Jan. 6, 1953

H. E. BALSIGER

2,624,159

GRINDING MACHINE

Filed Feb. 21, 1946

8 Sheets-Sheet 1

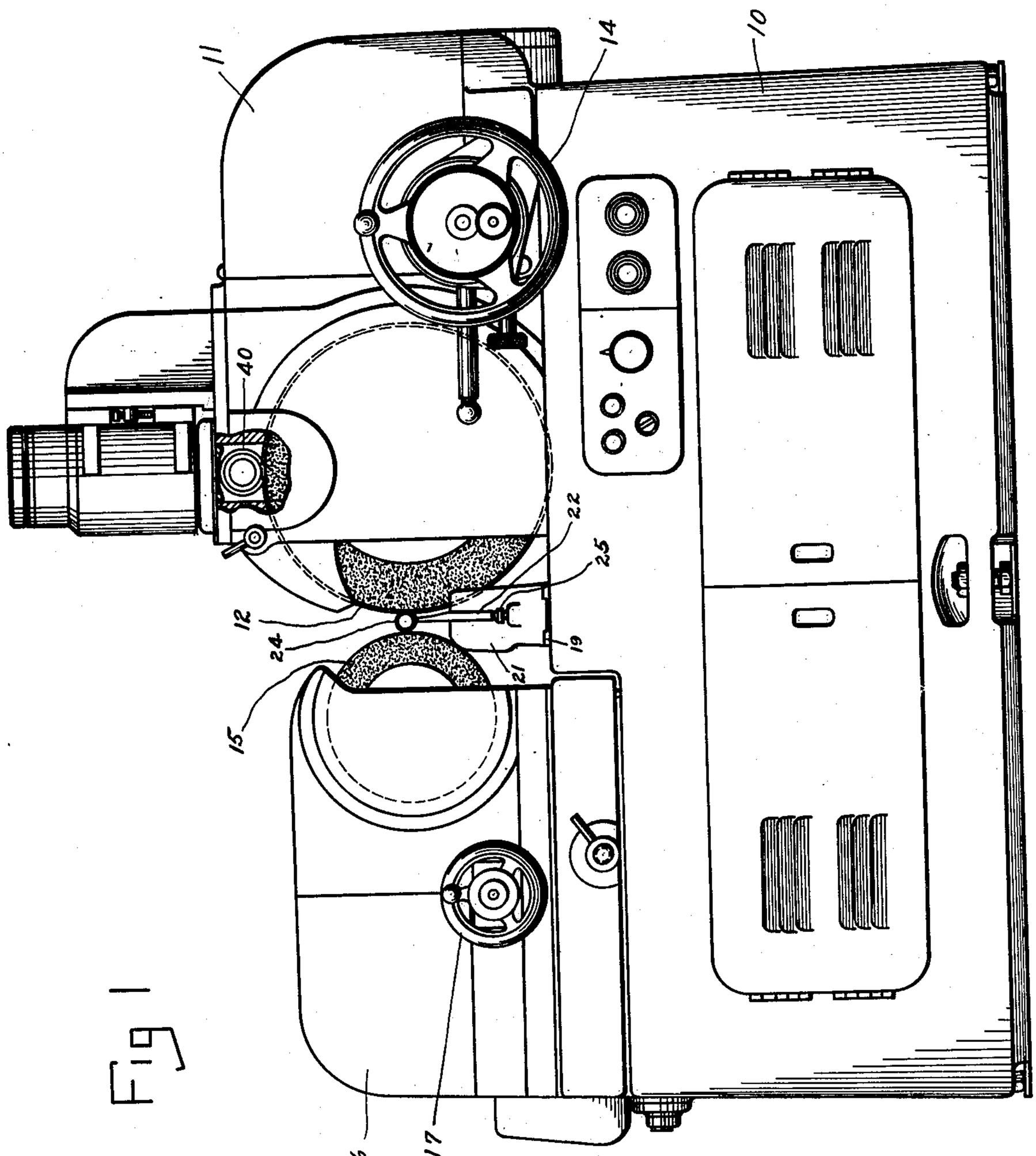

Fig 1

Inventor

HAROLD E. BALSIGER

By

Hugh M Rocke Attorney

Jan. 6, 1953

H. E. BALSIGER

GRINDING MACHINE

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8 Sheets-Sheet 2

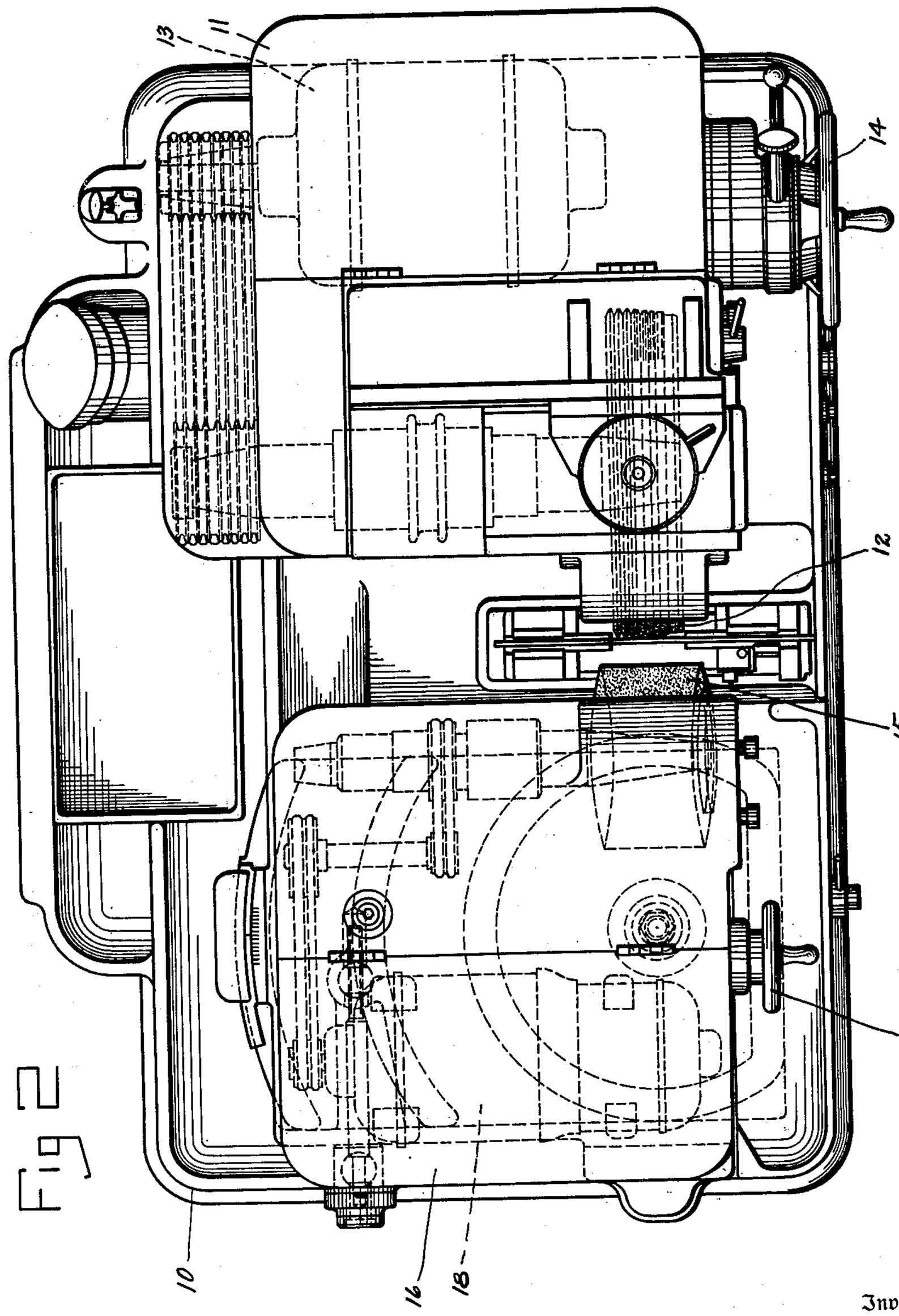

Fig 2

Inventor

HAROLD E. BALSIGER.

By

Hugh D Rocke Attorney

Jan. 6, 1953

H. E. BALSIGER

2,624,159

GRINDING MACHINE

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8 Sheets-Sheet 3

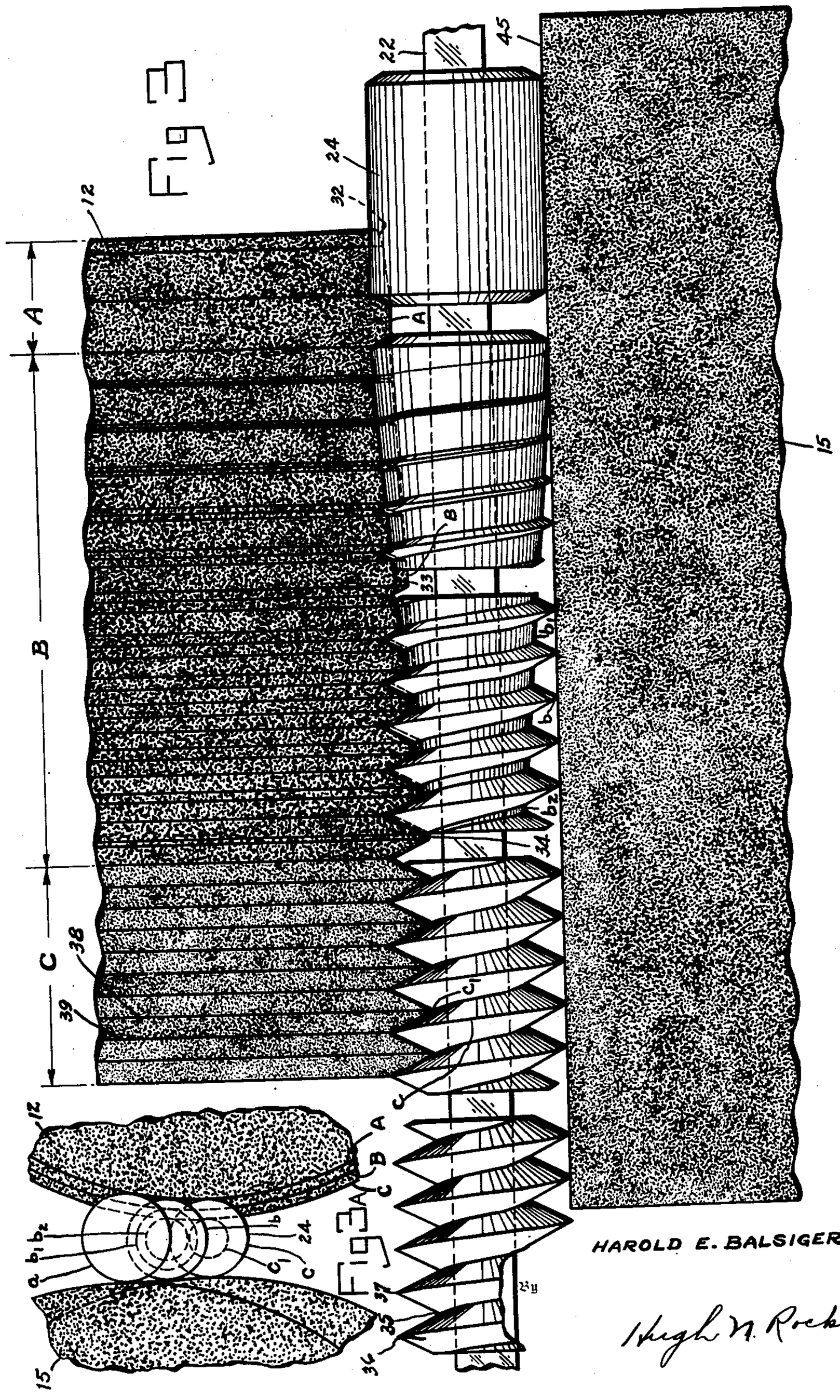

FIG. 3

Inventor

HAROLD E. BALSIGER

By

Hugh M. Rocke Attorney

Jan. 6, 1953

H. E. BALSIGER

2,624,159

GRINDING MACHINE

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8 Sheets-Sheet 4

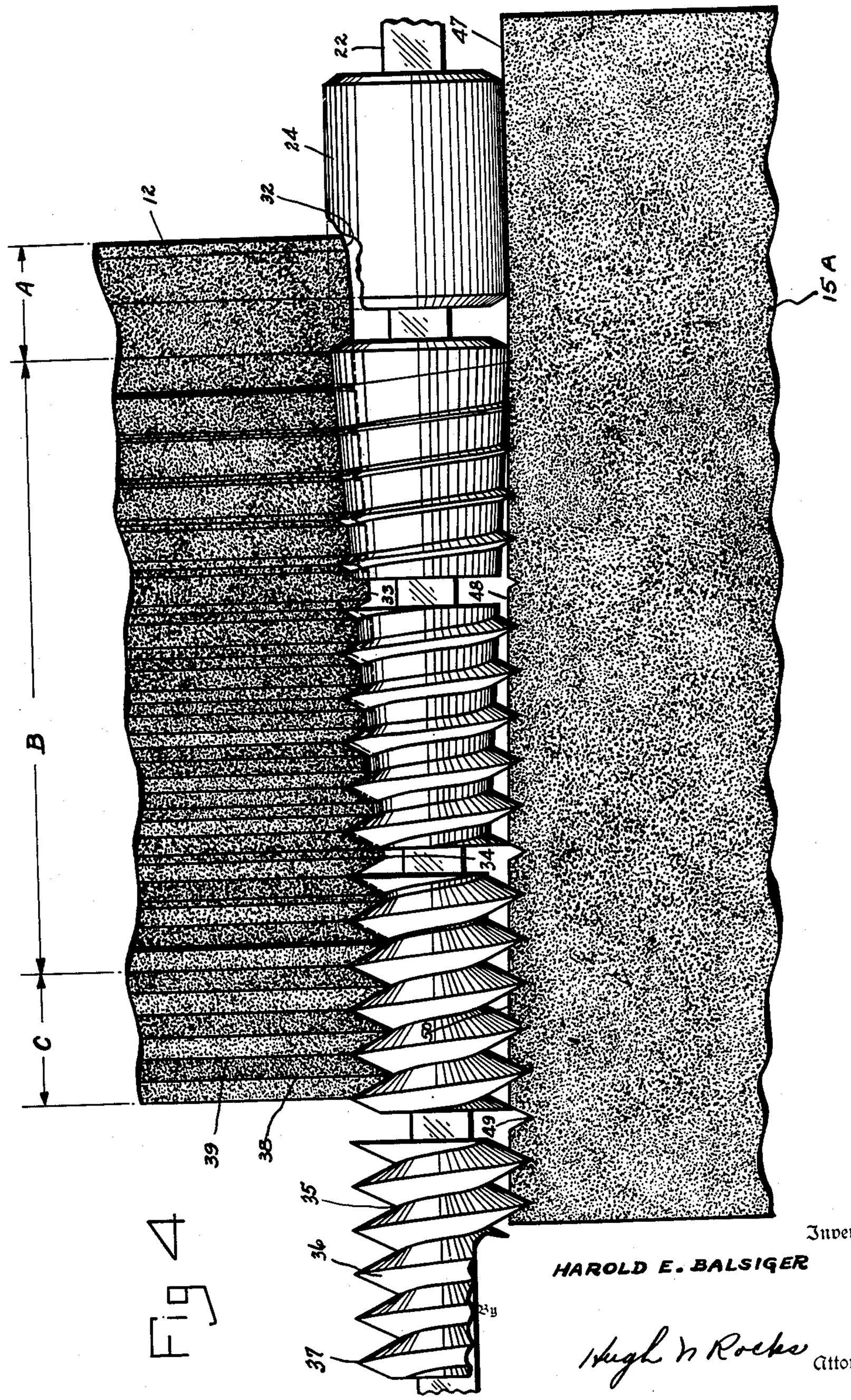

Fig. 4

Inventor

HAROLD E. BALSIGER

By

Hugh M Rocks Attorney

Jan. 6, 1953

H. E. BALSIGER

GRINDING MACHINE

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8 Sheets-Sheet 5

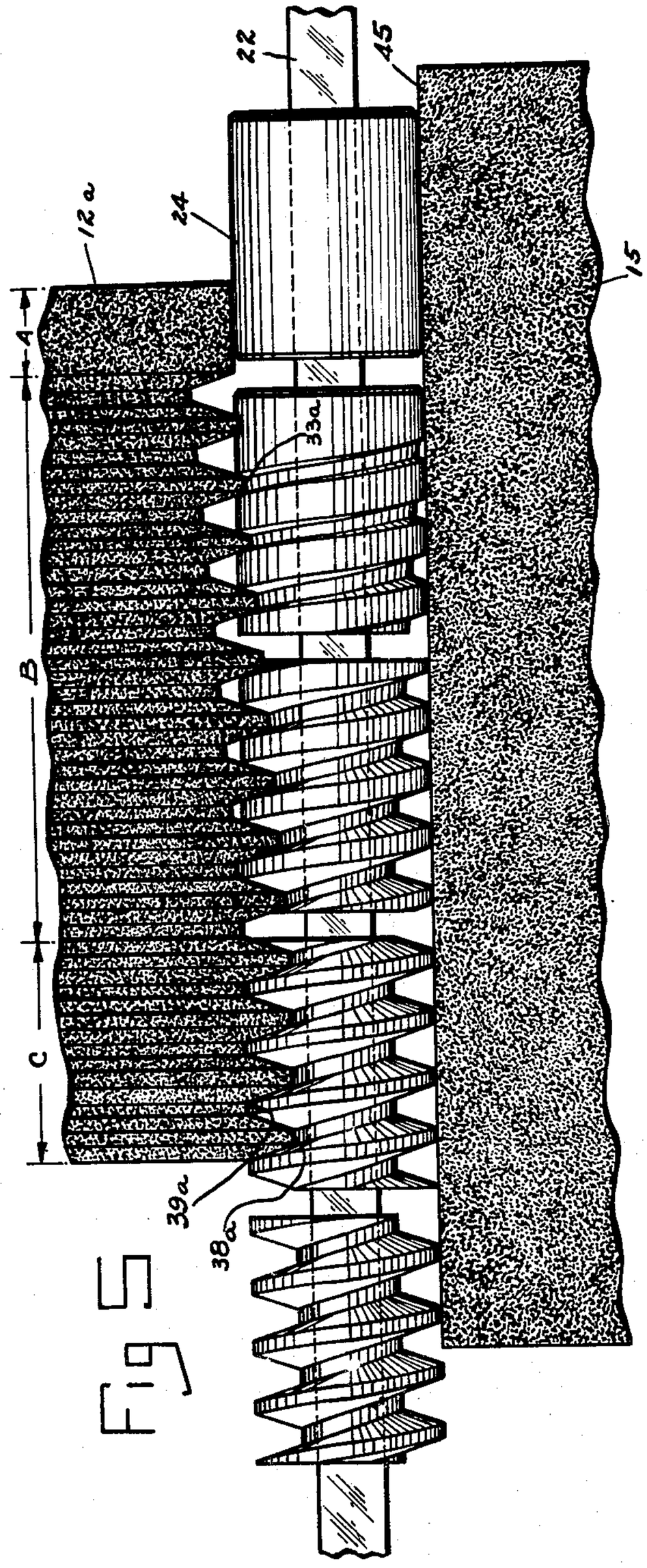

FIG. 5

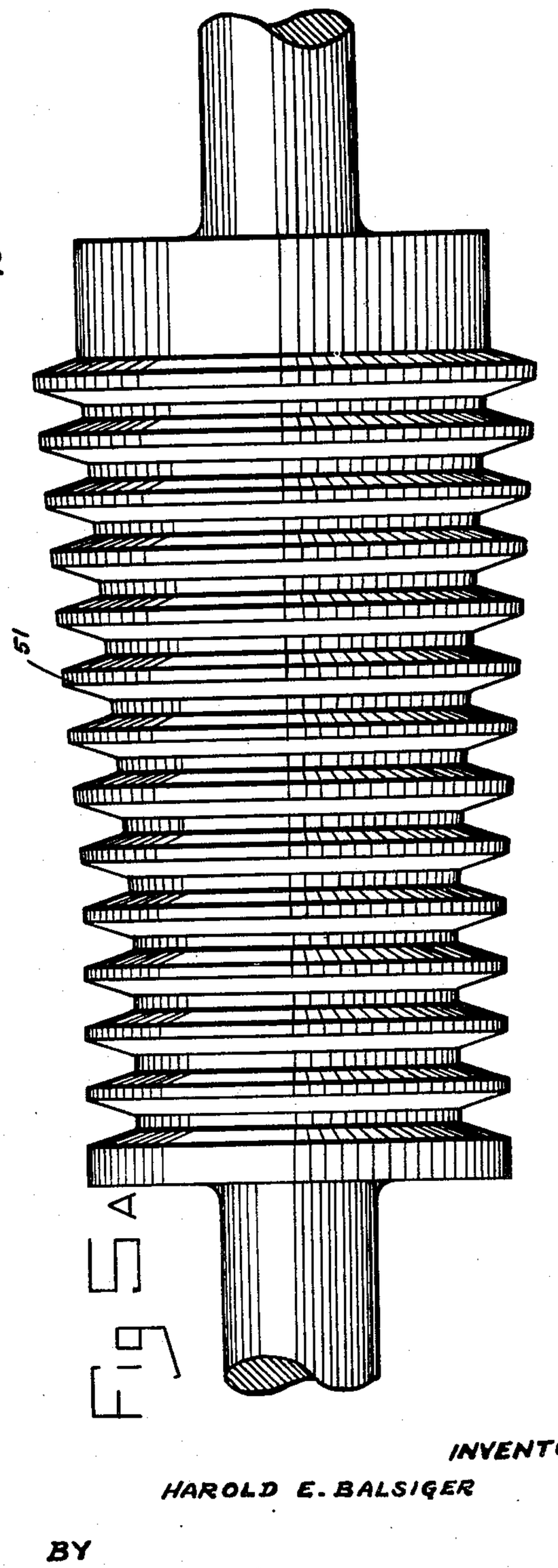

FIG. 5A

INVENTOR

HAROLD E. BALSIGER

BY

Hugh M Rocks ATTORNEY

Jan. 6, 1953

H. E. BALSIGER

GRINDING MACHINE

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8 Sheets-Sheet 6

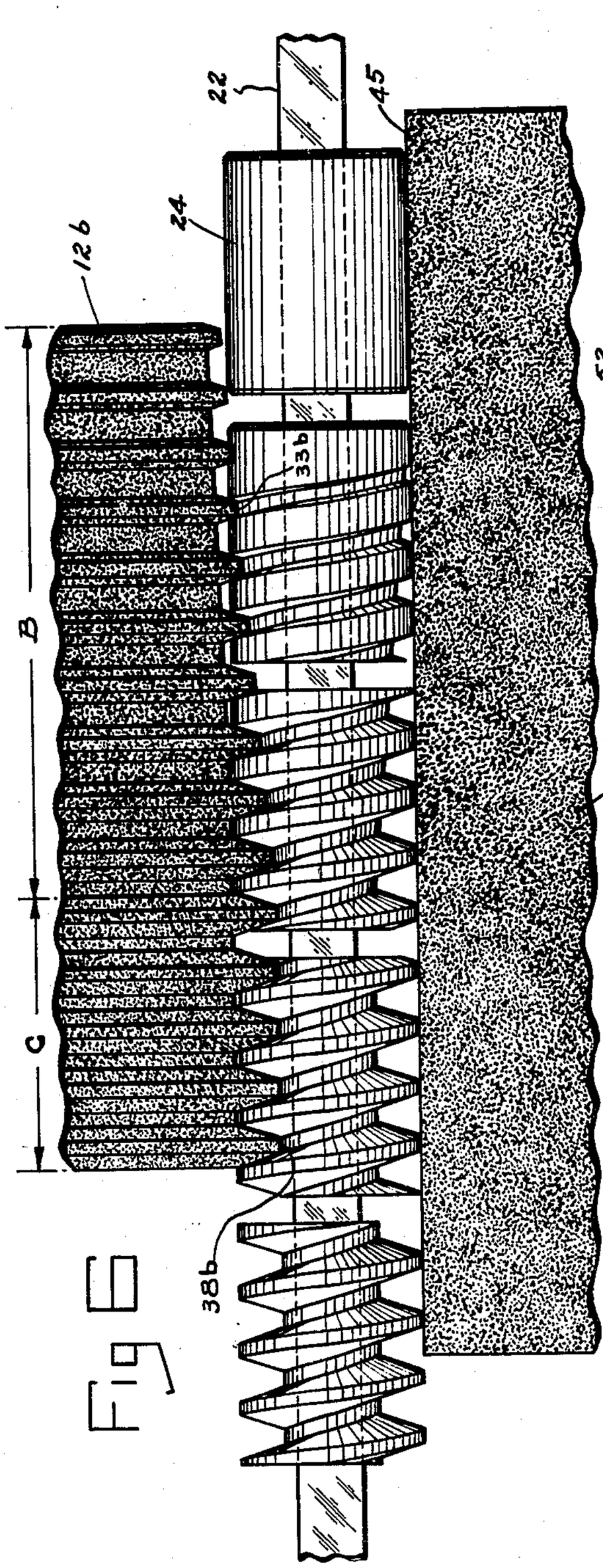

FIG 6

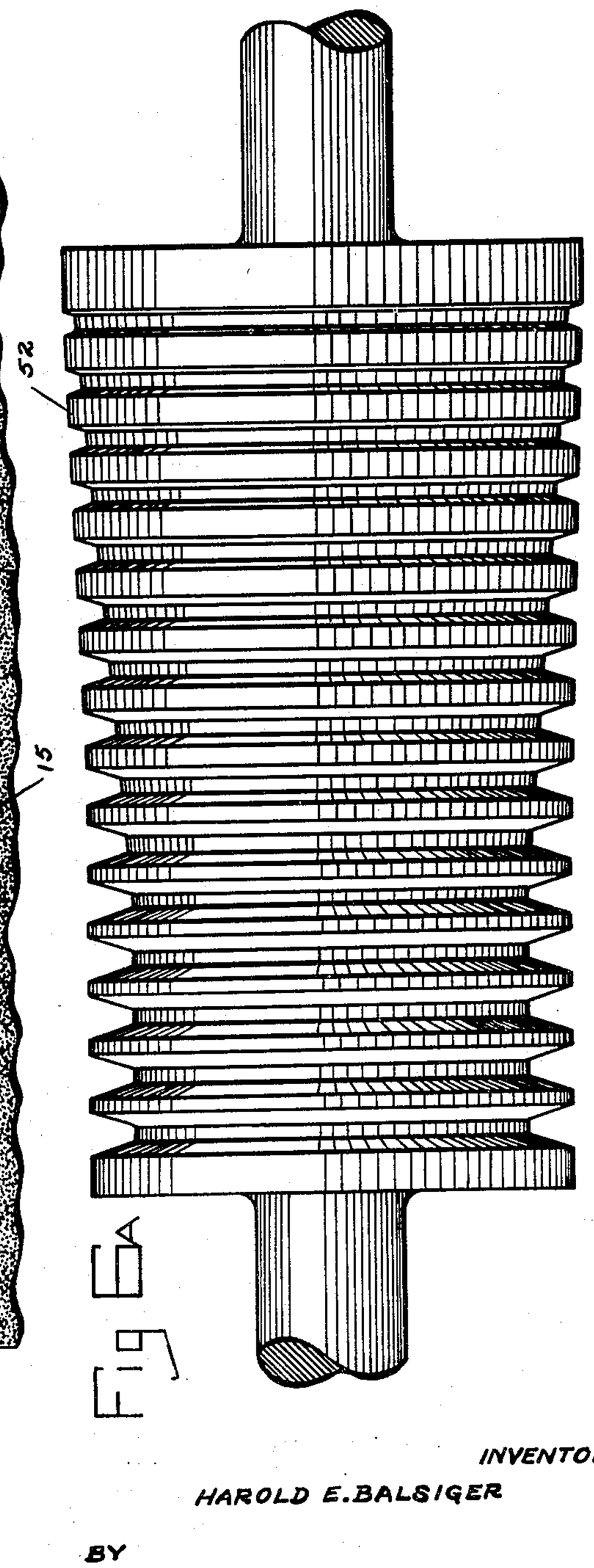

FIG 6A

INVENTOR

HAROLD E. BALSIGER

BY

Hughes & Rocke ATTORNEY

Jan. 6, 1953

H. E. BALSIGER

GRINDING MACHINE

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Fig 7

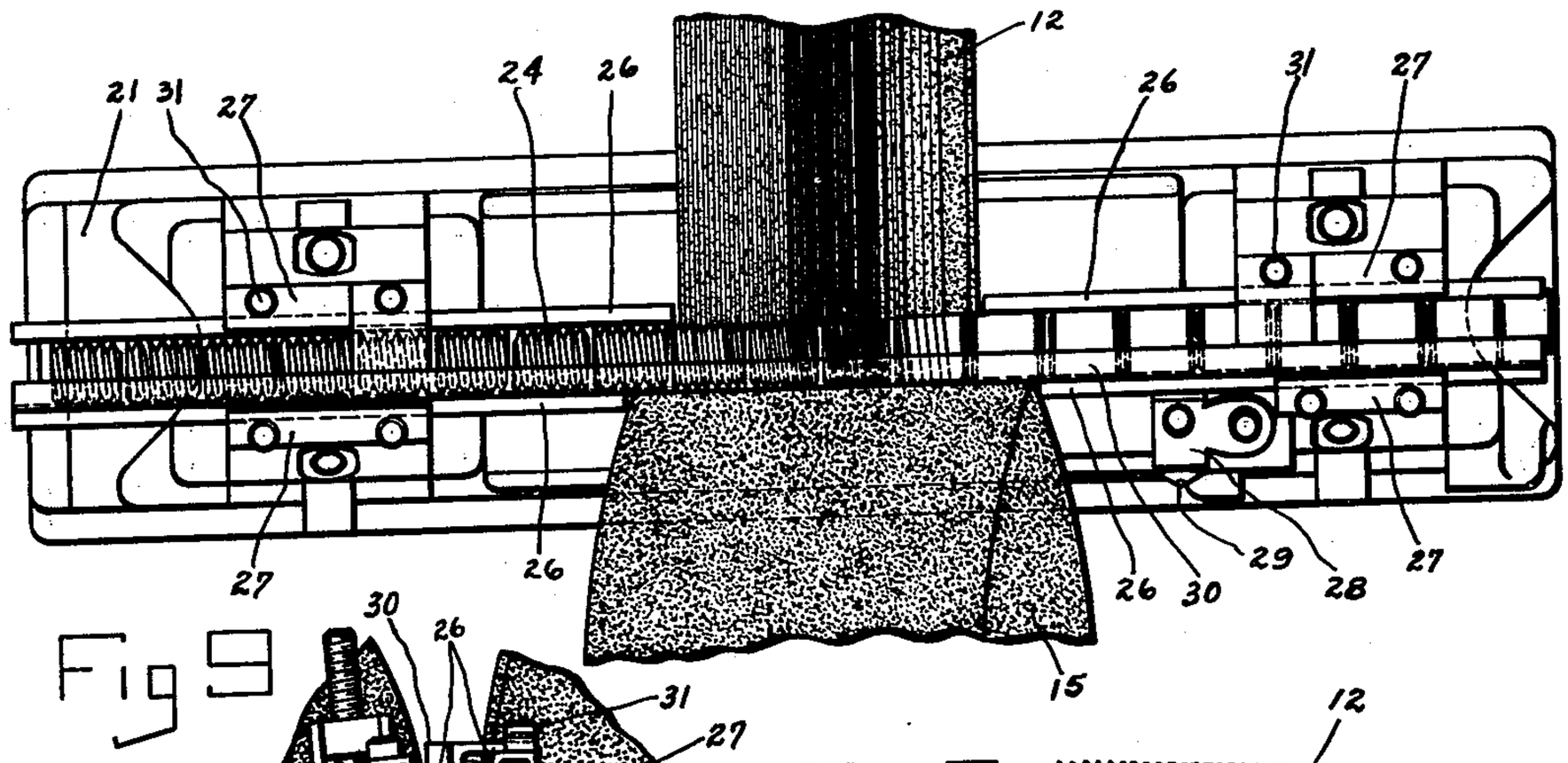


Fig 9

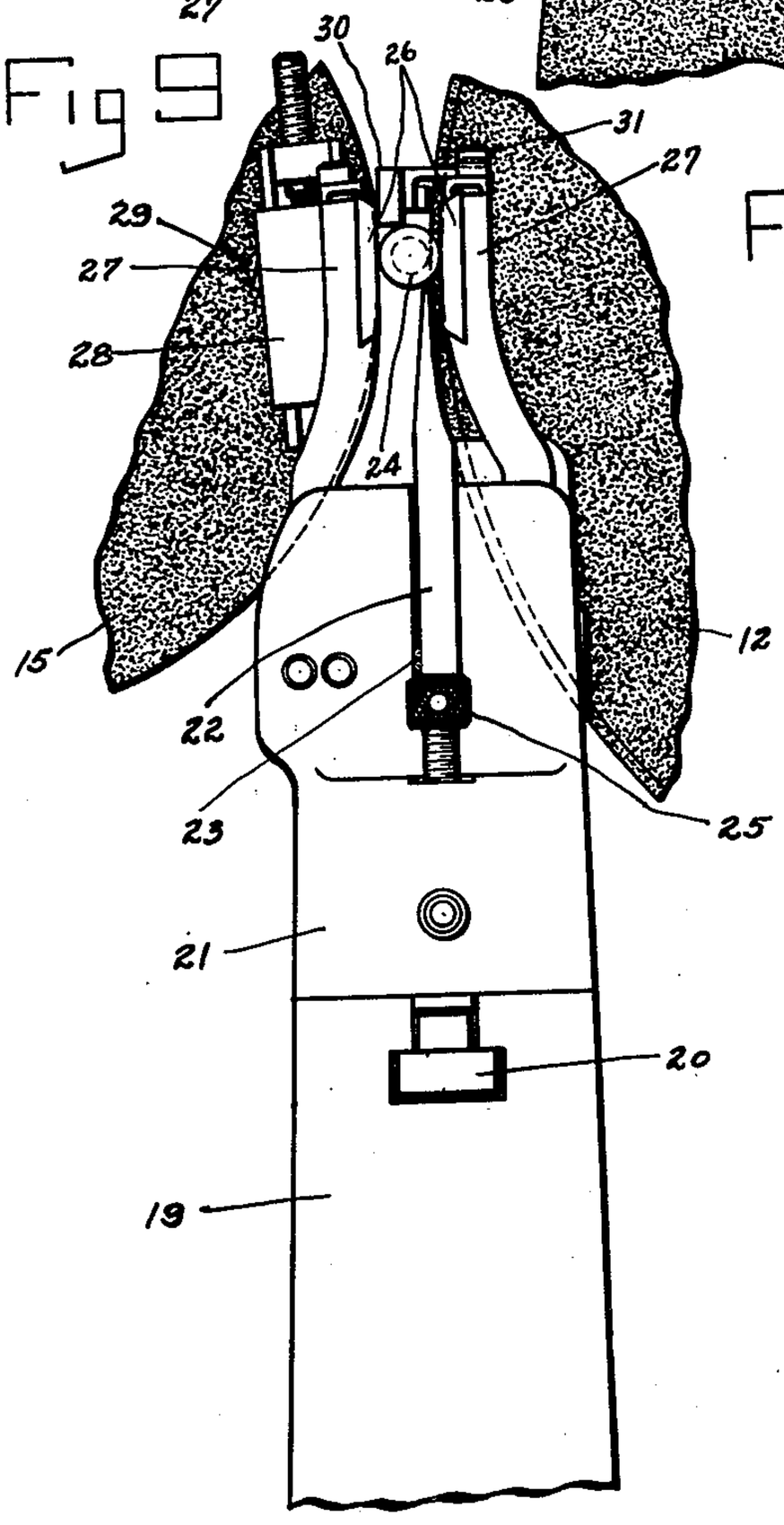
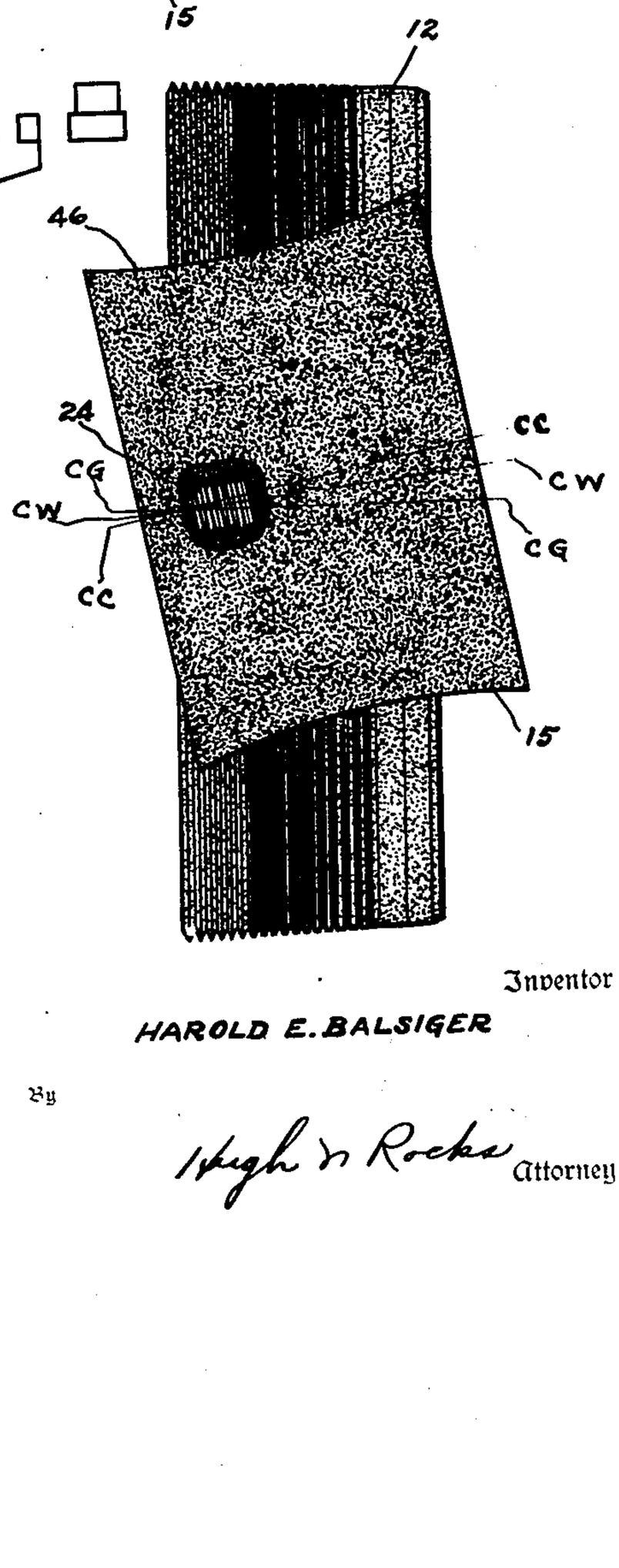


Fig 8



Inventor

HAROLD E. BALSIGER

By

Hugh D. Rocks Attorney

Jan. 6, 1953

H. E. BALSIGER

GRINDING MACHINE

2,624,159

Filed Feb. 21, 1946

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Fig 10

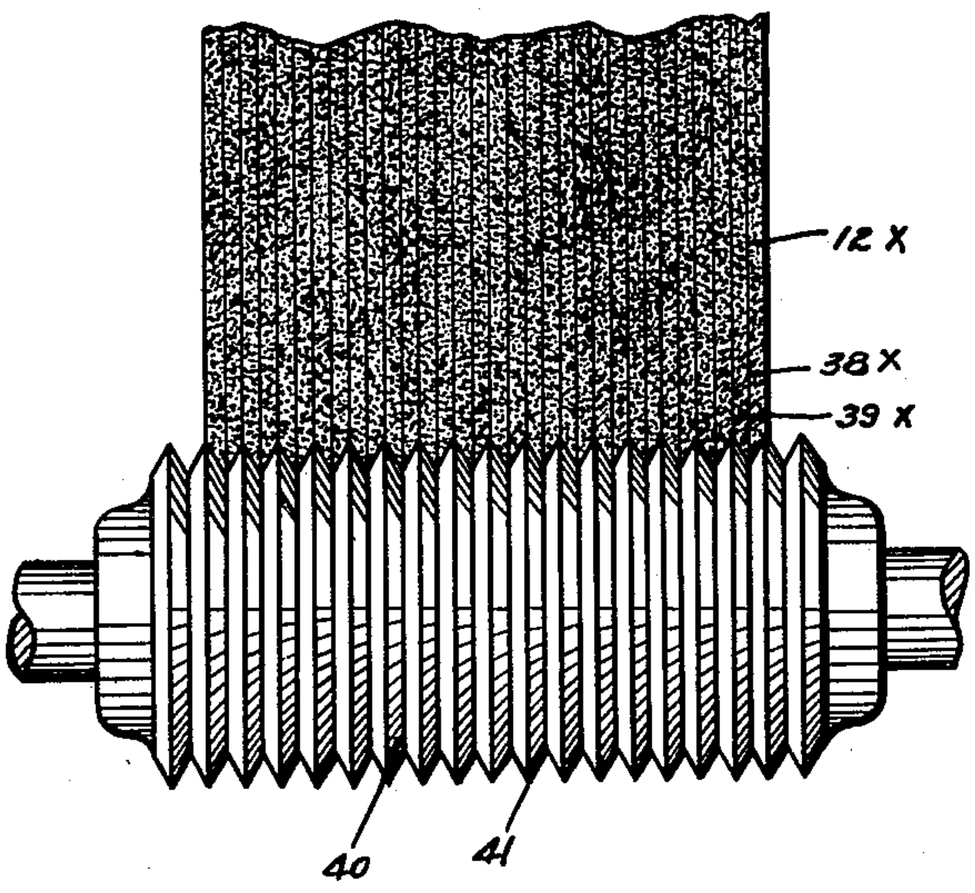


Fig 11

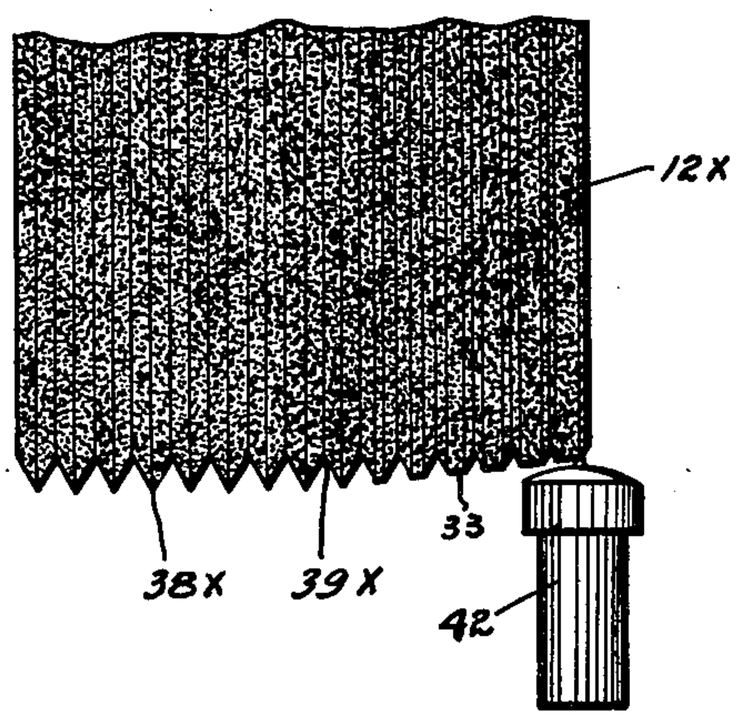


Fig 12

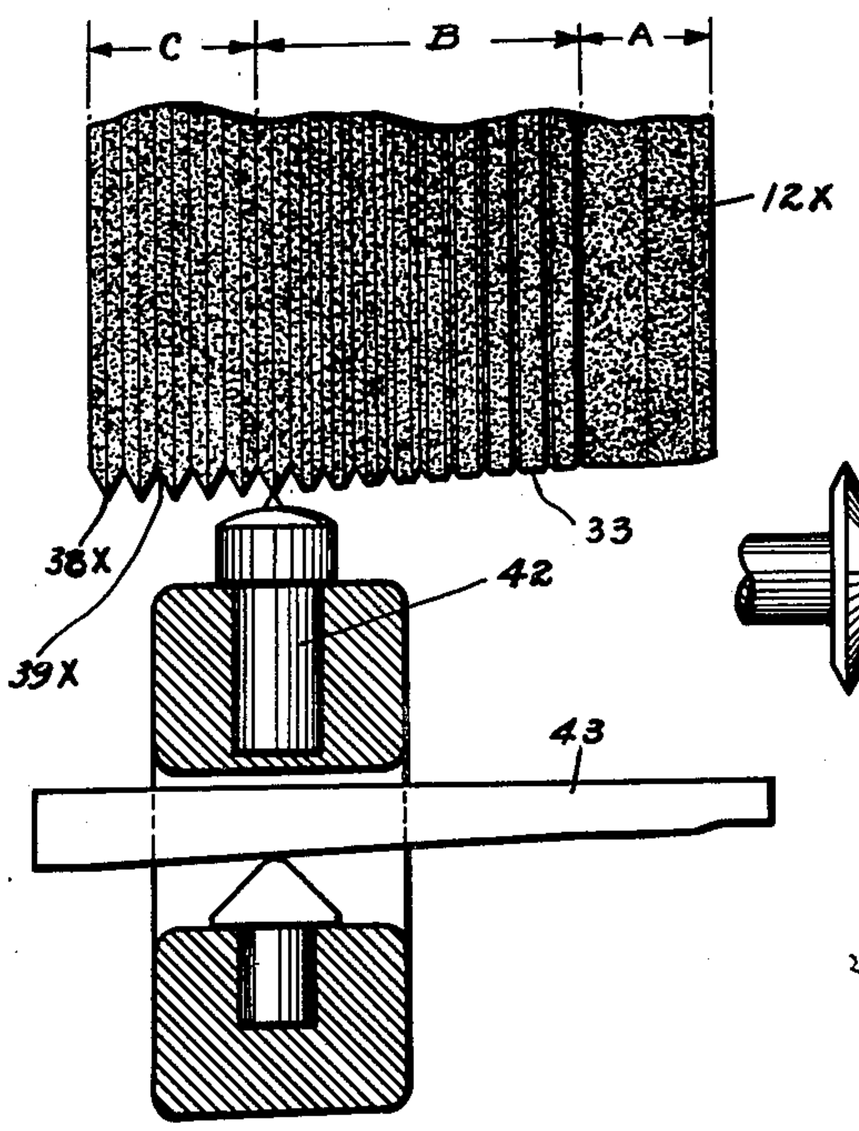
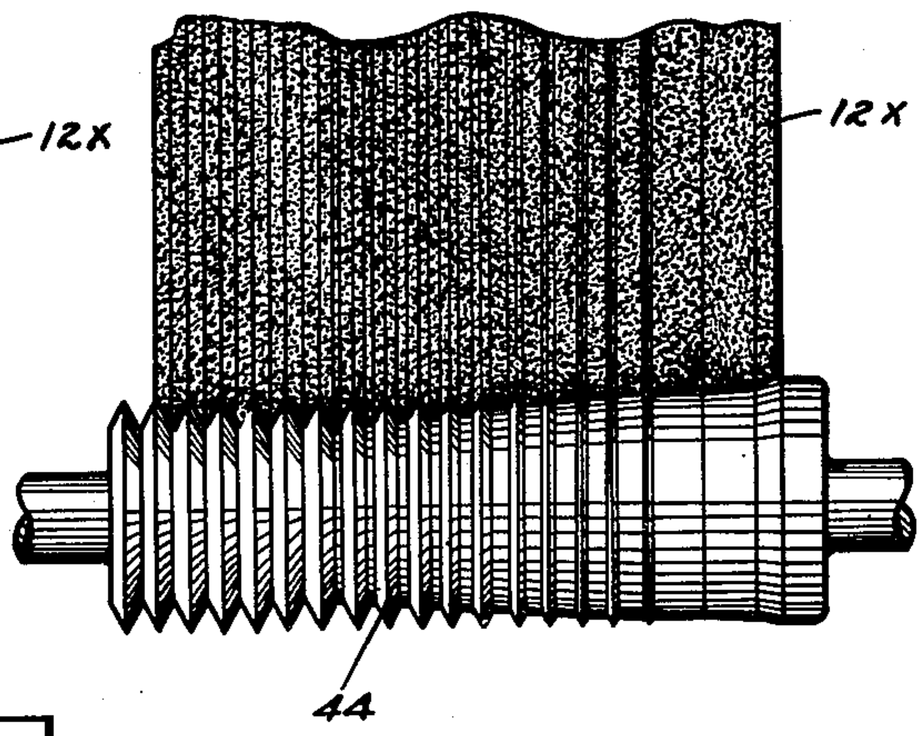


Fig 13



Inventor

HAROLD E. BALSIGER

By

Hugh M Rocker. Attorney

Patented Jan. 6, 1953

2,624,159

UNITED STATES PATENT OFFICE

2,624,159

GRINDING MACHINE

Harold E. Balsiger, Waynesboro, Pa., assignor, by mesne assignments, to Landis Machine Company, Waynesboro, Pa., a corporation of Pennsylvania

Application February 21, 1946, Serial No. 649,263

12 Claims. (Cl. 51—103)

1

The invention relates to apparatus for grinding screw threads, and is directed particularly to the formation of screw threads progressively by a centerless grinding procedure. In certain respects, the present invention may be regarded as an improvement upon the invention described and claimed in application Serial No. 543,780, filed July 7, 1944, by M. A. Hollengreen, H. E. Balsiger, and M. S. Gjesdahl, and entitled Grinding Machine, and which issued as Patent No. 2,556,843 on June 12, 1951, and various references will be made herein to that application for a more detailed disclosure of specific apparatus with which the present improvements may be employed, or by means of which they may be practised.

In said application Serial No. 543,780 there is disclosed and claimed an apparatus and a method for generating screw threads by centerless grinding. In accordance with the invention of said application, screw threads of a predetermined helix angle are generated in a centerless grinding machine comprising a control wheel, a grinding wheel provided with annular grinding ridges and having its axis arranged at an angle to the axis of the control wheel substantially double the helix angle of the thread to be formed, and a work support substantially bisecting the angle between the axis of said wheels and serving to guide the work pieces axially through the grinding throat between the spaced grinding and control wheels. The grinding wheel disclosed in said application is substantially cylindrical in shape and is provided with a series of peripheral, annular ridges of substantially uniform height and diameter, with intervening annular grooves which conform generally to the shape of the thread to be ground.

While a grinding wheel of the specific form disclosed in said application has been found to operate very satisfactorily in the production of screw threads, its use has given rise to certain problems in connection with the introduction of the work pieces to the grinding throat, the initial formation of the thread on the work, the production of defective threads, and non-uniform wear of the grinding ridges. Notwithstanding the fact that the work pieces enter the grinding throat at a comparatively wide portion thereof and are then advanced through a progressively narrowing throat during the thread grinding operation, difficulties have been encountered in feeding the work pieces into the grinding throat, in initiating the proper rate of endwise movement of the work, and in controlling the extent to which the initial grinding ridges on the grinding wheel bite into the work. Other difficulties have been encountered by reason of irregularities in the shape of the cylindrical work pieces and a lack of uniformity in their diameter.

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The principal objects of the present invention therefore are to overcome the difficulties enumerated above. In the main, these objects are attained by providing the grinding wheel with a peripheral rough-grinding zone comprising a series of annular grinding ridges progressively increasing in diameter and merging into a finish-grinding zone comprising a series of annular ridges of uniform diameter with intervening grooves corresponding generally in shape to the thread to be produced.

Other objects of the invention are attained by providing the periphery of the grinding wheel, in advance of the rough-grinding zone, with a plain grinding zone which serves to cooperate with the control wheel to reduce the work pieces to uniform diameter and to remove any irregularities in their diameter, and also to facilitate the entrance of the work pieces into the thread grinding throat and initiate the proper rate of feed of the work pieces axially in order to minimize the production of inaccurate threads.

Further objects of the invention are attained by the provision, in a centerless thread-grinding machine, of a grinding wheel which is so formed that, in a single pass of the work pieces across the wheel, it operates to reduce the work pieces to uniform diameter, to generate a thread on the work pieces by a rough-grinding operation, and to finish-grind the thread thus formed. Additional objects are attained by the provision, in such a machine, of a grinding wheel which is so formed that, in a single pass of the work pieces, it operates to reduce the work pieces to uniform diameter and finish-grind the threads formed thereon. Still other objects of the invention are attained by the provision, in such a machine, of a grinding wheel which is so formed that, in a single pass of the work pieces, it operates to reduce them to uniform diameter and to form thereon threads having a desired helix angle.

The invention also has for an object the provision of a thread grinding wheel with grinding ridges which are so formed and arranged that successive ridges remove substantially uniform increments of stock as the threads are formed on the work pieces, thus distributing the wear uniformly on the grinding ridges, prolonging the

useful life of the grinding wheel, and producing more uniform and accurate threads.

Still other objects and advantages of the invention will be apparent from the following description, taken with the accompanying drawing wherein:

Fig. 1 is a front elevational view of one form of a centerless grinding machine equipped with means for forming screw threads in accordance with the present invention.

Fig. 2 is a plan view of the machine shown in Fig. 1.

Fig. 3 is a diagrammatic plan view showing the formation of screw threads on cylindrical stock by the use of one form of grinding wheel made in accordance with the present invention and in cooperation with a plain control wheel and a work support in a centerles grinding machine such as shown in Figs. 1 and 2.

Fig. 3*a* is a diagrammatic end elevational view showing the position of a work piece at various points in its passage through the grinding throat of Fig. 3.

Fig. 4 is a view similar to Fig. 3, but showing a grooved control wheel.

Fig. 5 is a view similar to Fig. 3 but showing another form of grinding wheel.

Fig. 5*a* is a plan view showing a form of crushing roller which may be used for forming and dressing the grinding wheel shown in Fig. 5.

Fig. 6 is a view similar to Fig. 3, but showing a further form of grinding wheel.

Fig. 6*a* is a plan view of a crushing roller which may be used for forming and dressing the grinding wheel shown in Fig. 6.

Fig. 7 is a diagrammatic plan view showing various elements of a centerless grinding machine with the present improvements incorporated therein, also showing the manner in which screw threads are formed upon a succession of work pieces as they pass through the machine.

Fig. 8 is a diagrammatic side elevational view of the control wheel and a grinding wheel such as shown in Fig. 3, the control wheel being partly broken away to show a work piece in process of being threaded.

Fig. 9 is a diagrammatic front elevational view of the machine, showing the relative positions of the grinding wheel, the control wheel, the work rest, and the work guides.

Figs. 10, 11 and 12 illustrate diagrammatically the various steps involved in one method of forming grinding wheels of the type shown in Figs. 3 and 4; and

Fig. 13 is a diagrammatic illustration of another method for forming grinding wheels such as shown by Figs. 3 and 4 by a crushing operation.

As disclosed herein the present improvements are incorporated in a centerless grinding machine of the form shown in application Serial No. 524,948, filed March 3, 1944, and in application Serial No. 543,780 referred to above. It will be understood, however, that the improvements may be incorporated in and used with such other forms of machine as may be readily adapted to the grinding of screw threads.

As disclosed in Figs. 1 and 2, the machine used for illustrative purposes comprises a bed 10 and a grinding wheel base 11 slidably mounted thereon for movement to and from operative position. The present improvements are primarily concerned with the grinding wheel 12 which is rotatably mounted on base 11 and may be

driven by any suitable means, such as motor 13. The sliding movement of base 11 may be effected through suitable gearing by means of hand wheel 14.

A control wheel 15 is rotatably supported on a base 16 which is slidably mounted for movement to and from operative position by means of a hand wheel 17 connected thereto through suitable gearing, such as shown in the pending applications referred to above. The control wheel 15 is angularly adjustable in both horizontal and vertical planes and may be driven by an electric motor 18. Traversing movement of control wheel 15 may be effected by means of an hydraulic motor in the manner disclosed in said application Serial No. 543,780.

An abutment 19 shown in Fig. 9 and forming a part of the bed casting has attached thereto by means of T-bolts 20 a work rest base 21. A work rest 22 mounted in a slot 23 in base 21 serves to support the work pieces 24 during their movement through the grinding throat between grinding wheel 12 and control wheel 15. The work rest 22 may be adjusted vertically by means of adjusting screws 25. Guide plates 26 are removably secured to supporting members 27 which are mounted on work rest base 21 for adjustment toward and away from each other to accord with the diameter of the work to be ground. Attached to one of the supporting members 27 is a wheel dressing device comprising a diamond holder 28 and a diamond 29 for dressing control wheel 15. A guard member 30 secured to two of the supports 27 by screws 31 at opposite sides of grinding wheel 12, and so positioned that it does not normally contact with the work pieces, may be employed to prevent the work pieces from being thrown out of the grinding throat during the grinding operation.

The operative face of the grinding wheel 12 shown somewhat in detail in Figs. 3 and 4, and shown more or less generally in Figs. 1, 2, and 7 to 12, is provided with three peripheral grinding zones, a plain grinding zone A for reducing the work pieces to uniform diameter, a ridged zone B for rough-grinding the threads on the work pieces, and a ridged finishing zone C for finish-grinding the threads thus formed.

The plain-grinding zone A is formed on a section substantially cylindrical in shape although it may be tapered slightly, if desired, to provide a peripheral grinding surface progressively increasing in diameter for the purpose of facilitating the introduction of the work pieces to the thread-grinding zone. The entrance edge of the plain-grinding zone may also be beveled as indicated at 32 for the purpose of facilitating the introduction of the work pieces into the grinding throat between the grinding wheel and the control wheel. The plain-grinding section A also serves, in conjunction with the control wheel, to initiate the proper rate of axial movement of the work pieces and thus assists in the formation of more accurate threads thereon.

Rough-grinding zone B comprises a series of grinding ridges 33 which increase progressively in diameter in the direction away from plain grinding zone A. The width of the crest 34 of grinding ridges 33 decreases progressively in the same direction, while the width at the base is uniform and is substantially equal to the pitch of the thread to be ground. With a grinding wheel of this particular form, the initial rough-grinding ridges are thus low and broad and

progressively increase in height while progressively decreasing in width of crest. The diameter of the ridges **33** increases from a diameter at one end of the zone substantially the same as the diameter of the plain-grinding zone A to a diameter at the opposite end of the rough-grinding zone which is slightly less than would be required to form the root of the groove **35** of the thread **36**.

The formation and arrangement of the rough-grinding ridges **33** are such that, as the work pieces **24** are advanced endwise across the face of the grinding wheel **12**, each ridge cuts the groove **35** slightly deeper than the preceding ridge to thus form the thread **36** incrementally. With ridges of this form, the thread crest **37** is first formed on the work, and successive ridges grind deeper toward the root of the thread as the work pieces move axially across the grinding wheel and through progressively narrowing portions of the grinding throat.

The finish-grinding zone C is continuous with the rough-grinding zone B and is provided with a plurality of annular, V-shaped grinding ridges **38** and intervening V-shaped grooves **39** of a shape corresponding substantially to that of the particular screw thread to be ground. The diameter of the ridges **38** is uniform and is slightly greater than the diameter of the final ridge **33** on the rough-grinding zone so that these ridges serve to complete the root of thread **36** as well as finish-grind its sloping walls. The thread is therefore complete as the work pieces emerge from the grinding throat after their passage axially across the face of the grinding wheel and downwardly through the progressively narrowing throat.

One method of forming the grinding wheel shown in Figs. 3 and 4 is illustrated diagrammatically in Figs. 10 to 12. As shown in Fig. 10 a crushing roller **40** having on its peripheral surface a plurality of uniform V-shaped ridges **41** may be employed for the purpose of providing the peripheral surface of a cylindrical abrasive wheel **12***x* with a series of annular, V-shaped ridges **38***x* of uniform diameter and with intervening V-shaped grooves **39***x*. Such a crushing operation is well understood in the art and requires no further description herein. The next operation in this method of forming the grinding wheel involves the formation of the grinding zones A and B. These grinding zones may be formed by means of a diamond dressing tool **42** mounted in some suitable position, such as in the grinding wheel fender, or on control wheel base **16**. If the dressing tool **42** is mounted on wheel base **16**, this base is adjusted angularly in a horizontal plane for traversing in this position so as to pass the dressing tool **42** across the face of the ribbed abrasive wheel at an angle to the wheel axis. If mounted in the wheel fender, the dressing tool **42** may be guided by a forming bar **43** such as disclosed in said application Serial No. 524,948.

As illustrated in Figs. 11 and 12, the V-shaped ridges **38***x* on the entrance end of the abrasive wheel **12***x* are dressed down to such an extent as to provide the plain grinding zone A, and this zone may be slightly tapered over the initial portion thereof, or over its entire width, if desired. As illustrated in Fig. 12 of the drawing, the rough grinding zone B is dressed to such an extent as to remove decreasing portions from the crests of ridges **38***x* in this zone and form blunt ridges **33** increasing successively in diameter from a diameter at one end approximating that of the plain grinding section to a diameter at the opposite end slightly less than the diameter of the V-shaped ridges **38** on the finish-grinding section.

Another method of forming a grinding wheel such as illustrated in Figs. 3 and 4 is shown in part in Fig. 13. By the method there disclosed a cylindrical abrasive wheel **12***x* is first diamond dressed to provide a suitable taper for the rough-grinding section and to provide the plain-grinding portion. The ridges and intervening grooves on the rough-grinding and finish-grinding sections are then formed by means of a crushing roller **44** having a contour suitable for producing ridges and grooves of this shape.

In the operation of generating screw threads with the grinding apparatus described above, work blanks **24** may be fed to the entrance end of the grinding throat between the grinding wheel **12** and the control wheel **15** by any suitable means. As the blanks **24** engage with plain grinding section A of grinding wheel **12** they are reduced to a uniform diameter while being advanced axially on the work rest **22** by the control wheel **15**. The endwise movement of the work pieces is at the rate of the pitch of one ridge per revolution of the work. As fully disclosed in said application Serial No. 543,780, this rate of feed is obtained by tilting the control wheel **15** so that its axis is angularly spaced from the axis of the grinding wheel by an angle substantially double the helix angle of the screw thread to be ground, with the work rest **22** bisecting this angle. The relative angular positions of the grinding wheel **12**, the control wheel **15**, and a work piece **24** in its passage through the grinding throat are illustrated diagrammatically in Fig. 8 of the drawing. The center line of the grinding wheel **12** is indicated therein by the letters CG, the center line of the control wheel by the letters CC, and the center line of a work piece by the letters CW. As described in detail in application Serial No. 543,780 referred to above, the angle between the axis of the work piece, line CW, and the axis of the grinding wheel, line CG, is the helix angle of the screw thread which is to be ground, and the angle between the axes of the grinding wheel and the control wheel, lines CG and CC, is double this helix angle.

As the work passes section B of wheel **12**, each succeeding ridge **33** grinds a little deeper than a preceding ridge by reason of the increased diameter of succeeding ridges. Thus the crest of the thread and a shallow helical groove of a width substantially equal to the pitch of the thread to be ground are formed first, and successive ridges grind the groove deeper, the width of the groove decreasing with the depth until the root of the thread has been nearly formed. When the work reaches finishing section C, the threads are approximately to size and the ridges **38** of section C merely remove the remaining increments of stock and thus perform a finish-grinding operation on the rough-ground thread.

The position of a work piece at various points in its passage through the grinding throat shown in Fig. 3 is illustrated diagrammatically in Fig. 3*a* of the drawing. The lines A, B and C on the grinding wheel **12** of Fig. 3*a* correspond with the respective sections indicated by the same letters in Fig. 3. The relative vertical positions of a particular work piece while passing each of the above mentioned sections is indicated on Fig. 3*a* by small letters *a*, *b* and *c*. Thus the

blank work piece passes section A at the elevation indicated in Fig. 3*a* by the letter *a*. In this section there are no ribs on the grinding wheel to start a thread groove in the work. In the position indicated by the letter *b* in Fig. 3*a* the work piece is passing section B and the rough-grinding ribs **33** penetrate the work piece to an increasing depth as indicated by the dotted circles b_1 and b_2. When the work piece passes section C of the grinding wheel it has dropped to the position indicated at *c* in Fig. 3*a*. In this position the ribs **38** of section C perform a finish-grinding operation on the screw thread and penetrate to the root of the thread as indicated by the dotted circle c_1.

The control wheel **15** shown diagrammatically in Fig. 3 is substantially cylindrical in shape and is provided with a plain operating face **45**. It will be understood, however, that the peripheral surface of this wheel may be dressed so as to form a concave face **46** thereon, as illustrated in Fig. 8, for the purpose of providing a straight line axial movement of the work pieces across the operating face of the grinding wheel in a manner well understood in the art.

The control wheel **15***a* shown diagrammatically in Fig. 4 of the drawing is provided with a substantially cylindrical entrance section **47** which merges into a tapered section **48** increasing in diameter in the direction of the exit end of the grinding throat. The tapered section **48** is provided with a succession of grooves **49** progressively increasing in depth and providing intervening ridges **50** of progressively increasing diameter. Grooves **49** receive the crest of threads **36** as they are formed on the work pieces. The ridges **50** are not of sufficient diameter to reach the root of the thread as it is being formed, their function and that of the intervening grooves being to provide greater surface contact between the control wheel and the work in order to control the speed of the work more effectively. The use of such a control wheel is sometimes found desirable in grinding threads on work pieces of large diameter.

The grinding wheel **12***a* shown in Fig. 5 is generally similar to the wheel shown in Figs. 3 and 4 except that the tapered, rough-grinding portion B is provided with ridges **33***a* approximating in shape the finished groove of the thread. In other words, the ridges **33***a* are of progressively greater diameter although they are of uniform height when measured from the tapered peripheral surface of the rough-grinding section. Ridges of this shape are particularly effective in providing a good start in grinding a thread on a blank work piece. In forming the wheel shown in Fig. 5, a cylindrical abrasive wheel is first diamond dressed to a template of a shape substantially that of a line joining the crests of the ribs **33***a* on the tapered section. A crusher **51** such as shown in Fig. 5*a* is then employed to form the ridges **33***a* and the intervening grooves on the rough-grinding section B and the ridges **38***a* and intervening grooves **39***a* on the finishing section C. With this form of grinding wheel the ridges on the rough-grinding and finish-grinding sections have substantially the same shape.

The grinding wheel **12***b* shown in Fig. 6 is provided with a rough-grinding section B and a finish-grinding section C as in the case of the grinding wheels described above, but it has no plain grinding section for operating upon the work pieces as they enter the grinding throat. Such

a grinding wheel may be used when the stock consists of work pieces of uniform diameter. The grinding ridges **33***b* on the rough-grinding section increase successively in diameter as well as in height when measured from the peripheral surface of the tapered portion. With this type of grinding wheel, the grooves on the tapered section are not of full depth as they are on the wheel shown in Fig. 5, and the bottoms of the grooves may thus be used to form the outer diameter of the finished screw, this operation being performed gradually so that all surfaces of the thread are reduced progressively. The cylindrical finishing section on this form of wheel is provided with ridges **38***b* of uniform diameter and conforming to the shape of the groove of the thread to be ground as in the case of the grinding wheel of Fig. 5.

The grinding wheel shown in Fig. 6 may be formed in the manner described above in connection with the wheel shown in Fig. 5. The crushing roller **52** shown in Fig. 6*a* may be employed in forming and dressing the grinding wheel of Fig. 6. It is generally similar to the crushing roller **51** shown in Fig. 5*a* except that the taper of the portion which forms the rough-grinding section of the wheel is modified so as to provide a broader face on the initial ridges on this section of the roller, these ridges decreasing successively in diameter and in width of face toward the opposite end of the roller.

All forms of the grinding wheels described above may be considered as comprising a tapered or frustum portion having thereon a series of peripheral grooves with intervening annular ridges which increase progressively in diameter and serve to rough-grind screw threads on work pieces of cylindrical shape, and a cylindrical portion continuous with the tapered portion and having thereon a series of peripheral grooves with intervening annular ridges of uniform diameter and serving to finish-grind the threads generated by the rough-grinding portion. In all cases, it will be noted that the diameter of the initial ridge on the rough-grinding section approximates the diameter of the grooves on the finishing section. With the wheels shown by Figs. 3 and 4, the grooves on both the rough-grinding and finish-grinding sections are of substantially the same diameter. With the wheels of Figs. 5 and 6, the grooves on the rough-grinding portion increase progressively in diameter in the direction of the finish-grinding section, the final groove approximating the diameter of the grooves on the finishing section. All the grooves on the wheel shown in Fig. 5 are of substantially the same depth and of progressively increasing diameter on the rough-grinding portion, while the grooves on the rough-grinding portion of the wheel of Fig. 6 increase progressively in diameter in the direction of the finishing section but are of increasing depth when measured from the crests of the intervening ridges.

As will be apparent from the above description and the drawing, the improvement provides, in a centerless grinding machine, means whereby cylindrical work pieces may be introduced into the grinding throat and into operative relation with the grinding ridges at the proper rate of feed for forming uniform threads of unusual accuracy; means whereby the extent to which the initial thread grinding ridges on the grinding wheel bite into the work may be controlled; means whereby the beginning of the thread on the work piece, and consequently the entire thread, may

be formed with accuracy; means whereby the production of defective threads is reduced to a minimum; means whereby wear on the grinding ridges is uniformly distributed so that the life of the grinding wheel is thereby materially lengthened; and means whereby threaded work pieces of uniform diameter are assured.

For the sake of best results, we believe that the pitch of the ridges of the grinding wheel and the angle between the faces of the grooves and of the ridges of the grinding wheel, should be determined in accordance with the formulas indicated and explained in our said co-pending application Serial No. 543,780. In other words, the pitch of said ridges should be equal to the pitch of the screw threads to be formed times the cosine of the helix angle thereof, while the angle between the faces of the grooves and of the ridges of the grinding wheel should be the angle A_n whose tangent is tangent A times the cosine of the helix angle of the screw thread to be generated, where A_n is half the apex angle of the ridges on the grinding wheel and where A is half the apex angle on the screw thread.

While certain specific forms of grinding wheel having the present inventive concept incorporated therein have been disclosed herein, other forms for attaining the objects of the invention will readily suggest themselves. It will be understood, therefore, that the invention is not intended to be limited to grinding wheels of the precise forms and arrangement of parts disclosed herein, but is intended to include all forms which come within the scope of the claims hereto appended. Such forms include grinding wheels which involve various arrangements of the grinding zones or sections described above. As heretofore disclosed, the rough-grinding and finishing sections of the grinding wheel may be used without the plain-grinding section. Similarly the plain-grinding section may be used with either the rough-grinding section or the finishing section without the other. It is also desired to point out that, while the grinding wheels disclosed herein are designed and constructed to form certain types of threads, the invention is not limited to the formation of any specific type or types but is equally applicable to various screw threads.

What I desire to claim is:

1. In a centerless grinding machine for progressively generating screw threads on cylindrical work, a grinding wheel having a plain grinding zone on one end of its peripheral surface for reducing the work to uniform diameter, an intermediate peripheral zone having thereon a plurality of annular ridges successively increasing in diameter for progressively rough-forming a screw thread on the work, and a thread finishing zone on the opposite end of said peripheral surface and having thereon a plurality of annular ridges of substantially the same diameter and conforming substantially to the shape of the grooves of the finished thread.

2. A grinding wheel for centerless grinding screw threads of predetermined pitch and angle, comprising a plain grinding section formed on one end thereof and having a smooth peripheral grinding surface, a cylindrical finishing section formed on the opposite end and having a series of annular ridges and intervening grooves on its peripheral surface and conforming substantially to the shape of the finished thread, said intervening grooves having a diameter substantially equal to the diameter of said plain grinding section, and a tapered intermediate section having thereon a series of spaced annular ridges progressively increasing in diameter from a diameter substantially equal to the diameter of said plain grinding section to a diameter substantially equal to the diameter of the ridges on said cylindrical section, the spacing of the ridges on the intermediate and finishing sections, measured from center to center, being substantially uniform.

3. A grinding wheel for centerless grinding screw threads on cylindrical work, comprising a tapered, thread generating section having thereon a plurality of annular, sloping ridges uniformly spaced and successively increasing in diameter for progressively forming a screw thread on the work, and a substantially cylindrical plain grinding section adjoining the smaller end of said thread generating section and having a diameter substantially equal to the diameter of the smallest of said ridges for reducing the work to uniform diameter and for cooperating with a control wheel to feed the work to the thread generating section.

4. A grinding wheel for centerless grinding screw threads, comprising a peripheral thread grinding zone having thereon a plurality of annular, sloping ridges uniformly spaced when measured from center to center, and a substantially cylindrical plain grinding zone adjoining one end of said thread grinding zone for reducing the work to uniform outer diameter and for cooperating with a control wheel to feed the work to the thread grinding zone.

5. A grinding wheel for grinding a helical groove in a work piece and having a smooth grinding section on one end of substantially uniform diameter, an intermediate tapered section consisting of annular grinding ridges varying progressively in diameter as they recede from said smooth grinding section, and a section on the opposite end consisting of annular grinding ridges of substantially uniform diameter, the diameter of the ridge of said last section being greater than that of the other sections.

6. A grinding wheel for grinding a helical groove in a work piece and having thereon a smooth grinding section of substantially uniform diameter and a tapered section adjoining said smooth section and consisting of annular grinding ridges increasing progressively in diameter as they recede from said smooth grinding section.

7. A machine for generating screw threads including a base, a grinding wheel rotatably mounted thereon, a control wheel rotatably mounted thereon, means for rotatively supporting a work piece in operative relation to said wheels, said grinding wheel having peripheral ridges thereon varying progressively in diameter but corresponding generally in shape to the screw thread to be generated on a work piece, said control wheel also having peripheral ridges formed thereon and varying progressively in diameter.

8. In a centerless grinding machine for generating screw threads, a grinding wheel having on its peripheral surface a plurality of annular thread grinding ridges progressively increasing in diameter in the direction of feed of the work across said surface and providing intervening grooves spaced to conform to the thread to be formed, and a control wheel having on its peripheral surface a plurality of ridges progressively increasing in diameter in the direction of feed of the work and providing intervening

grooves of substantially uniform diameter and spaced to conform to the thread to be formed.

9. A through feed centerless grinding machine for producing finished screw threads on a work piece including peripherally opposed grinding and control wheels, a work rest for supporting a work piece in operative relation to said wheels, said control wheel being tiltable to effect endwise movement of the work relative to the grinding wheel, said grinding wheel having a cylindrical portion adjacent the exit end thereof, a frustum portion adjacent the entrance end, said frustum portion being continuous with said cylindrical portion and tapering in a direction toward the entrance end of the grinding wheel, a series of annular ridges and intervening annular grooves formed on said cylindrical portion and having a shape and spacing conforming substantially to the shape and spacing of the finished thread to be formed, and a series of annular ridges formed on said frustum portion and spaced to conform substantially to the spacing of the thread to be formed, said frustum portion of the grinding wheel and the opposed control wheel forming a tapered throat having an entrance at least equal to the diameter of the unthreaded work piece, said control wheel being tilted in a direction to cause the work piece entering the frustum portion of the grinding throat to move continuously through the frustum portion for rough grinding and then through the cylindrical portion for finish grinding.

10. In a grinding machine, peripherally opposed grinding and control wheels forming a grinding throat, a work rest for supporting a work piece in operative relation to said wheels, said control wheel being mounted for angular adjustment to effect a feeding action of a work piece past said grinding wheel, said grinding wheel having a portion of uniform diameter at the finishing end thereof, a tapered portion adjacent to and continuous with said uniform diameter portion and tapering inwardly toward the opposite end of said wheel, uniformly spaced annular ridges on said wheel of a shape suitable for grinding a screw thread on a work piece, the grinding throat formed by the ridges on said tapered portion having a width at the entrance end equal at least to the diameter of the unthreaded work piece to be ground, the width at the finishing end being less than that at the entrance end by the depth of the thread, said control wheel being tilted in a direction to cause the work piece entering the end of the tapered portion to move continuously through said tapered portion for rough grinding and then through said uniform diameter portion for finish grinding.

11. In a centerless grinder, a grinding wheel and a control wheel peripherally opposed to one another and spaced to provide a grinding throat, a work rest for supporting work pieces in operative relation to said wheels, said control wheel being tiltable so as to provide an axial feeding movement of a work piece relative to the grinding wheel, said grinding wheel having a plain grinding zone on one end of its peripheral surface for reducing the work to uniform diameter, an intermediate peripheral zone having thereon a plurality of annular ridges successively increasing in diameter for progressively rough-forming a screw thread on the work, and a thread finishing zone on the opposite end of said peripheral surface and having thereon a plurality of annular ridges of substantially the same diameter and conforming substantially to the shape of the grooves of the finished thread.

12. An abrasive thread grinding wheel having a peripheral working face comprising a series of circumferentially parallel thread grinding ribs and intervening grooves in axially successive continuity, said ribs having flank surfaces at substantially equal angles to the wheel axis, the root surfaces of the grooves between said ribs lying on a common line of tangency parallel to the wheel axis, a group of said ribs progressively decreasing in radial dimension to an initial incipient thread forming rib at the work entrance side of the wheel, and the crest surfaces of the latter ribs and the root surfaces of the grooves between said ribs progressively increasing in width to the work entrance side of the wheel.

HAROLD E. BALSIGER.

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