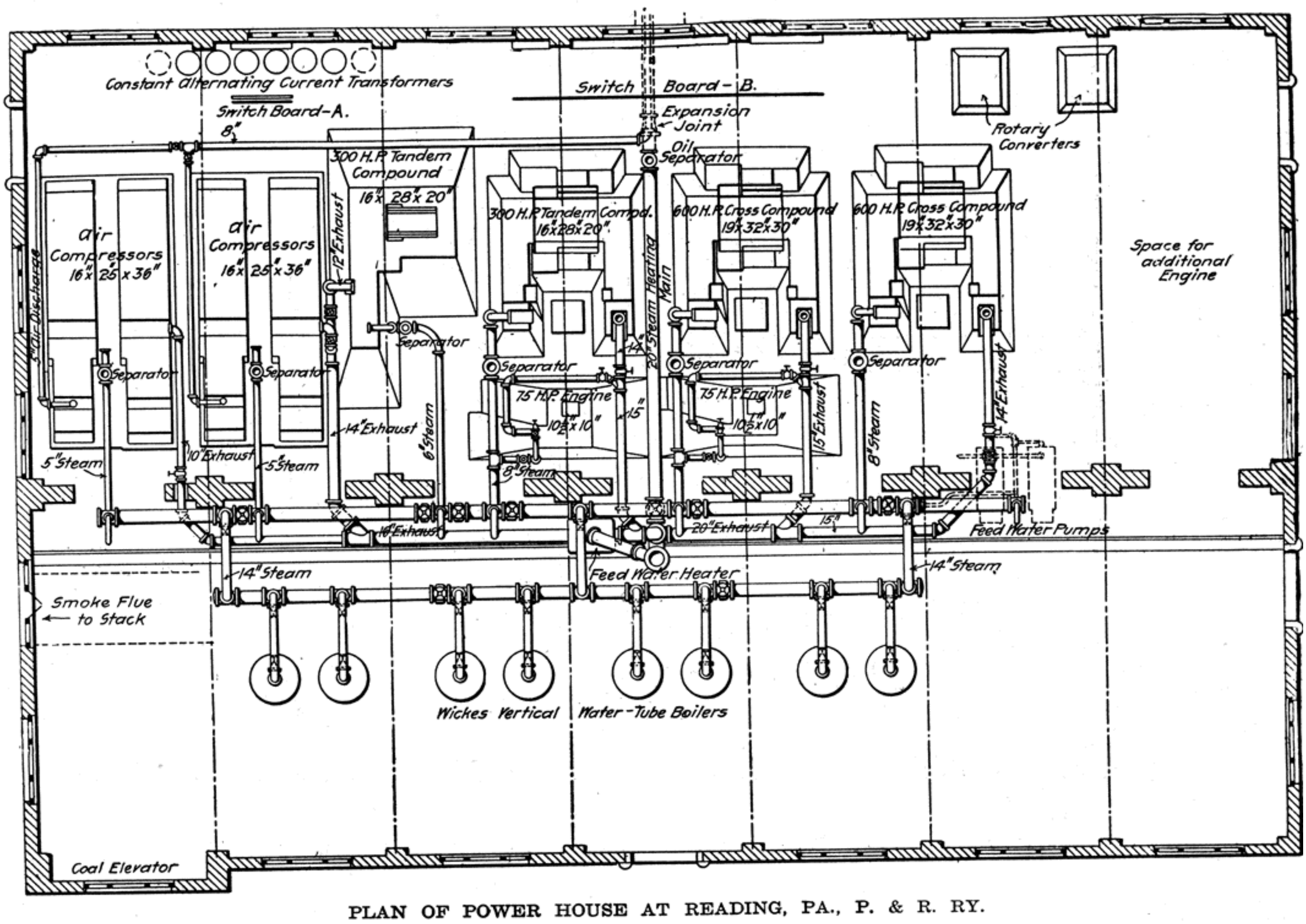

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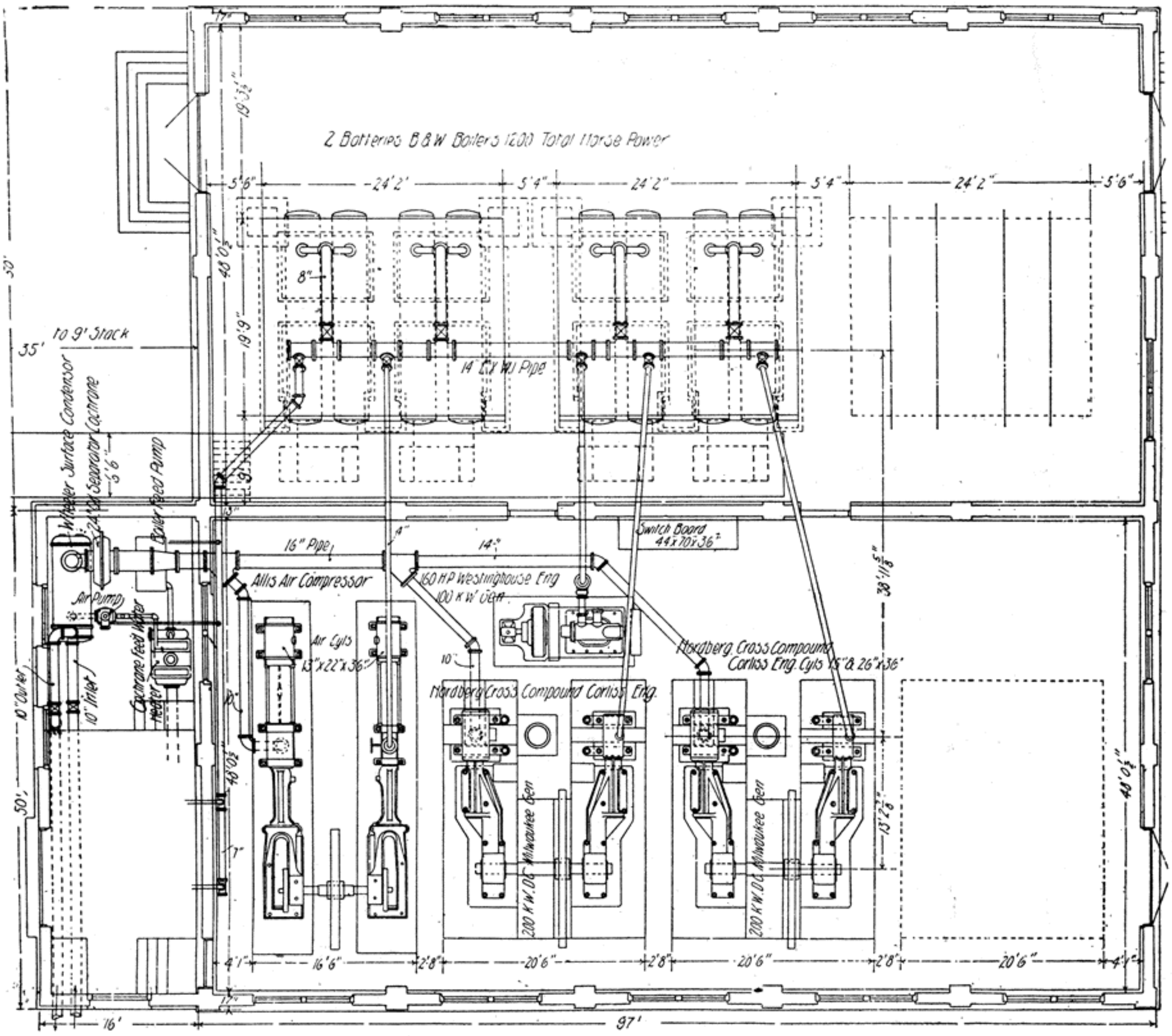

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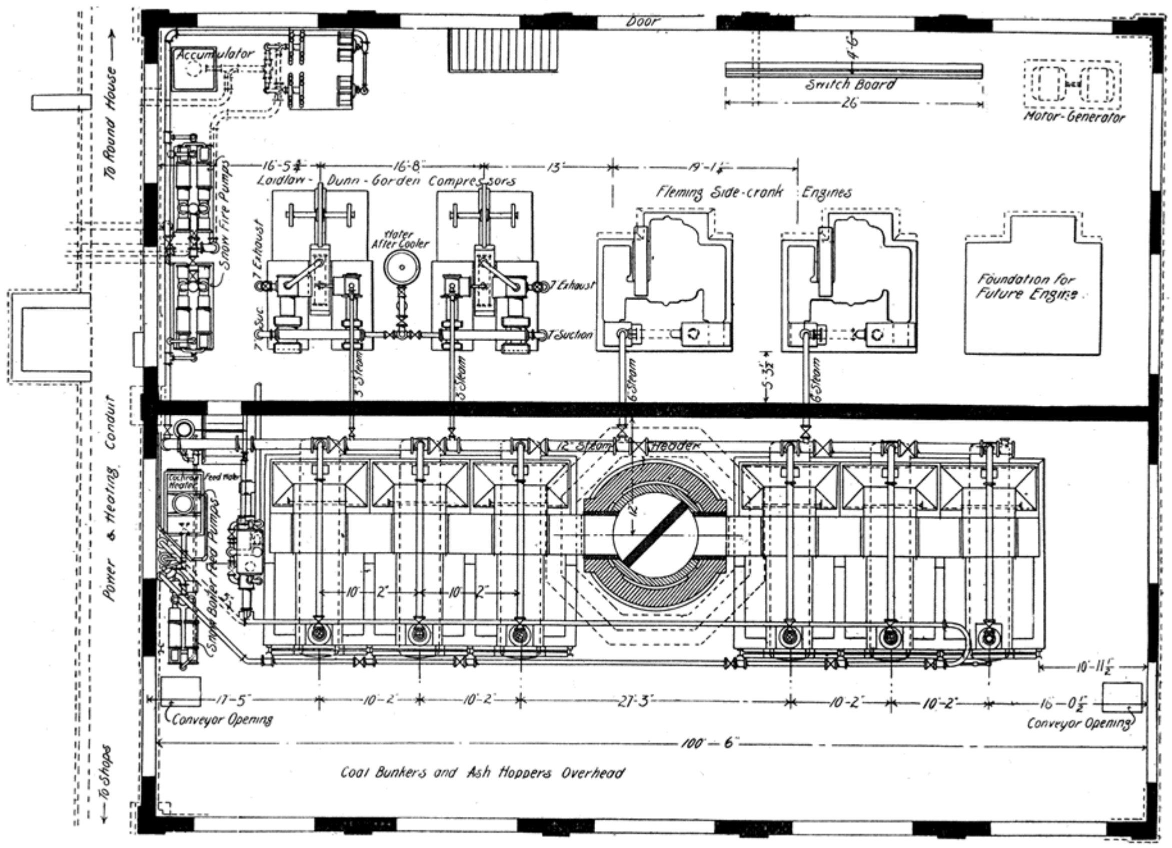

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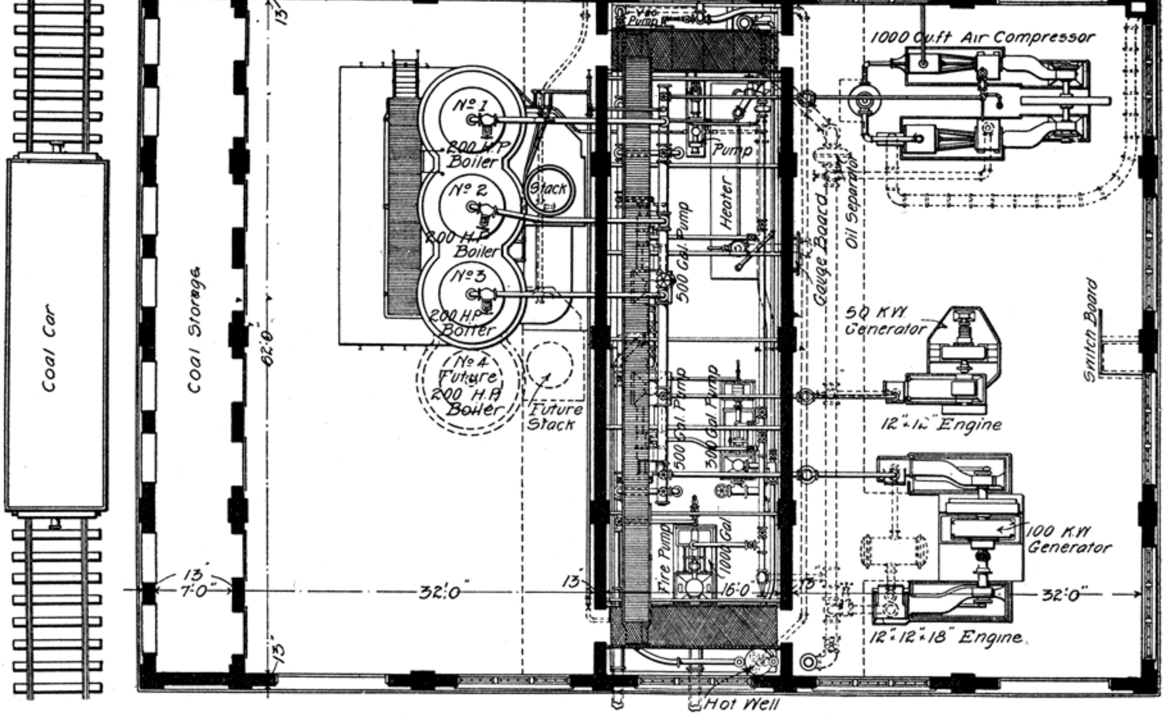


PLAN OF POWER HOUSE AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.

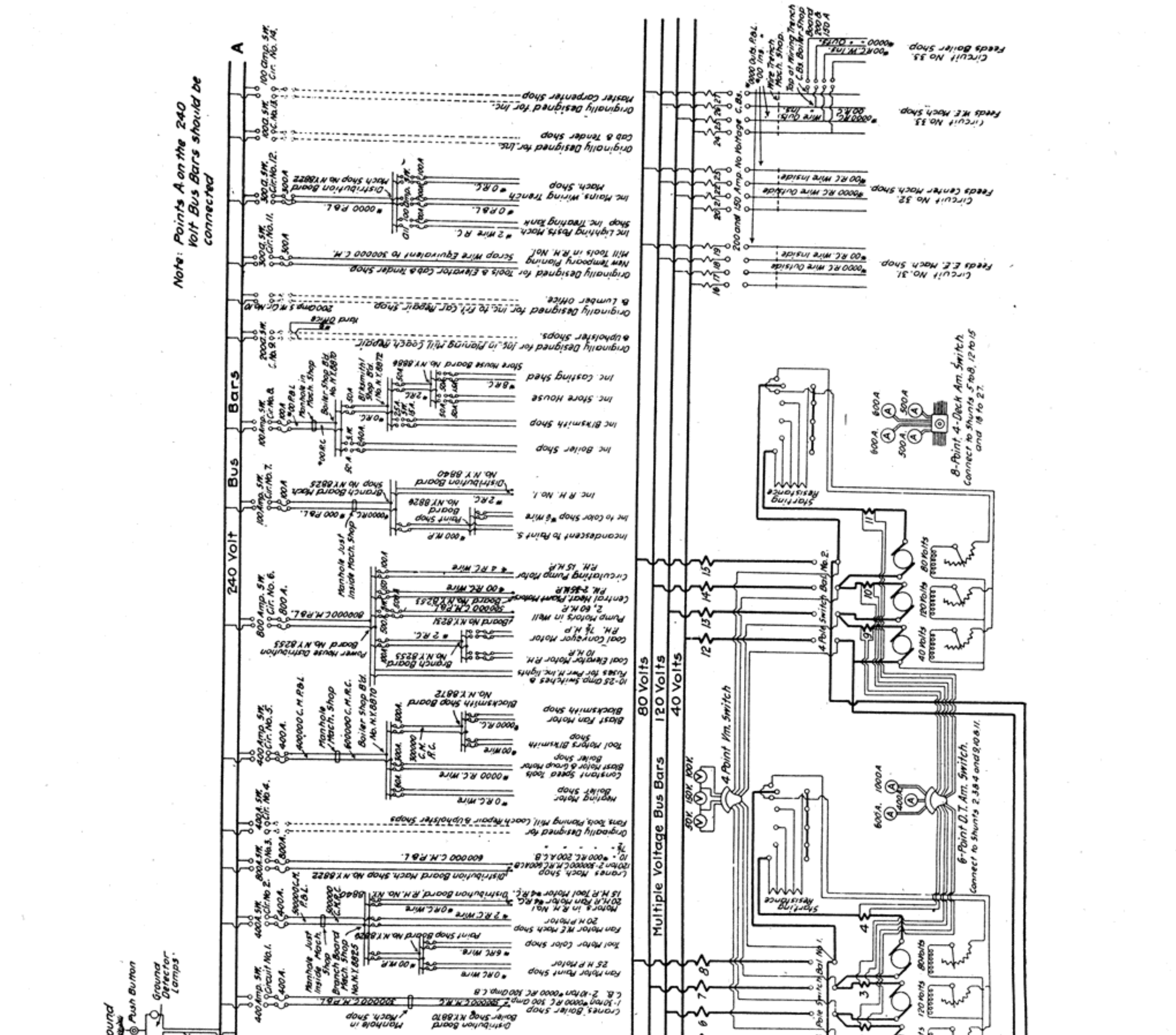
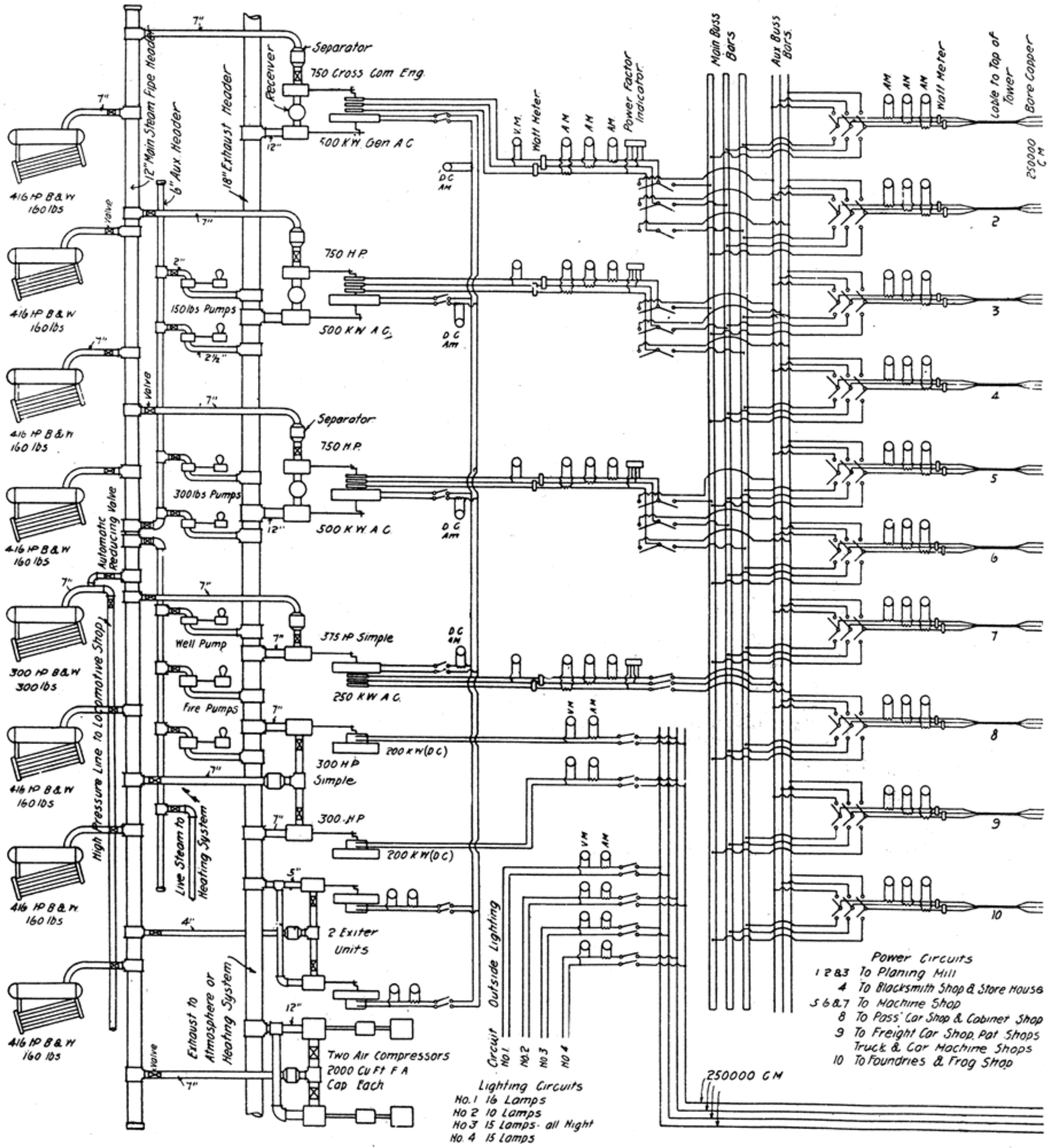


DIAGRAM SHOWING ELECTRICAL DISTRIBUTION OF POWER AT McKEES ROCKS, PA., P. & L. E. R. R.



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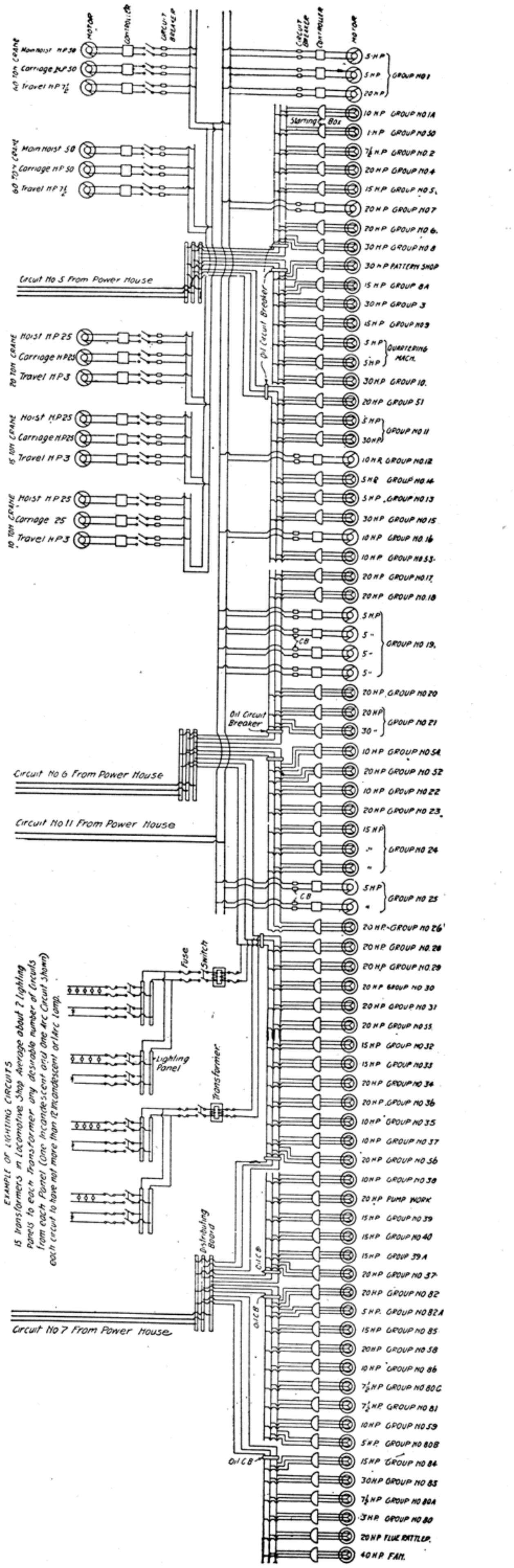

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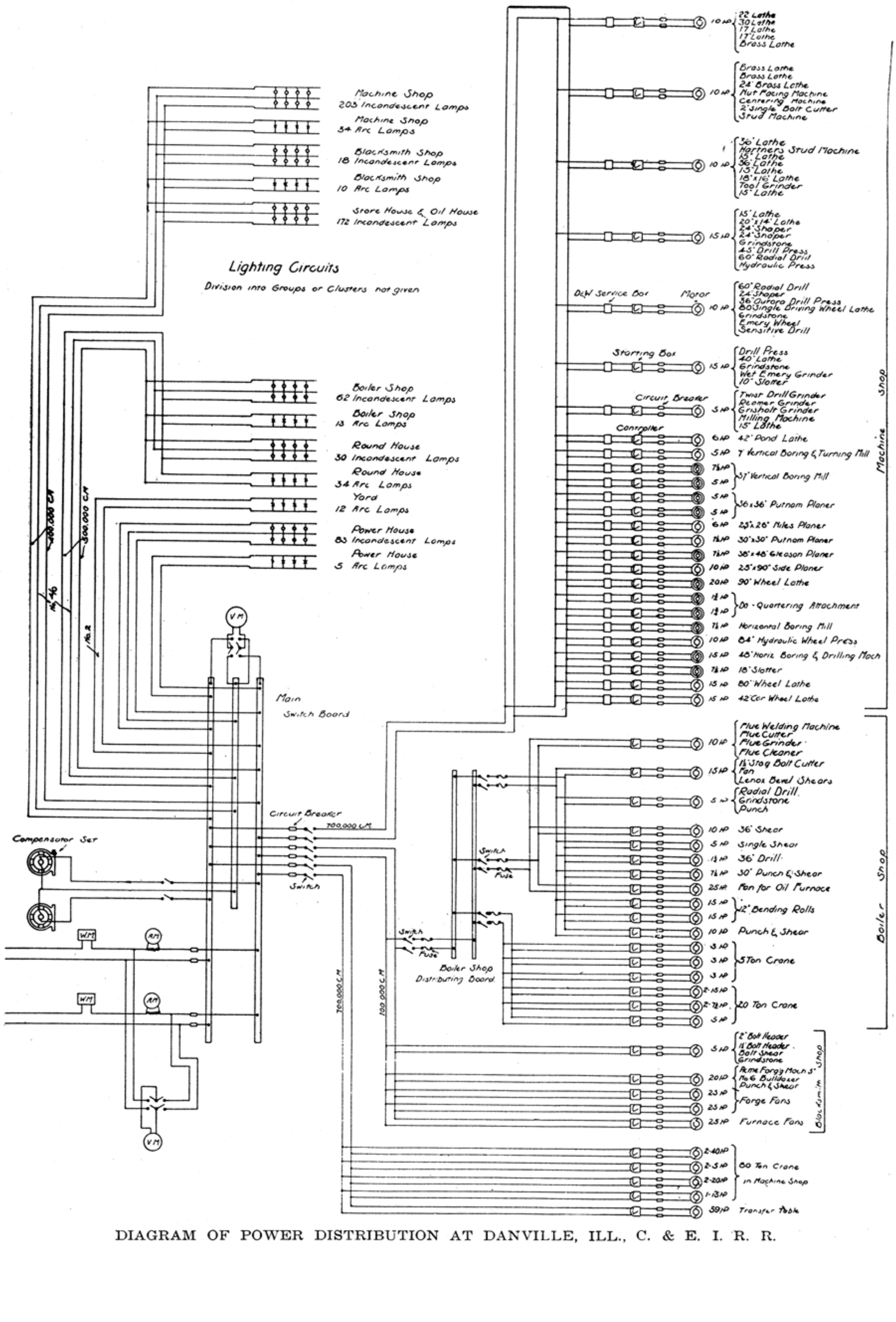

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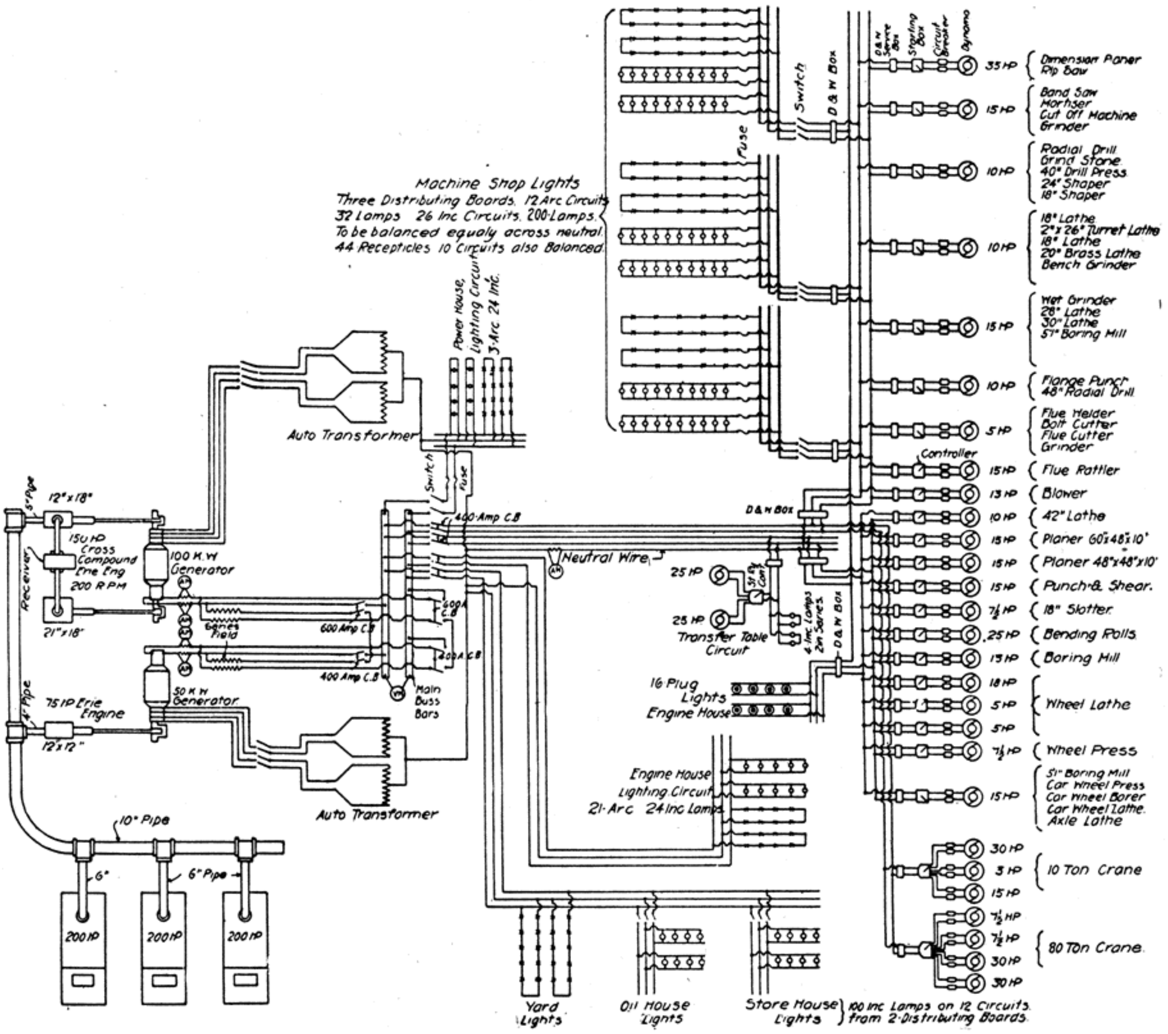

DIAGRAM OF POWER DISTRIBUTION AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.