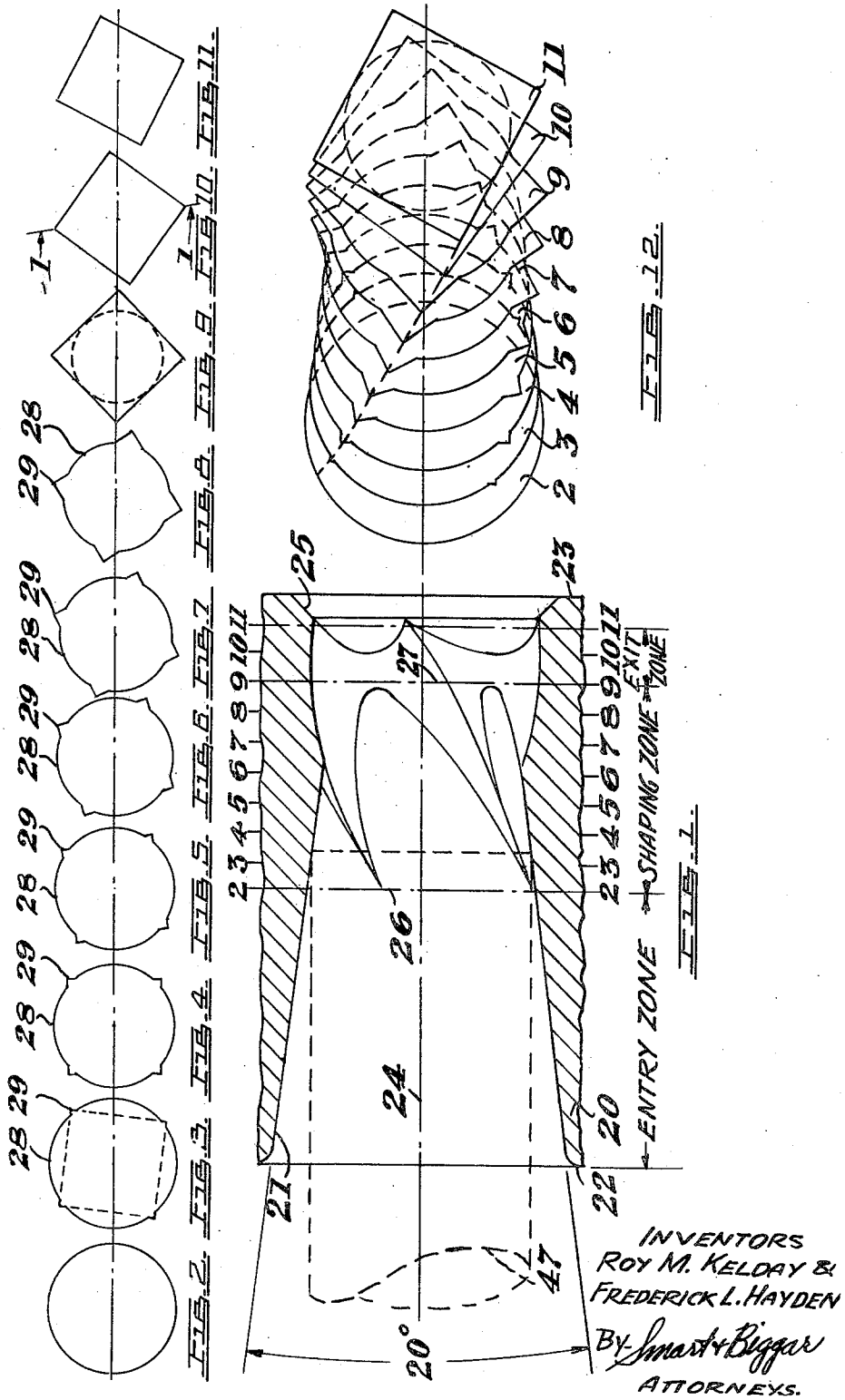
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WIRE DRAWING DIE

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WIRE DRAWING DIE

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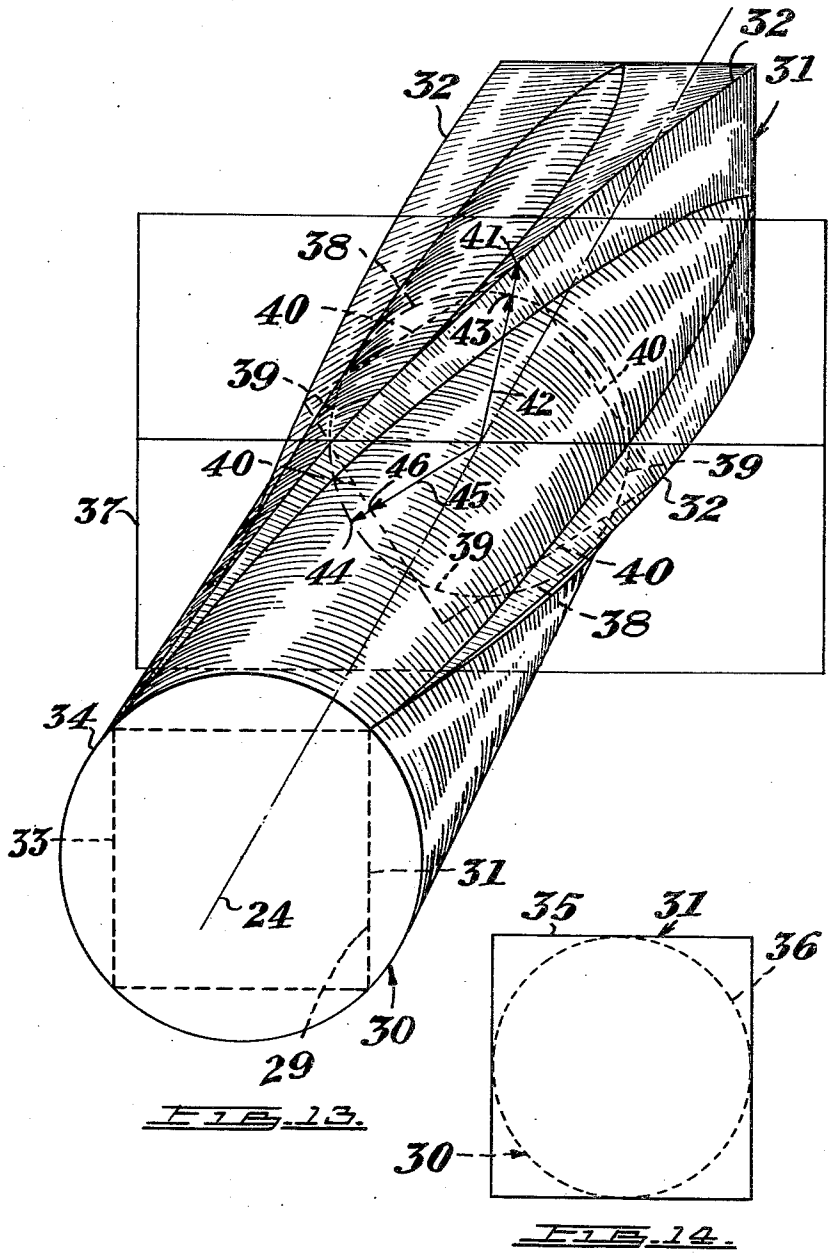


FIG. 13.

FIG. 14.

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WIRE DRAWING DIE

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This invention relation to wire drawing dies adapted for the drawing of wire having a general cross-sectional shape which is non-circular and of which the orientation varies helically along the length of the wire.

In our prior application, Serial No. 434,034, now U.S. Patent No. 2,928,528, we described and illustrated an apparatus and method for production of wire of the kind in question. The die there illustrated and described has a passage therethrough of gradually diminishing cross-sectional area throughout a substantial part of its working length, the passage having a general cross-sectional shape which is non-circular and is helically twisted about its longitudinal axis throughout the portion of non-circular cross-sectional shape. According to the prior application the passage might be of non-circular cross-sectional shape throughout its length, or might be of circular cross-sectional shape at its entry face, becoming of non-circular cross-sectional shape as it progresses through the passage to the exit face. In both forms of this die the drawing of the wire to its final non-circular cross-sectional shape was effected either wholly or principally in the portion of the passage having such shape, that portion being of gradually diminishing cross-sectional area over its length.

We have now developed a die which permits easier drawing of wire of the kind in question, has very substantially longer life, and may be made more cheaply and conveniently than dies of the kind previously described. This improved die differs essentially from the former die in that all dimensional reduction of the wire drawn through it is effected on arcuate surfaces and the portion of the periphery of the wire subject to drawing action is progressively and substantially decreased in each succeeding increment proceeding through the shaping portion of the die passage.

The improved wire drawing die according to the invention has a passage therethrough which extends from the entry face to the exit face along a straight longitudinal axis and which includes a shaping zone of substantial length. The shaping zone is of continuously decreasing cross-sectional area towards its exit end over its entire length and is of a cross-sectional shape such that the distance between the longitudinal axis and any point on the periphery of the zone, when measured along a line in the transverse plane which includes that point and is perpendicular to the longitudinal axis, is the greater of

(*a*) The distance which would be measured along the same line between the axis and the periphery of a first figure of the same length as the shaping zone and of continuously decreasing circular cross-sectional area over its entire length constructed so as to be concentric with the longitudinal axis and to have the entry end of the shaping zone as its base, and

(*b*) The distance which would be measured along the same line between the longitudinal axis and the periphery of a second figure of the same length as said shaping zone and of uniform cross-sectional shape and substantially uniform cross-sectional area throughout its length and constructed so as to have the exit end of the shaping zone as a base and being helically twisted about the longitudinal axis with a uniform lead,

the second figure having a maximum radial dimension equal to the radius of the first figure at the entry end

of the shaping zone and a minimum radial dimension equal to the radius of the first figure at the exit end of the shaping zone. By the term "lead" is meant the amount of advance along the longitudinal axis for each revolution of twist. By the term "maximum radial dimension" is meant the radius of the smallest circle centred on the longitudinal axis which could be circumscribed about the figure in a plane perpendicular to the longitudinal axis, and by the term "minimum radial dimension" is meant the radius of the largest circle centred on the longitudinal axis which could be inscribed within the figure in such a plane. Substantially the minimum cross-sectional area of the passage is at the exit end of the shaping zone. The die is so formed that substantially all dimensional reduction of wire drawn through the die is effected on surfaces which are arcuate in planes perpendicular to the longitudinal axis of said passage.

The die passage preferably includes an exit zone as well as the shaping zone. The exit zone is of uniform non-circular cross-sectional shape and substantially uniform cross-sectional area throughout its length but is helically twisted about the longitudinal axis of the passage with a uniform lead. The entry end of the exit zone coincides with the exit end of the shaping zone, and the cross-sectional shape of the shaping zone is such that the second figure referred to above in connection therewith has the same uniform cross-sectional shape and substantially uniform cross-sectional area as the exit zone and is helically twisted with the same uniform lead as the exit zone. The presence of an exit zone is desirable because, if the shaping zone extends to the exit face of the die or to the beginning of the usual relief portion at that face, then as the die wears the exit end of the shaping zone may lose the true cross-sectional shape desired in the drawn wire. If that shape is, for example, square, the drawn wire as a result of wear of the die may have slightly convex sides. In some cases an exit zone may also be desirable to give additional helical twist to the passage and thus assist in the rotation of the die.

The die passage also preferably includes an entry zone. This zone ordinarily serves simply as a mouth leading to the shaping zone where the drawing and shaping of the wire take place, though some drawing—but no shaping—of the wire may be effected in it by presenting to the die wire of a diameter greater than the diameter of the passage at the entry end of the shaping zone. Usually, however, the diameter of the incoming wire is chosen to be slightly smaller than the passage diameter at that point, so that the wire first strikes the die just beyond the entry end. The entry zone is of circular cross-sectional shape concentric with the longitudinal axis of the passage, and is preferably of continuously decreasing cross-sectional area towards its exit end.

It will be appreciated from the above that although the die passage is of continuously decreasing cross-sectional area, i.e. inwardly tapered, over a substantial part of its length, and is also helically twisted over a substantial part of its length, so that wire passed through it is drawn and at the same time given a helical shape, nevertheless only those surfaces of the passage which are arcuate in cross-section are inwardly tapered, so that there is no dimensional reduction of wire on the non-arcuate surfaces of the passage which are helically twisted. The arcuate surfaces on which drawing does take place act in the same way on the incoming wire regardless of the relative orientation of the die and wire consequent upon the rotation of the former.

The invention will be more fully described by reference to the attached drawings, which illustrate an embodiment of it, and in which:

FIGURE 1 is a longitudinal section through the improved die taken along the line 1—1 of FIGURE 10;

FIGURE 2 is an outline of the cross-section of the passage along the line 2—2 of FIGURE 1;

FIGURES 3 to 11 are corresponding outlines of the cross-sections of the passage taken along the lines 3—3, 4—4, 5—5, 6—6, 7—7, 8—8, 9—9, 10—10, and 11—11 respectively of FIGURE 1;

FIGURE 12 represents a combination of the outlines shown in FIGURES 2 to 11 inclusive partially superimposed one upon the other to indicate more fully the relationship between them and the helical twisting of the passage, the outlines in this figure being numbered to correspond with the numbering of FIGURES 2 to 11;

FIGURE 13 is a schematic view serving to illustrate in principle the formation of the shaping zone of the passage, and

FIGURE 14 is a view looking at the far end of FIGURE 13.

As shown in FIGURE 1, the die **20** has therethrough a passage **21** extending along a straight longitudinal axis **24** from the entry face **22** to the exit face **23** of the die where it terminates in a conventional relief **25**. Between the entry face **22** and the inner end of the relief **25** the die passage, as shown in FIGURE 1, includes three zones; an entry zone extending from the entry face to the section line **2—2**, a shaping zone extending from the section line **2—2** to the section line **9—9**, and an exit zone extending from the section line **9—9** to the inner end of the relief portion **25**. The entry zone of the passage is of circular cross-sectional shape concentric with the longitudinal axis **24** and, as shown, is of continuously decreasing cross-sectional area throughout its length from the entry face **22** to the section line **2—2**, its cross-sectional outline in that plane being shown in FIGURE 2. The exit zone of the passage is of uniform square cross-sectional shape as appears from FIGURES 9, 10 and 11, and is of substantially uniform cross-sectional area, i.e. is substantially untapered throughout its length as can be seen from the fact that the squares shown in FIGURES 9, 10 and 11 are of substantially the same dimensions. As best illustrated by the three outlines at the right-hand end of FIGURE 12, the exit zone is helically twisted about the longitudinal axis **24**.

The shaping zone of the passage has an entry end coinciding with the exit end of the entry zone, these coinciding ends being numbered **26** in FIGURE 1, and has an exit end coinciding with the entry end of the exit zone, these latter coinciding ends being numbered **27** in FIGURE 1. The shaping zone has a shape which may be regarded as the shape resulting from a merger of (*a*) an extension to the exit end of the shaping zone of the inwardly tapered entry zone as illustrated, with (*b*) an extension to the entry end of the shaping zone of the helically twisted substantially untapered exit zone as illustrated. At its entry end the shaping zone is of fully circular cross-section as shown in FIGURE 2 and at its exit end it is of fully square cross-section as shown in FIGURE 9, and between these ends its cross-section is in effect partly square and partly circular as shown in FIGURES 3 to 8, the arcuate portions **28** of the cross-sectional outline progressively diminishing in extent and the square corners **29** progressively increasing in extent as the exit end of the shaping zone is approached. At the plane of FIGURE 9 the arcuate portions have disappeared as indicated by the inscribed dotted line circle in that figure. The corners **29** through the shaping zone constitute, it will be seen, grooves of which the bottoms lie throughout their length in the periphery of a cylinder having the radius of the entry end of the shaping zone and are all twisted with the same helix angle. The arcuate portions **28**, constituting the periphery of the die bore between the grooves lie, as will be apparent, in the periphery of a cone which diminishes throughout the shaping zone from the radius of the entry end of that zone to a radius the same as the minimum radial dimension of the exit end of the shaping zone and hence

of the outcoming square wire. Because, as indicated above, the exit zone is substantially untapered, substantially the minimum cross-sectional area of the passage occurs at the exit end of the shaping zone in the plane illustrated in FIGURE 9.

It has been found that the inward taper of the arcuate surfaces in the shaping zone should generally be between about 14° and 26°, an inward taper of about 20° being preferable in most cases. Usually the same taper is present in the entry zone, as is indicated in FIGURE 1.

As mentioned above, the exit zone is substantially untapered, and the same is true of the non-arcuate surfaces in the shaping zone. In practice, solely for easier manufacture of the die, a taper of 2° or even 4°, which is of negligible practical significance in the operation of the die, may be used, and this taper may be either an inward one like that of the arcuate surfaces in the shaping zone or may be a reverse taper.

It will be noted that as one progresses along the passage from the plane illustrated in FIGURE 3 to the plane illustrated in FIGURE 9, the orientation of the square corners **29** changes, the rate of such change being determined by the lead of the helical twist in the exit zone of the passage which is carried on through the shaping zone, as most clearly appears from FIGURE 12.

The outline of the shaping zone can thus be defined by reference to two figures as illustrated in principle in FIGURE 13. It should be borne in mind that FIGURE 13 does not show a practical case, various proportions and dimensions having been exaggerated for purposes of clearer illustration. These two figures are of the same length as the shaping zone. The first figure, **30**, is of continuously decreasing cross-sectional area over its entire length, being preferably a right circular cone, and is constructed so as to be concentric with the longitudinal axis **24** and to have the entry end of the shaping zone, seen at the near end of FIGURE 13, as a base. The second figure, **31**, is of uniform square cross-sectional shape and substantially uniform cross-sectional area throughout its length and is constructed so as to have as a base the exit end of the shaping zone, which is the far end of FIGURE 13, shown in FIGURE 14. It is, moreover, helically twisted about the longitudinal axis **24**, as can be seen from the lines **32** illustrating its corners. Where the die passage includes an exit zone the helical twist in the shaping zone, defined by a figure such as **31**, has the same lead as the helical twist in the exit zone, as appears from a consideration of FIGURE 12. The figure **31** has, as is shown in the near end of FIGURE 13 where the square **33** shows the end of the figure **31**, a maximum radial dimension equal to the radius of the figure **30** at the entry end of the shaping zone. Thus, at that entry end half the diagonal of the square **33** is equal to the radius of the circle **34** representing the base of the figure **30**. The minimum radial dimension of the figure **31** is equal to the radius of the figure **30** at the exit end of the shaping zone as can be seen from FIGURE 14, in which half the side of the square **35** representing the base of the figure **31** is equal to the radius of the circle **36** which represents the section of figure **30** at the exit end of the shaping zone.

The cross-sectional shape of the shaping zone corresponds to the cross-sectional shape of the composite figure outlined in FIGURE 13 and results from the merger of the figures **30** and **31**. Thus this cross-sectional shape may be defined by reference to the distance between the longitudinal axis **24** and any point on the periphery of the shaping zone when measured along a line in the transverse plane which includes the point and is perpendicular to the axis **24**. One such plane **37** is shown for purposes of illustration in FIGURE 13. The dash line **38** represents the outline of the periphery of the shaping zone in the plane **37**, the dotted lines **39** representing the periphery of the figure **30** in that plane where it differs from that of the shaping zone, and the dotted lines **40**

correspondingly representing the periphery of the figure 31. The distance between the longitudinal axis 24 and a point 41 on the dash line 38 (which at that point follows the periphery of the figure 31), measured along the line 42 in the plane 37 is, as can be seen, greater than the distance along that line to the periphery of the figure 30 at 43 on the dotted line 39. In the case of another point 44 on the dash line 38 (which at that point follows the periphery of the figure 30), the distance between the longitudinal axis 24 and this point 44 measured along the line 45 in the plane 37 is greater than the distance along that line to the periphery of the figure 31 at 46 on the dotted line 40. The two points 41 and 44 are representative of any point on the periphery of the shaping zone. Thus, it is clear that the cross-sectional shape of that zone is such that the distance between the longitudinal axis 24 and any point on the periphery of the zone, when measured as indicated, is the greater of the distances measured in the same way between the longitudinal axis 24 and the periphery of a figure having the characteristics of the figure 30 and the periphery of a figure having the characteristics of the figure 31.

In practice, as explained earlier, the first figure, 30, would be one having an inward taper of between about 18° and about 24°, and the second figure, 31, might have a taper of 2° to 4° either in the same or the reverse direction.

In the case illustrated the cross-sectional outline of the second figure, 31, and of the exit zone is square, but many other non-circular cross-sectional outlines may be adopted.

In FIGURE 1 an incoming round wire to the die is shown in dotted lines at 47. It will be noted that this wire first comes in contact with the die between the planes represented by FIGURES 3 and 4. The reason for this is that to use wire of a greater diameter, e.g. a diameter greater than that of the passage in the plane represented in FIGURE 2, may under some conditions put too great a strain on the wire and the drawing apparatus. On the other hand, for many purposes for which the drawn wire will be used the fact that the corners, as a result, are not perfectly sharp but are slightly rounded is unimportant.

It will be apparent from the relation of the wire to the passage, shown in FIGURE 1, that in such a case the presence of an entry zone is unnecessary so far as actual drawing and shaping are concerned. All drawing and shaping take place in the shaping zone, the drawn wire simply passing through the exit zone with no, or no appreciable, dimensional reduction and no change of cross-sectional shape.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Die for drawing circular stock to helical stock of polygonal cross section having a maximum radial dimension the same as the radius of the circular stock, said die having a bore including an entrance zone and a shaping zone, said shaping zone being circular at its entry end and having grooves extending lengthwise throughout said zone corresponding to the corners of the polygonal stock, the bottoms of said grooves throughout their length lying in the periphery of a cylinder of the circular stock radius and all being twisted with the same helix angle, the periphery of the die bore between said grooves lying in the periphery of a cone diminishing throughout the shaping zone from the radius of said entry end to a radius the same as the minimum radial dimension of the polygonal stock, whereby the periphery of the stock between said corners will be worked to a smaller size and gradually form the sides of the polygon while the corners thereof remain constant.

2. The die of claim 1 wherein said grooves comprise four in number to form said polygonal stock.

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