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Contents:

(Illustrated articles are marked with an asterisk.)

Special Notice to Advertisers.

The circulation of the Scientific American has become so large that we are compelled to put it to press one day earlier in the week. Advertisements must be handed in before Friday noon, to insure their publication in the issue of the succeeding week.

SAFETY VS. ECONOMY IN THE CONSTRUCTION OF STEAM BOILERS.

Two kinds of experiment are now and have been for some time in progress, having for their common object the improvement of steam boilers. These experiments are conducted by two sets of inventors, and have each done much to educate the steam consuming public. The first has for its aim the increase of the factor of safety to its highest point; the other aims at the increase of economy in the production of steam.

It is, perhaps, a little singular that those who aim at greatest safety, as well as those who aim at maximum economy, should have for the most part adopted tubular construction, with the distinction that the greater economy party use the tubes as flues through which to transmit the gases of combustion, and thus enlarge the heating surface; while the safety party put water in the tubes, and apply the heat out side, thereby securing great heating surface, while accumulated rupturing power is reduced.

Neither of these systems has proved altogether satisfactory. Unequal contraction and expansion have been a cause of manifold evils in the economy tubular system; and such boilers are confessedly not as safe as desirable. The safety tubular system, though safe, is uneconomical.

Notwithstanding this, the number of boilers constructed so as to make safety the principal point secured, are multiplying in the market, and are finding ready sale in many instances. There is without doubt a mean between these extremes, a mean that gives both maximum economy with maximum safety, so far as these can be simultaneously attained, and we believe we have seen boilers in which this mean is attained; but it is not our purpose to commend any particular boiler, however much it might serve us in illustrating our views upon this subject.

Most of those boilers in which the attainment of maximum safety is made the paramount object, are subject to the great defect of foaming, or priming, as it is called, so that the amount of water passed through them by the action of heat is no index of their true evaporative power. And as the economy of a boiler is entirely dependent upon its evaporative power, or the amount of water it can truly convert into steam per given weight of coal consumed, it may well be doubted whether the factor of safety is not too dearly purchased in this class of boilers.

Some recent experiments, to which we may refer more particularly at a future time, seem to show that in the ordinary mode of estimating the quality of steam by the hand, and its appearance when discharged into the air, very great errors in judgment are committed; and it is probable that many boilers claimed to evaporate from 12 to 13 lbs. of water per lb. of coal consumed, do not really do more than half that. It is further probable, that absolute normal steam from working boilers is much more rarely delivered to steam engines than is at present supposed.

The experiments referred to have also rendered it almost certain that the proportion of priming within certain limits is exactly as the rate at which the steam is delivered—all other things being equal—and that there is a limit to rapid delivery beyond which almost any boiler will prime, more or less, no matter how well it is constructed; and still another limit, below which no boiler will prime, no matter what its form may be. And further, these experiments indicate that boilers deemed safe when delivering wet steam may be unsafe when this delivery is so reduced as to force them to deliver dry steam; although, of course, no boiler composed of small pipes, or their equivalent, can produce such havoc by explosion, as one in which the water and steam are massed, and disruptive pressure accumulated upon an outside shell.

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THE STUDY OF IMPRACTICABILITIES.

In this utilitarian age there are to be found many who are impatient of all that seems impracticable. They chafe at all propositions and attempts that do not clearly bear the stamp of practical skill and finished attainments. He who in his quiet workshop is studying for a solution to perhaps some impossible mechanical problem, and the one who timidly suggests some plan having in it elements of failure, plainly discoverable to the experienced and skillful, are as much the subjects of derision to this class of men, as those who dogmatically insist that wrong is right, and persistently parade their ignorance before the world.

The history of all improvement will show that failure has done as much to elevate the world as success. Even in the financial world, men need the instruction drawn from their failures to finally succeed. Few indeed march steadily on to wealth from the beginning of their career.

As in business, so in art and science. The artist perfects himself by the study of his faults. The scientist makes repeated failures ere he succeeds in originating some great and instructive experimental discovery. Scarcely an approach to perfection in mechanical construction exists that has not advanced by the gradual elimination of defects.

What is an improvement but the removal of impracticable elements. Who shall deny then the educating power of impracticabilities?

There is occasionally a correspondent who criticises the course of the Scientific American, because in its publication and illustration of new inventions, it does not deny its columns to such occasional ones as are faulty. If our views, as above given are correct, we should by making such a denial be narrowing the educational influence of our paper. We wish it distinctly understood that, while in our editorial statements we aim at scientific accuracy, and in our selections from foreign and home sources of miscellaneous contents, choose only such as we deem of general value, we do not wish to adapt our paper to skilled engineers and technical experts alone. We occupy a broader field, and believe we are doing far more good by acting as the general organ for the expression of the inventive talent of our country, learned as well as unlearned.

It is not enough that an invention has in it elements of impracticability to exclude it from our columns. Its publication proclaims a mechanical want, shows how it has been attempted to supply the want, and may suggest even by its impracticabilities how a practicable device may be constructed.

Probably no one of the readers of this journal has been called upon to study more critically and attentively the various devices illustrated and described in it, than the present writer of the descriptions which accompany the engravings. He certainly has not found that study devoid of interest, or of mental profit, albeit he has met with some of little practical merit. Judging from his own experience he now avows his belief that, of all the departments of this widely circulated and popular journal, none is of greater general value than that of the illustrated mechanical descriptions.

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NEW MECHANICAL MOVEMENTS.

On page 192, current volume, we published some problems in new mechanical movements, which seem to have attracted considerable attention. We have received many so-called solutions, which, upon examination, have proved incorrect, but the incorrectness of which could scarcely be pointed out without giving a clue to the correct solutions.

We have also received diagrams of supposed new mechanical movements not called for by the problems proposed. Some of these show evidence of having never got further than the paper upon which they are drawn; and we would here remark, that it is well to scrutinize with very great care, any movement not experimentally demonstrated to be correct, before making any statements as to what it will do.

For instance, a gentleman from Massachusetts sends us a diagram of a movement by which it is claimed rotary motion can be converted into reciprocating motion, and *vice versa.* The device is neither new, nor will it do what is claimed for it. It is simply a slotted crosshead with straight slot inclined at an angle of forty-five degrees to the line of direction in which it reciprocates. In the slot slides a block through the center of which plays a crank wrist.

The device will convert a rotary into a reciprocating motion, but will not perform the converse movement. It has only the functions of the slotted crosshead placed at right angles with the line of direction in which the reciprocation takes place.

Problem second, in the article above referred to, has received but two original solutions, which we give below; we think one of these is a very ingenious one. Others have been proffered but they are old. One of these is the method described by Fairbairn. The problem was enunciated as follows: "Required to produce a variable rotary motion in a shaft driven directly by a belt from a pulley having a uniform constant rotary motion, without the use of anything but the one belt and the two pulleys; no cone pulleys or their equivalent to be allowed. All the motions to be continuous and in the same direction."

Fairbairn's method, above alluded to, is to make the driven pulley eccentric to its shaft, and use a belt long enough to accommodate itself to the eccentricity with a friction pulley to take up the slack. This does not conform to the conditions of our problem, which admits nothing but a belt between the two pulleys.

Mr. A. K. Smith, of Nebraska, Ohio, sends a solution new to us, but he says not new to himself, as he saw it many years since. The method described by him is to make the driven pulley eccentric and use an elastic belt. This is a proper solution of the problem.

R. B., a modest young machinist, of Buffalo, N. Y., shows that the elastic belt need not be used. With proper proportions an ordinary leather belt may have slack enough to compensate for the eccentricity of the driven pulley This is also a correct solution.

Mr. L. A., of Brooklyn, N. Y., who does not seek celebrity, and therefore does not wish his name published in full, gives the most ingenious solution of any received. He accomplishes the required result by the use of two ordinary pulleys with shafts in their geometrical centers, but connected by a belt, one half of which is elastic and the other half inelastic. Whenever the elastic half of the belt is put on the stretch, it will yield so that the opposite side of the belt will be slack, the slack increasing as the elastic side receives more and more of the tension. When the inelastic half of the belt transmits the motion there will be no slack on the opposite side. The belt, therefore, alternately shortens and lengthens while transmitting the motion, thus rendering the speed of the driven pulley variable, as required. It is obvious that the greater the resistance which the driven shaft has to overcome, the greater will be the variation in the speed.

The inventor of this movement has employed it to produce some very life-like automatic movements in toy figures.

We hope to receive original solutions to the other problems in due time.

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METALLIC HYDROGEN.

At a recent meeting of the Lyceum of Natural History, in New York, a paper was read by Dr. Loew, assistant in the College of New York, on the preparation of hydrogen amalgam, that deserves the attention of scientific men everywhere.

The researches of Graham, which we published at the time, went to show that hydrogen could be alloyed with palladium, and that it was also contained in meteoric iron. He condensed the hydrogen in the palladium, and came nearer proving its metallic character than any other person had done. Schoenbein, in his search for ozone, found a method for making the peroxide of hydrogen, that was simpler than any hitherto known, and which brought him to the very threshold of discovering hydrogenium. Schoenbein's experiment was this: An amalgam of zinc and mercury is violently agitated in water; the water is then filtered, and on being examined with iodide of starch and protosulphate of iron will be found to contain peroxide of hydrogen or oxygenated water. The experiment is a very beautiful one, and is now repeated in the class room. Dr. Loew has carried the investigation further, and has, instead of oxidizing the hydrogen, succeeded in combining it with the mercury. He takes an amalgam composed of not more than three or four per cent of zinc, and shakes it with a solution of the bichloride of platinum; the liquid becomes black, and a dark powder settles to the bottom. The contents of the flask are then thrown into water and hydrochloric acid added to dissolve the excess of zinc. The amalgam of hydrogen and mercury at once forms in a brilliant voluminous mass, resembling in every way the well known ammonium amalgam. It is soft and spongy and rapidly decomposes, but without any smell of ammonia. The hydrogen escapes, and soon nothing but pure mercury is left in the dish. The experiment appears to show conclusively that an amalgam of hydrogen and mercury can be formed, and that hydrogen is really a metal. It would also throw some doubt upon the existence of the amalgam of ammonium and mercury, and offer an explanation of that compound on the basis of its being the same amalgam of hydrogen and mercury that is prepared in the way now pointed out by Dr. Loew. The smell of escaping ammonia must be traced to some other source than the existence of that radical in combination with mercury.

The question may arise, What practical value can be derived from this discovery? We may not be able to appreciate its importance at this early stage, but heretofore it is easy to perceive that the possession of metallic hydrogen will enable us to make a vast number of compounds artificially, and will give us an explanation of many phenomena that are now obscure. If Professor Graham had not published his researches, the experiment exhibited by Dr. Loew would have attracted the attention of the world; as it is, it is likely to excite much interest both in this country and in Europe.

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USES OF FLUOR SPAR.

We are sometimes asked to give the applications of Fluor Spar, and as we cannot answer these questions separately, we we propose, for the benefit of all of our readers, to devote some space to an account of the properties and uses of this valuable mineral.

Its name indicates two things—first, that it easily melts or flows; secondly, that as a spar it is frequently found associated with ores in our mines, for the Germans gave the name spar to the minerals which occur with metals, as, for example, calc spar, feldspar, iron spar, manganese spar. When worked up into ornamental objects, it is known as Derbyshire spar, from one of the localities where fancy articles are made. It is sometimes found in beds, but generally in veins, and often occurs as the gangue of metallic ores.

There are many applications of fluor spar, some of which we purpose to give in this article.

ALUM FROM FELDSPAR.

The manufacture of alum and other compounds of potash from feldspar has long been regarded as a desirable thing; this result can be obtained for alum by fusing the feldspar with fluor spar and treating the mass with sulphuric acid. In this way the silica is expelled in combination with the fluorine as hydro-fluosilicic acid, and the sulphuric acid unites with the alumina and potash of the feldspar to produce alum, while the lime of the fluor spar being insoluble can be collected on filters or removed by decantation, in the form of gypsum. O[illegible]ash salts can be produced from the alum.

HYDRO-FLUOSILICIC ACID.

Gay-Lussac observed many years ago, that when fluor spar and silica were fused together, some of the fluorine combines with the silicon in the form of fluoride of silicon, and escapes with the gaseous products of combustion. Many attempts were made to save this gas, but without success, until Tessie du Motay constructed a furnace by which, it is claimed, that 68 per cent of the fluoride is economized. Plans of the furnace were shown at the Paris Exhibition of 1867, together with a large suite of salts prepared by means of the hydro-fluosilicic acid. Among these salts we recall pure caustic potash, carbonate of potash, silico fluoride of potassium, silico fluoride of sodium, silico fluoride of barium, and caustic soda. As many of our ores contain fluor spar, and as, in the process of smelting, the fluorine is expelled, it is well worth while to save the incidental product of fluoride of silicon by conducting it into water and converting it into hydro-fluosilicic acid. This latter acid has many applications in the arts, and if we could obtain it cheaply and in abundance, it would prove of great value. It has been recommended for the decomposition of bones and guanos; for the manufacture of artificial stones; for fixing colors in paintings with soluble glass; for the preparation of pure tartaric acid, by removing the potash from tartars; to remove lime and potash from the juice of beet-root; and in some of the operations in the manufacture of pins.

HYDROFLUORIC ACID.

For etching on glass, fluoric acid has long been employed, and for this purpose it can be readily prepared by pouring sulphuric acid upon pulverized fluor spar. The operation must be conducted at a gentle heat, in a leaden or platinum retort. When required pure, the latter metal is indispensable. It is, also, sometimes customary to pass the gas through ammonia or potash to produce the fluorides of ammonium or potassium, also to be used for etching glass or for the resolution of minerals.

It is proper to state in this connection, that great precautions must be observed in handling hydrofluoric acid. The preparation of the gas is attended with great danger, as it attacks violently the organs of respiration. A drop of the acid on the skin produces fearful ulcers, and on the tongue, instant death. In a concentrated state it must be preserved in platinum bottles, and in a dilute form, can be kept in gutta-percha bottles.

FLUOR SPAR AS A FLUX.

It has been observed that lime alone occasions a loss of 5 or 6 per cent of iron, in blast furnaces, and that a small addition of fluor spar remedies this evil, as it keeps the slag more uniformly liquid, so that the iron is not caught in it, but falls rapidly through it, and the slag can, by blowing out the furnace, be more easily removed than when other flux is used. The fluor spar also prevents the formation of graphite and removes phosphorus. The proper proportion is about 50 lbs. to 100 lbs. pig iron, or 40 lbs. to 100 lbs. spiegel iron. A larger quantity might prove injurious to the walls of the furnace. In small crucible operations, fluor spar can be recommended as a valuable flux, and in blow-pipe analysis it has a similar application. [See page 229, Vol. XIX., letter of S. D. Poole, Lynn, Mass.]

PREPARATION OF ALUMINUM AND MAGNESIUM.

Metallic aluminum has been made by fusing the double chloride of aluminum and sodium with a proper proportion of metallic sodium, but the actual operation is attended with some practical difficulties, which are said to be removed by the addition of fluor spar. The mixture usually taken is composed of 100 parts double chloride of aluminum and sodium, 50 parts fluor spar, and 20 parts sodium. These substances are intimately mixed and introduced upon the hearth of a furnace previously heated to redness. The doors of the furnace are closed while a strong heat is brought to bear, and by occasional stirring the metallic aluminum will flow down to the front of the inclined hearth. By permitting the more fluid portion of the flux to run away, some fluoride of aluminum can be saved as an incidental product. Magnesium can be prepared in a similar manner by fusing 600 parts chloride of magnesium, 480 parts fluor spar, and 230 parts sodium, in a suitable crucible. The sodium must be freed from naphtha and cut into small pieces so as to be intimately mixed with the chloride and fluor spar, it is then projected into a crucible previously heated to redness, and the cover held down during the first stormy reaction by an iron weight. The magnesium will be found scattered through the slag in small bright pellets, from which it can be separated by crushing and washing.

HYDRAULIC CEMENT.

It is not an easy thing to graduate the heat in the preparation of hydraulic cement so as to prevent the formation of hard slag. By mixing fluor spar with the limestone, a greater range of heat is found to be admissible, and a second burning can be obviated and the properties of the cement are said to be improved.

An excellent cement can also be made by fusing feldspar, lime, and fluor spar together, and separating the potash by dissolving in water. This has the additional merit of securing a most valuable incidental product in the potash.

ANTOZONITE.

A variety of fluor spar has been discovered in Germany, which, on the application of heat, gives off an odor that forcibly recalls chlorine, and, twenty years ago, was supposed to contain that gas. Schoenbein considers the odor to be due to a modified form of oxygen which he calls antozone, and he names this variety of the fluor spar antozonite. A French chemist, also, takes the ground that fluor spar contains oxygen. If either of these theories could be proved by experiment, other and important uses would be opened up to this mineral.

SEPARATING GOLD AND SILVER.

The Stevens flux, for treating mineral ores, is essentially fluor spar, obtained in the treatment of cryolite for soda, and there is, consequently, nothing particularly new about it. According to experiments conducted by Dr. Chandler, of the School of Mines, Columbia College, the amount of fluor spar required in the working of gold quartz is very large, often one hundred per cent, so that the economy of the process must depend upon the cost of the fluor spar at the mines. It is doubtful if fluor spar can be economically employed on a large scale in treating gold quartz. In the working of titaniferous iron ores it now has considerable employment, and may add to the value of that class of ores.

The above are some of the uses to which fluor spar can be applied, from which it will be apparent that it is a valuable mineral, worthy of the attention of metallurgists and manufacturers everywhere.

THE INCREASED USE OF COLD-ROLLED SHAFTING.

The use of cold-rolled shafting is, so far as we can learn, steadily increasing, and its application to purposes where exactitude of diameter, superior strength and rigidity, as well as the highest perfection of finish is required, has now become very extensive.

For our own part we have certainly never seen anything in the way of shafting, superior in point of elegance of finish to this product of cold-rolling.

This beautiful finish, however, is not gained at a sacrifice of strength as might be supposed by those unacquainted with the process, as the following table of results obtained in experiments performed by Major William Wade, of the United States Department, will show.

We may also state that similar tests were made by John P. Whipple, Chief Engineer, U. S. N., and William Fairbairn, Esq., Manchester, England, with like results.

The table is a summary of the average results obtained from numerous experiments made with bar iron, rolled while hot, in the usual manner, compared with the results obtained from the same kinds of iron, rolled and polished while cold, by Lauth's patent process, as manufactured by Jones & Laughlins, of Pittsburgh, Pa., whose advertisement will be found in another column.

	Iron rolled while		Ratio of increase by cold rolling.	Average rate per cent of increase.
	Hot.	Cold.		
TRANSVERSE—Bars supported at both ends, load applied in the middle, distance between the supports 30 inches. Weight, which gives a permanent set of one tenth of an inch, viz.: 1½ in. square bars.	3,100	10,700	3,451	162½
Round bars, 2 in. dia.	5,200	11,100	2,134	
Round bars, 2¼ "	6,800	15,600	2,294	
TORSION—Weight which gives a permanent set of one deg., applied at 25 in. from center of bars. Round bars, 1¾ in. diameter, and nine in. between the clamps	750	1,725	2,300	130
COMPRESSION—Weight which gives a depression, and a permanent set of one hundredth of an inch, to columns 1½ inch long and ⅝ in. in diameter	13,000	34,000	2,615	161½
Weight which bends, and gives a permanent set, to columns 8 in. long and ¾ in. diameter; viz.: Puddled iron	21,000	31,000	1,476	64
Charcoal bloom iron.	20,500	37,000	1,801	
TENSION—Weight per square inch, which caused rods ¾ in. dia. to stretch and take a permanent set, viz.: Puddled iron	37,250	[illegible]	[illegible]	95
Charcoal bloom iron.	42,439	[illegible]	[illegible]	
Weight, per square in., at which the same rods broke, viz.: Puddled iron	55,760	83,156	1,491	[illegible]
Charcoal bloom iron	50,927	99,293	1,950	
HARDNESS—Weight required to produce equal indentations	5,000	7,500	1,500	50

NOTE.—Indentations made by equal weights, in the center, and near the edges of the fresh cut ends of the bars, were equal; showing that the iron was as hard in the center of the bars as elsewhere.

SCIENTIFIC INTELLIGENCE.

SEPARATION OF ANIMAL AND VEGETABLE FIBER.

M. Shervord has invented an ingenious method for the separation of animal fiber from vegetable. The process does not alter the structure or color of the animal fiber, and permits the use of cotton and linen fiber separated from it for numerous purposes. It is sufficient to suspend the goods in an atmosphere of nitrogen or carbonic acid, and to cause the vapors of perfectly dry sulphuric, phosphoric, or hydrochloric acid to enter the room. These fumes disintegrate the vegetable fiber and leave intact the animal—the two fibers can thus be separated and appropriated to their respective uses.

CLEANING ENGRAVINGS.

It very often happens that fine steel engravings get stained with moisture on the wall, or specked with mildew, and it becomes an important question how to bleach them. One of the best methods is to moisten them carefully and suspend them in a large vessel partially filled with ozone. The ozone bleaches them perfectly without attacking the fiber of the paper.

For the evolution of ozone the simplest way would be to clean pieces of phosphorus and place them, half covered with water, in the bottom of the jar in which the pictures are suspended. On a large scale, a Ruhmkorff coil and constant discharge of electricity would be preferable. It is somewhat surprising that this method of cleaning fibers has not been more generally applied.

INFLUENCE OF FORESTS UPON RAIN.

The London *Athenæum* contains another example of the influence of forests upon the quantity of rain. In several districts of Australia there is a perfect rage for cutting down timber, and where this devastation has been carried out, the quantity of water that falls in a year has greatly diminished; from 37 inches in 1863 it has decreased to 17 inches in 1868. In 1869, from January to July, comprising two of the wet months, there only fell 11 inches of rain.

In Victoria the want of water is becoming a serious question, and the Government has been compelled to appoint an inspector of forests intrusted with the duty of preserving the trees already existing, and to establish nurseries for young sprouts wherever admissible. By a judicious planting and preservation of forests it is anticipated that a decided improvement can be effected in the climate of the country.

The residents of New England, who permit the mountains to be stripped of their trees for the production of charcoal, would do well to consider at what a cost to the water power of the States, to the fertility of the farms, to the climate of the country, and to the health of the community, all this momentary gain is attained. While other governments are planting trees at great expense, they are cutting them down to obtain a few chaldrons of charcoal.

MORIN'S EXPERIMENTS UPON THE PUNCHING OF METALS.

General Morin, one of the ablest of French engineers, and who has given to the world one of the best treatises on mechanics extant, has been extending his investigations to the determination of the power expended in the punching of metals and plastic substances.

The results of a large number of experiments are given by him in a paper read before a recent session of the Academy of Sciences, Paris, which demonstrate that the same elements of resistance enter into the operation of punching as in that of shearing. In short, a punch and die may be considered as a shears with circular blades. The coefficient of pressure in punching, per any given area of section, will be exactly that for shearing the same area of section, without reference to the thickness of the material.

The measure of force, necessary to effect the various punchings easily gives the value of the resistance to shearing, in case of the ordinary metals. This resistance (per square meter) is determined to be, for

	Kil.
Lead	1,820,000
Block tin	2,090,000
Alloy of lead and tin	3,390,000
Zinc	9,000,000
Copper	18,930,000
Iron	37,570,000

It is difficult to give these figures in exact denominations of English measures and weights. A square meter is 1·196 square yards, nearly; and a kilogramme is, approximately, 2·205 lbs. avoirdupois.

THE GREAT UNION DEPOT ON FOURTH AVENUE, NEW YORK.

The contract for this enormous structure has been finally awarded to the Architectural Iron Works at the foot of Fourteenth street, New York. The depot is intended to accommodate the trains of the Harlem, Hudson River, and New York Central Railroads. For the latter a branch road will be built to connect with the Harlem, the trains being switched off in the neighborhood of Spuyten Duyvil. The car house will have accommodations for twelve single trains, while, if it be necessary, double or even treble that number can be accommodated.

Photographs of the plans and drawings were sent to Europe for bids, but it was found that American founderymen could more than compete with any bids received abroad.

The foundation of this immense structure, to be the largest of the kind on this continent, is well under way—in fact, nearly completed. The contract calls for the completion of the entire structure within eight months from its date. If not completed within the time specified, the contractor is to forfeit and have deducted from the contract price $500 a day for every day over; and if completed within the time specified, the contracter is to receive, in addition to the contract price, the sum of $200 for each day the work is so completed and accepted by the engineer.

The weight of iron to be used will be over 8,000,000 pounds. It will require 100,000 square feet of glass in the roof alone, and 90,000 square feet of galvanized corrugated iron to cover the roof. The roof over the car-house will extend over an area limited south and west by the office buildings, east by the Fourth avenue, and north by a line 30 feet 6 inches south of Forty-fifth street. The entire length of the roof will be 652 feet, and it will be 199 feet 2 inches in width between the walls, and supported by 32 arched trusses, placed 20 feet four inches apart. These great arches will be set upon the foundation, whose upper face is 2 feet below the surface of the ground, rising to an elevation of 94 feet from the springing line to the extrados of the arch.

The car-house is to be lighted through three skylights extending over the entire length of the roof—one on the center, double pitched, and two single ones on each side of the center. The rewill be seven courses of ventilators running the entire length of the roof, faced up with stationary sheet iron slats.