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Baues et al.

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[54] **ORTHODONTIC ARCH WIRE**

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[21] Appl. No.: **95,699**

[52] **U.S. Cl.** .... **32/14 A**
[51] **Int. Cl.** **A61c 7/00**
[58] **Field of Search** .... 140/149, 111; 32/14 A, 14 B, 14 D

[56] **References Cited**

UNITED STATES PATENTS

3,444,621 5/1969 Pletcher .... 32/14 A

Primary Examiner—Robert Peshock
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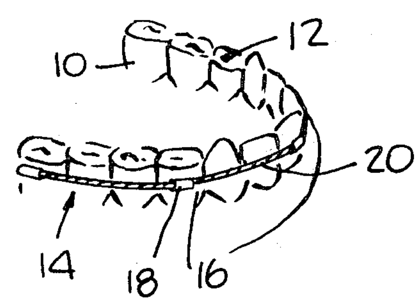
[57] **ABSTRACT**

Orthodontic arch wire comprising three segments of wire twisted together to form a single stranded arch wire with turns which have an angle with the longitudinal axis of the wire of sufficient magnitude but less than 90° and which have a sufficient number of turns per inch of length of wire such that the wire has the characteristics that it does not fray when cut and the segments do not separate when bent at an angle of at least 90° and when the ends thereof are flicked repeatedly. The twisted wire is preferably subjected to precipitation hardening at a temperature of from about 950° to about 975° Fahrenheit to increase its tensile strength. Apparatus for twisting the wire comprises a rotatable chuck and a fixed chuck mounted on a slidable shaft, each chuck having a pair of posts for forming a continuous length of wire into three spaced substantially equal and parallel segments. Affixed to the end of the slidable shaft is a weight for maintaining the parallel segments of wire under substantially constant tension. A set screw engageable with a V slot in the shaft prevents rotation of the shaft during twisting of the wire but permits rotation thereof after completion of twisting to relieve torsional stresses in the wire built up during the twisting operation. A method of forming the arch wire is also disclosed.

14 Claims, 8 Drawing Figures



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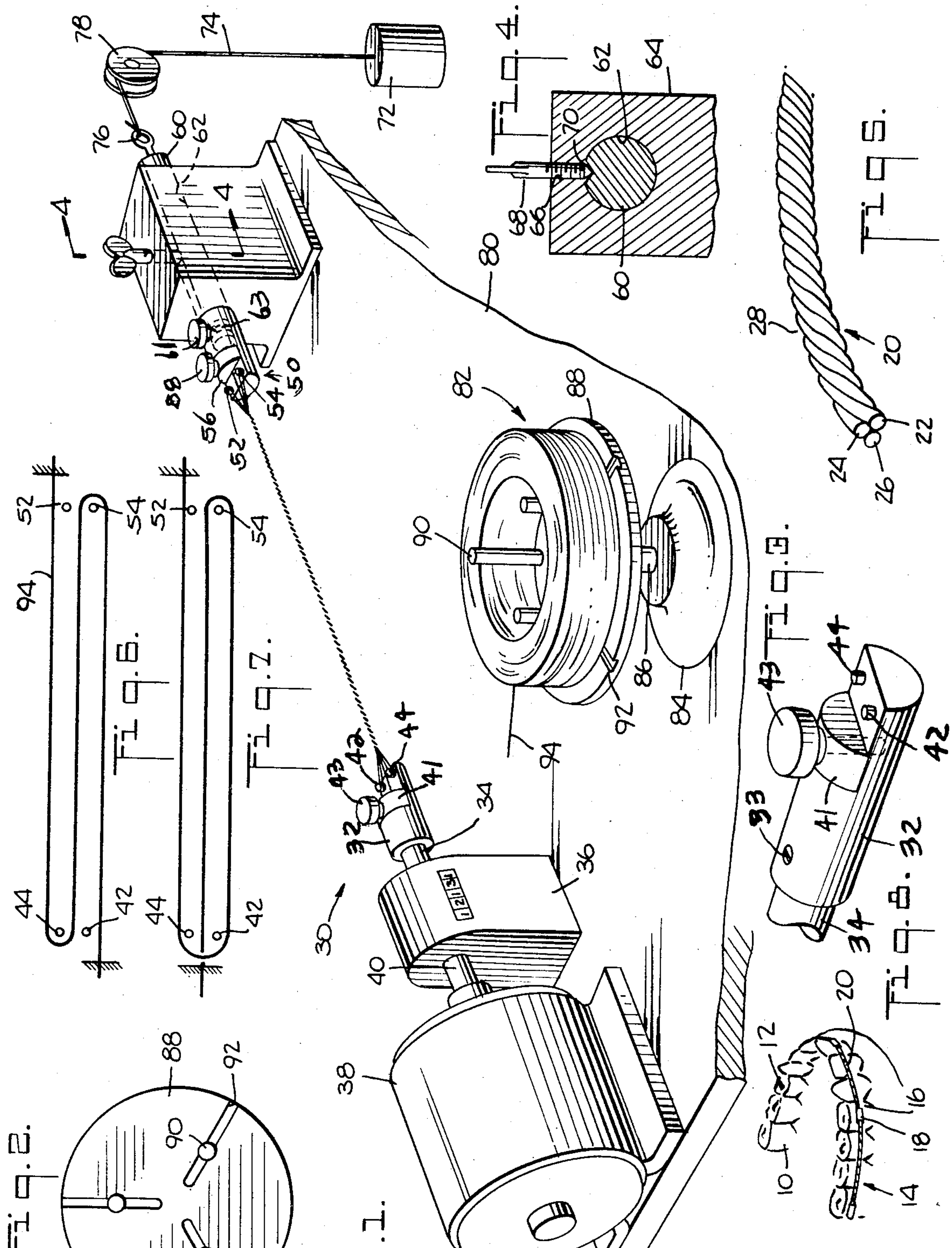

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ORTHODONTIC ARCH WIRE

FIELD OF THE INVENTION

This invention relates to the field of orthodontic appliances and more particularly to new and improved orthodontic arch wire and to new and improved method and apparatus for making same.

BACKGROUND OF THE INVENTION

Orthodontic appliances are known for straightening maloccluded teeth and for establishing the normal dental arch of the teeth. It has been proposed to use orthodontic arch wire comprising strands of twisted wire. Thus, U.S. Pat. No. 3,052,981 discloses an orthodontic arch wire comprised of three individual pieces of wire twisted in the form of a helix of zero diameter having turns whose planes are perpendicular to the axis of the wire. It has been found that this wire is extremely difficult to manufacture since the strands have a tendency to break during the twisting operation before the desired configuration of the turns is achieved. U.S. Pat. No. 3,444,621 also discloses an arch wire comprised of three individual pieces of twisted wire which are twisted only enough to keep the wire from unraveling when tension is removed from the wire. It has been found that this wire is susceptible to fraying when cut and separating when flicked or bent at right angles. In addition, in order to prevent the individual strands from separating, it has been found necessary to solder the ends of this wire.

OBJECTS OF THE INVENTION

It is thus an object of the present invention to provide new and improved arch wire for orthodontic appliances which is effective in straightening maloccluded teeth and establishing the normal dental arch thereof.

It is another object of the present invention to provide new and improved orthodontic arch wire which has good spring temper and which is easy to handle, which does not fray when cut and the strands of which do not separate when bent or repeatedly flicked.

It is yet another object of the present invention to provide new and improved method and apparatus for making orthodontic arch wire in a safe, efficient and economic manner.

SUMMARY OF THE INVENTION

These and other objects and advantages are achieved according to the present invention wherein new and improved arch wire is provided which is effective in straightening maloccluded teeth and establishing the normal dental arch thereof. Said arch wire has good spring temper, is easy to handle, does not fray when cut and the strands of which do not separate when bent or repeatedly flicked. According to the apparatus and method of the present invention, orthodontic arch wire is produced in a safe efficient and economic manner.

In general, the orthodontic arch wire of the present invention comprises three segments twisted together to form a signal stranded arch wire with turns which have an angle with the longitudinal axis of the wire of sufficient magnitude preferably in the range of about at least 16½° but less than 90° and which have a sufficient number of turns per inch of length of wire generally at least about 28 turns per inch such that the wire has the

characteristics that it does not fray when cut and the segments do not separate when bent at an angle of at least 90° and when the ends thereof are flicked repeatedly.

According to an aspect of the method of the present invention, after a continuous length of wire has been formed into three spaced substantially parallel segments and twisted to obtain the desired turn angle and turns per inch, the tensile strength of the twisted wire is subjected to precipitation hardening at a temperature of from about 950° to about 975° Fahrenheit.

One embodiment of the apparatus of the present invention comprises means for holding three segments of a continuous length of wire in spaced, parallel relationship, weight means for tensioning of the wire segments during twisting thereof and means for twisting the wire segments into a single orthodontic arch wire. According to one aspect of the apparatus of this invention means are provided for relieving the torsional stresses in the twisted wire after it has been twisted. According to another aspect of such apparatus, said twisting means comprises a rotatable chuck and a stationary chuck movably mounted to and away from said rotatable chuck and said holding means comprises a pair of posts mounted on each of said chuck about which said length of wire is wound in three spaced, substantially parallel segments.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of preferred apparatus according to the present invention for twisting orthodontic arch wire;

FIG. 2 is a plan view of the rotatable stand of FIG. 1 for holding a coil of wire;

FIG. 3 is a partial perspective view of one of the chucks of FIG. 1;

FIG. 4 is a sectional elevational taken along line 4—4 of FIG. 1;

FIG. 5 is a partial perspective view of a preferred embodiment of the orthodontic arch wire of the present invention;

FIGS. 6 and 7 are diagrammatic views of preferred configurations of a continuous length of wire formed into three parallel segments prior to being twisted into the arch wire of the present invention; and

FIG. 8 is a perspective view illustrating the application of the orthodontic arch wire of FIG. 5 to the correction of a set of lower teeth.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the Figures there is shown a preferred embodiment of the orthodontic arch wire of the present invention and preferred apparatus for making same. According to the present invention new and improved orthodontic arch wire is provided for use in dental appliances for straightening maloccluded teeth and establishing the proper dental arch therefor. FIG. 8 shows a lower set of teeth 10 having individual teeth 12 to which a dental appliance 14 has been attached for orthodontic purposes. Appliance 14 comprises teeth bands 16 having lugs 18 to which is attached orthodontic arch wire 20. The function of arch wire 20 is to urge maloccluded teeth through bands 16 into their normal position and to establish alignment of the teeth into a proper dental arch. Thus, arch wire **20** must possess sufficient flexibility and tensile strength to accomplish these functions and in addition must be easy to handle by the orthodontist fitting the arch wire to the patient's teeth.

According to the present invention, a continuous length of wire is formed into three spaced, substantially equal and parallel segments (FIGS. **6** and **7**), the segments being twisted together to form a single stranded arch wire with turns which have an angle with the longitudinal axis of the wire of sufficient magnitude and which have a sufficient number of turns per inch of wire such that the wire has the characteristics that it does not fray when cut and the segments do not separate when bent at an angle of at least 90° and when the ends thereof are flicked repeatedly but which have an angle which is substantially less than 90° with the longitudinal axis of the wire. As shown in FIG. **5**, arch wire **20** comprises segments **22**, **24** and **26** twisted together to form turns **28**. The turn angle and turns per inch of wire **20** will depend upon the desired overall diameter of arch wire **20** and the diameter of wire segments **22**, **24** and **26** used to form arch wire **20**. In order to be usable with standard orthodontic appliances, arch wire **20** preferably has an overall diameter of from about 0.0145 inches to about 0.0215 inches and is made from wire segments having a diameter of from about 0.006 inches to about 0.010 inches.

In general, the diameter of wire segments **22**, **24**, **26** and the overall diameter of arch wire **20** will determine to some extent the angle of turn with the longitudinal axis and the number of turns per inch of length of the orthodontic arch wire of the present invention. Table I gives examples of arch wire **20** considered to be within the scope of the present invention.

TABLE I

Ex.	Wire Seg. Dia. (in.)	Overall Dia. (in.)	Angle of Turns with Long. Axis (deg.)	Turns/in.
A	0.007	0.0149	20	33
B	0.007	0.0149 20		33
B	0.0007	0.0149	29½	42
C	0.008	0.0170	16½	28
D	0.008	0.0169	17½	32
E	0.008	0.0170	21½	36
F	0.008	0.169	29	44
G	0.009	0.0195	19½	28
H	0.009	0.0193	21	32
I	0.009	0.0195	26	36
J	0.009	0.0195	29	45
K	0.010	0.0215	24	28
L	0.010	0.0215	27	37
M	0.010	0.0215	32	46½

Arch wire **20** may be made from any material well known to those skilled in orthodontia, such material for example being stainless steel or the like.

Referring now to FIGS. **1–4** there is shown preferred apparatus for making orthodontic arch wire according to the present invention. As shown, apparatus **30** comprises rotatable chuck **32** mounted on shaft **34** as by means of locking screw **33** (FIG. **3**) of revolution counter **36**. Counter **36** is driven by motor **38** by means of shaft **40**. Chuck **32** is provided with a separable member **41** secured thereto by clamp screw **43**. Chuck **32** is split in half at its free end and is provided with posts **42** and **44** the purpose of which will be described in greater detail hereinafter.

Stationary chuck **50** is also split at its free end and is provided with separable member **56** secured thereto by clamp screw **58** and is also provided with posts **52** and **54**. Chuck **50** is secured to the end of a shaft **60** by clamp screw **61** projecting into groove **63** on the end of shaft **60**. Shaft **60** is slidably mounted in bore **62** of block **64**. Block **64** is provided with threaded bore **66** (FIG. **4**) communicating at right angles with bore **62** and set screw **68** threaded in bore **66**. Screw **68** is adapted to project into a V shaped channel **70** in shaft **60**. The purpose of set screw **68** and channel **70** will be more fully explained hereinafter.

In order to tension the wire during the twisting operation **30**, shaft **60** is biased away from chuck **32** by means of weight **72** secured to shaft **60** by means of rope **74** secured to shaft **60** by means of eye bolt **76**. Rope **74** passes over frictionless pulley **78** mounted on base member **80** by suitable brackets (not shown). Motor **38**, counter **36** and block **64** are also mounted on base member **80**.

A rotatable wire feed stand **82** is also mounted on base member **80** and comprises base **84**, vertical pivot **86** mounted on base **84**, turntable **88** rotatably mounted on pivot **86**, and posts **90** mounted for sliding movement in slots **92** of turntable **88**. A coil of wire **94** is supported on turntable **88**, disposed about posts **86** which are adjusted to press against the inner loops of the coil. Post **86** may be adjusted to accommodate coils of wires of different diameters.

In operation, set screw **68** is tightly clamped to shaft **60** to permit the securing of a length of wire **94** between chucks **32** and **50** without the biasing influence of weight **72** on the wire during this operation. A length of wire **94** is unwound from stand **82**, such unwinding being facilitated by the rotation of turntable **88**, and the end thereof is inserted between member **56** and chuck **50** and is securely clamped by screw **58**. Wire **94** is then formed into three spaced, substantially equal and parallel segments by passing it around posts **52** and **54** and posts **44** and **42** respectively of chucks **50** and **32** and severing the desired length thereof from the coil and clamping the severed end between member **41** and chuck **32** by means of screw **43**.

FIGS. **6** and **7** diagrammatically illustrate two preferred configurations for forming wire **94** about posts **52**, **54** and **44**, **42**. FIG. **6** shows wire **94** being looped about the posts in the configuration of the letter S and FIG. **7** shows wire **94** being looped about the posts in the configuration of a distorted numeral "6". In either case, posts **52**, **54** and **44**, **42** support the three segments of wire **94** is spaced, substantially parallel relationship, the three segments being substantially equal in length. It has been found that wire formed in this manner prior to the twisting operation, will be substantially free of kinking during twisting thus greatly increasing the efficiency of the operation.

After wire **94** has been securely clamped in chucks **32** and **50**, set screw **68** is backed off sufficiently to permit shaft **60** to slide in bore **62** while preventing rotation thereof. Weight **72** now acts on shaft **60** to bias it away from chuck **32** thus subjecting the segments of wire **94** to the desired tension. The value of weight **72** and consequently the amount of tension applied to wire **94** will vary according to the physical characteristics and diameter of wire **94** and the length of span between chucks **32** and **50**. Thus, in general, the longer the span of wire to be twisted and the thicker in diameter such wire is, the greater the weight **72** that must be used to apply the desired tension during the twisting operation.

It has been found, that by maintaining a constant bias on shaft **60** and thereby a constant tension on wire **94** during the twisting operation, wire breakage is greatly minimized and the incidence of wire kinkage is also substantially reduced.

Rotation of chuck **32** is now initiated to twist wire **94**, by starting motor **38** which is connected to chuck **32** by means of shaft **40**, counter **36** and shaft **34**. As the wire is twisted, the length thereof will be reduced and shaft **60** will slide in block **64**. The number of revolutions that wire **94** is twisted is indicated by counter **36** and will depend to a great extent on the characteristics and length of the wire being twisted. In general, the wire must be twisted a sufficient number of revolutions so that there is formed a single stranded arch wire with turns which have an angle with the longitudinal axis of the wire of sufficient magnitude and which have a sufficient number of turns per inch of length of wire such that the wire has the characteristics that it does not fray when cut and the segments do not separate when bent at an angle of at least 90° and when the ends thereof are flicked repeatedly but which have an angle which is substantially less than 90° with the longitudinal axis of the wire.

Following Tables II – V illustrate a number of samples of twisted wire formed on apparatus **30**, as described hereinabove, from continuous lengths of wire having diameters of 0.007 inches, 0.008 inches, 0.009 inches and 0.010 inches. Each sample was twisted according to the conditions indicated and then cut with a conventional wire cutter and the cut ends bent at an angle of at least 90° with the aid of a conventional pair of pliers and subjected to repeated flicking with a finger. A standard optical comparator (such as made by Scherr-Tumico, Inc. of St. James, Minn.) was used to facilitate measurement of the turns per inch and turn angle of the twisted wire. As is known optical comparators enlarge the image of an object and project the enlarged image on a screen.

In following Table II each of the samples was formed from wire segments of 0.007 inches diameter having an initial length of 40 ¾ inches. A tensioning weight of 2.2 lbs. was applied.

TABLE II

No. of Revolutions	Overall dia. (in.)	Turns/ Inch	Angle Of Turn (deg.)	Remarks
50	Sample unwound before test			
100	0.0138	1½	3½°	Frayed before snapping Unraveled at 90° Turn.
200	0.0144	11¼	5°	Frayed on 3rd snap Unraveled on 90° Turn.
300	0.0148	18	9½°	Did not separate when cut. Separated on 4th snap. Unraveled on 120° Turn.
400	0.0149	26½	14°	Does not fray on repeated snaps. Unraveled on 120° Turn.
450	0.0149	30	17°	Does not Fray upon multiple snapping. Unraveled on 270° Turn.
500	0.0149	33	20°	Does not Fray upon multiple snapping. No unraveling on 180° Turn.
600	0.0149	42	29½°	Does not Fray upon multiple snaps. No unraveling on 360° Turn.

In following Table III each of the samples was formed from wire segments of 0.008 inches diameter having an initial length of 40 ¾ inches. A tensioning weight of 5.75 lbs. was applied.

TABLE III

No. of Revolutions	Overall Dia. (in.)	Turns/ Inch	Angle of Turn (deg.)	Remarks
50	Sample unwound before test			
100	0.0157	2	1½°	Falls apart on cutting
200	0.0168	12	6½°	Frayed on 3rd snap. Unraveled on 90° Turn.
300	0.0169	19 ½	11°	No Fraying on multiple Snaps. Unraveled on 90° Turn.
400	0.0170	28	16 ½°	No Fraying on multiple snaps. Did not unravel on 90° Turn.
450	0.0169	32	17 ½°	No Fraying on multiple snaps. Did not unravel on 90° Turn.
500	0.0170	36	21 ½°	No Fraying on multiple snaps. Did not unravel on 90° Turn.
600	0.0169	44	29°	No Fraying on multiple snaps. No unraveling on 90° Bend.

In following Table IV each of the samples was formed from wire segments of 0.009 inches diameter having an initial length of 40 ¾ inches. A tensioning weight of 5.4 lbs. was applied.

TABLE IV

No. of Revolutions	Overall Dia. (in.)	Turns/ Inch	Angle of Turn (deg.)	Remarks
50	Sample unwound before test			
100	0.0182	4 ½	4°	Frayed on 1 st snap. Unraveled on 90° Bend.
200	0.0194	12 ½	8°	Frayed on 8th snap. Unraveled on 90° Bend.
300	0.0194	20	13°	Frayed on 10th snap. Slightly Unraveled on 90° Bend.
400	0.0195	28	19 ½°	No Fraying on multiple snaps. No unraveling on 90° Bend.
450	0.0193	32	21°	No Fraying on multiple snaps. No unraveling on 90° Bend.
500	0.0195	36	26°	No Fraying on multiple snaps. No

				unraveling on 90° Bend.
600	0.0195	45	29°	No Fraying on multiple snaps. No unraveling on 90° Bend.

In following Table V each of the samples was formed from wire segments of 0.010 inches diameter having an initial length of 40 ¾ inches. A tensioning weight of 6.75 lbs. was applied.

TABLE V

No. of Revolutions	Overall Dia. (in.)	Turns/ Inch	Angle of Turn (deg.)	Remarks
50	Sample unwound before test			
100	0.0201	4 ½	4°	Frayed on 1st snap. Unraveled on 90° Turn.
200	0.0214	12	8 ½°	Frayed on 2nd snap. Unraveled on 90° Turn.
300	0.0215	20	15°	Frayed on 3rd snap. Unraveled on 90° Turn.
400	0.0215	28	24°	No Fraying on multiple snaps. No unraveling on 90° Turn.
500	0.0215	37	27°	No Fraying on multiple snaps. No unraveling on 90° Turn.
600	0.0216	46 ½	32°	No Fraying on multiple snaps. No unraveling on 90° Turn.

After the segments of wire **94** have been twisted the desired number of revolutions to form the orthodontic arch wire according to the present invention, the torsional stresses built up therein during the twisting operation may be relieved by moving shaft **60** toward chuck **32** thus relieving the tension on wire **94** and by backing screw **61** out of channel **63** to permit rotation of chuck **50**. Thereafter, the twisted arch wire may be cut at both ends without fear of unsafe whiplash or wire kinkage and the unwanted end pieces removed from chucks **32** and **50**.

The tensile strength of the orthodontic arch wire is preferably increased by precipitation hardening. Where the arch wire is comprised of stainless steel, the arch wire is placed in a vessel filled with an inert gas such as argon and heated for a period of about an hour at a temperature of from about 950° to 975° Fahrenheit. The wire is then allowed to cool to ambient temperature. It has been found that arch wire treated in this manner has increased tensile strength over untreated wire.

Additional examples of arch wire **20** within the scope of the present invention are as follows:

Example N		
Overall diameter	0.0215	inches
Angle of turn with long. axis	41	degrees
Number of turns per inch	46	
Example O		
Overall diameter	0.0195	inches
Angle of turn with long. axis	30	degrees
Number of turns per inch	45	

Although specific examples of the present invention have been given hereinabove, it will be understood that such examples are illustrative only and are not to be taken as limiting the scope of the present invention.

What is claimed is:

1. Orthodontic arch wire comprising three segments of wire twisted together, said twisted arch wire having turns which have an angle with the longitudinal axis of the wire of sufficient magnitude but less than 90° and which have at least 28 turns per inch of length of wire such that said wire has the characteristics that it does not fray when cut and the segments do not separate when bent at an angle of at least 90° and when the ends thereof are flicked repeatedly.

2. The orthodontic arch wire of claim **1** wherein said wire segments have a diameter of from about 0.007 inches to about 0.010 inches.

3. The orthodontic arch wire of claim **2** wherein said turns of said twisted arch wire have an angle of at least about 16 ½° with the longitudinal axis of sad wire but of substantially less than 90° with said axis.

4. The orthodontic arch wire of claim **2** wherein said turns of said twisted arch wire have an angle of from about 16 ½° to about 41° with the longitudinal axis of said wire.

5. The orthodontic arch wire of claim **2** wherein said twisted arch wire has from about 28 to about 46 ½ turns per inch of length of said wire.

6. The orthodontic arch wire of claim **2** wherein said turns of said twisted arch wire have an angle of from about 16 ½° to about 41° with the longitudinal axis of said wire and said wire has from about 28 to about 46 ½ turns per inch of length of said wire.

7. The orthodontic arch wire of claim **1** wherein said turns of said twisted arch wire have an angle of at least about 16 ½° with the longitudinal axis of said wire but of substantially less than 90° with said axis.

8. The orthodontic arch wire of claim **1** wherein said turns of said twisted arch wire have an angle of from about 16 ½° to about 41° with the longitudinal axis of said wire.

9. The orthodontic arch wire of claim **1** wherein said twisted arch wire has from about 28 to about 46 ½ turns per inch of length of said wire.

10. The orthodontic arch wire of claim **1** wherein said turns of said twisted arch wire have an angle of from about 16 ½° to about 41° with the longitudinal axis of said wire and said wire has from about 28 to about 46 ½ turns per inch of length of said wire.

11. The orthodontic arch wire of claim **1** wherein said wire segments have a diameter of about 0.007 inches, wherein said turns of said twisted arch wire have an angle of from about 20° to about 29 ½° with the longitudinal axis of said wire and wherein said wire has from about 33 to about 42 turns per inch of length thereof.

12. The orthodontic arch wire of claim **1** wherein said wire segments have a diameter of about 0.008 inches, wherein said turns of said twisted arch wire have an angle of from about 16 ½° to about 29° with the longitudinal axis of said wire and wherein said wire has from about 28 to about 44 turns per inch of length thereof.

13. The orthodontic arch wire of claim **1** wherein said wire segments have a diameter of about 0.009 inches, wherein said turns of said twisted arch wire have an angle of from about 19 ½° to about 29° with the longitudinal axis of said wire and wherein said wire has from about 28 to about 45 turns per inch of length thereof.

14. The orthodontic arch wire of claim 1 wherein said wire segments have a diameter of about 0.010 inches, wherein said turns of said twisted arch wire have an angle of from about 24° to about 32° with the longitudinal axis of said wire and wherein said wire has from about 28 to about 46 ½ turns per inch of length thereof.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,729,824 Dated May 1. 1973

Inventor(s) Dietrich Baues; Richard Marini & Donald McCauley

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, Table I, Example B has been printed twice and should read as follows:

--B 0.007 0.0149 29 1/2 42--

Column 3, Table I, Example F, "0.169" should be --0.0169--

Column 4, line 53, place quotation marks around letter S.

Column 8, claim 3, line 20, correct spelling of "said".

Signed and sealed this 29th day of January 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents