United States Patent [19]

Sunnen

[11] **3,800,482**

[45] **Apr. 2, 1974**

[54] **HONING MANDREL WITH ERROR COMPENSATION MEANS**

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[22] Filed: **July 31, 1972**

[21] Appl. No.: **276,858**

[52] **U.S. Cl.** **51/339,** 51/351
[51] **Int. Cl.** **B24b 9/02**
[58] **Field of Search** 51/331, 338, 339, 340, 51/342, 343, 344, 345, 346, 350, 351

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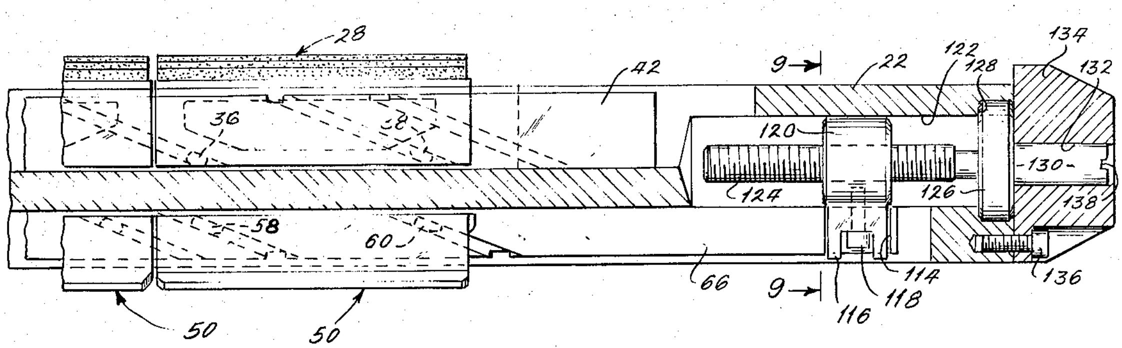
[57] **ABSTRACT**

A multiple stone, multiple guide shoe honing mandrel particularly suitable for honing long bores and bores formed by spaced surface portions including honing a plurality of aligned surfaces such as the aligned main bearing surfaces on engine blocks and the like, said mandrel having provision for spaced rows of honing stone and guide shoe assemblies all of which are adjustable radially to change the operating honing diameter thereof, the means for adjusting the radial positions of the stone assemblies being located for adjustment at the opposite end of the mandrel with respect to the means for adjusting the radial positions of the guide shoe assemblies to compensate for expansion and contraction of the said assemblies due to temperature changes, material growth and for other reasons.

18 Claims, 16 Drawing Figures



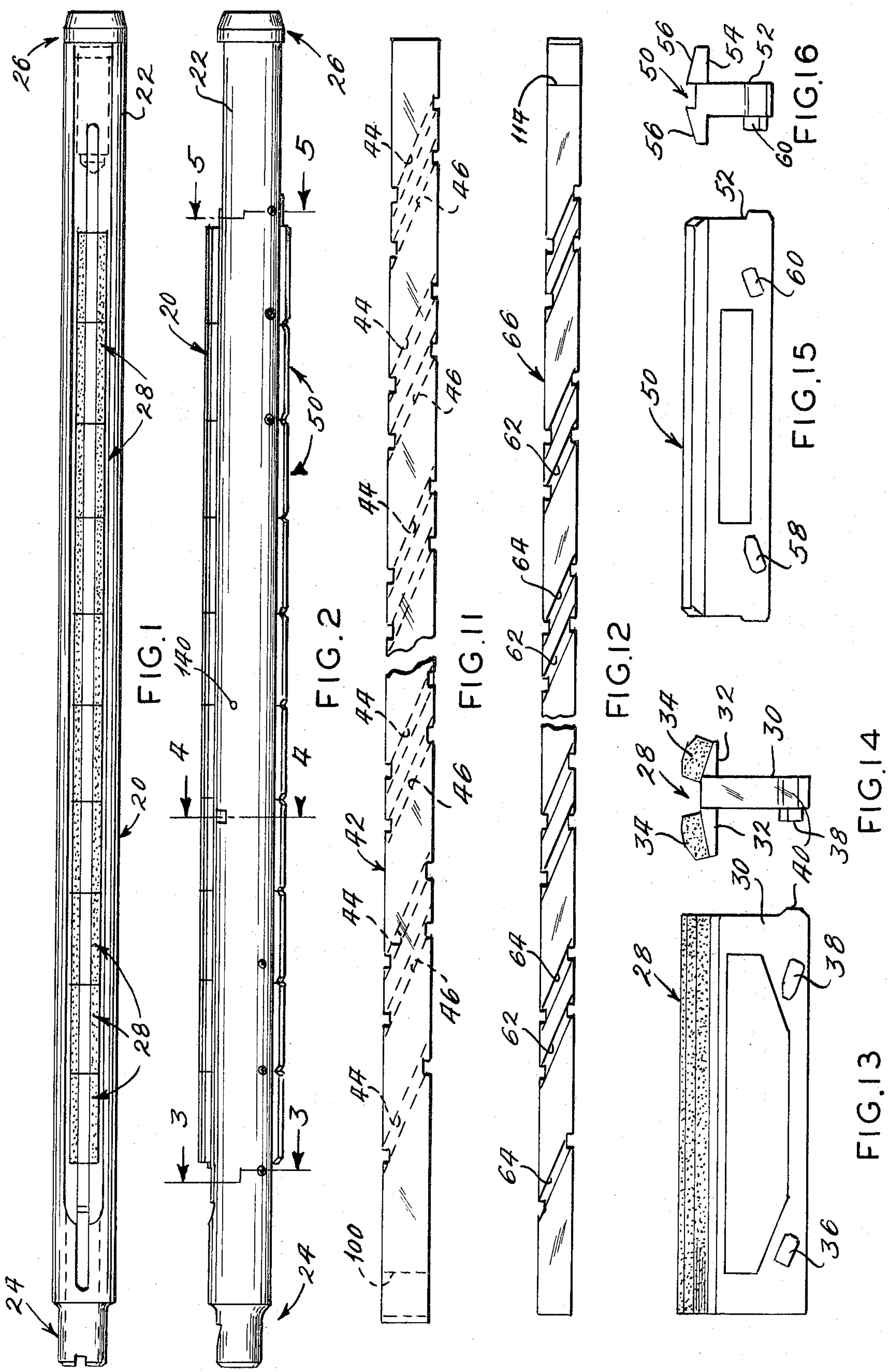


FIG.1
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FIG.16

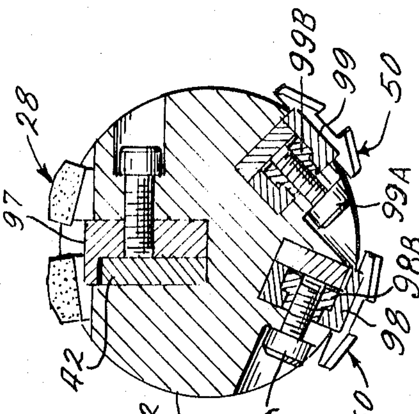

FIG.5

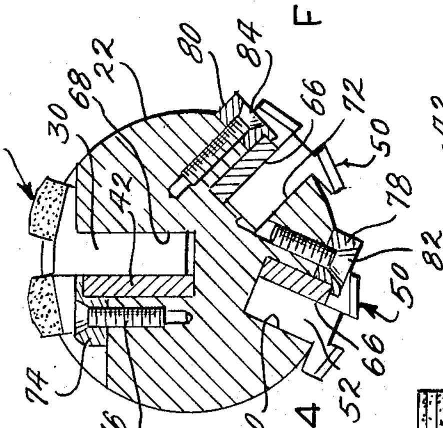

FIG.4

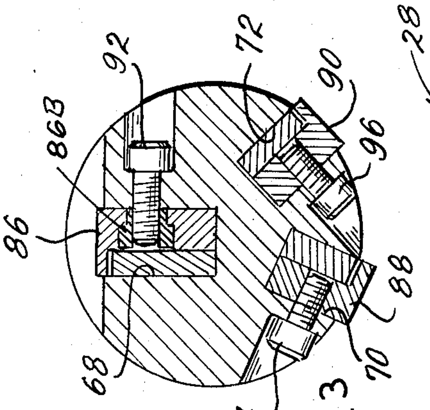

FIG.3

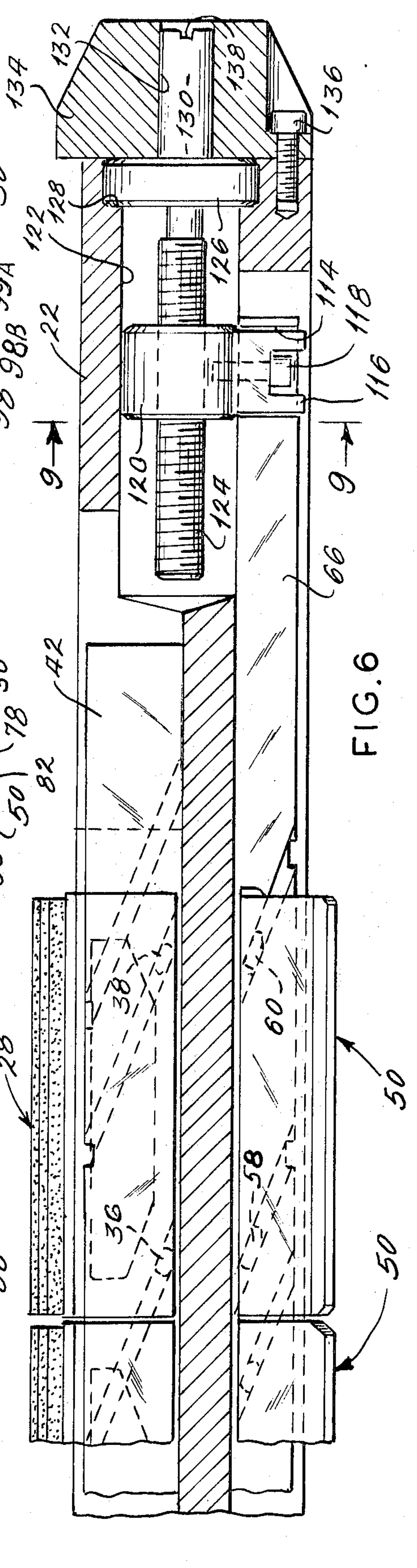

FIG.6

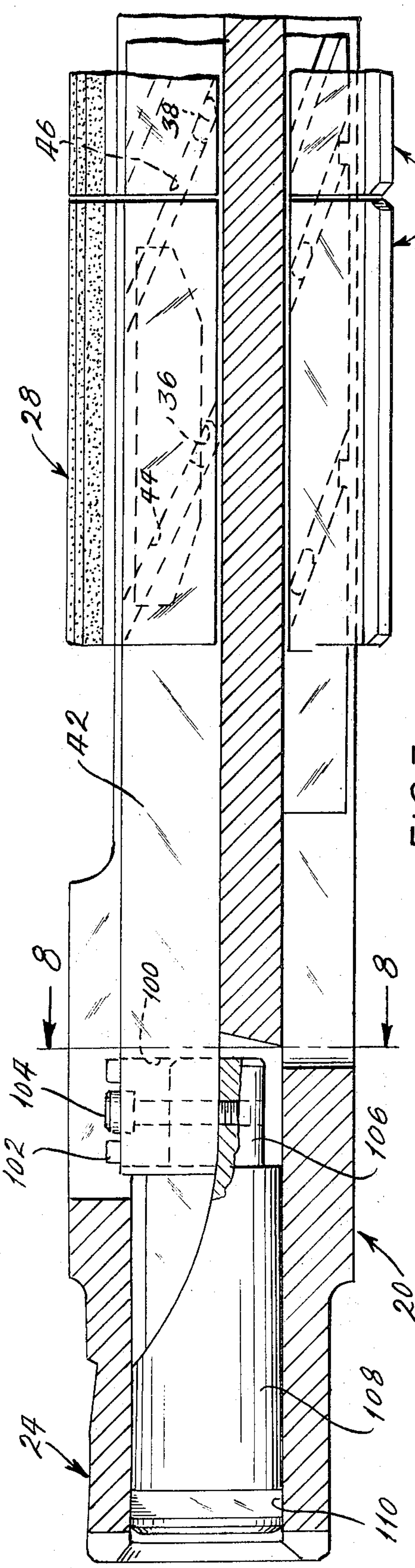

FIG.7

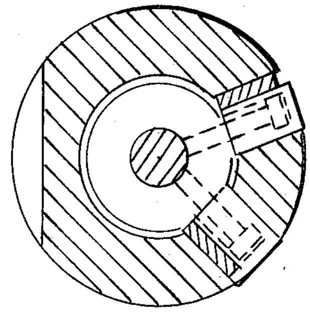
FIG.9

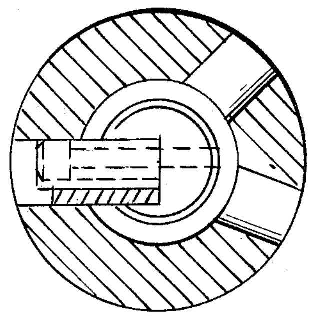
FIG.8

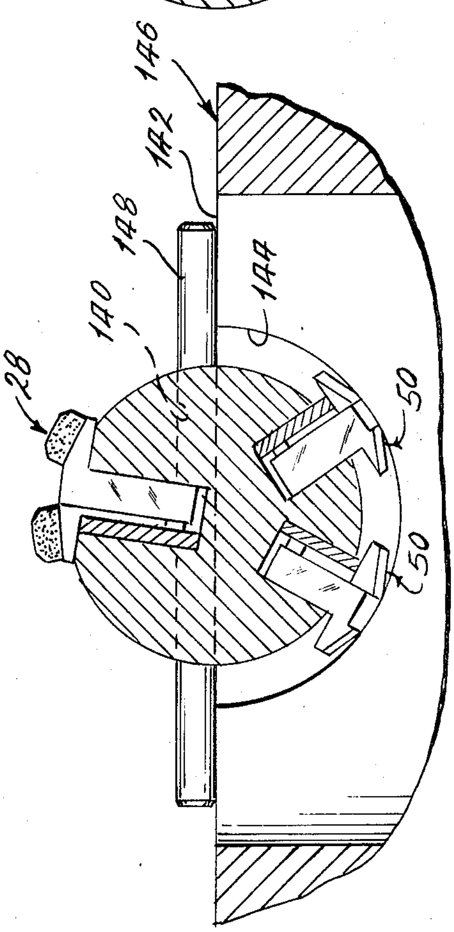

FIG.10

HONING MANDREL WITH ERROR COMPENSATION MEANS

There are in existence many different honing mandrel constructions that employ multiple aligned stone assemblies and multiple aligned guide shoe assemblies including some mandrels that have the aligned stone and guide shoe assemblies located on different sides thereof. In all of the known constructions, however, either the guide shoes have not been radially adjustable or they have been adjusted by means which are controlled from the same end of the mandrel and in consort with means that adjust the radial positions of the stone assemblies. For the most part, the known constructions have also used cam or cam type wedge means to radially advance or retract the stones and/or the guide shoes but all such devices are controlled by means located at one end of the mandrel such as by means operated from the honing machine itself. In the known constructions where the stone assemblies and the guide shoe assemblies are positioned in end-to-end abutment in respective grooves formed in the mandrel, endwise expansion or contraction of the same assemblies due to temperature change, material growth and/or otherwise effects a change in the overall longitudinal dimension of the respective aligned assemblies. The number and the lengths of the assemblies involved determines the overall amount of expansion and contraction that occurs. For example, if each individual assembly expands by about the same amount, then the total expansion will be cumulative and will depend on the number of aligned assemblies involved. In the typical mandrel construction as indicated, the means for adjusting the radial positions of the stones and guides include longitudinally movable wedge members that have spaced cam surfaces or grooves which cooperate with means on the assemblies. Usually the expansion or contraction of the wedge member differs somewhat from the overall expanson and contraction of the associated assemblies it adjusts. Therefore, if one end of each row of assemblies to be adjusted is fixed on the mandrel, then as expansion or contraction of the assemblies occurs, the work engaging surfaces of the assemblies will become somewhat angularly related to the axis of the mandrel rather than remaining parallel thereto. Also, the effect is cumulative causing the endmost stones or shoes at one end of the mandrel to be considerably higher or lower radially than the stones, or shoes at the opposite end of the mandrel. If the wedge members used for adjusting the stone and guide shoe assemblies are oriented the same, and constructed to be operated and controlled by means located at the same end of the mandrel, then the effects of expansion and contraction for the stone and the guide shoe assemblies will be cumulative. That is, the errors produced by expansion or contraction of the stone assemblies will add to the errors resulting from expansion or contraction of the guide shoe assemblies, and the combined effect will be to double or substantially double the amount of honing error that is produced from end-to-end of the mandrel.

The present mandrel construction overcomes these and other imperfections and errors produced by existing multi-stone, multi-guide mandrels, and particularly in relatively long multiple stone, multiple guide shoe mandrels such as are used to simultaneously hone all of the bearing surfaces associated with main bearing assemblies on engine blocks and other like devices. To accomplish this, one of the endmost stone assemblies on the subject mandrel is positioned against a fixed stop so that all endwise expansion and contraction of the stone assemblies on the subject mandrel is relative to the same fixed stop and to each other. In other words, all expansion and contraction of the stone assemblies is either toward or away from the stop. The radial positions of the stone assemblies is under control of wedge means which are operated by means that attach one end to adjustment means on the honing machine. On the other hand, the fixed stops for the one or more rows of aligned guide shoe assemblies are located at or near the opposite end of the mandrel from the fixed stop for the stones, and the wedge means for adjusting the radial positions of the guide shoe assemblies are effectively oppositely oriented relative to the wedge means for the stone assemblies and are under control of adjustment means located at the opposite or free end of the mandrel. This means that the effect of expansion and contraction of the stone assemblies is in an opposite direction from the effects of expansion and contraction of the guide shoe assemblies, and also oppositely controlled, so that any errors that might otherwise be introduced due to expansion or contraction is compensated for or neutralized in the present mandrel. With the present construction, therefore, it is possible to hone much more nearly perfectly aligned bearing surfaces all of the same size or diameter and in a single continuous operation. As indicated above, this is especially desirable when honing long bore surfaces and surfaces formed by spaced aligned surface portions such as the spaced main bearing surfaces on an engine block.

It is therefore a principal object of the present invention to provide means for more accurately honing long bore surfaces and spaced aligned cylindrical surfaces to the same final diameter and in a continuous and uninterrupted operation.

Another object is to teach the construction and operation of a multiple stone, multiple guide mandrel construction which has means to compensate for errors due to expansion and contraction of the parts.

Another object is to compensate for errors in honing mandrels and like devices by adjusting the stone and guide assemblies using means operable from opposite ends of the mandrel.

Another object is to provide means for more accurately adjusting the operating positions of the work engaging members on a honing mandrel or like device.

Another object is to provide improved means for centering a honing mandrel having work engaging stones and guide shoes in a bore to be honed and improved means to compensate for unequal wear of the work engaging elements.

Another object is to provide means to neutralize the effects of expansion and contraction of the work engagement elements on a honing mandrel.

Another object is to provide an elongated multiple stone, multiple guide shoe honing mandrel which is of relatively simple construction and can be accurately operated even by persons having relatively little skill and training.

Another object is to provide means to make all of the main bearing surfaces on an engine block or like device more nearly identical in size and more accurately in alignment with each other.

Another object is to provide a special purpose honing mandrel which can be operated by means of a relatively simple handgrip type power source.

Another object is to make the movable parts of an engine more freely rotatable relative to the fixed parts.

Another object is to provide means for accurately preadjusting the radial positions of the work engaging elements of a honing mandrel before proceeding to hone.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specification which discloses a preferred embodiment of the subject mandrel in conjunction with the accompanying drawings, wherein:

FIG. 1 is a plan view of a honing mandrel constructed according to the present invention;

FIG. 2 is a side view of the mandrel of FIG. 1;

FIG. 3 is a cross-sectional view taken on line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view taken on line 4—4 of FIG. 2;

FIG. 5 is a cross-sectional view taken on line 5—5 of FIG. 2;

FIGS. 6 and 7 are enlarged cross-sectional views taken on the axis of the mandrel of FIGS. 1 and 2, FIG. 6 showing a portion adjacent to the free end thereof, and FIG. 7 showing a portion adjacent to the end of the mandrel that is attached to a power source or honing machine;

FIG. 8 is a cross-sectional view taken on line 8—8 of FIG. 7;

FIG. 9 is a cross-sectional view taken on line 9—9 of FIG. 6;

FIG. 10 is a cross-sectional view taken near the center of the subject mandrel and showing the mandrel positioned on the lower half of a bearing surface to be honed and in position to adjust the radial locations of the guide assemblies;

FIG. 11 is an enlarged side view of the wedge assembly used for adjusting the radial positions of the stone assemblies;

FIG. 12 is a side view of the wedge assembly used for adjusting the radial positions of guide assemblies;

FIG. 13 is a side view showing one of the stone assemblies used on the subject mandrel;

FIG. 14 is a right end view of the stone assembly of FIG. 13;

FIG. 15 is a side view of one of the guide assemblies used on the subject mandrel; and,

FIG. 16 is a right end view of the guide assembly of FIG. 15.

Referring to the drawings more particularly by reference numbers, number **20** in FIGS. **1** and **2** refers to an elongated honing mandrel constructed according to the present invention. The mandrel **20** includes an elongated body portion **22** which is constructed of a suitable material such as steel or aluminum. The left end portion **24** of the mandrel **20** as shown is constructed to cooperate with a power source or with means on a honing machine, and the opposite or free end portion **26** is to extend into the work to be honed. During operation, the mandrel **20** is rotated about its axis and is also reciprocated axially in the work so that it will hone all portions of the work surface or surfaces. It should be understood that the mandrel is initially adjusted to a desired operating condition which is a condition in which all of the work engaging elements on the mandrel engage or almost engage the work surfaces. Thereafter, during honing the work engaging elements or at least some of them, usually the stone assemblies, are advanced radially outwardly under pressure to maintain all of the work engaging elements continuously operatively engaged with the work. This condition is maintained until the work surface has been honed to some final desired size.

Again referring to FIG. **1**, it is seen that the mandrel **20** is constructed to accommodate a plurality of similar aligned stone assemblies **28** on one side thereof. The structural details of a typical stone assembly **28** are shown in FIGS. **13** and **14** where the assembly **28** is shown as including a backing portion **30** which includes integrally spaced upper portions or shelves **32** each of which has attached to it a similar work engaging stone member **34**. The stones **34** are shown positioned in spaced parallel relationship on the assembly **28**, and when a plurality of the assemblies **28** are mounted in alignment on the mandrel **20**, as shown, there will be two spaced rows of the stones **34** extending along most of the length of the mandrel with the backing portions **30** extending into the body of the mandrel for support. The backing portion **30** of the stone assembly **28** shown in FIG. **13** is provided with two sidewardly extending and angularly related cam portions **36** and **38** and these portions cooperate with adjustment means which are provided to adjust the radial positions of the stone assemblies as will be explained.

Each of the backing portions **30** of the stone assemblies is also provided with a relatively narrow endwardly extending portion **40** on one or both opposite ends thereof. The portions **40** may be somewhat exaggerated in size as shown in FIG. **13**, and these portions are very accurately machined during construction of the assemblies, and after the assemblies have been aged, in order to make the overall length of each stone assembly as accurate dimensionally as possible. This is done so that when a plurality of similar stone assemblies **28** are installed in alignment on the mandrel **20** their combined overall length end-to-end on the mandrel will be as accurately predetermined as possible. Even with this precaution, however, some changes in length will occur with changes in temperature and to some extent also due to material growth which is a recognized phenomenon. This length change may produce significant honing errors especially as the length of the mandrel and the number and the length of the stone assemblies increases. The material used in the construction of the backing portions **30** of the stone assemblies must also be taken into account in this regard. These dimensional changes must be dealt with, and if possible, compensated for, if the subject mandrel is to be able to accurately hone true cylindrical surfaces and especially long bore surfaces or bores formed by spaced cylindrical surface portions arranged over a relatively long distance. A typical example of where such surfaces exist and need to be accurately honed precisely to the same dimensional accuracy are the spaced surfaces which form the main bearing surfaces on engine blocks and like devices. Only when all of these surfaces are honed to the same final dimension and are in alignment will the best operating condition of the engine be achieved. Furthermore, as already noted, any longitudinal expansion or contraction of the aligned stone assemblies **28** used on the present mandrel will be cumulative and will produce the greatest errors between locations at opposite ends of the surfaces being honed. That is to say, if 10 aligned stone assemblies are installed in end-to-end abutment on the mandrel, then any expansion or contraction of the individual assemblies will be multiplied by the number of such assemblies. For example, if each assembly were to expand a thousandth of an inch, then 10 aligned assemblies will expand 10 one-thousandths of an inch, and as will be explained, if all of the aligned assemblies are adjusted by moving the same adjustment member, and assuming the adjustment member expands or contracts at a different amount or not at all as compared to the stone assemblies, the effect will be to cause the stone assembly at one end of the assembly to project radially outwardly a further distance on the mandrel relative to the mandrel axis than the stone assembly at the opposite end of the mandrel. The inbetween stone assemblies will then be expected to vary in their radial positions more or less linearly from end-to end. If this condition is not compensated for in some way the mandrel will hone unequal sized surfaces on the different portions of the work. This is highly undesirable and results in finally honed members in which it is difficult, if not impossible, to install freely rotatable members such as the rotatable members of an engine which are supported for rotation on the main bearing surfaces. The present mandrel includes provisions to overcome these and other disadvantages and to make it possible to hone almost perfect cylindrical surfaces even when the surfaces are relatively long or are formed by relatively widely spaced portions, and it does so by making all portions being honed in perfect axial alignment. It also achieves these results in a single continuous and uninterrupted operation.

FIG. 11 shows an elongated wedge member **42** having a plurality of spaced and angularly related grooves **44** and **46** formed along one side thereof. Each adjacent pair of grooves **44** and **46** are positioned to cooperatively engage the sidewardly projecting cam portions **36** and **38**, respectively on one of the stone assemblies **28**. In other words, when the wedge **42** and the stone assemblies **28** are positioned in a mandrel groove provided therefor as will be explained, each of the aligned stone assemblies will cooperate with an adjacent pair of the grooves **44** and **46** along the length of the mandrel, and the adjacent stone assemblies will also be in end-to-end abutting relationship. If the aligned stone assemblies expand or contract longitudinally, and the cumulative amount of the expansion or contraction is different from the elongation or contraction of the wedge member **42** used to adjust their radial positions, then the sidewardly projecting cam portions **36** and **38** on certain of the assemblies will place them at different radial positions of adjustment relative to the other assemblies and to the axis of the mandrel. The effect of this will be cumulative from one end of the mandrel to the other as already stated so that the greatest difference in the radial positions of individual stone assemblies should be expected to be between the two opposite end stone assemblies. Similar conditions may also exist with respect to the guide assemblies used on the subject mandrel, as will be explained, and this fact is made use of on the subject mandrel by having the effect of the expansion and contraction of the guides take place in the opposite direction from the stone assemblies.

FIGS. **2, 4** and **5** show that the subject mandrel **20** also has two rows of similar aligned guide shoe assemblies **50.** The structural details of a typical guide assembly are shown in FIGS. **15** and **16.** The guide assemblies **50** are somewhat similar in construction to the stone assemblies **28** including each being formed with a backing portion **52,** an integral cross-portion or shelf **54,** and a pair of work engaging shoe portions **56** attached to or integral with respective opposite sides of the shelf portion **54.** Each of the shoe assemblies **50** also has a pair of spaced sidewardly extending cam portions **58** and **60** which are located near opposite ends thereof in positions to engage spaced grooves **62** and **64,** respectively formed in another adjustment member or wedge **66,** one of which is provided for adjusting each row of the guide assemblies. FIGS. **4** and **5** show that there are positions on the mandrel **20** for two similar rows of guide shoe assemblies **50,** which rows are positioned near the opposite side of the mandrel from where the row of stone assemblies **28** is located. The stone assemblies **28** and their associated wedge member **42** are positioned in a mandrel groove **68,** and the guide assemblies **50** and their associated wedges **66** are positioned in other mandrel grooves **70** and **72.** The wedge member **42** associated with the stone assemblies **28** is held in position in the groove **68** by means of one or more retaining members **74** and associated threaded members **76** which are attached to the mandrel (FIG. **4**) in a manner to permit free sliding longitudinal movement of the wedge **42** in order to adjust the radial positions of the stone assemblies. In like manner, the wedge members **66** are held in place in their respective mandrel grooves **70** and **72** by other retaining members **78** and **80** and associated screws **82** and **84** (FIG. **4**).

FIG. **3** is a cross-sectional view taken on the mandrel at a location that is beyond the ends of the leftmost stone and guide assemblies as shown in FIGS. **1** and **2.** This figure shows the provision of other members **86, 88** and **90** which are attached to the mandrel in the respective mandrel grooves **68, 70** and **72** by associated screws or threaded members **92, 94** and **96.** These members form stops for abutting the ends of the respective rows of assemblies **28** and **50,** and are also included to retain the wedges in the mandrel grooves while at the same time enabling free sliding longitudinal adjustments thereof.

FIG. **5** is a cross-sectional view taken at a location beyond the opposite or right ends of the stone and guide assemblies, and is included to show the corresponding opposite stop members **97, 98** and **99** abutting the opposite ends of the rows of assemblies **28** and **50** and for retaining and supporting the associated wedge members in their respective grooves while permitting relatively free sliding longitudinal movements thereof.

In the preferred construction shown in the drawings, the members **88, 90** and **97** are fixedly attached to the mandrel in their respective grooves and are not movable or adjustable longitudinally. The members **86, 98** and **99,** on the other hand, are adjustable to a limited extent in their respective mandrel grooves to accommodate some variation in the lengths of the assemblies **28** and **50.** This is accomplished by loosening threaded members **92, 98**A and **99**A which are engaged respectively with locking members **86**B, **98**B and **99**B. These locking members have sidewardly extending portions which cooperate with engaged openings or grooves formed in the members **86, 98** and **99.** When loosened, the said members are moved against the respective ends of the rows of assemblies and held under finger pressure thereagainst while tightened to hold the assemblies in an initial abutting condition. Thereafter, during operation of the mandrel these members remain fixed but do not interfere with normal adjustment. Even when initially set, however, the dimension of the assemblies may cause them to engage the associated wedge members in such a manner as to introduce error due to variations in their radial positions as aforesaid. Bear in mind, however, that the non-adjustable fixed stop **97** for the stone assemblies is at the opposite end of the mandrel from the non-adjustable fixed stops **88** and **90** for the guide shoe assemblies, and this is important to the construction because it is this feature which when the adjustable stops are set, cancels out or neutralizes errors caused by variations in the lengths of the assemblies due to expansion and contraction thereof.

FIG. **7** shows in enlarged detail the left end portion of the mandrel **20** including the adjustment or wedge member **42.** The left end of the wedge **42** extends beyond the end of the leftmost stone assembly **28,** and the wedge **42** is shown provided near its left end with a transverse groove **100** (FIGS. **7** and **11**). This groove cooperates with a member **102** that is attached by threaded member **104** to an end portion **106** of an operator member **108.** The member **108** is positioned for sliding movement in a cylindrical bore **110** formed in the left end portion **24** of the mandrel **20,** and means external of the subject mandrel are connected to the member **108** to move it axially in the mandrel bore **110** during honing in order to adjust the radial positions of the stone assemblies and keep them engaged with the work. Also, when the member **108** and the attached wedge **42** are moved to the right as shown in FIG. **7** the stone assemblies will be expanded radially outwardly on the mandrel by the interaction between the sidewardly extending cam portions **36** and **38** on the stone assemblies and the respective grooves **44** and **46** in the wedge member **42.** This is the usual situation during a honing operation. When the same members are moved to the left, the stone assemblies will be retracted radially on the mandrel.

FIG. **6** is a sectional view taken through the opposite end of the mandrel **20** and shows the corresponding opposite or free end of the stone adjustment member **42.** FIG. **6** is also included to illustrate the means employed for adjusting the radial positions of the guide assemblies **50.** As explained above, each row of the guide assemblies is provided with its own adjustment member or wedge **66** and these are mounted to be moved longitudinally in respective mandrel grooves. The right end of each of the adjustment members **66** is provided with a transverse slot or groove **114,** and these grooves cooperate with respective members **116** provided for attaching them to adjustment means. The attaching members **116** have portions that extend into and cooperate with the grooves **114,** and they have other portions which receive threaded members **118** used for attaching them to a cylindrical member **120.** The cylindrical member **120** is positioned to be moved in a cylindrical bore **122** formed in the associated end of the mandrel body **22,** and the member **120** also threadedly cooperates with a threaded adjustment member **124** as clearly shown. The threaded member **124** is fixedly connected to a larger diameter cylindrical portion **126** which is constructed and positioned to rotate, but not to move axially, in a groove **128** formed at the end of the mandrel body portion **22.** The member **124** and the cylindrical portion **126** are also connected to an endwardly extending portion **130** that extends into a bore **132** formed in a mandrel end cap **134** which is connected to the end of the mandrel body **22** by means of one or more screws **136.** The end surface of the portion **130** is provided with a screwdriver or like slot **138** so that when a screwdriver or other similar tool is positioned in engagement therewith and rotated, it will rotate the threaded member **124** but without permitting the threaded portion to move longitudinally because of the cooperation between the portion **126** and the annular groove **128** in which it is positioned. Rotation of the threaded member **124** therefore produces longitudinal movement of the member **120** and of the attaching members attached thereto including the members **116** and the wedges **66.** As in the case of the stone assemblies, this causes all of the guide shoe assemblies **50** to move radially outwardly or inwardly depending upon the direction of the rotation of the member **124.** In the usual situation the positions of the guide shoe assemblies are present or adjusted initially before a honing operation or before a series of honing operations, and ordinarily they do not need to be readjusted or reset until some later time after completion of a number of honing operations when the shoes begin to show wear. This is because the guide shoes usually wear much slower than the stones, and therefore do not require nearly as frequent adjustment, unless of course, the honing diameter is to be changed so that the mandrel can hone at a different diameter altogether.

When the subject mandrel is to be used to hone the aligned surfaces of a main bearing assembly, it hones all of the bearing surfaces simultaneously in a continuous opration as already stated, in which case it is important to initially adjust the radial positions of the guide shoe assemblies **50** so that the mandrel will be centered in the work. Each of the bearing surfaces to be honed in this case is usually formed by two semi-cylindrical portions located on different parts of the engine block. In order to set up to hone such surfaces the two parts of the block are separated from each other as by removing the upper block portion. With the lower halves of the bearing surfaces now exposed, the subject mandrel is rested in the position as shown in FIG. **10** of the drawings. In this position, the guide shoe assemblies **50** are facing downwardly and are resting on the bearing surfaces, and the stone assemblies **28** are extending upwardly. Special means are provided on the mandrel for adjusting the initial setting positions of the guides. These means include a transverse hole **140** (FIGS. **2** and **10**) which extends through the mandrel at a central location along the length thereof. The hole **140** is oriented to be at a right angle to an imaginary plane located on the bisector of the angle formed by radii which extend through the centers of the rows of aligned shoe assemblies **50.** The lower side of the hole **140** as shown should also be on or as near as possible to a diameter of the mandrel.

A rod member **148** which is longer than the diameter of the mandrel is positioned in the hole **140** and its opposite ends extend from both opposite ends of the hole **140.** The end portions of the rod **148** are then positioned to extend over a portion **142** of the engine block **146** which is at a location where there is a bearing surface to be hone. It is important that the lower side of the hole 140 and of the rod 148 be located on a diameter of the mandrel so that when the mandrel is in the position described, accurate adjustment of the radial positions of the guide assemblies 50 can be made. This is done by rotating the member 124 using a screwdriver or like tool which is engaged in the slot 138. This adjusts the radial positions of the guide shoes which are adjusted so that they just engage with all of the similar diameter bearing surfaces 144 along the length of the mandrel. If the shoes are adjusted to extend radially outwardly too far on the mandrel they will cause the center of the mandrel to be too high above the portions 144, and it will then be possible to rotate the mandrel a certain amount about its axis between positions in which the opposite ends of the rod 148 engage the spaced upper surfaces 142 on the opposite sides thereof. On the other hand, if the guide shoes are adjusted to be too far retracted on the mandrel then the entire weight of the mandrel will be supported by the ends of the rod 148, and it will be possible to tilt or rock the mandrel on the rod 148. The proper adjustment and best honing condition is obtained when the radial positions of the shoes are such that the mandrel can neither be rotated or tilted. This condition is relatively easily obtained to a high degree of accuracy even by persons having relatively little skill and training. When this condition has been achieved, the rod 148 is removed from the hole 140 and the upper half of the engine block is set in place and attached before honing is commenced. This is preferably done with the stone assemblies 28 in retracted positions. Thereafter, during a honing operation the mandrel is rotated and reciprocated and the stone assemblies 28 are simultaneously advanced radially outwardly under pressure to maintain all of the assemblies 28 and 50 engaged with the work and to simultaneously and continuously hone the entire surface or surfaces until they have reached some desired final size and smoothness.

In the smaller diameter sizes of the subject mandrel there may not be enough room between the mandrel grooves to accommodate a hole such as the hole 140 which extends entirely through the mandrel. In these cases, two aligned counterbores and two separate pin pieces, one pin piece extending from each opposite side of the mandrel, can be used for the same purposes.

In the usual situation, the stone assemblies will wear relatively much faster than the guide assemblies and therefore will need more frequent replacement. However, after a certain amount of work has been done, the guides will also wear and this may necessitate periodic further adjustment and/or replacement of the guides to maintain the best possible operation conditions.

The subject mandrel has many possible applications and uses in addition to being used to hone main bearing surfaces including especially any use where it is desired to hone relatively long bores. In fact, it can be used to accurately hone any long bore surface whether it is formed by a single surface or by a plurality of spaced and aligned surface portions. Bearing and other types of surfaces honed in this manner are much more nearly perfect cylinders and provide much smoother and freer operation especially between the honed surfaces and another member that is to be supported for rotation therein than are surfaces formed by any other known means. Furthermore, and importantly, the subject mandrel can be operated on or in conjunction with known and existing honing machines and it can also be operated by other even simpler means such as by means of a relatively simple hand grip type tool. In either case, the control means must include means to rotate the mandrel as well as means to advance the stone assemblies under pressure to keep their work engaging members engaged with the work. There are in existence known universal connection and adapter means which can be used for these purposes. The subject mandrel can be operated in a horizontal, vertical or at any other angle, and relatively little skill and training is required for an operator to be able to use the subject mandrel with a high degrees of precision and accuracy.

Thus there has been shown and described a novel honing mandrel construction which has error compensation means and means for adjustment thereof which fulfill all of the objects and advantages sought therefor. Many changes, modifications, alterations, variations, and other uses and applications of the subject mandrel will, however, become apparent to those skilled in the art after considering this specification and the accompanying drawings. All such changes, modifications, alterations, variations, and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the claims which follow.

What is claimed is:

1. A honing mandrel for honing elongated cylindrical surfaces comprising an elongated mandrel body having an axis and spaced support means located adjacent to opposite sides thereof, a plurality of honing assemblies each having an abrasive work engaging portion and a support portion for cooperating with the mandrel supporting means, said honing assemblies being located adjacent the support means on one side of the mandrel body, a plurality of guide assemblies each having a work engaging portion and a backing portion for cooperating with the support means on the opposite side of the mandrel body, separate adjustment members for radially positioning the honing assemblies and the guide assemblies on the mandrel body, each of said separate adjustment members having a separate surface portion associated with each assembly to be radially positioned thereby, said surface portions on each of said adjustment members being parallel to each other and acutely angularly related to the axis of the mandrel, and each of said assemblies having a surface thereon oriented to be in surface-to-surface slidable engagement with the respective surface portions on the associated adjustment member, the surface portions on the adjustment member associated with the honing assemblies being effectively oppositely angularly oriented with respect to the axis of the mandrel relative to the surface portions on the adjustment member associated with the guide assemblies.

2. The honing mandrel defined in claim 1 wherein said honing assemblies and said guide assemblies are positioned on the mandrel in spaced rows of aligned assemblies, and stop means on the mandrel against which opposite ends of the said rows abut so that any longitudinal expansion and contraction of the honing assemblies will take place in an opposite direction on the mandrel relative respectively to any longitudinal expansion and contraction of the guide assemblies.

3. The honing mandrel defined in claim 1 including means on the different respective separate adjustment members adjacent to opposite ends of the mandrel

adapted for connection to means used to control the positions thereof.

4. The honing mandrel defined in claim 1 wherein said plurality of guide assemblies are arranged in at least two parallel rows of aligned guide assemblies on the mandrel, a similar adjustment member being provided for each of said rows, and means coupling said similar adjustment members for movement in concert.

5. The mandrel defined in claim 1 including threaded means operatively connected to one end of at least one of said separate adjustment members, said threaded means being adjustable to control the longitudinal position of the said adjustment member on the mandrel.

6. The honing mandrel defined in claim 1 wherein said adjustment members are elongated members having a plurality of spaced grooves formed in one side thereof, each of said honing and guide assemblies having sidewardly engaging projections cooperatively engageable with respective ones of said grooves in the associated adjustment member.

7. The honing mandrel defined in claim 1 including means to retain said honing and said guide assemblies and the associated separate adjustment members on the mandrel, said retaining means permitting longitudinal movement of the adjustment members on the mandrel.

8. The honing mandrel defined in claim 1 wherein each of said honing assemblies has a pair of spaced parallel abrasive work engaging portions, and each of said guide assemblies has a pair of parallel work enging guide shoe portions.

9. A honing mandrel comprising an elongated body to be rotated about an axis parallel to its longitudinal dimension, a plurality of work engaging stone assemblies, means on one side of the body for mounting said stone assemblies in aligned end-to-end abutting condition, an adjustment member mounted for longitudinal movement on said body adjacent to said stone assemblies, said adjustment member and each of said stone assemblies having mutually engageable portions which cooperate during longitudinal movements of said adjustment member to move the stone assemblies radially on the body, means forming a fixed stop on the mandrel body near one end thereof against which one end of the row of aligned stone assemblies abuts so that any dimensional change that occurs in the length of the said assemblies takes place toward and away from said fixed stop, means associated with said one end of the mandrel body engageable with the adjustment member to effect longitudinal movements thereof, a plurality of other work engaging assemblies, means on the mandrel body for mounting said other assemblies in at least one other row of aligned assemblies and at a location on the mandrel body in opposed relationship to the aligned stone assemblies, a second adjustment member mounted for longitudinal movement on the mandrel body adjacent to said other row of aligned assemblies, said second adjustment member and each of said other assemblies having mutually engageable portions which cooperate during longitudinal movements of said second adjustment member to move said other assemblies radially on the body, means forming a second fixed stop on the mandrel against which one end of the row of said other assemblies abuts, said second fixed stop being located adjacent to the opposite end of the mandrel body from the fixed stop associated with the stone assemblies, and other means on the mandrel body for moving said second adjustment member to radially reposition the said other assemblies, said means for moving the adjustment member associated with the stone assemblies being controlled from the opposite end of the mandrel body relative to said other means for moving the second adjustment member.

10. The honing mandrel defined in claim 9 wherein said other assemblies are arranged in two parallel rows of aligned assemblies on said mandrel body, each of said rows having an associated second adjustment member and means on the mandrel forming a fixed stop.

11. The honing mandrel defined in claim 9 wherein said cooperative means on said stone assemblies and on said adjustment member include cam means defined by engaged relatively movable surfaces oriented at an acute angle relative to the longitudinal dimension of the mandrel.

12. The honing mandrel defined in claim 11 wherein said cooperating means on said other assemblies and on said second adjustment member include cam means defined by engaged relatively movable surfaces, the engaged cam surfaces associated with said other assemblies being effectively oppositely acutely angularly oriented relative to the longitudinal dimension of the mandrel as compared to the engaged cam surfaces associated with the stone assemblies.

13. The honing mandrel defined in claim 9 including means for establishing an initial operating centerline for the mandrel including means for adjusting the radial position of said other assemblies in at least one row of said aligned other assemblies, said means including a pin and means on the mandrel for mounting the pin in a position having the ends thereof extend from opposite sides of the mandrel body.

14. A honing mandrel comprising an elongated body, a plurality of work engaging assemblies including work abrading assemblies and guide assemblies, means on one side of the mandrel body for mounting the work abrading assemblies in aligned end-to-end abutment, other means on the mandrel body spaced from the aligned row of abrading assemblies for mounting the guide assemblies in aligned end-to-end abutment, means forming a first fixed stop on the mandrel body against which one end of the row of aligned abrading assemblies abuts so that any longitudinal expansion or contraction of the assemblies will be toward or away from the fixed stop, means forming a second fixed stop on the mandrel body against which one end of the row of aligned guide assemblies abuts, said first and second fixed stops being located on the mandrel to abut opposite ends of the respective rows of aligned assemblies, first and second adjustment members mounted for longitudinal movement on the body, said first adjustment member having separate portions thereon cooperatively slidably engageable with means on each of the said abrading assemblies to simultaneously change the radial positions of said assemblies during said longitudinal movements, said second adjustment member having separate portions thereon cooperatively slidably engageable with means on each of said guide assemblies to change the radial positions thereof during longitudinal movements, and separate means associated with opposite ends of the mandrel and engageable respectively with the first and second adjustment members to effect longitudinal movements of said respective ad-

justment members to change the honing diameter of the mandrel.

15. The honing mandrel defined in claim **14** including a second row of aligned guide assemblies and means on the mandrel for mounting said second row in position spaced from but parallel to the other rows of aligned assemblies, and a separate second adjustment member longitudinally movable on the mandrel body to control the radial positions of said guide assemblies in said second row.

16. The honing mandrel defined in claim **15** wherein said second adjustment member and said separate second adjustment member are coupled for movement in concert.

17. The honing mandrel defined in claim **14** wherein said first and second adjustment members have spaced beveled surface portions, and each of said work engaging assemblies has at least one beveled surface portion slidably engageable with respective ones of the beveled surface portions on the associated adjustment member, the beveled surfaces on the said first adjustment member and on the respective work engaging assemblies being effectively oppositely acutely angularly related to the longitudinal dimension of the mandrel relative to the beveled surfaces on the second adjustment member.

18. A honing mandrel having multiple stone and multiple guide assemblies and means to compensate for expansion and contraction of the assemblies due to temperature changes, material growth and the like comprising an elongated mandrel body adapted to be rotated about its longitudinal dimension during a honing operation, means for mounting a plurality of the stone assemblies in aligned end-to-end abutment along one side of the mandrel body, means establishing a first fixed abutment on the body against which one end of the row of aligned stone assemblies abuts so that any endwise expansion and contraction of the stone assemblies is toward or away from the first fixed abutment, a first adjustment member for simultaneously adjusting the radial positions of all of the aligned stone assemblies on the body, said first adjustment member extending along the mandrel body adjacent to the stone assemblies and having at least one surface portion acutely angularly oriented relative to the axis of the mandrel associated and slidably engageable with each of the said stone assemblies so that longitudinal movements of the adjustment member radially reposition the stone assemblies on the body, said first adjustment member having means associated with one end thereof for engagement with means to operate it, means for mounting a plurality of said guide assemblies in end-to-end abutment extending along the mandrel body at a location thereon that is substantially opposite from the row of stone assemblies, means establishing a second fixed abutment on the body against which one end of the row of guide assemblies abuts so that endwise expansion and contraction of the guide assemblies is toward or away from the second fixed abutment, the first and second fixed abutments being located on the body adjacent opposite ends of the respective rows of aligned assemblies so that expansions and contractions of the respective rows occur in opposite directions on the mandrel, a second adjustment member positioned extending along the mandrel body adjacent to the aligned guide assemblies, said second adjustment member having at least one surface portion acutely angularly oriented relative to the axis of the mandrel associated and slidably engageable with each of the said guide assemblies so that longitudinal movements of said second adjustment member will radially reposition the guide assemblies on the mandrel, said second adjustment member having means associated with one end thereof for longitudinally moving it, said one end of the second adjustment member being adjacent to the opposite end of the mandrel body from the said one end of the first adjustment member.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,800,482 Dated April 2, 1974

Inventor(s) Joseph Sunnen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the References Cited, "2,263,871" should be "2,263,781"

Column 1, line 23, "same" should be "said"

Column 8, line 23, "present" should be "preset"; line 36, "opration" should be "operation".

Column 11, line 19, "engaging" should be "extending"; line 31, "enging" should be "engaging".

Signed and sealed this 24th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
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