June 13, 1939. F. J. HOHNHORST 2,162,013

ABRADING WHEEL

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Fig. 1.

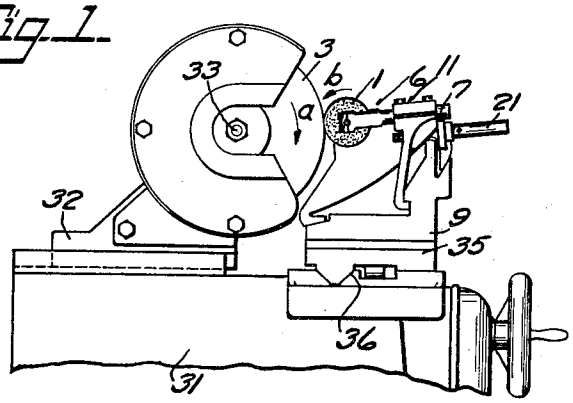


Fig. 3.

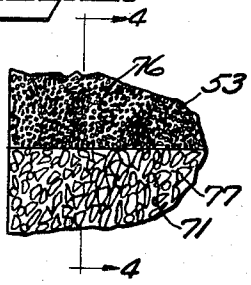


Fig. 4.

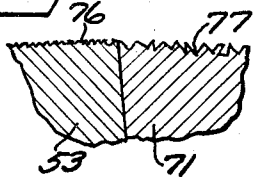


Fig. 2.

INVENTOR:
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by W. D. Belcher
His Attorney.

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ABRADING WHEEL

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Fig. 5.

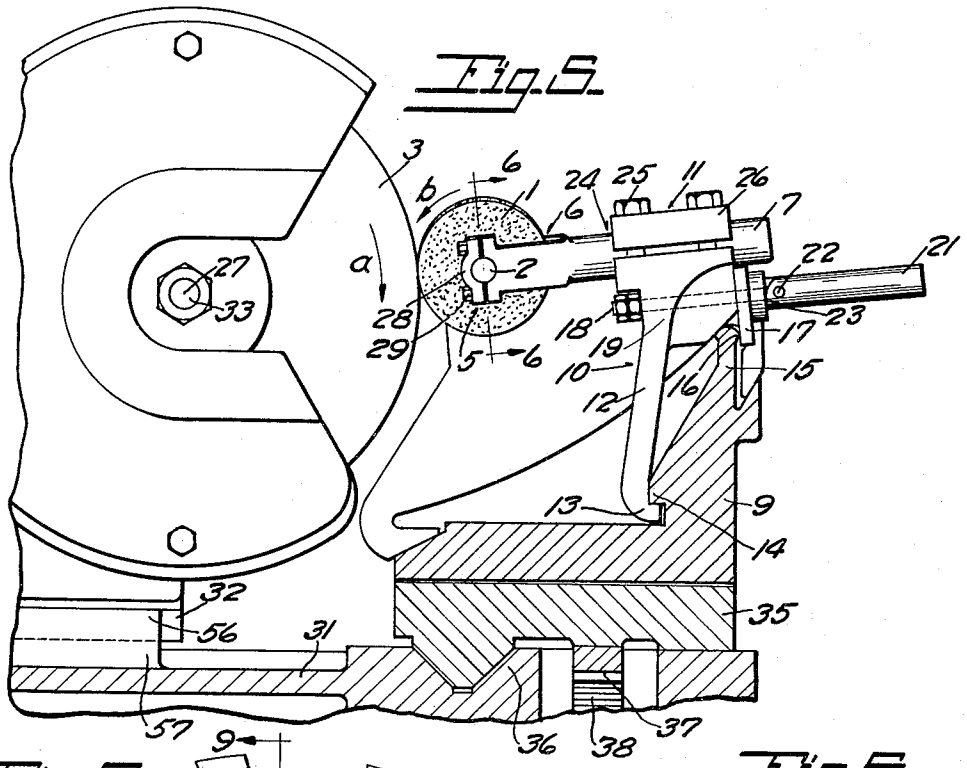


Fig. 7.

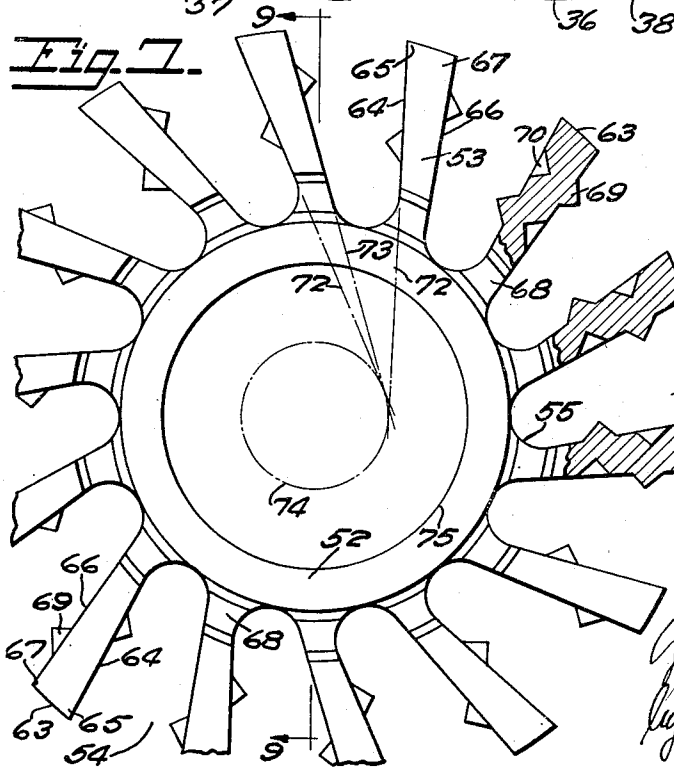
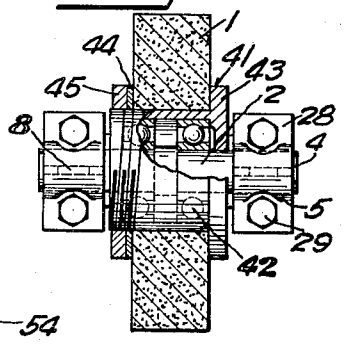


Fig. 6.



INVENTOR:
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His Attorney.

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ABRADING WHEEL

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Fig. 8.

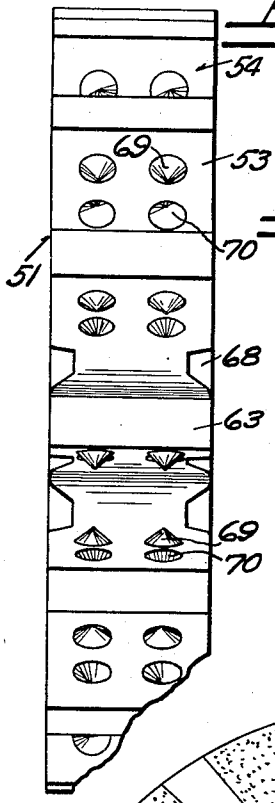


Fig. 9.

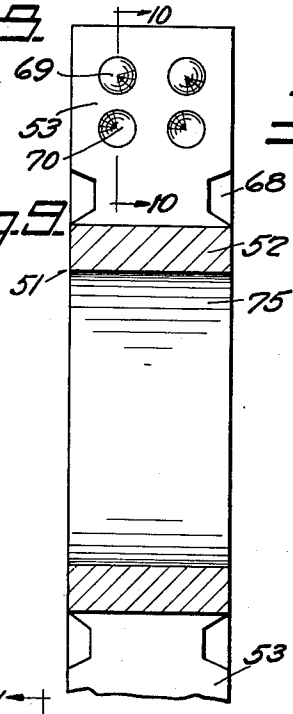
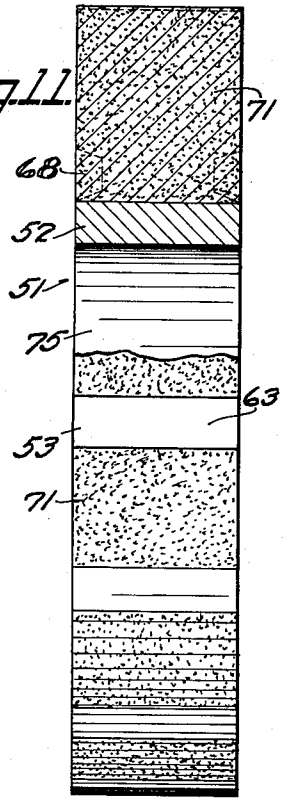


Fig. 11.



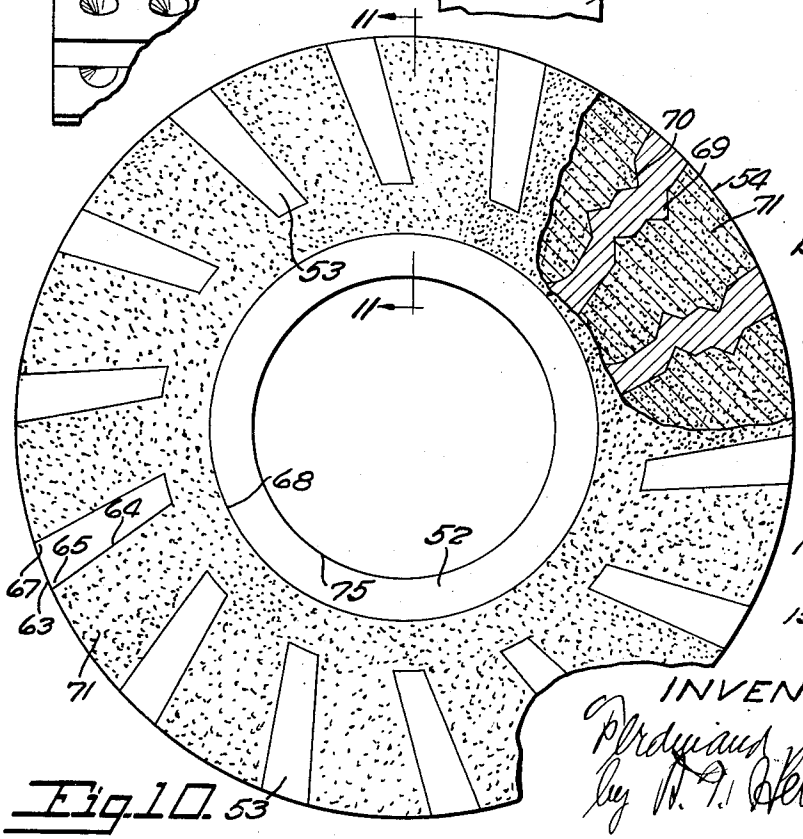
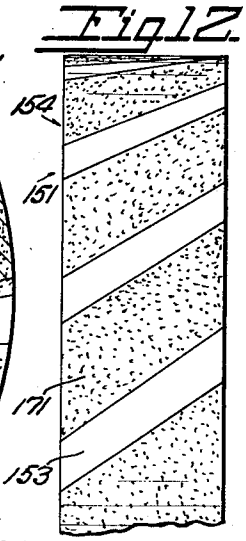


Fig. 10.

Fig. 12.



INVENTOR.

Frederick J. Hohnhorst,

by W. P. Blackstock his Attorney.

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Fig. 13.

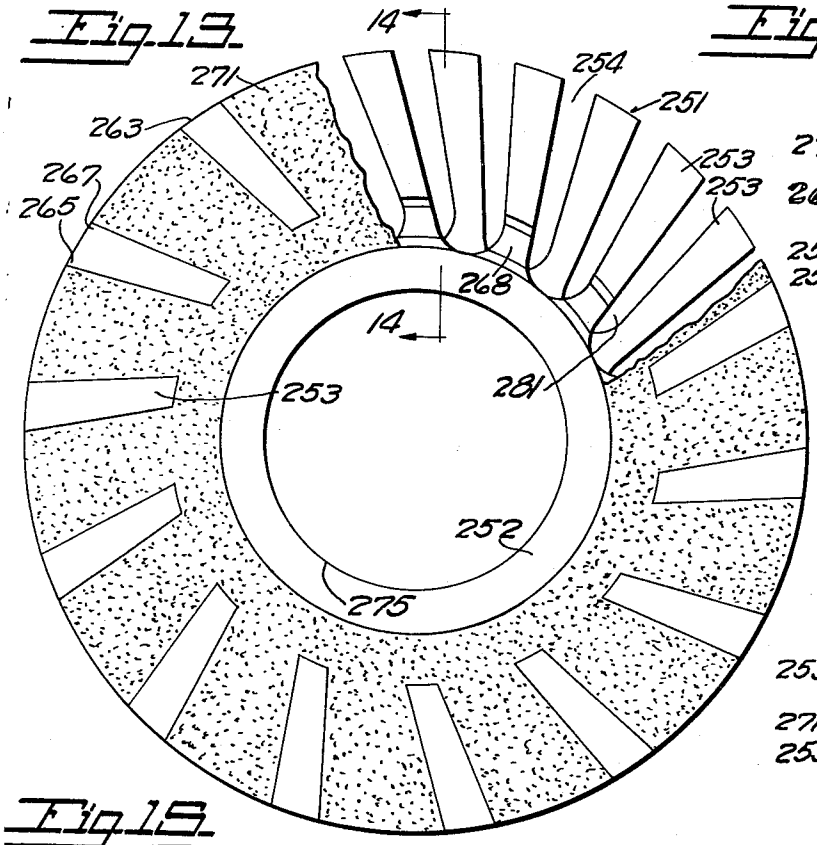


Fig. 14.

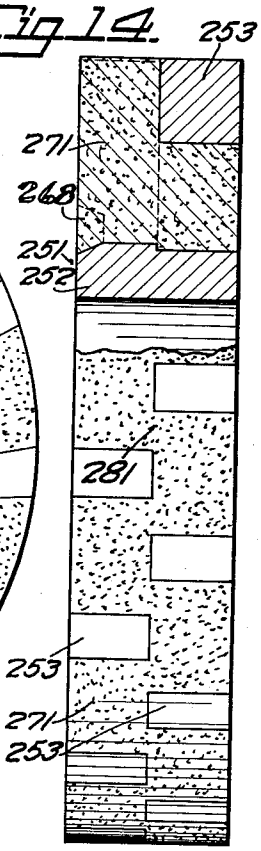


Fig. 15.

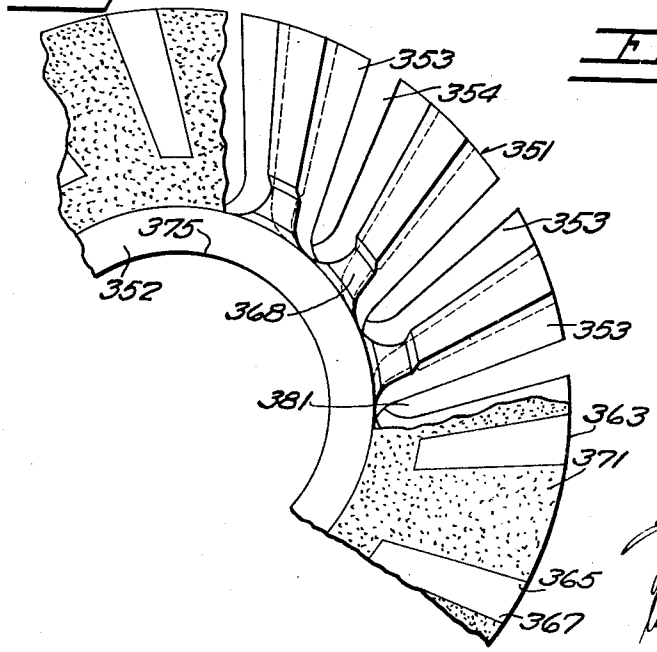
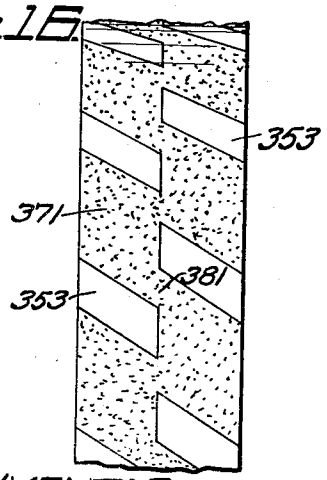


Fig. 16.



INVENTOR:

Virginius J. Hohnhorst,

by H. T. Hohnhorst, His Attorney.

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ABRADING WHEEL

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Fig. 17.

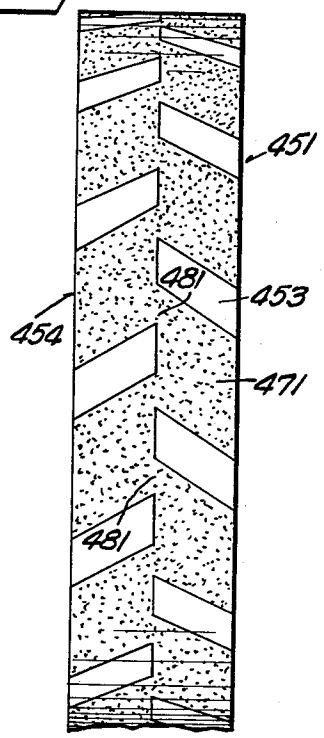


Fig. 18.

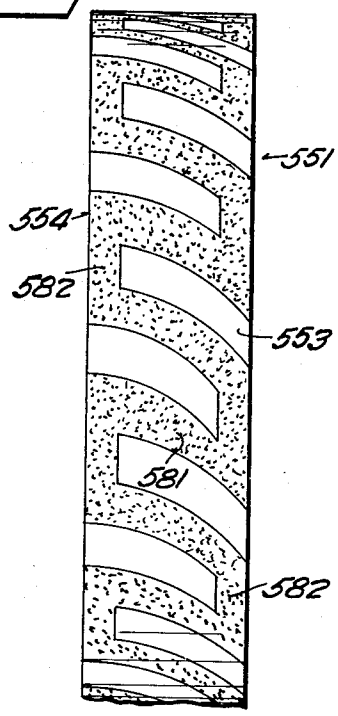


Fig. 19.

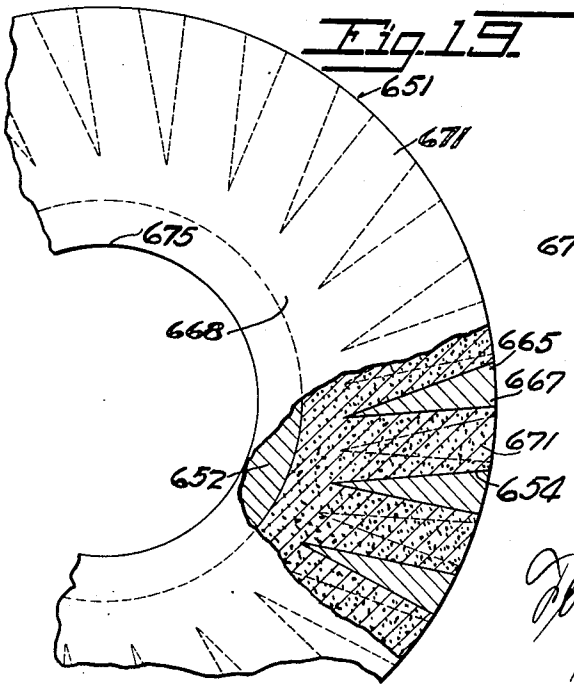
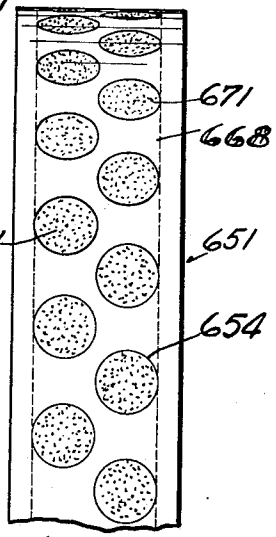


Fig. 20.



INVENTOR:
Ferdinand J. Hohnhorst,
by W. P. Ebersole, His Attorney.

Patented June 13, 1939 2,162,013

UNITED STATES PATENT OFFICE

2,162,013

ABRADING WHEEL

Ferdinand J. Hohnhorst, Covington, Ky.

Application February 5, 1938, Serial No. 188,871

10 Claims. (Cl. 51—206)

My invention relates to abrading wheels employable for truing and dressing grinding wheels used in grinding or polishing surfaces of metal and other substances in precision grinding.

It is the object of my invention to provide a new and improved abrading wheel to true, clean and dress the grinding surface of the grinding wheel by bringing the grinding surface into its true grinding plane for effective action on the work by removing the foreign substances which have accumulated in the pores and interstices in the grinding surface during the grinding operation; by exposing fresh grains in the grinding surface; and by sharpening the grains exposed at the grinding surface; further, to provide novel means in an abrading wheel whereby a plurality of truing and dressing effects, which are complemental to each other, are imparted in alternation to the grinding wheel, during coactive rotations between the abrading wheel and the grinding wheel; further, to provide a novel abrading wheel which imparts different truing and dressing effects in novel manner upon the grinding surface of the grinding wheel by reversals of rotation of the abrading wheel; and, further, to provide novel means whereby truing and dressing of the grinding wheel is speedily accomplished and an accurate, clean and sharp grinding surface is quickly applied to the grinding wheel.

My invention consists in providing novel means for accomplishing the various objects stated; further, in providing an abrading wheel with arms having spaces therebetween in novel relation and filled with abrading composition; further, in providing an abrading wheel including a foundation or spider provided with an abrading face and having a fly-wheel effect upon the abrading wheel; further, in providing a novel abrading wheel including a substantially heavy foundation or spider provided with spaces opening at the abrading face of the wheel and having a higher melting point than the fixing point of abrading composition in said spaces; and, further, in providing an abrading wheel including a spider having a hub and arms effectively connected with said hub and extending tangentially in the abrading wheel.

My invention consists, further, in providing a novel abrading wheel comprising a spider having outwardly extending arms having a higher melting point, and abrading composition therebetween having a fixing point of lower temperature and connected across said arms for forming an integral body of abrading composition annularly connected throughout the body of the abrading wheel; and, further, in providing an abrading wheel with a hub and arms rigid therewith which increase in thickness toward the outer periphery of the wheel in order to provide spaces between said arms for bodies of the abrading composition and to maintain a uniform proportion between said bodies of abrading composition and said arms throughout cylindrical planes of different diameters in said abrading wheel, in order to maintain the proportion of arms and bodies of abrading composition acting upon the grinding wheel throughout the various diameters to which the abrading wheel may be worn.

My invention will be further readily understood from the following description and claims, and from the drawings, in which latter:

Fig. 1 is an end elevation of an exemplifying grinding machine, partly in vertical section, and partly broken away, having my improved device mounted therein operative relation to the grinding wheel.

Fig. 2 is a plan view of the same, partly broken away.

Fig. 3 is a heroic enlargement of a detail showing a plan view of a portion of my improved abrading wheel.

Fig. 4 is a cross-section of the same, taken on the line 4—4 of Fig. 3.

Fig. 5 is a vertical section of the exemplifying grinding machine, taken on the line 5—5 of Fig. 2, and partly broken away, showing an exemplifying fixture for the abrading wheel.

Fig. 6 is an end elevation of the mounting for the abrading wheel, partly in section, on the line 6—6 of Fig. 5, and partly broken away.

Fig. 7 is a side elevation of the foundation or spider of my improved abrading wheel in preferred form partly in section.

Fig. 8 is an edge elevation of the same, partly broken away.

Fig. 9 is a longitudinal section of the same, taken on the line 9—9 of Fig. 7, and partly broken away.

Fig. 10 is a side elevation of my improved abrading wheel in its preferred form, partly in section on a line corresponding to the line 10—10 of Fig. 9, and partly broken away.

Fig. 11 is an edge elevation of the same, partly in section on the line 11—11 of Fig. 10, and partly broken away.

Fig. 12 is an edge elevation, showing a modification of my improved device, partly broken away.

Fig. 13 is a side elevation, showing a further

modification of my improved device, having the abrading composition partially removed to expose the spider, and partly broken away.

Fig. 14 is an edge view of the same, partly in section on a line corresponding to the line 14—14 of Fig. 13, and partly broken away.

Fig. 15 is a side elevation of a further modification of my improved device, having the abrading composition partially removed to expose the spider, and partly broken away.

Fig. 16 is an edge elevation of the same, partly broken away.

Fig. 17 is an edge elevation, showing another example of my improved device, partly broken away.

Fig. 18 is an edge elevation of an additional example of my improved device, partly broken away.

Fig. 19 is a side elevation of another example embodying some of the features of my improved device, partly in section and partly broken away; and,

Fig. 20 is an edge view of the same, partly broken away.

The abrading wheel of my invention in its preferred form is exemplified in Figs. 1 to 11 inclusive. Figs. 1, 2, 5 and 6 include a mounting for the abrading wheel similar to that shown in Letters Patent of the United States No. 1,715,835 and No. 1,803,062, to myself and Ferdinand J. Kroeger, for Mechanism for truing and dressing grinding wheels, dated respectively June 4, 1929, and April 28, 1931. It is, of course, obvious that the abrading wheel may be mounted otherwise, and it is also within the contemplation of my invention that the abrading wheel may be presented with its axis parallel with or at an angle to the axis of rotation of the grinding wheel with which it coacts.

In the exemplification stated the abrading wheel, shown at 1, is rotatable about a stub, shaft or axle, exemplified as an axle 2, as exemplified in the aforesaid patents, or in other suitable manner. For the purposes of the present invention the abrading wheel is preferably so mounted that it may be presented to the grinding wheel 3 so as to rotate in one direction or the opposite direction for purposes hereinafter described. In the exemplification stated the axle 2 has ends 4, suitably fixed in clamp bearings 5 of a head 6, shown as a fork on a shank 7. The axle may be held by a key 8 to prevent its rotation.

The shank 7 is arranged to be secured to a table 9 of the grinding machine, as by being received in a clamp 10, from the head 11 of which an arm 12 extends, the arm having a jaw 13 coacting with a guide 14 on the table. The table is provided with a rail 15, and the rail is provided with a clamping face 16. A clamp plate 17 is loosely connected with the head.

An adjustable stem 18 is located in a bearing 19 in the head, a handle 21 being pivoted to the outer end of the stem by a pin 22. The handle has a cam face 23, which acts on the clamp plate 17 for clamping the rail 15 between the clamping parts 13, 17 at desirable positions along the rail.

The head 11 has a clamp bearing 24 to hold the stem 7 in rigid position after it has been clamped. The stem may be released sufficiently to permit it to be adjusted lengthwise in its bearing and to be turned in its bearing by unscrewing the bolts 25 in the cap 26 of said bearing, threaded into the body of said bearing, so as to present the abrading wheel 1 with its axle parallel with the axis 27 of the grinding wheel, or at a desirable angle thereto, or for turning said stem half way around in said bearing for presenting either side of the abrading wheel 1 uppermost, so as to cause its rotation in respectively opposite directions for purposes hereinafter described. The cap 26 may be again clamped upon the stem 7 when the abrading wheel 1 is properly presented toward the grinding wheel.

The direction of rotation of the abrading wheel may also be reversed by reversing its position end for end in the bearings 5. This latter may be accomplished by releasing the caps 28 of the bearings as by unscrewing the bolts 29 from the bodies of said bearings, and reversing the axle 2 end for end in the bearings, whereupon said axle is again clamped in said bearings by reclamping the caps by means of said bolts.

Grinding wheels during operation become impregnated with particles of dirt and metal from the work being operated on, and become comparatively glossy, and thereby lose their grinding effect, their granular structures also becoming dull at the grinding face, thereby reducing their grinding or polishing properties.

It is essential in precision grinding that the grinding wheel shall be maintained in true cylindrical form, and that its grinding face shall be dressed in accordance with the duty it is to perform as, for instance, for rough grinding, semi-rough or commercial grinding, for fine grinding, for polishing, and for grindings of different stages of fineness or roughness. It is furthermore desirable that frequent truings and dressings of the grinding wheel shall be made so as to maintain uniform accuracy in the work, and it is among the objects of my invention to provide ready and convenient means whereby these desiderata may be readily and quickly obtained.

The grinding machine may be of any desired kind, and is exemplified as comprising a frame 31, on which there is a slide 32 adjustable in suitable manner on the frame, and supporting a grinding wheel 3 on an axle 33 in suitable bearings 34 on the slide.

A saddle 35 is slidable on guideways 36 on the frame, and supports the table 9, and is operable by means of a rack 37 with which a pinion 38, suitably driven, meshes, for providing suitable endwise feed in reverse directions between the work, usually supported between centers 39, 40 on the table and suitably rotated, or the abrading wheel 1, and the grinding wheel 3, although this endwise feed may be obtained by endwise movement of the grinding wheel with relation to the work, or the abrading wheel, as explained in Letters Patent of the United States No. 1,544,985, granted to me and Ferdinand J. Kroeger, July 7, 1925, for Mechanism for truing and dressing grinding wheels.

In the present exemplification the abrading wheel 1 is shown mounted on the axle 2 by being secured to a shell 41 rotatable about the axle on ball bearings 42, for instance, in manner more particularly shown and described in the aforesaid Patent No. 1,803,062, whereby the abrading wheel is rotatable about and held endwise with relation to said axle. The abrading wheel is clamped to the shell between an annular flange 43 on said shell at one end thereof and a collar 44 and nut 45 at the other end thereof, the nut being threaded to this other end of said shell.

The abrading wheel is preferably much harder than the grinding wheel and of smaller diameter than the diameter of the grinding wheel on which it operates. Rotation is imparted to the grinding

wheel, for instance, in the direction of the arrow *a* by suitable power means, while rotation is imparted to the abrading wheel by its contact with the grinding wheel, the direction of rotation of the abrading wheel being indicated by the arrow *b*. In the exemplification stated, the upper surface of the abrading wheel rotates toward the grinding wheel. If the abrading wheel be reversed, the respective upper and lower surfaces of the abrading wheel will also be reversed and the abrading wheel will rotate in the opposite direction. Rotation of the grinding wheel continues in the same direction in usual practice.

The abrading wheel in its preferred form comprises a foundation **51** which may also be termed a spider. It comprises a hub **52**, and arms **53**, having spaces **54** between them. This spider is preferably an integral structure made of heavy material, and may be exemplified as of cast iron, and as imparting a fly-wheel effect to the abrading wheel, so that rotation of the abrading wheel will be maintained with force and for a considerable length of time after its contact with the rotating grinding wheel is interrupted, so as to maintain rotation of the abrading wheel preferably with abrasive force until contact is again made between the abrading wheel and the grinding wheel. The arms have substantial connections, as **55**, with the hub, being shown as firmly filleted to said hub, and forming an integral structure therewith.

The force of such contact between the abrading wheel and the grinding wheel is adjusted by suitable means, whereby relative approach or recession is obtained between the grinding wheel and the abrading wheel. For example, the slide **32**, on which the grinding wheel is mounted, may be adjusted toward and from the work supporting table 9 on suitable guides **56** on a support **57**, the guides extending crosswise of the machine. The slide is adjustable in a direction perpendicular to the axis of rotation of the grinding wheel by means of an adjusting screw **58** journaled in bearings **59** on the support **31**, and having threaded connection in a nut **60** fixed to the slide. The slide is suitably clamped in adjusted position by a clamp **61** after adjustment. The screw **58** is rotatable by means of a hand wheel **62**. Such a device is more fully shown and described in Letters Patent No. 1,395,391, granted on the application of Edward R. Conners, for a Device for truing and dressing grinding wheels, and dated November 1, 1921.

The portion of the foundation or spider in which the spaces **54** are located increases in bulk toward its outer periphery so as to enhance the fly-wheel effect of the same. Means are also thus provided whereby the proportions in area between the foundation and the spaces therein are maintained at the outer periphery of the wheel, that is, in the plane of its abrading face, throughout the wear of the wheel. Thus the arms **53** increase in thickness from their inner ends toward their outer ends, at which latter the abrading faces **63** of said arms are located. The side wall **64** at one side of the arm and the outer abrading face **63** of the arm form an acute angle **65** with each other to form a cutting edge or toe, or an undercut throat clearance at one side of the arm, and the other wall **66** and said outer peripheral abrading face form an obtuse angle **67** with each other to form a smoothing heel or drag at the latter angle.

Annular recesses **68** are provided at the bases of the arms. These recesses or grooves preferably connect with the spaces between the arms and extend partway across the arms and around the end of the hub.

The side walls of the arms may also be provided with irregular faces shown as protuberances or lugs **69** at one side of the arms and as recesses **70** at the other side of the arms, these lugs and these recesses preferably being opposite each other to maintain the selected increasing thickness of the arms outwardly.

Bodies **71** of abrading composition are located in the spaces between the arms and preferably extend into the recesses at the bases of the arms and in the side faces of the arms and about the lugs on the arms, preferably to form a homogeneous mass, filling all the recesses and spaces and receiving all the lugs in the foundation or spider for forming a composite abrading wheel with said spider. The bodies of abrading composition between the walls are thus firmly held in said spaces between the walls and are also connected with each other throughout the abrading wheel.

This abrading composition is preferably a mixture of grains of carborundum, emery or other abrading substance with a suitable binder or bond connecting the same and preferably having adhesive properties with the material composing the foundation or spider. The grains and the bond are such as to be most adaptable for the character of abrading which is to be performed by the abrading wheel. The grains may be coarser or finer, harder or softer, and the bond may be of such character or be fixed to have greater or less abrading effect, according to the duty which the abrading wheel is to perform, and the bond may be such as to intimately hold the grains together and to the foundation or spider. It may harden by evaporation, preferably in the presence of heat.

The abrading composition is preferably applied to the foundation or spider while plastic, as in a suitable mold, to give to the abrading wheel its desired form, being shown as a cylinder. It may be of suitable thickness. It is permitted to harden sufficiently for convenient handling, and the combined foundation or spider and the plastic material, after suitable hardening and evaporation of the latter, is placed in a suitable kiln, and there subjected to heat of degrees of temperatures and durations dependent on the character of bond and of the hardness of the composition desired in the finished wheel in order to fix the abrading composition. Such heat is less than the critical temperature of the material of which the foundation or spider is composed. The heated abrading wheel is permitted to slowly cool, as in a heat controlled chamber or leer, or prevent warping and to maintain rigid connection between all parts of the wheel.

Thus the spider may be composed of cast iron which melts at a temperature of about 2000 degrees Fahrenheit to approximately 2700 degrees Fahrenheit. A silicate bond may be used in the abrading material which melts in a range of about 250 to 300 degrees Fahrenheit and in its melted or fused state unites with the abrading grains and the surface of the foundation or spider. A vitreous bond which melts at a low heat, for instance, 1000 degrees Fahrenheit, or other bond which melts or fuses at a lower heat than the melting point or critical temperature of the foundation or spider, may also be employed. The foundation or spider remains in its original form, state and condition, and having its original prop-

erties, unaffected by the heat and fixing of the abrading composition.

The arms are exemplified as slanting in similar directions about the axis of the wheel, being exemplified specifically as extending tangentially from the hub. The arms preferably contract in thickness toward their inner ends, for instance, by locating the respective sides of the walls in planes represented by the dotted lines 72, 73, which converge toward their inner ends, and both of which are tangents to a circle within the hub of the wheel, for instance, by being tangent to a circle 74 within the hub of the abrading wheel.

As an exemplifying proportion, it may be stated that the foundation or spider is six inches in diameter, its hub is three inches in diameter, and that the arms including their filleted ends are one and a half inches long. The annular recesses or grooves 68 are three-eighths inch wide at their outer ends, these recesses or grooves extending across the inner or filleted ends of the arms, leaving the effective lengths of the arms outside said recesses or grooves one and one-eighth inches. The bore 75 in the hub is of such diameter, for example, two and three-eighths inches, as to fit the axle or sleeve to which the abrading wheel is to be secured. The outer ends of the arms may be three-eighths inch thick in angular distance and the inner ends of their effective lengths for proportional wear purposes, at the outer margins of the recesses or grooves 68, may be one-fourth inch thick in angular distance. The spider may be provided with fourteen of such arms. The spaces 54 may be fifteen-sixteenths inch in angular width at their outer peripheral ends and five-eighths inch wide in angular distance at the outer margins of the recesses or grooves 68, that is, at the inner ends of the effective lengths of the arms. The ratio between the outer peripheral or abrading surfaces at the outer ends of the arms and the outer ends of the bodies 71 of abrading composition in the spaces 54 may therefore be in the proportion of one to two and a half, throughout the decreasing sizes of the abrading wheel and the effective length of the arms due to wear. The spaces 54 are, similarly to the arms 53, exemplified as slanting in similar directions about the axis of the wheel, and are exemplified specifically as extending tangentially about the hub. The abrading wheel may of course be worn to still smaller diameters to include the abrasive composition in the recesses or grooves 68. These dimensions and proportions are given as illustrations and not as limitations, and these proportions and relations may be dispensed with within the scope of appended claims.

My improved device performs both a truing and a dressing operation upon the grinding wheel. In order to do perfect grinding upon the work, the grinding wheel must be perfectly round, and in a grinding wheel performing work during which there is lengthwise feeding movement between the grinding wheel and the work, the grinding face of the grinding wheel must be a true cylinder, and the grains in its grinding face must be sharp, and the grinding face clear of obstructing and deleterious substances.

The abrading wheel is harder than the grinding wheel, and its abrading grains are bound together more securely than are the grinding grains in the grinding wheel so as to have an abrading effect upon the grinding wheel, and to sharpen and clear the grinding face of the latter.

When performing a rapid truing operation or rough dressing operation upon the grinding wheel, my improved abrading wheel is rotated with the cutting edges 65 or throat clearances of its abrading arms moving toward the grinding wheel in advance of the abrading faces 63 on the outer ends of said respective arms and of the heels 67 of said respective arms, whereby the acute angles of the cutting edges of the abrading arms are presented to the grinding wheel in advance of the outer abrading portions thereof for cutting into the grinding wheel, especially at any high portions of the grinding surface of the same, and thereby quickly reducing the grinding surface of the grinding wheel to a true cylinder. Each of these cutting edges is followed by the outer abrading face of the spider, in turn followed by the smoothing action of the heel, and in turn followed by the abrading action of the body of abrading composition, these steps being repeated in rapid sequence of action upon the grinding wheel for quickly reducing the grinding wheel to true cylindrical form and clearing the grinding face, producing a duplex action upon the grinding wheel.

In order to obtain a finer finish of the grinding face of the grinding wheel, the abrading wheel is reversed in position so as to present the less abruptly cutting or smoothing heels of the abrading arms to the grinding wheel in advance of the outer abrading faces of the arms and the toes thereof, followed by the abrading faces of the bodies of abrading composition. This has the effect of producing a finer, smoother finish upon the grinding surface of the grinding wheel to impart a finer finish or polish or lapping effect upon the work.

My improved abrading wheel will perform truing action upon the grinding wheel during either direction of rotation of the abrading wheel and will at the same time also dress or clean and sharpen the grinding surface of the grinding wheel. The more rapid action and rougher finish is obtained within a given time by presenting the throat clearance or cutting edges 65 toward the grinding wheel than by presenting the drag or heel ends 67 toward the grinding wheel.

These actions of my improved device upon the grinding wheel have been demonstrated in practice, and it is assumed that centrifugal action upon the tangentially projected arms of the rapidly revolving abrading wheel has a tendency to project said arms slightly toward radial positions to expose their cutting edges toward the grinding wheel when the abrading wheel is rotated with its cutting edges presented forwardly when truing or rough dressing the grinding wheel, and that when the abrading wheel is reversed so as to present the heel edges of the abrading arms toward the grinding wheel, the obtuse angles of said heel edges have a dragging or smoothing effect upon the grinding surface of the grinding wheel for providing said grinding wheel with a finer finish.

Furthermore, the outer abrading faces or areas of the arms of a material such as cast iron, are provided with closely associated slight pores or interstices as at 76 in Figs. 3 and 4, which have a clearing and sharpening effect upon the grinding surface of the grinding wheel. The action of each of the arms upon the grinding wheel is followed by the action thereon of the following body of abrading material, which has more widely separated larger pores or interstices, as at 77 in Figs. 3 and 4, in its abrading area, and which is a substantially lighter and less resistant material than the material of which the arms are

composed, and has a greater tendency to yield to pressure between the grinding wheel and the abrading wheel than have the heavier, stronger and denser arms of the foundation or spider, and produce a sharpening effect upon the grains of the grinding wheel, and a clearing effect to clear the surface of the grinding wheel of any particles of the material taken up thereby during the grinding operation.

The outer ends of the walls of the finer and closer pores in the abrading surfaces of the outer ends of the arms form closely associated cutting edges which act mainly to sharpen and clear the smaller grains of the grinding wheel and the smaller films of bond between the grains, and the outer ends of the walls of the coarser and more greatly spaced pores in the abrading surfaces in the outer ends of the bodies of abrading composition form more widely separated cutting edges which act mainly to sharpen and clear larger grains of the grinding wheel and the larger films of bond between the grain, acting in sequence to provide the grinding wheel with an even grinding surface.

The bodies of abrading composition further act as cushions upon the grinding wheel to cushion the harder blows of the arms, and to aid in rendering the cutting edges of the arms effective, and to equalize the abrading action of the abrading faces of said bodies and said foundation or spider upon the grinding wheel to produce a rapid, effective and uniform truing and dressing of the same.

The rapid successive operations of the grinding areas of the heavier foundation or spider, and the grinding areas of the bodies of the abrading composition produce a remarkable and rapid truing and clearing and sharpening of the grinding surface of the grinding wheel.

Extreme intimacy of action of the various abrading edges and abrading areas of the foundation or spider and the bodies of abrading composition are obtained by making the foundation or spider of substantially heavier material than the material of the bodies of abrading composition per cubic unit to produce a fly-wheel effect in the plane of the abrading wheel. As an example, it may be stated that a cylinder of cast iron which is six inches in diameter and has a hole two and five-eighths inches in diameter, and is one and one-fourth inches long, weighs one hundred and ten ounces, and a cylinder of similar size of fixed abrading composition weighs thirty-six and three-quarter ounces. Such cylinder of cast iron weighs substantially three times as much as a similar cylinder of the abrading composition.

As a further example, the spider exemplified, made of cast iron, weighs forty-eight ounces, and the abrading composition therein weighs nineteen and one-half ounces, and the same spider, having the fixed abrading composition therein as a completed abrading wheel, weighs sixty-seven and one-half ounces. Thus the spider weighs substantially two and a half times as much as the fixed abrading composition in the example stated, producing a decided fly-wheel effect in the midst of the abrading wheel upon the abrading wheel when rotating in contact with the grinding wheel.

The abrading wheel may be presented to the grinding wheel with its axis parallel with the axis of the grinding wheel or at an angle thereto, thereby presenting the outer ends of the arms in similar directions to the outer peripheral grinding face of the grinding wheel if such arms are parallel with the axis of rotation of the abrading wheel. If an abrading wheel with arms extending parallel with its axis is presented at an angle to the grinding wheel, such angle in practice does not exceed seven degrees so as not to impart too great a side thrust to the abrading wheel. The greater such angle the coarser will be the abrasive action and resultant finish of the grinding surface of the grinding wheel.

Such arms may however be formed to extend in angular directions in the abrading wheel, as exemplified in Fig. 12. In this exemplification the arms have an angle of thirty-six degrees to the axis of the abrading wheel, for especially coarse work, but the angle may be much less for finer work. Abrading wheels having arms extending at an angle to the axis of the abrading wheel are usually presented to the grinding wheel in a plane parallel with the plane of the grinding wheel.

The angle of presentation of the abrading wheel to the grinding wheel and the angle at which the arms are located in the abrading wheel cause greater or less abrading effect upon the grinding wheel. The greater the angle of presentation of the abrading wheel and its arms to the grinding wheel the coarser will be the abrading effect.

Exemplifying the speed of rotation of the exemplified abrading wheel during its coaction with the grinding wheel, it may be stated that a proper speed of rotation for a grinding wheel twenty inches in diameter is approximately between nine hundred and fifty and eleven hundred and fifty revolutions per minute, so that an abrading wheel coacting therewith and rotated by surface contact of its outer peripheral abrading face with the grinding face of the grinding wheel and having a diameter of six inches, will rotate approximately between three thousand and thirty-nine hundred revolutions per minute, and that such rotations of the abrading wheel, due to the presence in its midst of the comparatively heavy foundation or spider, will be with great force to produce effective abrasion of the grinding surface of the grinding wheel, and that such speeds of rotation of the abrading wheel will be maintained between coactions thereof with the grinding wheel, to produce uniform and regular abrasive effects upon the grinding wheel for quickly producing an even and regular truing and dressing of the grinding wheel.

It will be assumed that reciprocation in axial direction of the grinding wheel takes place between the abrading wheel and the grinding wheel during the truing and dressing of the grinding wheel, and that at each such reciprocation there is silghtly more than a complete lengthwise passage between the wheels, so that reversal of direction takes place while the wheels are out of contact, the fly-wheel effect of the foundation or spider maintaining the acquired speed of the abrading wheel between contacts for continued uniform action of the abrading wheel on the grinding wheel.

There may be a feed, as by rotation of the handle **62**, to cause approach between the grinding wheel and the abrading wheel, while truing or rough dressing the grinding wheel, during which the cutting edges **65** of the abrading arms rotate in advance of the abrading surfaces of said arms. Such feed may be three- to five-thousandths of an inch at the end of each such reciprocation, and a few reciprocations, say four to six, are ordinarily sufficient to complete such

truing or rough dressing, and a finer dressing may be obtained by less depths of feed, and by permitting a few reciprocations, say two or three, between the wheels without feed. If a less intensive truing, or a fine dressing or a dressing suitable for polishing work by the grinding wheel is desired, the abrading wheel is reversed to present its heels 67 forwardly for coaction with the grinding wheel, a few reciprocations between the wheels, say four to six, with a feed of one- to two-thousandths of an inch per reciprocation, and one or two reciprocations without feed, are usually sufficient to obtain such desired truing and dressing. The numbers of reciprocations and depths of feed are dependent on the condition of the grinding wheel.

In the modification shown in Fig. 12, the arms 153 extend in lateral directions at a considerable angle to the axis of rotation of the abrading wheel, exemplified as an angle of thirty-six degrees. The various parts of my improved device in this modification are designated by similar reference numerals raised to the series 100.

In the modification shown in Figs. 13 and 14 there are two series of arms 253 of less width, the arms of the respective series being arranged in staggered relation to each other, and having recesses 281 between them, throughout which the abrading composition extends for further uniting the abrading composition at the respective ends of the abrading wheel. The respective parts in this modification are designated by similar reference numerals raised to the series 200.

In the modification shown in Figs. 15 and 16 there are also two series of arms 353, the arms of the respective series being staggered with relation to each other about the axis of the abrading wheel, and having spaces 381 therebetween containing the fixed abrading composition for uniting the bodies of abrading composition in the respective spaces between the arms at the respective ends of the abrading wheel. These arms are shown in angular relation to the axis of the abrading wheel of similar but reverse angles to those shown in Fig. 12. In this modification the parts are designated by similar reference numerals raised to the series 300.

In the modification shown in Fig. 17, the arms 453 are arranged in two series, end for end, the arms of the respective series having spaces 481 therebetween through which the abrading composition extends, the arms of the respective series being arranged in staggered relation and at oppositely projecting angles to the axis of the abrading wheel. In this modification the parts are designated by similar reference numerals raised to the series 400.

In the modification shown in Fig. 18 the arms 553 extend only partway across the width of the abrading wheel, having recesses 582 at the respective ends of alternating arms filled with the abrading composition to further connect the bodies of abrading composition between the arms, and the arms being curved with relation to the axis of the abrading wheel. The parts in this modification are designated by similar reference numerals raised to the series 500.

In the modification shown in Figs. 19 and 20, the foundation or spider 651 is represented as a cylinder of the heavier material having spaces 654 therein, extending tangentially in the cylinder and arranged in overlapping rows about the cylinder, and having bodies 671 of abrading composition fixed therein. In this modification the parts are designated by similar reference numerals raised to the series 600.

My improved device forms a simple, efficient and economical and quickly operating abrading device, having a duplex truing and dressing effect upon the grinding wheel so arranged that by rotating the abrading wheel in one direction a coarser truing and dressing effect is produced upon the grinding wheel than by rotating the abrading wheel in the opposite direction for producing a finer truing and dressing effect and a polishing action upon the grinding wheel. Extreme accuracy of truing and dressing is also obtained by incorporating a fly-wheel effect into the truing and dressing wheel so that the resultant benefits therefrom are imparted directly at the point of coaction between the abrading wheel and the grinding wheel. The specific gravity of the foundation or spider is substantially greater than the specific gravity of the abrading composition to impart centrifugal effect to the abrading wheel the direct radial lines of force of which are in the midst of said abrading surfaces. The wear resistance of the foundation or spider and the density of its abrading surface are preferably substantially greater than the wear resistance and density of the abrading surface of the abrading composition in the abrading wheel.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An abrading wheel comprising a foundation the outer periphery of which is in the cylindrical face of said wheel and is an abrading surface and provided with spaces all of which extend longitudinally from the inner portion of said foundation slantingly in similar directions about the axis thereof and are open at such outer periphery, and abrading composition in said spaces the outer periphery of which is in said cylindrical face and is an abrading surface complemental to said first-named abrading surface, said abrading surfaces respectively being of substantial angular width and extending lengthwise of the axis of said wheel and alternating repeatedly about said cylindrical face, and said foundation being of substantially greater weight than said abrading composition to impart a fly-wheel effect to the abrading wheel.

2. An abrading wheel comprising a supporting spider having abrading arms all of which extend slantingly in the plane of the wheel in similar directions about the axis of said wheel, said abrading arms having acute angular cutting edges at one side and smoothing heels at the other side of their outer ends which have outer peripheral abrading faces in the cylindrical face of said wheel, and bodies of abrading composition hardened in the spider between said arms and having outer peripheral abrading faces in said cylindrical face between said first-named peripheral abrading faces, the supporting spider being of substantially greater specific gravity and weight than said bodies to impart a fly-wheel effect to the abrading wheel.

3. An abrading wheel having a cylindrical abrading face arranged to act on a grinding wheel for truing and dressing the same, the said abrading face composed of the outer ends of alternate metallic and non-metallic bodies extending lengthwise inwardly in the body of said wheel and having alternate metallic and non-metallic abrading faces and so proportioned cross-sectionally throughout their lengths as to

maintain the proportions of areas of said respective metallic and non-metallic abrading faces during wear throughout the various diameters to which the wheel may be worn.

4. An abrading wheel having an outer annular edge abrading face arranged to act on a grinding wheel for truing and dressing the same, the said abrading face composed of the outer ends of alternate heavier and lighter bodies all of which are arranged slantingly in the abrading wheel substantially perpendicular to and in similar directions about the axis of said wheel so as to form cutting toes and smoothing heels on said respecive bodies presented forwardly during respectively opposite rotations of the abrading wheel for respectively a rougher action and a smoother action on the grinding wheel, and the said heavier bodies being substantially heavier than said lighter bodies to impart a fly-wheel effect upon the abrading wheel the direct radial lines of force of which are in the midst of said abrading surfaces.

5. An abrading wheel for a grinding wheel, said abrading wheel comprising a preformed foundation having a central hub and arms all of which are tangential in similar directions to a circle within said hub and having tangential spaces all of which extend in similar directions therebetween, and bodies of abrading composition in said spaces, the outer ends of said arms and said bodies respectively being abrading areas of different densities alternating in the peripheral path of said wheel to respectively impart different abrading effects, and said foundation being substantially heavier than said bodies to impart a fly-wheel effect to said wheel upon rotation of said wheel.

6. An abrading wheel for a grinding wheel, said abrading wheel comprising a preformed foundation having a central hub and arms all of which are tangential in similar directions to a circle within said hub and having tangentially extended spaces therebetween all of which extend in similar directions, and bodies of abrading composition in said spaces, the outer ends of said arms and of said bodies respectively being abrading areas of different densities in the peripheral path of said wheel to respectively impart different abrading effects, and whereby to impart greater resistance to yielding by said abrading areas at the outer ends of said arms than by said abrading areas on said bodies upon contact thereby with the grinding wheel, and said foundation being substantially heavier than said bodies to impart a fly-wheel effect to said wheel upon rotation of said wheel.

7. An abrading wheel for a grinding wheel, said abrading wheel comprising a foundation having a central hub provided with a central bore and arms all of which are tangential in similar directions to a circle within said bore, and having spaces therebetween all of which are tangential in similar directions to a circle within said bore, and bodies of abrading composition in said spaces, the outer ends of said arms and of said bodies respectively being abrading areas of different densities, and said abrading areas being normally in a cylindrical plane whereby the outer ends of said arms are acutely formed at one of the sides of said arms and obtusely formed at the other side of said arms, so that upon rotation of the abrading wheel in one direction rougher coaction obtains with the grinding wheel by said advancing acutely formed edges and upon rotation of said abrading wheel in the opposite direction finer coaction obtains with the grinding wheel by said advancing obtusely formed edges for respectively comparatively rougher and finer abrasive action upon the grinding wheel.

8. An abrading wheel for a grinding wheel, said abrading wheel comprising a foundation having a central bore and arms extending outwardly from said foundation transverse to the axis of said wheel at points distanced from said bore, and having spaces therebetween, the said arms increasing in thickness toward their outer ends in such proportion that the relative cross-sectional areas of said arms and of said spaces throughout cylindrical planes at different distances from the axis of rotation of the abrading wheel remain the same, and bodies of abrading composition in said spaces, the outer ends of said arms and of said bodies respectively being abrading areas of different characters and resistances to wear, which by said increasing thicknesses of said arms remain proportionately the same in area throughout the decreasing diameter of said abrading wheel due to such wear.

9. An abrading wheel comprising a spider having a hub and arms projecting outwardly therefrom to form spaces between said arms, said arms increasing in thickness outwardly, said arms provided with projections and recesses opposite each other to preserve the proportional thicknesses of said arms at said projections and recesses, and bodies of abrading composition fixed in said spaces, said arms and said bodies arranged about the axis of the wheel and respectively provided with abrading faces at their outer ends, and the thicknesses of said arms proportioned throughout their lengths and at said projections and recesses as to maintain the proportions between the areas of said respective abrading faces throughout the various diameters of the wheel due to wear.

10. An abrading wheel comprising a spider having a hub and series of arms extending outwardly therefrom in a plurality of rows the arms in which are in staggered relation about the axis of the spider, the arms in said respective rows having spaces therebetween about said axis and the arms of adjacent rows having spaces therebetween merging with said first-named spaces, and abrading composition fixed in said spaces to form a continuous body of abrading composition about said axis, the outer ends of said arms provided with separated abrading faces and the outer periphery of said body of abrading composition provided with an abrading face which is continuous and has said first-named abrading faces therein to form an outer continuous cylindrical abrading face.

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