Aug. 27, 1963

H. SCHOCH ETAL

METHOD FOR THE MECHANICAL TWISTING OF COLD-FORMED PROFILE STEELS

3,102,060

Filed Dec. 14, 1959

3 Sheets-Sheet 1

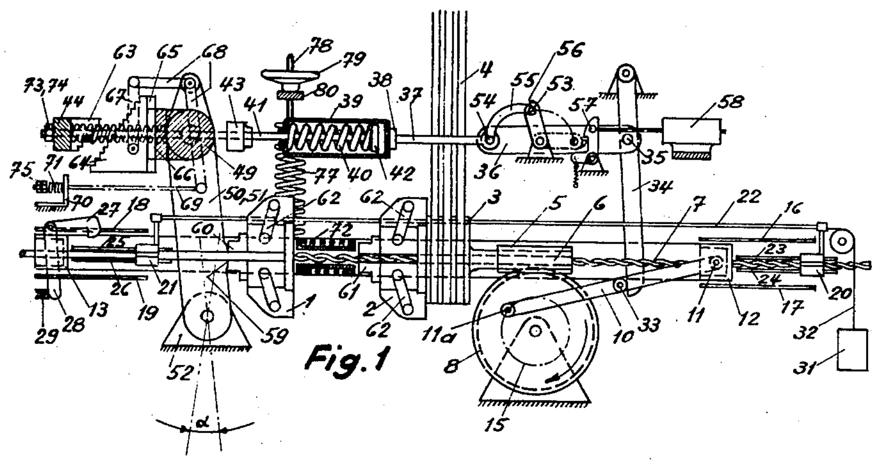


Fig. 1

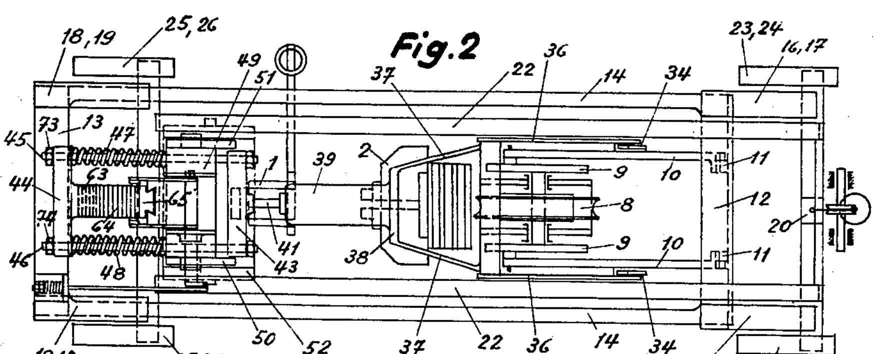


Fig. 2

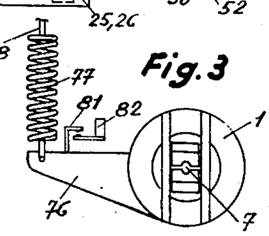


Fig. 3

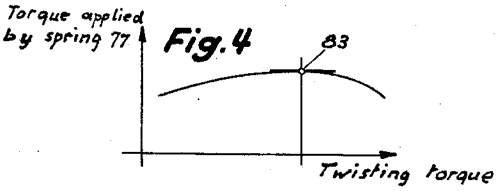


Fig. 4

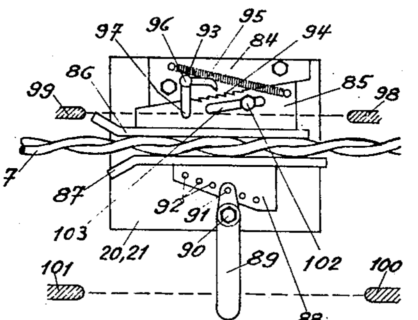


Fig. 5

Aug. 27, 1963 H. SCHOCH ETAL 3,102,060

METHOD FOR THE MECHANICAL TWISTING OF COLD-FORMED PROFILE STEELS

Filed Dec. 14, 1959 3 Sheets-Sheet 2

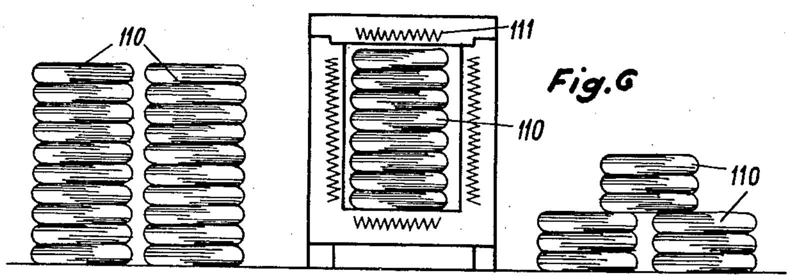


Fig.6

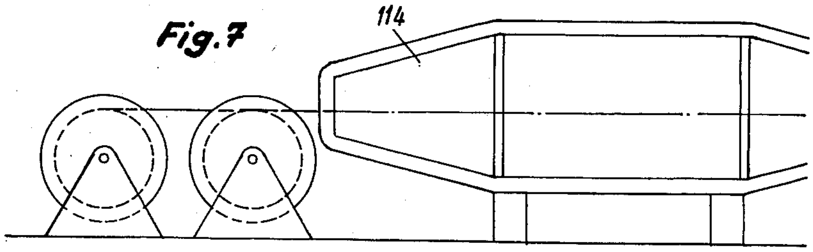


Fig.7

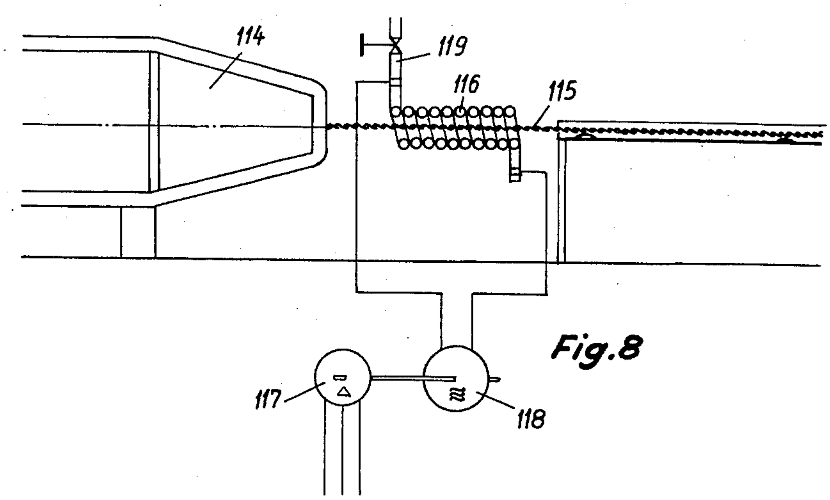
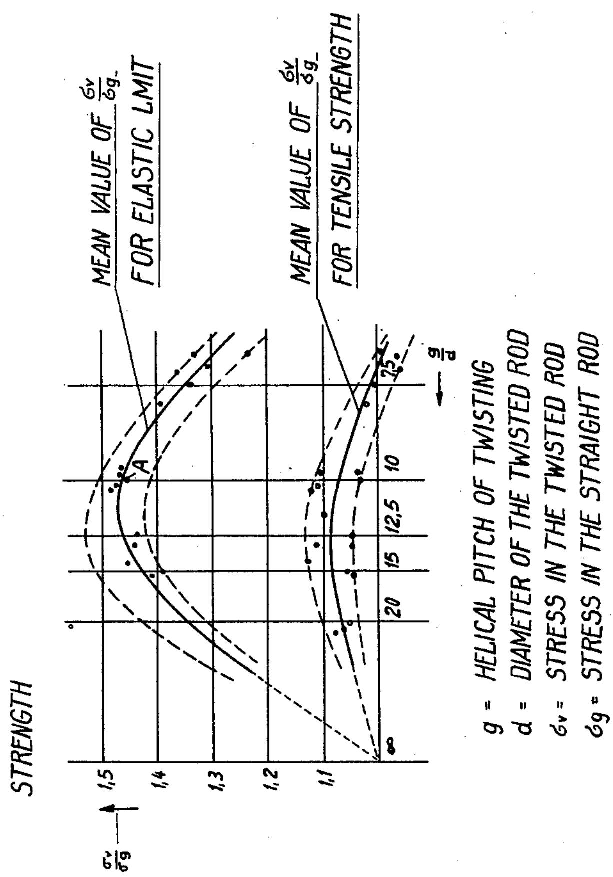


Fig.8

Fig. 9


STRENGTH
MEAN VALUE OF $\frac{\sigma v}{\sigma g}$
FOR ELASTIC LMIT
MEAN VALUE OF $\frac{\sigma v}{\sigma g}$
FOR TENSILE STRENGTH
A
1,5
1,4
1,3
1,2
1,1
25
10
12,5
15
20
∞
$\frac{g}{d}$
$\frac{\sigma v}{\sigma g}$
g = HELICAL PITCH OF TWISTING
d = DIAMETER OF THE TWISTED ROD
σv = STRESS IN THE TWISTED ROD
σg = STRESS IN THE STRAIGHT ROD

United States Patent Office

3,102,060

Patented Aug. 27, 1963

1

3,102,060

METHOD FOR THE MECHANICAL TWISTING OF COLD-FORMED PROFILE STEELS

Hans Schoch, Zurich, and Eugen Wyss, Adliswil, near Zurich, Switzerland, assignors to Ernst Schoch Actiengesellschaft, Basel, Switzerland

Filed Dec. 14, 1959, Ser. No. 859,530
Claims priority, application Austria Dec. 15, 1958
6 Claims. (Cl. 148—12)

The present invention relates to a method for mechanically twisting cold-formed profile steels, particularly reinforcement wires of less than 5 millimetres diameter for concrete, in which the twisting is effected continuously or in sections between champing members, which are axially slidable or at a fixed distance from one another, preferably at a high rate of deforming, as well as to a machine for carrying out this method.

Such methods and machines suitable for carrying them out have already become known. They are based on the following facts:

The tensile strength of concrete amounts to about 1/10 of the compressive strength thereof. The transmission of outer forces applied to the concrete is possible only over the contact surface. In order to increase the transmission of forces one has endeavoured to increase the capacity of adhesion by profiles deviating from the round profile and by means of knots. However, since the cross section area of a rod increases by the square, while the surface increases linearly, the exploitation of the steel in reinforced concrete is limited to this profile.

The highest tensile stresses occur in prestressed concrete, the reinforcements of which compress the concrete zone under the permissible loading and thereby reduce the width of cracks, if any. Since with all steels the modulus of elasticity remains constant, higher strains result in higher stresses, and accordingly in otherwise equal conditions larger widths of cracks occur in the concrete with slack reinforcements without prestressing. At the present state of prestressing technique the economy is limited to special structures of abnormal width of span (bridges etc.). For by far the greatest part of applications of reinforced concrete slack reinforcements are used, the thinnest reinforcement carrying the theoretically highest permissible loads and being able to be executed at present only with high carbon steels or alloy steels. The less expensive sorts of iron lean in carbon are out of the question with the permissible steel stresses, which are at present still limited.

With an increasing cross section area of the steel its capacity of adhesion drops under otherwise equal conditions. Even with cross section areas of 3.14 square centimetres the tensile strength and elastic limit of high grade steels can no longer be exploited.

A measure for the possibility of exploiting the steel is given by the theory of the compound characteristic, which is based on the ratio of the cross section area to the circumference of the steel, and permits big and large the following allowable stresses, provided one succeeded in developing for the thin cross sections inexpensive steel sorts lean in carbon content, having sufficient tensile strength, and for the thicker sorts in developing steels having sufficient capacity of adhesion.

2

Compound characteristics for normal and high grade concrete qualities, wherein:

Fe=cross section area of steel in square centimetres
U=circumference of steel in centimetres.

Fe/U, cm.	U/Fe, cm.$^{-1}$	Roundprofile, mm. diameter
above 0.5	below 2	above 20
0.2 to 0.35	5 to 2.86	8 to 14
0.075 to 0.2	13.3 to 5	3 to 8

are:

Permissible stress kg./cm.^{2}	Tensile strength of steel to be guaranteed, kg./cm.^{2}
1,700	3,030
2,500	4,500
4,000	7,200

The tensile strength of ordinary iron can not be exploited since owing to insufficient surface area the capacity for adhesion no longer suffices for transmitting the force to be taken by the concrete. Wastage of iron is unavoidable, since, even with 1700 kg./cm.^{2}, widths of gaps are to be expected which by far exceed the permissible limit of 1/4 millimetre.

With stabilised Martin steels as well as with the cheaper twisted steels brittleness failures have become known. The twisting of harder steels having initial strengths of 6000 kg./cm.^{2} has been unsatisfactory so far. Owing to the great tolerances and differences in hardness as unavoidable with unstabilised cheaper steels great differences in helical pitch resulted when twisting. Now the unexploited heavier cross sections on the one hand and the qualitative additions required by the steel works for descaled bar material or alloy additions on the other hand have the effect that by far the most unhomogeneous sorts of iron are allotted to reinforcements for concrete, and that examination of the cross section areas, which are statically loaded, becomes compulsory. For this purpose testing by torsion covering all bars is suitable. Even with the low rate of deforming as usual at present "pipes" become apparent. Elimination of material liable to brittleness failure becomes however possible only at a high rate of deformation.

Practice has taught that twisting at a high rate of deforming gives already valuable information about liability to brittleness failure of cold-twisted steels. For example the critical cross section can be determined depending on the preceding cold deformation. While at the same degree of deformation a 3.7 mm. diameter material may be faultlessly twisted at a high rate of twisting already a thickness of material of 3.00 mm. fails owing to contraction and rupture due to poor elongation.

Hitherto one has been of opinion that a conversion of the structure of steels lean in carbon modifying their properties of strength occurs only at an annealing temperature of 520° C., and that lower temperatures have little effect in this respect. By tests it has however been established that on the behaviour of such steels when twisted previous annealing at considerably lower temperatures has an extremely beneficial effect. This applies in the first place to cheaper steels cold-deformed by rolling or drawing. Particularly with wires of less than 5 millimetres diameter, such as those which have proved most favourable for concrete reinforcements according to the compound characteristics stated hereinabove and which have been produced by cold drawing and/or cold rolling a considerable improvement as regards brittleness failure is attained by treatment according to the present invention.

According to the invention these previously cold-formed work pieces are brought to a temperature between 360° and 450° C. by annealing, and are only subsequently twisted at a maximum temperature of 300° C.

In this manner it is possible to faultlessly twist even cheaper and non-stabilised steels having a comparatively low carbon content (below 0.25%), and to use the same in the reinforced concrete technique at very much higher permissible stresses than hitherto usual, i.e. for tasks for which hitherto more expensive steels of higher carbon content had to be used. Considerable economic advantages result from this fact.

In many cases it may be advantageous to quench the work piece between the annealing and the twisting and/or to anneal the same a second time after the twisting at temperatures not exceeding 450° C.

It has moreover been shown that with some steels optimum values are obtained only when the effective period of preliminary annealing at the aforesaid temperature is rather long, namely between 10 minutes and 4 hours.

If it is intended to attain a particularly close helical pitch of twisting, it is convenient to carry this twisting out in several stages, an annealing period at a temperature between 360° and 450° being interposed at any one time.

Hereinafter some test results will be described in more detail for the explanation of the surprising effect of the method according to the invention. In the following table the symbols mean this:

D^{mm}—diameter of the wire test specimen in millimetres
T^{c}—annealing temperature in centigrades
t^{min}—period of annealing in minutes.
p^{kg}—breaking load in kilograms
p^{kg/mm^2}—specific breaking load in kilograms per square millimetre
n—number of twists at which breakage occurred (in brackets: length of twisting in centimetres)

From the rise of n to double and three times the value (table of test results) it can be clearly seen that an optimum of torsion resistance with a minimum drop in tensile strength is attained, in contrast to the opinions hitherto held, already at preliminary annealing temperatures between 360 and 450° C., namely with an annealing period lasting generally between 10 minutes and 4 hours. Only in isolated cases already a preliminary annealing period of a few minutes has been found as effective. The great scatter is obviously to be explained by the fact that cold-drawn and cold-rolled wires of different origin and of irregular crystal lattice were investigated.

Test results

Investigation of the twisting breakage strength of cold-

formed steel wires of different diameters after preliminary annealing to 360°–440° C.:

D^{mm}	t^{min}	T^{c}, degrees	p^{kg}	p^{kg/mm^2}	n
(a) 3.12	1	360	682	90.8	3
	60		644	84.2	10
(b) 2	1	360	565	73.9	3
	8		534	69.8	4
	60		528	69.0	16
(c) 3.12	1	360	568	74.2	3
	8		544	71.1	5
	60		525	68.6	7
	240		520	68.0	11
(d) 3.12	1	400	685	89.5	5
	8		665	86.9	9
	60		630	82.4	10
(e) 3.12	1	400	553	72.3	4
	8		517	67.6	9
	60		510	66.7	13
(f) 3.12	1	440	660	86.2	6
	2		654	85.5	9
	4		630	82.3	10
	60		604	78.9	9

The invention moreover relates to a machine for carrying out the method described. This machine is characterised in that ahead of the twisting device an annealing furnace is arranged through which runs the work piece to be twisted.

After the twisting machine likewise a device for annealing the work piece may be provided.

Even when using comparatively thick profiles it is moreover convenient to provide a release mechanism on the twisting machine for preventing an excessive deformation of the profile at the moment of passing the maximum strengthening possible of the work piece.

Profiles of say medium dimensions are produced economically often in the form of rolled wire at maximum rate of passing through. The corresponding yield of ring material is to be expected which as regards being true to caliber (unilateral rolling, flat rolling, excessive rolling etc.) no longer satisfies the normal commercial sales requirements and can be used only as a stretched wire in the reinforced concrete technique. In this branch trueness to cross section area as a statically loaded structural element is important, while the trueness to profile or caliber is pronouncedly irrelevant. However in order to discover faulty spots such as "pipes," twisting is advantageous here too. Weak cross sections are then characterised by abnormally close helical pitch when twisted. In spite of the possible tolerances in helical pitch, steels which are too soft and have an increased liability to brittleness failure are excessively twisted (close helical pitch), while the harder and larger cross section area sections are deformed too little, so that the elastic limit and tensile strength do not undergo the increase desired.

This disadvantage is conveniently overcome in that when twisting section-wire at a high rate of deformation the section of the rod following at any time the section actually being twisted is sensed as regards its dimensions. In accordance with the effective dimension the twisting members are automatically adjusted and allow a practically homogeneous twisting event of rod material not true to caliber. Thereby also the liability to brittleness failure is reduced, and sections particularly liable to failure are eliminated by breakage at a poor deformation. Exploitation of the cheaper non-stabilised steels, which shown considerably higher deformation values of the elastic limit and tensile strength as compared with Siemens-Martin and stabilised steels, is no longer to be found objectional. For this purpose a sensing device is provided on the machine for ascertaining the tolerance profiles of the work piece to be twisted.

In order that the invention may be clearly understood and readily carried into effect, an embodiment thereof will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 shows the twisting device in side elevation and partly in longitudinal section.

FIG. 2 is a plan view to FIG. 1 from above,

FIG. 3 is an end view of a detail of FIG. 1.

FIG. 4 is a graph plotting a torque applied by a spring of the embodiment according to FIGS. 1 to 3 against the twisting torque,

FIG. 5 shows a modification of a detail in side elevation on a larger scale.

FIG. 6 shows wire coils and an annealing furnace on a smaller scale.

FIGS. 7 and 8 show a twisting device and annealing device in series in a diagrammatic general arrangement in two consecutive parts, FIG. 8 being the continuation of the right hand side of FIG. 7.

FIG. 9 is a graph plotting values of strength against the ratio of the helical pitch of twisting to the diameter of the twisted rod.

In the drawings, **1** denotes the fixed head and **2** the torsion head. **3** denotes the driving disc which is driven by a driving motor (not shown) by means of a belt **4** and sets the twisting head **2** in rotation. **5** denotes a worm coupled to **3** and having a bore **6** for allowing the twisted iron **7** to pass through it. **8** denotes a worm wheel which is coupled with two crank discs **9** and **10** which are connected to a forward cross beam, **13**, by means of tension bars **14**, so that cross beams **12** and **13** can perform a reciprocating movement in the axial direction of the machine, the amplitude of which corersponds approximately to the diameter of the pitch circle **15** of the crank pin. To this diameter corresponds also the magnitude of the champing stretch of the material to be twisted between the end of the tongues of the twisting head. The cross beams **12** and **13** are guided in slide tracks **16** and **17** or **18** and **19**, respectively. The same length of stroke (diameter of the crank pitch circle) applies also to a rear and forward dog **20** and **21**, respectively, which are fixedly connected to one another by means of the pull rod **22**, **20** and **21** being in turn guided in further tracks **23** and **24** or **25** and **26**, respectively. At the forward cross beam **13** engages a pawl **27** into the forward dog **21** and carries the same with it on its stroke towards the left until a fork **28** abuts a release member **29**, disengaging the pawl **27** from **21**, so that the forward dog **21** and the rear one, **20**, coupled to it move very quickly into their extreme right position owing to the dropping of a weight **31**, and remain there until also the forward cross beam **13** has reached the right hand side extreme position, and the pawl **27** consequently engages again on the forward dog **21** and at the subsequent stroke to the left pulls the forward- and the rear-dog into the extreme left hand side position, the weight **31**, which is connected to the rear dog **20** by a cable or chain **32**, being correspondingly raised. It is clear that the two cross beams **12** and **13**, provided the number of revolutions per minute of the crank discs **9** is not excessively high, always move somewhat more slowly to the right, than the dogs **20** and **21**, which are connected to the dropping weight **31**. The maximum speed of the cross beam **13** (for thin wires) amounts to 30 cm. in ½ second, i.e. 60 centimetres per second; the 30 cm. drop of the weight **31** is covered (apart from friction) in $t=0.45\sqrt{h}=0.45\sqrt{3}=0.24$ sec.: i.e. 125 centimetres per second, which is about twice as fast. What importance applies to this circumstance will be explained later.

At every stroke (of 30 centimetres) to the right, equal to the diameter of the crank pitch circle, rollers **33** mounted on the connecting rods **10** move about 30 centimeters to the right and thereby impart a counterclockwise movement to two clamping levers **34**. Accordingly also the pin **35** moves to the right. To the pin **35** webs **36** are connected on which two obliquely extending tension members **37** (FIGS. 1, 2) engage which are integral with a member **38**. On this member **38** a spring casing **39** containing a comprsession spring **40** is attached. A pull rod **41** has at its right hand side end a plate **42** and passes through the spring **40** in such a manner that the plate **42** abuts the right hand side end of the spring **40**. Into this pull rod **41** a nut (not shown) is built which abuts the spring casing **39** and serves for preloading the compression spring **40**. Finally the pull rod **41** ends in a cross beam **43** to which it is attached fixedly.

A movement of the pin **35** to the right involves also, generally speaking, a movement to the right of the cross beam **43**. This movement is transmitted in the same sense to a cross beam **44**, since the beams **43** and **44** are fixedly connected to one another by two pull rods **45** and **46**. These two pull rods pass through compression springs **47** and **48**, which abut a cylinder **49**. This cylinder is pivotally mounted in two presser levers **50** and **51**, which are journalled on a support **52**.

From this description it follows, that firstly a movement to the right of the pin **35** involves loading of the compression springs **47** and **48** provided the presser levers **50** and **51** are held stationary for one reason or other.

Secondly a movement to the right of the pin **35** closes a toggle lever **53**, since the pin **54** partakes in this movement to the right and imparts through link **55** a clockwise turning movement to the toggle lever **53**, so that its nose **56** can engage a pawl **57**. This pawl remains closed and accordingly detains the toggle lever **53** in the position shown in dotted lines, until a magnet **58** receives an electric impulse and thereby knocks the toggle lever out of its dead centre position. Thereby the toggle is opened with a jerk, provided the compression springs **40** and **47**, **48** had been loaded.

It will now be explained why these compression springs are loaded.

In case the two presser levers **50** and **51** turn in the clockwise direction, their noses **59** abut the tongues **60** of the fixed head **1**. When previously the iron to be twisted had been pushed through the tongues **61** of the fixed head as well as of the twisting head, the tongues **60** as well as **61** bear on the iron when the nose **59** moves to the right since the tongues are articulated on thrust links **62**. Accordingly the tongues **60** and **61**, respectively, meet a natural resistance, i.e. the levers **50**, **51** cannot perform any further rotary movement in the clockwise sense. When in the meantime the pin **35** nevertheless continues its movement towards the right, the comparatively weak compression springs **47** and **48** are forcibly loaded, i.e. these springs are loaded because upon a movement to the right of the pin **35** the cross beam **44** likewise moves to the right.

On the cross beam **44** a stepped wedge member **63** is mounted. An opposite wedge member **64** is mounted on the cylinder **49**. From FIG. 1 it can be seen that the two stepped wedges are at a certain distance from one another, when the crank pin **11***a*, as shown in FIG. 1, has just moved out of its left hand side dead centre position in the clockwise sense. (This position of the crank pin **11***a* has been chosen in the drawing in order to show how the pawl **27** is just being disengaged from the dog **21**.)

A movement to the right of the pin **35** accordingly involves also an approach of the wedge member **63** towards the wedge member **64**.

As will be clear from FIGS. 1 and 2, the wedge member **64** is guided slidably in an opposite member **66** by means of a dove-tail joint **65**. A displacement of member **64** upward or downward is effected by a link **67**, which is articulated to the bell crank lever **68**. One leg of lever **68** is connected to a pull rod **69**, and the latter is guided in the angle piece **70** and biased by a compression spring **71**.

Accordingly the wedge member **64** moves up when the levers **50**, **51**, move clockwise, and down, when the levers **50**, **51** move in the anticlockwise sense.

Accordingly, when the pin 35 moves to the right, the wedge member 64 will continue moving up until the levers (50, 51) come to a standstill in their clockwise movement, since, as explained hereinabove, the tongues 60 and 61, respectively, bear on the inserted iron to be twisted.

However, when the pin 35 continues moving to the right, the vertical up-movement of the wedge member 64 is terminated, but then a horizontal movement of the wedge member 63 towards the right takes place, i.e. the latter approaches more and more the wedge member 64, until eventually the two toothed steps of 63 and 64 engage one another, whereby even this movement is blocked. When the pin 35 nevertheless continues its movement to the right, there is nothing left but the pull rod 41 consuming part of the path of the compression spring 40, i.e. loading the latter.

It has now to be stated that the two compression springs 47 and 48 are chosen so weak that they could never twist an iron, but can merely overcome existing frictions and load the spring 72 for the opening of the head. For the twisting operation proper in any case the very strong compression spring 40 has to be used.

If the tongues 60 and 61 were already in contact with the iron, when the crank pin coming from the left hand side has not yet reached its right hand side dead centre position, i.e. if the strong compression spring 40 were already effective, the inserted iron would be pretwisted an amount not controllable by adjustment of the machine, until the crank pin 11*a* had reached its right hand side dead centre position. (The twisting period proper extends from the right to the left dead centre position in the lower 180° semi-circle.) The upper 180° semi-circle is reserved for purely a follow-up movement.

Moreover it should be remarked that any application of the strong compression spring 40 before the right hand side dead centre position of the pin 11*a*, i.e. before the worm gearing 5, 8 had been preloaded by the clamping lever 34, could destroy this gearing.

The machine has accordingly to be adjusted in such a manner that the force of the spring 40 is applied only shortly before the right hand side dead centre position of the pin 11*a*.

This is done in such a manner that a standardised gauge bar is inserted from the front into the fixed head, and a similar one from behind into the twisting head. Then by turning the driving disc 3 the position of the crank pin 11*a* slightly before the right hand side dead centre position is adjusted. The tongues 60 and 61 have now to bear on these gauge bars. Then the driving disc 3 is turned further until the crank pin 11*a* is accurately in its right hand side dead centre position. It is clear that the compression spring 40 then must have covered a part, although a small one, of its expansion path. This, however, could be the case only when the stepped toothings of the wedge pieces 63 and 64 interengage with one another. When these toothings are spaced apart a certain distance from one another, the position of the crank pin 11*a* slightly before the right hand side dead centre position has to be restored, and by tightening the nuts 73, 74 the cross beam 44 and thereby the wedge member 63 to be moved to the right until firstly the stepped toothings interengage with one another in the dead centre position of the pin 11*a*, and secondly the spring 40 has covered a part, although only a little, of its spring path. Since the inserted gauge bars have a certain importance as will be shown later, care has to be taken that the wedge member 63 in this dead centre position is approximately in the middle of the stepped toothing of member 64. This can be attained by loosening or tightening the nuts 75. The compression spring 71 effects a compensation, in case the wedge members 63 and 64 interengage with one another, while the levers 50 ,51 yet continue moving in the clockwise sense. This would be the case with a wrong adjustment of the wedge members.

The gauge bars have been used for attaining an adjustment of the machine to irons true to tolerances. When however the iron to be twisted has diameters below and/or above the permitted tolerances, the device of the stepped wedges must compensate these deviations from correct dimensions.

This is done as follows:

It has been explained hereinabove that the two compression springs 27 and 28 have the function of placing the tongues on to the iron, in order to sense as it were the quality of the diameter of the iron. Moreover it has been stated that the wedge member 64 moves right up when the two levers 50, 51 perform a large angular turn to the right, while this wedge member is in the lowest position when the levers 50, 51 are in the extreme left hand side angular position. In other words: the angle α is indirectly a measure for the over-all amount the wedge member 64 can move from one extreme position to the other. It is clear that the heads 1 and 2 are completely opened, when the levers 50, 51 are in the extreme left hand side position as approximately illustrated in FIG. 1, and that the heads 1 and 2 are completely closed, when the levers 50, 51 have covered the angle α and have reached the extreme right hand side position.

This interval between "tongues completely opened" and "tongues completely closed" may approximately form a measure of the amount permitted for the under- and/or over-dimensioning of the iron to be twisted. This is only approximately so, since the full range between "completely open" and "completely closed" cannot be exploited, otherwise it would not be possible to push the iron on in the position "heads opened."

Assuming the iron had once an excess dimension of +1 millimetre over the standard diameter of the gauge bar, and another time a deficiency of —1 millimetre, the wedge member must move from the middle position shown in FIG. 1 in the first case into the extreme low position, in the second case into the extreme high position, i.e. the deviation of ±1 millimetre are a criterion of how far the excess or deficiency in dimension may reach in order to be safely coped with by the machine.

When these deviations in dimensions are kept (the excess dimension can inherently not be surpassed) it can be ascertained that both with an iron thicker than the nominal dimension as with an iron which is too thin the strong compression spring 40 is reloaded to the same extent when closing the heads, i.e. no pre-twisting takes place with too thick an iron until the pin 11*a* has reached the right hand side dead centre position, and too thin an iron is twisted exactly like the normal iron or too thick an iron beginning from the same moment, mainly from the accurate right hand side dead centre position of the pin 11*a* onward. Of course the rods or wires to be twisted may assume any excess- and deficiency-values between the limits ±1 millimetre. The variation of these diameters is simply catered for by a different adjustment of the stepped wedge members.

It has initially been stated that the speed of the two dogs 20 and 21 carrying along the iron when moving to the right, i.e. by the proper following up by the dropping weight, which is twice the speed of the cross beams 12 and 13, has a great importance. For, if the iron would be made to follow up only at the speed of the cross beams 12 and 13, which depends on the crank drive, the feed of irons having an excess dimension would be braked by the tongues contacting the iron too early namely by the action of the sensing springs 47 and 48. With irons having an excess dimension of +1 millimetre this may be equivalent to a loss of 50% in feed. It is therefore necessary to increase the feed-velocity of the iron to such an extent at least that the iron following up has reached its end position already when the heads 1, 2 just begin to perform their closing operation.

Now the importance of the illustration in FIG. 3 will be considered, which makes the opening of the heads dependent on the iron to be twisted itself, instead of on the machine. In this case the fixed head **1** is mounted rotatably about the iron **7** lying in the axis of the machine, so as to be capable of turning a few angular degrees to the right or to the left. On the fixed head **1** a rocker arm **76** with tension spring **77** is attached, see FIGS. 1 and 3. A pull rod **78** has a screw thread at its upper end, while the tapping is provided in a hand wheel **79**, which rests on a cross beam **80**. By means of the hand wheel **79** the tension spring **77** can accordingly be loaded or relaxed. To the rocker arm **76** there is attached also an electrical contact piece **81**, the opposite contact piece **82** of which is mounted stationarily on the machine. Rotary movement of the fixed head **1** in the counterclockwise sense closes the contacts **81, 82**, while a movement in the clockwise sense opens the same. By closing the contacts **81, 82** the magnet **58** is energized, i.e. the heads **1** and **2** are opened. The machine performs the twisting in the counterclockwise sense. When a certain degree of twisting is exceeded, which may overcome the force of the adjusted tension spring **74**, the heads **1, 2** are accordingly opened automatically.

Another device may be provided, by which the conditions according to FIG. 4 are taken into account. In FIG. 4 the increase in force when twisting an iron is plotted, i.e. the torque, which the tension spring **77** has to oppose, the torque gradually increasing during the twisting operation; FIG. 4 shows the rise of this torque. At the point **83** this torque has reached its maximum. In order fully to exploit this maximum by the machine, it is not sufficient to keep the point **83**, since the maximum itself can not be ascertained mechanically, only the torque at which this maximum is just being given up, i.e. when the torque applied to the arm **76** just drops a small amount. At this very moment the heads are opened. According to a conventional diagram, FIG. 9, wherein the strength values of a usual steel rod are plotted against the twist, this is the point A.

Thereby a device has been provided, by means of which a rod is subject to the same rise in force over its entire length; it could be said that the iron had been twisted in conformity with its material.

In FIG. 5 one of the dogs **20** or **21** is illustrated. As long as the iron does not exceed, or drop below, a normal diameter dimension, i.e. as long as its diameters deviate from the nominal dimension only by the usual tolerances, the feed does not constitute any problem. The difficulties start here, too, only at the moment when the iron diameter exceeds or drops below the ordinary tolerances i.e. when substantial excesses or deficiencies in diameter occur. With **20, 21** in FIG. 5 the dog (feeder-device) is denoted which is symbolically indicated in FIG. 1 as being movable to-and-fro in the guide tracks **23** and **24** or **25** and **26**, respectively. Fixedly screwed to it there is a wedge piece **84**, along which its opposite member **85** may slide to-and-fro along its oblique face. The angle of this oblique wedge face is so selected, that the wedges are self-locking, i.e. for steel at about 15°. On the end face of the member **85** there is a guide plate **86** connected to the member **85**. On the plate **20, 21** a lever **89** is mounted pivotally about a screw **90**, a strong compression spring (not shown) between the lever **89** and plate **20, 21** assuring a certain friction for the lever. Depending on the diameter of the iron **7**, a pin **91** is inserted into one of the holes **92**. A tension spring **93** tends to force the guide plate **86** always to contact the iron **7** snugly. On the oblique wedge face of the wedge piece **85** there is a ratchet toothing **94** into which may engage a pawl **95**. This pawl **95** is pivotally mounted at **96**, the pivot axle **96** being fixedly connected to the wedge piece **84**. The lever **89** is shown in the closed position of the dog; when the latter is opened, the lever **89** is turned about 15° to the left from the position illustrated.

For adjustment, this dog-mechanism is brought into the position illustrated relative to the abutments **98, 99** and **100, 101**, the lever **89** recording about 15° with the gauge bar **7** inserted. When the pawl **95** is in the position illustrated, i.e. out of engagement with the toothing **94**, the guide plate **86** will likewise bear at once on the gauge bar under the bias of the tension spring **93**. In this condition a screw **102** has to be positioned approximately in the middle of a slot **103**. When this is not the case, the pin **91** has to be withdrawn and to be inserted into that hole **92**, for which this standard starting position in attained.

When the dog **20, 21** moves to its left hand side starting position at the left hand stroke of the machine, the lever **89** is brought into the closing position illustrated in FIG. 5, owing to the abutment **101**. The iron **7** is then clamped between the guide plates **86** and **87**. In this position the abutment **99** has also moved a fork **97** of the pawl **95** to the right, i.e. it has brought the pawl **95** out of engagement with the toothing **94**, so that the wedge piece **95** can move to the left under the bias of the spring **93**; only thereby the clamping of the iron **7** between the guide plates **86, 87** has been made possible. When the plate **20, 21** moves into its extreme right hand side position, the abutment **100** opens likewise the lever **89**. Slightly prior to this the abutment **98** has brought the pawl into the closing position, so that the opening position of the device established by the lever **89** is maintained at least until the device has reached the extreme left hand side position. Accordingly the iron **7** is left untouched by the guide plates **86, 87** during the twisting period.

It is clear that the wedge pieces **84** and **85** perform the same function as regards irons having excess or deficiency of dimensions as the wedge members **63, 64** according to FIG. 1. When the iron is too thick as compared with the standard dimension, the wedge piece **85** lies more to the right of its middle position; when it is on the other hand, too thin, more to the left. Thereby an automatic consideration of excess or deficiency in dimensions is assured.

FIG. 6 shows wire coils **110** which are annealed in the annealing furnace **111** to a temperature below 520° C. before the wires get into the twisting machine **114** (FIG. 7). From the twisting machine **114** the twisted work piece **115** gets according to FIG. 8 into a high frequency furnace **116**, in order to be annealed again. The high frequency furnace is supplied with current by a high frequency generator **118** driven by an electric motor **117**. On the high frequency furnace a cooling line **119** is provided.

The device according to FIG. 8 may be dispensed with, when the work piece is not to be annealed again after being twisted.

While we have described herein and illustrated in the accompanying drawings what may be considered a typical and particularly useful embodiment of our said invention we wish it to be understood that we do not limit ourselves to the particular details and dimensions described and illustrated, for obvious modifications will occur to a person skilled in the art.

What we claim as our invention and desire to secure by Letters Patent, is:

1. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25%, such as concrete reinforcement wires of less than 5 millimeters diameter, the steps of first uniformly heating the cold-drawn workpiece to a temperature of between 360° C. and 450° C. while moving it lengthwise through said high temperature zone, cooling said workpiece to room temperature while continuing its lengthwise movement, and twisting said workpiece to a helical permanent pitch a plurality of times while at said room temperature.

2. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25% and a diameter of less than 5 millimeters, particularly concrete reinforcement wires, the steps of uniformly heating said workpiece to a tempera-

ture of between 360° C. and 450° C., cooling said workpiece to room temperature and then twisting said workpiece to a close helical permanent pitch a plurality of times while at said room temperature.

3. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25% and a diameter less than 5 millimeters, particularly concrete reinforcement wires, the steps of uniformly heating said workpiece throughout to a temperature of between 360° C. and 450° C., cooling said workpiece to room temperature and then twisting said workpiece to a close helical permanent pitch a plurality of times while at said room temperature between two clamping members which are arranged at a fixed distance from each other.

4. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25% and of a diameter less than 5 millimeters, particularly concrete reinforcement wires, the steps of uniformly heating said workpiece throughout to a temperature of between 360° C. and 450° C., cooling said workpiece to room temperature, and twisting said workpiece to a close helical permanent pitch a plurality of times with a high deforming speed between two clamping members which are arranged at a fixed distance from each other.

5. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25% and having a diameter of less than 5 millimeters, particularly concrete reinforcement wires, the steps of uniformly heating said workpiece to a temperature of between 360° C. and 450° C., maintaining said temperature for a period of time between 10 minutes and 4 hours, cooling said workpiece to room temperature, and then twisting said workpiece to a close helical permanent pitch a plurality of times while at said room temperature.

6. In a method of mechanically twisting workpieces consisting of cold-drawn profile steel having a carbon content below 0.25% and having a diameter of less than 5 millimeters, particularly concrete reinforcement wires, the steps of uniformly heating said workpiece to a temperature of between 360° C. and 450° C., cooling said workpiece to room temperature, twisting said workpiece to a close helical permanent pitch a plurality of times while at said room temperature, and then re-heating said twisted workpiece to a temperature not exceeding 450° C.

References Cited in the file of this patent

UNITED STATES PATENTS

167,766	Hunt	May 1, 1875
1,095,324	Hall	May 5, 1914
1,692,505	Hoffman	Nov. 20, 1928
2,260,779	Hoffman	Oct. 28, 1941
2,723,702	Wyss	Nov. 15, 1955
2,816,052	Hoff et al.	Dec. 10, 1957
2,881,108	Nachtman	Apr. 7, 1959
2,881,822	Henry	Apr. 14, 1959

OTHER REFERENCES

Journal of the Iron and Steel Institute, vol. 108, No. II, 1923, pages 273–283, pages 275–277 particularly relied on.

Metals Handbook, pages 2 and 18, 8th ed., 1961.

ASTM Standards, pages 91–94, Part I–A (Ferrous Metals), 1946.

The Making, Shaping and Treating of Steel, pages 558–559, 7th ed., 1957.