Nov. 10, 1964 H. F. RUSCHMANN **3,156,283**

OPERATING UPON SHEETS OF FOIL

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FIG. 8

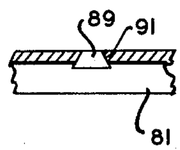


FIG. 2

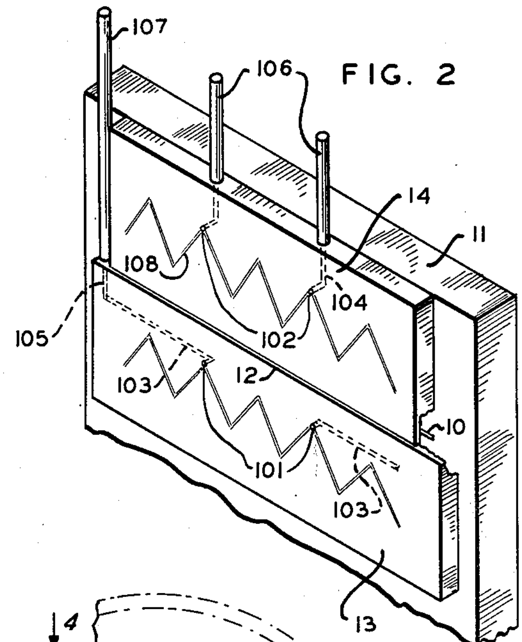
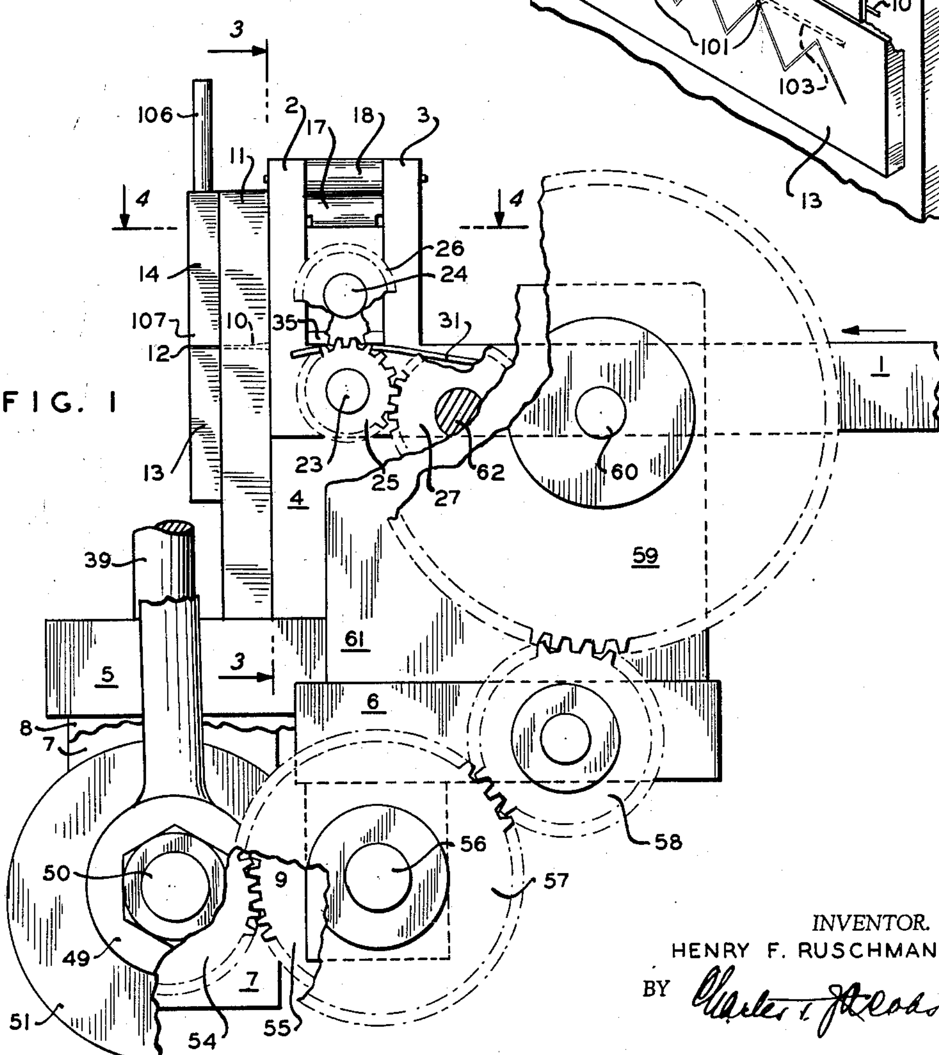


FIG. 1



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OPERATING UPON SHEETS OF FOIL

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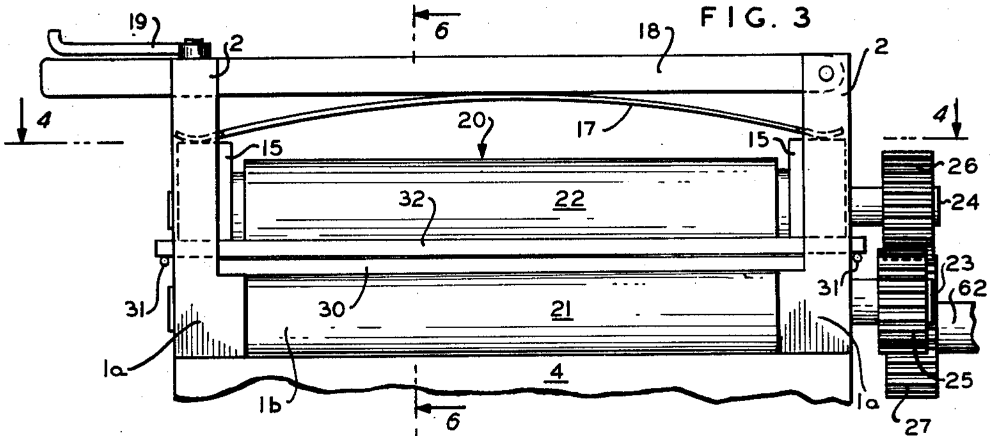

FIG. 3

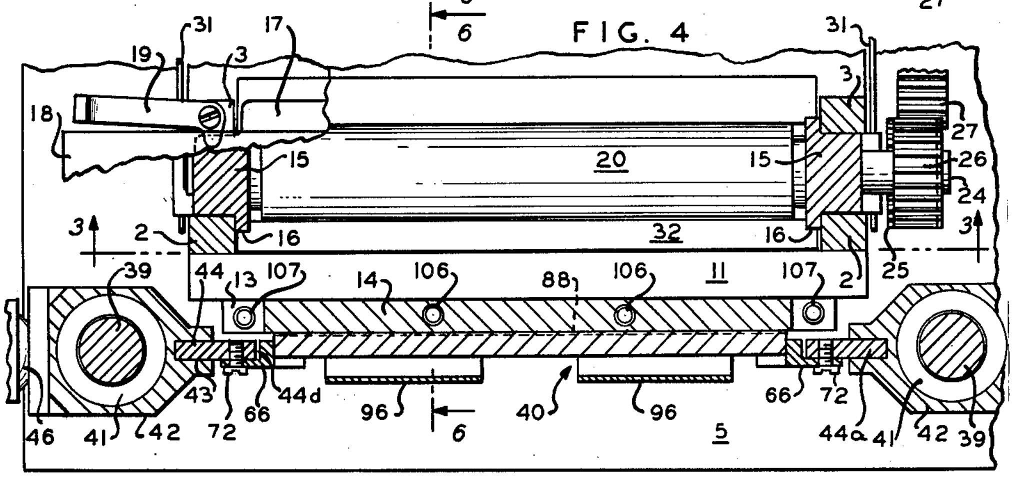

FIG. 4

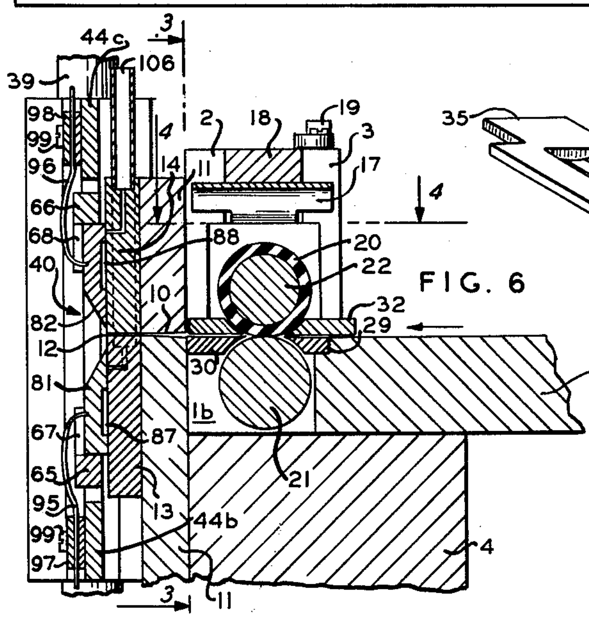

FIG. 6

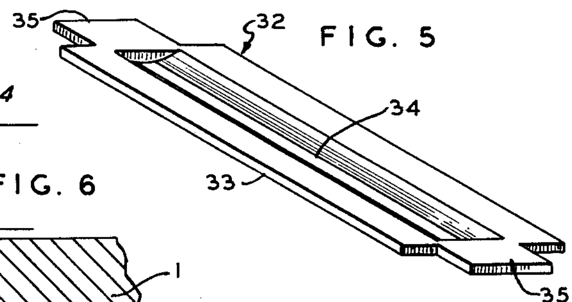

FIG. 5

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OPERATING UPON SHEETS OF FOIL

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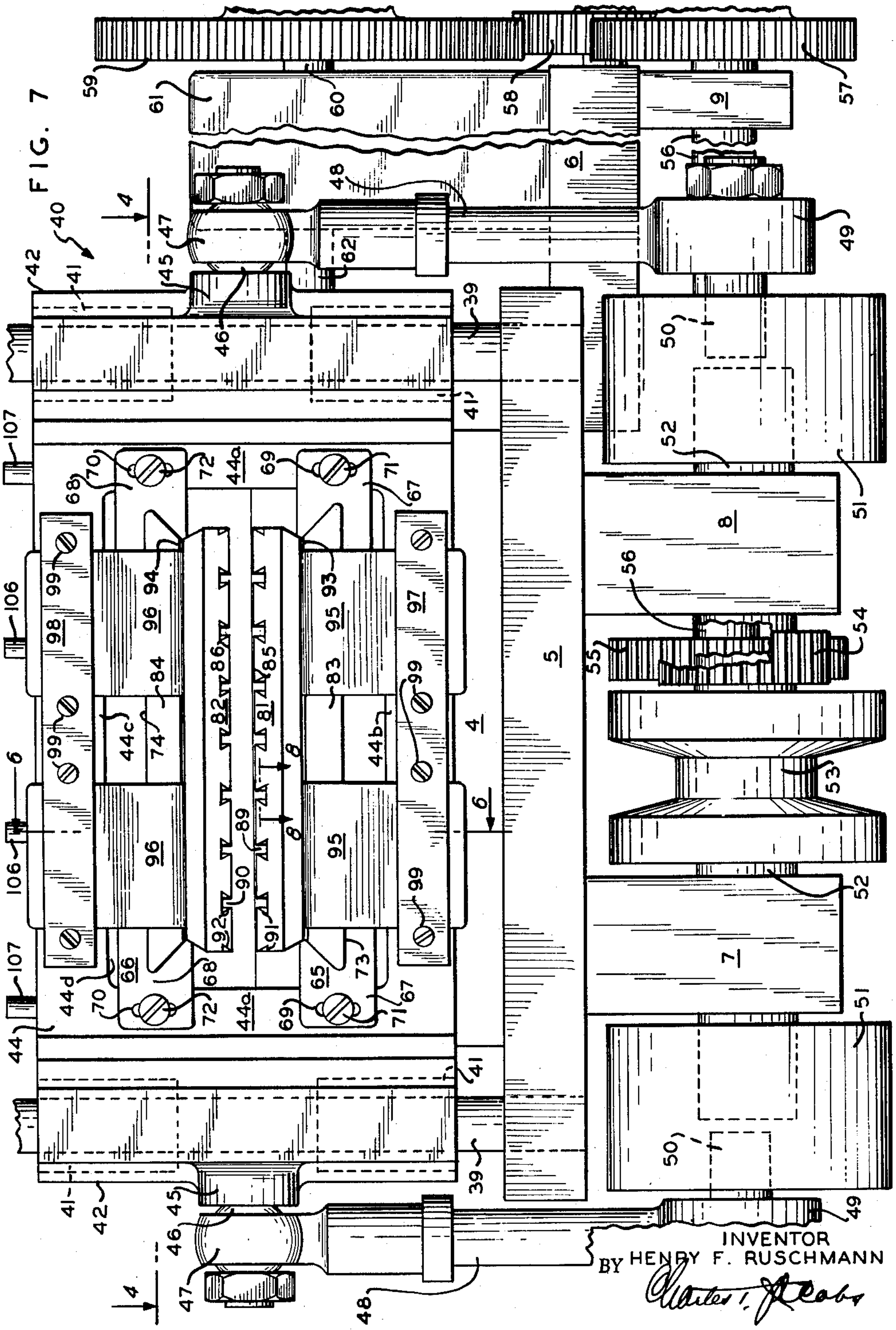

FIG. 7

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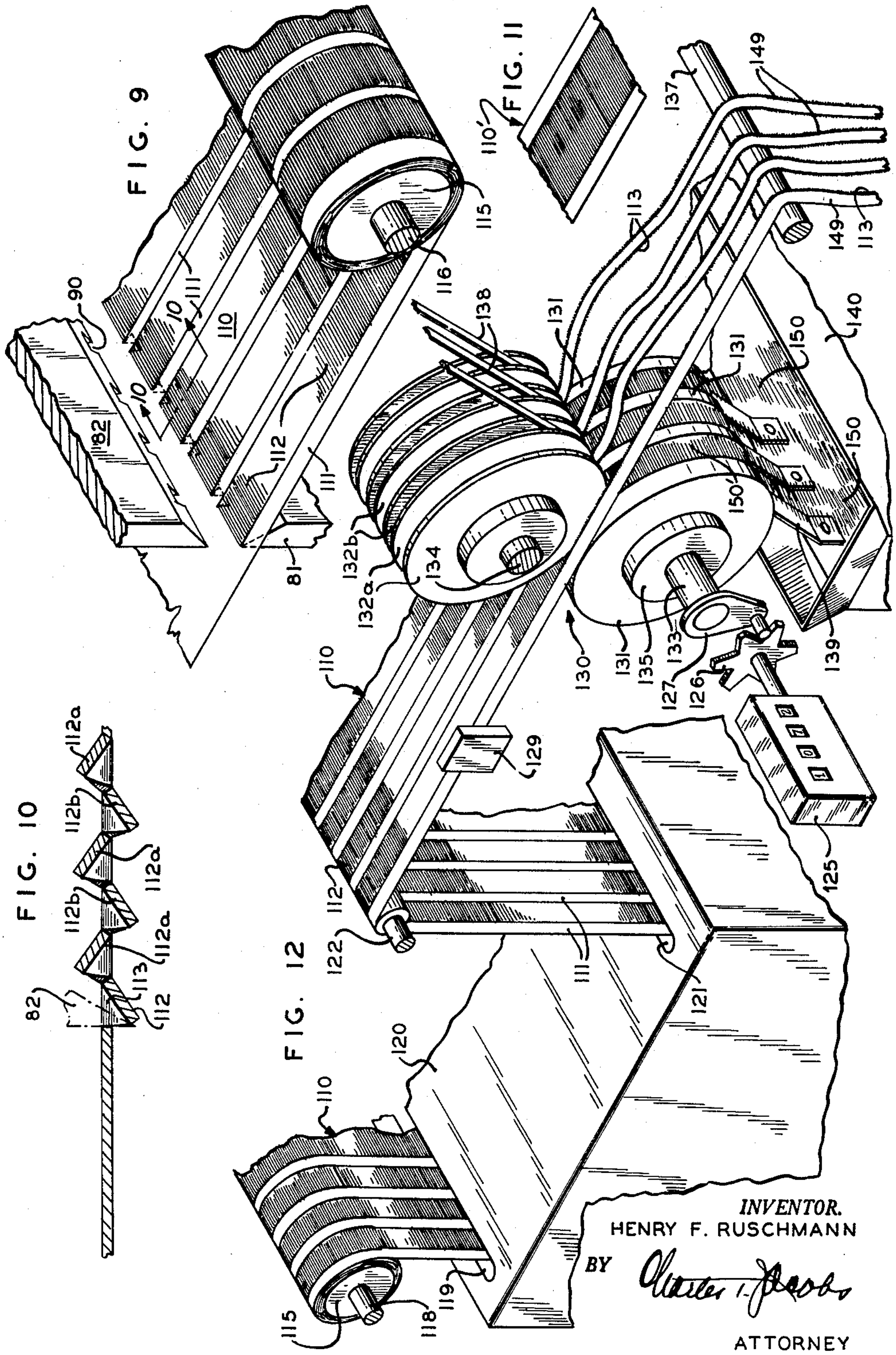

FIG. 9

FIG. 10

FIG. 11

FIG. 12

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United States Patent Office 3,156,283 Patented Nov. 10, 1964

3,156,283
OPERATING UPON SHEETS OF FOIL

Henry F. Ruschmann, Mine Brook Road, Bernardsville, N.J.

Filed Feb. 14, 1961, Ser. No. 100,775
14 Claims. (Cl. 153—2)

This invention relates to operating upon sheets of foil, especially though not limitatively lengthy sheets such as are usually handled in rolled arrangement. The foil which the invention contemplates may be either of metal (of which one example is aluminum), or of organic material (of which one example is cellulose acetate), or of combined materials such as metal coated with, or laminated together with films of, organic material.

In an important one of its aspects the invention is concerned with the production of "slivers"—e.g., strips of narrow (for example, .005") width, of limited (for example, .375") length, and of thickness of such a general order of magnitude as .001"—of combined-material foil and with their introduction in proper condition into another substance in which they are to be dispersed in a predetermined proportion. Neither such other substance nor the product of such dispersion of the slivers therein forms any part of the present invention; as to them it will therefore be sufficient merely to state that one example of such a substance is a solid foam of organic material, and that with the slivers suitably dispersed therein the resulting product finds important use in installations for the detection of aircraft, missiles and the like.

For such and other purposes it is desirable that the slivers be of precise dimensions; that they be capable of quite precise metering (i.e., determination of their number without individual counting); that they be amenable to surface treatment such as de-greasing, drying, oxidizing, lacquering and the like; and that—in spite of such treatment and other handling including shipping, and on the other hand in spite of their inherent softness and general fragility—they nevertheless be available in essentially straight and flat condition for introduction into the substance in which they are to be dispersed.

It is an object of my invention to provide slivers of foil material of very precise dimensions. It is an object to provide such slivers in a form facilitating quite precise metering thereof. It is an object to provide such slivers in a form highly amenable to treatment of the principal surfaces. It is an object to provide such slivers in a form amenable to other handling, including shipment, without appreciable risk of damage thereto. It is another object to introduce the slivers, into a substance in which they are to be dispersed, in essentially straight and flat condition in spite of their surface treatment, shipping and/or other handling. It is an object to do these things with a minimum of wastage of the original foil material.

In achieving the objects set forth above I operate first upon the sheet of foil in a manner, hereinafter set forth, which produces a novel intermediate product whose general nature might be described as web-like. I have found that this web-like product is itself useful for ornamentation, for novelty adaptations, for fluid-filtering purposes, and it may have still other utilities.

It is an object of my invention to provide a novel web of foil material useful for ornamentation and/or novelty adaptations. It is an object to provide such a web useful for fluid-filtering purposes. It is an object to provide such a web having still other useful functions.

It is an object of my invention to provide improved methods and apparatus for the accomplishment of the objects stated above, including improved methods and apparatus for separating the slivers from the web.

It is an object to provide improved methods and apparatus for the cutting or shearing of foil generally.

Other and allied objects will appear from the following description and the appended claims.

In relation to its more specific objects stated above, the invention comprises a method and apparatus for converting the original foil sheet, without removal of any of its material, into a web in which the transverse elements are in the form of narrow strips or slivers merging at their extremities with longitudinal bands; preferably the transverse elements are inclined in alternate directions out of the plane of those bands, thus effecting an openness and a semi-transparency of the web between the longitudinal bands. The invention also comprises such a web of foil material. If the web is to be converted into discrete slivers, the invention contemplates any treatment desired for the principal surfaces of the slivers being performed on the web before that conversion; the invention still further contemplates the transportation of the web, either after or preferably before any surface treatment, to the vicinity of the apparatus by which the slivers will be dispersed in another substance. The invention further comprises a method and apparatus for converting the web into discrete slivers by appropriate cutting away of the longitudinal bands, following which the invention preferredly contemplates the prompt and direct introduction of the slivers into that substance.

In relation to the broader objects stated above, the invention comprises an apparatus in which suitable knife means are reciprocated along a cutting surface to shear a sheet of foil being fed transversely to that surface; in which preferably the reciprocation is in timed relation to the feeding; in which the knife means may shear the sheet for less than its full width; in which continuous lubrication may be fed to the plane of contact between knife means and cutting surface; in which th e stroke of the knife means and its distance of penetration thorugh the sheet are interrelated to permit continuous feeding; and in which other features as well contribute to an adaptability of the apparatus to relatively high-speed operation.

In the detailed description of my invention hereinafter set forth reference is had to the accompanying drawing, in which:

FIGURE 1 is a righthand elevational view of an apparatus or machine according to my invention for converting the original foil sheet into the web mentioned above, but with the knives and their holders and the knife carriage and its guides omitted;

FIGURE 2 is a perspective view of the cutting surface and of the blocks which form and integrate it;

FIGURE 3 is a front elevational view of the apparatus as seen immediately to the rear of the elements shown in FIGURE 2, being taken along the line 3—3 of FIGURE 1;

FIGURE 4 is a horizontal cross-sectional view taken along the line 4—4 of FIGURES 1 and 3, this and later figures including a showing of the knives, knife holders, knife carriage, etc.;

FIGURE 5 is a perspective view of the guide plate associated with the upper feed roller;

FIGURE 6 is a vertical cross-sectional view taken along the line 6—6 of FIGURES 1, 3 and 4;

FIGURE 7 is a front elevational view of the apparatus;

FIGURE 8 is an enlarged fractional horizontal cross-sectional view, taken along the line 8—8 of FIGURE 7, through a portion of the lower knife;

FIGURE 9 is a perspective view showing the web emerging from apparatus such as that of earlier figures and being suitably rolled up;

FIGURE 10 is a greatly enlarged longitudinal cross-sectional view of a minute length of the web as and just after it has so emerged;

FIGURE 11 is a perspective view of a web having only marginal longitudinal bands; and

FIGURE 12 is a perspective view of a further apparatus according to my invention for effecting the conversion of the web into discrete slivers of the foil material, this apparatus among other things providing for any desired surface treatment of the web immediately prior to such conversion.

Reference now being had to the drawing and initially to FIGURE 1, there will be seen a bed 1 along the top of which there may be fed forwardly—i.e., leftwardly as seen in FIGURE 1—a sheet of foil. The bed 1 may be provided at its forward corners with upright rectangular posts 2, and at its sides somewhat to the rear of posts 2 with upright rectangular posts 3; these four posts are shown as integral with the bed, but it will be understood that they may be separate elements attached in any convenient manner. The forward portion of the bed 1 may be secured on top of the relatively large spacing block 4, for example of similar width to that of bed 1. Immediately forward of the bed 1 and front posts 2 and spacing block 4, and secured to those elements, may be the vertical transverse block 11 of medium horizontal thickness, provided at the level of the top of the bed with a vertically thin horizontal slit 10 (seen in dotted lines in FIGURE 1) through which may pass foil which has moved forwardly along the top of the bed. To the front surface of the block 11, and as seen both in FIGURES 1 and 2, there may be secured the blocks 13 and 14, permissibly somewhat thinner horizontally, the former below and the latter above the level of the slit 10. The blocks 13 and 14 are vertically separated by a slot 12 aligned with the slit 10, the vertical dimension of slot 12 and that of the forward portion of slit 10 being somewhat, but preferably only slightly, greater than the thickness of the foil to be operated upon—it being understood that in many of the figures of drawing this dimension has been relatively exaggerated for the sake of clear illustration.

The slot 12 forms, in the cutting surface, a thin orifice through which the sheet of foil may be fed. The sheet is propelled forwardly, to emerge from the orifice, by mechanism seen in FIGURES 1, 3, 4 and 6. Basically this mechanism comprises a pair of transversely arranged horizontal rollers 21 and 22 (see FIGURE 6). The roller 21 is located below the plane of the top of the feed bed 1 in a cut-away space 1*b* (see FIGURES 3 and 6) provided, at the front of the bed 1 throughout its central portion, between side portions 1*a* of the bed which are conveniently of somewhat greater width than that of the posts 2 and 3, and its shaft 23 may be journalled in those side portions 1*a*. The roller 22 is located vertically above the roller 21 and above the plane of the top of the feed bed 1, its shaft 24 being journalled in blocks 15 whose position in a horizontal plane is established by the posts 2 and 3 but which may move vertically in a locus established by those posts. Each of the two blocks 15—resting on a respective end portion 35 of a guide plate 32, through an aperture in which the roller 22 extends downwardly and which is hereinafter more detailedly described—has its main portion between the respective posts 2 and 3, but has an inner flange portion 16 of greater dimension in a front-and-back direction and overlapping the posts in that direction; the flange portions 16 are maintained substantially in contact with the posts by the roller 22.

The lower roller may be wholly of metal, preferably with a polished surface. The upper roller 22 is desirably provided with a rubber surface layer 20, preferably of external diameter similar to that of the lower roller 21, the length of which may if desired be limited to coincide with that of the lower roller.

The guide plate 32 is subjected to upward bias, as by cantilever wire springs 31 secured to and extending forwardly from more rearward side portions (not indicated) of the bed 1 to have their forward end portions underneath the outwardly projecting end portions 35 of the guide plate 32; this upward bias of course also biases upwardly the blocks 15 and thus the upper roller 22. This upward bias of the upper roller serves to separate the two rollers for loading, or threading of a sheet of foil through, the apparatus. After such loading has been accomplished the blocks 15, and thus the upper roller 22 (and the guide plate 32), will be pressed downwardly, overpowering the bias mentioned above, so that the upper roller presses against the lower roller with the sheet of foil therebetween. This downward pressing may be accomplished by a relatively large and powerful bow-shaped leaf spring 17, whose downwardly inclined end portions may be loosely retained between the posts 2 and 3 and may rest on top of the blocks 15. The central portion of this spring may be pressed downwardly, and the force of the spring thus exerted on the blocks and roller and plate, by a lever 18 pivoted to the upper end portions of the righthand posts 2 and 3, movable to a horizontal spring-compressing position in which its lefthand portion lies between the upper end portions of lefthand posts 2 and 3, and restrainable in that horizontal position as by a lock such as 19 pivotally mounted to the top of the rear lefthand post 3.

The sheet of foil is propelled forwardly in order to carry it through the slit 10 and the slot 12. In order to insure that it passes to the slit 10 it is desirable to provide a suitable guiding system. Below the path of the foil the guiding system may comprise the lower guides 29 and 30 (see particularly FIGURE 6) having top surfaces in alignment with that of the bed 1, guide 29 extending from the bed to a little behind the uppermost or longitudinally central line along the surface of the lower roller 21, and guide 30 extending from a little forward of that line to the block 11. The surfaces of these guides closest to the roller 21 are of concave cylindrical-section form conforming to the surface of but slightly spaced from that roller. Guide 29 may be supported in forwardly extending cantilever arrangement from the nonmarginal portion of the bed 1, while guide 30 may be supported at its ends on the bed's front side portions 1*a* referred to above. Above the path of the foil the guiding system may comprise the transversely arranged guide plate 32 which has already been mentioned and which in its entirety is seen in FIGURE 5. This may have the end portions 35 each of which extends between a respective pair 2–3 of posts and outwardly therebeyond to be pressed up against by a respective one of the springs 31 as mentioned above; between the end portions the guide plate may have a main portion 33 provided with a central cut-out 34 of concave cylindrical-section form which conforms to the surface 20 of the upper roller and downwardly through which that roller may extend to protrude slightly therebelow while being held by its journalling blocks 15 very slightly spaced from the concave surfaces of the cut-out.

It will be appreciated that the limit of downward movement of the blocks 15 and upper roller 22 and guide plate 32 by spring 17 will be established by that roller pressing against the lower roller 21 with the foil therebetween, and that the parts will be so dimensioned that guide plate 32 will then be spaced from bed 1 and lower guides 29 and 30 sufficiently to pass freely the thickness of the foil. for practical reasons (including the facts that the guide plate 32 is a movable rather than a uniquely stationary element and furthermore is not in intimate contact with the rear of block 11) it is desirable to provide in the rear portion of the slit 10 some tolerance to slight variations in the level of the leading edge of a newly loaded sheet of foil. This is readily done by slightly flaring the slit 10 so that at its rear extremity it is vertically somewhat wider than at its front, as seen in FIGURE 6.

It will be understood that the function of the apparatus as thus far described is to feed or advance the sheet of foil forwardly along the bed **1** and through the slit **10** and the slot **12**, and that this is accomplished by rotation of the lower and upper rollers **21** and**22** between which the foil is pressed. To provide for this rotation the shafts **23** and **24** of those respective rollers are provided at their righthand ends with respective gears **25** and **26** which intermesh when the upper roller is brought down into its illustrated operative position; the pair of these gears may be driven by a gear **27** which is located to the rear of and meshed with the gear **25**, and which itself is rotated in a suitable manner hereinafter described.

The advancing foil emerging forwardly from the slot **12** is operated upon by knives; the fronts of the blocks **13** and **14** together form a cutting surface, lapped to a thoroughly smooth plane state, along which the knives operated. As to positions along the plane of the cutting surface the knives are held in respective knife holders, and these are mounted in a knife carriage which is reciprocated along vertical guides. This structure may now be described with reference to FIGURES 1, 4 and 6 already referred to and the further FIGURES 7 and 8.

To the bottom of the block **4** there may be secured the base **5** which extends a substantial distance forwardly under and beyond the blocks **11** and **13** (see FIGURE 1) and a substantial distance transversely in each direction beyond the block **4** (see FIGURE 7). Near the two front corners of the base **5** there may extend upwardly from that base respective cylindrical carriage guide rods **39** (see FIGURES 1, 4 and 7). On these rods the carriage, designated as **40**, may be arranged for up-and-down reciprocation. The carriage may comprise left- and righthand vertical end members **42** each surrounding a respective one of the guide rods **39**; each of these end members may be provided at both bottom and top with a ball sleeve bearing **41** to provide for relatively frictionless travel along the rod. The portion of each end member facing toward the other may be extended sufficiently to accommodate the formation therein of a respective vertical slot **43**, and secured in and extending between the two slots **43** may be a carriage plate **44** which with the end members **42** forms the unitary carriage **40**. The front-and-back position of the carriage guide rods **39** is such as to bring the rear of the carriage plate **44** very close to, though slightly spaced forwardly from a condition of actual contact with, the cutting surface formed by the fronts of blocks **13** and **14**.

On the outer side of each carriage end member **42** there may be provided a central boss **45**, to which may be secured the sphere portion **46** of a respective spherical rod end **47**. Each of these rod ends forms the upper portion of a respective connecting rod **48**, which at its lower extremity is provided with a respective rod bearing **49**. Each rod bearing **49** is fitted about a respective horizontal pin **50** extending outwardly from a respective solid cylindrical element **51**, the two elements **51** being coaxially disposed below the base **5** and arranged for simultaneous rotation. The pins **50** have a common axis which is, however, displaced somewhat from the axis of the elements **51** so that the pins move eccentrically when those elements are rotated; this eccentric movement is of course transmitted by the rods **48** to the carriage **40**, where it manifests itself as a reciprocating vertical movement of the carriage along the carriage guide rods **39**.

To provide for rotation of the elements **51** they may be secured on the respective ends of a horizontal main shaft **52** which is journalled in the plane of the guide rods **39** in suitable blocks **7** and **8** extending downwardly from the base **5**. Between these blocks there may be secured on the main shaft **52** a pulley **53**, for example suitable to be driven by a V-belt, and it will be understood that it is by the driving of the pulley **53** that the elements **51** are rotated and the carriage subjected to reciprocating movement. It is also desirably this same driving of the pulley **53** which causes the turning of the gear **27** described above, and thus the feeding or advancement of the sheet of foil—it being desirable in particular that the gear **27** be positively (i.e., non-slippingly) coupled with the pulley **53**, this resulting in a definite predetermination of the relationship between the frequency of carriage reciprocation and the speed of foil advancement.

To cause the driving of the pulley **53** to turn the gear **27** there is secured on the main shaft **52**, next to the pulley **53**, a gear **54** which engages a gear **55** positioned therebehind and secured on the lefthand end of a secondary shaft **56**. This secondary shaft may be journalled in the block **8**, and in a block **9** extending downwardly from the righthand end portion of a shelf **6** which itself extends rightwardly from the base **5**. At its righthand extremity the secondary shaft **56** may carry the gear **57**, which through a suitable coupling gear **58** drives a gear **59** secured on the input shaft **60** of a suitable speed reducer **61**; this speed reducer, desirably of the gear-operated variety in order that its action may be positive, may be mounted on the shelf **6**. It is on the leftwardly extending output shaft **62** of this speed reducer that the foil-advancing gear **27** is secured.

In directing attention to the knife holders and knives—of each of which there is desirably a lower as well as an upper one—it may first be mentioned that the carriage plate **44** is provided with a large central cut-out **44*d*** resulting in its exposed portions being the margins **44*a*** adjacent the respective carriage end members **42** and, extending transversely therebetween, a bottom strip **44*b*** and a top strip **44*c***. The lower knife holder **65** is a horizontal strip extending between the plate margins **44*a***, having a thickness of which the major portion is aligned in a front-and-back direction with that of the carriage plate **44**, but having additional forward thickness which is used to form flanges **67** overlying the fronts of the plate margins; it may be held to the plate margins as by screws **71** passing through vertically elongated holes **69** in the flanges **67**. The upper knife holder **66** is a similar strip, extending similarly and having similar flanges **68**, it may be held to the plate margins as by screws **72** passing through vertically elongated holes **70** in those flanges.

In its upper portion the lower knife holder **65** is provided with a wide dovetail cut-out **73**, and in its lower portion the upper knife holder **66** is provided with a similar cut-out **74**; it is by fitting of their "heels" into these dovetail cut-outs that the knives are held by the knife holders as to movement along the plane of the adjacent cutting surface formed by the fronts of blocks **13** and **14**. The lower knife, designated as **81**, is in the form of a wide vertically short piece of hardened material, of thickness typically of the same order of magnitude as that of the knife holder **65**, approximately the lower half of which constitutes its heel **83** and is fitted into the dovetail cut-out **73**; from the heel the knife **81** extends in its full thickness upwardly for a short further distance, and thereabove its front surface is bevelled rearwardly to intersect its rear surface in the upwardly directed cutting edge **85**. The upper knife, designated as **82**, is in the form of a similar piece of hardened material of similar thickness, approximately the upper half of which constitutes its heel **84** and is fitted into the dovetail cut-out **74**; from the heel **84** the knife **82** extends in its full thickness downwardly for a short further distance, and therebelow its front surface is bevelled rearwardly to intersect its rear surface in the downwardly directed cutting edge **86**. The rear surfaces of the knives **81** and **82** may be provided with respective horizontal grooves **87** and **88** of relatively substantial vertical dimension (see FIGURE 6), thereby among other things minimizing the knife area which will frictionally engage the cutting surface formed by the fronts of blocks **13** and **14**.

The lower knife **81** is biased, into contact of its rear surface with the cutting surface formed as mentioned above, by a pair of relatively wide leaf springs **95** of which the lower portions are held between horizontal strips **97** clamped to the front of the bottom carriage-plate strip

44b as by screws 99; from those strips 97 the springs 95 may curve spacedly around the knife holder 65 to press their rearwardly directed upper edges into a horizontal groove 93 provided at about the vertical mid-line of the front surface of the lower knife. The upper knife is biased into contact of its rear surface with the cutting surface by corresponding springs 96 whose upper portions are similarly held between horizontal strips 98 similarly clamped to the front of the top carriage-plate strip 44c, from which strips 98 the springs 96 may curve correspondingly to press their rearwardly directed lower extremities into a horizontal groove 94 similarly provided in the front surface of the upper knife. It will be understood that as a result of this arrangement the rear surfaces, and thus the cutting edges, of the knives are maintained dependably in contact with the cutting surface, without impairment of that contact by possible minor malalignments of the carriage guide rods 39 or the like—yet that by reason of the dovetail fitting of their heels in the knife holders the knives are positively held against shifting relative to the carriage along the plane of the cutting surface, and are subjected to the vertical reciprocating movement of the carriage.

It may here be mentioned that it is desirable to minimize the mass of the carriage and the parts carried thereby, in order to permit a maximum speed of operation of the apparatus together with a minimum vibratory effect of that apparatus. It is for this reason among others that the carriage is principally constituted by the relatively thin and largely cut-out plate 44.

In order to permit relatively high-speed operation of the apparatus and at the same time to preclude galling of the rear surfaces of the knives and of the cutting surface formed by the fronts of blocks 13 and 14, it is desirable to provide a suitable continuous lubrication along the plane of contact of those surfaces. For this purpose the forward surfaces of the lower and upper blocks 13 and 14 may each be provided with at least two oil-outlet holes, 101 and 102 respectively (see FIGURES 2 and 6). The holes 102 in the upper block 14 may communicate with respective vertical holes 104 leading to the top of that block, where the holes 104 may in turn communicate with respective oil-supply tubes 106 concentric therewith and extending upwardly from that block. The holes 101 in the lower block may communicate first with respective horizontal holes 103 which extend to near the outer edges of that block and there communicate with vertical holes 105 leading to the top of that block, where the holes 105 may in turn communicate with respective oil-supply tubes 107 concentric therewith and extending upwardly from that block; the lower block 13 is made wider than the upper block 14 in order to accommodate the arrangement just described. (Illustration of the righthand vertical hole 105 and oil-supply tube 107 has been omitted from FIGURE 2 to avoid interference with other features of that figure.)

Distribution of the oil emerging from the oil-outlet holes 101 and 102 over the cutting surface and the rear surfaces of the knives is facilitated by the grooves 87 and 88 formed in the knives as mentioned above, and may be still further facilitated by light diagonal grooving, schematically indicated as 108, cut in the front surfaces of the blocks 13 and 14.

In the normal use of the apparatus the cutting edge 85 of the lower knife will be positionally adjusted (by vertical movement of the knife holder 65 under the associated screws 71) so that when the carriage has reached the top of its stroke that edge will have been raised to a minute extent—typically .0015″ or .002″—above the top of the slot 12 (which in FIGURE 7 is shown as a single line in order to minimize exaggeration of its vertiand dimension.) Accordingly FIGURE 7, which illustrates the knife edge 85 as being minutely below the slot 12, may be taken as illustrating the condition of the apparatus with the carriage in the position which it will occupy slightly prior to or slightly after reaching the top of its stroke; these alternative conditions are those for which the pin 50 and rod bearing 49 in FIGURE 1 have been presented. If it be assumed that the main shaft 52 is driven counterclockwise as seen in FIGURE 1 (which it will be if the input and output shafts of the speed reducer 60 turn in the same direction), then FIGURE 1 uniquely illustrates the condition of the apparatus when the carriage is approaching (rather than receding from) top position, and it will be convenient to consider FIGURE 7 as illustrating the same condition. In these figures, then, the knife edge 85 is about to reach and pass upwardly over the slot 12, and therefore to reach and upwardly pierce a sheet of foil being fed forwardly out of that slot. As the operation of the apparatus continues the knife edge 85 will reach and upwardly pierce the foil, progressing a minute distance therebeyond and then receding downwardly.

Correspondingly the cutting edge 86 of the upper knife will be adjusted so that when the carriage has reached the bottom of its stroke that edge will have been lowered to a similar minute extent below the bottom of the slot 12. Accordingly at a time one-half cycle—a cycle being one revolution of the main shaft 52, or one full up-and-down reciprocation of the carriage—later than that at which the knife edge 85 reached and upwardly pierced the sheet of foil from below, the cutting edge 86 will reach and downwardly pierce it from above, progressing a minute distance therebeyond and then receding upwardly. Still one-half cycle later the cutting edge 85 will again reach and upwardly pierce the sheet, and so on in a continuous alternation. The sheet being meanwhile steadily advanced between the rollers 21 and 22, the effect of the alternate piercing thereof by the two knives is to subject the sheet to shearing, twice in each cycle, along parallel transverse lines whose separation each from its neighbor is the distance by which the sheet advances during each half cycle. The magnitude of that separation may of course be controlled by choice of the gearing (including the reduction ratio of the speed reducer 61) lying between the main shaft 52 and the rollers 21 and 22.

FIGURE 6 will be understood to illustrate the carriage at a position a little below the mean between its uppermost and lowermost positions.

In the discussion above no special attention has been paid to the fact that the slot 12 will have a vertical dimension at least slightly greater than the thickness of the foil, with the result that adjacent the orifice in which the slot at its front terminates the sheet of foil may be capable of being slightly displaced by the knives up and down within the slot before being actually pierced. In clarification it may be pointed out that by "reaching" the sheet of foil there is meant above a reaching (by the knife edge) of the adjacent one of the sheet's surfaces under a condition of the opposite surface of the sheet being in contact adjacent the orifice with the corresponding surface of the slot 12.

It may be mentioned that from the time either knife edge reaches and has begun to pierce the sheet of foil, on to the time that edge has arrived at a corresponding position in its receding 15 movement, the rear surface of that knife will tend to act as a closed gate across the slot 12, temporarily interfering with the emergence of the sheet of foil through the orifice in which that slot terminates at its front. With typcial minute distances of further travel of the knife edges after reaching and just passing through the sheet (i.e., as mentioned above) and with typical lengths of stroke of the carriage (e.g., .200″), the percentage of a half-cycle during which this "closed-gate" action will occur will be one of the order of 15% or less. This percentage of the separation between the transverse paths of shearing of the sheet is ordinarily a very small percentage indeed of the distance from the cutting surface to the line of contact of rollers 21 and 22 with the sheet, and the sheet readily accommodates to the short stoppages at the cutting surface by minute digressions from plane condition within the last-mentioned distance.

It will of course be appreciated that one of the two knives might be omitted, with the results that the shearing would occur only once in each cycle, and that the separation between the parallel transverse paths of shearing would be the distance by which the sheet advances during the whole cycle. This is ordinarily disadvantageous, since the ultimate limitation on the quantity (i.e., length) of foil operated on per unit of time by an apparatus of this character is in general not the speed by which the sheet of foil may be advanced, but rather the maximum practical frequency of reciprocation of the carriage, which maximum does not shift appreciably whether both or only one of the knives be employed; it follows that that quantity per unit of time is substantially twice as great with two knives as with one. The use of the two knives has further advantages as well, which have to do with the product of the operation of the apparatus and which are hereinafter set forth.

The knives have been thus far described without reference to any special characteristics of their cutting edges in the direction transverse of the apparatus. If those cutting edges were to be continuous in that direction and were to extend to the edges of the sheet of foil, the operation of the apparatus would of course produce individual transversely cut strips of the foil, each of a length equal to the width of the sheet and of a width equal to the distance by which the sheet advances every half cycle. To produce other results those cutting edges may be made discontinuous, and/or may be terminally limited, in appropriate manners.

To produce the web described early hereinabove the cutting edges of the knives may be subdivided into a plurality of transversely spaced sections. Thus the lower knife 81 may be provided with a plurality of vertical cuts extending for at least a very short distance downwardly from the cutting edge 85, each cut having a width equal to the width of the respective longitudinal band which it is desired be present in the web; the upper knife 82 will be provided with a corresponding plurality of vertical cuts 90 extending for at least a very short distance upwardly from the cutting edge 86, of similar widths to the corresponding cuts 89 and respectively aligned therewith transversely of the apparatus. As illustrated in FIGURE 7, each knife will be provided with seven of the cuts 89 or 90, resulting in seven longitudinal bands in the nonmarginal portions of the web; furthermore the width of the knives will be made sufficiently less that of the sheet of foil to provide for a marginal longitudinal band at each side of the web. The spacings of the cuts from the ends of the knives and from each other will desirably be made uniform, to result in uniform inter-band dimensions in the web.

In order to insure that the sides of the cuts 89 and 90 will not produce unintended tears at the extremities of the lines of shearing of the sheet of foil by the adjacent sections of the knife edges, it is desirable to bevel those sides of the cuts so that they intersect the rear surfaces of the knives at an acute angle and thus themselves form with those rear surfaces vertical short cutting edges. This has been illustrated by the bevelled surfaces 91 and 92 on the lower and upper knives, respectively, in FIGURE 7 but may be better seen in the enlarged fractional cross-sectional showing of FIGURE 8. The ends of the knives should of course be provided with similarly bevelled surfaces 91 and 92, as has been indicated in FIGURE 7.

FIGURE 9 illustrates the knives 81 and 82 of earlier figures, with a sheet of foil emerging forwardly from between the knives—by which it has been operated on so that it has been converted into a web 110 such as hereinbefore mentioned; in the interest of simplicity the widths of knives and web have been broken off, but it will be understood that no necessary differentiation from the showings of earlier figures is thereby intended. In this figure there will be seen in the web the longitudinal bands 111 which by reason of the cuts 89 and 90 in the knives are left unsheared, and in the longitudinal paths between those bands a succession of transverse strips 112 which are very narrow—i.e., of very small dimension longitudinally of the web 110, which dimension may if desired be much smaller than that indicated in this figure—and which merge at their extremities with the bands 111.

FIGURE 9 also illustrates the winding up of the web on a cylinder or spool 115 suitably carried on a mandrel 116 which, by means themselves well understood and not herein necessary to show, is slip-driven to wind up the web as fast as it emerges from the apparatus, but without placing the web under longitudinal tension sufficient either to distort it or to affect the operation of the apparatus from which the web emerges.

FIGURE 10 illustrates a typical cross-section taken longitudinally through the last few transverse strips 112 of the web to have been formed by the knives, and through a contiguous short portion of the sheet which is about to arrive at the knives, all in very greatly exaggerated size; it also illustrates in dash-dot lines the cross-section of the end portion of one of the knives (by way of example, the upper knife 82) at substantially its extreme (e.g., lowermost) position. The strip 112 which is in contact with the bevelled front of the knife 82 will be seen to have been rocked by the knife front counterclockwise as seen in this figure—i.e., to have been displaced downwardly adjacent its rear edge—about its forward edge into an inclination downwardly out of the plane of the longitudinal bands 111; it (as well as the second, fourth etc. strip which is located forwardly from it and which will of course have been similarly affected by the same knife) is specially designated as 112*b*. On the other hand the intervening strips 112 will have been conversely affected by the lower knife 81; each will have been rocked by the front of that knife clockwise as seen in this figure—i.e., will have been displaced upwardly adjacent its rear edge—about its forward edge into an inclination upwardly out of the plane of the longitudinal bands 111, these intervening strips being specially designated as 112*a*.

What has just been said of course applies to the strips 112 throughout their lengths (i.e., dimensions transverse of the web) except at their very end portions 113 in immediate adjacency to the longitudinal bands 111; within those end portions 113 the strips 112 of course progressively lose their inclinations, to merge into the longitudinal bands in the plane of the latter.

It may here be stressed that the feature of alternate inclinations of the strips 112 just described—which without difficulty survive the rolling up of the web on spool 115 so long as the slip-drive of the mandrel 116 is adjusted to avoid unnecessary and excessive longitudinal tension on the web in the winding-up process—has several distinct advantages.

Some of these advantages spring from the resulting greater openness of the web, not only in comparison with a web formed by shearing but with no inclination of the strips (which would tend to be devoid of openness), but also in comparison with a web formed with inclination of all of its strips in the same direction. One such advantage has to do with surface treatment of the web, such as degreasing, drying, oxidizing, coating with lacquer or other agents, etc.; this advantage is that the high degree of openness of the web provided by the alternate inclinations of the strips facilitates the access of the treating agents—whether solvent, air, oxidizer, lacquer or other coating agent, or still other agent—to all the surfaces of the web. Another such advantage has to do with novelty adaptations, wherein the alternate inclinations increase the degree of "semi-transparency" of the web material between the longitudinal bands, while at the same time increasing the number of directions from and to which light reflections will be effected by that portion of the web. Still another such advantage has to do with fluid-filtering uses, for which the alternate inclinations afford new combinations of perviousness with area, strength and other parameters.

Another class of advantage has to do with uses in which there may be desired a distinction in freedom of movement of the web surface along another surface; with the alternate inclinations such a distinction is provided on both faces of the web. There may well be still other advantages and classes of advantage.

The apparatus shown in FIGURES 1 through 8 and above described is specifically appropriate to the production of a web having nine (two marginal and seven other) longitudinal bands 111; it will however be of course understood that by suitable formation of the knives and choice of the width of the sheet of foil that number may be increased at will, and may be decreased to any number as low as two without destroying the web nature of the resulting product. The last-mentioned variation is illustrated by the web 110' of FIGURE 11, which also illustrates the obvious variability of inter-band distance by showing such a distance materially larger than in the case of the web of earlier figures.

Attention may now be directed to the use of the web 110 as an intermediate product in the process of producing slivers of foil such as early hereinabove discussed, which slivers will of course be formed by the strips 112 upon their suitable removal from the web. It has already been noted that the web may be rolled up on a spool such as 115 without injury to the strips 112, and it is further true that the web as thus rolled up is well adapted for shipping without risk of injury to those strips. It is accordingly preferred that the web be transported in rolled-up arrangement to the location at which the slivers are to be introduced into another substance or otherwise used. This, keeping the slivers in predetermined and parallel relation to each other, has the important advantage of avoiding their being placed in agglomerations in which their orientation one to another will be random, and in which the weight of upper ones and the forces incident to shipping and other handling will result in serious deformation and even entanglement of many of them—and of avoiding the alternative practise of trying to place thin layers of the slivers between layers of packing material, which practise still involves the slivers being in random arrangement and subject to some of the same deforming forces as mentioned above or similar ones.

Both because of possible past history of the sheet of foil as of the time it is converted into the web, and also because of its exposure to some oil in the process of that conversion (i.e., as it emerges from the orifice and is operated upon by the knives of earlier figures) it will frequently be desirable that the slivers ultimately to be produced be subjected to a surface treatment consisting of a degreasing operation followed by suitable drying. Furthermore for many uses the slivers may require a further treatment of their principal surfaces—i.e., of the faces and their side edges—such as oxidizing, lacquering, coating with other agents, subsequent re-drying and/or other surface treatment. According to my invention any such treatment or treatments is or are performed on the slivers while they remain parts of the web; further, although these surface treatments or any of them may be performed on the web at any desired location, it is preferable that they be performed in the operative vicinity of the substance into which the slivers are to be introduced or of the environment in which they are to be otherwise used. In this connection it may be pointed out that the inclination of the strips out of the plane of the longitudinal bands, and especially their preferred inclinations in alternate directions, discussed above, are a very great facilitation, not only in providing access of the treating agent or agents to the surfaces of the strips but also in avoiding bridging from one strip to its neighbor by relatively thicker or more viscous agents.

Accordingly in FIGURE 12 I have illustrated certain apparatus located in the operative vicinity of a chute 140 which denotes a passage leading, preferably quite directly, into a batch of the substance into which the slivers are to be introduced or into any other apparatus or system in which the slivers are to be employed. This apparatus may be for example first comprise a mandrel 118 on which the web 110, rolled up on the spool 115, may be mounted—typically, after web and spool have been transported any desired distance from the apparatus in which the web was formed and rolled up (e.g., that of which the terminal portion is illustrated in FIGURE 9 on the same sheet of drawing).

From the thus-mounted spool 115 the web 110 may be drawn down into an enclosure 120 through a suitable slot 119 therein, and from that enclosure the web may emerge through a suitable slot 121, typically next to pass over an idler roller 122; the means for thus drawing the web will be described directly. The enclosure 120 may be considered as forming the confines of apparatus suitable to the continuous performance of each and every surface treatment which it is desired be performed on the principal surfaces of the slivers, which treatment or treatments will by that apparatus be performed on those surfaces while the slivers remain parts of the web. Within this apparatus the web may travel as far and through as many compartments as may be necessary or desirable, before emerging through the slot 121.

The web after emerging from the enclosure 120 is in condition to be cut longitudinally, within the confines of the longitudinal paths thereon occupied by the strips 112, in order to form the slivers as such. While any means for accomplishing this cutting may be employed, I have found preferable a suitable slitter 130 through which the web may be drawn longitudinally—and which in typical cases may itself form the means which draws the web off from the spool 115 on mandrel 118 and through the enclosure 120 and over the idler roller 122.

The slitter, which is illustrated schematically in FIGURE 12, may have two interrelated portions. The lower portion may comprise a series of parallel hardened discs 131 concentrically carried by and normal to a shaft 133 and therealong spaced apart from each other (surface to surface) by a distance equal to the length of the slivers to be produced—relative to which the length of the strips 112 in the web will preferably have been made very slightly longer, not merely for tolerance reasons but also so that there may be cut away from the slivers not only the full width of the longitudinal bands but also the very short end portions 113 (of the strips 112) which are in immediate adjacency to the longitudinal bands, within which the strips 112 progressively lose their inclinations, and within which the strips are therefore slightly twisted or distorted from plane configuration. The spacing of the discs may be accomplished by suitable annular blocks 135 of which an end one (on the outer side of the lefthand one of the discs 131) appears in FIGURE 12. The thickness of each disc 131 (with the permissible exception of the end discs in the series) may be equal to the width of a longitudinal band, augmented by the dimension (transverse of the web) of the strip end portions 113 to be cut away from the slivers along with the web (as mentioned above) times two.

The upper portion of the slitter may comprise a series of parallel hardened discs 132 concentrically carried by and normal to a shaft 134 parallel to shaft 133, the discs 132 being of the same diameter as but substantially thinner than the discs 131 and twice as many in number. The lefthand pair of the discs 132, designated as 132*a*, are spaced apart by a distance such that their peripheral portions may just enter between the peripheral portions of the lefthand and next-to-lefthand of the lower discs 131; the next pair of the discs 132, designated as 132*b*, are similarly spaced apart to permit their peripheral portions just to enter between the peripheral portions of the next-to-lefthand and second-from-lefthand of the lower discs **131** and are suitably spaced from the first pair to permit the entries just mentioned to take place simultaneously; and so on. Preferably the spacings of the discs **132** will be such that in order to accomplish the entries of peripheral portions mentioned above, the peripheral portion of each disc **132** at the region of such entry will be minutely strained toward that of the other of its pair (which is possible by reason of their relative thinness), in order to insure intimate contact between the upper- and lower-disc peripheral portions. The shafts **133** and **134** will be so spaced apart that the distance of the entries abovementioned (i.e., of overlap between the upper and lower discs as seen from the side) may be very minute—typically of the order of a few thousandths of an inch, that overlap having been somewhat exaggerated in FIGURE 12 for the purpose merely of emphatic illustration.

The shafts **133** and **134** may be journalled in suitable mountings (not shown), coupled together by suitable gears (not shown) to result in oppositely directed rotations of the two at identical peripheral speeds, and rotated (clockwise as to the lower shaft **133** as seen in FIGURE 12) by any suitable means (not shown).

The web being properly positioned and guided laterally by suitable means (schematically indicated by the guide **129** in FIGURE 12), the passage of the web through the slitter will result in the conversion of the web into waste ribbons **149** and the desired slivers **150**. The waste ribbons **149** will be formed by the respective lower discs **131** operating on and detaching the longitudinal bands **111** of the web together with the immediately adjacent end portions **113** of the strips **112**, the detached ribbons (except the two respectively including the margins) being forced by the respective discs **131** into arcuate positions displaced inwardly from the peripheries of the upper discs **132** by a trifle more than the minute distance of overlap between lower and upper discs and disposed between an outer surface of one pair of discs **132** and the nearby outer surface of the next pair. The waste ribbons will be induced by frictional contact of their edges with the upper-disc surfaces to attempt to stay in those positions and rotate with the upper discs; but this action (which of course could not be tolerated) may readily be foreclosed by suitable fingers **138** extending, from any convenient mounting (not shown), diagonally downwardly to between the respective pairs of upper discs **132**, these fingers serving to cam the waste ribbons outwardly from those positions. The non-marginal waste ribbons may pass from the respective fingers, and the marginal waste ribbons may pass directly, over a nearby idler roller **137** to fall therebeyond.

On the other hand the slivers **150**—which will be detached by reason of the respective pairs of upper discs **132** operating thereon—will be forced by those respective disc pairs into positions which are slightly displaced inwardly from the peripheries of the lower discs **131** and which are disposed between mutually facing lower-disc surfaces; these positions will be parallel transverse ones, and each sliver will tend to remain in a respective one of these positions by reason of the frictional contact of its extremities with the lower-disc surfaces, as indicated at **150'** in FIGURE 12. Each sliver may be permitted to make a third or so of a revolution (of the lower shaft) while remaining so positioned, and may then be cammed outwardly from between the discs **131** by one of a group of fingers **139** which may extend diagonally upwardly from below the slitter into the respective inter-lower-disc spaces.

The slitter **130** may be and preferably is located directly above the chute **140**, so that all the slivers detached from between the discs **131** by the fingers **139** will fall directly and freely and in a steady stream from each finger into the chute and will therethrough pass to their destination, which is preferably both the ultimate one and close at hand. The chute will also inherently receive any random slivers which might detach themselves from between the discs **131**. As a subordinate matter, the rear side of the chute **140** may form a convenient mounting base for the fingers **139**.

As a means of cutting the web longitudinally to separate the slivers therefrom, the slitter has the important advantages first of smooth and steady unidirectional movement, favoring the maintenance of the slivers in straight and flat configurations; secondly, of being operable without oiling of those of its parts which come into contact with the web, so that de-greasing and other surface treatments of the web previously effected inure fully to the benefit of the final slivers.

I have found that the making of a web in the manner and of the nature described above, the effecting of any necessary shipment and of any necessary or desired surface treatment while the material is in the web form, and the conversion from that form into slivers directly followed by their introduction into the substance or other environment in which they are to be dispersed or otherwise ultimately used as described above, results in slivers in the ultimate environment which are of very precise dimensions and are straight and flat to a superlative degree.

Furthermore it is readily possible to meter the slivers very precisely by metering of the web, since the number of slivers per unit length of the web—or per unit weight of the web if the weight per unit length of the original sheet of foil has been accurately controlled—is for all practical purposes an utter constant. A particularly convenient and accurate way of metering the slivers is by the use of a suitable means adjacent the slitter for measuring the length of foil subjected to the longitudinal cutting; this means may for example be a revolution counter coupled to one of the shafts of the slitter. Thus in FIGURE 12 I have illustrated such a counter **125** fixedly supported in any convenient manner adjacent the lefthand end of the lower shaft **131** of the slitter and having, on a thin stem extending from the counter, an actuating star wheel **126** which may for example be advanced, one notch at each revolution of the lower shaft **131**, by a small arm **127** extending from that shaft.

While I have disclosed my invention in terms of particular steps, particular products and particular apparatus, it will be understood that I intend thereby no unnecessary limitations. Among other things I intend no unexpressed limitation of the apparatus according to my invention to the production of slivers, or to shearing along lines of limited length or along closely spaced lines. Further, it will be understood that by the use of particular terms I do not intend unnecessarily narrow meanings; in referring to a back-and-forth movement by the term "reciprocate" and its derivatives, for example, I do not imply that such movement must be rectilinear. Modifications in many respects will be suggested by my disclosure to those skilled in the art, and such modifications will not necessarily constitute departures from the spirit of my invention or from its scope, which I undertake to define in the following claims.

I claim:

1. A method of making and introducing into another substance with which they are to be compounded narrow slivers of foil, comprising the steps of (1) providing an integral sheet of the foil having a plurality of spaced-apart continuous longitudinal bands and having therebetween adjacent transverse strips of width equal to that, and of length at least as great as that, of the slivers to be made, (2) forming the slivers from said strips by cutting the sheet longitudinally at two transversely separated positions between said bands, and (3) from the cutting operation introducing the slivers into said substance while maintaining the slivers continuously free of application thereto of appreciable deforming forces.

2. The subject matter claimed in claim 1 wherein said

forces include the forces incident to substantial agglomerations of the slivers.

3. A method of making narrow slivers of foil, comprising the steps of (1) advancing a sheet of the foil longitudinally while repetitively performing the operation of shearing the sheet across at least one longitudinal path bounded on the sheet by path margins spaced apart to provide for the length of the slivers, in each operation to complete a narrow inter-margin strip by formation of the second edge thereof, the first edge thereof having been formed by the preceding shear, and thereafter (2) cutting the sheet longitudinally at two transversely separated positions within the path to form discrete slivers from said strips.

4. The subject matter claimed in claim 3 wherein each said operation further includes inclining the strip completed in that operation substantially about its first edge out of the plane of the adjacent margins.

5. The subject matter claimed in claim 3 wherein each alternate one of said operations includes inclining the strip completed in that operation substantially about its first edge in one direction, and each intervening one of said operations includes inclining the strip completed in that operation substantially about its first edge in the opposite direction, out of the plane of the adjacent margins.

6. For the production of narrow slivers of foil whose faces and principal edges require surface treatment, the method claimed in claim 3 further including, between said steps numbered (1) and (2) and while said strips remain parts of the sheet, the step of subjecting said strips to said surface treatment.

7. The subject matter claimed in claim 6 wherein said last-recited step is performed by subjecting the entire sheet to said surface treatment.

8. For the making of narrow slivers of foil, whose faces and principal edges require surface treatment, and the introduction of the surface-treated slivers into another substance with which they are to be compounded, the method claimed in claim 6 wherein said step numbered (2) is performed in the operative vicinity of said substance, further including the subsequent step of (3) from the cutting step introducing the slivers directly into said substance.

9. For the production of narrow slivers of foil whose faces and principal edges require surface treatment, the method claimed in claim 3 wherein each said operation includes displacing an edge of the strip completed in that operation away from the nearest other-strip edge, further including, between said steps numbered (1) and (2) and while said strips remain parts of the sheet and an edge of each strip remains thus displaced, the step of subjecting said strips to said surface treatment.

10. For the making of narrow slivers of foil and their introduction into another substance with which they are to be compounded, the method claimed in claim 3 further

including the subsequent step of (3) from the cutting step introducing the slivers into said substance while maintaining the slivers continuously out of any substantial agglomeration thereof.

11. For the making of narrow slivers of foil and their introduction into another substance with which they are to be compounded, the method claimed in claim 3 further including the subsequent step of (3) from the cutting step introducing the slivers into said substance while maintaining the slivers continuously free of application thereto of appreciable deforming forces.

12. For the making of narrow slivers of foil and their introduction into another substance with which they are to be compounded, the method claimed in claim 3 wherein said step numbered (2) is performed in the operative vicinity of said substance, further including the subsequent step of (3) from the cutting step introducing the slivers directly into said substance.

13. For the making and metering of narrow slivers of foil, the method claimed in claim 3 further including, in association with the step numbered (2), metering the length of the sheet thus cut longitudinally.

14. A method of operating upon a sheet of foil comprising advancing the sheet longitudinally while repetitively performing the operation of shearing the sheet across at least one longitudinal path bounded on the sheet by path margins in each operation to complete an inter-margin strip by formation of the second edge thereof, the first edge thereof having been formed by the preceding shear, each alternate one of said operations including inclining the strip completed in that operation substantially about its first edge in one direction, and each intervening one of said operations including inclining the strip completed in that operation substantially about its first edge in the opposite direction, out of the plane of the adjacent margins.

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