July 5, 1960 H. D. MacMASTER ET AL 2,943,357

METHOD OF MAKING ABRASIVE ARTICLES

Filed Dec. 2, 1955 5 Sheets-Sheet 1

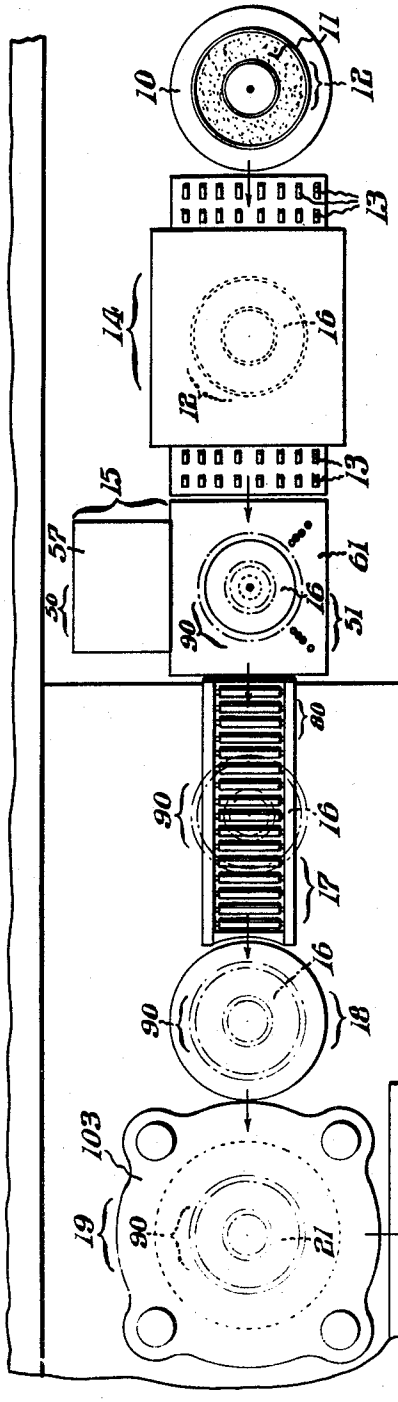


FIG. 1.

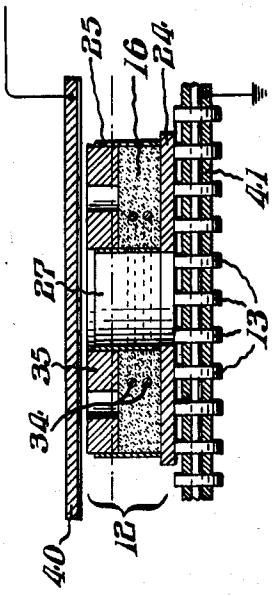


FIG. 5.

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July 5, 1960 H. D. MacMASTER ET AL 2,943,357

METHOD OF MAKING ABRASIVE ARTICLES

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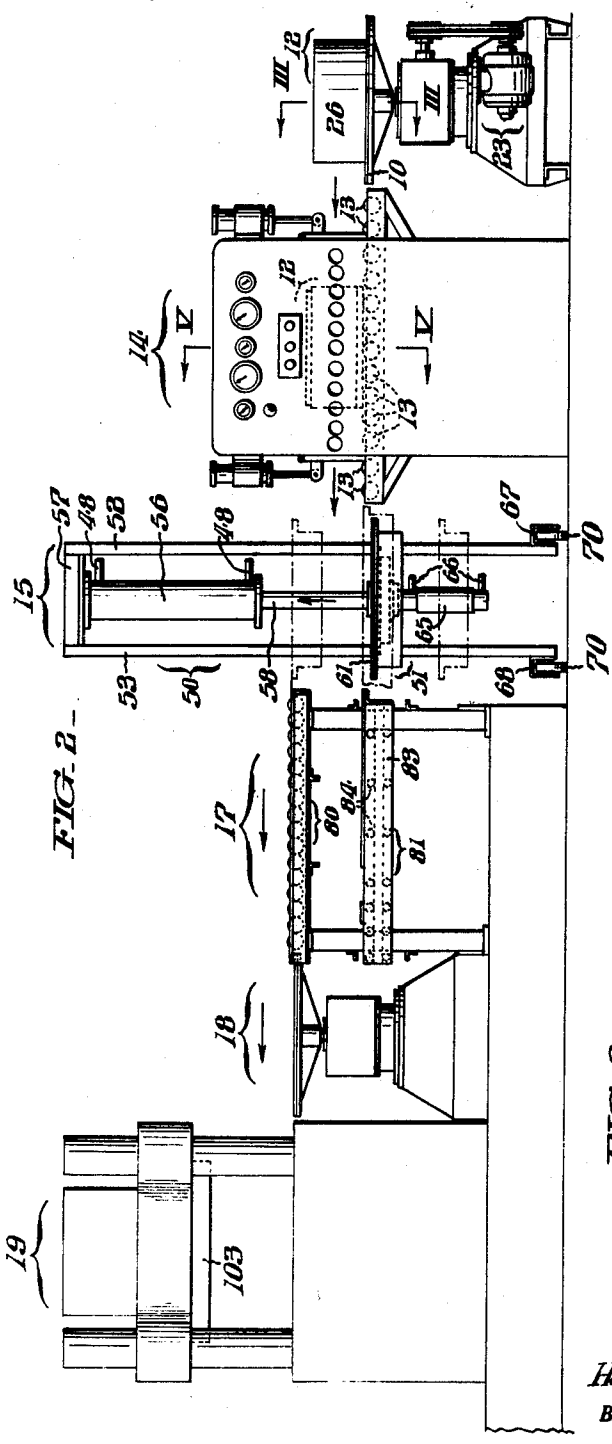


FIG. 2.

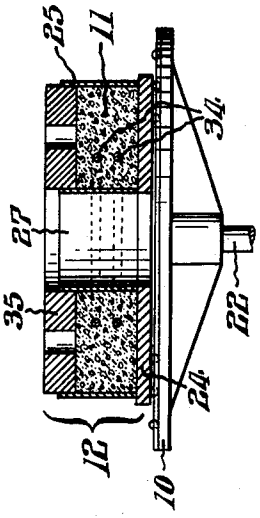


FIG. 4.

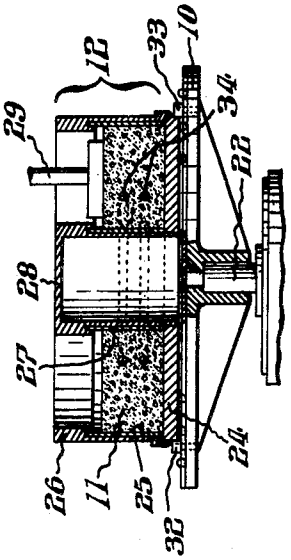


FIG. 3.

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July 5, 1960 H. D. MacMASTER ET AL 2,943,357

METHOD OF MAKING ABRASIVE ARTICLES

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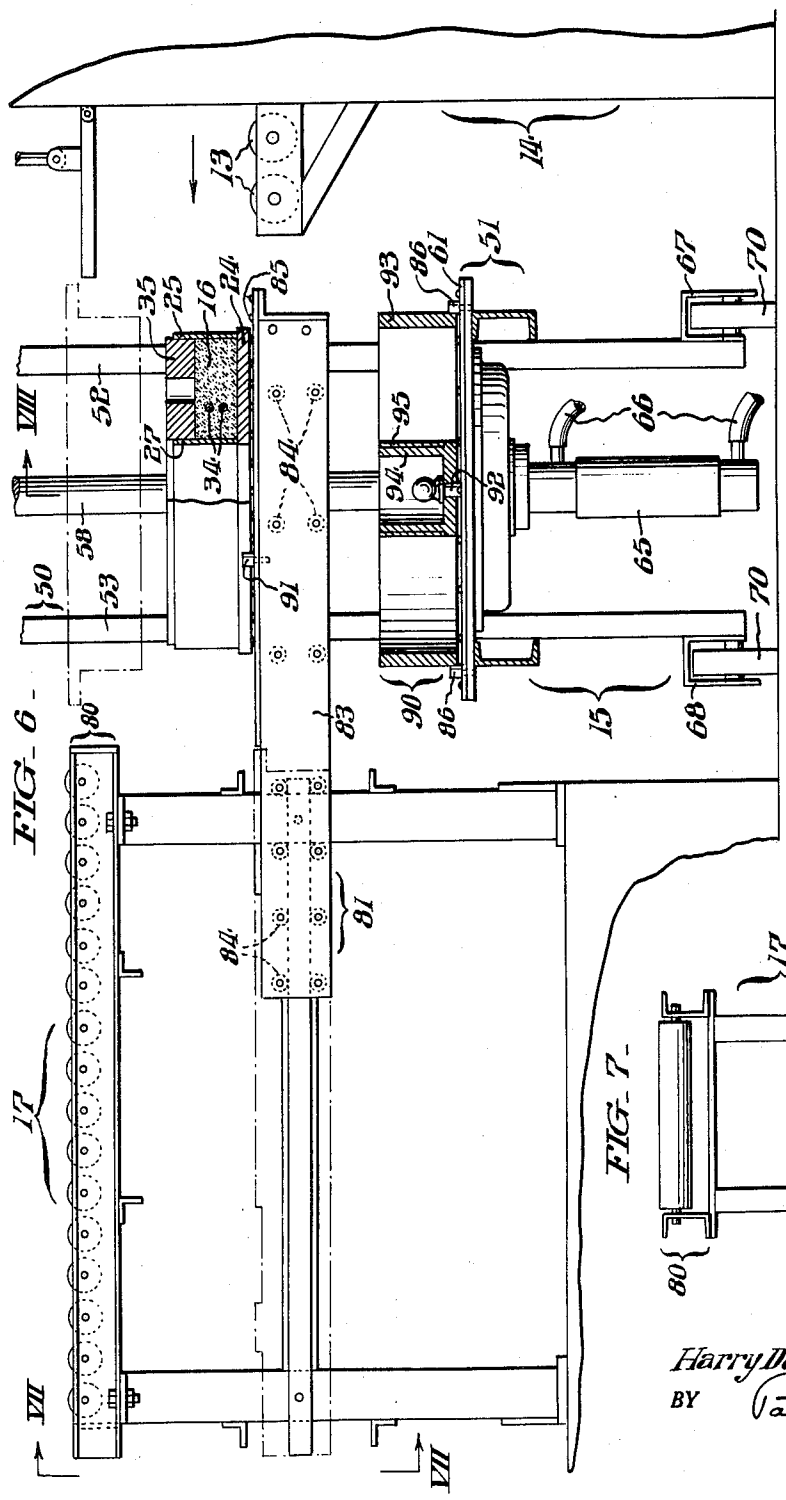


FIG. 6.

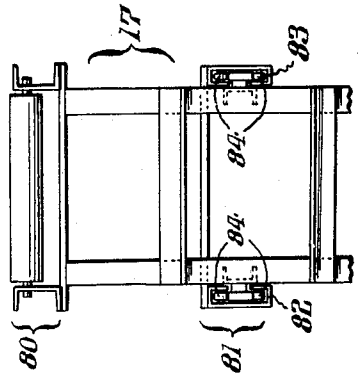


FIG. 7.

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METHOD OF MAKING ABRASIVE ARTICLES

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FIG. 8

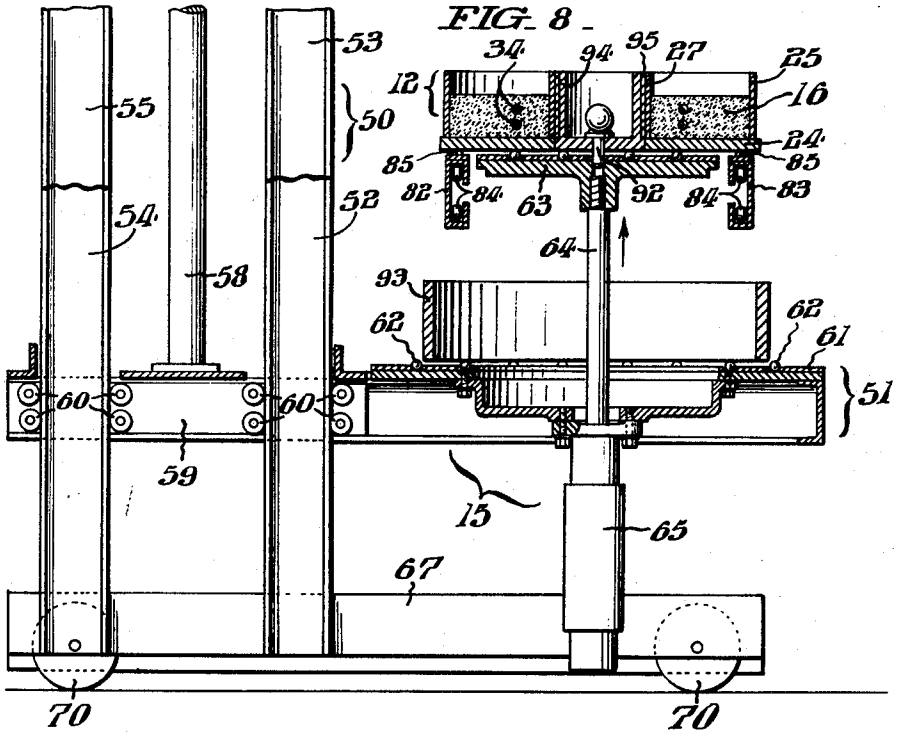
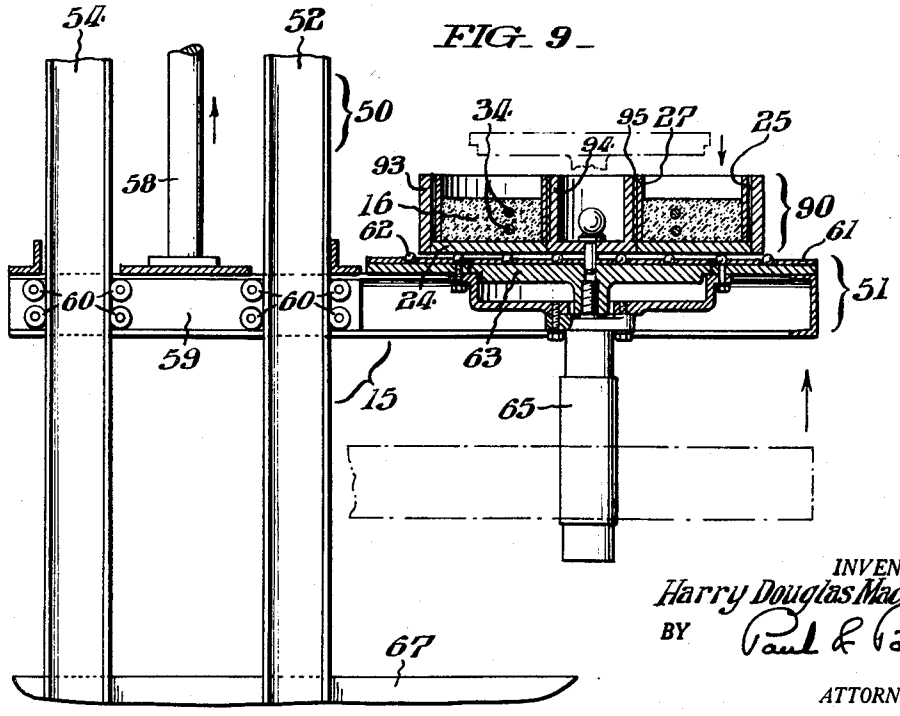


FIG. 9



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METHOD OF MAKING ABRASIVE ARTICLES

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FIG. 10.

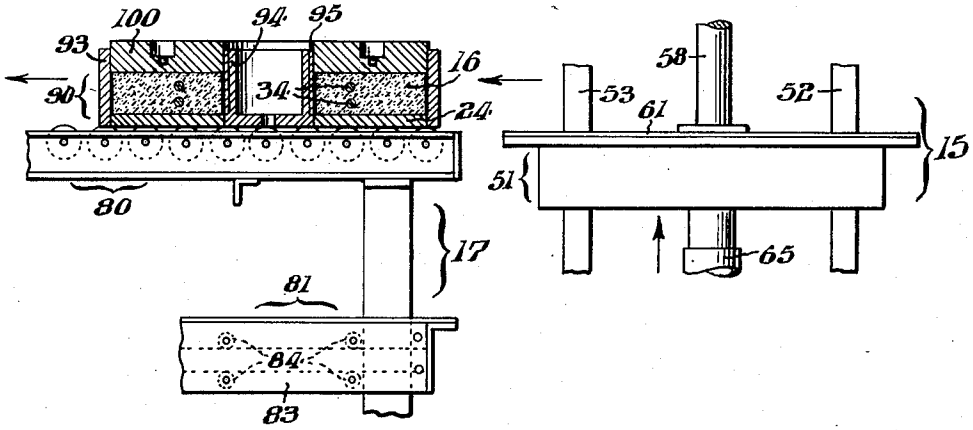


FIG. 11.

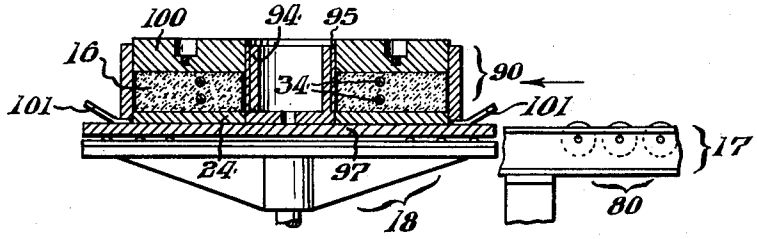


FIG. 12.

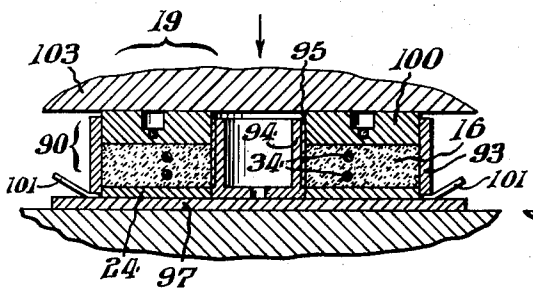


FIG. 13.

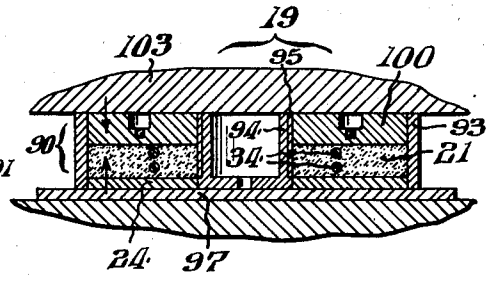


FIG. 14.



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United States Patent Office 2,943,357 Patented July 5, 1960

2,943,357

METHOD OF MAKING ABRASIVE ARTICLES

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Filed Dec. 2, 1955, Ser. No. 550,726

3 Claims. (Cl. 18—55)

This invention relates to a method for use in the manufacture of abrasive materials and particularly organic bonded making abrasive grinding wheels. It is known in the art to combine abrasive particles with a suitable bonding material forming a matrix upon the application of heat and pressure to form abrasive articles.

Current methods comprise filling a grinding wheel mold with a suitable mixture of abrasive binder and applying sufficient pressure or heat and pressure to set the binder. These methods of making grinding wheels do not lend themselves to efficient mass production, since each wheel must be formed and pressed in the same mold. Until the mixture of abrasive and binder is set in the press, the material obviously cannot be handled as a separate entity, since it is simply a loose granular mix.

It is accordingly a purpose of this invention to provide a method of making abrasive articles which is continuous and suitable for mass production.

It is also an object of this invention to provide a method of making abrasive articles in which a preliminary blank of the article is produced which can be handled as a separate entity.

It is a further object of this invention to provide a two stage method of making grinding wheels in which a preliminary blank of the grinding wheel is formed without the need of applied pressure.

In accordance with the objects stated above, the invention provides a method of making abrasive articles whereby a suitable mixture of abrasive particles and binder material in dry granular form is poured into a preliminary form having the desired shape and dimensions of the finished article. The abrasive mixture in the preliminary form is subject to preliminary heating by placing it in a pre-heater producing current on a high frequency radio wave. Even the higher frequencies may be employed successfully. The temperature in the pre-heater is maintained at a temperature sufficient to cause the resin to flow slightly. One of the principal advantages of this method is the slight flow of binder material caused by pre-heating. The flow of resin tends to eliminate entrapped air and to more closely bond with the abrasive grains. To some extent the preheater performs a preliminary pressing operation employing only gravity and the weight of the article to compress it. For most resinoid binder materials now in use, the temperature range of 100° F. to 250° F. may be used. We have found that temperatures in the range of 150° F. to 170° F. are most successful. By means of high frequency heating, the internal portions of the wheel are directly subject to heating, without the need for heat transfer through the outer parts of the article. Among the many resultant advantages is the prevention of development of internal stresses in the article. In the pre-heater, the abrasive mixture is a nonconductor positioned in the air gap of a condenser and the preliminary heating is provided by the high frequency waves. After the pre-heating, the binder in the abrasive mix is found to be partially cured, so that the mixture is no longer simply a loose granular mix but is in the form of a preliminary blank of the article to be produced. The preliminary blank is removed from the preliminary mold and may then be inserted in the usual press mold and subjected to sufficient pressure to form the finished abrasive article.

One embodiment of the method and apparatus of the invention is illustrated in the accompanying drawings of which:

Fig. 1 is a plan view partially cut away showing a layout of the apparatus provided by the invention with arrows indicating the progress of the abrasive article forming material through the apparatus.

Fig. 2 is a side elevation of the apparatus of Fig. 1;

Fig. 3 is a side elevation in cross section along the lines III—III of Fig. 2 showing the abrasive mixture in place in the preliminary mold form;

Fig. 4 is a side elevation in cross section showing the preliminary mold form as it appears prior to entry into the pre-heater;

Fig. 5 is a cross sectional view along the lines V—V of Fig. 2 showing the preliminary mold form in the preheater;

Fig. 6 is a side elevation partially in cross section showing the preliminary mold form after it has left the preheater and is stationed at the transfer lift where the preliminary blank is removed;

Fig. 7 is an end view along the lines VII—VII of Fig. 6;

Fig. 8 is a sectional view along the lines VIII—VIII of Fig. 6 showing the removal of the preliminary blank from the preliminary mold form;

Fig. 9 is a side elevation partially in cross section further showing the removal of the preliminary mold form and introduction of the preliminary blank into the press mold;

Fig. 10 is a side elevation partially in cross section showing the preliminary blank in the press mold leaving the transfer lift;

Fig. 11 is a side elevation partially in cross section showing the preliminary blank in the press mold at the worktable;

Fig. 12 is a sectional view showing the preliminary blank in the press mold in the final press before the pressing operation.

Fig. 13 is a sectional view showing the preliminary blank in the press mold in the final press after the pressing operation;

Fig. 14 is a cross section view of a grinding wheel made in accordance with the invention.

The apparatus used in the invention is illustrated in Figs. 1 and 2. The apparatus includes a turntable **10** where the abrasive mixture **11** of binder material and abrasive particles is placed in the preliminary mold form **12**. The preliminary mold form travels on the rollers **13** through the pre-heater **14** where it remains for a length of time sufficient to set the abrasive mixture **11** in the preliminary mold form **12** forming the preliminary blank **16**. After the pre-heater **14**, the mold form **12** travels on the rollers **13** to the transfer lift **15** where the preliminary blank is removed from the preliminary mold form **12** and inserted in the final press mold **90** (Fig. 9). The final press mold **90** then travels on the conveyor **17** to the worktable **18** where it is prepared for final pressing. The mold **90** is then placed in the press **19** where the final molding operation takes place, and it is then transferred to the stripping table **20** where the finished grinding wheel **21** is removed from the mold.

The method of the invention is illustrated in the steps of Figs. 3–13. In Fig. 3 the preliminary mold form **12** iis shown on the starting turntable **10**. The turntable **10** is rotatable on the vertical axis **22**, and is rotated by means of the drive apparatus **23** shown in Fig. 2. Preliminary mold form **12** includes a bottom mold plate **24**, an

outer cylindrical plastic liner 25 which is held on the mold plate 24 at this stage of the process by means of the metal frame 26 and an inner plastic liner 27 which is held in place by the metal frame 28. The abrasive mixture 11 is poured into the preliminary mold form 12 and leveled with a leveling device 29 while the turntable 10 is rotated. The preliminary mold form 12 is centered on the turntable 10 by means of the index pins 32 and 33 which retain the mold plate 24 during rotation. In the particular grinding wheel shown are included a pair of steel rings 34 which increase the safety factor of the finished grinding wheel. Fig. 4 shows the preliminary mold form 12 as it is ready to be delivered to the pre-heater 14. The retaining frames 26 and metal frame 28 have been removed, and the aluminum plate 35 has been placed over the abrasive mixture 11 within the plastic liner 25. The mold form 12 is then placed in the pre-heater 14 where the preliminary setting operation takes place.

Pre-heater 14 provides electric current at a very high frequency in the radio or television frequency range. The preliminary mold form 12 is a thin plastic band nonconductive and non-heating material so that the flow of current is directed toward the abrasive mixture which itself is a dielectric. The mold form material must be such as will not heat up under the high frequency waves. It has been found that silicone glass, fluorinated hydrocarbons, polyethylene and polystyrene sheets are satisfactory for this purpose. The plastic liner is kept as thin as possible to minimize the grade distortion of the wheel to replace the liner 25 in the final molding operation as will be hereinafter more fully described. As shown in Fig. 5, the abrasive mixture is placed in the air gap between the upper electrode 40 and the lower electrode 41. The aluminum plate 35, being a good conductor, offers no resistance to the current and the same is true of the mold plate 24. These become, in effect, floating electrodes, concentrating the heat energy in the body of the wheel. The rollers 13 in the pre-heater are made of rubber, ceramic or other non-heating and nonconductive material.

When the pre-heated abrasive mixture in the preliminary mold form 12 leaves the pre-heater 14, it travels to the transfer lift 15 as shown in Fig. 6. The transfer lift 15 includes the transfer elevator 50 and the transfer table 51. The transfer elevator 50 has a frame made up of the spaced vertical beams 52, 53, 54 and 55. The elevator cylinder 56 is suspended from the plate 57 connected to the tops of the vertical beams 52, 53, 54 and 55. The cylinder 56 is actuated hydraulically through the connecting hoses 48 to raise and lower the piston rod 58 which carries the elevator table 59. The vertical travel of the elevator table 59 is guided along the vertical beams 52, 53, 54 and 55 by means of the guide rollers 60. Extended forward of the elevator table 59 and attached thereto is the transfer table 51. The face plate 61 of the transfer table 51 is provided with ball rollers 62 spaced to form a rolling surface. The center portion 63 of the face plate 61 is mounted on the piston 64 which rides vertically in the hydraulic cylinder 65. The hydraulic pressure is provided through the hoses 66. The entire transfer lift 15 is mounted on transfer beams 67 and 68 which in turn are mounted on wheels 70.

Next adjacent the transfer lift 15 is the conveyor 17 comprising a pair of vertically spaced horizontal roller sections 80 and 81 fixed to vertical frame members which are attached to the ground. The lower conveyor 81 is slid toward the pre-heater 14 to pick up the mold form 12. This conveyor 81 is a pair of spaced beams 82 and 83 riding on internal rollers 84 and having a series of ball rollers 85 fixed in their upper surfaces. The preliminary mold form 12 rolls along the ball rollers 85 until it meets the index pins 91 which centers it over the face plate 61 of the transfer table 51. When the preliminary mold form 12 leaves the pre-heater, as shown in Fig. 6, a final press mold 90 is centered on the transfer table 51 of the transfer lift 15 which is centered by the centering pin 92 and index pins 86. The press mold 90 includes the outer shell 93, inner shell 94 and the thin metal liner 95 disposed on the shoulders of the inner shell 94.

In the next step, illustrated in Fig. 8, the platform 63 is forced upward by the air cylinder 65 to support the bottom mold plate 24 on the ball rollers 85. The apparatus for actuating the air cylinder 65 is connected to the lead hoses 66, shown in Fig. 6, and is not further illustrated. It may be any usual means for actuating an air cylinder. The rising platform 63 carries with it the inner shell ring 94 held by the centering pin 92 and the thin metal liner 95. These are inserted in the inner plastic liner 27 of the preliminary mold form 12 as shown in Fig. 8. At this point the rising platform 63 supports the bottom mold plate 24 and the preliminary mold form 12. The conveyor tracks 81 are retracted to their storage position shown in dot-dash in Fig. 6, and the preliminary mold form 12 is lowered on the platform 63 by actuating the air cylinder 65 while, at the same time, the lower transfer table 51 carrying the outer shell 93 is raised by the air cylinder 56. When they meet, as shown in Fig. 9, the preliminary mold form 12 is fitted in the outer shell 93. The plastic liners 25 and 27 are then removed manually and the final mold 90 is raised on the transfer table 51 to the level of the upper conveyor 80 as shown in Fig. 10. It will be appreciated that the material used for the liners 25 and 27 is sufficiently light in weight that they may be easily removed manually without the need for heavy handling equipment.

At this stage, the press mold cover plate 100 is inserted in the outer shell 93, and the entire mold 90 is transferred on the conveyor 80 to a plate 97 on the work-table 18 where the outer shell 93 is raised on the shims 101 as shown in Fig. 11. It should be noted that due to the removal of the plastic liners 25 and 27, there are spaces between the abrasive mixture and the outer and inner shells 93 and 94. The mold form 90 is placed in the press 19 and the head 103 is lowered against the cover plate 100 with sufficient force only to compress the abrasive mixture to fill these spaces. The shims 101 are then removed and the final press operation as shown in Fig. 13 takes place. By means of the shims 101, equal spacing above and below the outer shell 93 is provided so that substantially equal pressure is applied to the top and bottom of the abrasive mix. The mold 90 is then released from the press 19 and transferred to the stripping table 20 where the cover plate 100 is removed. The outer shell 93 and inner shell 94 and liner 95 are also removed and the finished grinding wheel 21 is lifted from the base mold plate 24. The final product is shown in Fig. 14.

From the time that the preliminary mold 12 leaves the pre-heater 14, the abrasive mixture is a coherent mass which can be handled without danger of distorting the form of the finished grinding wheel. The preliminary blank can be handled by the apparatus described above to deliver it to the final press 19 in the same form in which it was originally made up. By means of the method and apparatus of this invention, it is possible to break down the manufacture of abrasive articles into a series of individual steps adapted for mass production, which is not possible with known methods. The molding station at the press, required in known methods, is now eliminated. Thus, the final press is not limited in its operation by the amount of time necessary to make up a level of abrasive mixture. It is possible to make preliminary blanks and stock pile them for future use, and it is likewise possible to arrange a plurality of pre-heaters feeding to a single press or to have a plurality of preliminary turntables making up various types of abrasive articles in preliminary form feeding them to one or more preheaters. Quality control of finished abrasive articles is greatly improved by this method and apparatus, since it is possible to spe-

cialize in the make-up of the articles at the preliminary turntable and to reject faulty wheels upon inspection for defects after pre-heating. The uniformity of temperature distribution, the time required for setting the resins and the weight and balance of the articles may be controlled and checked between the transfer elevator **15** and the final press **19**.

The substantial advantages of the method and apparatus of this invention over known methods and apparatus in the manufacture of grinding wheels have been established experimentally. The known methods include cold pressing, oven pre-heating followed by cold pressing, and hot pressing.

In cold pressing the abrasive mix is formed in a final press mold and then subjected to sufficient pressure to reduce the abrasive mix and binder to wheel size at room temperature of about 70° F. The binder resin in this case is cured later by oven after-heating at about 350° F. to 370° F. This method is technically quite simple, but it requires considerable handling of the materials involved at the press. The quality of wheels which can be produced by this method by any normal pressures is quite limited.

In the oven pre-heating method, the abrasive mixture and binder resin is formed in the final press mold and subjected to direct heat in a baking oven to flow the resin. The mixture is then subjected to a cold pressing operation. In this method it is necessary to subject the press mold to oven temperatures in the range of 200° F., and the heating of the abrasive mixture and binder resin through the wheel is not uniform. The unequal heating tends to introduce stresses in the wheel which reduce its quality. In the oven pre-heating, it is usually desired to bring the entire wheel mixture up to about 160° F. To do this it is necessary to use a forced hot air draft at about 200° F., and it is seldom possible to raise the temperature of the wheel to a uniform temperature in any reasonable time. In view of the long heating time, it is necessary to keep a large number of wheel molds in the oven to maintain an efficient production rate.

The hot pressing method is basically unsatisfactory because of the extensive amount of time in the press required to reduce the wheel to proper size and cure. In this method the press is heated by steam or electricity and the wheel is pressed and heated simultaneously.

The table below illustrates the relative qualities of a 20 inch diameter grinding wheel made by known methods and by the method of the invention. The wheels used comprised a powdered thermo-setting phenol formaldehyde resin binder and a suitable wetting agent with cryolite mineral filler and aluminum oxide abrasive grains of 10–20 mesh size. The table shows two different pressures in the final press, and the quality is expressed in terms of the porosity of the finished wheel. The porosity is the ratio of the air space in the wheel to the geometric volume of the wheel, expressed as a percentage.

Porosity

Pressure	Cold Pressed, percent	Oven pre-heat, percent	Dielectric pre-heat, percent
1,100 Tons	10	6	4
600 Tons	12	8	6

It will be noted from the table that the porosity of grinding wheels produced by the method of this invention is less than that for either of the known methods shown. Furthermore, the oven pre-heating method does not provide a preliminary blank of the grinding wheel which can be handled and transferred to a final mold. The oven pre-heating method, by virtue of the unequal rate of heating and the fact that the center of the wheel seldom reaches the desired temperature, does not possess the structural properties required in a preliminary blank.

It has also been determined that the wheels produced by the method and apparatus of this invention have good strength and grinding properties without the attendant brittleness often found in wheels made by known methods. For no expected or apparent reason, the wheels made by this method have a fully cured binder resin having all of the required physical properties for effective grinding while retaining a great degree of resiliency in the binder resin not found in other wheels. This resiliency has been determined by shop testing methods such as digging into the wheel with a cold chisel. The resiliency is further apparent in trimming finished wheels in that the trimming operation is performed with substantially less vibration than in the case of other wheels and by the way that the wheels trim cleanly without spalling.

In addition to the advantages produced in the abrasive articles made according to the method of this invention are the attendant manufacturing advantages provided thereby. It has been found that the elapsed time required to produce a wheel in mass production using known methods is normally about ten minutes, whereas the elapsed time per wheel with the dielectric method and apparatus of this invention is only about five minutes. Also, about twenty man-minutes are required to mass produce grinding wheels by known methods, whereas only about fifteen man-minutes are required to produce a wheel by the method of this invention. It is further noted that in the oven pre-heating method to produce a single wheel can take as long as seventy minutes or more in the heating oven, so that it is only by mass production that any time efficiency can be obtained. With the dielectric method and apparatus, a single wheel can be produced within the elapsed time of five minutes regardless of the number of wheels involved.

Many variations are, of course, possible in the particular embodiment of the invention described above without departing from the spirit of the invention as defined by the following claims.

Having thus described our invention, we claim:

1. A method of forming a grinding wheel of the type described comprising placing a substantially dry predetermined mixture of abrasive particles and binder material in a substantially non-conductive and non-heating preliminary mold form having the shape of the article to be produced, subjecting said mixture in said mold form to electric current having a frequency in the range of 10–100 megacycles without the application of molding pressure for a length of time sufficient at least to partially set said binder material, then transferring said heated mixture to a final press mold while still possessing sufficient heat to effect final molding and then compressing said mixture by the application of molding pressure above, without the application of additional heat.

2. A method of forming a granding wheel of the type described comprising placing a quantity of mixed abrasive particles and dry binder material in an electrically non-conductive and non-heating mold form, placing said mold form containing said abrasive particles and dry binder material between spaced electrodes, passing current through said electrodes having a frequency of 10–100 megacycles without the application of molding pressure to form a preliminary blank having the shape of the article to be produced, transferring said preliminary blank to a final press mold while still possessing sufficient heat to effect final molding and then compressing said blank by the application of molding pressure alone to form the grinding wheel.

3. A method of producing a grinding wheel of the type described comprising placing a predetermined quantity of a predetermined unbonded mixture of abrasive particles and binder resin in a plastic preliminary mold form of the same shape as the grinding wheel to be produced, partially curing said resin by subjecting said mixture in said form to high frequency electric current in the range of 10–100 megacycles without the application of mold-

ing pressure, placing said preliminary mold form containing said mixture inside a final press mold form, said mixture still possessing sufficient heat to effect final molding, removing said plastic mold form and subjecting said mixture in said final press mold to sufficient pressure to form the finished grinding wheel.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,943,357 July 5, 1960

Harry Douglas MacMaster et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 52, for "above" read -- alone --; line 54, for "granding" read -- grinding --.

Signed and sealed this 27th day of December 1960.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents