Feb. 25, 1964 A. JURAS 3,122,038

METHOD AND APPARATUS FOR SIZE REDUCTION

Filed Dec. 29, 1959 7 Sheets-Sheet 1

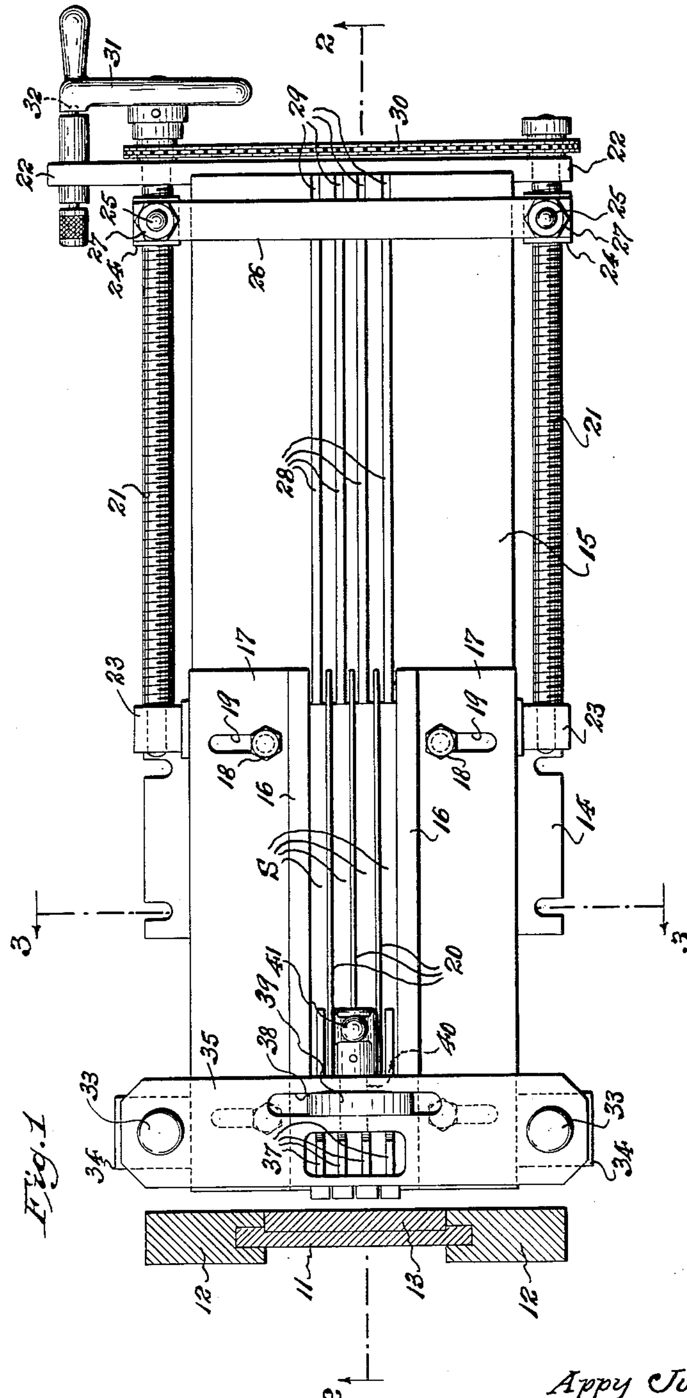

Fig. 1

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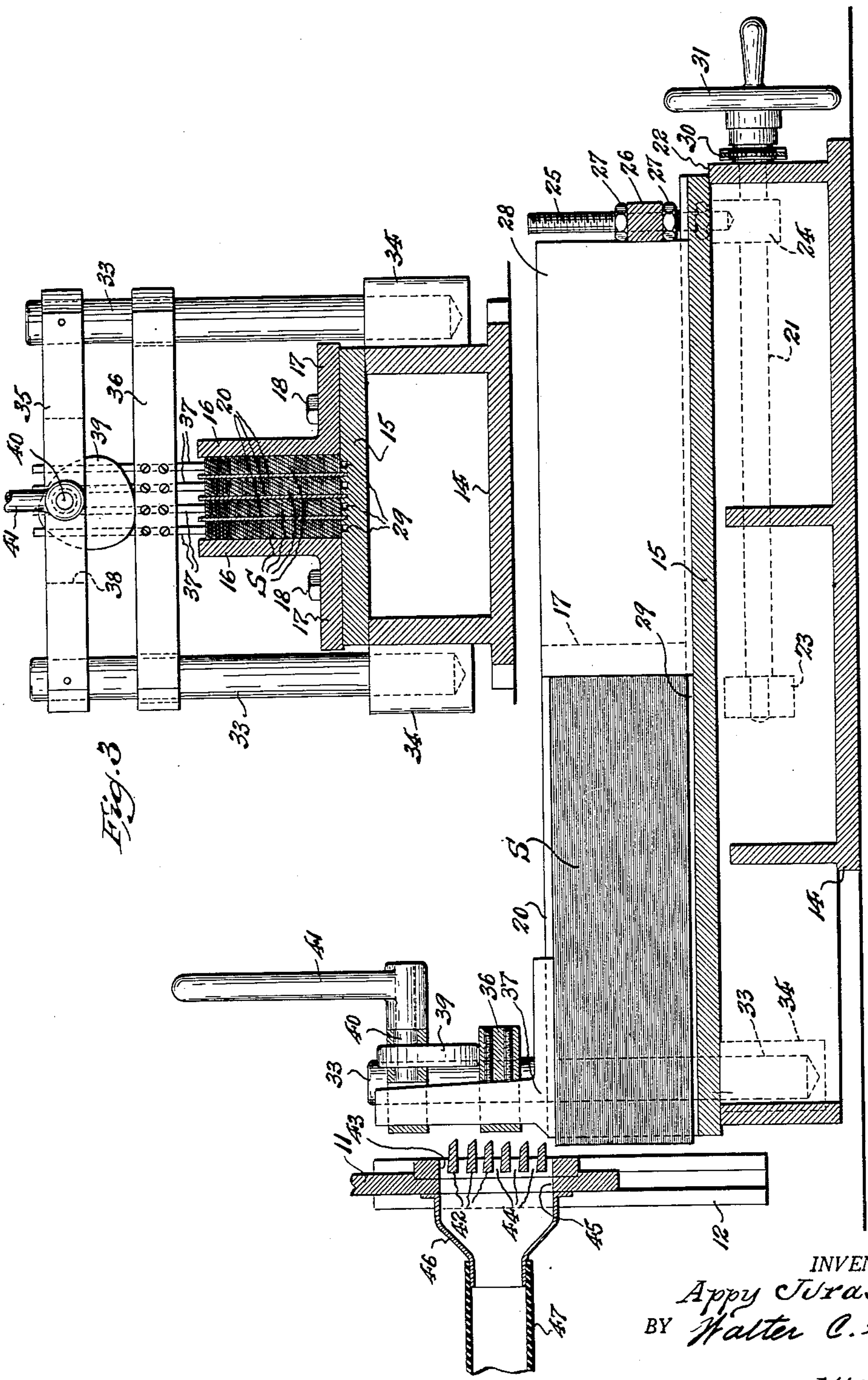

Fig. 3

Fig. 2

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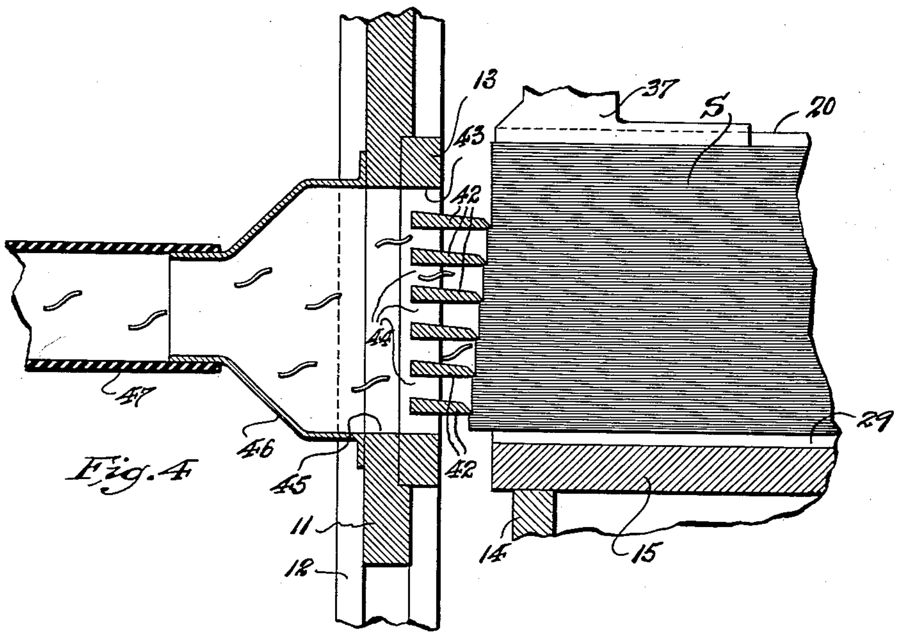

Fig. 4

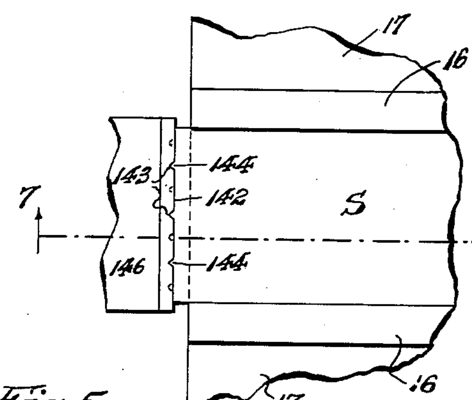

Fig. 5

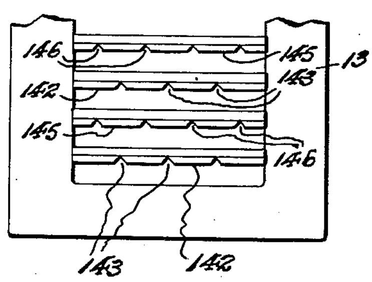

Fig. 6

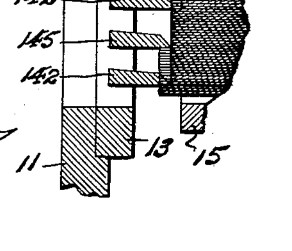

Fig. 7

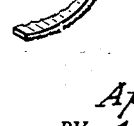

Fig. 10

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METHOD AND APPARATUS FOR SIZE REDUCTION

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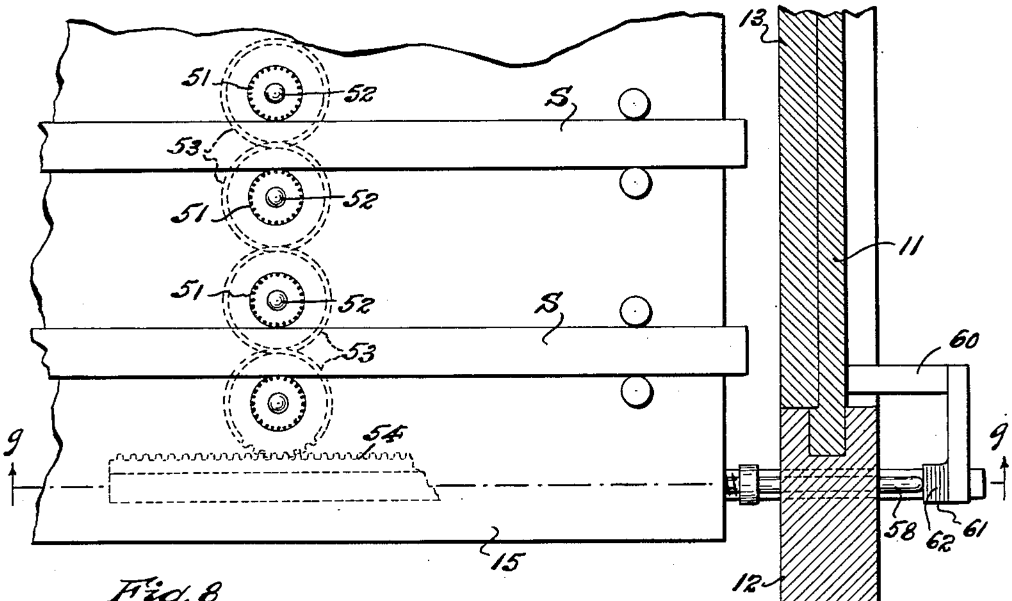

Fig. 8

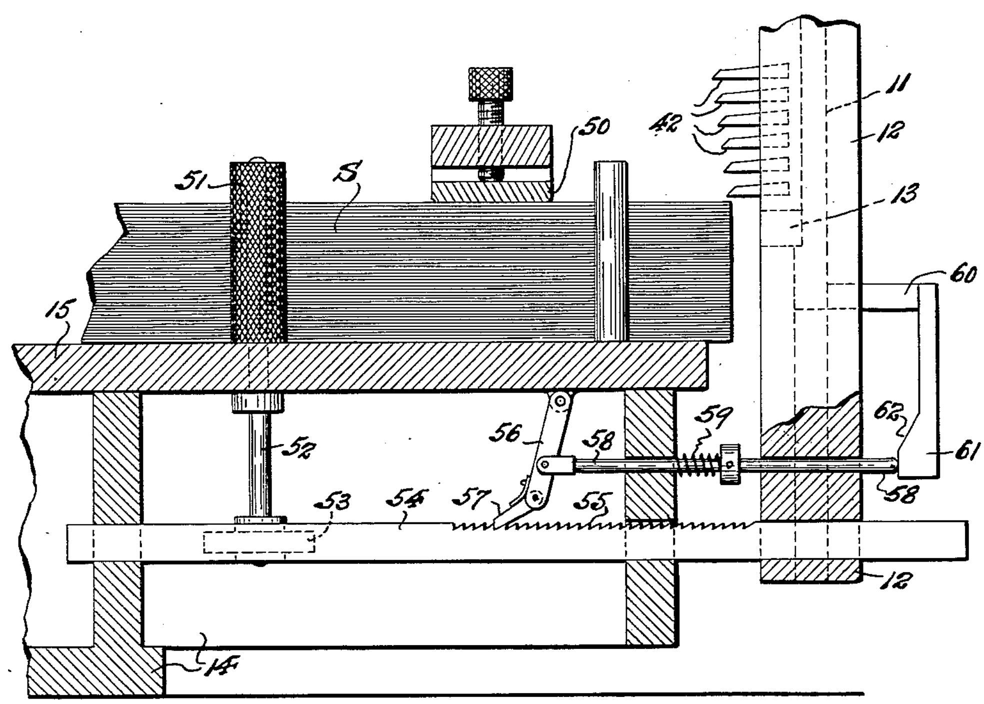

Fig. 9

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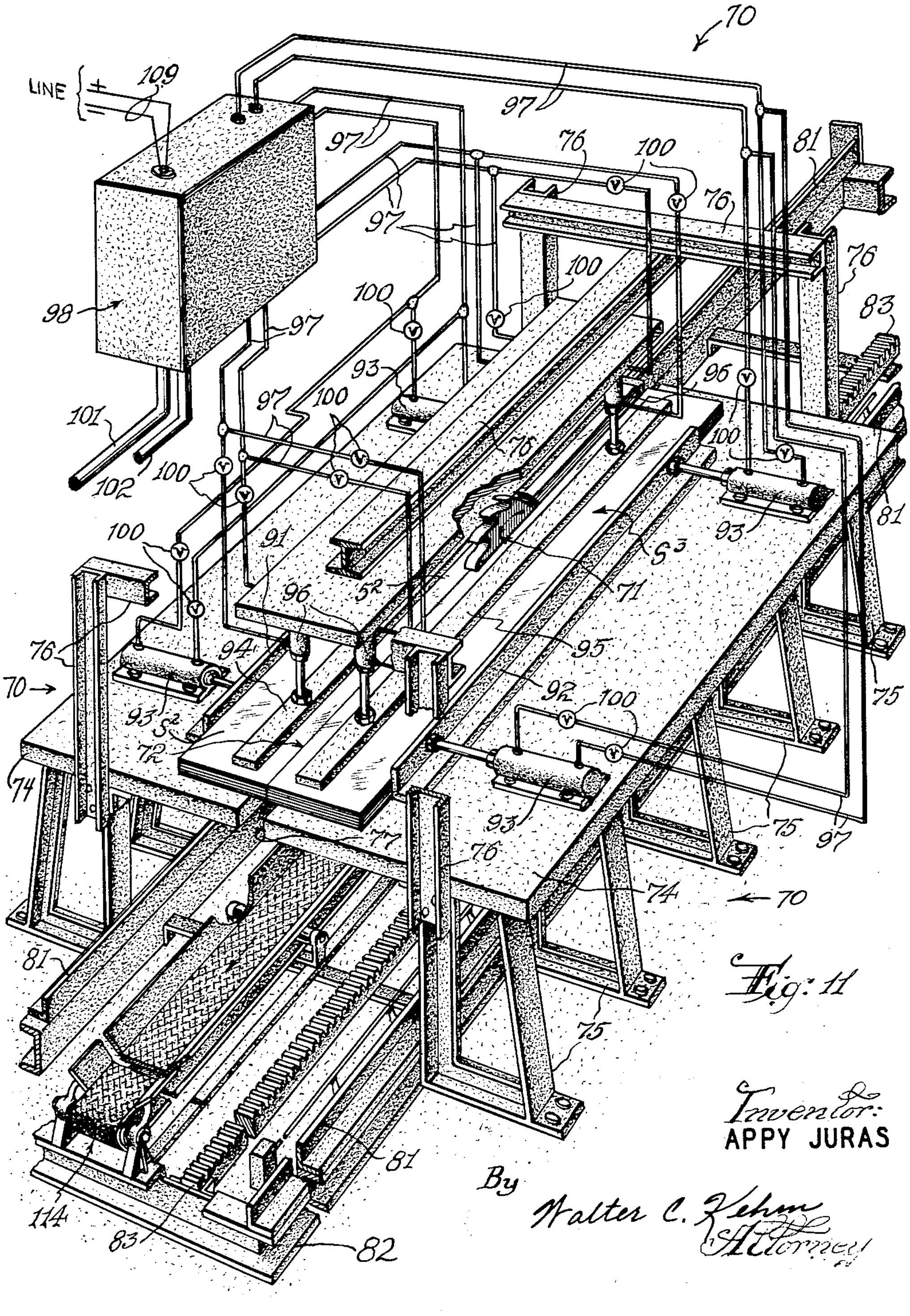

Fig: 11

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Fig. 12

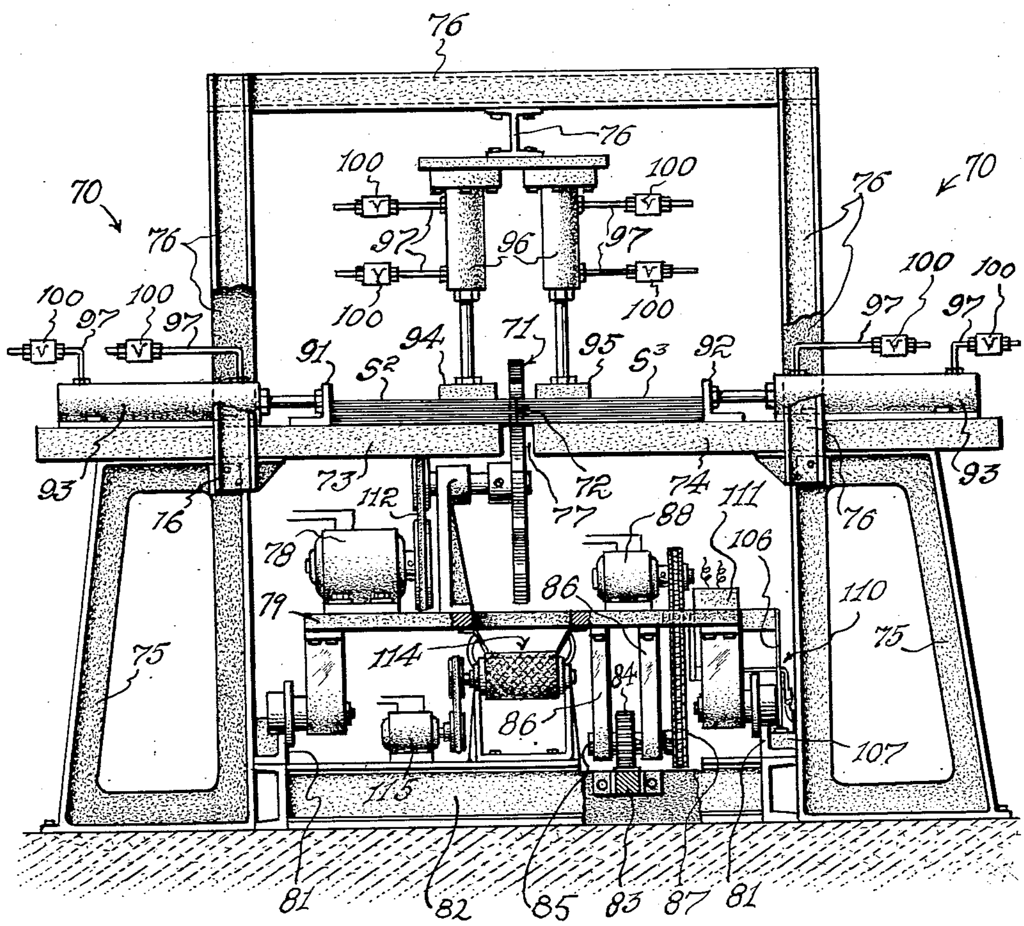

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Fig. 15

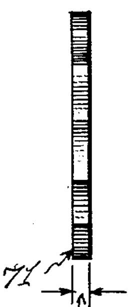


Fig. 16

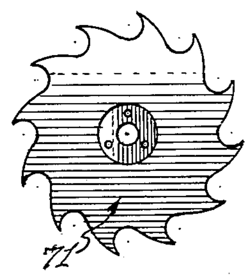


Fig. 13

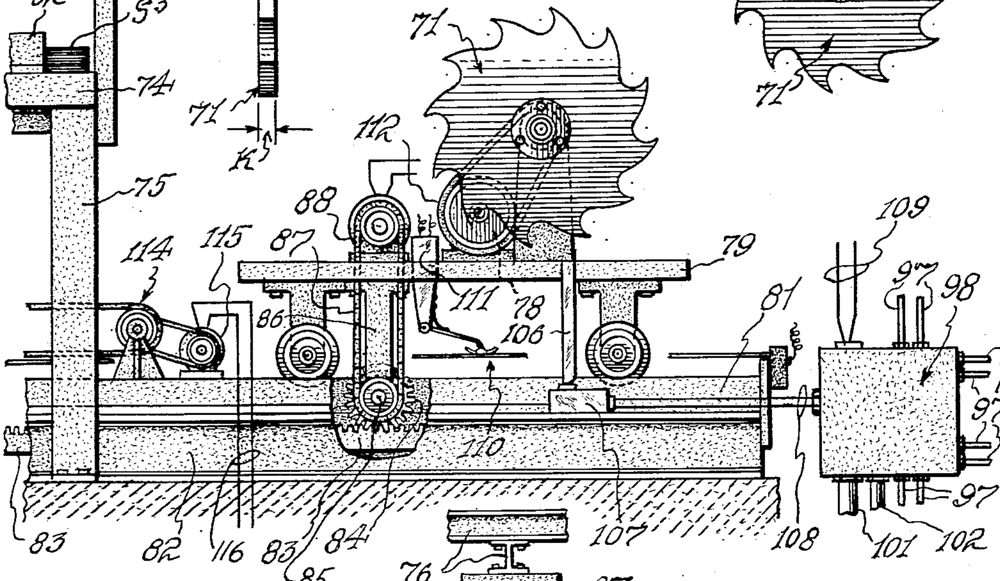
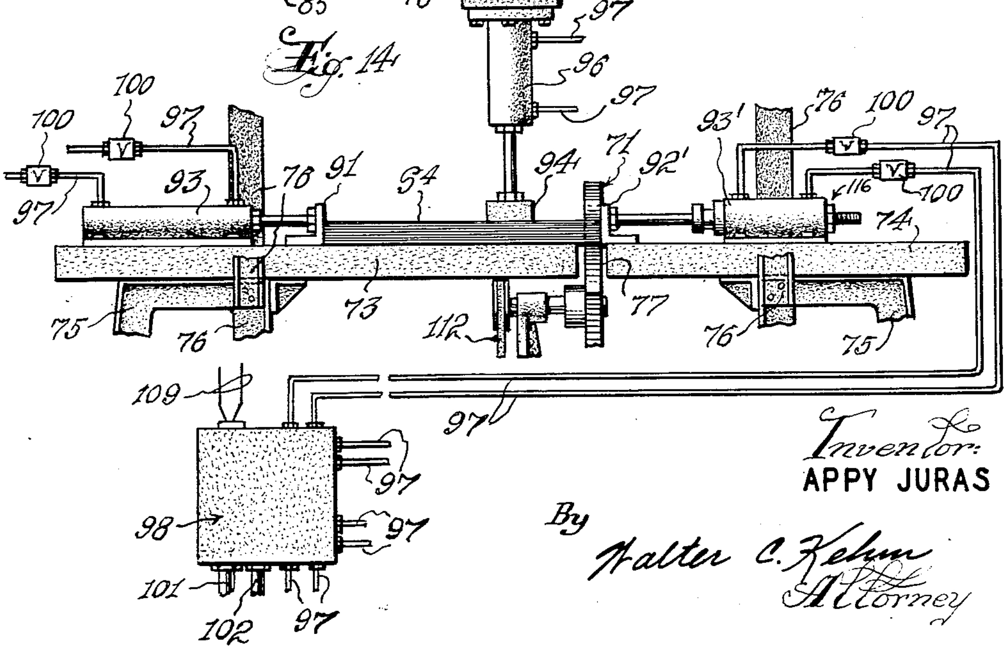


Fig. 14



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United States Patent Office

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METHOD AND APPARATUS FOR SIZE REDUCTION

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Filed Dec. 29, 1959, Ser. No. 679

9 Claims. (Cl. 83—24)

This invention relates to size reduction of materials. More particularly, it relates to size reduction by cutting particles of relatively small size from a relatively large size work piece.

This application is a continuation-in-part of application Serial No. 708,509, filed January 13, 1958, now abandoned.

The invention was occasioned by a need for material in suitable fiber form for particular uses. Thus, metallic fibers of relatively short length and substantially uniform cross-sectional dimensions are particularly well suited for use in fiber metallurgy, as a material for making up porous beds for certain filtering services, for use as reinforcing material or matrices for incorporation in plastic or other compositions such as ceramics and cermets.

Attempts have been made to produce short fibers by cutting fine wire or standard steel or other metallic wool into short lengths. These attempts have not provided a satisfactory fiber. Cut wire fibers are not satisfactory for the reason that they are costly and possess but poor adhesion to plastic material and to each other, although substantially uniform in cross-sectional dimensions and length. Steel and other metallic wool, when cut into short lengths, produce fibers which are irregular or non-uniform in cross-sectional dimensions and lengths, and, when accumulated in mass, involve an undesirably high bulk factor, as well as poor handling characteristics.

This invention has for an object to provide a method and means for producing short fibers which avoids the aforesaid undesirable characteristics of cut wire or cut steel or other metallic wool fibers; and to such end to produce fibers of selected uniform lengths and cross-sectional dimensions, and to selectively produce such fibers from various selected metals, or combinations thereof, such as tungsten, stainless steel, brass, bronze, copper, nickel, molybdenum, steel, silver, aluminum, or other desirable metals or metallic alloys, or combinations of metals with other materials, or metals having organic or inorganic coatings or other rigid material such as plastics.

According to the invention, fibers are produced by passing a toothed cutting tool transversely of an edge portion of a sheet or stack of sheets or material of composition for the fibers to move the teeth of the tool through the sheet or stack and cut pieces therefrom. The cutting tool is so proportioned and is used in the manner that the cutting kerf of the teeth substantially exceeds the thickness of the sheet. Hence, the width of the cutting element or kerf establishes the length of the fibers cut from the sheet. The thickness of the sheet and the bite of the teeth determine the cross-sectional dimensions of the fiber.

In a preferred embodiment of the method of the invention, a rotating saw blade is employed as the cutting tool. The saw is employed in the manner that the cutting kerf thereof is substantially greater than the thickness of the sheet, and so that the saw is advanced through the sheet to provide a bite substantially less than the cutting kerf. Thus, the bite and sheet thickness determine the cross-sectional dimensions of the sheet and the cutting kerf or width of the cutting element or tooth determines the length of the fibers, the amount of bite being established by the longitudinal speed of the cutting tool and its speed of revolution.

Advantageously, where a saw is employed, it can be passed through the sheet along an edge thereof to make the cut from the edge a distance up to about the kerf of the saw. Conveniently a plate saw as is commonly used to cut metal plate can be used for the fiber making operation. A saw generally suited for the operation is Oliver No. 838 plate saw, a product of Oliver Machine Company, Grand Rapids, Michigan. Such saws usually include a table for supporting the work, means for clamping the work in place for cutting, and a power driven circular saw mounted on a car which in turn is mounted on a track disposed to guide the saw over a cutting path in which the work is disposed. Means are provided for reciprocating the car over the track so that it can be alternately advanced through the work and returned for another such advance.

According to the invention, where a plate type saw is employed, the saw can be driven through a cycle including a cutting pass, during which the saw is moved from an initial position spaced from the sheet or work over the cutting path through the work, and a return pass, during which the saw is returned to the initial position, and the work can be advanced toward the cutting path intermittently and between the cutting pass and return pass and so as to present an edge portion of the work for cutting during each cutting pass.

Moreover, according to the invention, a saw, advantageously a plate type saw, can be employed in a manner generally suitable and, it is believed, novel, for the production of particles of relatively small size, and not necessarily of fiber form, from pieces of relatively large size. This manner of operation involves disposing two pieces of relatively large size adjacent each other, passing a saw through the pieces to form a cut in each piece along adjacent portions of the pieces and cut from each piece particles of relatively small size. Preferably, the relatively large pieces are placed in abutting relationship so that the saw in making the cut follows along the junction of the pieces. The abutting relationship results in the pieces providing support one for the other and hence facilitates the cutting operation. Desirably, a plate saw is employed for the cutting of two work pieces at one time, and the procedure of cycling the saw between a cutting pass and a return pass with intermittent advance of the work pieces can also be employed.

When the relatively small size particles cut from two work pieces at one time are fibers and the work pieces are sheets, the sheets are disposed in end to end relationship so that an edge portion of each sheet is cut away during each cutting pass of the saw. The cutting is in the manner that the distance of the cut from the edge of each sheet substantially exceeds the thickness of the sheets and the bite of the saw. Hence, there is cut from each sheet fibers of length corresponding to the cutting kerf or depth of cut measured from the sheet edge, and of cross-sectional dimensions corresponding to the saw bite and the thickness of the sheet.

Instead of using a saw, the cutting tool can be in the form of a broach having vertically spaced cutting teeth arranged in the manner that each adjacently above cutting tooth projects outwardly beyond the one beneath it a distance equal to the desired bite for the teeth. The broach can be passed transversely of an edge portion of the sheet so as to move the teeth of the broach through the sheet and cut pieces therefrom. The cutting kerf of the broach is such that it substantially exceeds the thickness of the sheet and the bite of the teeth and hence pieces of fiber form are cut from the sheet, the thickness of the sheet and the bite of the broach determining the cross-sectional dimensions of the fiber and the cutting kerf of the broach determining the length thereof. The broach can be reciprocated to provide a cutting pass during which the fibers are cut from the sheet and a return pass during which the broach is returned for commencing another cutting pass. Further, the sheet can be advanced following each cutting pass and before commencement of the next cutting pass so as to position the stack for cutting action of the broach for each cutting pass thereof.

While the method of the invention can be employed to cut fibers from a single sheet, it is preferred to cut the fibers from a stack of sheets, the cutting tool being passed transversely of an edge portion of the stack to move teeth of the cutting tool through the sheets and cut pieces therefrom. It is desirable to work on a stack since this permits an increased production rate, and further, facilitates the cutting since adjacent sheets provide mutual support and hence permit more rapid cutting action and greater uniformity in dimensioning of the fibers produced.

The method of the invention will be further described, and the apparatus of the invention will be described with reference to the accompanying drawings where preferred embodiments of the invention are depicted. The representations in the drawings are representative of the invention, but do not disclose the full scope thereof, the extent of the invention being as is set forth in the accompanying claims.

In the drawings:

FIG. 1 is a plan view, in part section, of an illustrative embodiment of apparatus by which the method of producing fibers according to this invention can be carried out employing a cutting tool in the form of a broach; FIG. 2 is a vertical longitudinal sectional view of the same, taken on line 2—2 in FIG. 1; FIG. 3 is a transverse vertical sectional view of the same, taken on line 3—3 in FIG. 1; and FIG. 4 is a fragmentary longitudinal sectional view, similar to that of FIG. 2, but drawn on an enlarged scale to show the progress of a cutting stroke of the broach or cutting tool of the apparatus.

FIG. 5 is a fragmentary plan view showing a modified form of broach or cutting tool; FIG. 6 is a fragmentary face view of said modified form of broach or cutting tool; and FIG. 7 is a vertical longitudinal sectional view, taken on line 7—7 in FIG. 5 to show the progress of a cutting stroke of said modified form of broach or cutting tool.

FIG. 8 is a fragmentary plan view, in part section, of a modified type of apparatus, employing a cutting tool in the form of a broach and by which the method of producing fibers according to this invention can be carried out, this type of apparatus including means for automatically advancing superposed metallic sheets or strips subject to the operation of a reciprocated broach or cutting tool; and FIG. 9 is a longitudinal sectional view of the same taken on line 9—9 in FIG. 8.

FIG. 10 is a perspective view of a metallic fiber, produced by the method of this invention, said view being greatly enlarged.

FIG. 11 is an isometric view of a plate saw suitable for use in producing fibers according to the invention; FIG. 12 is an end elevation of said plate saw, a portion of the superstructure being broken away in order to better illustrate the invention; and FIG. 13 is a side elevation of the end portion of said plate saw remote from the foreground in FIG. 11.

FIG. 14 is an end elevation of a plate saw of form alternate to that shown in FIG. 11.

FIG. 15 and FIG. 16, respectively, are end and side elevational views of a saw element suitable for use with a plate saw machine such as that of FIG. 11 or FIG. 14.

The apparatus, broadly considered, comprises a toothed cutting tool, a work table for supporting the work to be cut by movement of the tool through its cutting path, and means for cycling the tool from an initial position over its cutting path and a return pass to return the tool to its initial position. Additionally, the apparatus includes work manipulating means for advancing the work toward the cutting path a distance corresponding to the extent of the cut made during the cutting pass and to dispose material of the work piece in the cutting path for the cutting thereof. Desirably, the apparatus includes actuating means for the work manipulating means. The actuating means is responsive to a position of the cutting tool in the cycle thereof and effective to actuate the work manipulating means intermittently and between the tool cutting pass and return pass. Thus, for each cutting pass of the tool an edge portion of the work can be disposed in the cutting path for cutting during the cutting pass and particles of relatively small size can be cut from the work.

Referring to the drawings, wherein like reference characters refer to corresponding parts, in FIGS. 1–9, apparatus employing a cutting tool in the form of a broach is represented. FIGS. 1–4 inclusive disclose one illustrative embodiment of apparatus by which the fiber production method of this invention can be carried out. At one end of the apparatus is located a broach or cutting tool mechanism. This mechanism comprises a vertically reciprocable broach ram 11 that is slidably supported by and between stationary slideway members 12. Suitably affixed to the broach ram is a broach or toothed cutting tool 13 of novel character hereinafter more particularly described. The broach ram 11, with the broach or cutting tool 13 carried thereby, is adapted to be vertically reciprocated by any suitable power actuated driving mechanism (not shown).

Opposed to the broach or cutting tool mechanism is means for supporting and feeding a stack or stacks of superposed metallic sheets or strips S subject to the cutting action of said mechanism. As shown, by way of illustration, this means comprises a base frame 14 upon which is suitably affixed a bed plate 15. The stack or stacks of metallic sheets or strips S are supported by the bed plate 15 subject to longitudinal advance thereover toward the broach or cutting tool mechanism. The stack or stacks of sheets or strips are moved between upstanding, laterally spaced apart guide members 16, the base flanges 17 of which are secured to the bed plate 15 by releasable bolts 18 that pass through slots 19 with which said base flanges are provided. This arrangement permits relative adjustment of the guide members 16 to accommodate the same to the width of the stack or stacks of the sheets or strips S to be operated upon.

The metallic sheets or strips to be operated upon are thin, ranging from .0002 up to .062 of an inch in thickness, whereby one cross-sectional dimension of fibers produced therefrom is determined by the selected thickness of the individual sheets or strips. The sheets or strips are superposed to form a stack thereof of suitable height commensurate with the stroke amplitude of the broach or cutting tool. A stack or stacks of from three to four inches in height has or have been found to be practical, although higher stacks can be used in ratio to the power and stroke of the broaching equipment.

It has been found advantageous to utilize metallic sheets or strips of selected width, whereby the width thereof predetermines the length dimension of fibers produced. As shown in FIG. 1, a plurality of stacks of sheets or strips S of selected width can be supported side by side upon the bed plate 15 between the guide members 16. In such case, it is preferable to provide the bed plate 15 with upstanding partition plates 20 for extension between and so as to separate the stacks of sheets or strips one from another.

Feed means is provided for advancing the stack or stacks of metallic sheets or strips S over the bed plate 15, after each cutting stroke of the broach or cutting tool 13, whereby to feed the same forward to a position ready for a next cutting stroke of the broach or cutting tool on the parts of said stack or stacks which were laid bare by the preceding stroke or left thereafter. An illustrative form of such feeding means, as shown in FIGS. 1 and 2, which is a manually operable type, comprises feed screws 21 respectively extending along opposite rearward side portions of the base frame 14. The rearward ends of the feed screws 21 are journaled in lateral extensions of a transverse end wall 22 of said base frame. The forward ends of the feed screws 21 are journaled in bearings 23 which project from the sides of said base frame. The feed screws are threaded through traveling nuts 24 that are movable thereon. Upstanding from the respective traveling nuts are screw-threaded posts 25, which support a transverse push bar 26, in bridging extension between said posts, at a level above the bed plate 15. The push bar 26 is vertically adjustable relative to the surface of the bed plate 15, and is adapted to be fixed in a desired adjusted position by binder nuts 27 which are threaded unto the posts 25 above and below said push bar. Suitably affixed by their rearward ends to the push bar 26 are forwardly extending vertical push plates 28. Said push plates 28 correspond in number and lateral spacing to the number and spacing of the stacks of metallic sheets or strips S which are supported upon and movable over the surface of the bed plate 15. The forward ends of the push plates 28 abut the rear ends of the stacks of sheets or strips S. Preferably, the bed plate 15 is provided with longitudinal guide channels 29, disposed in alignment with the stacks of sheets or strips S. The bottom edge portions of the push plates 28 ride in said guide channels 29, whereby to be so guided thereby as to maintain aligned propelling engagement with the rear ends of the stacks of sheets or strips S.

The feed screws 21 are connected together, for simultaneous rotation, by chain and sprocket transmission means 30 which extends therebetween. Affixed to the rear end of one of the feed screws 21 is a hand wheel 31 for imparting rotative movement to the feed screws. This hand wheel can be indexed for cooperation with a yieldable stop detent 32, whereby e.g. one revolution of the hande wheel will so rotate the feed screws 21 as to advance the push bar 26 and push plates 28 the required distance to feed forward the stacks of sheets or strips S that amount which will position the latter for a succeeding operation of the broach or cutting tool 13 after completion of a preceding operation thereof. The pitch of the feed screws can be so predetermined as to cause the required amount of forward feed movement of the stacks of sheets or strips S when the hand wheel 31 completes one revolution. It will be understood that this arrangement and mode of operation for advancing the stacks of sheets or strips a required distance is merely one of various ways which can be resorted to for attaining a desired measured, step by step advance of the stacks of sheets or strips S, whereby to feed the latter subject to the operation of the broach or cutting mechanism.

After the stacks of sheets or strips S have been advanced to a position ready for cutting action of the broach or cutting tool 13, releaseable means is provided for clamping the stacks so as to hold the same against displacement during such cutting action. An illustrative form of stack clamping means is shown in FIGS. 1, 2 and 3, and comprises a pair of upstanding guide posts or columns 33 which are disposed at opposite side portions of the base frame 14, to upstand therefrom adjacent to the forward end of the bed plate 15, said guide posts or columns being footed in supporting members 34 which project from exterior sides of said base frame 14. Secured to the upper end portions of the guide posts or columns 33, to extend therebetween in bridging relation thereto, is a stationary bridge bar 35. Slidably mounted on and between the guide posts or columns 33, for vertical movements thereon below the stationary bridge bar 35, is a transverse clamp bar 36. Secured to said clamp bar, are a plurality of dependent clamp members or fingers 37, that correspond in number to the number of stacks of sheets or strips S supported upon the bed plate 15.

The bridge bar 35 is provided with a longitudinal slot 38 in which is mounted a clamp bar actuating cam 39. This cam is rotatively supported by a shaft 40 journaled in the bridge bar 35, and a hand lever 41 for operating said cam is secured upon an external end portion of the shaft 40. The cam 39 engages the clamp bar 36, and, when rotated in one direction, exerts downward thrust against the latter, whereby to lower the clamp members or fingers 37 into holding engagement respectively with the respective stacks of sheet or strips S, and, when rotated in the opposite direction, allows the clamp bar to rise and thus relax the pressure of the clamp members or fingers 37, whereby to release the stacks of sheets or strips S from the holding engagement thereof, when it is desired to advance said stacks over the bed plate 15, ready for an ensuing cutting action of the broach or cutting tool after a previous cutting operation of the latter has been completed.

Whereas in some case it is desirable to release the pressure on stacked superposed sheets using the clamping means described, an alternative effective means involves advancing the stack of sheets while a constant clamping pressure is applied to said stack, the action of the feed mechanism being adapted to overcome the resistance of the clamping pressure, so as to allow the stack to move forward.

The broach or toothed cutting tool 13 is provided with a plurality of vertically spaced, transverse cutting teeth 42, which project toward the means for supporting and feeding the stack or stacks of sheets or strips S subject to the cutting action of said broach or cutting tool. The cutting teeth 42, in the upward succession thereof, progressively increase in outwardly projecting distance from the broach or cutting tool 13 toward the stack or stacks of sheets or strips S opposed thereto, so that the cutting edge of each adjacently above tooth projects beyond the cutting edge of the tooth beneath it a selected distance.

As thus far described, the operation of the broach is in the manner that it is moved transversely of an edge portion of the stack S to cut along only parallel planes pieces of fiber form from the sheets. The length of each piece, in the corresponding one of said planes, can be determined by either the kerf or width of the broach teeth, or the width of the stack S as is the case for the embodiment of the drawings wherein the kerf or cutting edge of the teeth spans the width of the stack S.

By "kerf" of the cutting tool teeth is meant the width of the teeth or length along the cutting edge thereof and by "cutting kerf" is meant the depth of the cut made by the tool and measured in the direction of the tooth cutting edges. Thus, "cutting kerf" has reference to an application of the tool for cutting and is, in operative effect, the effective kerf of the saw in a given application.

According to the invention, the cutting kerf of the teeth substantially exceeds the thickness of the sheets and the bite (i.e. the depth of cut of each tooth measured in a direction perpendicular to the cutting edge thereof) of the teeth. Thus, the length of the fibers produced is determined by the kerf and the cross-sectional dimensions of the fibers are determined by the sheet thickness and the bite of the teeth. By reason of the relationship of the cutting teeth 42 one to another, the lowermost tooth will make a first fiber cutting transit downwardly across the ends of the stacks of sheets or strips S opposed thereto, followed by successive fiber cutting transits of the succeeding cutting teeth across the ends of said stacks of sheets or strips (see FIG. 4). Due to this arrangement a considerable quantity of fibers is produced by each descending cutting stroke of the broach or cutting tool 13 and it is unnecessary to advance the broach along the planes of the sheets and into the stack during the forward passes, as contrasted with the advance of the saw during such passes as described in connection with a succeeding embodiment.

The fibers produced by the above described broaching operation of the broach or cutting tool may be allowed to drop away by gravity for collection in an underlying receptacle. Preferably however, the cutting teeth 42 of the broach or cutting tool 13 are arranged to bridge across an opening 43 with which the broach or cutting tool is provided, and said cutting teeth 42 are vertically spaced apart to provide open passages 44 contiguous thereto, which passages communicate with said opening 43. The broach ram 11 is provided with an opening 45 in register with said opening 43 of the broach or cutting tool 13. Mounted on the back of the broach ram 11, in register with its opening 45, is a collecting hood 46 which leads to a flexible conduit 47, whereby the fibers produced by the cutting stroke of the broach or cutting tool 13 are drawn or sucked through the passages 44 contiguous to the cutting teeth 42, and thence through the openings 43 and 45 to the hood and conduit, being thus conveyed from the apparatus for delivery to suitable place of collection.

The length of the fibers produced by the broaching operation can be 1/32" to 2". Although it is probably preferable to predetermine the length of fibers produced by broaching sheets or strips of widths which correspond to the desired length of fiber, other methods may be utilized to obtain a selected fiber length from sheets or strips of widths in excess of the selected fiber length. For example, as shown in FIGS. 5 to 7 inclusive, this may be done as follows:

A single stack of sheets S' is deposited upon the bed plate 15 between the suitably adjusted guide members 16, subject to advance thereof for operative engagement by the broach or cutting tool 13. The cutting teeth of the broach or cutting tool are modified. These modified cutting teeth comprise sets or pairs thereof. Each set or pair of these cutting teeth comprise a lowermost tooth 142, the cutting edge of which is interrupted, at spaced intervals corresponding to the selected length of fiber to be produced, by indented cutting edges 143 that are adapted to leave dividing projections 144, of the broached edge portions of the sheets, that form divisions determining the ends of the selected length of a produced fiber, and an upwardly adjacent tooth 145, the cutting edge of which can be likewise interrupted, at spaced intervals, by indentations 146, which are located in staggered relation to the indented cutting edges 143 of the adjacently below cutting tooth 142. After the cutting edge of a tooth 142 cuts through a sheet of the stack S', to thereby sever therefrom a plurality of desired fibers, the remaining edge of said sheet will possess dividing projections 144 outwardly extending therefrom. These projections 144, upon following descent of the succeeding tooth 145, will be sheared away, leaving the remaining edge of the sheet in straight extension ready for the broaching action of a following tooth 142 and associated tooth 145. It will be understood that the above described arrangement of associated cutting teeth 142 and 145 is but one of various arrangements and cutting teeth design which may be resorted to for the broaching of fibers of predetermined length from sheet material in excess of such length.

Although in the illustrative embodiment of fiber producing apparatus above described, the means for advancing the stack or stacks of sheets or strips is shown as a manually operable type, it is quite possible, and in many cases may well be desirable to provide means, synchronized with the reciprocating movements of the broach or cutting tool, adapted to automatically advance the stack or stacks of strips coincident with the recovery stroke of the broach or cutting tool from each operative stroke thereof.

An illustrative form of an automatic stack feeding or advancing means is shown in FIGS. 8 and 9. In the illustrative arrangement to this end, a desired number of stacks of sheets or strips S are supported upon the bed plate 15 in suitably laterally spaced apart parallel relation. Said stacks are adapted to be held down upon the bed plate 15 against upward displacement by a suitable adjustable frictional holding means or clamp 50. Each stack of sheets or strips S passes between pairs of upstanding feed rollers 51, the peripheral surfaces of which are knurled or otherwise prepared to make good gripping or frictional engagement with opposite sides of an engaged stack. The feed rollers 51 are mounted on vertical shafts 52 that are journaled in the bed plate 15. Said shafts 52 are geared together by successive intermeshing drive gears 53 (see FIG. 8). The means to intermittently drive the gears 53, whereby to impart rotative stack advancing movement to the feed rollers 51, as shown, comprises a rack 54, the teeth of which engage an outermost drive gear 53. This rack 54 is slidably supported in connection with the base frame 14 and the lower portion of a slideway member 12 of the broach or cutting tool guide means. The rack 54 is provided on its top surface with ratchet teeth 55. Pivotally dependent from the underside of the bed plate 15 is an oscillatory lever 56, to the lower end of which is pivotally carried a spring pressed pawl 57, which is adapted to engage the ratchet teeth 55 of the rack 54. Also slidably supported in connection with the base frame 14 and the lower end of a slideway member 12 of the broach or cutting tool guide means is a push rod 58, the forward end of which is pivotally joined to the lever 56. This push rod 58 is yieldably retracted to a normal initial position by spring means 59. Secured to the broach ram 11, so as to move up and down therewith as it is operatively reciprocated, is a bracket extension 60 by which is carried a cam element 61 provided with a downwardly and forwardly inclined cam face 62. This cam element 61 is so disposed as to move in a path crossing the axis of the push rod 58. When the broach or cutting tool 13 descends to perform a fiber broaching or cutting stroke, the cam element will disengage the push rod 58, so that the latter will be retracted to normal initial position. As the broach or cutting tool 13 ascends, after completion of a broaching or cutting stroke thereof, and the same approaches the end of its ascending recovery stroke, the cam face 62 of the cam element 61 will traverse the opposed end of the push rod 58, thereby imparting forward movement to the latter so as to swing forward the lever 56 to advance the pawl 57 carried thereby, thus, through the engagement of said pawl with ratchet teeth 55 of the rack 54, advancing said rack a predetermined amount. The advancing movement of the rack 54 is transmitted to the drive gears 53, which gears drive the feed rollers 51 in proper directions to advance the stacks of sheets or strips S, whereby to position the same subject to the ensuing descending broaching or cutting stroke of the broach or cutting tool 13. Here again such automatic sheet or strip stack advancing mechanism is merely illustrative of one of various types of means by which automatic feeding advance of stack or stacks of sheets or strips may be attained in timed relation to operative reciprocation of the fiber broach or cutting tool actuating mechanism.

A preferred manner of producing fiber according to the invention is to utilize a saw, i.e. a tool formed by a plate having a continuous series of teeth along the edge thereof. It has been found the use of a saw permits relatively rapid production, and further results in production of fibers of more uniform size. The saw is used in the manner that the thickness of the sheet and the bite of the saw determine the cross-sectional dimensions of the fibers and the cutting kerf determines the length thereof. Advantageously, the saw is in the form of a power driven circular saw, and a plate saw having a circular blade can be employed. Such saws are depicted in FIGS. 11–14 of the drawings. These saws are Oliver Plate Saws as manufactured by Oliver Machinery Company of Grand Rapids, Michigan, suitably improved to adapt them for the purposes of the invention.

The plate saw shown in FIG. 11 and FIG. 12 is adapted to cut fibers from two stocks S^2 and S^3 simultaneously, the operation being in the manner that the stacks are placed in abutting end to end relation and the saw is passed along the adjoining edge portions thereof to form a cut in each stack.

Plate saw 70 (FIG. 11 and FIG. 12) includes a circular saw blade 71 and means shortly to be described for driving the saw and simultaneously moving it over a cutting path along which the stacks S^2 and S^3 are in abutment, as indicated at 72.

The saw includes work supporting tables 73 and 74 disposed one on each side of the saw, and suitable table legs 75 and superstructure 76 (FIG. 12) for disposing the tables 73 and 74 so as to provide therebetween a cutting path 77 for the saw blade 71.

The saw blade 71 is driven by motor 78, and the saw blade and motor along with other equipment shortly to be described is mounted on a car 79 which is arranged for movement over a track 81, whereby the saw blade is provided to be moved along the cutting path 77.

The track 81 is secured to track foundation 82 which can be bolted to the floor. Car driving means are provided for reciprocating the car 79 over the track so that it can be advanced from an initial position, which is shown in FIG. 13, wherein the end of the track remote from the foreground of FIG. 11 is shown, over the cutting path and through the work, e.g. the stacks S^2 and S^3, and then returned to the initial position. The car driving means includes a gear rack 83, secured to the track foundation, and pinion 84 arranged for cooperation with the rack 83 and mounted on the car 79. The mounting of the pinion is by way of the shaft 85 which is journaled in depending arms 86. The pinion is connected by a chain 87 to a car driving motor 88 mounted on the car 79. Means for stopping, reversing, and starting the car driving motor 88 are provided but are not shown since these auxiliary items are common to plate saws of the type described and form no part of the present invention.

As thus far described, the plate saw provides for the cycling of the saw blade 71 relative to the work from an initial position (FIG. 13), wherein the saw is spaced from the work, over a cutting path through the work to form a cut therein, and a return pass, during which the saw is returned to the initial position.

The invention includes provision of work manipulating means for advancing the work toward the cutting path a distance up to about the kerf of the saw, and actuating means for the work manipulating means. The actuating means can be responsive to a position of the saw in the cycle thereof, and effective to actuate the work manipulating means intermittently and between the saw cutting pass and return pass. Thus, for each cutting pass of the saw an edge portion of a work piece on each table can be disposed in the cutting path for cutting during the cutting pass.

In the embodiment shown in the drawings, the work manipulating means includes the fences 91 and 92 and the fence actuating air cylinders 93, which cylinders are operative to advance the stacks S^2 and S^3, by working against the fences 91 and 92, toward the cutting path 72. The manipulating means also includes the clamp bars 94 and 95 which are served by air cylinders 96. The air cylinders 96 are operative to press against the clamp bars and force the stacks S^2 and S^3 into tight engagement with the work tables 73 and 74. If desired, feed screws could be used in place of the air cylinders 93 which are connected to the fences 91 and 92.

Air lines 97, which include adjusting valves 100, are connected to the cylinders 93 and 96 and to a control unit 98, to which air supply and exhaust lines 101 and 102 are connected. The control unit 98 is for actuation of the cylinders 93 and 96 in a suitable sequence and in suitable time relation with the position of the saw, so as to provide the stacks S^2 and S^3 in suitable position for the cutting operation. The control unit can be operated manually or automatically. In either event, the operation is in the manner that after the saw has traversed the

return pass to the point where it is clear of the stacks S^2 and S^3 and is at or adjacent its initial position (FIG. 13), pressure on the clamp bars 94 and 95 is released and pressure on the fences 91 and 92 is applied, so that the stacks are forced toward the cutting path 77 and into abutting relation. Following abutment of the stacks, which can be sensed by buildup of pressure in the fence actuating cylinders 93, pressure is again applied to the clamp bars 94 and 95 so as to secure the stacks in place. At this time the stacks are ready for another cutting pass of the saw blade 71, and of course this sequence of operations must be completed before the cutting is commenced.

An arrangement for automatic operation of the work manipulating means, and whereby the actuating means for the work manipulating means is responsive to a position of the car 79, is indicated in FIG. 13. As is there shown, a finger 106 is mounted on the car 79 and a switch 107 is arranged on the track foundation 82 to be engaged by the finger 106 after the saw blade 71 has cleared the work on its return pass. The switch is connected by power lines 108 to the control unit 98 and the latter unit is also serviced by power supply lines 109, and it is provided with suitable means for effecting operation of the air cylinders 93 and 96 to manipulate the work as aforesaid and to provide edge portions of the stacks S^2 and S^3 in the cutting path for the cutting thereof upon the ensuing cutting pass of the saw blade 71.

Auxiliary equipment not heretofore specifically referred to and shown in FIGS. 11–13 are the third rail connection 110 (FIG. 13) and the associated junction box 111 on the car 79, all for supplying power to car mounted motors 78 and 88; the drive belt 112 (FIG. 13) interconnecting the motor 78 and saw blade 71; and the belt conveyor 114 (FIG. 11) its drive motor 115 and the motor power supply lines 116, the conveyor being disposed beneath the cutting path 77 for receiving fibers cut from the stacks S^2 and S^3 and conveying them to a suitable location. If desired a vacuum conveyor system (not shown) can be used in combination with the belt conveyor 114 to handle the fibers.

In operation of the apparatus shown in FIGS. 11–13, while it is desirable that the stacks be advanced before each cutting pass into abutting relation as the abutment provides added support for the sawing operation, this is not essential and the stacks can be advanced so that they are left spaced apart for the cutting pass.

In FIG. 14, there is indicated a plate saw arrangement wherein but a single stack S^4 is the work piece. This arrangement is in general similar to the embodiment of FIGS. 11 to 13, except a fence 92' is provided to limit travel of the stack S^4 in movement toward the cutting path 72. The fence 91 and its actuating cylinders 93, and the clamp bar 94 and its actuating cylinder 96 can operate as described above for the plate saw of FIG. 11. The fence 92' and its actuating cylinder 93' are arranged to operate in the manner that the piston of cylinder 93' extends upon movement of the stack S^4 toward the cutting path 72, an amount sufficient to suitably limit travel of the stack, and following abutment of the stack S^4 and the fence 92' and application of clamping pressure to clamping pressure to clamping bar 94 by cylinder 96, the piston of cylinder 93' retracts to withdraw the fence 92' from a position in which it would interfere with the saw blade 71. Means in the form of adjusting nuts 116 are provided for adjusting the throw of the piston of cylinder 93' and hence for adjusting the extent to which the stack S^4 is advanced upon movement of the stack advancing fence 91. The stack can be advanced an amount equal to the kerf of the saw 71 or a lesser amount depending on the length desired for the fibers.

As described above, the sheet thickness and saw bite will determine the cross-sectional dimensions of the fibers. As in the case of the broach type cutting tool the sheets can be in the range of .0002–.062 inch. The saw bite depends on the speed at which the saw is advanced through the work. The slower the advance speed, the finer the fiber. A suitable range of saw bite is .0001–.02 inch although I have successfully utilized bites up to .062 inch. The fiber length can be the kerf of the saw teeth or less. It can be .01 inch up to ½ inch or up to as much as 3 inches or even greater. Where edge portions of two sheets are cut simultaneously the length of the fibers, if the lengths are to be equal, can be up to half the kerf of the saw.

A circular saw as depicted in FIGS. 15 and 16 is well suited for the purposes of the invention. The kerf of the saw, which is indicated by the reference letter k is relatively wide and the saw teeth are of the form commonly used for milling, i.e. the teeth do not extend axially from the plate forming the body portion of the saw. Equivalents of such a saw, such as a milling cutter can of course be used. Suitable circular saws are a Simonds 18" diameter, 60 tooth, 0.195" kerf with a 0° face angle, all teeth alike and straight across the top (4MR), and the same Simonds saw except with a #5MR tooth design and alternate top bevel. Alternatively, a 24" diameter saw with 12 teeth can be used and such a saw can be operated at faster feed speeds than the 18" saws specified above.

There is no limit to the size, in length, width or thickness, of the work which can be handled on a plate saw. A 6" high stack of sheets which are 6 feet wide by 12 feet in length can be used. Plate saws are available which have a 12 foot cutting path and have been found to be well suited for the purposes of the invention.

Suitable operating conditions for the saw are an advance through the work of 1–40 feet per minute, a speed of the return pass of 40 feet per minute and a saw blade speed of 2200 r.p.m.

By the method and apparatus according to this invention metallic fibers of precision controlled cross-sectional and length dimensions can be rapidly produced, and are found to possess a bulk factor considerably less than fibers produced from cut steel wool or other metallic wools, having one-third to one-half less bulk than do the latter. Such low bulk factor is deemed to be due to the uniformity of cross-sectional and length dimensions, and also to the fact that the fibers possess but a minimum of curl or twist. The produced metallic fibers according to this invention possess better physical properties for the reason that the same can be broached from thin rolled sheet metal with less generation of heat during the cutting action, and consequently the original temper of the metallic stock is not appreciably altered or reduced. Said metallic fibers also possess better preforming characteristics when massed together for the reason that the same better hold together after being compressed to a desired shape, and have less tendency to spring back after being so shaped.

In the broaching of the metallic fibers from sheet metal stock by the method and apparatus of this invention, it is not necessary to utilize lubricants, with the result that the produced fibers are clean and free from objectionable oils, although lubricants may be used if presence thereof in the final product is desired.

Also by the method and apparatus of this invention mixtures of predetermined proportional quantities of the fibers of various metals or metallic alloys can be produced by the simple method of stacking selected metal or metallic alloy sheets in desired combination.

Although the production of metallic fibers has been stressed in the above description of the method and apparatus of this invention, it will nevertheless be understood that the invention includes production of the fibers from other than metallic sheet materials. The method and apparatus can be employed to produce fibers from plastic sheets, such as Mylar, nylon, cellophane, vinyl, polyethylene, polystyrene, cellulose acetate, etc.

For example, a multiplicity of sheets of selected plastic material can be cut according to the invention, whereby to produce plastic fibers of substantially uniform selected dimension. Also combinations of fibers of selected plastic material and of metal can be produced, in like manner, by stacking sheets of these materials in suitably alternated relation. The relative proportions of a so produced mixture of metal and plastic fibers may be varied at will. For example, if the produced mixture is to comprise equal quantities of metal and plastic fibers, then equal numbers of metal and plastic sheets are superimposed in alternated relation in the stack. If, on the other hand, the produced mixture is to contain a greater proportion of metal than plastic fibers, or vice versa, then plurality of sheets of the predominate material are interposed between sheets of the other material, when stacking the sheets preparatory to cutting. For example, assume that it is desired to produce a mixture of metal and plastic fibers in relative proportions of three parts of the metal fibers to one part of the plastic fibers, then three metal sheets can be stacked between single sheets of plastic, or superposed groups of selected numbers of the respective sheet materials can be alternated in the stack in such numbers as calculated to effect the desired proportional relationship of the respective materials in the produced mixed fibers.

Combinations of mixed metal and plastic fibers have been found to possess desirable characteristics not obtainable by use of metal fibers alone, such as preformability at comparatively low pressure; or the mixture can be preformed, without substantial applied pressure, by application of heat adequate to soften the plastic fiber content of the mixture, whereby to cause the plastic fibers to adhere to the adjacent metal fibers in a preformed mass or body of selected shape.

Mixed fibers can also be produced from various selected sheet plastic materials, organic coated metal sheets, or other combinations of selected sheet materials.

Having now described my invention, I claim:

1. Apparatus for cutting pieces of predetermined size from a work piece comprising a toothed cutting tool, each tooth of which has one straight cutting edge of length corresponding with the length of the fibers to be produced, a work table for supporting work to be cut by the cutting tool by movement of the tool relative to the work over a cutting path, means for cycling the tool relative to the work from an initial position spaced from the work along the cutting path through the work to form a cut therein by cutting engagement of the cutting tool teeth and the work, each successive tooth being operative to cut one of said pieces and a return pass during which the tool is returned to said initial position, work manipulating means for advancing the work toward the cutting path a distance corresponding to the extent of said cut to dispose material of the work piece which was laid bare by the preceding cut in the cutting path for cutting thereof, actuating means for the work manipulating means responsive to a position of the cutting tool in the cycle thereof and effective to actuate the work manipulating means intermittently and during the return pass, whereby for each cutting pass of the tool an edge portion of the work can be disposed in the cutting path for cutting during the cutting pass and particles of relatively small size can be cut from the work.

2. Apparatus as recited in claim 1, wherein the cutting tool is in the form of a saw.

3. Apparatus as recited in claim 1, wherein the work piece is in the form of stacked thin strips of material, means to support a plurality of such strip stacks in side by side relation and in endwise opposition to the tool whereby to dispose end portions of the stacked strips subject to the cutting action of said tool, and means to hold the strip stacks against displacement during the cutting action of the tool.

4. Apparatus as recited in claim 1, wherein the work piece is in the form of stacked sheets of material, and

the cutting tool is in the form of a broach having vertically spaced cutting teeth, arranged such that each adjacently above tooth projects outwardly beyond the one beneath it a distance equal to the desired bite, transversely of the edge portions of the sheets.

5. Apparatus as recited in claim 4, wherein the cutting teeth of the broach are spaced apart to provide passages leading rearwardly from said teeth through the broach, and suction means connected with the broach, in communication with said passages, adapted to carry away produced fibers to a place of collection.

6. A method of producing fibers which comprises passing a toothed cutting tool, each tooth of which has one straight cutting edge of kerf length corresponding with the length of the fibers to be produced, transversely of an edge portion of a stack of sheets of material of composition for said fibers, while supported on a work table, to move the teeth of said tool relative to the work over a cutting path, through the sheets of the stack along lines corresponding with said cutting edges, the kerf of the cutting teeth substantially exceeding in length the thickness of the sheets and the bite of the teeth, cycling the tool relative to the work by a forward pass from an initial position spaced from the work over a path through the work to cut one of said fibers with each successive tooth, and a return pass during which the tool goes back to said initial position, and advancing said work toward the cutting path a distance corresponding to the extent of said cut to dispose material of the work piece, which was laid bare by the preceding cut, in the path of tool movement for cutting thereof, said advancing of the work being responsive to the position of the cutting tool in the cycle thereof and effective to actuate the work during the return passes of the tool, whereby for each cutting pass of the tool, an edge portion of the work is disposed in the tool path for cutting during each forward pass, and elongated pieces of linear fiber form are cut from the sheets, the thickness of the sheets and the bite of the teeth determining the cross-sectional dimensions of the fibers, and the kerf length of the teeth determining the fiber length.

7. A method as recited in claim 6, wherein the cutting

tool is a saw and the method includes advancing said saw along the planes of the sheets and into the stack during the forward pass.

8. A method as recited in claim 6, wherein the method includes passing said tool simultaneously into a plurality of such stacks while they are arranged in side-by-side parallel relationship with edge portions thereof in alignment, with the tool passing transversely of the aligned edge portions.

9. A method as recited in claim 6, wherein the cutting tool is in the form of a broach having vertically spaced cutting teeth, arranged such that each adjacently above tooth projects outwardly beyond the one beneath it a distance equal to the desired bite, transversely of the adjacent edge portions of the sheets, to give the effect of advancing said broach parallel to the planes of the sheets and into the stack during the forward passes while moving the teeth of said broach transversely through said sheets.

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