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MINE TIMBERING.

THE square system of timbering, in use in most of our large mines on the Pacific coast, was first introduced in Australia by Mr. W. H. Patton, who adopted it in the Broken Hill Proprietary mines, although it does not seem to be so satisfactory to the people there as to our miners, who are more familiar with it. The accompanying description and plans were furnished by Mr. Patton to the report of the Secretary of Mines for Victoria:

"The idea is supposed to have originated in the German mines, but in a crude form. It was introduced among the mines of the Pacific coast of America some 20 years ago, by a gentleman named Diederheimer. Its use there is universal, and experience has evolved it from the embryo state to its present perfection. The old system and its accompanying disadvantages are well known. A drive would be put in for a certain distance, when it had to be abandoned until it could be filled up with waste material and made secure. This process entailed much expense. The stuff had first to be broken on the surface, then sent below, trucked along the drives, and finally shoveled into place. Ventilation was impaired and the drives were filled with dust. The men worked in discomfort, and were not in a condition to perform a full measure of labor. Under the system as adopted in the Proprietary mine, these disadvantages disappear. The cost is one-third less, ventilation is perfect, and every portion of the faces are accessible at all times. Sawn timber is used throughout; the upright and cross pieces are 10 inches by 10 inches, and stand 4 feet 6 inches apart; along the course of the drive, the cross pieces are five feet in length, and the height of the main drives and sill floor sets are 7 feet 2 inches in the clear. In blocking out the stopes, the uprights are 6 feet 2 inches, just one foot shorter than those in the main drives. The caps and struts are of the same dimensions and timber as the sill floor. The planks used as staging are 9 inches by 2½ inches; they are moved from place to place as required, and upon them the men stand when working in the stopes and in the faces. A stope resembles a huge chamber fitted with scaffolding from floor to roof. The atmosphere is cool and pure, and there is no dust. Stage is added to stage, according as the stoping requires it, and ladders lead from one floor to the other; the accessibility to all the faces is a great advantage.

If, while driving, a patch of low grade ore is met with, it can be enriched by taking a higher class from another face, and so on. Any grade can be produced by means of this power of selection. Opinions have been expressed that this system of timbering is not secure, and that pressure from above would bring the whole structure down in ruins. But an opinion such as this is due to miscomprehension of the facts. If signs of weakening in the timbers become apparent, the remedy is very simple. Four or more of the uprights are lined with planks, and waste material is shot in from above, and a strong support is at once formed, or if signs of crushing are noticed, it is possible to go into the stope, break down ore, and at once relieve the weight.

TRANSIT IN LONDON, RAPID AND OTHERWISE.*

By JAMES A. TILDEN.

THE methods of handling the travel and traffic in the city of London form a very interesting subject for the study of the engineer. The problem of rapid transit and transportation for a city of five millions of inhabitants is naturally very complicated, and a very difficult one to solve satisfactorily.

The subject may be discussed under two divisions: first, how the suburban travel is accommodated, that is, the great mass of people who come into the business section of the city every morning and leave at night; second, how the strictly local traffic from one point to another is provided for. Under the first division it will be noted in advance that London is well provided with suburban railroad accommodation upon through lines radiating in every direction from the center of the city, but the terminal stations of these

roads, as a rule, do not penetrate far enough into the heart of the city to provide for the suburban travel without some additional methods of conveyance.

The underground railroad system is intended to relieve the traffic upon the main thoroughfares, affording a rapid method of transportation between the residential and business portions, and in addition to form a communicating link between the terminals of the roads referred to. These terminal stations are arranged in the form of an irregular ellipse and are eleven in number.

One of the most noticeable features of the underground system in London is that it connects these stations by means of a continuous circuit, or "circle," as it is there called. The line connecting the terminal stations is called the "inner circle." There is also an extension at one end of this elliptical shaped circle which also makes a complete circuit, and which is called the "middle circle," and a very much larger circle reaching the northern portions of the city, which is called the "outer circle." The eastern ends of these three circles run for a considerable distance on the same track. In addition to this the road branches off in a number of directions, reaching those parts of the city which were not before accommodated by the surface roads, or more properly the elevated or depressed roads, as there are no grade crossings.

With regard to the accommodation afforded by this

is one cent per mile for third class, one cent and a half for second class, and two cents for first class, but no fare is less than a penny, or two cents. Omnibus fares in some instances are as low as a penny for two miles. This is not by any means the rule, and is only to be found on competing lines. The average fare would be a penny a mile or more.

The fares on the main lines which accommodate the suburban traffic are somewhat higher than on the underground, perhaps 50 per cent. more. In every case, on omnibus, tram cars or railroads, the rates are charged according to distance. The system such as in use on our electric, cable and horse cars and on the elevated road in New York, of charging a fixed fare, is not in use anywhere.

The ticket offices of the underground roads are generally on a level with the street. In some instances both the uptown and downtown trains are approached from one entrance, but generally there is an entrance at either side of the railroad, similar to the elevated railroad system. In purchasing a ticket, the destination, number of the class, and whether it is a single or return ticket have to be given. The passenger then descends by generally well lighted stairways to the station below, and his ticket is punched by the man at the gate. He then has to be careful about two things; first, to place himself on that part of the platform where the particular class which he wishes to

take stops, and secondly, to get on to the right train. In the formation of the train the first class coaches are placed in the center, the second and third class respectively at the front and rear end. There are signs which indicate where passengers are to wait, according to the class. There is a sign at the front end of the engine, which to those initiated sufficiently indicates the destination of the train. The trains are also called out, and at some stations there is an obscure indicator which also gives the desired information. The stations are from imperfectly to well lighted, generally from daylight which sifts down from the smoky London atmosphere through the openings above.

The length of the train averages about eight carriages of four compartments, each compartment holding ten persons, making a carrying capacity of 320 passengers. The equipment of the cars is very inferior. The first class compartments are upholstered and cushioned in blue cloth, the second class in a cheaper quality, while most of the third class compartments have absolutely nothing in the way of a cushion or covering either on the seat or back, and are little better than cattle pens. The width of the compartment is so narrow that the feet can easily be placed on the opposite seat, that is, a very little greater distance than would be afforded by turning two of our seats face to face. The length of the compartment, which is the width of the car, is about a foot and a half less than the width of our passenger cars, about equal to our freight cars. Each compartment is so imperfectly lighted by a single lamp put into position through the top of the car that it is almost impossible to read.

The length of time which a train remains at a station is from thirty to forty seconds, or from three to four times the length of time employed at the New York elevated railroad stations. The reason for this is that a large proportion of the doors are opened by passengers getting in or out, and all these have to be shut by the station porter or guard of the train before the train can start. If the train is crowded one has to run up and down to find a compartment with a vacant seat, and also hunt for his class, and as each class is divided into smoking and non-smoking compartments, making practically six classes, it will be observed that all this takes time, especially when you add the lost time at the ticket office and gate.

The ventilation of the tunnels and even the stations is oftentimes simply abominable, and although the roads are heavily patronized there is a great amount of grumbling and disfavor on this account. The platforms of the stations are flush with those of the cars, so that the delay of getting in or out is very small, but the doors are so low that a person above the average height has to stoop to get in, and cannot much more than stand upright with a tall hat on when he is once in the car. The monitor roof is unknown.

The trains move with fair speed and the stations are plainly and liberally marked, so that the passenger has little difficulty in knowing when to get out. There are two signs in general use on English railroads which

THE SQUARE SYSTEM OF TIMBERING IN MINES.

system: it is a convenience for the residents of the western and southern parts of London, especially where they arrive in the city at any of the terminal stations on the line of the "circle," as they can change to the underground. They can reach the eastern end of the "circle," at which place is located the bank and the financial section of London, in a comparatively short time. For example, passengers arriving at Charing Cross, Victoria or Paddington stations, can change to the underground, and in ten, fifteen and thirty minutes respectively, reach the Mansion House or Cannon street stations, which are the nearest to the Bank of England. In a similar manner those arriving at Euston, St. Pancras or King's Cross on the northern side of the "circle," can reach Broad Street station in ten or fifteen minutes, which station is nearest the bank on that side of the "circle."

In a number of cases the underground station is in the same building or directly connected by passages with the terminal stations of the roads leading into the city. Examples of this kind would be such stations as Cannon Street, Victoria or Paddington. They are not, however, sufficiently convenient to allow the transference of baggage so as to accommodate through passengers desiring to make connection from one station to another across the city. Hand baggage only is carried, about the same as it is on the elevated road in New York. The method of cross town transfer, passengers and baggage, is invariably done by small omnibuses, which all the railroads maintain on hand for that special purpose. A very large proportion of the travel, however, if not the largest, is obtained by direct communication by means of the "circle" on branch lines with the various residential portions of north, west and south London.

Approximately on the underground railroad the fare

* Abstract from a paper read before the Boston Society of Engineers, 11 April, 1890.

are very simple and right to the point, namely, "Way Out" and "Way In," so that when a passenger arrives at a station he has no question how to get out of it. The ticket is given up as the passenger leaves the station. There is nothing to prevent a passenger with a third class ticket getting into a first class compartment excepting the omnious warning of 40 shillings fine if he does so, and the liability of having his sweet dreams interrupted by an occasional inspector who asks to see the denomination of his ticket. All compartments intended for the use of smokers are plainly marked and are to be found in each class. Almost the entire part of the railroads within the thickly settled portions of the city run in closed tunnels. Outside of this they frequently run in open cuttings, and still further out they run on to elevated tracks.

With regard to the equipment of the suburban or surface lines not belonging to the underground system the description is about the same. The cars are generally four compartments long and sometimes not exceeding three. They are coupled together with a pair of links and fastened to the draw bar on one car and the other thrown over a hook opposite and brought into tension by a right and left hand screw between the links. This is obviously very inconvenient for shunting purposes, especially as the cars are not provided with hand brakes and no chance to get at them if there were any. Consequently it appears that when a train is made up it stays so for an indefinite period. A load of passengers is brought into the station and the train remains in position until it is ready to go out. As the trains run very frequently this appears to be a very economical arrangement, as no shunting tracks are needed for storage. The engine which brings the train in of course cannot get out until the train goes out with the next load. Turn tables for the locomotives are but very little used, as they run as double enders for suburban purposes.

In conclusion it will be safe to say that the problem of rapid transit for a city as large as London is far from solved by the methods described. Although there are a great many miles of underground lines and main lines, as they have been called throughout the paper, and although grade crossings have been entirely abolished, allowing the trains to run at the greatest speed suitable to their frequency, still there are a great many sections which have to depend entirely upon the omnibus or tram car. The enormous expense entailed by the construction of the elevated structures can hardly be imagined. We have but one similar structure in this country, which is that running from the Schuylkill River to Broad Street station, in Philadelphia. The underground system is even more expensive, especially in view of the tremendous outlay for damages. This goes to show that money has not been spared to obtain rapid transit.

After all, the means to be depended upon when one desires to make a rapid trip from one part of the city to another is the really admirable, cheap, always ready, convenient and comfortable London hansom; while the way to see London is from the top of an omnibus, the most enjoyable, if not the most expeditious, means of conveyance.

[Continued from SUPPLEMENT, No. 809, page 12930.]

RIVETED JOINTS IN BOILER SHELLS.*

By WILLIAM BARNET LE VAN.

FIG. 11 represents the spacing of rivets composed of steel plates three-eighths inch thick, averaging 58,000 pounds tensile strength on boiler fifty-four inches diameter, secured by iron rivets seven-eighths inch

FIG. 11.

diameter. Joints of these dimensions have been in constant use for the last fourteen years, carrying 100 pounds per square inch.

Punching Rivet Holes.—Of all tools that take part in the construction of boilers none are more important, or have more to do, than the machine for punching rivet holes.

That punching, or the forcible detrusion of a circular piece of metal to form a rivet hole, has a more or less injurious effect upon the metal plates surrounding the hole, is a fact well known and admitted by every engineer, and it has often been said that the rivet holes ought all to be drilled. But, unfortunately, at present writing, no drilling appliances have yet been placed on the market that can at all compare with punching apparatus in rapidity and cheapness of working. A first-class punching machine will make from forty to fifty holes per minute in a thick steel plate. Where is the drilling machine that will approach that with a single drill?

The most important matter in punching plates is the diameter of the opening in the bolster or die relatively to that of the punch. This difference exercises an important influence in respect not only of easy punching but also in its effect upon the plate punched. If we attempt to punch a perfectly cylindrical hole, the opening in the die block must be of the same diameter as the point of the punch, or, at least, a very close fit. The point of the punch ought to be slightly larger in diameter than the neck, or upper part, as shown in Figs. 12 and 13, so as to clear itself easily.

When the hole in the bolster or die block is of a larger diameter than the punch, the piece of metal thrust out is of larger diameter on the bottom side, and it comes out with an ease proportionate to the difference between the lower and upper diameters;

FIG. 12.

FIG. 13.

or, in other words, it produces a taper hole in the plate, but allows the punching to be done with less consumption of power and, it is said, with less strain on the plate.

As to the difference which should exist between the diameter of the punch and the die hole, this varies a little with the thickness of the plate punched, or should do so in all carefully executed work, for it is easy to understand that the die which might give a suitable taper in a three-fourths inch plate would give too great a taper in a three-eighths inch plate. There is no fixed rule; practical experience determines this in a rough and ready way—often a very rough way, indeed, for if a machine has to punch different thicknesses of plate for the same size of rivets, the workman will seldom take the trouble to change the die with every variation of thickness. The maker of punches and dies generally allows about three sixty-fourths or 0.0468 of an inch clearance.

The following formula is also used by punch and die makers:

$$\text{Clearance} = D = d + 0.2t$$

where

D = diameter of hole in die block;

d = diameter of cutting edge of punch;

t = thickness of plate in fractions of an inch;

that is to say, the diameter of the die hole equals diameter of punch plus two-tenths the thickness of the plate to be punched.

Example.—Given a plate $\frac{3}{8}$ or 0.375 of an inch thick, the diameter of the punch being $\frac{1}{2}$ or 0.5125 of an inch, then the diameter of the die hole will be as follows:

$$\text{Diameter of die hole} = 0.5125 + 0.375 \times 0.2 = 0.5875 \text{ inch diameter,} \\ \text{or say } \frac{3}{8} \text{ or } 0.375 \text{ inch diameter.}$$

Punches are generally made flat on their cutting edge, as shown in Fig. 12. There are also punches made spiral on their cutting edge, as shown in Fig. 13. This punch, instead of being flat, as in Fig. 12, is of a helical form, as shown in Fig. 13, so as to have a gradual shearing action commencing at the center and traveling round to the circumference. Its form may be explained by imagining the upper cutter of a shearing machine being rolled upon itself so as to form a cylinder of which its long edge is the axis. The die being quite flat, it follows that the shearing action proceeds from the center to the circumference, just as in a shearing machine it travels from the deeper to the shallower end of the upper cutter. The latter is not recommended for use in metal of a thickness greater than the diameter of the punch, and is best adapted for thicknesses of metal two-thirds the diameter of the punch.

Fig. 14 shows positions of punch and attachments in the machine.

It is of the greatest importance that the punch should

FIG. 14.

be kept sharp and the die in good order. If the punch is allowed to become dull, it will produce a fin on the edge of the rivet hole, which, if not removed, will cut into the rivet head and destroy the fillet by cutting into the head. When the punch is in good condition it will leave a sharp edge, which, if not removed, will also destroy the fillet under the head by cutting it away.

Punching possesses so many advantages over drilling as to render it extremely important that the operation should be reduced to a system so as to be as harmless as possible to the plate. In fact, no plate should be used in the construction of a boiler that does not improve with punching, and further on I will show by the experiments made by Hoopes & Townsend, of Philadelphia, that good material is improved by punching; that is to say, with properly made punches and dies, by the upsetting around the punched hole, the value of the plate is increased instead of diminished, the flow of particles from the hole into the surrounding parts causing stiffening and strengthening.

Drilling Rivet Holes.—In the foregoing I have not referred to the drilling of rivet holes in place of punching. The great objection to drilling rivet holes is the expense, from the fact that it takes more time, and when drilled of full rivet size we are met with the difficulty of getting the rivet holes to correspond, as they are when punched of full rivet diameter. When two plates are drilled in place together, the drill will produce a burr between the two plates—on account of their uneven surfaces—which prevents them being brought together, so as to be water and steam tight, unless the plates are afterward separated and the burr removed, which, of course, adds greatly to the expense.

The difference in strength between boiler plates punched or drilled of full rivet size may be either greater or less than the difference in strength between unperforated plates of equal areas of fracture section. When the metal plates are very soft and ductile, the operation of punching does no appreciable injury. Prof. Thurston says he has sometimes found it actually productive of increased strength; the flow of particles from the rivet hole into the surrounding parts causing stiffening and strengthening. With most steel and hard iron plates the effect of punching is often to produce serious weakening and a tendency to crack, which in some cases has resulted seriously. With first class steel or iron plates, punching is perfectly allowable, and the cost is twenty-five per cent. less than drilling; in fact, none but first class metal plates should be used in the construction of steam boilers.

In the original punching machines the die was made much larger than the punch, and the result was a conical taper hole to receive the rivet. With the advanced state of the arts the punch and die are accurately fitted; that is to say, the ordinary clearance for a rivet of (say) three-fourths of an inch diameter, the dies have about three sixty-fourths of an inch, the punch being made of full rivet size, and the clearance allowed in the diameter of the die.

Take, for example, cold punched nuts. Those made by Messrs. Hoopes & Townsend, Philadelphia, when taken as specimens of "commercial," as distinguished from merely experimental punching, are of considerable interest in this connection, owing to the entire absence of the conical holes above mentioned.

When the holes are punched by machines properly built, with the punch accurately fitted to the die, the effect is that the metal is made to flow around the punch, and thus is made more dense and stronger. That some such action takes place seems probable, from the appearance of the holes in the Hoopes & Townsend nuts, which are straight and almost as smooth as though they were drilled.

Therefore I repeat that iron or steel that is not improved by proper punching machinery is not of fit quality to enter into the construction of steam boilers.

STRENGTH OF PUNCHED AND DRILLED IRON BARS.

HOOPES & TOWNSEND.

Thickness of bar in inches.	Thickness outside of hole in inches.	Punched bars broke in pounds.	Drilled bars broke in pounds.
$\frac{3}{8}$ or 0.375	$\frac{3}{8}$ or 0.375	31,740	28,000
$\frac{3}{8}$ or 0.375	$\frac{3}{8}$ or 0.375	31,380	26,950
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.25	18,820	18,000
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.25	18,750	17,590
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.1875	14,590	13,230
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.1875	15,420	13,750
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.125	10,670	9,320
$\frac{5}{8}$ or 0.625	$\frac{5}{8}$ or 0.125	11,730	9,580

It will be seen from the above that the punched bars had the greatest strength, indicating that punching had the effect of strengthening instead of weakening the metal. These experiments have given results just the reverse of similar experiments made on boiler plates; but the material, such as above experimented upon, is what should be placed in boilers, tough and ductile, and the manner of, and care taken in, punching contribute to these results.

It is usual to have the rivet holes one-sixteenth of an inch in diameter larger than the rivets, in order to allow for their expansion when hot; it is evident, however, that the difference between the diameters of the rivet hole and of the rivet should vary with the size of the rivet.

The hole in the die is made larger than the punch; for ordinary work the proportion of their respective diameters varies from 1:1.5 to 1:2.

As I have before stated, the best plate joint is that in which the strength of the plate and the resistance of the rivet to shearing are equal to each other.

In boilers as commercially made and sold the difference in quality of the plates and rivets, together with the great uncertainty as to the exact effect of punching the plates, have, so far, prevented anything like the determination either by calculation or experiment of what might be accepted as the best proportions of riveted joints.

In regard to steel plates for boilers Mr. F. W. Webb, of Crewe, England, chief engineer of the London and Northwestern Railway, has made over 10,000 tests of steel plates, but had only two plates fail in actual work; these failures he thought were attributable solely to the want of care on the part of the men who worked the plates up.

All their rivet holes for boilers where punched in a Jacquard machine, the plates then annealed, and afterward bent in rolls; they only used the reamer slightly when they had three thicknesses of plate to deal with, as in butt joints with inside and outside covering strips. These works turn out two locomotive boilers every three days.

The Baldwin Locomotive Works, which turn out on an average three locomotives per day, punch all their rivet holes one-sixteenth inch less in diameter and ream them to driven rivet size when in place. They also use rivets with a fillet formed under head made in solid dies.

Rivets.—Rivets of steel or iron should be made in solid dies. Rivets made in open dies are liable to have a fin on the shank, which prevents a close fit into the holes of the plates. The use of solid dies in forming the rivet insures a round shank, and an accurate fit in a round hole. In addition, there is secured by the use of solid dies, a strong, clean fillet under the head, the point where strength is most needed.

Commencing with a countersunk head as the strong

* A paper read at a meeting of the Franklin Institute. From the journal of the Institute.