March 10, 1964 D. E. MARQUIS ETAL 3,124,023

DIES FOR PIPE AND TUBING TONGS

Filed April 18, 1960 4 Sheets-Sheet 1

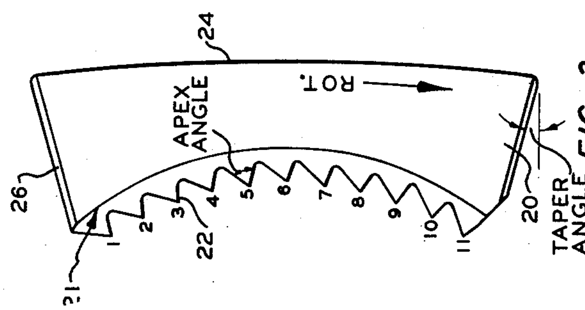

FIG. 2

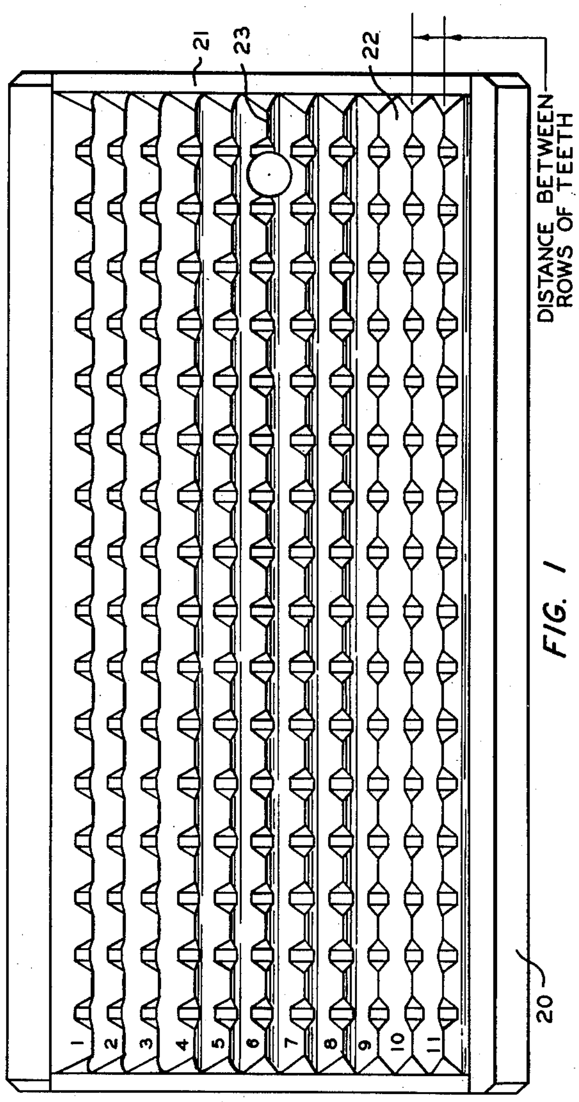

FIG. 1

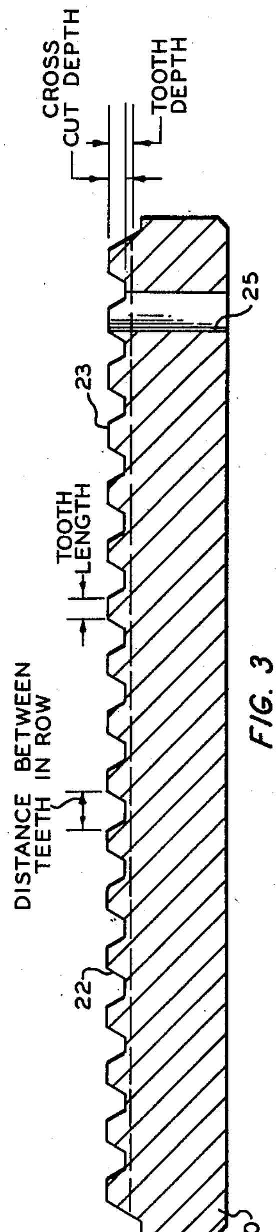

FIG. 3

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DIES FOR PIPE AND TUBING TONGS

Filed April 18, 1960 4 Sheets-Sheet 2

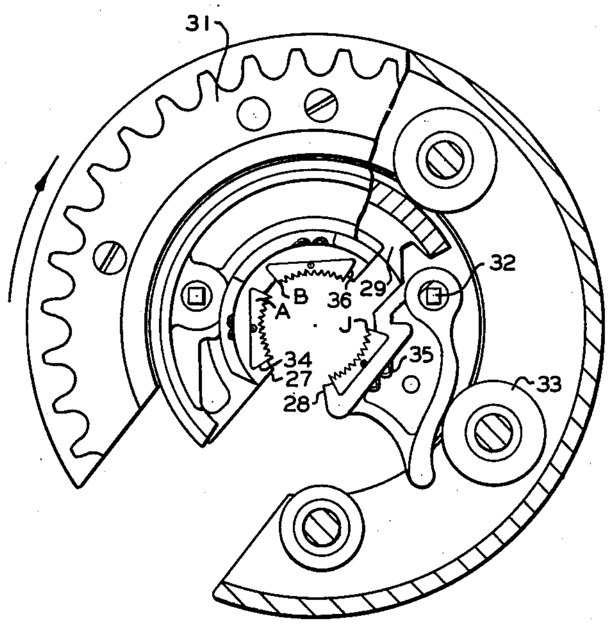

FIG. 4

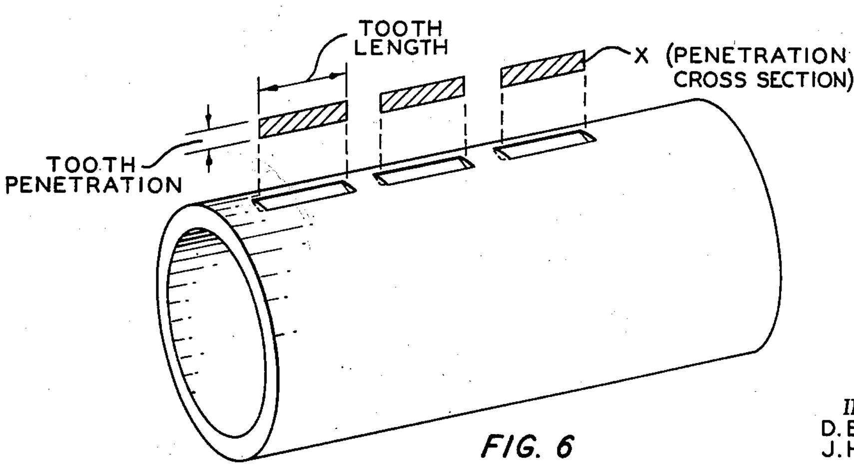

FIG. 6

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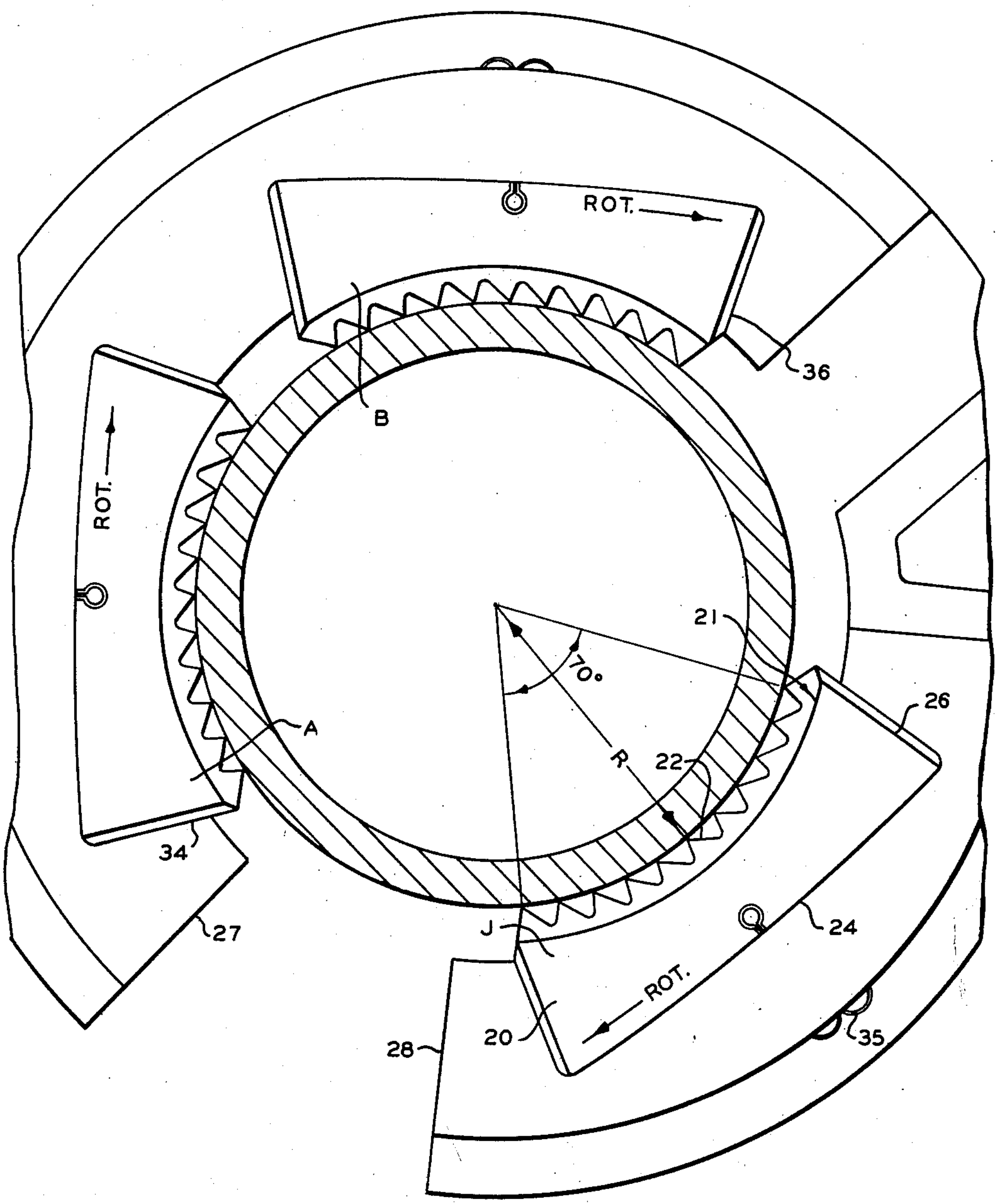

FIG. 5

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DIES FOR PIPE AND TUBING TONGS

Filed April 18, 1960 4 Sheets-Sheet 4

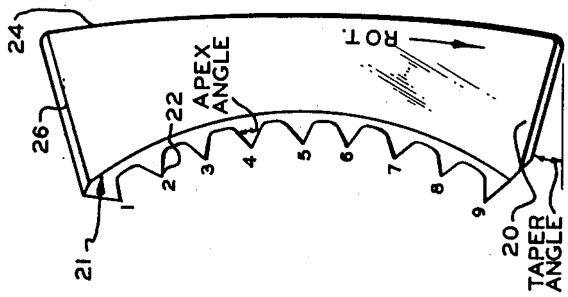

FIG. 8

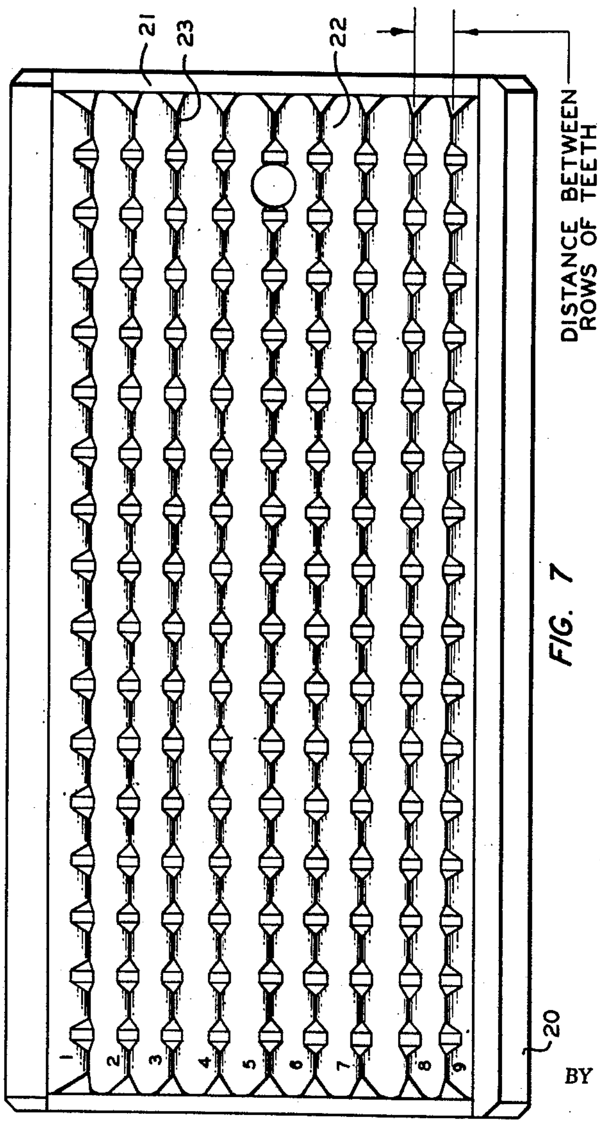

FIG. 7

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United States Patent Office

3,124,023

Patented Mar. 10, 1964

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3,124,023

DIES FOR PIPE AND TUBING TONGS

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Filed Apr. 18, 1960, Ser. No. 22,842
10 Claims. (Cl. 81—186)

This invention relates to a die for pipe and tubing tongs. In one aspect this invention relates to an improved die which, when employed in pipe and tubing tongs, causes less damage to the pipe or tubing being made up or broken out with the aid of said tongs. In another aspect this invention relates to an improved die for pipe and tubing tongs which die provides maximum contacting surface of essentially the same curvature as the outer circumference of the pipe or tubing to which said die is applied.

The development of new high strength tubing has helped solve many of the problems encountered in the completion of high pressure oil and/or gas wells. Said new tubings are fabricated from new alloy steels and have a yield strength in the range of API P–105 grade tubing, i.e., 105,000 p.s.i. minimum yield. In said new steels the increase in yield strength is accompanied by a decrease in ductility.

Even with the improved results which can be obtained with said new tubing, operators of high pressure oil and/or gas wells have continued to encounter tubing failures all too frequently. Inspection of tubing joints which have failed has revealed that, with few exceptions, the origin of the failure occurred at a point where damage to the tubing through handling was evident.

Thus, while said new tubing has solved many of the problems formerly encountered, the use of said new tubing has created problems in the handling of the tubing itself. Handling techniques and equipment employed with old type tubing have proven highly unsatisfactory for the new type tubings. Well operators have thus been faced with the problem of reducing handling damage which has caused many unnecessary failures. As mentioned above, the increase in yield strength of said new steels is accompanied by a decrease in ductility. The stress in a ductile steel is able to redistribute itself around discontinuities and damaged areas, but in a non-ductile brittle material less stress redistribution occurs, resulting in a concentration of stress in the vicinity of any damage. These characteristics of the new alloys require more care in the handling of the less ductile tubing. For example, in the operation of high pressure wells employing said new tubings, brittle failure at the die mark has been encountered in a number of instances; tubing failures have occurred during the normal operation of wells where the rupture passed directly through the die marks; and stress corrosion failures have occurred in the region of the die marks.

Thus, it has been found that much of the handling damage is caused by the dies in the tongs employed in making up and breaking out joints of tubing. As a result of extensive field, laboratory, and experimental tests we have invented a new die for pipe and tubing tongs, which die reduces damage to said pipe or tubing to the

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minimum, but yet provides efficient safe handling in making up and breaking out strings of pipe or tubing.

Thus, broadly speaking, the present invention resides in an improved die having an improved tooth type, contact pattern, and size which provides maximum contact area and minimum penetration, resulting in the elimination or mitigation of tubing failures due to die damage.

An object of this invention is to provide an improved die for pipe and tubing tongs. Another object of this invention is to provide an improved die for pipe and tubing tongs which provides maximum tooth contacting areas and minimum tooth penetration, thereby resulting in the elimination or mitigation of tong die damage. Another object of this invention is to provide an improved die which is less subject to clogging. Still another object of this invention is to provide an improved die which is easier to clean. Another object is to provide an improved power tong adapted to be employed with said die. Other aspects, objects and advantages of the invention will be apparent to those skilled in the art in view of this disclosure.

Thus, according to the invention there is provided a die for pipe and tubing tongs, said die comprising: a bar-like body having a concave working face provided with a plurality of buttressed teeth thereon; said teeth having a substantially triangular cross section and being arranged in from 5 to 9 spaced apart parallel rows per inch of said concave working face; each of said teeth having an apex length or contacting surface within the range of 1/16 to 1/4 inch; said teeth being spaced apart in said rows a distance within the range of from 1/16 to 1/4 inch; and said apexes of said teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said die is to be employed.

We have found said combination of factors or elements to be essential in reducing die damage to the minimum. The concave working face provides the curved foundation necessary for realization of maximum advantage from the other elements of the combination. The buttress type teeth of substantially triangular cross section provide maximum tooth strength which is highly desirable when employing maximum applied torque. Said buttress type teeth also provide a better initial "bite" which is particularly desirable when working with dirty or scaly tubing. The specified spacing of the rows of teeth, the specified tooth apex or contacting length, and the specified spacing of said teeth in said rows all cooperate to provide an interrupted marking pattern. Said interrupted marking pattern is essential in order to avoid a continuous or elongated marking pattern which causes a concentration of immediate damage and sets up a concentration of stress forces which lead to future failures. The arcuate contacting surface of essentially the same curvature as the curvature of the outer circumference of the pipe or tubing with which the die is to be employed spreads the applied forces over the maximum area and insures that each tooth will bear its share of said applied forces and reduces individual tooth penetration to the minimum.

Each of said elements is critical to the combination, within the above specified limits, in that each cooperates with the others to provide a unitary end result, i.e., a die, which when employed in a pipe or tubing tong and applied to a pipe or tubing, will cause minimum damage to said pipe or tubing.

As used herein and in the claims, unless otherwise specified, the expression "arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said die is to be employed" refers to the curved surface presented by the apexes or contacting surfaces of the die teeth. Said contacting surface is of course an interrupted surface. The curvature of said surface can be further defined in terms of radius of curvature. For example, consider a nominal two inch tubing having an outside diameter of 2.375 inches plus or minus 0.031 inch, the usual tolerance to which such tubing is manufactured. The radius of curvature of the outer wall of said tubing is 2.375/2 or 1.1875 inches, which would be the radius of curvature R (see FIGURE 5) of the arcuate contacting surface provided by the tooth apexes or contacting surfaces of a die fabricated in accordance with the invention and intended to be employed with a tubing or pipe having an outside diameter of 2.375 inches.

As used herein and in the claims, unless otherwise specified, the terms "buttress type teeth" and "buttressed teeth" refers to a tooth (or teeth) which is slanted in the direction of applied torque, is substantially triangular in cross section, but which is asymmetrical with respect to a line which is perpendicular to the base of said tooth and which passes through the apex of said tooth, so that one side of said tooth contains more metal and is therefore reinforced, the reinforcement being on the side away from said applied torque to resist the same. A symmetrical tooth is one which has the same amount of metal on both sides of said line which is perpendicular to the base of said tooth and which passes through the apex thereof.

FIGURE 1 is a plan view of one preferred embodiment of a die fabricated in accordance with the invention.

FIGURE 2 is an end view of the die illustrated in FIGURE 1.

FIGURE 3 is a longitudinal cross section view of the die of FIGURE 1 taken along the apex of row **6** only.

FIGURE 4 is a diagrammatic view, partly in cross section, illustrating a conventional tubing power tong which has been modified to employ the dies of the invention.

FIGURE 5 is an enlargement of the gripping mechanism of the power tongs of FIGURE 4 and illustrates the relationship between the teeth of the die of the invention and the circumference of a pipe or tubing.

FIGURE 6 is a diagrammatic illustration of "penetration cross section" as used in analyzing the action of tong dies.

FIGURE 7 is a plan view of another preferred embodiment of a die fabricated in accordance with the invention.

FIGURE 8 is an end view of the die illustrated in FIGURE 7.

Referring now to said drawings the invention will be more fully explained. In said drawings like reference numerals are employed to designate like elements. FIGURES 1, 2 and 3 illustrate one presently preferred specific embodiment of a die in accordance with the invention and which is particularly adapted to be employed with a nominal 2 inch tubing having an actual outside diameter of about 2.375 inches. Said die comprises a bar-like body **20** having concave working face **21** provided with a plurality of buttressed teeth **22** superimposed thereon. Said teeth have a substantially triangular cross section, and in the particular embodiment illustrated are arranged in 11 parallel rows spaced apart about 9/64 inch. Each of said teeth has an apex or contacting surface **23** (sometimes referred to as tooth length) of about 3/32 inch. Said teeth are spaced apart in said rows a distance of about 1/8 inch at their apexes to provide about 17.5 inches of total lineal contacting surface. Thus, said 11 rows of teeth provide a contacting surface consisting of 187 points of contact. Said contacting surface provided by said teeth apexes or contacting surfaces is an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe and tubing with which said die is intended to be employed, in this specific embodiment a 2 3/8 inches O.D. tubing. In FIGURE 1 the vertical numbers **1** to **11** designate row numbers.

In the specific embodiment illustrated, each of said teeth **22** has an apex angle of about 72 degrees. As employed herein and in the claims, unless otherwise specified, the term "apex angle" refers to the angle included by the apex and the faces of the tooth. The tooth depth is about 0.090 inch and the tooth cross cut depth is about 0.060 inch. It is to be noted that said tooth cross cut depth is less than the tooth depth. This is an important feature of the dies of the invention. The smaller cross cut depth renders the die largely self-cleaning because materials which tend to accumulate between the teeth, both transversely and longitudinally, accumulate in a waffle-like pattern wherein one dimension is less than the other, is consequently less stable, and more apt to not adhere to the die.

In the specific embodiment illustrated the back face **24** of the die is slightly convex and the side faces **26** are tapered. The amount of curvature on said convex back is not critical so long as it is not large enough to cause instability. In the die illustrated said curvature is about equal to the curvature of a circle having a radius of 12 inches. If desired, said back face **24** can be flat. Said tapered sides are tapered at an angle of about 15 degrees. Said tapered sides are advantageous in holding the dies of the invention in the grooves provided in the bushing and jaw of the tongs. Said convex back is provided to enable or provide a slight rocking motion within said grooves when the dies are first brought into contact with the pipe or tubing and thus aid in fitting or placing the die to the tubing or pipe with which it is to be employed. Opening **25** is provided for convenience in "stringing" the dies for temporary storage as when a string or wire is passed through a set of dies to keep them separate from other similar dies. The specific embodiment of the die of the invention illustrated in FIGURES 1, 2 and 3 has an overall length of 3 7/8 inches and a width at the base of 2 inches.

Referring now to FIGURE 4, there is illustrated a conventional power tong which has been modified to accommodate the dies of the invention. Said power tong is of the general type illustrated in U.S. Patent 2,618,467 issued to C. A. Lundeen on November 8, 1952. Said power tong comprises a bushing **27** and a jaw **28** which are part of an inner ring assembly **29** which is actuated by an outer ring assembly **31**. Said bushing **27** is provided with two adjacent tapered grooves **34** and **36** which contain dies A and B fabricated in accordance with the invention. Said dies are held in place in said bushing and said jaw by means of cotter pins **35** at the top and bottom (not shown). The sides of said tapered grooves **34** and **36** are tapered at approximately the same angle as the side faces of said dies A and B but said grooves are slightly wider than said dies A and B so as to provide room for said dies A and B to "rock" on their convex back faces in said grooves when said jaw **28**, containing die J, is brought into contact with a tubing (not shown). Said bushing **27** is stationary in said inner ring assembly **29** while said jaw **28** is hinged at the point **32** so that as said outer ring assembly **31** rotates in the direction indicated by the arrow with respect to said inner ring assembly, the roller **33** will roll along the cam surface of said jaw **28** and cause die J to be moved into contact with a tubing or pipe (not shown). Power tongs of the general type here illustrated are well known to those skilled in the art and no further explanation of their operation is believed necessary. Further details concerning the operation of power tongs of this general type can be found in said Patent 2,618,468.

FIGURE 5 illustrates more clearly the relationship between the dies A, B, and J, fabricated in accordance with the invention, and a tubing which has been placed in the power tongs and jaw **28** closed. It will be noted that the contacting surface provided by the teeth of each of said dies A, B and J covers an area of the tubing equivalent to about 70 degrees of the circumference of said tubing, or a total area of 210 degrees for three of said dies. In the practice of the invention it is preferred that each die cover an area of the tubing which it contacts equivalent to at least about 60 degrees of the circumference of said tubing. This feature of the invention, i.e., the apexes of the teeth of said dies providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said dies are employed, provides an important advantage of the invention.

Referring to said Patent 2,618,468 it will be noted that each of the dies **93**, **94**, and **95** has a maximum contact surface of only about 20 degrees on the surface of the pipe or tubing. Said dies **93**, **94** and **95** in FIGURES 5 and 6 of said Patent 2,618,468 are conventional flat face dies provided with four teeth running the entire length of the die. Due to the flat faces of said standard die and the curvature of the tubing, only one of said teeth and perhaps a trace of a second tooth makes contact with the tubing. Since each die is approximately 3⅞ inches long, this results in a total of only about 17 lineal inches of contact, all concentrated in three or more continuous die marks. This concentration of the die marks is highly undesirable, particularly with the new type tubings, due to the stress patterns developed.

The invention is of course not limited to the die having the specific dimensions or the specific tooth marking patterns discussed above in connection with the drawings. For example, in another embodiment of the invention, illustrated in FIGURES 7 and 8, the die is essentially the same as that discussed above except that said second embodiment die is provided with only 9 rows of teeth having 153 points of contact providing 14.34 lineal inches of contact on each die, or a total of 459 points of contact amounting to a total of 43.03 lineal inches of contact when three dies are employed in combination. The teeth in this embodiment of the invention have an apex angle of about 68 degrees. This last mentioned embodiment of the die of the invention allows for wider spacing (about 11/64 inch) between the rows of teeth which improves the self-cleaning features of the dies of the invention. Said last disclosed embodiment of the invention is thus preferred when working with dirty or scaly tubing.

The improved die of the invention is most advantageously employed in connection with the smaller sizes of high pressure tubing, such as nominal 2, 2½ and 3 inch tubings, having outside diameters of 2.375, 2.875 and 3.5 inches respectively, fabricated from the new alloys discussed above and which are therefore most subject to handling damage. However, said dies can also be employed with great advantage when making up larger sizes of pipe and tubing, e.g., up to and including nominal 7 inch pipe or tubing, and larger.

It is within the scope of the invention to provide dies having a concave working face provided with a plurality of buttressed teeth superimposed thereon and arranged in from 9 to 13 parallel rows which are spaced from about 0.12 to about 0.18 inch apart. In such dies the tooth length, distance between the teeth in each row, and cross cut depth would be essentially the same as for the above discussed embodiments. The apexes of the teeth in said dies would also provide an arcuate contacting surface having a curvature essentially the same as the outer circumference of the tubing or pipe with which they are to be employed.

Stated another way, the improved dies of the invention can be fabricated with the buttress type teeth arranged in from 5 to 9 spaced apart parallel rows per inch of concave working face. Each of said buttress type teeth would have an apex angle within the range of about 45 to 90 degrees, preferably within the range of 65 to 75 degrees. The apex angle of the teeth will vary with the other dimensions, e.g., number of rows of teeth. Each of said teeth would have an apex length or contacting surface **23** within the range of about 1/16 to ¼ inch. Each of said teeth would have a longitudinal depth within the range of 0.01 to 0.1 inch and a cross cut depth within the range of 0.03 to 0.07 inch. Said teeth would be spaced apart in said rows a distance within the range of about 1/16 to about ¼ inch. The apexes of said teeth, as in the previously described embodiments, would provide an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with whcih the die is to be employed.

We have found that the torque transmitting force, or pushing force, of a die tooth is developed over an area which can be defined as the "penetration cross section." This area is the product of the tooth length (apex length or contacting surface length) and the tooth penetration. Said penetration cross section is illustrated diagrammatically in FIGURE 6. Thus, referring to said FIGURE 6, let X_T=the total penetration cross section of a die, then:

X_T=(average tooth penetration)×(number of contacting teeth×length of tooth)

X_T=(average tooth penetration)×(number of contacting rows×inches of contact surface per row).

We have found, in general, that dies having a total penetration cross section within the range of 0.12 to 0.19 square inches and a tooth length within the range of 1/16 to ¼ inch, are satisfactory. Using said penetration cross section as a guide, a great number of tests, both in the laboratory and in the field, were run using both conventional standard product dies available from various die manufacturers and special dies made according to special specifications. These test dies included various tooth styles, patterns, and sizes, such as symmetrical, buttress and circular styles, pyramid, coarse and standard long tooth, flat and curved contacting surfaces, and flat and curved back surfaces. Dies having a flat working face were eliminated early in favor of dies having a concave working face. While it appeared that a buttress type tooth was preferred so as to obtain better initial "bite" and minimum slip, it was found that with all other factors being substantially the same, said buttress type teeth caused more penetration than could be tolerated. However, it was unexpectedly found that when the individual tooth contacting area was increased, the penetration of the buttress type tooth was decreased without sacrificing any appreciable amount of its superior "bite" and minimum slip properties.

The following examples will serve to further illustrate the invention.

EXAMPLE I

A large number of dies having various tooth types and arrangements were tried in the field under actual operating conditions on tubing installed in operating wells. The objective of these tests was to determine the type of die which caused the minimum amount of die damage; and to determine ways and means for holding tooth penetration to a maximum of 10 mils (0.010 inch), preferably 6 mils if possible, when employing up to 6000 ft.-lbs. maximum applied torque.

The candidate dies were installed in a conventional power tong similar to that illustrated in FIGURE 4 herein and that illustrated in said Patent 2,618,468. The bushing and jaw of said power tongs were modified where necessary to accommodate the candidate dies.

From these tests all dies having a straight working face and all dies having tooth types other than (1) buttress type and (2) symmetrical type, were eliminated. The test results given in Table I below on five different dies are representative of the tests on dies having said two types of teeth.

Table I

Die No.	Description of Die	Tubing Type [2]	Applied Torque, ft. lbs.	Penetration Cross Section (X)—square inches				
				Jaw Die, Die J, X_J	Bushing Dies		Die A+Die B, X_A+X_B	Total X_T
					Die A, X_A	Die B, X_B		$X_A+X_B+X_J$
1 [1]	Symmetrical type teeth, 6 rows of teeth, 13 teeth per row, die length 3¾ inches, die width 1⅝ inches, tooth apex length 0.104 inch, total lineal contact 1.35 inch per row.	4340	2,500	0.0371	0.0175	0.0202	0.0377	0.0748
2 [1]	Buttress type teeth, 7 rows of teeth (the same as No. 1 otherwise).	4340	2,500	0.065	0.0364	0.0608	0.0972	0.1622
1 [1]	See above	9 chrome	4,200	0.0371	0.0169	0.052	0.0689	0.106
2 [1]	See above	9 chrome	4,200	0.0586	0.0216	0.0472	0.0688	0.1274
3 [1]	Same as No. 1 except die had 4 rows of teeth and a width of 1 inch.	4340	4,400	0.0364	0.0148	0.0162	0.031	0.0674
4 [1]	Same as No. 2 except die had 4 rows of teeth and a width of 1 inch.	4340	4,400	0.0614	0.0649	0.0628	0.1277	0.1891
5	Symmetrical type teeth, 12 rows of teeth, 30 teeth per row, die length 3¾ inches, die width 1⅝ inches, tooth apex length 0.04 inch, total lineal contact 1.2 inches per row, arcuate contacting surface having a curvature essentially the same as outer circumference of tubing.	4340	2,500	0.0461	0.036	0.024	0.060	0.1061

[1] While number of rows of teeth per die varied, the dies were built with a radius of curvature about 5/64 inch greater than the nominal radius of the outer wall of the tubing. As a result only an average of about 4 rows of teeth per die contacted the tubing for the 1⅝ inches dies and about 3 rows for the 1 inch dies. Penetration cross sections X_J, X_A and X_B were calculated from actual conditions for each die, i.e., the number of rows of teeth contacting the tubing.

[2] All dies tested on nominal 2½ inch tubing of type steel shown.

The data given in the above Table I show that the total penetration cross section (X_T) for dies 1, 3, and 5 having symmetrical type teeth were much less than for dies 2 and 4 having buttress type teeth. These data show that a die having symmetrical type teeth develops less penetration cross section for the same applied torque than does a die having buttress type teeth. Thus, from the standpoint of penetration cross section, a die having symmetrical type teeth would be preferred.

The test data also showed that when considered from the standpoint of penetration alone, the dies having symmetrical type teeth would be preferred to dies having buttress type teeth because of the smaller penetration. These data are given in Table II below. These test data are from the same test runs as the data given in Table I above.

Table II

Die No.	Tooth Type	Average Tooth Penetration—mils		
		Jaw Die, Die J	Bushing Dies	
			Die A	Die B
1	Symmetrical	9.2	6.4	4.3
2	Buttress	13	8.6	12.3
3	Symmetrical	9	5.5	6
4	Buttress	15.2	24	15.5
5	Symmetrical	3.5	3	2.5

The data given in Table I show that the average total penetration cross section produced and used to transmit torque for the two types of dies was:

$$X_T \text{ (Symmetrical)} = 0.0886 \text{ sq. in.}$$
$$X_T \text{ (Buttress)} = 0.1595 \text{ sq. in.}$$

The test data showed a trend toward the following distribution of total penetration cross section, X_T, among the three dies J, A, and B:

Dies having symmetrical type teeth;

$$X_J = X_A + X_B$$
$$X_A = X_B$$

since

$$X_T = X_J + X_A + X_B$$

$$X_J = \frac{X_T}{2} \text{ and } X_A = X_B = \frac{X_T}{4}$$

Thus, the data showed that when employing dies having symmetrical type teeth, the jaw die J does about ½ the work whereas the bushing dies A and B each do about ¼ the work.

Dies having buttress type teeth;

$$X_J = X_A = X_B$$

since

$$X_T = X_J + X_A + X_B$$

$$X_J = X_A = X_B = \frac{X_T}{3}$$

Thus, the data showed that when employing dies having buttress type teeth, all three dies A, B and J do about the same amount of work. From this standpoint the dies having buttress type teeth are preferred.

EXAMPLE II

On the basis of observations during the tests described in the above Example I three dies having symmetrical type teeth and meeting the above determined total penetration cross section requirement of 0.0886 sq. in. for dies having symmetrical type teeth were fabricated. It was desired to reduce the average tooth penetration to 3 mils (0.003 inch) if possible. In order to fit into the power tongs being employed the overall dimensions of each die were set at a length of 3¾ inches and a width of 2 inches. A tooth contact length of 1/32 inch with 3/32 inch space between the teeth in the row was chosen. For a die 3¾ inches in length this will permit 30 teeth per row or a total contact area of 0.936 inches per row of teeth.

Since the total penetration cross section of 0.0886 sq. in. for dies with symmetrical type teeth is to be met, and since the above distribution analysis showed the jaw die J does ½ the work when the dies have symmetrical type teeth, then

$$X_J = \frac{0.0886}{2} = 0.0443 \text{ sq. in.}$$

since tooth penetration is to be held to 3 mils average, then

$$\text{total contact} = \frac{0.0443}{0.003} = 14.8 \text{ lineal inches}$$

$$\text{No. of rows} = \frac{14.8}{\text{inches/row}} = \frac{14.8}{0.936} = 15.7$$

Three dies were fabricated with 16 rows of 30 teeth each with the rows being spaced about 7/64 inch apart. Said teeth were superimposed on a concave working face with the apexes of the teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of a 2.875 inch O.D. tubing.

Said dies were then heat treated to impart a Rockwell C hardness of 61–63 to the teeth surfaces. When tested in a power tong on 2.875 inch O.D. tubings made of 4340 steel and tubings made of 9 chrome steel having Rockwell C hardnesses in the range of 25 to 32, and employing from 2500 to 5000 ft. lbs. of applied torque, the dies slipped and the die teeth acted much in the manner of a cutting tool.

These dies had the proper amount of total contacting surface and met the penetration cross section requirements. However, the individual tooth contacting length (apex length) was not enough to support the penetrated metal and the die slipped.

EXAMPLE III

On the basis of observations during the tests described in the above Example I three dies having buttressed type teeth and meeting the above determined total penetration cross section requirement of 0.1595 sq. in. for dies having buttress type teeth were fabricated. The average tooth penetration was set at 3 mils (0.003 inch), die length at 3⅞ inches, and die width at 2 inches for the same reasons as in Example II. A tooth contact length of 3⁄32 inch with ⅛ inch space between the teeth in the row was chosen. For a die 3⅞ inches in length this will permit 17 teeth per row or a total contact area of 0.1591 inches per row.

Since the total penetration cross section of 0.1595 sq. inch. for buttress type teeth is to be met, and since the above distribution analysis showed that all three dies A, B, and J do about equal work when the dies have buttress type teeth, then

$$\text{Number of contact rows} \times \text{inches/row} = \frac{X_T}{\text{penetration}}$$

$$\text{Total contact (all 3 dies)} = \frac{0.1595}{0.003} = 53.2 \text{ lineal inches}$$

$$\text{Number of contact rows} = \frac{53.2}{1.591} = 33.4$$

$$\text{Number of contact rows per die} = \frac{33.4}{3} = 11.1$$

Three dies were fabricated with 11 rows of 17 teeth each with the rows being spaced about 9⁄64 inch apart. Said teeth were superimposed on a concave working face with the apexes of the teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of a 2.375 inch O. D. tubing.

Said dies were then heat treated to impart a Rock well C. hardness of 60–61 to the teeth surfaces. When tested in a power tong on 2.375 inch O.D. tubings made of 4340 steel and tubings made of 9 chrome steel having Rockwell C hardnesses ranging from 25 to 32, and employing from 2500 to 5000 ft. lbs. of applied torque, the action of the dies was satisfactory in every respect.

The die described immediately above is the die illustrated in FIGURES 1, 2 and 3. In numerous subsequent tests of this die on various types of tubings and employing from 2000 to 3000 ft. lbs. of applied torque on make-up, the tooth penetration has averaged from 2 to 4 mils; when employing from 2000 to 5000 ft. lbs. of applied torque on break-out, the tooth penetration has averaged from 4 to 6 mils. Considering the severity of use, the die life has been entirely acceptable.

Tests on another die fabricated like the die of Example III above except that it contained only 9 rows of teeth have also been successful.

As will be realized by those skilled in the art in view of this disclosure, variations in the outside diameter of the pipe or tubing with which the dies of the invention are employed will affect the performance of said dies. However, due to the general high standard of products

produced by American manufacturers of pipe and tubing, said variations are, in general, very small. For example, the API specifications for such products provide that tubings having an outside diameter of 4" and smaller, tolerance permitted in said outside diameter is plus or minus 0.031 inch. Tubing manufactured by American manufacturers is nearly always well within this tolerance. It will also be realized by those skilled in the art that variations in the hardness, e.g., Rockwell C, of the pipe or tubing will also affect the performance of said dies. It is believed clear that the teeth faces of said dies should have a hardness greater than the hardness of the pipe or tubing with which said dies are to be employed.

The 9 chrome steel referred to herein contains 8 to 9 percent chromium and can contain either about 0.5 or about 1.0 percent molybdenum.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto. Various other modifications will be apparent to those skilled in the art in view of this disclosure. Such modifications are within the spirit and scope of the invention.

We claim:

1. A die for pipe and tubing tongs, said die comprising: a bar-like body having a concave working face provided with a plurality of buttressed teeth thereon; said teeth having a substantially triangular cross section and being arranged in from 5 to 9 spaced apart parallel rows per inch of said concave working face; each of said teeth having an apex length within the range of from 1⁄16 to ¼ inch; said teeth being spaced apart in said rows a distance within the range of from 1⁄16 to ¼ inch; and said apexes of said teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said die is to be employed.

2. A die for pipe and tubing tongs, said die comprising: a bar-like body having a concave working face provided with a plurality of buttressed teeth thereon; said teeth being arranged in from 5 to 9 spaced apart parallel rows per inch of said concave working face; each of said teeth having an apex angle within the range of 45 to 90 degrees, an apex length within the range of 1⁄16 to ¼ inch, a longitudinal depth within the range of 0.01 to 0.1 inch, and a cross cut depth within the range of 0.03 to 0.07 inch, with one of said dimensions for said longitudinal depth and said cross-cut depth being less than the other said demension; said teeth being spaced apart in said rows a distance within the range of 1⁄16 to ¼ inch; and said apexes of said teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said die is to be employed.

3. A die according to claim 2 wherein said apex angle is within the range of 65 to 75 degrees.

4. A die according to claim 2 wherein said body is provided with a slightly convex back face, and with tapered side faces.

5. A die for pipe and tubing tongs, said die comprising: a bar-like body having a concave working face provided with a plurality of buttressed teeth thereon; said teeth being arranged in from 8 to 12 parallel rows spaced from 0.12 to 0.18 inch apart; each tooth having an apex length within the range of from 1⁄16 to ¼ inch; said teeth being spaced apart in said rows a distance within the range of from 1⁄16 to ¼ inch to provide from 12 to 20 inches total lineal contacting surface and said apexes of said teeth providing an arcuate contacting surface having a curvature essentially the same as the outer circumference of the pipe or tubing with which said die is to be employed.

6. A die according to claim 5 wherein: said teeth are arranged in 11 parallel rows spaced about 9⁄64 inches apart; each tooth has an apex length of about 3⁄32 inch; said teeth are spaced apart in said rows a distance of about ⅛ inch to provide about 17.5 inches total lineal contacting surface; and said apexes of said teeth provide

an arcuate contacting surface having a curvature essentially the same as the outer circumference of a 2⅜ inch O.D. tubing.

7. A die according to claim 6 wherein each of said teeth has an apex angle within the range of from 65 to 75 degrees, and the number of teeth in each of said rows is 17.

8. A die according to claim 5 wherein: said teeth are arranged in 9 parallel rows spaced about $\frac{11}{64}$ inch apart; each tooth has an apex length of about $\frac{3}{32}$ inch; said teeth are spaced apart in said rows a distance of about ⅛ inch to provide about 14.35 inches total lineal contacting surface; and said apexes of said teeth provide an arcuate contacting surface having a curvature essentially the same as the outer circumference of a 2⅜ inch O.D. tubing.

9. A die according to claim 8 wherein each of said teeth has an apex angle within the range of from 65 to 75 degrees, and the number of teeth in each of said rows is 17.

10. A die according to claim 5 wherein said teeth are arranged in from 9 to 11 parallel rows spaced from about $\frac{9}{64}$ to about $\frac{11}{64}$ inches apart; each tooth has an apex length of about $\frac{3}{32}$ inch; and said teeth are spaced apart in said rows a distance of about ⅛ inch to provide from about 14.35 to about 17.5 inches total lineal contacting surface.

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