June 21, 1955 R. J. KENNEDY 2,711,291

APPARATUS FOR PRE-STRESSING CONCRETE STRUCTURES

Filed Aug. 14, 1953 2 Sheets-Sheet 1

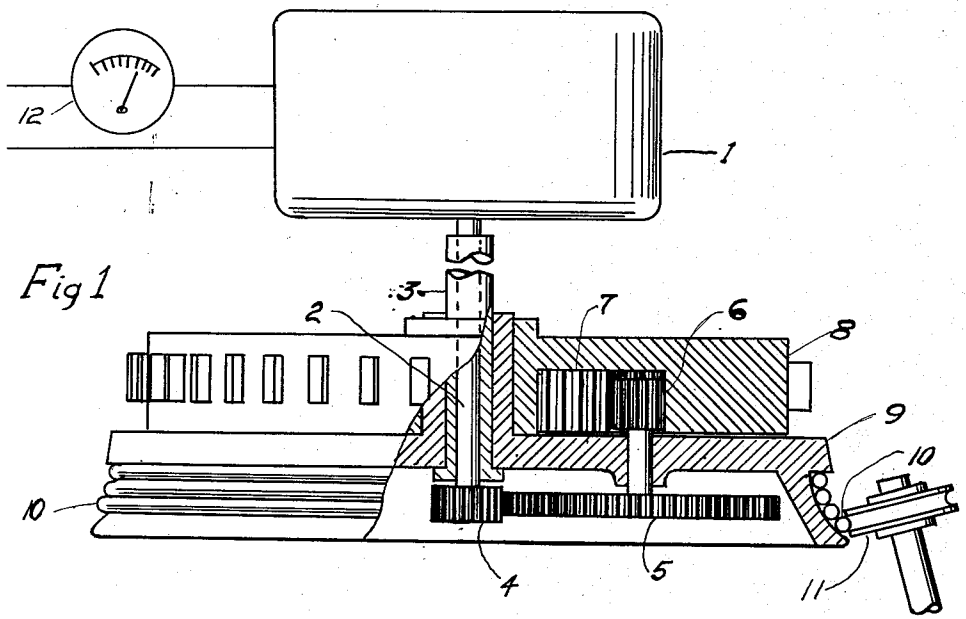


Fig 1

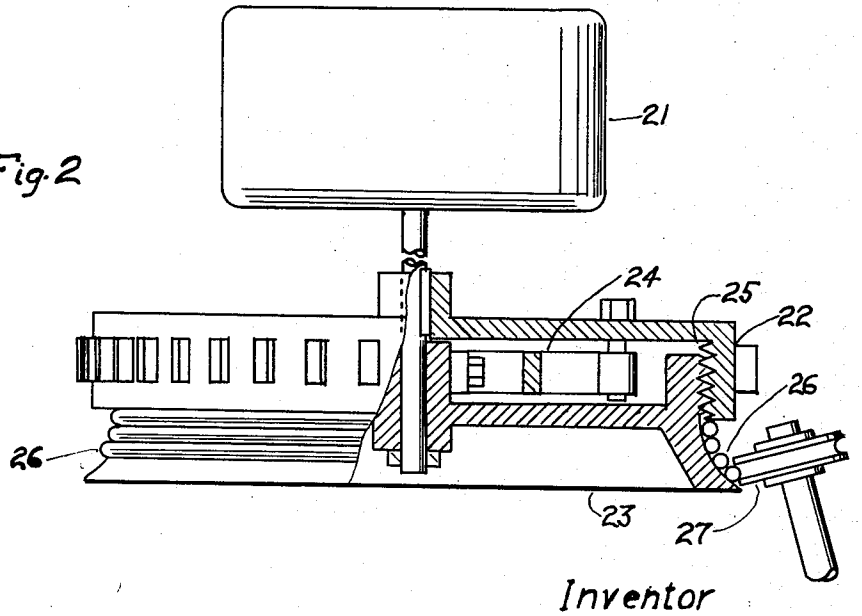


Fig. 2

Inventor

Roy J. Kennedy

June 21, 1955 R. J. KENNEDY 2,711,291

APPARATUS FOR PRE-STRESSING CONCRETE STRUCTURES

Filed Aug. 14, 1953 2 Sheets-Sheet 2

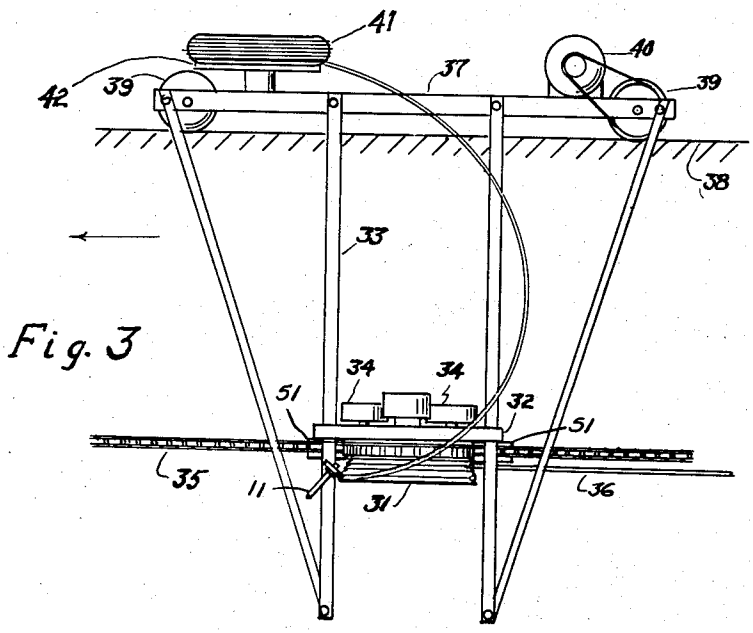


Fig. 3

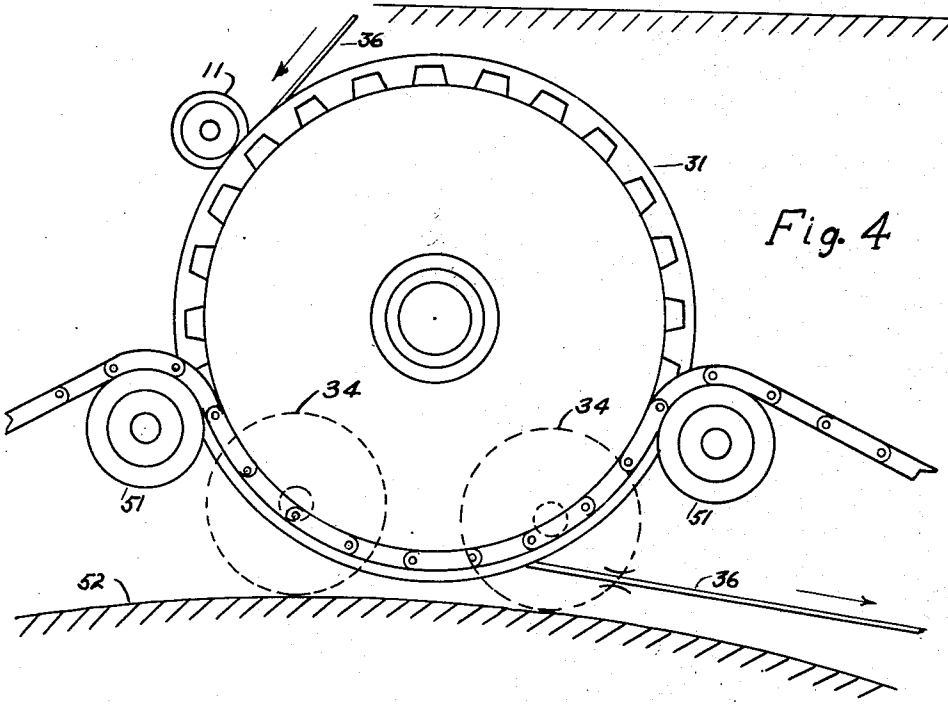


Fig. 4

United States Patent Office 2,711,291
Patented June 21, 1955

2,711,291

APPARATUS FOR PRE-STRESSING CONCRETE STRUCTURES

Roy J. Kennedy, Oakland, Calif.

Application August 14, 1953, Serial No. 374,375

4 Claims. (Cl. 242—7)

This invention concerns method and means for applying pre-stressed banding material, e. g. steel wire, to an object, e. g. a concrete tank or pipe.

The advantages claimed over previous methods and means are: (1) The apparatus is small and compact enough to be used without disturbing scaffolding used in construction of tanks; previously scaffolding has had to be removed and replaced. (2) Its power consumption is so small as to make operation feasible with portable electric power plant. (3) Accurate control of tension in wire permits closer, more economical design of structure to be reinforced. (4) A graph showing actual tension everywhere in wire can be obtained automatically, thereby assuring that the work meets specifications.

Reference is made to the accompanying drawings wherein:

Figs. 1 and 2 show diametral sections of two different forms of the unit whose rolling movement along the object places and stresses the reinforcing material.

Fig. 3 shows such a unit mounted on a carriage in position on a tank or the like, hereafter called the structure.

Fig. 4 is a simplified plan view of the unit mounted as in Fig. 3 and as seen from just below the supporting member.

In Fig. 1 is shown a motor **1** which by way of shaft **2** through the fixed member **3** and the reducing train of gears **4**, **5**, **6** and **7**, produces a torque tending to rotate the coaxially mounted members **8** and **9** with respect to each other and the fixed member **3**. The member **8** has teeth around its periphery which are intended to engage a continuous chain or the like which encircles the object to be reinforced and is kept at sufficient tension to prevent serious slippage. The periphery of member **9** is a surface of revolution onto which the banding wire **10** is guided beneath the roller **11** and from a smaller radius of which the wire unrolls onto the object. The shape of the surface of **9** is so designed as to insure that every element of the wire, in which in the operation of the device the tension steadily increases as it progresses toward the point of leaving **9**, shall slide and roll smoothly toward that point. The roller **11** is pressed (preferably by a spring) toward the axis sufficiently to prevent slippage of wire on **9** at point of rolling-on, but can be forced away to allow passage of a compact coupling on wire. The meter **12** is intended schematically as an indicator or recorder of the torque of motor and therefore of tension in the wire.

The motor **1** is intended to exert a constant torque regardless of its speed; this result can proceed from design of motor or from an auxiliary arrangement, e. g. a constant current regulator with a direct-current motor. Such regulation is simple because the power required is small. Since the final tension in the wire is proportional to this torque, the tension will then be independent of the speed of operation of the machine and of slippage of the chain along which it travels.

It can be shown readily that if the final tension in wire is T, the radius of **9** at which wire is unrolled is R_9, torque

of motor is L and radius of pitch-circle of **8** is R_8, then the unit is urged forward by a force

$$F=T\left(1-\frac{R_8}{R_9}\right)\pm\frac{L}{R_8}$$

The algebraic sign of the small term involving L depends on number of gears in the reducing train, which is over-simplified in the drawing. In this embodiment I prefer a value of

$$\frac{R_8}{R_9}$$

such that force F is nearly equal to the frictional force involved in the forward movement of the unit and its immediate carriage, i. e. that carried by the frame-work in Fig. 3, which will be discussed later. Since the frictional forces are roughly proportional to T, such a value of

$$\frac{R_8}{R_9}$$

will ensure that only a small force need be exerted by the frame-work on the tensing unit for any value of T; this fact becomes particularly important where high structures are concerned.

In this embodiment the ratio of the radius at which the wire is rolled onto member **9** to the radius R_9 affects the speed of rotation of **9**, but not the final tension of the wire.

In Fig. 2, the member **21** is a motor (presumably with gear-reduction) coupled to the member **22** which except for lack of internal gear-teeth is similar in structure and function to the member **8** of Fig. 1. Coaxial with **22** is the member **23** which likewise corresponds to member **9** of Fig. 1. One end of a strong spiral spring **24** is attached to **22** and the other end to **23**. Near their peripheries, **22** and **23** are provided with meshing screw threads **25** so that their distance apart along axis depends on their relative angular orientation which can be read on a stroboscopically illuminated scale about axis. The banding wire **26** shown wrapped about **23** rolls on under roller **27** at a radius of **23** which is determined by the number of turns of wire on **23** and the distance apart of **22** and **23**; the roller is so supported as to be capable of appropriate small movement in response to relative movement of **22** and **23** and to be adjustable in orientation about axis of **22** and **23**, but always presses the several turns of wire firmly together at right angles to their length, and tightly enough against **23** to prevent slipping, except in the case mentioned at end of discussion of this embodiment.

The action of this device in automatically maintaining a nearly constant tension in the wire is as follows: Under steady conditions of operation, with uniform slip S of chain per revolution of member **22**, then if R_p is radius of pitch-circle of **22** and r is ratio of length of an unstressed to a fully stressed element of wire, the radius of rolling-on to **23** should be

$$=r\frac{2\pi R_p-S}{2\pi}$$

and since r is necessarily less than 1 and S can not be negative, R must be less than R_p. Suppose now that for some reason the tension falls below the desired value; then spring **24** relaxes and rotates member **23** with respect to member **22** in such direction as to decrease their separation by the action of screw **25**; wire **26** is thus allowed to slide into region of periphery of **23** where radius of rolling-on is decreased; member **23** therefore rotates at slightly greater speed than **22**, so that tension in spring **24**, and consequently that in wire, increases until initial value is restored, when, too, a new value of R will have been established, if required. The action in case of

an accidental increase in tension is evidently just the opposite, but again restores initial value of tension. It will be evident that for accurate regulation it is desirable to have a small rate of change in tension of spring with angular displacement between 22 and 23; hence it might be desirable to use a fusee or long torsion spring; a small, constant-torque motor, geared as shown in Fig. 1, would act as spring with rate of change zero; the spiral spring has been shown here merely for simplicity of representation.

Instead of relying for regulation on the above-discussed variation in radius, evidently the same screw-action could be made to vary the force with which roller 27 presses the wire into contact with member 23, and so let wire slip to degree required for regulation.

In Fig. 3 a unit 31 such as those of Figs. 1 and 2 is shown mounted on a horizontal beam 32 which can move vertically in the frame-work 33. The unit is held out of contact with surface by rollers 34 as it moves along chain 35 and pays out the wire 36. Frame-work 33 is supported by carriage 37 which is propelled along parapet 38 of structure to be banded on rollers 39 driven by motor 40. The wire is led by way of guides (not shown) to unit 31 from coil or spool 41 mounted on a turn-table 42.

The unit 31 can be moved manually or automatically in vertical direction so that the wire will be applied spirally as the machine travels around the structure. It will be evident that the general arrangement enables the unit to be brought to very bottom of structure, where usually a great many turns of the banding must be applied.

Because the motor attached to unit 31 supplies just enough force to propel the unit, the frame-work 33 can be lightly built.

The plan view Fig. 4 shows unit 31 above referred to, and rollers 51 which hold chain 35 in positive engagement with sprocket of 31 and are so oriented about axis of 31 as to supply tension necessary to keep chain from slipping along structure. Means for supporting rollers adjustably are perhaps too obvious to require representation. The rollers 34 above referred to are above plane of view and so not shown as holding 31 away from structure 52.

The statement that the power required in these devices is small, which has been emphasized in the foregoing discussion, is confirmed in the following computation of power under conditions that have occurred in practice. It is easily shown that if friction of moving parts is disregarded, the power required (in horse-power units) is

$$\frac{T^2 s}{2 \times 550 MA}$$

where

T=tension in pounds

s= lineal speed of machine in ft. per sec.

M=Young's modulus for material of wire

A=cross-sectional area of wire in sq. in.

For $T=2500$, $s=7.5$, $M=2.8\times10^7$ and diameter of wire=0.15, the formula gives

Power=0.10 H. P.

I claim:

1. In apparatus for reinforcing a concrete structure by banding its convex surface with prestressed wire, means comprising a member arranged to roll tractively along the surface, a second member coaxially rotatable with respect to the first and having a region which is a coaxial surface of revolution onto which the wire is to wind and from which to unwind onto the structure, a roller resiliently holding the wire against the second member at the point of application of the wire to the second member to prevent slipping at that point between the wire and the second member, a motor geared to both rotating members so as to produce a torque resulting in tension in the wire as it unrolls, a mounting for the above mechanism, a framework supporting the mounting at various altitudes from top to bottom of the structure and itself arranged to roll along the top of the structure, a second motor on the framework for driving it circumferentially about the structure, means on the framework for varying the elevation of the mounted unit as the banding proceeds, and a source of wire on the framework.

2. In apparatus set forth in claim 1 an arrangement of gearing of the first-mentioned motor, and a value of the ratio between the radius at which the wire leaves the surface of revolution of the second member and the radius at which the first member rolls along the structure such as to produce a force on the suspended unit in the forward direction approximately equal to the overall frictional force opposing the motion of that unit.

3. In combination with the apparatus set forth in claim 1, a meter indicating the tension in the wire by means of the electric current supplied to the motor providing the stressing effort.

4. In apparatus for reinforcing a concrete structure by banding its convex surface with prestressed wire, means comprising a member arranged to roll tractively along the surface, a second member coaxially rotatable to a limited extent with respect to the first and having a region which is a coaxial surface of revolution of varying radius onto which the wire is to wind and from which to unwind under tension at a smaller radius, engaging screw-threads in the first and second members whereby a change in their relative angular displacement results in a compensating change in radius of rolling-on of the wire onto the second member, a roller resiliently holding the wire against the second member at the point of application to prevent slipping of the wire at that point, and a spring joining the two members and opposing their relative angular displacement.

References Cited in the file of this patent

UNITED STATES PATENTS

2,364,696	Crom	Dec. 12, 1944
2,370,780	Crom	Mar. 6, 1945
2,520,403	Hirsh	Aug. 29, 1950