April 23, 1935. A. L. BALL ET AL 1,998,919

MANUFACTURE OF ABRASIVE ARTICLES

Filed Nov. 12, 1931 3 Sheets-Sheet 1

Fig. 1.

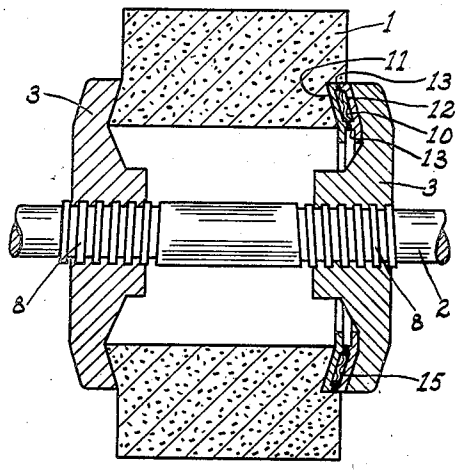


Fig. 2.

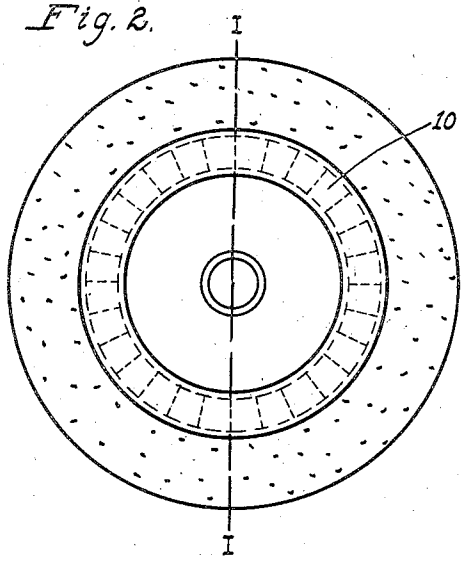


Fig. 3.

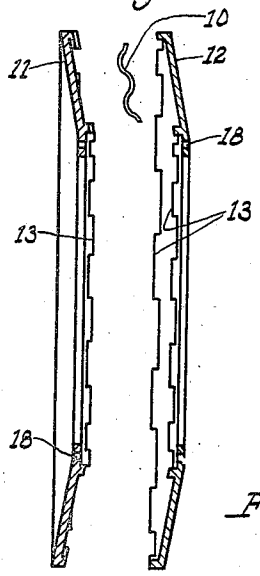


Fig. 4.

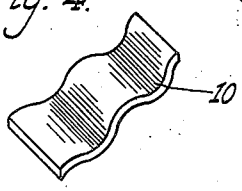
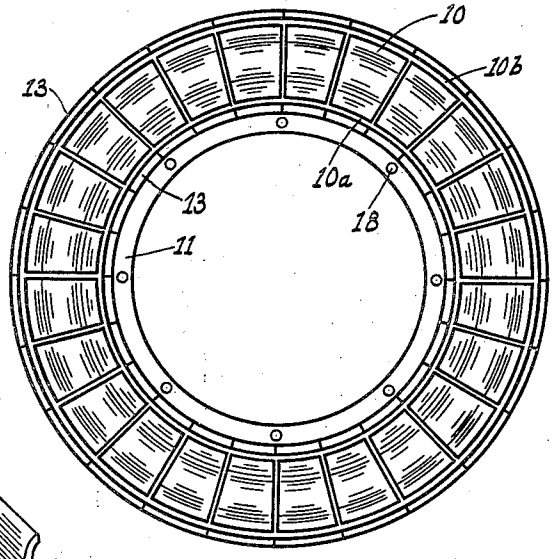


Fig. 5.



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Fig. 6.

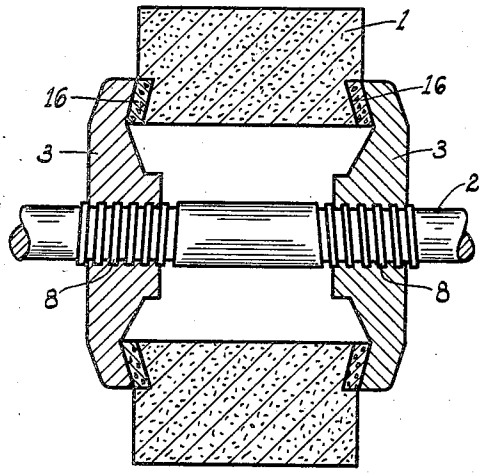


Fig. 7.

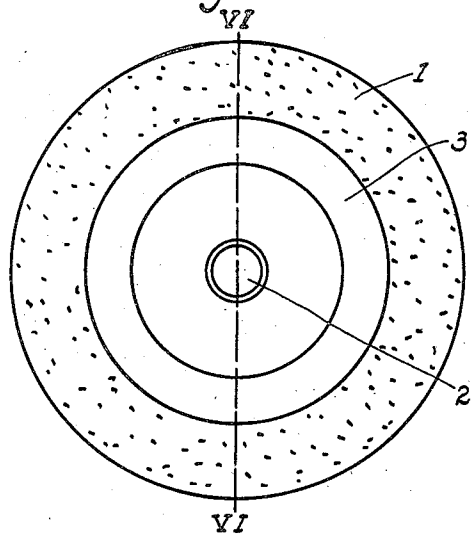


Fig. 8.

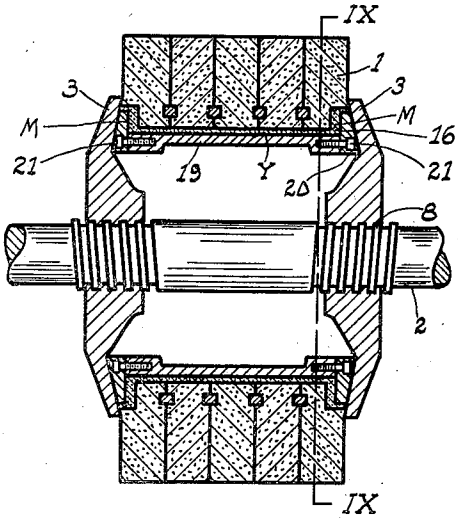
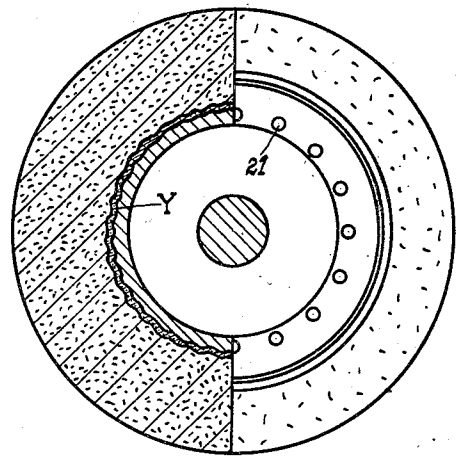


Fig. 9.



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MANUFACTURE OF ABRASIVE ARTICLES

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Fig. 10.

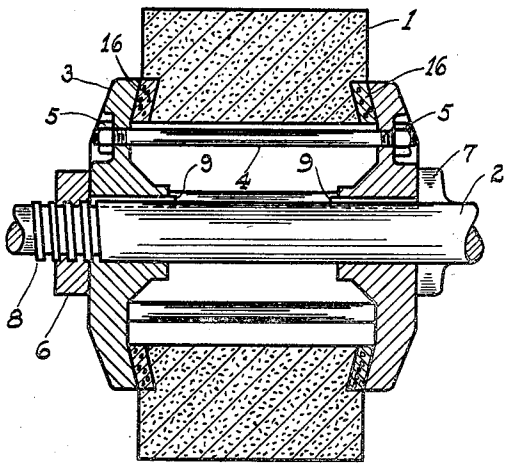


Fig. 11.

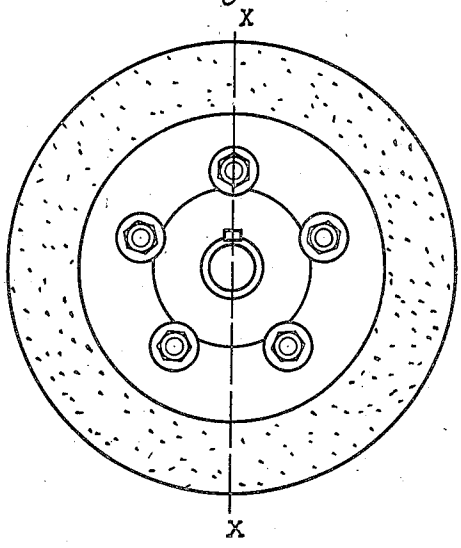


Fig. 12

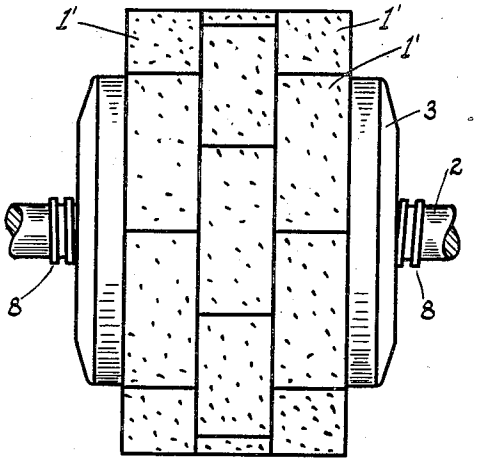
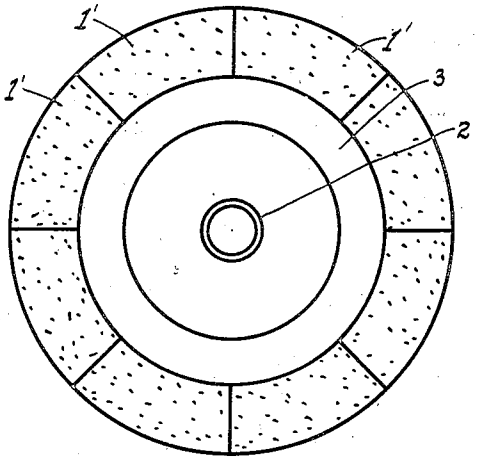


Fig. 13.



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UNITED STATES PATENT OFFICE

1,998,919

MANUFACTURE OF ABRASIVE ARTICLES

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Application November 12, 1931, Serial No. 574,532

12 Claims. (Cl. 51—168)

This invention relates to improvements in the manufacture of abrasive articles and is applicable to abrasive wheels intended for peripheral grinding although not limited to this method of grinding.

A typical operation in which abrasive wheels are subjected to temperature changes is that of grinding wood to produce paper pulp. Wheels intended for this type of service must resist changes at least from minus 40 degrees centigrade to plus 100 degrees centigrade. They furthermore must be made very rugged mechanically, in order to perform under loads as high as 2000 horsepower. They are made in sizes as heavy as eight tons, requiring a sixteen inch diameter steel spindle, and are mounted between right and left-hand threaded flanges to guarantee their proper mechanical functioning and safety.

The serious trouble encountered in the operation of an artificial abrasive wheel for such purposes is the building up of excessive flange pressure which may lead to the destruction of the wheel.

The more important causes of flange pressure are due (1) to the large driving torque, and (2) to differential expansion between steel spindle and abrasive body caused by temperature changes. The pressure due to the first cause may amount to from 500 to 900 pounds per square inch under the flange and is not serious; in fact, it is essential in order that the wheel may perform its work. The increase in pressure due to temperature change, such as cooling the wheel from 100 degrees centigrade to 10 degrees centigrade, however, may amount to three or four thousand pounds per square inch, and it is the magnitude of these secondary pressures acting upon the abrasive that, to a large degree, causes cracking of such wheels.

A large abrasive wheel, such as is used for pulp grinding, is made almost invariably of material that has a lower coefficient of thermal expansion than the steel shaft upon which it is mounted. The flanges that grip the sides of the wheel are threaded in left and right-hand directions respectively so that the power that turns the shaft tightens the flange grip upon the wheel sufficiently to carry the required load. The wheel and shaft become very hot during use and, although both expand, the shaft lengthens more than the abrasive body. During this change, however, the power continues to take up this increase in shaft length and preserves the tight flange grip upon the wheel. When the assembly cools, there is absolutely no relief from the forces generated by the steel shaft while trying to contract to its normal length when cool. The abrasive cannot contract sufficiently to afford the necessary relief; consequently, high pressures upon the abrasive result. If an abrasive wheel is capable of resisting the first few cycles of heating and cooling (possibly as a result of a slight disintegration of the cement grouting material or inadequately resilient gasket materials such as are commonly used under the driving flanges) the repeated cycles of operation cause the same extra tightening of the flanges, and cooling reapplies the same heavy flange pressure with its attendant threat upon the physical integrity of the wheel.

There are two broad classifications into which assembly methods for these large wheels fall; viz, (1) those which provide a ribbed metallic hub or drum structure wherein the rotating forces are applied to the abrasive entirely by means of large ribs which are inserted into the abrasive and which ribs are parallel to the driving shaft and contact with the abrasive essentially throughout the length of the arbor hole, and (2) those which provide no hub in the arbor hole, but which drive the wheel entirely by pressure directed upon the wheel by the flanges. Our invention has principally to do with the second type of mounting and with providing means for eliminating the excess flange pressure ordinarily caused by an abrasive assembly being subjected to temperature change.

In our invention, we provide combinations of thermal and elastic means for neutralizing the differential expansion between the abrasive and the steel shaft by placing under the flanges one of the following:

1. Springs of highly elastic properties which permit the proper amount of shaft contraction with no substantial increase in flange pressure;

2. The proper thickness of a material, such as sulfur, having a very high coefficient of thermal expansion to make the net coefficient of abrasive annulus the same as that of the shaft; or

3. A combination of the two classes of materials described under 1 and 2 above, which may be accomplished by materials such as synthetic resins with a relatively small percentage of inert filler. Such compounds possess a high coefficient of thermal expansion and are also very elastic in behavior.

Changes in the dimensions of a solid may take place because of heating, because of the application of force or because of the combination of both heat and force. In the first of these effects, the important factor is the coefficient of thermal ex-

pansion, while in the effect of force the important factors are compressibility and elasticity. We make use of both of these effects for the substances used in carrying out temperature compensation in our invention in conjunction with similar effects in the abrasive annulus and steel drive shaft, and we provide a construction member of suitable properties and dimensions.

Our invention is illustrated by the accompanying drawings in which:

Figure 1 is an axial section of an abrasive wheel and its driving flanges;

Figure 2 is an end view of the wheel shown between the flange and wheel in Figure 1;

Figure 3 shows axial sections of a composite bushing shown in Figure 1, the component parts being separated for clearness;

Figure 4 is a perspective view of a corrugated spring shown in Figure 3;

Figure 5 is an end view of part of the composite bushing shown in Figure 3;

Figures 6 and 7 are views similar to Figures 1 and 2 respectively showing a modified form of mounting;

Figures 8 and 9 are longitudinal (partly sectional) and half sectional end views, respectively, of another modified form of mounting;

Figures 10 and 11 are longitudinal (partly sectional) and end views, respectively, of a modified embodiment of our invention; and

Figures 12 and 13 are side and end views, respectively, of a mounted abrasive wheel in which the abrasive wheel is of segmental structure.

Figures 1 and 2 are views showing a method for carrying out our invention by interposing the permanently elastic mechanical system at 11, 12 and 13 between abrasive annulus 1 and flange 3 which provides the necessary degree of freedom to permit relative movement between the abrasive and shaft when the assembly is subjected to temperature changes and at the same time provide for the necessary flange pressure to drive the wheel.

Figures 6 and 7 illustrate another method of carrying out our invention. The highly expansive and elastic material 16, when interposed in suitable thickness between flanges 3 and abrasive annulus 1, serves to compensate for the difference in expansion between the abrasive 1 and steel shaft 2. This compensation, it will be seen, is the full equivalent of the compensation obtained by making the thermal expansions of abrasive and shaft equal.

Figures 8 and 9 are drawings of still another modification for carrying out our invention. A brief study of these illustrations will show that hub 19 is essentially an enlargement of shaft 2 and that the highly expansive substance 16 between the hub flanges 20 and abrasive 1 compensates for or prevents the accumulation of stresses due to thermal change in a manner similar to that described in the immediately preceding paragraph.

Figures 10 and 11 illustrate a method of using our invention in combination with a different type of mounting than those mentioned above. The use of iron tie rods 4, which connect the flanges 3 and which function expressly as bolts to produce the necessary flange pressure against the abrasive wheel, permit the shaft, flanges and bolts to be considered as a mechanical unit composed of parts whose coefficients of thermal expansion are the same. The highly expansive material 16, placed under flanges 3, is essential to compensate for the differences in coefficient of expansion between the mechanical unit and the abrasive annulus in the manner mentioned in the preceding paragraph.

Referring to Figures 1, 2, 3, 4 and 5 of the drawings, we will disclose in full detail our first method for carrying out our invention. In Figure 1, the abrasive annulus 1 is held in its axial position relatively to the shaft 2 by means of clamping members or opposed driving flanges 3. These flanges are threaded on the driving shaft by means of right-hand and left-hand engagement, respectively, as indicated at 8 in Figure 1. The direction of rotation of the wheel is such that increase of load increases the axial pressure on the abrasive. A mechanical system 15, embodying permanently elastic structural features, is placed between at least one of the driving flanges and the abrasive annulus 1. The members included in the structural combination 15 include a back plate 11, a front plate 12, and a series of corrugated springs disposed between the front and back plates and having their greatest dimensions extending radially with respect to the axis of rotation. The combination is shown in detail in Figures 3, 4 and 5. These springs are corrugated so as to resist close approach of the back plate 11 toward the front plate 12. Interlocking lugs 13 are shown on the front plate and also on the back plate. Each of these lugs fits into a corresponding recess in the opposing member. This eliminates any tendency for the wheel to sag in its mounting. The lugs also serve to retain the corrugated springs 10 in their radial position between the front and back plates. When the front and back plates and the intermediate spring members are assembled, bolts which pass through the holes 18 are tensioned (by means of nuts) sufficiently to enable the annular combination to be assembled in place between a driving flange and the wheel without causing, however, any appreciable compression of the corrugated springs. In this method of carrying out our invention it is necessary to take into account the relative thermal expansions of the abrasive and of the driving shaft as well as the temperature range encountered during the operation of the wheel and during idle periods. The spring element 10 is made from a metal of a suitable thickness and height of corrugation to compress a definite distance (approximately parallel to the axis of the wheel) under a definite change in pressure. When these factors have been properly ascertained and applied to the design of the abrasive wheel assembly it will be found, when the wheel is cooled from the highest temperature of operation, that the longitudinal (axial direction) contraction of the shaft 2, relatively to the abrasive annulus 1, will take place without causing undue stress in the abrasive wheel.

A second method in which our invention may be carried out is shown in Figures 6 and 7. In the modification illustrated by these figures, the driving flanges 3 are mounted on the driving shaft in the same manner as described in connection with Figures 1 and 2. As the abrasive wheel is rotated, the effect of increasing load is to make the flanges continually press the wheel more tightly until the maximum loading conditions are met. To take care of the differential thermal expansion between the shaft 2 and the abrasive annulus 1, rings 16 are inserted as shown in Fig. 6 between the driving flanges and the abrasive. Preferably the material of which 16 is composed should have a relatively high coefficient of thermal expansion (50 to 60×10^{-6} per centi-

grade degree or higher). We have found that by the use of such highly expansible material for the annulus 16 (and giving it an appropriate axial dimension) a thermally compensated assembly may be constructed as indicated in Fig. 6. By way of example, we may take the length of the abrasive between the flanges as 54 inches. The material 16 may be composed of 90 per cent of sulphur and 10 per cent of finely pulverized coke and should be 2 inches to 2¼ inches thick under each flange to compensate for the difference in expansion coefficients of the abrasive and the shaft. This material is placed in position (between the driving flanges and the abrasive) by pouring. Since the melting point of sulphur is approximately 114 degrees centigrade, and since the material is very fluid at 130 degrees centigrade to 150 degrees centigrade, such a pouring process is easily carried out by those skilled in the art. After having been poured into place, the mixture hardens as soon as it cools to 114 degrees centigrade and remains solid at temperatures below this point. The hardening temperature is sufficiently above the maximum operating temperature of a pulp wheel (100 degrees centigrade) to serve its purpose.

As a further illustration of the second method of carrying out our invention, we may mention that the annulus 16 may be made from various synthetic resins suitably compounded with a small proportion of finely granulated inert filler. The resinous mixture is heat hardened in position between the driving flanges and the abrasive so that the axial thickness of the insertion is from 1 to 3 inches. The large choice of materials of high coefficients of expansion and controllable elastic modulus which are thus obtainable permits compensation for the differential expansion of shaft and abrasive wheel.

Referring particularly to the first two cited methods of temperature compensation, it is understood that the coefficient of expansion of the mechanical system composed of members 10, 11 and 12 shown in Figures 1 to 5 inclusive may be varied by the selection of the materials of which these members are composed so that the net coefficient of expansion of the system is equal to or greater than that of the shaft (which is usually about 10 to 11.5×10^{-6} per degree centigrade for a steel shaft). In this way both the resilience of the spring member 10 and the higher coefficient of expansion of the mechanical system (10, 11 and 12) may contribute mutually to the compensation for stresses due to thermal changes. The first method of carrying out the invention provides the greater part of the compensation effect from the elastic properties of the spring and the remaining smaller effect from the coefficient of thermal expansion of the mechanical system referred to. In the second method of carrying out the invention, the proportion of these two effects is reversed; that is, the greater compensation effect is derived from the relatively high thermal expansion of the member 16 and the lesser effect is derived from the elasticity of the material of which 16 is composed. The relative degree to which these thermal and elastic properties function may be selected by the designer.

A third method of carrying out our invention, as illustrated in Figures 8 and 9, may be accomplished thus: An abrasive annulus 1 is provided with a metallic hub 19 to which are affixed hub flanges 20. The highly expansive material 16 is introduced as hereinbefore described between abrasive annulus 1, hub 19 and hub flanges 20. The thickness of the material 16 at locations marked M, i. e., between hub flange 20 and abrasive annulus 1, is selected according to the length of the assembly under consideration in order to counteract thermal change. The thickness of the same material at location marked Y is quite immaterial (so long as the longitudinal gripping action is not interfered with) and may be selected entirely by convenience.

It is sometimes desirable in carrying out this method of assembly to release one of the hub flanges 20 (after having positioned and allowed the material 16 to harden) and to insert a thin sheet of shim material such as .002 of an inch to .009 of an inch in thickness of steel between the end of hub 19 and hub flange 20, thereafter solidly tightening the hub flange holding screws 21. This assists not only in preventing thermal stresses but reduces the cumulative effect of any slight discrepancies in design over the range of temperatures to which the wheels are subjected such as minor inaccuracies in determining thermal expansion coefficients and slight variations in dimensions at M, etc.

The assembly just described is, of course, completed for commercial operating by mounting it in between the driving flanges 3 which are mounted upon shaft 2 in right and left-hand threaded relationship respectively, as shown at 8 in Figs. 1, 6, 8 and 10.

Figures 10 and 11 illustrate a method of mounting abrasive wheels which may be used in the art. Our invention is adapted to compensate for temperature changes when wheels are mounted in this manner. By reference to Figures 10 and 11, it may be seen that the abrasive annulus 1 is held in operating position upon shaft 2 by flanges 3 which are rotatable with the shaft due to keys 9. One flange is forced firmly against the shoulder 7 (which is rigidly assembled upon the shaft by keying, driving, shrinking, or any desired method), and the other flange is held securely against a side of the abrasive wheel by bolts made from steel or iron of the usual composition. Nuts 5 constitute means for producing the amount of flange pressure necessary when using the wheel. The wheel with flanges bolted on it is held securely against shoulder 7 by nut 6. An assembly as described requires a highly expansive material 16 under at least one flange and of a thickness calculated in conjunction with its coefficient of expansion and the respective coefficients of expansion of the abrasive material, steel shafting and bolts to counteract the differential expansion between the abrasive and the steel members. If this differential expansion is not corrected, serious flange pressures may result.

Having thus described our invention and included several different methods of carrying it out, what we claim as new and desire to secure by Letters Patent is embodied in the following claims.

We claim:

1. As an article of manufacture, an artificial abrasive wheel adapted for peripheral grinding wherein the power is transmitted from opposed driving flanges which press axially against the wheel, and wherein an annular member is disposed between one of the flanges and the wheel, said annular member having a coefficient of expansion which compensates in an axial direction for the difference between the respective thermal expansions of the wheel and of the supporting means.

2. As an article of manufacture, an artificial

abrasive wheel adapted for peripheral grinding, and driving means for said wheel comprising a shaft, a pair of opposed driving flanges mounted to turn on said shaft by right and left-hand threaded engagement respectively to hold the wheel between them, and a permanently elastic member mounted between one of said flanges and the abrasive wheel, said permanently elastic member comprising a front plate, a back plate and a plurality of corrugated springs interposed between the front plate and the back plate so that the springs extend in a general radial direction on application of increased pressure from the flanges.

3. As an article of manufacture, an artificial abrasive wheel adapted for peripheral grinding and driving means for said wheel comprising a shaft, a pair of opposed driving flanges mounted to turn on said shaft by right and left-hand threaded engagement respectively to hold the wheel between them, and a compensating annulus interposed between one of said flanges and the abrasive wheel, said annulus having such a coefficient of expansion and such dimensions that it compensates for relative changes of length in an axial direction caused by change in temperature in the shaft and abrasive wheel.

4. As an article of manufacture, an artificial abrasive wheel adapted for peripheral grinding and driving means for said wheel comprising a shaft, a pair of opposed driving flanges mounted to turn on said shaft by right and left-hand threaded engagement respectively to hold the wheel between them, and an annular member mounted between said flanges, said annular member having a coefficient of expansion at least as high as that of the driving shaft or abrasive wheel and having also a permanently elastic character whereby stresses arising from temperature changes are substantially compensated.

5. An article of manufacture comprising an artificially bonded abrasive wheel, opposed driving flanges adapted to transmit power from the driving shaft to the wheel, said flanges being mounted on said shaft by respective right and left-hand threaded engagement therewith to automatically grip the wheel as the load increases, and a permanently elastic member interposed between one of said flanges and the wheel, said member having a coefficient of expansion and a thickness which substantially compensate for the differential expansion between the driving shaft and the wheel while such member is sufficiently elastic to take care of residual differences of expansion.

6. A mounting for an abrasive wheel comprising a driving shaft, driving flanges for said wheel mounted on said shaft by respective right and left-hand threaded engagement therewith to transmit power to the wheel at opposite side contacts disposed at a substantial distance from said driving shaft, and a pressure transmitting member between at least one of said flanges and said wheel, the coefficient of expansion and the thickness of said member being such as to substantially compensate the differential expansion between the shaft and the abrasive wheel.

7. A mounting for an abrasive wheel comprising a driving shaft, driving flanges mounted on said shaft by respective right and left-hand threaded engagement therewith and transmitting power to the wheel with the aid of pressure exerted parallel to the axis of rotation, and a pressure transmitting member between at least one of said flanges and the wheel, the coefficient of expansion and the thickness of said member being such as to substantially compensate the axial differential expansion between the shaft and abrasive wheel.

8. A mounting for pulp wheels which are subjected to great extremes of temperature, said mounting comprising a driving shaft, driving flanges having respective right-handed and left-handed threaded connections with said driving shaft, a flanged annular hub member mounted in annular recesses in said driving flanges, said recesses constituting a centering device for said annular hub, a pulp wheel mounted concentrically on said annular hub, and a thermally expansive layer between said pulp wheel and said flanged hub, the thickness of the expansive layer between the hub flanges and the wheel sides being sufficient in relation to its expansion coefficient to substantially compensate for the differential expansion between the driving shaft and pulp wheel measured in a direction parallel to the axis of the shaft.

9. An abrasive wheel assembly for supporting and driving an abrasive annulus by means of lateral flanges, said assembly comprising a driving shaft provided on one side of the wheel with right-hand threads and on the opposite side with left-hand threads, a pair of correspondingly threaded driving flanges mounted on the threaded portions of the driving shaft, an abrasive annulus supported in both radial and axial directions by said driving flanges, and permanently elastic means for compensating between the axial expansions of said shaft and abrasive annulus, said means comprising a pair of plates inserted between one side of the abrasive annulus and its adjacent driving flange, the two plates being provided with interlocking lugs for the transmission of torque while permitting relative axial movement of the plates, and corrugated springs radially disposed between the plates to resist axial pressure exerted by the flanges on the sides of the abrasive wheel.

10. An abrasive wheel assembly comprising an abrasive annulus, right and left-hand threaded driving flanges mounted to turn on a correspondingly threaded driving shaft for transmitting power to said abrasive annulus by means of side contacts, and a compensating annular member interposed between at least one of said flanges and the abrasive annulus to compensate for differences between the axial expansions of said shaft and abrasive annulus respectively, said compensating annular member having a high coefficient of thermal expansion relative to that of the abrasive annulus and an axial dimension determined from its coefficient of expansion and those of the driving shaft and abrasive annulus to substantially compensate for temperature changes of the order of one hundred degrees centigrade, said compensating annular member being composed of one or more of the group of materials including synthetic resins and sulphur mixtures.

11. An abrasive wheel assembly comprising an abrasive annulus, right and left-hand threaded driving flanges mounted to turn on a correspondingly threaded driving shaft and to transmit power to the abrasive annulus with the aid of axial pressure, and a compensating annular member disposed between at least one of said flanges and the abrasive annulus and having an axial length and a coefficient of expansion of such magnitudes as to substantially compensate for differences of expansion between said driv-

ing shaft and said abrasive annulus, said compensating annular member being composed mainly of sulphur.

12. An abrasive wheel assembly comprising an abrasive annulus, right and left-hand threaded driving flanges mounted to turn on a correspondingly threaded driving shaft for transmitting power to the abrasive annulus with the aid of axial pressure, and a compensating annular member disposed between at least one of said flanges and the abrasive annulus and having an axial length and coefficient of expansion of such magnitudes as to substantially compensate for differences of expansion between said driving shaft and said abrasive annulus, said compensating annular member being composed mainly of a synthetic resin which has been hardened in situ.

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