United States Patent Office.

BENJAMIN C. TILGHMAN, OF PHILADELPHIA, PENNSYLVANIA.

Letters Patent No. 108,408, dated October 18, 1870.

IMPROVEMENT IN CUTTING AND ENGRAVING STONE, METAL, GLASS, &c.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, BENJAMIN C. TILGHMAN, of Philadelphia, Pennsylvania, have invented an Improvement in Cutting, Grinding, and Engraving Stone, Metal, Glass, and other Hard Substances; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompany drawing.

My invention consists in cutting, boring, grinding, dressing, pulverizing, and engraving stone, metal, glass, wood, and other hard or solid substances, by means of a stream of sand or grains of quartz, or of other suitable material, artificially driven as projectiles rapidly against them by any suitable method of propulsion.

The means of propelling the sand which I prefer, is by a rapid jet or current of steam, air, water, or other suitable gaseous or liquid medium; but any direct propelling force may be used, as for example, the blows of the blades of a rapidly-revolving fan, or the centrifugal force of a revolving drum or tube, or any other suitable machine.

The greater the pressure of the jet, the higher will be the velocity imparted to the grains of sand, and the more rapid and powerful their cutting effect upon the solid substance.

At a high velocity of impact, the grains of sand will cut or wear away substances much harder than themselves; corundum can thus be cut with quartz, sand, and quartz-rock can be cut or worn away by small grains or shot of lead.

I have sometimes used iron-sand composed of small globules of cast-iron.

By the term sand in this specification, I mean small grains or particles of any hard substance of any degree of fineness, of which common quartz sand is a type.

The hardest steel, chilled cast-iron, or other metal, can be cut or ground by a rapidly-projected stream of quartz sand.

Articles of cast or wrought metal may have their surfaces thus smoothed and cleaned from slag, scale, or other incrustation.

The surfaces of wrought stone in buildings or elsewhere, can thus be cleaned and refreshed.

By means of stencil-plates, screens, or suitable covering, substances, letters, or designs, can thus be cut or engraved upon hard substances.

By varying the shape, number, and direction of the projected streams of sand, and by giving to them and to the articles treated, suitable movements by means of lathes, planing or drilling-machines, or other known mechanical devices, cuts or holes may be made of any shape or size.

When sand of a brittle nature, such as quartz or emery, is very rapidly projected against a hard material, the grains are broken by the shock into fine powder, and the process may thus be used as a method of pulverization.

Where a jet of water under heavy pressure is used, as in hydraulic mining, the addition of sand will cause it to cut away hard and close-grained substances upon which the water alone would have little or no effect.

Pebbles or stones of size and weight as great as can be rapidly projected by the jet of water used, will have a battering, penetrating, and dislocating effect, which will assist the disintegrating and scouring action of the water.

Heretofore, when sand has been used as a grinding or cutting material, it has been applied between solid substances, moved over each other under heavy pressure, so as to make a series of scratches, as in the ordinary cutting of stone and glass, or else in a solidified form, as in a grindstone or sand-paper, or sometimes in a semi-fluid state, as when a body is rubbed or moved in a mass of sand.

The peculiar feature of my invention, which distinguishes it from other methods of cutting and grinding, is that each grain of sand acts, by its own velocity and momentum, like a bullet or projectile, and pulverizes, cuts, or indents the object it strikes.

From this peculiarity of action, it results that some substances, which, though comparatively soft, are also tough, or malleable, or elastic, and not pulverizable by a blow, such as copper, lead, paper, wood, or caoutchouc for example, are less rapidly cut and ground by the sand-blast, particularly at moderate velocities, than some much harder substances which are brittle or pulverizable, such as stone, glass, or porcelain.

Another peculiarity of the sand-blast is that the grinding or cutting action takes place upon irregular surfaces, cavities, corners, and recesses hardly accessible to ordinary methods.

I believe that steam will generally be found the most convenient impelling jet, particularly for high velocities, but in some localities air or water may be cheaper.

I have used steam of all pressures, sometimes exceeding four hundred pounds per square inch, and have found its efficiency to increase rapidly with the pressure.

I believe that when it is desired to cut or grind hard substances rapidly, it will be advantageous to use steam of as high pressure as can practically be made available, but each operator can choose the pressure most convenient for his circumstances, and the kind of work he wishes to do.

The following is a method of carrying my invention into effect, taking for example the cutting of stone by means of quartz sand, projected by a jet of steam of about three hundred pounds pressure per square inch?

The sand is fed into a funnel, *a*, which is connected by a flexible tube and turning-joint, *b*, with an iron or steel tube, *c c*, of any convenient length, and of about $\frac{11}{100}$ of an inch bore, which I call the sand tube.

This tube is firmly secured exactly in the center of another iron or steel tube, *d d*, of about one-half inch bore, which I call the steam-tube.

The interval between the tubes is closed at one end, *e*.

At their other ends both tubes are brought to the same length, but the bore of the outer tube *d* is here contracted to a diameter of $\frac{28}{100}$ of an inch, for about one-quarter of an inch from its end, and about half an inch of the end of the inner tube *c* is reduced to a cylinder of $\frac{23}{100}$ of an inch external diameter, so as to leave between the ends of the tubes a smooth regular annular opening, *m m*, of about $\frac{25}{1000}$ of an inch in width, continuing of this size for about a quarter of an inch in length, and then enlarging gradually to the full diameter of the steam-tube

This annular opening *m m* forms the passage for the escape of the steam.

The steam-tube *d* is connected with the steam-boiler by the holes *f f*, the T-piece *g*, the stuffing-boxes *h h h*, and the jointed pipes *o o o*, so as to allow it to be rotated and moved in any direction.

An iron or steel tube, *i i*, which I call the nozzle-tube, about $\frac{35}{100}$ of an inch in bore and six inches long, is fastened on the end of the steam-tube.

The end of the sand tube *c* is accurately adjusted, and firmly fastened exactly in the center of the steam-tube *d*, so that the annular opening is everywhere of the same width, and the nozzle-tube is adjusted so that its axis or central line coincides perfectly with the axis of the steam jet issuing from the annular opening.

The perfect accuracy of these adjustments is important.

The bore of the nozzle-tube is adjusted, by trial, to the size and pressure of the steam jet, so as to produce the amount of suction desired in the sand tube.

For the sake of brevity, the stream of sand impelled by the jet of steam, air, &c., will herein be called "the sand-blast," and the system of tubes for producing it will be called "the blast-pipe."

The sand used should be sifted of even size, and should be clean, hard, sharp, and dry, so as to run regularly through a small hole without clogging.

I have found sand which will pass through a sieve of forty wires per inch, and not through one of forty-eight wires, to cut faster than sand which will pass through a sieve of twenty wires, and not through one of thirty wires to an inch.

The steam should be dry and free from condensed water. When used at a distance from the boiler, a steam-separator or purger should be used, such as is well known to engineers, and the pipes kept well wrapped.

The operation is as follows:

The steam is turned on, and issues with great velocity from the annular opening *m m*. This creates a suction and current of air in the sand-tube *c c*.

A sliding-valve in the bottom of the sand-box is now opened, and lets a stream of sand of from one to two pints per minute fall into the funnel *a*, whence it is carried by the current of air through the sand-tube, and is sucked into the jet of steam and driven by it through the nozzle-tube, acquiring a high velocity, and finally strikes against the stone to be cut, which is held about an inch distant from the end of the nozzle.

The shattered fragments of the sand and stone, partly in very fine powder, and the waste steam, escape sidewise and backward. A dull red light may be seen at the point of impact of the sand and stone.

If the sand-blast is kept directed steadily at the same spot, a hole will gradually be cut, the diameter of which at the surface is greater than that of the steam-jet, but which grows smaller and becomes conical as it penetrates deeper into the stone.

I have observed that this tendency to form a conical hole increases with the hardness of the substance operated on, and that it diminishes as the pressure and velocity of the blast is increased. To make a hole or cut with parallel sides, I have found that the blast should be slightly inclined toward each side alternately. The angle of inclination will vary with the hardness of the stone and the pressure of the jet used.

In cutting granite with a steam-jet of about three hundred pounds pressure per square inch, I have found an inclination of about one in nine to make a parallel cut. Operating on rather soft burnt brick with the same jet without inclination, the sides of the cut were almost parallel.

Sufficient space must always be allowed for the escape of the current of waste steam and sand, and, consequently, when a deep hole is to be cut, its diameter must be great enough to admit this escape around the blast-pipe when it is advanced to near the bottom of the hole.

In cutting holes, I have found it convenient to use a blast-pipe, bent at a point about two inches back of the annular jet to an angle of about one in nine, and to use a nozzle-tube only about two inches long.

The blast-pipe, being rotated and directed successively to all parts, a hole of any shape can be cut with parallel sides, or the sides may be undercut, so that the hole will be of greater diameter at the bottom than at the top. Chambers for blasting-powder may thus be made.

In cutting long, narrow grooves I have found it convenient to arrange parallel guide-plates of iron or steel, *n n*, about one and a half inch wide, and projecting about three inches from the end of the nozzle-tube, leaving between the plates a space about equal to the bore of the nozzle-tube. The effect of these plates is to prevent the sand-blast from diverging, and to make the edges and surface of the groove more even and regular.

In dressing stone so as to produce a flat surface, I have found it convenient to cut first a narrow groove about half an inch deep, and then to break or split off the overhanging edge, and then continue or deepen the groove and break off the new overhanging edge, and so on.

When the stone varies in hardness in different spots, the workman must keep the blast directed upon the hard spots until he sees that they are worn down to the desired level, and must pass it quickly over soft spots as soon as he sees they are sufficiently cut.

As most kinds of stone contain frequent alternations of hard and soft spots, constant care and attention must be given by the operator to obtain an even surface.

A sheet-iron guard or shield is arranged to protect the face and eyes of the workman from the rebounding sand, and a narrow slit in it enables him to watch and regulate the progress of the operation.

Suitable movements are to be given to the blast-pipe, or to the stone, or to both, by hand or by any suitable machinery, so as to produce the shape of cut desired.

If the axis of the nozzle-tube and guide-plates does not coincide accurately with that of the steam-jet, they will be rapidly cut away by the sand-blast.

If any obstruction from dirt or scale chokes up one side of the annular opening of the steam-jet, the sand-blast will be distorted sidewise, and will rapidly cut away the nozzle-tube.

I have found the above-described method of introducing the sand into the impelling-jet by means of the suction produced by the jet itself, to give good results, but it is to be understood that I do not confine myself thereto. I am aware that part of the pressure of the jet is thereby lost, but I think the practical convenience counterbalances this loss. I have sometimes used a strong close vessel to contain the sand, and introduced a current of the steam, air, or water, under pressure, above the sand, and then, by suitably regulating the cock on the pipe leading to the top of the close vessel, and the cock on the pipe leading to the impelling-jet, a current of the fluid can be made to pass through the close vessel, and carry with it any desired quantity of sand into the impelling-jet.

When steam is used in this manner, the close vessel must be kept hot enough to avoid the condensation of water among the sand, which would prevent its running through the pipes.

A current of air forced into the close sand-box, at a pressure greater than that of the steam employed, may also be used as a means of conveying the sand into the impelling steam-jet.

I have observed that the quantity of stone cut by a given sand-blast in a given time is much greater when ample space for free escape is afforded to the sand and steam after they have struck the stone, than when the space for escape is narrow and confined.

When a rapid lateral motion is given to the blast-pipe, or to the stone, so that the sand is constantly striking upon a fresh surface, a much greater cutting-effect is produced than when the blast is kept pointed at one spot.

In the latter case it appears that the sand and steam rebounding back from the stone interfere considerably with the fresh sand which is being projected toward the stone. This interfering effect is particularly evident when a hole is cut but little larger than the diameter of the sand-blast.

I have noticed that when a sand-blast is held at four or five inches distance from a stone, a greater quantity will be cut than when the same sand-blast is held at but one inch distance. Also, that when a sand-blast is directed at an angle of from thirty to forty-five degrees with the face of a stone, a greater quantity will be cut than when the same sand-blast, at the same distance, (one inch,) is directed at an angle of ninety degrees with the face of the stone. The divergence of the sand-blast spreading it over a wider surface of the stone, and also giving it more room to escape, and thus to avoid interference with the oncoming sand, appears to be the explanation in these cases.

But I have found that in cutting a narrow groove, more progress is made by keeping the blast-pipe directed square at the stone, and keeping the stone as close to the guide-plates as its shape will permit; for although the gross quantity of stone cut away may be less than at a greater distance, the effect is more concentrated and confined to the desired spot and direction.

The quantity of sand to be used with a given steam-jet may be considerably varied, according to the object desired. When a soft stone is to be cut, over a wide surface, so that a free sideway-escape can be given, a quantity of sand two or three times as great as above described may be used; but where a hard stone is to be cut in a narrow groove, a small feed of sand produces a better result.

For purposes where only a small quantity of material is to be cut or ground away from the surface of a hard substance, and where only a moderate velocity of the sand is required, I have found the current of air produced by the ordinary rotary fan to be convenient.

I have used this method for grinding or depolishing glass, china, or pottery, either on entire surfaces or on surfaces partially covered and protected so as to produce an engraving of letters, ornaments, or designs.

In engraving designs, air is more convenient than steam as an impelling jet, in this respect, that the sand keeps dry and rebounds, leaving the pattern clear, while with steam the sand becomes damp and is apt to adhere to and clog the fine lines and corners.

The sand, being fed into the fan, is carried along by the current of air in a tube or close trunk, and strikes upon the glass, which is held or moved opposite the mouth of the trunk, and cuts, grinds, or stars its surface.

One arrangement which I have found convenient for flat glass, is to cause the air-current from the fan to descend in a narrow vertical tube of a cross-section about three feet long by one inch wide, into the top of which the sand is evenly introduced by numerous small pipes, at the rate of about twenty cubic inches per minute for each square inch of cross-section. A traveling apron carries the sheets of glass gradually and regularly beneath the sand-blast, at about one inch distance.

The finer the sand used, and the less the pressure of the blast, the finer is the grain of the depolished surface. Also the finer the sand used, the more weak and delicate may be the texture of the covering substance used to produce the design. Good results have been obtained with designs cut in a layer of wax, and with paper or lace pressed close to the glass, and using sand which passed through a sieve of fifty wires per inch, and an air-blast of the pressure of about one inch of water. With sand reduced to very fine powder, and an air-blast of a pressure of eight or ten inches of water, a very delicate depolishing of the surface of glass has been produced.

Numerous processes are known and used in the arts for producing, painting, or transferring designs on surfaces; any of these processes by which a design can be produced or transferred in a sufficiently tough and resistant medium, may be used to prepare a surface for being engraved by the sand-blast.

Many natural objects, such as plants, leaves, insects, &c., which can be fastened flat upon a surface, have sufficient strength and resistance to a blast of fine sand to admit of their outline being thus engraved.

Glass colored by a thin stratum of colored glass on one surface, may be ornamented by designs cut or ground through its colored stratum.

Designs engraved by the sand-blast to a sufficient depth, either in relief or intaglio, on a smooth surface, slate or glass, for example, can be reproduced by known processes of printing.

When the sand-blast at moderate velocities is directed upon a metallic surface, it removes but little of the metal, but the grains of sand make innumerable small indentations of the surface, and produce a frosted, dull mat or dead appearance. By using suitable stencil-plates, or covering-substances, designs or devices can thus be engraved on metallic surfaces.

If desired, the sand may be propelled by a current of air produced by suction, or a partial vacuum made in any convenient manner, as by a fan or steam-jet, or any other known machine; or the sand may be impelled by a mixed current of steam and air, produced by a steam-jet in the ordinary manner.

I have produced some cutting and grinding effects by sand impelled by the force of gravity. A stream of sand fed into the top of a high vertical tube, at first falls slowly, but after the air in the tube is set in motion, the sand gradually falls more rapidly, and can finally acquire velocity sufficient to grind or depolish glass.

I have described above several arrangements for projecting the sand with the requisite velocity, but I do not mean to confine myself thereto. Any method or arrangement may be used by which sufficient velocity can be artificially given to the sand to enable it to cut or grind the object.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The cutting, boring, grinding, dressing, engrav-

ing, and pulverizing of stone, metal, glass, pottery, wood, and other hard or solid substances; by sand used as a projectile, when the requisite velocity has been artificially given to it by any suitable means.

2. The artificial combination of a jet or current of steam, air, water, or other suitable gaseous or liquid medium, with a stream of sand, as a means of giving velocity to the sand, when the sand is used as a projectile as a means of cutting, boring, grinding, dressing, engraving, and pulverizing stone, metal, glass, pottery, wood, and other hard or solid substances.

3. The combination of a rotary fan, centrifugal machines, and other machines capable of giving direct mechanical impulse, with a stream of sand, as a means of giving velocity thereto, when the sand is used as a projectile as a means of cutting, boring, grinding, dressing, engraving, and pulverizing stone, metal, glass, pottery, wood, and other hard or solid substances.

4. As a new manufacture, articles of stone, metal, glass, pottery, wood, and other hard or solid substances, which have been cut, bored, ground, dressed, engraved, or pulverized by sand used as a projectile, when the requisite velocity has been artificially given to the sand by any suitable means.

5. As a new manufacture, articles of stone, metal, glass, pottery wood, and other hard or solid substances, which have been cut, bored, ground, dressed, engraved, or pulverized, by sand used as a projectile, to which the requisite velocity has been artificially given by a jet or current of steam, air, water, or other suitable gaseous or liquid medium.

6. As a new manufacture, articles of stone, metal, glass, pottery, wood, and other hard or solid substances, which have been cut, bored, ground, dressed, engraved, or pulverized, by sand used as a projectile, to which the requisite velocity has been given by a rotary fan, centrifugal machine, or other machine capable of giving direct mechanical impulse.

7. When a jet or current of steam, air, water, or any other suitable gaseous or liquid medium is employed to give velocity to sand used as a projectile, as a means of cutting, boring, grinding, dressing, engraving, or pulverizing stone, metal, glass, pottery, wood, and other hard or solid substances, the use of the following devices for introducing the sand into the jet of steam, air, water, &c.: First, The suction produced by the jet of steam, air, water, &c.; Second, A strong, close vessel, or sand-box, into which the pressure of the steam, air, water, &c., is introduced, and through which, when desired, a current of it may be made to pass.

B. C. TILGHMAN.

Witnesses:

R. A. TILGHMAN,
W. M. TILGHMAN.

B. C. TILGHMAN.

Engraving Machine.

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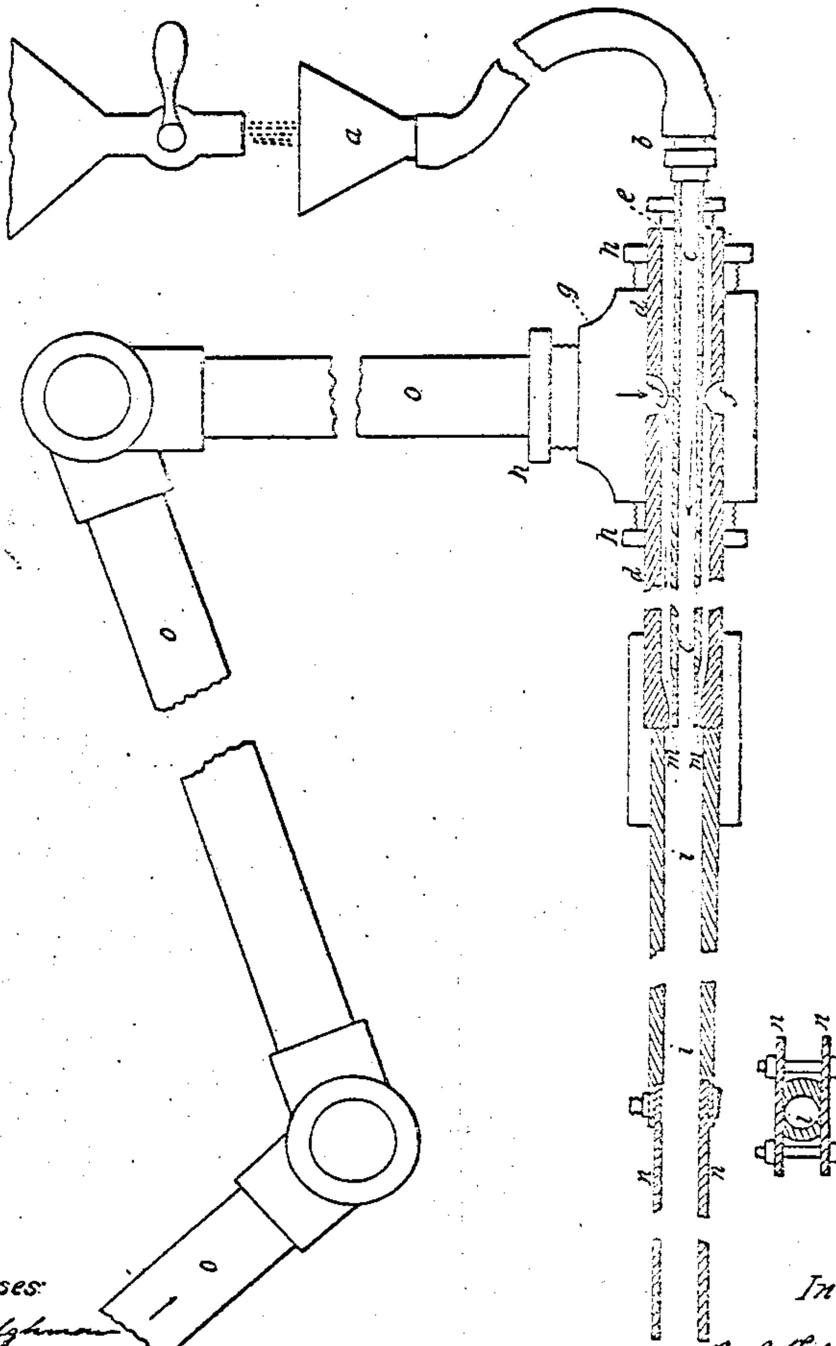

Witnesses:

R. A. Tilghman

W. M. Tilghman

Inventor:

B. C. Tilghman