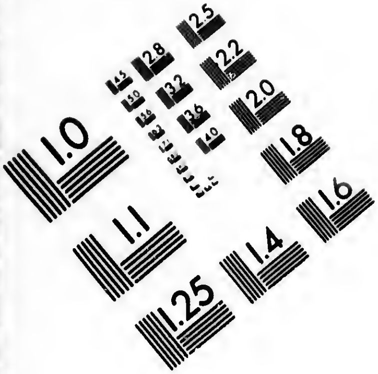

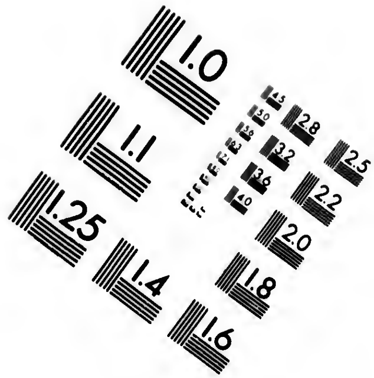

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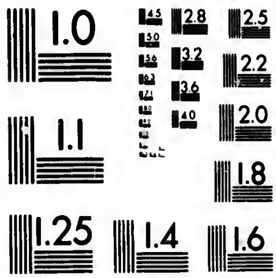


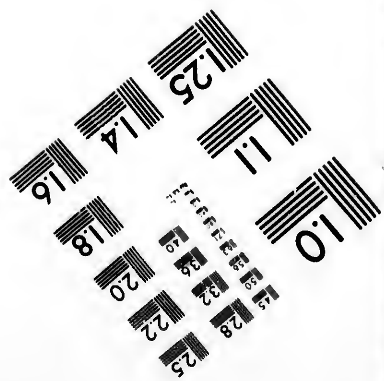

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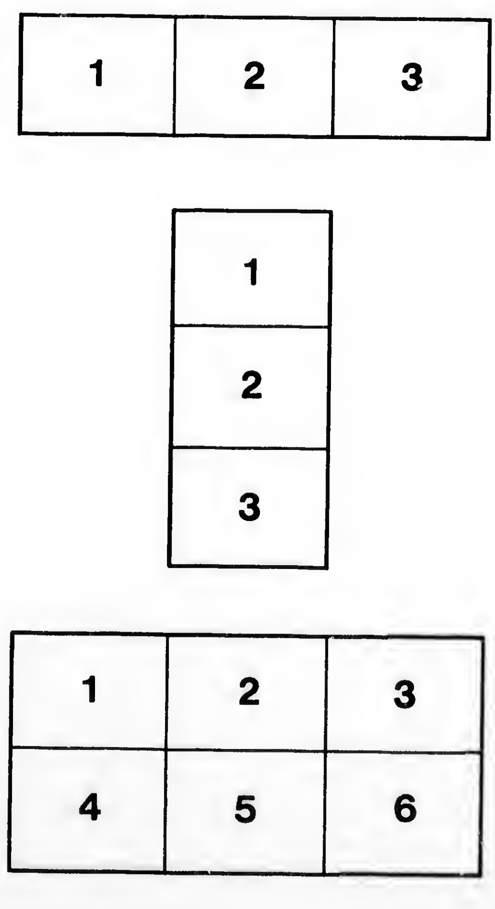

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The Canadian Society of Civil Engineers.

# WORK SHOPS,

## THEIR DESIGN AND CONSTRUCTIONS

BY

J. DAVIS BARNETT,

M.CAN.SOC.C.E.

BY PERMISSION OF THE COUNCIL.

EXCERPT MINUTES OF THE TRANSACTIONS OF THE SOCIETY.

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# Canadian Society of Civil Engineers.

## WORK SHOPS,

### THEIR DESIGN AND CONSTRUCTION.

By J. Davis Barnett, M. Can. Soc. C. E.

The author wishes to record a few notes on the design and construction of railway shops, and purposes not only to treat of the peculiarities that mark those of North America, but also to contrast some features with European practice, and if possible to indicate what is and what may be the modern development and progress in this art.

#### LOCATION.

A natural starting point is the *location* of the shops with reference to the terminal stations of the railway, and to some large town ; also the choice of land and its amount. A statement of the best American practice in this matter is given by Mr. C. Paine in the chapter on "Shops and Engine Houses" in his "Elements of Railroading." A point he strongly emphasizes, that *more* than enough land should at first be purchased (even if afterwards it is sold as building lots), will receive a unanimous endorsement.

#### FOUNDATIONS.

It would, for the present purpose, be a waste of time to enumerate those matters common to all dry, solid and effective foundations, but it may be remarked that in Northern climates, it is better that the sides of foundation walls and piers be *sloped* rather than stepped, so as to prevent as much as possible the earth gripping the wall, as it expands under the action of frost.

When the main supports of the overhead weights—such as roof-principals, crane-tracks, shafting, etc., are iron pillars; and "made ground" covers to any depth the natural foundation bed, the comparatively low price of iron has proved it to be economical to build short foundation piers, and to allow the iron pillars to run down below floor level, to the piers, instead of carrying up the piers to floor level, the pillars being socketed into broad cast-iron bases, bedded in cement.

Pillar footings and column bases, when above floor level, are usually bedded on rolled sheet or melted pig lead. The author is of the opinion that the running in, between base and cope stone, of a fine cement grout, would be quite as neat and effective, and certainly cheaper. Less concentrated weights, such as stationary engine and pump beds, and the footings of heavy machine tools, are satisfactorily bedded on their foundations with melted stick-sulphur.

Another instance of iron being used, to reduce the first cost of foundation, may be seen in the new erecting shop of the Grand Trunk Ry. at Stratford, where, instead of making continuous walls to carry the rails supporting the traverser table, it was found less costly and quite as efficient to build disconnected piers, and span them with wrought iron beams of I section, which carry the rails laid upon them longitudinally, and support the flooring laid transversely.

### WALLS.

It is advisable to emphasize the apparent wall construction; a good shop *looks* substantial. This is best accomplished by using bold pilasters or large piers to receive all roof and floor beams, setting them so that they stand out prominently, and spanning the panel between them with comparatively thin bonded walls, free from bats, if of brick.

This method of straight lines and prominent offsets not only satisfies the eye, but is of pronounced value in localizing and absorbing the vibrations received from the roof or machinery, and closer attention to these matters would result in our shops having a less tame—a less ugly—appearance, and a longer safe life. The permitted outlay on such new works rarely admits of the wall surface being broken into ornamental lines, or varied in color; but it is always possible to make a strong bony skeleton, whose very angularity will instinctively satisfy, by appearing to be quite equal to its special duty.

### ENGINE HOUSES OR LOCOMOTIVE SHEDS.

Intended for little else than the temporary storage of locomotives, engine houses in America vary more in first cost and permanence of material used, than in type of design. The ordinary arrangement in plan is an annulus or segment of an annulus—whose centre is that of the unroofed turntable, giving access to the radial tracks each leading into a single locomotive stall. The economics in the construction of the annulus are: either a narrow span of trussed ridge roof; or a so called flat roof (angle 5°), offering little obstruction to wind, and permitting the use of an inexpensive roof covering: low walls—the roof timbers are sometimes lower than the top of the engine chimney—and a short length of wall, as it is limited to the ends and outer ring, the inner ring being formed by the wooden door and door posts. A flat roof supported by pillars gives a very stiff building for the limited amount of material used, and if sloped inwards, the roof drainage is a simple matter.

The stack of the locomotive naturally going to the higher part of the building brings its front end close to the outer wall containing the windows, so that the most light is received where it is needed—on the moving parts of the machine.

Extending back into sparsely settled districts, as do many of the new railways on this continent, the primary consideration, in the erection of their buildings is low first cost, a future development of traffic, being relied upon to provide the revenue for erecting permanent structures. Hence, segmental engine houses of wood, with flat gravel-covered roofs are common, and if the materials for the ashpit, and its drainage, do not prove unusually expensive, they can be built for $850 per stall, the foundation consisting of cedar posts, 6 or 8 feet apart, carrying a mud sill, on which rests a pine frame of 6 to 8 ins. square scantlings, the roof being single sheeted with 1 or 1¼ in. tongued boards, and coated with paper felt, tar and gravel; the ashpit, 25 ft. long, being of brick or stone, and one iron smoke-jack being provided. The shell of a similarly roofed building with brick walls and stone foundation costs about $1000 per stall.

It was common some years ago in northern climates to sheet with inch boards on both sides of the scantling, and to fill in between with sawdust. This hastened decay by holding water and vermin, and the better practice now prevails of putting both sheetings outside, with tarred felt or thick paper between them. The use of clapboards or shingles for outside sheeting, much improves the otherwise primitive appearance of such an engine house.

The more permanent structures of this class are of brick, and those of modern date have roof principals, rafters and deck ridge beams of wrought iron throughout; the covering being of slate, preferably of small size, 8 by 16 or 9 by 18, with a quick angle or slope, at least equal to ¼ of span, which is never less than 66 ft.

In Canada, slate is rarely used for shop roof-coverings. Mr. J. W. Harkom (Member) informs the Author, that he has used New-Rockland slate on an engine-house in Maine for five winters without repair being needed, and he is familiar with roofs that have been covered with it for ten years, that show no injury from frost. Our native slates are very compact,—a point greatly in their favor. A report of the State Geologist for Vermont shows that the slate in this neighborhood has a water absorption (under vacuum test) of but $\frac{1}{400}$ of its weight. Mr. Harkom also mentions a successful experiment he carried out at Arthabaska, with the object of getting rid of the icicles that form at eaves, due to melting from heat communicated through the roof slating. He double-boarded or sheeted on the purlins, and then laid wood strips $1\frac{1}{2}$ by 1 inch thick on top, at proper distances apart, to which strips the slates were nailed. The air space below secures fairly equal temperature on both sides of the slate, thus preventing the excessive eave icicles common to slate covered engine-houses.

The fire risk from a roof covering of shingles—set in cement and occasionally lime-washed,—is very slight; in fact in high winds, with many live sparks flying about, it is probable that shingles so treated are safer than slate.

A liberal surface of glass is provided in the outer ring wall. Skylights flush with roof, being difficult to keep clean both inside and out, are of little use; and the small portion of each large door (forming the inner ring) that can be fitted with windows, makes it necessary to depend largely on the outer ring wall for natural light.

As to the number of engine stalls required, any railway in a moderate climate, having an engine house capacity equal to 60 per cent. of its locomotive stock, is well equipped; many American railways being content with 50 per cent.

In Great Britain a very common form of engine-house is the *longitudinal*, with parallel through tracks, and exit at both ends. Their capacity varies, rarely exceeding 80 engines. The roof is usually of the saw tooth pattern, a series of narrow spans, supported by hollow iron pillars, forming conduits for the water from gutter in roof valley to under ground drains. The roof is hipped unequally, favorite angles being 60° and 30°, and that side more nearly vertical is glazed with $\frac{3}{8}$ inch rolled or rough plate, and if possible is arranged to face North, so as to give a good light equally diffused throughout the wide building, without too much inconvenience from the direct rays of the sun. Snow and frost prevent the saw tooth roof being used in Canada, (the Author not knowing of a single example on this continent north of the State of New Jersey,) hence our roofs are of single slope ("flat") or single ridge of quick pitch, and as skylights have but a partial efficiency, the necessity for securing light from the side walls limits the width of a longitudinal engine-house.

An excellent example of this type of house built by The Grand Trunk Ry. at Montreal, is 76 ft. wide by 282 ft. long, with five parallel tracks through it, giving liberal accommodation for 25 long tender-engines. Any increase in capacity, could only be obtained by lengthen ing the building and tracks, which increases, out of all ratio, the difficulty of working the longitudinal type of house. This difficulty is the trouble and extra movement of other engines necessary to get a locomotive out and ready for service, should one on the same track in front of it, be undergoing for a few hours such light repairs, as the renewal of truck wheels, that prevented it from being moved until the work is completed. American criticism says that this is the main defect in the longitudinal type of house. It does not, however, in daily practice prove to be as awkward as it looks, if definite tracks are reserved for such repairs and for such engines as have to keep "shed-day" while their boilers are being washed out, and if the house-men (engine turners) learn what part of the house each engine should go to, before attempting to put it under cover.

Exit at both ends of such house, cannot be obtained where the yard room is limited. At Cardiff, on the Taff Vale Ry., England, the Locomotive Superintendent, being compelled to have one end of his new engine house blank, put in the middle of its length a traverse pit and table, crossing its ten tracks and then passing out, through a pocket on side wall, to a pa allel siding in the yard. This gives practically three exits, with exceptional economy in space. (See Proceedings Inst. C. E., Aug., 1884, p. 243.)

The Great Western Ry. of England has in many of its engine houses, combined both the longitudinal and the radial systems under one continuous hip and valley roof, and the North Eastern Ry., England, had such a preference for the radial system, that five turntables were put under one roof, 280 ft. wide by 450 ft. long, giving stallage for 95 engines. This is an extreme case and is probably unique, although in passing, it may be noted, that the late Howard Fry, in designing the extensive workships for the West Shore Railway at Frankfort, N. Y., laid them out so that the smithy, boiler-shop, foundry, erecting and machine shop stand radially to an open turntable. Having, however, unlimited land at his disposal, the tracks from the outer ends of these buildings are connected by easy curves to the yard sidings, so that a failure of the turn-table or the blocking of its pit will not necessarily lock up all entrance to these shops, such being the case with the tracks in an engine house, which converge on a central turntable as their sole means of exit. The Burlington and Missouri River Ry. at Plattsmouth, Neb., also has most of its shops in the shape of segments of an annulus centering on one turntable.

The best radius of track curve is an unknown quantity, but the New York Central Ry. safely uses curves as quick as 160 feet radius for their city freight-house.

The author would strongly endorse the longitudinal type of engine house. It is eminently serviceable where a large number of engines have to be turned out almost together in the busy portions of the day. An English officer, daily handling about 400 train engines at one terminal, in comparing the two systems, said, that if turntables controlled the exit of his engine houses, he believed it would be impossible for him to get the engines out on time for their trains, even with additional space and men placed at his disposal.

And this type as readily suits small establishments. An engine-house recently erected by the Grand Trunk Ry. at Lindsay (under the supervision of the Author) is 250 by 62 ft. It has two through tracks, with continuous ash-pits for 10 running engines, one through track for engines under repair, being washed out, or waiting under steam between trains. Parallel with the windows of one side wall, are two stationary boilers with overhead apparatus for sand storage and drying, three smiths and other fires, a stationary engine, a force pump with underground water supply tank, and still continuing in line with the shop and main shafting, are wheel lathes and other iron working machinery, the fitters' benches, and the wood working tools and benches, followed by foreman's office, clerks' office, and a two storied storeroom, with oil tanks below ground, the whole resulting in a cheap compact arrangement, every foot of floor space being used, while every corner and detail is well under the eye of the foreman. The tracks in yard form a triangle (or Y, as it is called) and a turntable with its pit is dispensed with, thus getting rid of one, source of probable failure and delay in getting engines out "on time."

Many engine houses are now equipped with a continuous pipe 1½ or 2 inches diameter, having branches to each stall and flexible couplings to each engine. Its uses are various. The steam and water from a boiler to be "blown off" and washed out, are sometimes used to heat the water with which the washing out is to be done. The pipe may be passed into a boiler of cold water, so as to shorten the time in raising steam after a washed out boiler is refilled, and sometimes, it is connected with the jet-blower at base of locomotive chimney, and the steam used in creating a draft to quicken up the newly lit fire. The two latter arrangements prevail where an injector or inspirator is used to give the washout water-pressure.

## OIL HOUSE.

A special feature of American engine-houses,—the outcome of the extensive use of mineral oil for lubrication as well as for light—is a detached oil house; a fire-proof brick structure with iron roof, roof covering and shutters, and concrete or asphalt floor. Underneath it (below track level) are iron storage reservoirs, with inlet pipes so arranged that oil received in bulk can gravitate from the tank-car into any one of them, from whence it is lifted by hand or steam pump into small tanks on upper floor, and is drawn thence by tap for engine and train use.

The concrete floor is at level of car-floor, or about 4 ft. 2 in. above rail level, to facilitate small shipments to out-stations, which in the more perfect equipments is by means of circular iron tanks holding 60 gallons. The cellarage around storage tank and the house, is warmed by steam pipe from outside, and the artificial light is gas, or as at Indianapolis, electric, no lamp or torch being admitted.

## SAND HOUSE.

The sand used to increase the adhesion of locomotive wheels would at first sight seem to be too small an item to require specific attention; but eight or ten tons is a daily issue at central stations. At Columbus, O., the sand store, having a capacity of 1,000 tons, is a neat wooden building with hinged shutters at top of walls, set so as to permit the air to assist in sand-drying; and the floor is of dry brick set on edge, with tile-drain below. When required for use, the top layer of sand is shovelled into hoppers, containing live steam pipes one inch diameter and spaced two and a half inches apart; when dry it falls through bottom opening on to a concrete floor.

The Grand Trunk Ry. has recently, by hand power, belt and bucket elevators, lifted the dry sand into overhead reservoirs, from whence it is allowed, through hose and molasses gate, to deliver directly into sand-box on top of locomotive boiler.

## COAL SHUTES, ETC.

Equipment for coal delivery to Tender may be passed over (the author having treated on this matter at large elsewhere), also the details of water supply and delivery, as the varying local necessities do not permit any uniformity in this matter.

## GENERAL REPAIRING OR ERECTING SHOP.

The amount of floor space to be devoted to the general repairs of locomotives and tenders, and its proportional division among the various buildings, is a wide question, on which little has been written; and in attempting to find an average taken from existing practice, difficulty is experienced, due to so many workshops manufacturing supplies for out-stations and for other departments, even when not manufacturing new engines.

Simply for repair purposes, the Author is of opinion that there should be floor or stall room in the erecting (repair) shop for 10 or 11 per cent. of the total engine stock. It may be expected that 4 or 5 per cent. will be in the paint shop going out, or in yard waiting to come into erecting shop for general repairs, and that 5 per cent. are having their boilers washed out, or undergoing running repairs of so trivial a nature, that they can be done in the engine house. This leaves 80 per cent. of the motive power effective and at work daily.

To illustrate—we will suppose the total number of engines on a railway to be 100; the working engines make a daily average of 133 miles or 4,000 per month, which multiplied by the 80 effective engines gives 3,840,000 miles per annum, and the repairs done in the erecting shop have to balance the wear and tear of this mileage.

The first question is one of time: How long does it take to repair an engine? An average common in America is—

Heavy repairs occupy 90 days—equivalent to a wear of 100,000 miles.
Medium " " 60 " " " 70,000 "
Light and specific repairs occupy 30 days—equivalent to a wear of 30,000 miles.
General average is 60 days (2 months) to a wear of 67,000 miles.

Each engine on a general average, occupying a stall for two months, gives the output of repaired engines for an erecting shop containing ten stalls as 60, which multiplied by the average mileage of 67,000 totals to 4,020,000, a sum just in excess of the mileage during the same period by the 80 effective engines.

There is (or should be) some relationship in size, between the erecting and other shops of the locomotive department, and Appendix A. gives from recent practice the comparative area of the other shops in percentages of the erecting shop.

It will be seen that the proportions vary; and it must be so when some establishments build more or less new work, while others are restricted to repairs only; some are confined to locomotive work, whereas in others material is manufactured for all departments, including even the telegraph department.

Also the "size" relationship will be varied by the uniformity and nterchangeability of the parts of the engine stock. Where their classes and styles are few, all the shops will be comparatively small, and the delay to engines in the erecting shop less. Thus any such table will only permit of a mean average being taken.

This being the case, under each heading is a second column, in which the size of each shop is given as a percentage of the whole—so that, given the total roofed surface that can be devoted to the locomotive department, its proportionate divisions can be approximately inferred

In America, the ordinary arrangement for erecting shops is, that the pits or stalls lie transversely to the main axis of the building, admission to them being by a transfer table or traverser, within the building in northern latitudes, and outside it where snow is likely to cause but little inconvenience. There is an obvious economy in size and cost of structure when the traverser can be put outside; but its free movement cannot be insured during a Canadian winter, and an attempt to use one in Montreal was, after much inconvenience, abandoned years ago. Hence, the shop must be wide enough for its work, and for the length of the traverser in addition, at once giving a span of roof justifying the use of intermediate supports. Two rows of pillars are often used, dividing the floor space into three bays, one on each side of and parallel with the traverser pit, as this brings the work and men close to the side windows. When the traverser is outside it is rarely that the floor is obstructed with more than one line of pillars. Whatever be the number and disposition of these internal supports, the roof is invariably of the single ridge, or gable pattern.

TRAVERSERS OR TRANSFER TABLES.

It was due to traversers being framed in timber that the pits in which they moved were at first so deep—even exceeding five feet. Rolled steel is now used for the frame, which is suspended from the axle journals on both sides of eight small wheels, and for which four parallel rails are provided, the full length of pit. Much ingenuity has been used in the endeavor to reduce the inconvenience of the pit, by making it as shallow as possible, and at Reading, the Philadelphia and Reading Railway in its new car shops has no pit, only a flush asphalt floor from wall to wall. As, however, the suspended or carrying rails of the traverser must be higher than the fixed rail over which they move, it is arranged that the tracks at each repair stall, instead of being spiked to cross-ties, are carried upon longitudinal timbers about 10″ square, thus lifting them above the floor level, and giving the necessary difference in height between the traverser bed rail and its suspended rail. The author is not familiar with any example on this Continent, of the European practice of making bed-rails for traverser and the transverse or stall tracks, flush with each other and continuous, except where slightly cut at intersection to allow the wheel flanges to pass. The shallow rails on the traverser only just clear the bed track on the floor, and the vehicle to be transferred mounts to them by running up tapered extensions of the suspended rail that are hinged—or rather pivoted—on its ends, and which when not pressed down by the wheels of the on-coming vehicle, are kept clear of the bed tracks by springs. This practice may be said to be a development of the "Dunn Traverser," at one time in common use for the transfer of carriages at terminal stations on English and Continental railways.

Having all rails flush, not only permits the rapid movement of men and small material, but allows the transfer, when traverser is engaged, of vehicles from a stall on one side of bay to the track immediately opposite. Having in view the possible failure of the traverser, some shops are, and all should be, provided with portable rails to span the width of pit.

Power to move the traverser is often communicated direct from boiler and engine carried upon it. This, though convenient enough, perhaps, for out-door service, has proved to be an unmitigated nuisance under cover in winter, when doors and windows must be kept closed. Endless chains, the full length of the bed with stopping and starting gear at one end, are sometimes used. The friction is considerable the chain having to be supported every eight or ten feet, and signals to control traverser movement have to be transmitted over long distances.

Stout wire cable, travelling at same speed as chain, offers less resistance, and if one of the forms of clip gear is used on the traverser, the single attendant travelling with it has its motion completely under control. The cable grip clip gear, used at West Albany, New York Central Ry., is a simple form of friction brake stopping the revolution of a set of three geared wheels. When locked, the traverser moves at same speed as rope. Two sets of such wheels are used, so as to give both up and down motion. When table is at rest, power is transferred to a capstan used in hauling vehicles on and off the traverser. At Alton, Mr. W. Wilson causes a small quick moving rope to give motion to one wheel and shaft, from which power to traverser and capstan is communicated through bevel friction wheels. Speed of traverser is slow, 25 ft. per minute, and that of the capstan is but 32 ft. per minute.

The outdoor traverser, built some years ago for the Wason Car Shops, Springfield, is 50 ft. long, and weighs 11 tons, being propelled by a boiler and engine of 12 N. H. P. A steam pressure of 15 lbs. will move it without load; 30 lbs. with heaviest passenger coach on, and 60 lbs. gives it a speed of 500 ft. per minute.

An interesting and successful attempt has just been made at Aurora, on the Chicago, Burlington & Quincy Ry., to give motion to a traverser and capstan through an overhead electric wire with a small trolley running on it connected to a 7½ H. P. Sprague motor. Its rapid motion is geared down, so that table can be run either at 100 or 200 ft. per minute. The table is 65 ft. 9 in. long by 15 ft. wide, and weighs empty about 15 (short) tons. The tractive resistance, unloaded, is about 250 lbs., equal to 17 lbs. per ton; loaded, it is 1500 lbs. or 37 lbs. per ton. Experiments on the Coln Minden Ry. at Deutzerfeld give the resistance of a traverser and load weighing 20 tons at 440 lbs., equal to a tractive resistance of 22 lbs. per (long) ton.

Cotton ropes moving at 3360 ft. per minute, are used (under cover) at Cologne on the Rhenish Ry., for coach traverser, friction clutches being used to change the speed, so that the table has a motion of 197 ft. and capstan of 64 ft. per minute.

Erecting shops equipped with traversers at low level, need in addition some means of lifting an engine off its wheels, and a hoist is usually fixed in the roof timbers either close to entrance or in centre of length of shop over the traverser bed. Lifting power is variously communicated to hoist by belt from shop shafting, by hydraulic pipe, by pneumatic pipe, and even by hand labour.

### OVERHEAD TRAVELLING CRANES.

The European practice of making the erecting shop narrow compared with its length, using three (or at most four) longitudinal tracks and spanning them for their whole length with overhead power traveling cranes, has not often been adopted in America, although we have specimens at the Canadian Pacific Ry., Montreal, at Altoona, West Burlington, Indianapolis, Roanoke, and at Hamilton, Ont.

Why so effective a method has been comparatively neglected, it is not easy to say, as by its use there is an economy in floor space, and the cranes can do duty for both traverser and hoist. Undoubtedly the roof, or a portion of it, must be carried up higher, so as to give head room for the cranes and their load to pass over engines being repaired; but the interest on this outlay and on that of the cranes (often exceeding the cost of both traveller and hoist), is but a fraction of the money and time saved in the daily working of the shop.

Two fish-bellied plate girders, extending from sidewall to sidewall, with their ends supported on plate box trollies, usually form the crane bed and carry one—or better still, two—travelling crabs. An independent boiler on crane—as a source of power—is now rarely used; but from the shop shafting motion is communicated to the crane by quick moving rope of steel wire, hemp, cotton or rawhide. If the distance crane has to travel is short,—say under 150 ft.—or if it is used in the foundry where heat and dust would materially shorten the life of a fibre rope, then longitudinal shafting (grooved or square), supported on tumbling bracket journals, is often used. In almost all cases where the winch forms part of the trolley, the transfer of motion to it from the end of crane is by such a shaft, although in the original cranes of this class designed by Mr. Ramsbottom the high-speeded cord was carried along the crane girder through the trolley to opposite end, and then back to side wall, bending the cord often and shortening its life.

Messrs. Fowler of Leeds use steel wire rope similar to that used in steam ploughing: their 12 ton crane being equipped with a $\frac{5}{8}$ in. diameter rope, moving at 270 ft. per minute. One, of 40 tons capacity and 50 ft. span, has the rope speeded to 400 ft. per minute, giving a slow lift of 2 ft. and a fast one of 4 ft. per minute, with a cross traverse of 28 ft., and a longitudinal motion of crane and load of 30 ft. per minute.

A 20 ton crane, using manilla rope of full $\frac{3}{4}$ in. diameter, running at a speed of 2540 ft. per minute, has a slow lift of 3 ft., and a quick one of 51 ft. per minute, with a cross traverse of trolley carriage of 16.8 ft., and a motion of the whole crane of 47.5 ft. per minute. It has the hoisting winch at one end, thus permitting the use of a 45 ft. span single box-girder partially open below, the trolley carriage travelling inside the box on the angle-irons forming the lower web.

The seven original Ramsbottom cranes at Crewe used long fibre cotton rope $\frac{5}{8}$ in. diam., weighing $1\frac{1}{2}$ oz. to the foot, having a tension of from 17 to 18 lbs. and a speed of 5000 ft. per minute. Larger diameters, lower speeds, and cheaper material, are now used, as at Swindon, where $4\frac{1}{2}$ in. rope at 970 ft. per minute is employed. Messrs. Penn have used rawhide rope moving at 1,500 ft. per minute: and a 50 ton crane employed on dock work has had five years service, without showing any wear on raw hide rope of $1\frac{1}{2}$ in. diameter.

At Aurora and Altoona, cotton rope with speeds of 5,000 ft. per minute are used, giving with the 25 ton cranes of the latter, a slow lift of 15 ft. and a quick lift of 81 ft. per minute, a crab traverse of 30 ft. and a crane travel of 50 ft. per minute.

The two cranes at Alton have each two crabs, so that the engine is suspended and independently moved at the four corners, a decided convenience when dropping frame and boiler on the wheels.

Where possible it is an advantage to put the crane attendant's platform below the main girder and close to the wall, so that the work below and not the crane machinery is in his view.

Pneumatic floor cranes for light weights, although not common, are used at Wilmington on the Philadelphia, Wilmington and Baltimore Ry. and at the Paige Works, Cleveland. The Missouri Pacific Ry. uses compressed air at from 60 to 80 lbs. pressure, to work small three-cylinder Brotherhood engines for giving motion to boring, valve facing and other portable machines, the air being compressed by a Westinghouse brake pump and distributed through small pipes. In the engine house, or in the shop after ordinary working hours, such portable motors can be coupled by rubber hose either to the air pump or the boiler of the nearest locomotive in steam.

The pneumatic transmission of energy is not in itself economical; but for the small powers mentioned it is far cheaper than shafting and more rapid than using manual labor.

At Seraing all classes of shop cranes are pneumatic. The reason for this practice is that with the large area under continuous roof the volume of pure cool air exhausted is of value in assisting ventilation and increasing the general health of the workmen.

Our shops, sheds and freight houses are rarely designed with the object of reducing manual labour in lifting, and many of us feel the regret expressed by Mr. Don J. Whittemore, ex-President American Society of Civil Engineers: "I could not prevail on our people to make use of cranes to the same extent that they are used in England, and in this we are at fault." As an after-thought, pillar and other fixed cranes are occasionally applied, but their value and efficiency is limited, and for equal outlays, by far the most economical results follow the use of movable cranes. Hoisting by unskilled labour is one of the most expensive parts of the old fashioned plant which American shops yet retain. Recent experience in the use of hydraulic drop-pits for removing single pairs of wheels, (although with all its advantages an inelastic convenience) provokes such strong commendations and approval as a labour and time-saving machine, that it is probable that the period is not far off when overhead power-lifts will be common in our shop equipment. The wear on the metal work of cranes is not rapid, and an allowance of five per cent. per annum on first cost, covers all depreciation, except in the matter of lifting chains which require care and frequent testing. Wire rope has replaced lifting chains with economical results, its only defect being an increased diameter in pullies and drums, the increase (about 25 per cent.) not being excessive as the speeds are slow.

To support an overhead travelling crane track, the plan usually adopted is, to increase the thickness of the brick side wall pilasters, and arch over the window and door openings flush with pilasters up to the elevated track level, thus securing a solid, safe support for crane travel, with the disadvantage of materially reducing the width inside shop and the window openings. Rolled iron, bolted to the walls, both for pillars and girders would to-day be the better practice. A good arrangement is to use stout cast iron pillars to support both the crane track and the roof principals, filling in between them with walls of just sufficient thickness to keep out the weather. It is difficult to use a single section of wrought iron for this double purpose, as the support for the track must be bolted on its side, and the weight from the crane is not then brought directly over the foundation, resulting in a tendency to throw the heel of the pillar outwards, and put the roof principal into compression. By using cast iron pillars, and varying their shape at the upper end, there is no difficulty in bringing the crane weights vertically on the underground foundations. The Author is not familiar with any example of a cast iron pillar doing such double duty in any northern climate.

### TRANSMISSION OF POWER.

In power transmission throughout workshops, small shafts, light pullies and high speed flat leather belts are common in, and belong properly to, America; but there is a growing tendency to dispense with shafting in favor of rope, and to use hemp or manilla rather than wire rope. Examples of the use of wire rope are to be seen at Altoona, St. Paul, Proctor, and the Buffalo, New York & Philadelphia Ry. has run its machine shop 312 ft. distant, with ½ wire moving at a speed of 6,900 ft. per minute, for two years without repair. At Columbus, motion is transmitted by hemp rope moving at 1,500 ft. per minute, and Mr. Drummond at Cowlairs, Scotland, uses rope throughout, even for transmission at right angles,—circumstances under which the Grand Trunk Railway prefers the use of V leather belting. Satisfactory instances of the use of hemp rope between engine and main shaft may be seen in Montreal at the Grand Trunk Railway shops and at the Redpath Sugar Refinery. A rope 2 in. diam., moving at 3,000 ft. per minute will transmit 25 H. P.:—that is, a duty equivalent to a 4 in. belt moving at the same speed. Three-ply manilla rope is better than four-ply. The pullies should be at least 30 times the diameter of the rope, and the shafts not less than 20 ft. apart, the angle of the groove in pulley rim 40°, the rope not being allowed to bottom in groove as in the case of wire rope. Some actual tensions are as follows: a manilla rope $6\frac{1}{2}$ in. in circumference, with a speed of 2,972 ft., transmits 23 H. P. with a tension of 256 lbs., another at 3,782 ft. transmits 40 H. P. with a tension of 349 lbs., a third has seven ropes of $1\frac{1}{2}$ in. diam. at 2,355 ft. transmits 34 H. P., with tension of 476 lbs., the tendency with increasing experience being to increase the tensions, which are still far below those used with iron and steel wire ropes. Hemp apparently suffers little from climatic influences and its life especially at the weak point—the splice—may be lengthened by coating it with beeswax and a little plumbago.

The Southern Railway of France has probably made the most complete application of hemp rope in the minute division and transfer of power. The through shaft in the shop is provided with numerous V pullies by which motion is given to three-quarter inch diameter hemp rope, so that at every point the power may be delivered to light overhead cranes as well as to numerous specially designed portable machine tools. For instance, in the boiler repair shop, not only are the drills so worked at any angle or in any corner, but the holes are tapped, and the screwed stays put in, much in the same way as similar work is done to a limited extent with the Stow flexible shaft.

Electric transmission has been used in Germany for some years under restricted conditions. It has some advantages, as the conductor is less clumsy than shafting, steampipe or rope, its position can easily be changed, and the motor is compact and less of a nuisance than a small steam engine. Loss of power there certainly is, but not much in the actual transmission between points far apart, if wire of reasonable diameter is used, and the less the power being taken off, the less is the percenage of loss in the transmitter, the opposite rule holding good with shafting. The chief loss is in the use of double machinery, the first to convert motion into current, and the second to convert current into motion. Every month is simplifying the problem and minimizing the waste; and the ready adaptability of electro-magnetic machine tools (without intermediate machinery) to the varied purpose of drilling, tapping, rivetting, chipping and caulking thick steel ship plates in position, their high duty and rapidity of work, are shown in the paper by Mr. F. J. Rowan, recently discussed by the Institution of Mechanical Engineers (see Proceedings, Aug., 1887), in concluding which he expresses his belief "that it will be found both economical and otherwise convenient to adopt electrical distribution in engineering workshops, instead of the existing system of shafting and belts, or even hydraulic distribution of power."

Transmission of power by steam pipe and independent engine for each shop has, up to date, not been common in countries liable to low temperature. In mild climates, the use of separate wall engines with the cranks coupled direct to shop shafting is most satisfactory, and a pair of locomotive cylinders are often use for such service, as the engines occupy little if any floor space when set vertically, and each shop can be run independently when it is necessary to work overtime.

With the use of modern asbestos and silicate coverings, there is but little loss by condensation in the long steam pipe. Mr. W. T. Bird in his careful experiments (see North of England Institution of Mining Engineers. Proceedings 1882–3) has shown that the condensation in an exposed pipe 1,000 ft. long is sufficient to reduce the steam to 76 per cent. of its boiler efficiency, while coating the same pipe with silicate cotton raises the efficiency to 95 per cent.

### MACHINE GROUPING.

At one time the aim in arranging a machine shop was to group the large machines close together, so that the heavy and bulky material steadily progressed from one to the other without retracing its path. With the adoption of light overhead cranes and single rail tramways for moving heavy weights, the rehandling of raw material has lost much of its importance and most of its expense, so that the favorite arrangement is to mass similar machines of all sizes close together, permitting one skilled man to be put in charge of the whole class. An alternative —when a charge-man is not employed—is to put one skilled attendant to each pair of such machines. However, the main advantage is that the whole floor space can be more fully utilized when machines of a class are massed, than when different machines of about equal size and capacity are grouped together.

When small machinery is placed on a narrow side gallery, it is better, if window light will permit it, to locate a double row of machines, back to back, in the centre of the gallery, thus leaving a narrow passage on each side, rather than to put them in two lines with the passage between them. This grouping enables each attendant more easily to keep his raw and finished material separate from that of his neighbours, and there is less countershafting needed. Its one defect is that it brings the attendants—usually boys—close together and face to face. Mr. W. Wilson has this arrangement of lathes on the ground floor at Alton.

The solidity of machinery designed for railway shop service permits tools with single cutters to take wide and deep cuts, and in milling machines allows of a much higher speed at cutting surface (by virtue of which they are rapidly displacing shapers, planers and slotters). The actual depth of cut has little influence on the cutting speed; hence, it has been found at the forge not economical to smith too close to size. This refers, of course, only to hand work. All wrought iron stamped or worked out under "formers" should, for several reasons, be made close to size.

### FOUNDRY.

Foundries for the production of iron castings rarely form part of American railway equipment, yet no shop returns a larger interest on the capital invested, is more useful in the rapid despatch of daily work, or more helpful in case of emergency. That these benefits may be realized, its design and details should not be fortuitous, even if many of them now in daily service suggest the inference that, like Topsey, they "growed."

Many years service—as well as recently created shops—shows that a most convenient plan is to divide the surface to be roofed over, into two sections of about equal length and span, placing them at right angles to each other, with the cupolas in the inner corner as the most central position without occupying floor room, the square of open land behind the cupolas being utilized for storage of scrap iron, fuel, &c. The foundry at Point St. Charles is practically based on such a ground plan, although an existing building was utilized for the purpose. (See Paper by Mr. F. L. Wanklyn (Member) in Proceedings Inst. C. E., vol. 88, part 2.)

Overhead travelling cranes are preferable, so that the molten metal will not need transfer from one crane to another; but if jib-cranes must be used, one set in front of and between the two cupolas will swing into both sections through an arc of fully 270°. The sand stores, core ovens, &c., being set close to inner wall, light is received through windows in the long outer walls.

What may be considered a model foundry has recently been completed at the Pittsburgh Locomotive Works. Mr. D. A. Wightman, the Superintendent says: "One of its peculiarities is the location of the core oven and core room, which are placed below the level of foundry floor, the top of the core ovens being on a line with said floor, and the runways—used by trucks out of the ovens—are covered, all except a hatchway left open for dropping the heavy dry sand cores and mould, down with a crane.

"The core room is on the same level with the core oven floors; but is left open at the top of the foundry roof, and receives its light from the main windows of the building. Communication between the core room and the south side of the core ovens is had by means of a passage way under railway track. The sand pits all open out of the core rooms and have manholes outside for shoveling the sand through from wagons and cars.

"This arrangment of core ovens was suggested in trying to obtain suitable light, as on one side at least nearly all foundries have their light shut out by core rooms, core ovens, and cupola house. The plan adopted obviates this difficulty, and you will probably conclude after examining the drawings that this building has better light from the ground than any foundry you have ever seen.

"The sand conveyer indicated on plan is simply a Gandy Belt, placed beneath the surface of the foundry floor, upon which the sand is thrown, from any point where it may be lying, and conveyed to an elevator which delivers it into a revolving screen, thence falling into the hoppers over the moulding machines, which are kept fairly full, so that upon opening them at bottom, the flasks are filled very quickly. The conveyer saves the labour of wheeling the sand up to and shoveling it into the moulding machines. One man takes care of all the sand for the two machines, whose output in castings varies from 5,000 to 12,000 lbs. per day."

### BRASS FOUNDRY.

An effective, well ventilated and therefore healthy brass foundry is a square, single-storied, semi-detached building, with the windows, moulder troughs, and core benches on the three open sides. A circular chimney is in the centre, having around it a ring of crucible furnaces below ground level. This arrangement requires separate core ovens on the face of blank wall, an expense justified where the output is large. In smaller foundries, the furnaces are in line in front of a blank wall, the flues between furnace and chimney passing around the core ovens, the chimney being supported on iron girders, six or seven feet above floor level, so that any portion of the furnaces, ovens or flues may be renewed without disturbing or weakening the chimney.

### SMITH'S SHOP.

The smithy used to be a narrow shop, with the fires ranged close to the side walls and an open central passage. This arrangement has been modified, as the large machinery which is displacing hand work is most conveniently set in line down the centre, with a passage on each side of it—that is a track between the machinery and each line of fires;

hence smithies have increased in width from 40 to more than 60 ft. Certainly the smith does not need much window light, yet he should not be made to stand between his work and the window when at the anvil, as is done when the fires are set at right angles to the sidewalls. The better plan, which has long prevailed at Sir W. Armstrong's works and elsewhere, is to group them in pairs set parallel to the wall.

A recent experimental attempt to draw off the forge smoke through underground flues by the natural draft of a 140 ft. brick chimney was not successful (whatever may be the result with higher and costlier chimneys). The most complete method of doing this, as at the Valley Falls shops on the Pittsburg and Western Ry., is to connect the smoke stack of each fire with a central smoke flue running parallel to and under the ridge of the roof, providing it at the outlet with a suction fan blowing into a short chimney, whose draft it improves. Brick hoods and smokestacks make a permanent arrangement when each fire or group of fires has a separate outlet; but if the building is to be kept fairly clear of smoke, movable sheet plate hoods are needed.

For ventilation, small flues from outside, passing through dwarf brick pilasters about two feet above floor level, with horizontal gratings opposite and under the control of each man, are effective for the admission of air, the smoke stacks or movable louvre boards in clerestory on roof being depended upon for exit, though neither are satisfactory at low temperatures unless the smoke flues have induced draft.

Pressure blast for fires should be distributed in overhead galvanized pipes, with a branch down to each set of hearths, and provided with hinged collapsing valves that freely fall open inwards when there is no pressure in the pipe. This simple device prevents any inflammable gas from accumulating in the mains after the fan is stopped, thus avoiding explosions when lighting up.

The number and variety of steam hammers is increasing, and as the interest on the first cost and the foundation for the handier sizes, does not amount to the wages of a striker, and as there is no comparison between the relative usefulness and productive value of the two, each new smithy is likely to have a larger number. The points in the setting of steam hammers worthy of note, are:—that the foundation for standard and for anvil must be kept quite distinct, that solidly bolted timber on end, makes one of the best supports for the anvil block, and that as no foundation fully absorbs the throb of a large hammer, the forge and smithy should be removed as far as possible from the shops holding tools of precision, but not beyond reach by a standard gauge track siding, with some yard-room being reserved near at hand in which to store the scrap, fuel and the steel dies, or "formers" that accumulate around a well used hammer.

### BOILER SHOP.

The boiler shop in all satisfactory works is detached, so that the noise of hand rivetting (not yet completely dispensed with) may be as little of a nuisance as possible. In height and width it is often a duplicate of the erecting shop, but with flush floor. It is worthy of note, that some works on this continent not using overhead travelling cranes in the erecting shop, appreciate their usefulness so far as to equip the boiler shop with them.

The hydraulic and other heavy machinery for handling thick plates is massed at one end, and the lighter equipment for thin plates and tender tanks at the other end of one side of the shop, the floor on the other side being left open for actual construction or repair. The plate furnace (with forced draft) is set, so that its flue may have a short run to the chimney erected for the forge or smithy, and close to the heavy flanging tools.

Standard gauge as well as trolly tracks cover the floor and the plate store (or rack) is close to main the track and to the furnace.

Accommodation should be ample, for the boiler shop, as most managers find, is one of the least flexible; and therefore it is wise to give it space and a full equipment of modern tools.

### FLOORS.

European practice in flooring, varies from wood block on solid foundation to plain block and plank, using clinker, hard packed cinder or clay in the smithy, and concrete or asphalt for paint shop. The German Railway Union recommend stone or tile—except where men stand at machines, and here wood should be used. Slate gives—all things considered—the best service and wear under foot, of any known substance, and being light, strong and durable can be strongly recommended for stairs and steps. The continuous concrete floor used at Columbus, has for its first course, six inches of broken stone, for its second, eight inches of finely broken stone mixed with cement, and for the finishing course, a compound of Portland cement, asphalt, and sand, four inches deep, which being slightly elastic, is not readily cracked by a sudden blow.

South and West of Pennsylvania a solid floor is made by rolling the earth, and then bedding, about thirty inches apart, half-round locust stringers in four inches of concrete, before it sets hard. The stringers are floored with two inch Georgia pine plank coated with hot tar.

Oak flooring is often used in that neighbourhood, not because it lasts any longer than white pine, but because it is cheaper in the local market. The Georgia Central Ry. coats the sills with rosin, packs the earth up to within half an inch of their top, spiking the planking down after boring holes through it. Rosin is then run in through these holes until the whole cavity is full, thus completely isolating the timber from the damp earth. In Canada a cheap floor for light weights is made by bedding half-round cedar in a foot of engine cinders, and nailing two inch pine plank on top.

Sellers, of Philadelphia, uses under his machine tools a continuous iron floor resting on brick foundation walls, and between the machines pine plank for the workmen to stand upon.

### TURNTABLES.

The American pattern of turntable is a "top deck" structure of cast iron up to the common diam. of 60 ft. The weight of table and load is carried on a single fixed central pyramid, with one of the many forms of antifriction caps on the top, to lessen the resistance to movement. No gearing is used to give the table motion, a short lever or hand spike stands out from one end, and two men are usually sufficient to walk the table and its load around.

A fixed circular rail in the pit and end wheel trollies at the outer ends of the girders are provided; but they come into use and carry weight only when the load is being moved on or off; at other times the table is in balance, and the trolly wheels ride justclear of the ring-rail.

When the turntable girders are of cast iron, it is advisable to dispense with any lock or catch to hold the table in line with the radiating tracks, on account of the danger to the castings, if the bolt is shot out suddenly while the table is in motion and because the engine-men will move an engine on to the table more carefully, when it is held in position by hand, than when it is locked.

With wrought iron tables these precautions are not so necessary, as they are not liable to failure by sudden side jar, but almost all wrought iron tables designed or built by dealers to their own specifications ultimately prove to be lacking in stiffness. For locomotive service, wrought iron turntables of 75 ft. diam. have been used at Roanoke, Virginia, with the object of getting rid of the frogs in the radiating tracks (which tracks were of mixed gauge).

Turntables of 100 ft. diam. are invariably of wrought iron with deep side girders, the load being carried on the bottom deck, and the weight supported and moved upon small tapered rollers massed in a ring of 10 or 12 ft. diam., the whole being similar in design to the ordinary form of "draw span" in American swing bridges, and therefore not lacking in stiffness. Part of the weight must be carried on the outer ring-rail, so as to restrict within narrow bounds, any tendency to balancing on the central ring support.

The motive power is usually an independent boiler and engine, running on the ring rail, and coupled to one end of the table by drag-links or other special form of adjusting connection, so that the oscillations of the table under unequal loading shall not interfere with the adhesion of the engine on its single rail.

In running sand about three years ago, the author put in a central foundation for a 50 ft. table, by making a timber hollow box frame of pyramid shape, 10 ft. square at base, 5 ft. square at top, and 4 ft. 6 in. deep, weighting it with rails to sink it as hand labour excavated the material from the centre. When the top was sunk flush with the level of pit, the anchor bolts, passing through two 12 in. baulks, were put in place, and the whole filled in with quick setting concrete. A sand pump was kept going the whole time until the frame was filled, and the mass was finished flush, to receive the base of the centre casting, no cap-stone being used.

CAR SHOPS.

The roofed space provided for the repairs of freight cars is usually limited, as twenty-five per cent. of this work can be done in the open air. The time occupied in the heaviest repair—viz., a rebuild—is short, and the detention of a car in the shop is brief, compared to the delay in the case of a locomotive, so that a total shop surface that will shelter one and a half per cent. of the freight car stock, will be found sufficient. It is probable, if the figures could be obtained, that an average for this continent would show but one per cent., and the nearer the approach to uniformity in detail in the car stock, the less the shop room needed.

The total outdoor track space provided for repairs, change of wheels and shop storage, is twice that under cover. There are in this matter wide variations in practice, due to climate and nature of traffic, the cars moving food, clothing, &c., requiring different treatment from cars moving coal and heavy minerals.

Table No. 2, Appendix B, gives from recent practice, the relative area of some American car shops, the percentages being shewn in double columns (as explained for Appendix A).

The annular form of car shop with radial tracks is occasionally used in America, requiring a turntable of exceptional dimensions—usually 100 ft. in diameter—to permit not only a coach or two freight cars, but also the small tank locomotive doing the shunting, to turn upon it. A large amount of shunting is required in and about a freight car repair shop, due to the short time occupied in an average repair to a car, and the passage of each vehicle over a turntable adds both to the time and to the cost of shunting.

The supposed difficulty in utilizing the whole floor space of a longitudinal shop, and which the annular shop was designed to avoid, is the delay in taking out a string of cars until all are finished, thus sometimes keeping the workmen idle waiting for work. However, even in one of the best examples of the annular shop, that of the Pennsylvania Ry. at Altoona, the radial tracks were intended to be three cars long, and therefore some sorting and dividing of cars is necessary before they can be put in, and all that the other type, with its long tracks, requires, is that this classing together of cars be done with a little more care and judgment, so that the whole string will be finished and ready to shunt out at the same time. There are good points in favour of the annular shop, if it is intended exclusively for new construction, one being the ease and rapidity with which material on trollies is delivered close to the workmen.

However, the author would endorse the longitudinal freight car shop which is of the simplest construction, often wide enough for six or seven parallel tracks, and from 200 to 500 ft. long. The walls, of brick or wood, the roof almost flat (the slope each way from middle being about one in twelve) and supported by timber posts eight or nine inches square. The posts though numerous do not seriously interfere with the work. The roof covering is cut for numerous skylights, gable-shaped and of quick pitch. Usually the floor is flush, that is, neither track pits, cranes, nor hoists are provided. The car bodies to be lifted, being light and bulky, and requiring in many cases to be sustained after they are lifted, it is found best to use quick moving hand jacks to lift, and dogs or trestles to effectively support them while the men do the work of repairing.

Numerous trolly roads cross the building in both directions, their union at intersection being made by cast iron turnables revolving on a central spindle. These tables may be of two castings, a base, forming both pit and foundation, and a revolving top with socket on underside.

This building and its contents are so liable to destruction by fire, as to justify large water pipes and numerous fire hose hydrants within it as well as without.

There is no real economy in the endeavor to repair freight cars and passenger coaches under one roof. The work is so different in character that men can rarely be transferred from one class to the other, and the dirt and dust inseparable from the cars should be kept away from the coaches. When both classes of repairs are done in the same building, it is imperative that a shop free from dust and at a higher temperature be used for painting and varnishing coaches in. It is often built directly opposite to the car repair shop, with a transfer table between. Here, as elsewhere, entrance from both ends of a longitudinal shop is desirable, and has been obtained in many recent designs.

At the Como workshops on the Union Pacific Railway, each stall in the paint shop is provided with an electric call bell, communicating through signal code, both with the foreman's office and the paint store, which latter building, as in all railway shops, is detached, and as far as possible of fire proof construction. Often it is provided with an underground cellar for the storage of all inflammable fluid. According to the best practice only one man at a time is allowed to work in this house mixing the paints and blending the colors, and in some cases the brushes and other tools used by the workmen are stored here and only issued as required. It is a "paint tool-room" in which much the same system prevails as in the "machine tool-room."

### WARMING AND VENTILATION.

Paint shops need special facilities for warming and ventilation. A successful arrangement is the use of a fan to draw air through a nest of small steam pipes, and then to force the warmed air into a light galvanized iron tube, from which it is passed into overhead branch pipes and delivered through slide-gratings below, the slides being within the control of the workmen.

At Columbus the paint shop is 75 by 135 ft. containing 272,665 cub. ft., and the steam pipes have a surface of 1,034 ft., or one superficial ft. per two hundred and sixty-three cub. ft. The fan has a maximum delivery of 218 cub. ft., and has been run as high as 200 revolutions per minute. The three main pipes leading from it are 30 and 24 in. diam: and the smallest delivery pipe is 8 in. diam. The air is used over and over again, and so used, it is said, without any annoyance from the odour of the paint. Running the fan during working hours only reduces the time in which the paint dries by one-tenth. The apparatus is widely adjustable to suit varying temperatures, as either live or exhaust steam can be turned into the heater pipes, and its amount regulated; or the speed of the fan can be varied within large limits, to which end a separate engine 6 in. by 9 in. stroke with steam at 80 lbs. pressure is used to give it motion. The success that attended this experiment has justified Mr. E. B. Wall in extending this system at Columbus to the machine, boiler, and blacksmith shops, and the annular car repair shop. At Bloomington the new locomotive erecting shop is warmed in this manner, the exhaust steam from the stationary engine is passed into an old boiler, through the tubes of which the air is drawn and then delivered into underground pipes, the outlet gratings being at the floor level.

This hot air method was in 1886 adopted for widely scattered shops at Cleveland, O., by Mr. J. Walker (see his communication to the Civil Engineer's Club of Cleveland, 13th Sept., 1887). He used a fan 10 ft. outside diam. with engine 6 in. by 9 in., running from 50 to 275 revols. per minute, the fan outlet being 42 in. square. With underground conduits across the yards, he finds that it requires 1 sup. ft. of steam pipe for each 100 cub. ft. of shop space, the initial air temperature when entering the fan, varying from 100° to 180° F. The conduits are of sewer pipe, the largest diameter of any main being 24 in., and they are trapped so as to get rid of any water that might gather. After the ground had dried there was no appreciable loss by radiation from the buried mains. This arrangement permits the fan and heater to be kept within the boiler house, and the water of condensation to be returned to the boiler at a temperature averaging 180°; but the air is not used a second time, which explains the increased ratio of pipe-heating surface per cubic ft. of space to be warmed. However, the shops and foundry are kept clear of smoke, the health of the men is all that can be desired, and the system can as readily be adapted to cooling in summer as to warming in winter.

Illustrative longitudinal types of coach and car shops may be seen at the Grand Trunk Ry. works Point St. Charles, and one of the worst specimens of the circular shop, although a very showy building, at Mount Clare on the Baltimore and Ohio Ry. It is 235 ft. inside diam. and fully 114 ft. to top of dome, yet has only space for 21 coach stalls and an inlet track.

### GENERAL DISPOSITION OF SHOPS.

What may be called the typical grouping of American railway shops is to place them parallel with each other, and with their longitudinal axis at right angles to the main track (or chief yard siding), with several traverser beds and tables between them. In other words, the shops lie side by side with their gable ends facing the track.

The stalls (or shop tracks) being at right angles to the length of the buildings, or parallel with the main track, if the traversers are set in line with each other, a passage through from shop to shop is provided: that is, it makes a through temporary passage parallel with main track.

Good examples of this arrangement are the St. Paul workshops of the Chicago and Kansas City Railway, and the West Chicago workshops of the Chicago and North-Western Railway, (Plate VII), and it has advantages, one of the chief being, that if sufficient width of land is secured, it permits extensions in length to be built uniform with the existing buildings, without interfering with the ordinary railway work; and when the addition is completed, does not necessarily require a resetting of the machines, shafting or warming pipes, etc. in order to fully utilize the added space.

Until the use of electrically moved overhead cranes changes the shape and size of such shops, does away with the traverser, and alters their relationship to the main track, this grouping will probably continue to be adopted. It necessitates the purchase of a block of land, wide but not long.

One of its most prominent defects is the necessity for skylights. The side walls are so cut up by large stall entrance doors, almost filling the wall panel, that there is little space for side windows except those of limited size, framed into the leaves of the doors; while, as the door openings cannot be kept quite close and tight, in latitudes where cold high winds prevail, these numerous inlets interfere with the comfort and efficiency of the workmen. However, for a correspondingly brief period in midsummer, the doors thrown wide open are an appreciated luxury, compensating in some measure for the winter inconvenience.

So grouped, the buildings are well isolated in case of fire, as not only does the width of the traverser pit intervene, but in addition, there is a space of from ten to fifteen feet between wall and edge of bed, ordinarily utilized in the storage of wheels and trucks.

A neat and compact arrangement of shops built in the summer of 1887 for the Maine Central Railway at Waterville, Me., is shown on Plate VIII. They are set on each side of a single traverser bed, and occupy but little land. The arrangement will not prove elastic should extensions become necessary.

In new works, buildings are rarely set closer than fifty feet apart: forty will usually fulfil the requirements of the fire insurance inspection, while a distance of thirty-five feet has been proved to be far too close for efficient side light even with one storied buildings.

The new shops of the Panhandle Ry. are set wide apart, with many large trees left standing in between them, forming a pleasing feature to the eye; but even in this country of cheap land, few railways subordinate considerations of economy, to the gratification of an æsthetic taste making the workshops ornaments in a natural park.

In vivid contrast to buildings spaced in this liberal manner, are the works of the London and South-Western Ry. at Nine Elms, London, where the space under the viaduct carrying the four track main line has to be utilized for shop room.

Freedom from snow, giving a wide liberty in roof design, simplifies the grouping of shops in Europe, and in Germany a style of shop not uncommon is one having a continued hip and furrow roof covering about seventeen bays. With sufficient glass (part of it movable) there is no reasonable limit to the amount of light and fresh air admitted, and when artificial heat is necessary, the lack of height in the building, is a help to the warming. In many instances the establishment is under one roof, as at St. Rollox on the Caledonian Ry., Scotland, the area being twelve acres—or the locomotive shops are under the one roof and the car shops under another. The number of trolly tracks and power cranes, and the compact setting, makes the handling of material and work a simple matter.

In plan, the tendency is, for the longitudinal axis of the main building, and the stall tracks, to run parallel with the main track, so that the plot of land required is long and narrow, as for instance in the Norwich new shops for the Lancashire and Yorkshire Ry., the erecting shop of 200 engines capacity, with six parallel tracks and a central machine bay is 1,520 feet long—almost one-third of a mile.

Although in Canada and the Northern States, shop roofs cannot be a continuous duplication of small pieces, yet the main buildings may have duplicate roofs, that is, a uniform span may be adopted for erecting, machine, boiler, car and paint shops, &c. The Pennsylvania Ry. has so designed and built combined shops, that the portion originally used as car shops, can at slight expense be adapted for locomotive repairs, when the growth in business shall justify the increase of this section and the removal of the car department to another location.

On the general question of grouping, the late A. L. Holley may be quoted. Speaking more particularly of steel works, he remarks "Joliet is perhaps the only establishment where railroads were laid out first and buildings made to fit......and in designing works, provision only can be made for mininum amount of rehandling and hand labor, by going over all the operations on paper by different arrangements again and again, and not trusting to general ideas to be worked out when it is too late to move a building that happens to be in the way."

For intercommunication, not only between the chief offices and foremen's offices, but also between shop and shop, and each bench and the too room, electric bells, telephone service and displayed signals to call persons moving about through the works, to the nearest telephonel are daily receiving more general adoption, and their usefulness is so marked, that a single experiment with them is sure to result in their permanent use.

From the Drawings accompanying this paper Plates VII and VIII have been prepared.

## APPENDIX A.

Showing the relative area of Railway shops for Locomotive Department. The first column gives the percentages in comparison with the erecting shops which is taken at unity (100); and the second column the percentage of the total roofed area devoted to locomotive purposes.

| Kind of Shop. | Hornesville. N.Y. L.E. & W. Ry. — Percentage of Erecting shop | Hornesville. N.Y. L.E. & W. Ry. — Percentage of whole. | West Burlington C.B. & Q. Ry. — Percentage of Erecting shop. | West Burlington C.B. & Q. Ry. — Percentage of whole. | Scranton D.L. & W. Ry. — Percentage of Erecting shop. | Scranton D.L. & W. Ry. — Percentage of whole. | Indianapolis G. S.L. & P. Ry. (Panhandle.) — Percentage of Erecting shop | Indianapolis G. S.L. & P. Ry. (Panhandle.) — Percentage of whole. | Chicago. C. & N.W. Ry. — Percentage of Erecting shop. | Chicago. C. & N.W. Ry. — Percentage of whole. | Howich L. & Y. Ry. — Percentage of Erecting shop. | Howich L. & Y. Ry. — Percentage whole. | Waterville. N. C. Ry. — Percentage of Erecting shop. | Waterville. N. C. Ry. — Percentage of whole. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Erecting............ | 100 | 29 | 100 | 23¾ | 100 | 34 | 100 | 14 | 100 | 15 | 100 | 39½ | 100 | 35 |
| Machine............ | 100 | 29 | 100 | 23¾ | 61 | 21 | *150 | 21 | 200 | 30 | 24¾ | 10 | *100 | 35 |
| Boiler............... | 50 | 14 | 63 | 15 | 44 | 15 | 111 | 15½ | 72 | 11 | 22½ | 9 | 18 | 6 |
| Smithy............... | 43 | 12 | 63 | 15 | 44 | 15 | *178 | 25 | 110 | 16½ | 13 | 5 | *20 | 7 |
| Tender.............. | ...... | ...... | ...... | ...... | 23½ | 8 | ...... | ...... | 72 | 11 | ...... | ...... | ...... | ...... |
| Tool room .......... | } 29 | 8 | ...... | ...... | ...... | ...... | } 29 | 4 | } 15 | 2 | ...... | ...... | ...... | ...... |
| Engine & boiler hse. | | | 10 | 2½ | 16 | 5¾ | | | | | ...... | ...... | *11 | 4 |
| Stores............... | } 29 | 8 | 85 | 20 | 3 | 1 | } 100 | 13 | 56 | 9 | 17 | 6½ | } 30 | 10½ |
| Offices.............. | | | ...... | ...... | ...... | ...... | | | ...... | ...... | 21 | 8 | | |
| Flue, copper and tin | ...... | ...... | ...... | ...... | ...... | ...... | 55 | 7½ | 36 | 5½ | ...... | ...... | ...... | ...... |
| Foundry (iron)....... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 13⅓ | 5 | ...... | ...... |
| Paint................ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 14½ | 5½ | ...... | ...... |

* Starred items give area of combined shop for Car as well as Locomotive department.

## APPENDIX B.

Showing the relative area of Railway shop for Car Department. The first column gives the percentages in comparison with the combined area of both Passenger and Freight erecting shops, which is taken as unity (100), and the second column, the percentage of the total roofed area devoted to car purposes.

| Kind of Shop. | West Burlington C. B. & Q. Ry. | | Como N. P. Ry. | | Indianapolis Panhandle Ry. | | Chicago C. & N. W. Ry. | | Houston H. & T. C. Ry. | | Waterville Maine, C. Ry |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage of erecting shops. | Percentage of whole. | Percentage of erecting shops. | Percentage of whole. | Percentage of erecting shops. | Percentage of whole. | Percentage of erecting shops, | Percentage of whole. | Percentage of erecting shops. | Percentage of whole. | Percentage of erecting shops. | Percentage of whole. |
| Passenger Coach erecting. | } 100 | 20 | } 100 | 21 | } 100 | 17 | } 100 | 24 | } 100 | 30 | } 100 | 22 |
| Freight Car erecting...... | | 20 | | 16 | | 17 | | 12 | | 23 | | 18 |
| Paint per both............ | 56 | 24 | 77½ | 30 | 77 | 26 | 68 | 25 | 45½ | 24½ | †100 | 39 |
| Machine (iron)............ | Locom. used. | shops | 29 | 11 | 19 | 6½ | 22 | 8 | 23 | 12⅛ | Locom. used. | shops |
| Machine (wood & saw mill) | 38 | 16 | 27 | 10 | 38 | 13 | *34 | *12⅓ | ........ | ........ | 41 | 16 |
| Stores.................... | 42 | 17 | } 17 | 7 | ........ | ........ | 31 | 11 | 4 | 2 | } 13 | 5 |
| Offices................... | ........ | ........ | | | ........ | ........ | ........ | ........ | 3½ | 2 | | |
| Engine and boiler house.. | 5 | 2 | 10 | 4 | 5 | 2 | ........ | ........ | 2 | 1 | ........ | ........ |
| Dry Kiln.................. | ........ | ........ | 4 | 1 | ........ | ........ | 5 | 1½ | ........ | ........ | ........ | ........ |
| Upholstery and Varnish.... | ........ | ........ | ........ | ........ | 32 | 10 | ........ | ........ | ........ | ........ | ........ | ........ |
| Cabinet................... | ........ | ........ | ........ | ........ | 29 | 8½ | ........ | ........ | ........ | ........ | ........ | ........ |
| Smithy.................... | ........ | ........ | ........ | ........ | ........ | ........ | 12 | 4½ | 9 | 5 | ........ | ........ |
| Tin shop, &c ............. | ........ | ........ | ........ | ........ | ........ | ........ | 2 | 1 | ........ | ........ | ........ | ........ |

*Includes Cabinet shop. †Includes Locomotive paint shop.

## DISCUSSION.

One point of the paper on workshops particularly draws attention, "How long does it take to repair an engine?" The author states as an average common in America that heavy repairs occupy 90 days, medium repairs 60 days, light and specific 30 days. The speaker must take entire exception to such an average. If the author, in using the word "America," means that part of this continent called the "United States," the speaker cannot challenge the statement; but so far as Canada is concerned, in his experience, the figures are incorrect. In any properly designed and organized *divisional repair* shop, the limit of time for a heavy repair should be 60 days, it being understood that the author, in speaking of heavy repairs, does not include engines "rebuilt." A medium repair occupies about 30 days at the very outside, and light and specific repairs from 7 to 14 days. Mr. F Brown.

In *main* shops of a large Railway Company with proper supervision, the length of time occupied in these different classes of repairs should be very much reduced. A heavy repair should occupy a maximum of 42 days, a medium repair 21 days, and light and specific from 3 to 14 days. Under these circumstances the author's figures for comparative area of erecting shops would be entirely wrong, and careful attention given to the outfit of the machine shop must considerably reduce the necessary area of the erecting shop.

To show what can be done in well organized shops, a couple of instances may be given. In June, 1886, an order was given to the Canadian Pacific Railway shops, Montreal, to build some Consolidation engines, which were an entirely new class; *a complete set of working drawings* had to be made, all quantities got out, materials imported and otherwise prepared, and the first engine was on the road exactly 90 days after receipt of the order.

Later on, in June, 1887, the same shops received an order to build some 17″ × 24″ road engines, for which all materials had to be procured, some of them imported, and the first engine on the order was on its trial trip 77 days after receipt of that order. These statements are merely advanced to prove what can be done and what is done in Canada, and are not puffing advertisements such as were published lately in an American Railway Paper, stating that in the Altoona shops on the Pennsylvania Railway, a locomotive was "erected" inside of 17 hours. Illustrations of this performance were distributed freely, and the recipients were asked to place this absurd assertion in a conspicuous place. Practical men know this performance to be utter nonsense, so far as "erecting" in the true sense of the word is concerned.

The speaker also desires to ask the author to explain why he calculates on four or five per cent. of his motive power being in the yard, "waiting to come into the erecting shop for general repairs." If the shop is properly designed, where is the necessity for any engine to be kept waiting for repairs? This provision is one which it seems difficult to account for, and it calls for explanation.

**Mr. Wallis.** He was glad to note that the author expressed preference for the "longitudinal" type of running shed, and fully endorsed his remarks in reference thereto.

On the Grand Trunk Railway, there were but two exceptions to the circular type of shed or round house commonly so called, both referred to in the paper.

The one at Montreal contained five tracks, and accommodated twenty-five engines, while that at Lindsay had four tracks and was designed for twenty engines.

The larger of the two with its approaches, iron turntable standing outside, water service pipes, steam warming arrangements, sand house and tool store, cost about $50,000.00 or at the rate of $2,000.00 per nominal engine accommodated.

The sheds were built in some degree as an experiment, but from his experience elsewhere with similar ones he had little doubt when he designed them of their being successfully worked.

The round house with some advantages had one serious defect. If built of wood with the usual felt and gravel roof, so common in Canada, it was unusually liable to take fire, and he knew of an instance when nine locomotives were burnt almost beyond recognition, it having been impossible to extricate them from the shed whose exit was controlled by a central turntable.

The same defect was also forcibly apparent in case of accidents which occasionally happened to turntables, and he was sure that many Railway officers could recall instances of annoying delays resulting from this cause, which could not have occurred with "longitudinal" sheds and outside turntables.

It would also be readily understood that while a round house could only accommodate the specific number of engines for which it was designed, a long shed constructed with the same length of standing room could house a percentage beyond that number, varying with the length of the engines and the number of parallel tracks within it. In severe weather this was an important consideration, and when tank engines formed part of the equipment, additional accommodation of twenty per cent., or say one engine per track, might be obtained.

The difficulty mentioned by the author in the arrangement of the engines for prompt despatch did not exist, or at any rate was not felt in practical operation.

He thought it likely that the author's estimated cost of $1,000.00 per pit for round house did not include water service pipes, and arrangements for warming and turning engines; but, setting aside the question of first cost, the only advantages which he had been able to discover for that type of shed were those of better light and more convenient location.

Skylights were not satisfactory because they were difficult to keep clean, and subjected the roof to unnecessary chances of decay, and it was clear that the distribution of light from side windows was better in a circular shed.

As to location, angles or corners were often formed in large yards by the leads of the sidings from the main line, and these corners made convenient sites for square or circular houses, when otherwise the adoption of the long shed might be attended with loss of ground space.

In regard to repair shops, he noticed how widely different, on different railways, was the division of the total floor space among the various shops. The tendency seemed to be towards unduly large erecting shops, and this might explain the rather high average given for engines under repairs. The average for the year 1888, for all classes of repairs on the Grand Trunk Ry., was 35 days, but he was sure that this could be still further decreased with the aid of a liberal expenditure in the direction of the machine shop.

The division of time as between engines under heavy, medium and light repairs, was somewhat different from his experience, but as the character of the repairs might vary widely in various shops, it was difficult to establish an exact comparison. He thought that 130 days, 12 days and 3 days, was more nearly the average under the heads mentioned, when the heavy repairs constituted for the most part an almost entire reconstruction, and included a new boiler, and perhaps new cylinders, with time allowance necessary for painting and to allow for the delay caused by waiting for materials, a large quantity of which it was not usual to keep in stock.

Heavy repairs such as he had indicated would enable an engine to endure three years work, with perhaps an intermediate medium repair, consisting of retubing and turning tyres, so that not more than 14 or 15 per cent. of the stock need be out of the service on this account.

He was aware that under favorable conditions, and with special effort, much better results could be obtained, and he had in this manner turned out new engines at the average rate of one every eight days, for a whole year; but this was exceptional in railway works largely engaged in extensive repairs, which, he might add, required more labour and longer time.

Light repairs, in his nomenclature, were such as could be executed for the most part in the running sheds, and consisted of rebushing outside connecting rods, closing brasses, facing valves and seats, and changing truck and tender wheels.

Referring to the question of the foundry, he said that the foundry at Montreal on the Grand Trunk Ry. was an old engine shed of the cruciform type, which answered the purpose remarkably well; the radial cranes swung from the inner angles. He might have preferred to use overhead cranes, but the roof was not high enough to admit them.

**Mr. J. Harkom** A review of the very full information contained in the paper under discussion has led the writer to believe that more attention might be given to "Location," and that the remarks of the author on acquiring a sufficiency of land are worthy of being followed up.

The necessity for "elbow room" has been so frequently shewn by the growth of railway enterprises far beyond the views of their promoters, that it may fairly be assumed when new railways are being constructed they will in the future (more or less remote) require, for their rolling stock and other equipment, more facilities than are needed when the railway is first constructed, and which for the simplest reasons are made as small as can be considered consistent with the requirements of the business expected on the road.

The question of land is one which lends itself to a different method of dealing, compared with the construction of works, and is one to be treated from an entirely different standpoint.

Works of any kind which might be constructed in advance of immediate requirements would not only lock up unnecessary capital, but deteriorate and cause expense for repairs.

On the contrary, land always has been, and always must be, so long as proprietorship in it is recognized, a good investment in such localities as those under consideration, returning good interest on capital invested, and never being cheaper than before the railway is built.

The instances of cramped sites given by the author show the advisability of the policy advocated wherever it is practicable.

The creation of new shops on a line already built is subject necessarily to somewhat different conditions, but the same principle should govern.

The disposition of shops in large works, such as noticed by the author, appears to the writer of the very first importance, and the latter endorses heartily the principle that the general plan should be rectangular rather than those referred to at Frankfort, N.Y., and Plattsmouth, Nebraska.

A great argument in favor of the rectangular system, is that all the area of the works can be more fully utilized in that way than by any radial arrangement, and the possibility of communication from shop to shop is of very great benefit in works of the kind, especially in locomotive shops, which, in the writer's opinion, should run as described by the author.

In car shops, on the contrary, their length should be in the direction of the main tracks, or so that they can be readily shunted by means of sidings from them, the idea being that in the case of passenger cars, whole trains should be turned out together, as is regularly done in England and in many cases in the Grand Trunk Railway shops at Montreal.

The supposed difficulty, noticed as such by the author, should never exist if a proper knowledge of what is required to be done to each car has been obtained before it goes to the shop, as should be the case, and what better opportunity is afforded for sorting cars than the sidings leading to such a shop as described, with six or seven tracks? For it must not be forgotten that the sorting of cars has to be done, whatever kind of shop is used.

The transfer and turntable are not only higher in first cost than common sidings, but are more expensive to maintain, more cumbrous and slow, where so many more cars have to be handled than engines in the shops, the objections on that score not being of so much importance in the case of the latter. More cars can actually be worked upon in a longitudinally arranged shop than in the other kinds, thus reducing the area to be roofed and walled, to say nothing of warming in a cold climate. This is applicable to both freight and passenger car shops for erection; while for car machine shops, both for wood and iron, the benefit in rapid handling of the bulky material used in them, through the use of tracks parallel to them and easily accessible, is very great.

An important consideration in the location and general disposition of car shops is the ready reception from and delivery to traffic of the cars.

The approaches to these shops should never be hampered, or the result will be a pecuniary loss, by cars being kept from traffic when they are badly needed.

To return to the locomotive shops, the writer is under the impression that the author, while giving many examples, has not laid down, in a sufficiently clear manner, the order in which the several shops should stand, nor the location of that very important establishment "the stores," and with that idea suggests the following as embodying principles, the neglect of which affects in an unfavorable manner the working expenses.

The fact, that in large works, every time a piece of work is handled, it costs more or less money, should never be lost sight of, and that system is the best which provides for the fewest handlings outside those absolutely necessary for manufacture and treatment in the different processes.

All material should be delivered at the stores, weighed, measured, and tested by officials of that department.

The stores should be located in such a position, that easy access can be had to them by tracks and waggons.

The object of the works being to turn out finished articles in the shape of engines and cars, the store should be placed between the two sets of shops, with the idea that raw material supplied from them should issue in the shape of finished work at the opposite end of each set of shops.

The shops handling the heaviest material should be nearest the stores, therefore the first shop in the locomotive series should be the boiler shop, then the smith's shop, the machine shop, wheel shop, erecting shop, tin shop, and paint shop in the order in which they are named.

Lumber being a special article of large bulk, and necessitating a large stock, should be kept in its own yard a considerable distance from the works; but access to it should be readily had from the main tracks.

The position of the Foundry is much the same as that of the stores, and should be located as near to both locomotive and car shops as possible.

Two tracks should run the whole length of the works with frequent cross-over switches and connection to the transfer table in boiler and erecting shops, if such is used; and by the simple precaution, in first laying out the shops, of establishing the floor levels two feet above the mean out-door level, which will ensure dry ground around the shops, the traversers may be worked out of doors, even in Canada, so saving the extra roof referred to by the author.

Where the traverser can thus be used, it is, in the opinion of the writer, far preferable to the overhead crane system, which calls for construction of the shops in a much more expensive manner than the traverser system.

A very vital requisite in all large works is a good and effective system of drainage, with easily accessible manholes at junction points.

If possible, the water pipes should be laid in such a way that breaks can be attended to without cutting off the whole supply of the works. This can be done by double mains, and the laying out of sectional areas, which can be cut off separately if required.

A very important question is that touched on by the author, under the head of transmission of power, in the last two paragraphs.

The location of boiler houses is an important one, and the writer is of opinion that by the careful building of steam pipes, with provision for their expansion (not necessarily of the gland pattern so frequently used), and protection from radiation, steam can be economically carried long distances.

The use of one large engine to drive a large quantity of machinery in such shops is not so good as a number of small engines, each working its own group of machinery, and therefore the construction of central boiler houses, with track accommodation for the handling of fuel and refuse, is a good arrangement.

The writer has so far treated the supposed works as situated all on one side of the main works tracks; and it having been assumed that the whole have been laid out, the tracks included, on fresh ground, these would of course have been placed in the centre of the plan.

The occupation of the other side will now be considered, and it is there that the Foundry, stationary boilers, and such shops for the manufacture of permanent way materials, should be located, with such sidings as are needed for all these works.

The locomotive yard should be on the same side as the erecting shop, to which, if it can be so arranged, there should be two tracks or sidings one for the delivery of new boilers and engines for repair, and the other for the exit of the completed engines *en route* to the paint shop.

Engine or running sheds are a different class of buildings, and necessarily vary, as shown in the paper under discussion.

They should be always located at a distance from the works so called.

The importance of being able to enter or leave at opposite sides or ends cannot be too highly rated, whatever be the shape of the house, whether annular or rectangular.

This was evidently understood in the case of a rectangular shop at Cardiff, mentioned by the author; and, if necessary, the writer thinks that a loop around a shop should be constructed to gain the end desired, which is to allow engines to be regularly and, in cases of necessity, promptly turned out for service.

Whether the shop shall be of the general annular shape or rectangular is not of such great moment, intelligent supervision and handling will give good results with either, while in case of fire, the rectangular type has great advantages over the other, and is not dependent on the turntable to empty it, should the latter break down, which, as a piece of machinery, it is liable to do.

A very valuable addition to the usual plan of covering these buildings is a double roof, which successfully prevents condensation in cold weather, and also prevents the formation of icicles. A shed roof repaired last fall (1888), under the supervision of the writer, has given excellent results during the last winter, and justified the expectations formed of it.

The old roof was a flat one, a little over half an acre in extent, covered with the ordinary gravel and tar felt.

The gravel was all scraped off the felt, which was patched and repaired with Sparham roofing material, where such was necessary, after which four-inch scantlings were laid, and common boards laid on them, the ends being partially closed by overlapping at eaves, in order not to entirely prevent circulation. The building was then handed over to the roofers, who readily gave a ten years' guarantee for the roof, the contractor telling the writer that his experience of double roofs was that he had no repairs to do to them, the action of the weather, snow ice, &c., being practically reduced to the very lowest possible point.

As an economy in this direction, the writer is satisfied good results will follow, while the extra expense will be scarcely felt.

For slate on pitch roofs, the writer, as mentioned by the author, has had excellent results by laying the slates on strips pitched the right distance apart, three winters at Arthabaska having failed to show an icicle on the eaves, and others since built give the same result. Slate on a pitch roof of one in three and a half has been successfully laid by the writer on fuel sheds, and this winter he has seen the snow slide off that roof.

The slate mentioned by the author is unsurpassed in quality, and the writer took steps to compare it with English (or Welsh) slate when in England, in 1886, at the "Colinderies," the comparison being in the highest degree favorable to the Canadian.

On the subject of ventilation the writer would like to make a few remarks as to the material and construction of ventilators, which he holds should be so constructed that in cold weather condensation on their sides should be avoided.

The use of iron has the effect in cold weather, of creating a conflict of currents in all iron ventilators, which the writer has found is not done when wood is used, the sides being doubled and an air space left around them.

The painting of the insides with fireproof paint makes them perfectly safe, while a down draught never takes place in them. The writer has in cold weather seen vapor descend on an iron ventilator, and directly pass to and out of a ventilator made as described of wood. A number of these are in use on engine sheds, placed there under the writer's supervision, with good results, and they are in use on the roofs of the smith's shop and foundry of the Grand Trunk Ry. at Montreal.

He took exception to the vague title of the author's communication, which he thought might have been more correctly entitled "Railroad Shops," as it had reference to them only. Mr. Atkinson.

Basing his remarks upon the different headings as they appeared in the paper, he referred first to the foundations, and asked what protection was provided for iron pillars run down below the floor level, as he thought they would be liable to rust if the ground was "made." It was probably a cheap way of building a shop, but he doubted whether the maintenance of the pillars would be economical.

In building up the supports for the rails, he noticed that the system of iron girders had been adopted at the Stratford shops, and asked if they were supposed to make the side of the pit, because if so, the space below would require filling up, of which, however, there was no mention. No doubt the result would be a very good floor, and one on which engines could be easily moved about when required.

Nothing was said about the pits, and as he had seen some of very bad construction, he would like to hear from the author on the subject. He knew nothing worse than pits made with a concave floor; they were inconvenient and costly to maintain, and the workmen often stood in water unless there was a good system of drainage.

He advocated a convex floor with a brick set down at each side about 4 inches deep, to act as a gutter, which would render it much more pleasant for men while working and easier to keep in repair, as it could be taken up at any time without interfering with the rest of the flooring.

As to the walls, roof trusses ought to be supported upon heavy pilasters, and no one could afford to build anything more than a light wall between. The heavy pilasters put outside the wall took up a considerable amount of room which might be used for shop room, if put inside, in which case they would also be useful in erecting or machine shops, for carrying crane ways, etc.

Referring to engine houses, it seemed that the author had contemplated a flat roofed engine house, with an outer ring much higher than the inner one, causing the slope of roof to be inwards. Most of the roofs he had seen sloped outwardly, giving a roof 6 or 8 feet lower at the outside than if sloped inwardly, and as in cold climates like that of Canada, the number of cubic feet of air to be heated was a consideration, he was of opinion that the best results in this respect would be obtained with a roof sloping outwardly. There was usually sufficient light for most purposes with an inner wall of wood and glass; but if more light was required, a half mansard type of roof with windows above would supply the deficiency.

The author had referred to the cedar foundation posts, 6 or 8 feet apart as "carrying a mudsill." This, the speaker presumed, was a misprint and should have read, "placed upon a mudsill."

The system of roof adopted by Mr. Harkom, would give great freedom from icicles, which were alike destructive to the engine house roof and walls; but he was of the opinion that the slates would easily be blown off if subjected to strong winds, and that, unless there was a blockade, there would be great liability to fire from the depositing of sparks.

The rectangular style of engine house was not much used in Canada, although it would probably give the greatest amount of satisfaction when the ground covered and the cost were taken into consideration.

The "Oil House" and "Sand House" might have been omitted from the paper, and more space given to the details of shop building. For example, the class of roof and the material and construction of the same had not been touched upon. He had no doubt that the area of the erecting shop (as he had since been informed by the author) was a good average for the American system of repairs, but he wished the author had given some information as to what could be done in regard to the output of engines for a given size of shop, because there was no doubt that the time given would demand a larger shop than those of modern construction.

Deep traversers or transfer tables were generally admitted to be more of a nuisance in a shop than otherwise, if they could be done without, and were therefore made as shallow as possible.

He had seen one of a new pattern mentioned in the Railroad Gazette, as being adopted by the Pennsylvania Ry., but did not know whether it was used inside or outside. It was 60 feet long, and he did not think it would be necessary to put a traverser of that length in a shop for engines; but if used for coaches, it would not be long enough for the later and larger classes, and the design was too deep and heavy to be economical.

The systems of obtaining power for traversers were so various, that it could scarcely be a present subject of discussion. Everyone used just what they thought suited best.

The remarks on overhead travelling cranes led the speaker to think that the author was much in favor of their use, although he did not say so. From his experience, he should be very sorry to be without them. A break down with an overhead travelling crane was as bad as having 20 or 30 men away from the shop, and it was impossible to get the same amount of work done on the same floor space without cranes. They were handy alike for moving heavy and light weights, saved an immense amount of time, and were not liable to cause accident to the men working around.

Of the cranes under the speaker's direct charge at the Canadian Pacific shops, the speed of the slowest is $2\frac{1}{2}$ feet per min. raising, and $3\frac{1}{2}$ feet per min. lowering; the next being six feet per min. raising, and $7\frac{1}{2}$ feet per min. lowering; and the quickest 17 feet per minute raising, and 22 feet per min. lowering, suitable for all light work. The travelling speed is 60 feet per min., and the traversing speed of crab 40 feet per minute.

They were made by Craven Bros., of Manchester, who were among the best manufacturers in England for good and efficient work. The capacity is 25 tons; each has a single crab with double chains to the lower pulley or hook, with three speeds of lifting and lowering as before mentioned. The span is about 55 feet, rail to rail, and the cost about $3,000 f.o.b. Liverpool; tramways and cost of placing in position being of course additional items. They occupy 8 feet in height from the lower side of the cross girders to top of the crab, are supported upon cast iron pillars, and are driven by $1\frac{1}{4}$in. manilla rope, running at a speed of 2,500 feet per minute.

In cranes with two crabs, the chains have to be so long, that the wear and tear become excessive, and the danger from broken links much greater.

In the matter of driving power the author seemed to be in error. At the Canadian Pacific shops they had been using a leather belt which had been in service for 5 years, but having now given way it was being replaced by a rubber one.

It was almost impossible to discuss the subject of machine grouping without a plan of the shop, giving the location of the other shops, and information as to the delivery of material, and whether or not cranes were used in transferring the same, He has under his charge a single rail crane of Ramsbottom type, with a capacity of three tons, and a radius of 13 feet, which is of great assistance in moving heavy weights about the shop, and which enables them to do a large amount of work in the course of the day. This crane travels at a speed of 44 feet per minute raising, and at $6\frac{1}{2}$ feet per minute lowering, the driving rope being $\frac{3}{4}$ in. diameter and travelling 1,500 feet per minute. He does not know that it is preferable to an overhead travelling crane, but it is much cheaper for the amount of service it gives, and does not take up much side room.

In placing machinery in a gallery, it should be located down the two sides, as this plan would give greater facilities for the storage and transfer of work than a passage down each side of a double row of machines, by which method a wider gallery would be required, in order to get an equivalent amount of work done.

Referring to the foundry, the author says that a most convenient plan is to divide the surface to be roofed over into two sections of about equal length and span, placing them at right angles to each other. He did not know whether the author intended this to be of cruciform or T section, but did not think that any one in designing a new foundry would build it similar to that at Point St. Charles which would not permit the use of an overhead crane, probably the best piece of machinery that could be put into a foundry. Sellers of Philadelphia had replaced radial by overhead cranes, and he had been informed that the change had given great satisfaction. It appeared that there was considerable loss of ground and a good deal of expense in building a shop of the kind mentioned. The same length of wall would cover almost twice the area if built in the form of a complete square or rectangle, with only a slight addition in the cost for roofing; and he thought that the author's idea of a foundry would bear considerable discussion before being adopted.

In a brass foundry one of the most important requirements is a good draught, or something to take its place, in order to shorten as much as possible the time required for melting.

In the smiths' shops, no doubt many were using the central smoke flue referred to by the author. He had got rid of a smoky shop by making the roof a better type of ventilator. The ordinary single span roof with a clere-story open below, and having louvre sides, was not adapted for getting rid of smoke. The louvres allowed snow to blow in, and the air could not get out freely, causing the shop to become full of smoke. He roofed up the principals of the main roof with boarding to within about two feet of the ridge pole, leaving the clere story open at each side by taking out the louvres, and made a ventilator of it along the whole length of the shop. He came to think of this method by observing the new Canadian Pacific Railway station on Dominion Square, which had a clere-story roof open at the bottom, and with which there was invariably a great deposit of snow, and the smoke did not get out as it should do. If the roof were boarded up to within a short distance of the centre, the smoke would pass out through the opening.

The speaker here illustrated his improvement on the blackboard, and said that if the roof boards were continued to within about 18 in. of the centre, and the louvres taken out, the snow would blow right across without having the opportunity of dropping down into the shop, and a suction of smoke would be produced at the side.

The roof was the same as before, held up by ordinary supports, and boarded across in sections of about 15 ft. When there was no wind the heated air went out of its own accord, while the cross boarding prevented the wind going down into the shop, no matter which way it might be blowing.

He had an excessive amount of smoke in one of his shops from two large furnaces in addition to small ones, and the first result of his arrangement was the removal of the sulphur which had given them much trouble, the smoke following it away.

He had not attempted to reduce the amount of suction, simply leaving it open. The clere-story was left exactly as before, and he boarded up within about 2 ft. from the centre of the ridge poll.

While speaking upon this subject he said he intended to try his system of ventilation in a shop which it was necessary to keep warm at night, and in doing so he would put rising and lowering doors, one on each side, so that when either was raised it would act as a deflector. In this way he felt sure he could clear a smoky shop in 20 minutes.

The author's remarks on the boiler shop were too meagre for the speaker to take exception to, or to agree with. This shop was the most difficult of all to deal with, both as to the handling of material and the bringing in and taking out of work, and would of itself form an excellent subject for a paper.

The author had said little about the arrangement of tools or what system of cranes should be most freely used. In the Canadian Pacific Railway shops there is a radial crane worked by hydraulic power which is found to be very serviceable. It had given some trouble in the past, but it now proves most efficient.

A plank flooring was generally used for both machine and erecting shops if possible; but sometimes earth was used, and iron borings with salammoniac made a good covering for an earth floor, as it became hard as asphalt.

A type of roof which he considered very suitable for a longitudinal engine shed is one having clere-storys 8 or 10 ft. high, with windows in the sides; considerable light is admitted, the shop can be easily heated, and the cubic capacity may be as small as possible. If the shop was wide enough for five tracks, the middle track could have a row of posts down each side forming a clere-story. One row of posts in each of these spaces would not amount to much, and the roof could be of cheap construction, making up for the extra space required.

He was not surprised at Mr. Brown taking exception to the time occupied in making a heavy repair, and 130 days—as quoted by Mr. Wallis—astonished him. He accounted for the difference between that and the time mentioned by Mr. Brown, by the fact that the Canadian Pacific shops were well supplied with machinery, being laid out for building shops, and containing probably on that account a larger quantity of machinery than was found attached to most erecting shops. An engine coming in badly damaged would frequently be turned out in six weeks, probably with repairs to boiler, and new fire-box.

About 50 per cent. of the Canadian Pacific locomotives were of foreign construction, and these were sent to the shop for repairs as often as engines of their own build. They did not hesitate to replace the details of such engines by standard details, although this was not often done, as their stock was extremely small, and they were more frequently handicapped waiting for castings from outside than for what they could make themselves. For forgings only, an engine was not delayed long, and if a new set of wheels were required, but a short time was taken to turn the engine out if the wheels were on hand, but they were generally delayed waiting for castings.

In the time occupied in building the Consolidation engine at the Canadian Pacific, there was a delay of nearly two weeks waiting for castings, and the total time taken was the very shortest they could possibly make it. A complete set of drawings, as understood in a building establishment, had to be prepared, and this was done with a very limited staff in the drawing office in 2½ months. Their foreign built engines were constantly coming into the shop for new cylinders. They had exceptional advantages in their shops from their system of cranes, which could only be appreciated by those using them.

Mr. MacPherson

The Society is indebted to Mr. Barnett for a most valuable paper, which must have taken some time to prepare if the author has not more spare hours than most railway officers.

The writer had hoped to have been present at the discussion, but was prevented by business, and the following remarks are submitted, though not at all commensurate with his interest on the subject.

The experiment referred to as carried out by Mr. Harkom, to get rid of the icicle formation on the eaves of an engine house, would appear to be an expensive method, though correct in principle.

The same end was attained with comparatively little expense, in an engine house erected under the writer's supervision, at Hochelaga, in 1886, by building a few pieces of 2 in. diam. iron pipe into and through the walls, just under the roof at the gables.

Several brick engine houses built on the Canadian Pacific Ry. previous to this, without these air holes, have given great trouble, on account of the icicles backing the water up under the eaves and ruining the walls. The one referred to at Hochelaga has given no trouble in this respect, and the icicle formation is very slight. At the same place may be seen a 65 foot wrought iron turntable, which length does away with the frogs leading to the engine stalls; the angle being 9 degrees between centre of pits.

It would appear that the American practice of radial engine houses and turntables is preferable to the English or longitudinal type, at all points where time is any object, and it would be interesting to know how the English officer mentioned, turned his engines when handling 400 train engines daily at one terminal; if they were turned on a "T," it would certainly take more time than on turntables, and his bare statement that he could not have done the same work over turntables, until the definite time consumed in turning is given, seems far from conclusive.

In regard to the engine house at the Canadian Pacific station, the sides of the double roof are not finished. Mention has been made of the snow blowing in. It was proposed at present to put small windows all around, which could be closed in time of snowstorms, without interfering with the light. They were to be opened and shut by a small chain running along the side of the roof. The slat system could not be made to keep the snow out, and also afford an exit for the smoke.

Mr. Peterson had received several letters from different railroad companies, with various plans of slats at the side of louvre roof made of sheet iron, but they all said they could not ventilate and keep the snow out at the same time.

They made several designs of roof, but found it was no use trying to do so and put in windows. Mr. Atkinson's plan appeared to be a good one; it allowed of a through draught acting something like an injector.

Mr. Barnett.

Mr. J. D. Barnett, in replying, said that no one better appreciated Mr. Atkinson's criticism than he did. He admitted that the title of the paper was vague, and that he might perhaps with advantage have enlarged on some points and cut down on others. He thought, that almost all, who had attempted a comprehensive paper of the kind, set out with a general idea of what they wanted, and as the work progressed, it could be noticed that they were apt to give more attention to those points in which they were more particularly interested; but even if wanting at some points, he felt like apologizing for the length of the paper. When persuaded into writing it, he intended including the workshops of American firms exclusively building locomotives, making a special point of giving the relative proportions the various shops bore to each other; but finding it was difficult to get complete information, he had to give up the idea, and the communication resolved itself into one on Railway Workshops, the so-called "erecting shops" being dealt with only in reference to locomotive repairs.

Replying to Mr. Atkinson, he did not see why the corrosion should be excessive in pillars which were carried down below floor level. There should not be and, as far as he knew, there was not any excessive corrosion. If a pillar were properly coated with tar, and the earth not often disturbed, the corrosion could not be such as to lessen the strength of the pillar. So long as iron was deep enough below ground to exclude atmospheric air and was free from actual contact with water, oxidation was not excessive.

Evidently there was some misunderstanding about the pit rails at Stratford, which were intended to carry the traverser upon which the locomotive was moved from one end of the shop to the other, and not for the engine pits, the sides of which were brick with a timber sill on the top.

His experience with pilasters inside the walls was that it resulted in a dirty and untidy shop. The dirt accumulated in the corners, and workmen piled there the old material and scrap, so that altogether it was difficult to keep the shop neat in appearance.

A pilaster, too, would cut off part of the light. It was a convenient arrangement to run the workmen's benches down the side wall close to the windows, and pilasters would cut the benches off into short lengths of 16 or 18 feet, although with benches there would not be quite the same temptation for workmen to place scrap and refuse in the corners. One of the most untidy shops he had ever seen was one with deep inside pilasters.

The "mud sill," technically speaking, was the lowest timber, the one on which the posts rested when a timber post foundation was used. In Ontario, however, it was common to call the sill on which the upper frame rested the mud sill, and he had used the vernacular rather than the strictly correct term.

That the space between the double roof should be a fire-trap was not a necessity. An opening between the two roofs could permit the passage of a current of air through, and yet the edges might be blocked so that sparks could not get between them.

The suggested area of erecting shop did not exemplify the very best modern practice for a railway whose rolling stock was uniform. He had given some figures, showing what he thought should be the comparative size of the erecting shop. He would have liked to divide the floor space of the erecting shops given in the tabular statement, by the number of engines owned and repaired by the various railways, so as to show that they fairly corresponded with the floor surface allowed in the ten pit erecting shop reduced from the mileage figures given; but the information could not readily be obtained.

The figures he had given, shewing the number of days an engine was under repair, were not far from average American (United States) practice, especially in the case of the erecting shops of those railways on which there was a large variety of locomotive stock, and in which the number of machines and the machine shop surface was limited. It was comparatively easy for railroad officers to persuade their board of directors to give them additional roofing, but it was often a difficult matter to get their sanction for the purchase of modern machine tools, and as long as they were limited in the number and efficiency of their tools, an engine must necessarily be a long time in shop.

Why Mr. Brown, in this statement, should have excluded *rebuilding*, the speaker did not understand, seeing that it was a factor in every-day work, and as much a necessity during the year as the doing of medium, specific and light repairs, and therefore must be allowed for in any average of work to be done or of floor space upon which to do such work.

He had worked out the time average for the Stratford shops of the Grand Trunk Railway for the whole year ending 1887. All the labour being devoted to repairs (the rebuilding being done at Montreal), the figures were :—

76 engines received heavy repairs, occupying an average of 62 days;

21 engines received medium repairs, occupying an average of 29 days; and

37 engines received specific and light repairs, occupying an average of 20 days.

Since that date Stratford shops had been largely increased, and were now in full swing. For the sake of comparison he had worked out the figures for the six weeks, since the establishment had been enlarged and fairly equipped with machinery and tools, and found them to be as follows :—

11 engines received heavy repairs, occupying an average of 92 days;

12 engines received medium repairs occupying an average of 32 days; and

16 engines received specific and light repairs, occupying an average of 23 days.

The figures covering so brief a period were of course only approximate, nothing else could be expected under the circumstances. Such figures, he believed, had never before been published, and he had hoped, by putting such information together as he could obtain, to provoke some such discussion as had taken place. He hoped and expected to learn something himself as one of the results of the discussion.

It was undoubtedly the case, as had been remarked, that the question of actual machine grouping depended upon the shape of the shop and the number of cranes, etc.; but the point he desired to make clear was that when they had very few hoisting tools, cranes, and overhead traversers, it was necessary that all large tools handling bulky material should be grouped close together. Since the general adoption of cranes and the liberal use of overhead hoisting tackle, however, it seemed to him that that necessity had disappeared because of the ready movement of heavy masses; whether the weight was two or ten tons and the distance five or thirty feet, it made little difference in moving it about the shop when the material was once suspended. The result of this had been that in the modern shop there was a tendency to group tools and machines of the same kind together, and in that way to minimize the attendance required at them, thus effecting a decided saving in the cost of labour.

The speaker then illustrated on the blackboard from existing practice several ground plans of foundries, showing how in the form of right angle building recommended, a single jib crane would sweep the major part of the whole floor, but that if overhead traversing cranes were provided, either a square or rectangular building was the best, while for convenience in clearing the cupolas and yet handling the metal buckets to advantage, the traversing girders of the crane should lie parallel with the line of the cupolas.

He was much pleased with Mr. MacPherson's communication, showing how he got rid of icicles; apparently he trusted to an out-flowing current of warm air at the level of the eaves, to melt the icicles, or to prevent their formation. If that would always do its work, he considered it one of the most valuable hints he had received that evening. He had been troubled much with icicles in a shop 120 feet wide, and if such a simple expedient as allowing a fine current of warm air from the shop to play upon the icicles was always successful, he felt much obliged to Mr. MacPherson for the information.

The statement made by an English railway official, that he would have great difficulty in handling 400 engines daily if his engine sheds had been annular, was impeached by Mr. MacPherson. The speaker said the point the officer made was, that although he had to turn his engines on the turntable, the rectangular form of shed permitted him to turn his engines outside and get them exactly right in position to take out their next trains shortly after their arrival at the shed, and nine or ten hours before they were due outwards again; whereas, had he an annular engine house, he could not have got the engines turned and into position by train time, at certain busy hours of the day, without taking them from the protection of the engine house, and leaving them outside, which would entail extra siding room where space was valuable. The engine in both cases would have to be turned on the table; but the advantage with the rectangular shed was that this could be done so many hours before train time, without putting the men in the running shed, or those who had to do shed repairs, to any inconvenience.

Mr. Brown's information, as to the brief time in which an engine could be built, was interesting, but had no reference to any matter mentioned in the paper. He (Mr. Brown) did not understand why 4 or 5 per cent. of the engines should be "waiting repair." That was scarcely what the paper said. In trying to discover what proportion of engines could be counted upon to be in steam daily, the speaker had given the matter some consideration, and found (as everybody else would find on going into the matter) that there were a few days lost, from the time an engine left the erecting shop until it was in condition for handling traffic. If the pit room in the erecting shop was limited, the painting should not be done there, but in any warm building which needed to be only of simple construction; and if the most was to be made out of the erecting shop space, the engines should only be *repaired* there, and moved into a building (similar to that mentioned) for painting and finishing.

From what he had said, it would be seen that a portion of the rolling stock would not be actually under repair nor yet actually in traffic. Engines sometimes had to wait for pit room or for painting, and there was nearly always something being waited for, causing a certain proportion of engines to be out of service. He was still of the opinion that 4 to 5 per cent. of the total stock would be in that intermediate state, not absolutely in the erecting shop occupying pit room, nor in the round house ready for traffic, and this contingency had to be allowed for in getting at the desired estimate of the mileage that would, under ordinary conditions be obtained from 100 engines in a year.

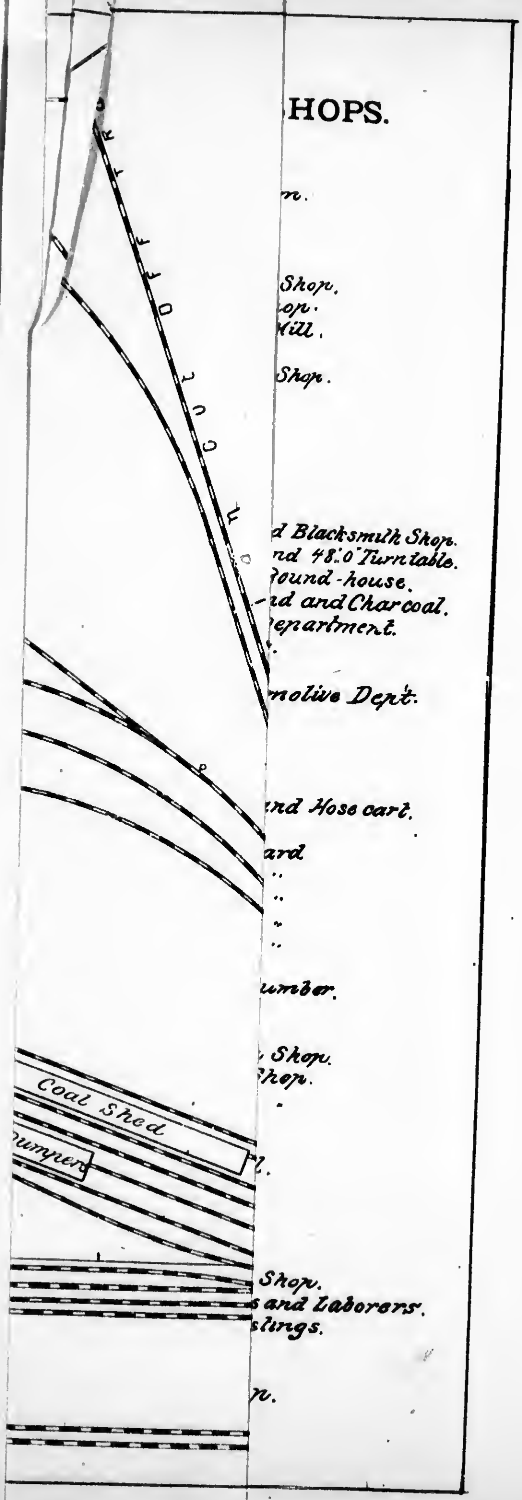
The figure o $1,000.00 per engine stall did not include pipes and other internal fittings. The first part of the paragraph in question described the most primitive form of section of annular engine-house found on this continent; and in giving other prices, the speaker had adhered to the primitive type of construction, adding, however, a little more stability. The price quoted was for a simple brick shed with stone foundations, no allowance being made for water pipes or steam pipes, etc.

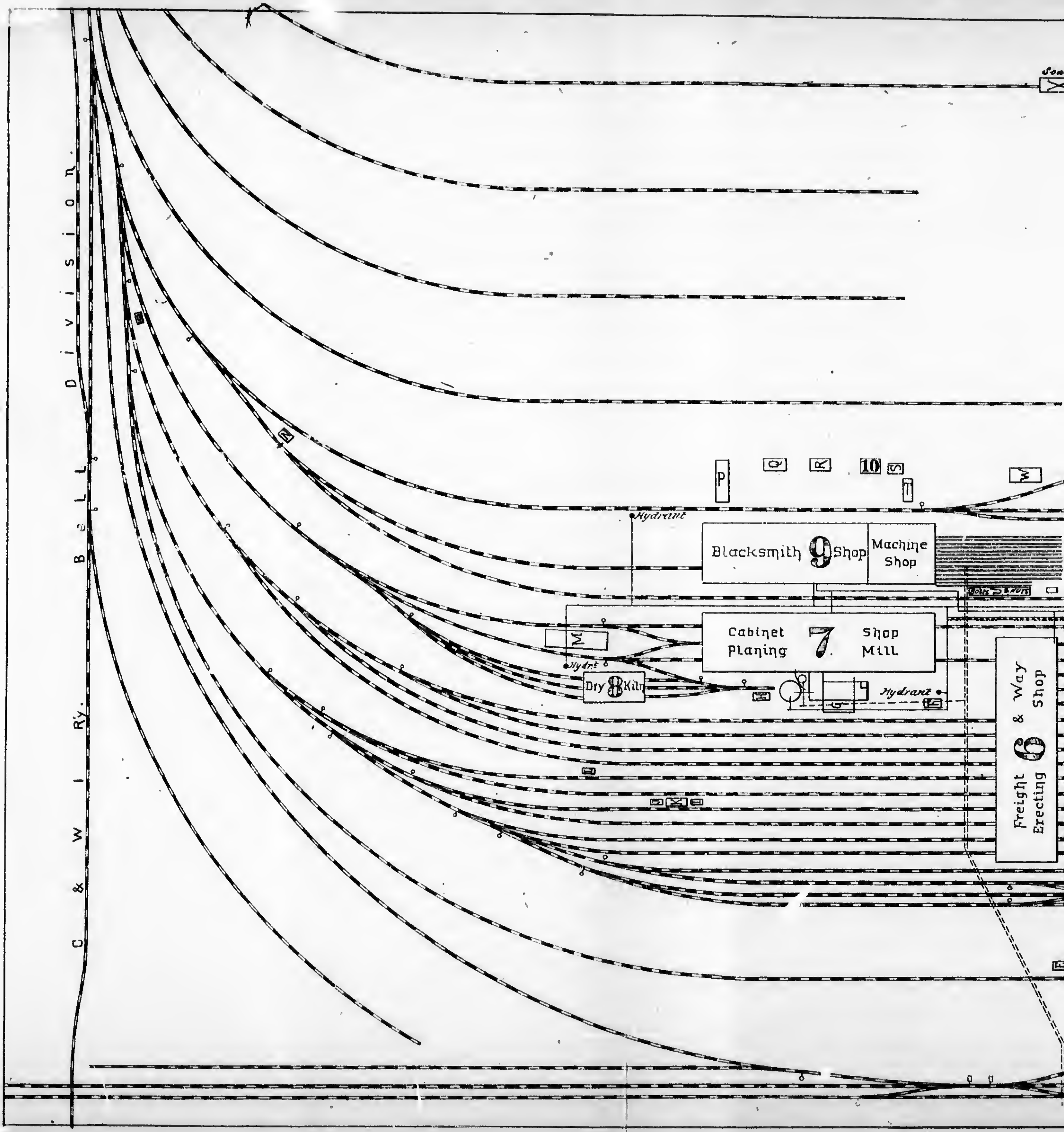
Supplementing his remarks as to a central turntable in the annular arrangement of shed giving trouble, the author had a very lively recollection of one of them breaking down at a station under his charge at 2 o'clock in the morning, about one hour before the passenger trains concentrating at that junction were due. Every passenger engine was locked up for nearly ten hours, putting the Traffic Department into great disorder. Such a serious mishap did not often occur, but it was a rare thing for a district officer to go through a winter without some failure to a turntable, although they were made of the best material and design. Of course with a longitudinal type of shed, a turntable was necessary, and it was used in putting the engines into the shed ready for traffic; therefore, until every engine in the shop was cleared out, no great inconvenience from the break-down of a turntable would be felt. There was plenty of lee-way with a shed full of engines, during which time the accident could be made good. In the case he had mentioned, passenger engines and every other kind wanted were unavailable; shunting engines had to be used, and some engines were run tender first.

Mr. Harkom had given an ideal plan of the grouping of shops and of their relation to one another. The author at first intended basing his communication on an arrangement of that kind, but afterwards considered that such a course would be of less interest, and would not provoke so much discussion as if the matter were dealt with as it existed under the limitations of actual practice. The drawings exhibited and the figures given in the appendix illustrated quite modern practice.

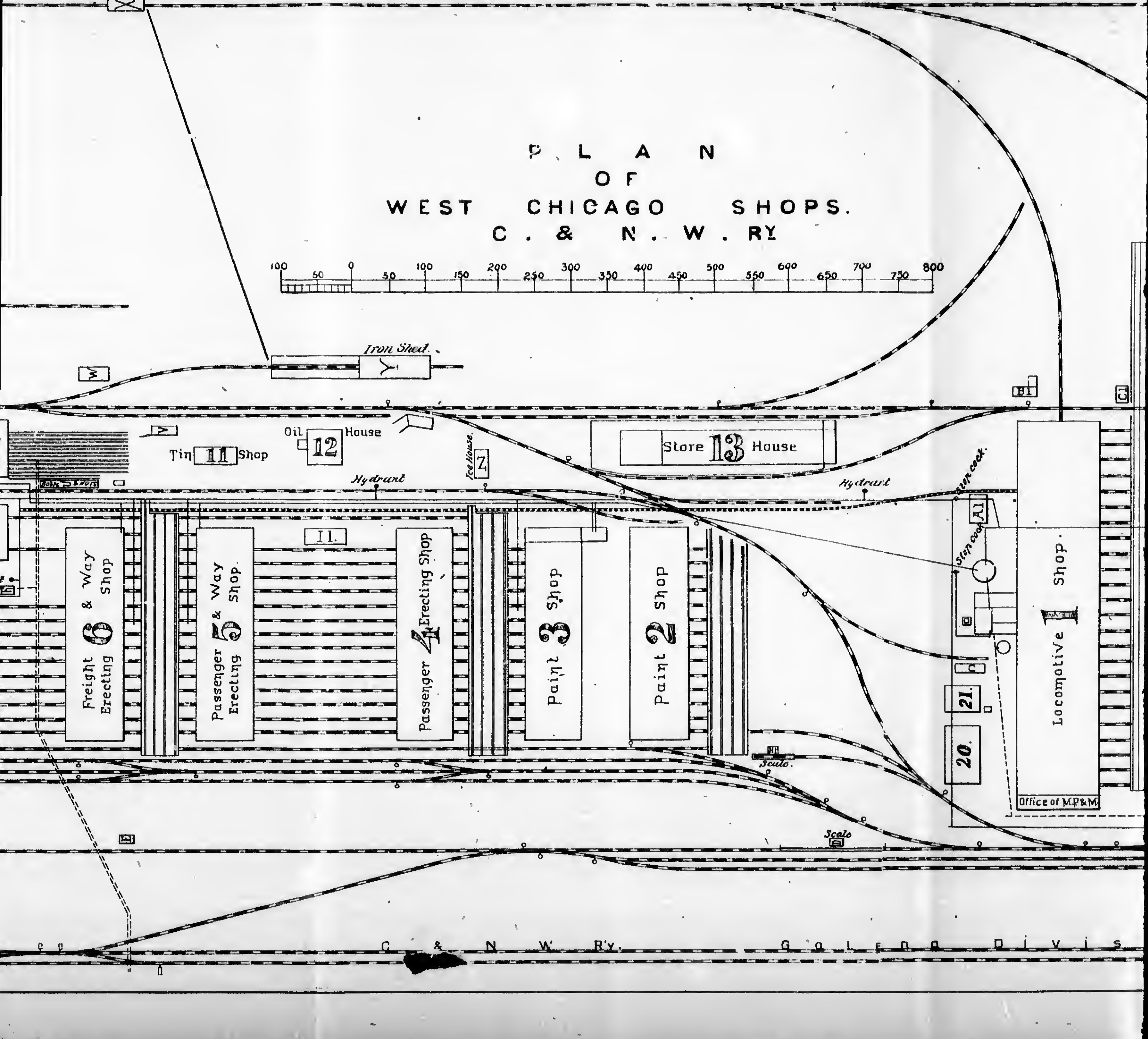
Mr. Harkom had stated that traverser tables could be worked out of doors during a Canadian winter. The speaker was sorry Mr. McWood was not present at this discussion, as he would have been able to tell them about the trouble he experienced at Point St. Charles some 18 years ago, in endeavoring to handle a traverser in the deep snow and low temperatures which generally accompany a Canadian winter.

In his ideal grouping of shops, Mr. Harkom advocated placing the Locomotive and Car establishment on one side of the track, and the Engineer Department shops on the other side. This was rarely accomplished, and the better plan was to have all workshops on one side, and the village and residences of workmen with the station on the other, so that the workshops and residences of the workmen might be within reasonable distance of each other.

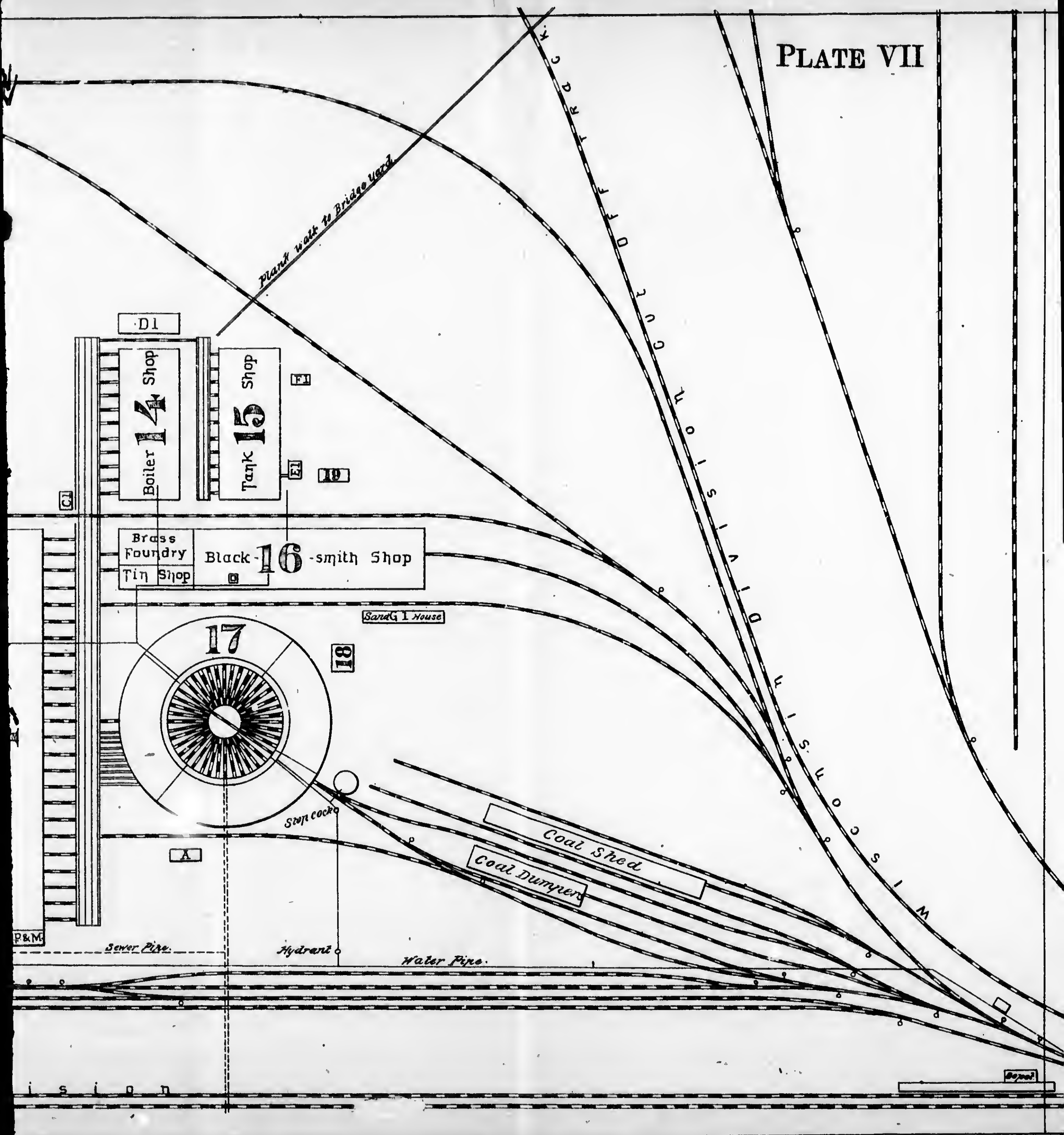

HOPS.
Shop.
Hill.
Shop.
Blacksmith Shop.
nd 48'.0" Turntable.
Round-house.
nd and Charcoal.
Department.
motive Dept.
nd Hose cart.
ard
umber.
Shop.
Shop.
Coal Shed
Dumpers
Shop.
and Laborers.
slings.


C & W I Ry. Bell Division
P
Q
R
10
S
T
W
Hydrant
Blacksmith 9 Shop
Machine Shop
Cabinet 7 Shop
Planing Mill
M
Hydrt
Dry 8 Kiln
Hydrant
Freight 6 & Way
Erecting Shop

# WORKSHOPS.


PLAN
OF
WEST CHICAGO SHOPS.
C. & N. W. Ry
100 50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800
Scale
Iron Shed
W
Store 13 House
Oil 12 House
Tin 11 Shop
Ice House
Hydrant
Hydrant
Stop cock
Stop cock
A1
B1
C1
I1.
Freight Erecting 6 & Way Shop
Passenger Erecting 5 & Way Shop
Passenger 4 Erecting Shop
Paint 3 Shop
Paint 2 Shop
Locomotive 1 Shop
21.
20.
Office of M.P.&M.
Scale
Scale
C. & N. W. R'y. Galena Divis

# PLATE VII



Plank walk to Bridge yard
D1
Boiler 14 Shop
Tank 15 Shop
F1
E1
19
C1
Brass Foundry
Tin Shop
Black-16-smith Shop
Sand & I House
17
18
Stop Cock
Coal Shed
Coal Dumper
A
P&M
Sewer Pipe
Hydrant
Water Pipe
Cut Off Track
Mission Division
ision
Depot

VII

# ANNEX
—TO—
## PLAN OF WEST CHICAGO SHOPS.

### BRICK BUILDINGS

- №1 { – 120'.0"×552'.0" – Locomotive Shop.
- { – 60'.0"×58'.0" – Boiler, Engine and Tool-room.
- №2. – 83'.0"×302'.0" – Paint Shop.
- " 3. – 80'.0"×302'.0" – " "
- " 4. – 80'.0"×302'.0" – Passenger Erecting Shop.
- " 5. – 80'.0"×302'.0" – Passenger & Way Erecting Shop.
- " 6. – 80'.0"×302'.0" – Freight & Way Erecting Shop.
- " 7. – 80'.0"×308'.0 – Cabinet Shop and Planing Mill.
- " 8. – 43'.0"×80'.0" – Dry Kiln.
- " 9. – 80'.0"×308'.0 – Machine- and Blacksmith-Shop.
- " 10. – 20'.0"×24'.0 – Shop for Fitting Car Castings.
- " 11. – 24'.0"×60'.0" – Tin- and Upholsterer Shop.
- " 12. – 50'.0"×50'.0" – Oil House.
- " 13. – 50'.0"×300'.0" – Store House.
- " 14 – 80'.0"×200'.0" – Boiler Shop.
- " 15. – 80'.0"×200'.0" – Tank Shop.
- " 16. – 80'.0"×402'.0 – Brass Foundry and Tin- and Blacksmith Shop.
- " 17. Diam. 280'.0" and 152'.8" Round House 40 Stalls and 48'.0" Turntable.
- " 18. – 30'.0"×36'.0" – Store and Boiler-room for Round-house.
- " 19. – 16'.0"×40'.0 – Store room for Patterns Sand and Charcoal.
- " 20. – 50'.0"×82'.0 – Drawing Room & Test Department.
- " 21. – 36'.0"×50'.0 – Electric Light Building.

### FRAME BUILDINGS

- A. – 15'.2"×40'.2" – Paint Store room for Locomotive Dep't.
- B.
- C. – 12'.5×41'.0 – Chip house.
- D. – 9'.0"×18'.0" – Scale house.
- E. – 12'.2"×20'.2" – Store house for Trackmen.
- F. – 10'.2×20'.4" – Store house for Oil, Waste and Hose cart.
- G. – 18'.4×39'.4 – House for Heating Boiler.
- H. – 10'.0"×20'.0" – Store house for Repair-yard
- I. – 7'×16' – " " " " "
- J. – 7'×16' – " " " " "
- K. – 9'×28' – " " " " "
- L. – 8'×16' – " " " " "
- N. – 12'×14' – Office for Lumberyard.
- M. – 24'.4"×84'.10" – Store house for dressed Lumber.
- O. – 8'.5×10'.6" – House for Lumber men.
- P. – 15'.3×55'.0" – Scrap iron for Furnace.
- Q. – 16'.6"×28'.2" – Store house for Blacksmith Shop.
- R. – 16'.2×28 – Store house for Machine Shop.
- S. – 13'×21' – " " " " "
- T. – 11'.6"×31'.8" – Store house for Axles.
- U. – 10'×80' – Bolt house.
- V. – 12'.2"×36'.2" – Store house for Charcoal.
- W. – 18'×42' – Chip and Scrap house.
- X. – 19'×30' – Scale house.
- Y. – 32'×100' – Iron scrap house.
- Z. – 18'.5×43'.2" – Ice house.
- A1. – 24'.2"×43'.2" – Store house for Locomotive Shop.
- B1. – 13'.5×43'.7"&(12'.6×16'.6") – Store house for Carpenters and Laborers.
- C1. – 16'.2×32'.2" – Store house for Brass Castings.
- D1. – – Scrap.
- E1. – 24'.3×16'.1" – Flue Cleaner.
- F1. – 13'.6"×24'.2" – Store house for Tank Shop.
- G1. – 16'.2"×166'.6" – Sand house.
- H1. – 10'.0"×12'.0" – Scale house.
- I1. – 60'.2×24'.2" – Cushion house.