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(54) ELECTROMAGNETIC DEVICE FOR THE INSERTION OF THE WEFT YARNS INTO A PROJECTILE WEAVING LOOM

(57) An electromagnetic weft yarn insertion device in a projectile weaving loom of the type wherein projectiles (1) are launched into the shed through the electromagnetic force caused by a plurality of adjacent coils (3) aligned along the projectile trajectory and sequentially activated during projectile movement. The coils (3) are activated in groups of more consecutive coils (4), the position of the group of activated coils (4) being sequentially moved forward by a single coil (3) at a time in agreement with the projectile (1) position.

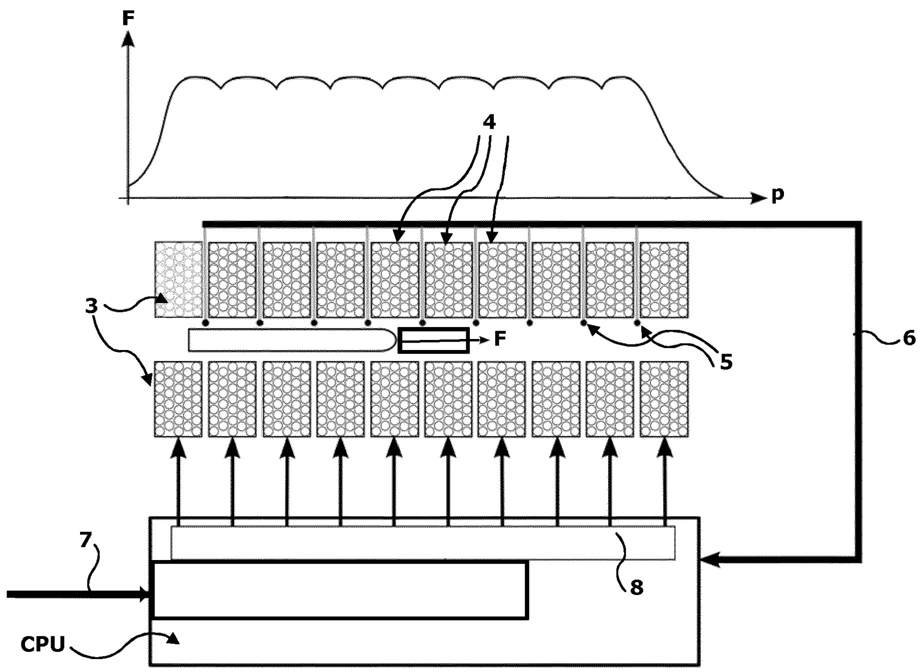

Fig. 4

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Description

[0001] The present invention relates to an electromagnetic device for the insertion of the weft yarns into a weaving loom of the projectile type.

FIELD OF THE INVENTION

[0002] As known, projectile weaving looms differ from the other types of looms by the fact that the weft yarns are inserted into the shed through a projectile, i.e. a tapered metal body of a suitable mass and shape, to which the end of the weft yarn is gripped.

[0003] At the shed outlet (usually in correspondence of the right hand-side of the weaving loom, with reference to the weaver's position) the projectile is slowed and stopped by a braking device, the weft yarn is loosened and hence the projectile is caused to return towards the launch side of the loom (usually the left hand-side) through a suitable continuous transport system. On the launch side, the individual in-coming projectiles are loaded onto a device which progressively brings them in front of the launching station where they are launched again into the shed, driving into the same another weft yarn.

STATE OF THE BACKGROUND ART

[0004] This type of loom, in the face of advantages detectable especially in the weaving of very wide fabrics, has some significant drawbacks. Firstly there are mechanical-type drawbacks, directly connected to the high impulse thrust which must be imparted to the projectile. In particular, in addition to the problems determined by the impulse thrust which the projectile undergoes by the launching member, the complication exists of devising a suitable mechanism which produces a sufficiently intense but not excessively invasive thrust.

[0005] GB 2.003.198 discloses a conventional launching device in which a launching member, meant to firmly abut on the rear end of the projectile, is supported on a lever driven by a torsion bar cyclically loaded through a cam mechanism.

[0006] As can be easily guessed, the system making use of the cam-loaded torsion bar represents a rather critical mechanical component, both in terms of the undergone and imparted stresses, and in terms of the opportunity of determining and controlling the motion law of the projectile in the launching step.

[0007] As a matter of fact, since the projectile is launched through the shed with a very high impulsive acceleration, and it is not subsequently controlled by any driving member, some typical weaving problems arise in projectile weaving looms e in particular a high initial stress of the weft yarns and a substantially uncontrolled behaviour of the projectile along the entire travel within the shed. In particular, when the thrust impulse does not occur perfectly symmetrically on the projectile, the projectile trajectory undergoes lateral oscillations which are controlled by the guides within which the projectile slides, but which worsen the effectiveness and the regularity of the launches.

[0008] JP-48-44559 (1973) of Mitsubishi Electric discloses a possible alternative solution for the projectile launch, where the projectile is brought to the maximum set launching speed no longer due to a mechanical thrust member, but rather due the acceleration produced on the projectile by an electromagnetic field in which the projectile is immersed. In particular said electromagnetic field is created by one or two coils arranged in sequence along the projectile trajectory, which trajectory passes through an internal axial cavity of the coils so as to create a magnetic field as even and parallel as possible around such trajectory.

[0009] Although the launching technology illustrated above has by now been known for various decades, a practical application of the same has by now never taken place. An exhaustive critical analysis of first-generation electromagnetic insertion systems of weft yarns, of the type illustrated above, is contained in the publication "Using electromagnetic force in weft insertion of a loom" (Fibres & Textiles in Eastern Europe - July/September 2005, Vol. 13, No. 3(51) - pages 67-70*),* where the author S.A. Mirjalili sets forth the results of a study carried out at the Textile Engineering Department of the University of Yazd (IRAN), for performing precisely the launch of a projectile made of a ferromagnetic material through an electromagnetic device.

[0010] In this publication it is detailed that the supply current of the coil of the electromagnetic launching device must be switched off when the projectile arrives at a central position of the coil and would hence begin to be affected by the braking action imparted by the second half of the coil. As a matter of fact, the stable equilibrium position of the projectile, if the current was steadily maintained in the coil, would be precisely in correspondence of a central position thereof, where the projectile would stop following a fast series of oscillations around such central position.

[0011] Based on this observation and, on the other hand, to be able to achieve a good compromise between the desired exit speed of the projectile and a good efficiency of use of the action of the magnetic field, the author suggests that the projectile has a length equal to 75-125% of the length of the coil.

[0012] However, the study in question ends noting that with this launching device it has not been possible to achieve projectile speeds comparable with those of mechanically-launched projectiles.

[0013] A more recent weft insertion device which exploits the electromagnetic force is finally disclosed in the patent publication DE-10 2009 019935 of Konrad Hilmar and comprises a loom provided with a single projectile which is alternatively sent into the shed due to two similar electromagnetic devices arranged at the two opposite ends of the shed, each of which consists of four adjacent coils. A microcontroller activates in succession said coils to accelerate or respectively brake the projectile, based on information relating to the projectile speed and to the angular coordinates of the main movement of the loom. The way in which the activation of the coils occurs is not disclosed in detail, but in any case it is clear that it occurs sequentially as the projectile advances.

[0014] The ratio between projectile length and coil length is not disclosed specifically here, but from the drawings it appears clearly how it is in the upper values of the range disclosed by the Mirjalili study illustrated above.

[0015] However, both the solutions proposed by the prior art illustrated above have not given satisfactory results in practical applications. As a matter of fact, the Mitsubishi solution, schematically illustrated in fig. 1, has the great disadvantage of imparting significant attraction forces F only in a small range of relative positions P between projectile and coil. Despite the fact that the coil has a much greater longitudinal development than the projectile, the space available for acceleration remains nevertheless highly limited and this, given a desired final launching speed of the projectile, implies very high accelerations and forces. Such accelerations and forces require the use of high currents, with resulting remarkable losses due to the Joule effect in the coils and hence a very low overall efficiency of the launching system, meant as kinetic energy of the projectile/electric energy used for the launch of the projectile. In this solution there are hence also great coil cooling problems, and important mechanical stresses of the weft furthermore arise.

[0016] Any further coil elongation, illustrated schematically in fig. 2, in any case would not improve the situation, since the electromagnetic force F imparted on the projectile, once the projectile finds itself fully within the coil, due to what has already been stated above, would be null. A greater dissipation would hence be produced, the electromagnetic force in the useful area being the same, due to the Joule effect in all the other coil sections not effective for the purposes of projectile acceleration.

[0017] Finally, in the Hilmar solution it is proposed to increase the number of the coils and to simultaneously reduce the longitudinal dimension thereof to a value remarkably smaller than the projectile length, so as to limit the losses due to the Joule effect and to hence improve the efficiency of the system. However, the electromagnetic force imparted by coils of such modest length is very low and even if the efficiency of every single coil is higher with respect to the one of the previous solutions, it is nevertheless not possible to succeed in accelerating the projectile up to interesting speeds from the point of view of the current industrial applications.

SUMMARY OF THE INVENTION

[0018] The object of the present invention is therefore to propose an electromagnetic device for the insertion of weft yarns, in a projectile weaving loom, which is devoid of the drawbacks mentioned above and hence allows to impart onto the projectile a high electromagnetic force along a longitudinal area as long as desired, so as to achieve the desired final speed of the projectile, without incurring the drawbacks described above of low electric effectiveness of the system and of excessive mechanical strains on the weft.

[0019] This object is achieved through an electromagnetic weft yarn insertion device into a projectile loom having the features defined in independent claim 1. Other preferred features of such weft insertion device are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Further features and advantages of the electromagnetic weft yarn insertion device into a projectile loom according to the present invention will in any case be more evident from the following detailed description of a preferred embodiment of the same, provided purely as a non-limiting example and illustrated in the attached drawings, wherein:

fig. 1 is a diagram which illustrates, in a weft insertion device of the above-described Mitsubishi prior art, the change of the electromagnetic force imparted by a coil on a projectile running through the same, against the position of the projectile tip;

fig. 2 is a diagram similar to fig. 1, in the case of a coil of a much greater length than the projectile;

fig. 3 illustrates the operation diagram of a device comprising individually-activated coils, such coils being shorter than the projectile, such as the one described in the Hilmar patent.

fig. 4 illustrates the operation diagram of an electromagnetic weft insertion device according to the present invention; and

fig. 5 illustrates a different embodiment of the electromagnetic weft insertion device of fig.4, provided with a more sophisticate control of the projectile position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] For a better understanding of the invention, in the diagrams of figures 1 to 3 is schematically shown the curve of electromagnetic force F imparted on a projectile by an electromagnetic weft insertion device of a conventional type, such as those disclosed by documents Mitsubishi, Mitsubishi with further elongated coil and Hilmar, against the position P of the projectile tip. For greater simplicity in the drawings only the positive branch of force F is illustrated, since it is clear that upon the progress of the projectile beyond a central position with respect to the coil, as described in the Mirjalili document, should the power supply of the coil not be switched off, an electromagnetic force of opposite sign and identical trend would arise.

[0022] In the lower part of fig. 1 projectile 1 is shown in waiting position in front of coil 2. When the coil is excited it develops an electromagnetic force F variable on the projectile depending on the positions P subsequently taken up by the same - as schematised in the upper part of fig. 1 - which involves a fast increase, from the starting position up to when the projectile tip arrives in correspondence of the entry area in the coil, followed by a rather limited range of maximum values, and hence a sudden drop until returning to zero when the projectile tip is in the proximity of the exit area from coil 2.

[0023] As already mentioned above, when commenting the publication by S.A. Mirjalili, this coil arrangement hence allows to impart significant attraction forces only in a limited range of relative positions between projectile and coil, i.e. in practice only in a first portion of the coil length. This circumstance causes the remarkable drawbacks already described above.

[0024] The use of a coil 2 of a greater length, as illustrated in fig. 2, does not change the shape of the curve of the above-described electromagnetic force F in the part of initial rise and of maximum peak, but only elongates the descending part of the curve, in which area the electromagnetic force nevertheless has very low values and finally null (when the projectile is entirely within the coil); this solution would hence imply a large worsening of system efficiency.

[0025] On the contrary, the use of a coil, or of a series of coils 2 of a shorter length, as proposed in the more recent Hilmar document and as illustrated in fig. 3, despite guaranteeing a greater effectiveness of the device, would proportionally reduce the maximum peak value of electromagnetic force F and hence would not allow to reach the desired launching speeds of projectile 1, in the rather limited spaces which can be made available to a device of this type on-board of a weaving loom.

[0026] In this state of the art, the solution proposed by the present invention, schematically illustrated in fig. 4, provides to use a plurality of coils 3, arranged consecutively in series along the launch trajectory of the projectile, each of such coils having a length which is a preferably integer submultiple **1/n** of the length of an optimal coil which allows to obtain, in stationary conditions, the desired electromagnetic force on a certain projectile 1 minimising the power lost by the Joule effect in said coil. The length of the above-said optimal coil ranges between 30% and 70% of the ferromagnetically active length of the projectile, preferably between 40% and 60% of the ferromagnetically active length of the projectile and even more preferably it is equal to half of such length. The submultiple **1/n,** the value of which determines the length of individual coils 3, can be optimised depending on constructive and economic parameters, in a field in which the value of n ranges for example between 2 and 10 and preferably between 3 and 6 and this causes coils 3 to have as a result a remarkably shorter length than that of projectile 1.

[0027] According to an important feature of the present invention, said reduced-length coils 3 are then sequentially activated in groups 4 of more coils, instead of individually as in the above-described Hilmar prior art, so as to create on projectile 1 the electromagnetic attraction effect of a coil of an optimal length, however, without being affected by the drawbacks typical of the same.

[0028] Moreover, as projectile 1 moves forward, also the position of the group of activated coils 4 is correspondingly moved forward, by a single coil 3 at a time and hence in an extremely gradual way, depending on the position reached by projectile 1 and with such a synchronisation as to always maintain on projectile 1 the maximum electromagnetic force. The curve of said force F against the position P of projectile 1 hence takes up the shape schematically represented in the top part of fig. 4 and the system hence always works in conditions by which electromagnetic attraction force F is obtained with the maximum efficiency and hence with the smallest energy waste. Fig. 4 shows an embodiment of the invention in which the submultiple **1/n** adopted for the length of coils 3 is 1/3 and wherein the group 4 of simultaneously activated coils comprises precisely 3 coils, so that each group 4 of simultaneously activated coils offers the same performances that a coil of optimal length, as defined above, would have on the projectile.

[0029] From what has been stated above it is clear that, when reducing the value of submultiple **1/n** selected for determining the length of coils 3, the curve of the electromagnetic force F imparted on the projectile changes from a pulsating trend to a more and more constant trend, in the face of an increasing complication and cost of the device. A simple optimisation calculation hence allows to define, for each individual device or type of loom the preferred value for said submultiple in global economic terms.

[0030] In order to adequately control the sequential activation of coils 3, along the launch trajectory there are provided position sensors 5 arranged between adjacent coils 3. Due to the reduced length of coils 3 sensors 5 can be arranged at a very close pitch so that the position control of projectile 1 is particularly effective. Sensors 5, chosen between one of the number of types available on the market (optical, infrared, capacitive, induction, etc.) depending on the particular embodiment of the invention, detect the position of projectile 1 within the electromagnetic weft insertion device and signal such position, by means of a line 6, to an electronic control CPU. This CPU receives from the loom control unit a signal 7 of the supply current of the coils (3) and, depending on the position of projectile 1, activates power stages 8 so as to supply such current sequentially - moving by a single coil 3 each time - in subsequent groups of coils 4 so as to simulate at each moment the electromagnetic force of a coil of optimal length, arranged in the ideal relative position with respect to projectile 1 to be accelerated, i.e., with the projectile tip in the proximity of the entry of the first coil 3 of each group of coils 4. The above-described electronic management of reduced-length coils 3 hence allows to accomplish the launch of projectile 1 reducing to a minimum the energy losses due to the Joule effect in the coils, hence remarkably containing the disposal problems of the heat thus produced and maximising the overall effectiveness of the system.

[0031] To the CPU for the management of the sequential activation of the groups of coils 4 a closed-loop control system 10, shown in fig. 5, can furthermore be added. In this case, instead of the already predefined current reference 7 described above, an external speed V or position S reference 9 at time t, coming from the loom, arrives to the control system 10. In other words, such external reference 9 is updated at any instant by the central control of the loom, depending on the angular position reached by the same or on a set loom operation time cycle. Such reference signal 9 is compared in block 11 with the actual position of projectile 1, as detected by sensors 5, and the current reference 7 sent to the control CPU is suitably modulated to slow down or accelerate projectile 1 depending on the above-said external reference.

[0032] Closed-loop control 10 hence allows to cause the projectile to follow a set motion law, hence allowing to equalise the power dissipated by the individual coils 3 while taking into account the fact that, given the low initial speed of projectile 1, first coils 3 are activated for a longer time.

[0033] The external reference 9 coming from the loom can finally comprise specific information on the individual weft being processed each time, so that the motion law of the projectile can be changed at each loom cycle, depending on the requirements of the particular weft being inserted.

[0034] With respect to the known electromagnetic devices for projectile launching, the electromagnetic device of the present invention comprises a number of advantages, among which:

- reduction of the overall costs, both manufacturing costs and running costs;
- high reliability;
- high efficiency;
- reduced mechanical stress of the weft and/or controllable mechanical stress depending on the weft type;
- control of the projectile acceleration curve;
- reduced use of projectile guiding systems (hooks), source of significant weaving drawbacks, due to the high launch directionality;
- higher working frequencies with respect to gripper looms. However, it is understood that the invention must not be considered limited to the special arrangements illustrated above, which make up only exemplifying embodiments thereof, but that different variants are possible, all within the reach of a person skilled in the field, without departing from the scope of protection of the invention, which is exclusively defined by the following claims.

Claims

1. Electromagnetic weft yarn insertion device in a projectile weaving loom of the type wherein projectiles (1) are launched into the shed through the electromagnetic force caused by a plurality of adjacent coils (3) aligned along the projectile trajectory and sequentially activated during projectile movement, **characterised in that** said coils (3) are activated in groups of more consecutive coils (4) **and in that** the position of the group of activated consecutive coils (4) is sequentially moved forward by a single coil (3) at a time in agreement with the projectile (1) position.

2. Electromagnetic weft yarn insertion device as in claim 1, wherein the length of each individual group of consecutive coils (4) ranges between 30% and 70%, and preferably between 40% and 60% of the ferromagnetically active length of the projectile (1).

3. Electromagnetic weft yarn insertion device as in claim 2, wherein said groups of more consecutive coils (4) have an overall length substantially equal to half the ferromagnetically active length of said projectile (1).

4. Electromagnetic weft yarn insertion device as in claim 1, wherein the length of each of said coils (3) correspond to a submultiple **1/n** of the length of an optimal coil which causes, in static conditions, the desired electromagnetic force on the projectile (1) with the smallest power dissipation due to the Joule effect.

5. Electromagnetic weft yarn insertion device as in claim 4, wherein in said submultiple **1/n,** number **n** is preferably an integer number ranging between 2 and 10 and preferably between 3 and 6.

6. Electromagnetic weft yarn insertion device as in claim 5, wherein said groups of simultaneously-activated, more consecutive coils (4) consist of **n** coils.

7. Electromagnetic weft yarn insertion device as in any one of the preceding claims wherein the activation of a group of more consecutive coils (4) is started when the projectile tip (1) lies at the entry of the first coil (3) of said group.

8. Electromagnetic weft yarn insertion device as in any one of the preceding claims, furthermore comprising a plurality of position sensors (5) arranged between adjacent coils (3), said sensors being apt to detect the projectile (1) position along the path within said coils (3) and to send a signal of said position to an electronic control processing unit (CPU) which causes the sequential activation of the coil groups (4).

9. Electromagnetic weft yarn insertion device as in claim 8, furthermore comprising a closed-loop control system (10) controlled through an external speed (V) or position (S) reference signal (9) at a certain time (t), coming from the loom depending on its angular position or on a set loom operation time cycle, wherein such external reference signal (9) is compared (in 11) with the actual position of the projectile (1), as detected by said sensors (5), and the current reference signal (7), sent to said control processing unit (CPU) for the sequential activation of said coil groups (4), is suitably modulated to slow down or accelerate the projectile (1) according to the values taken up by said external reference signal (9).

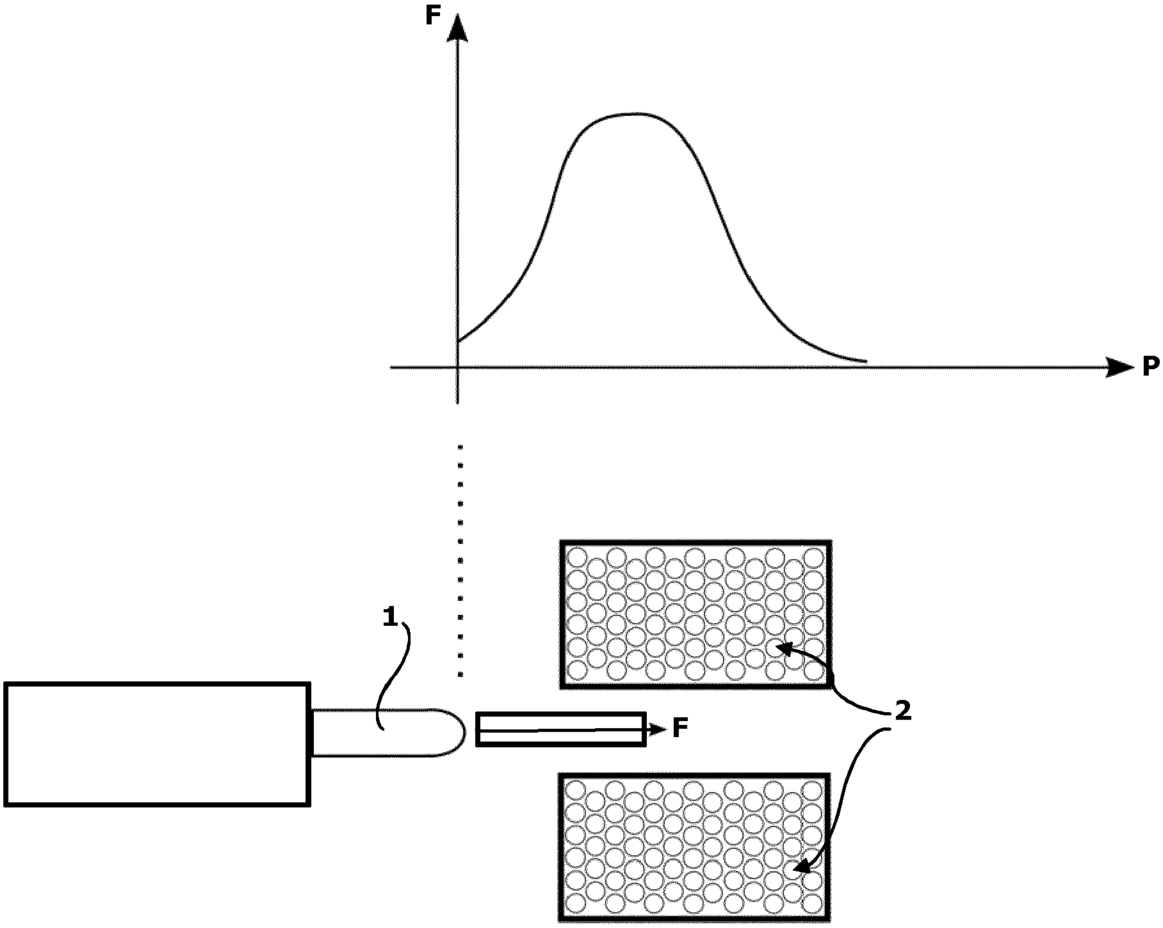

Fig. 1 (PRIOR ART MITSUBISHI)

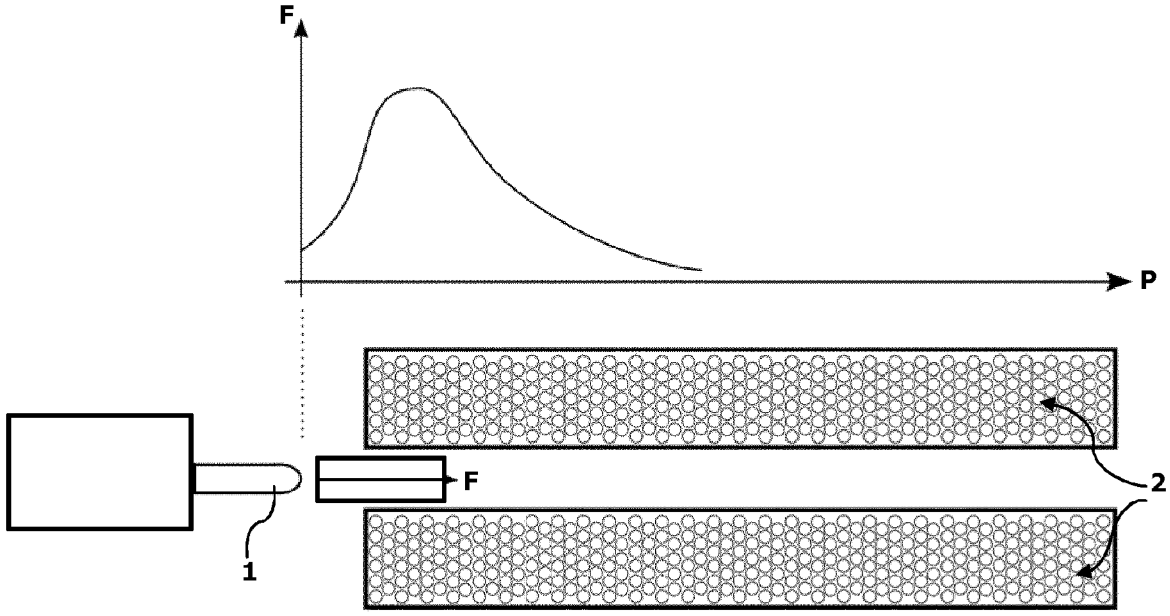

Fig. 2 (PRIOR ART – EXTENDED COIL)

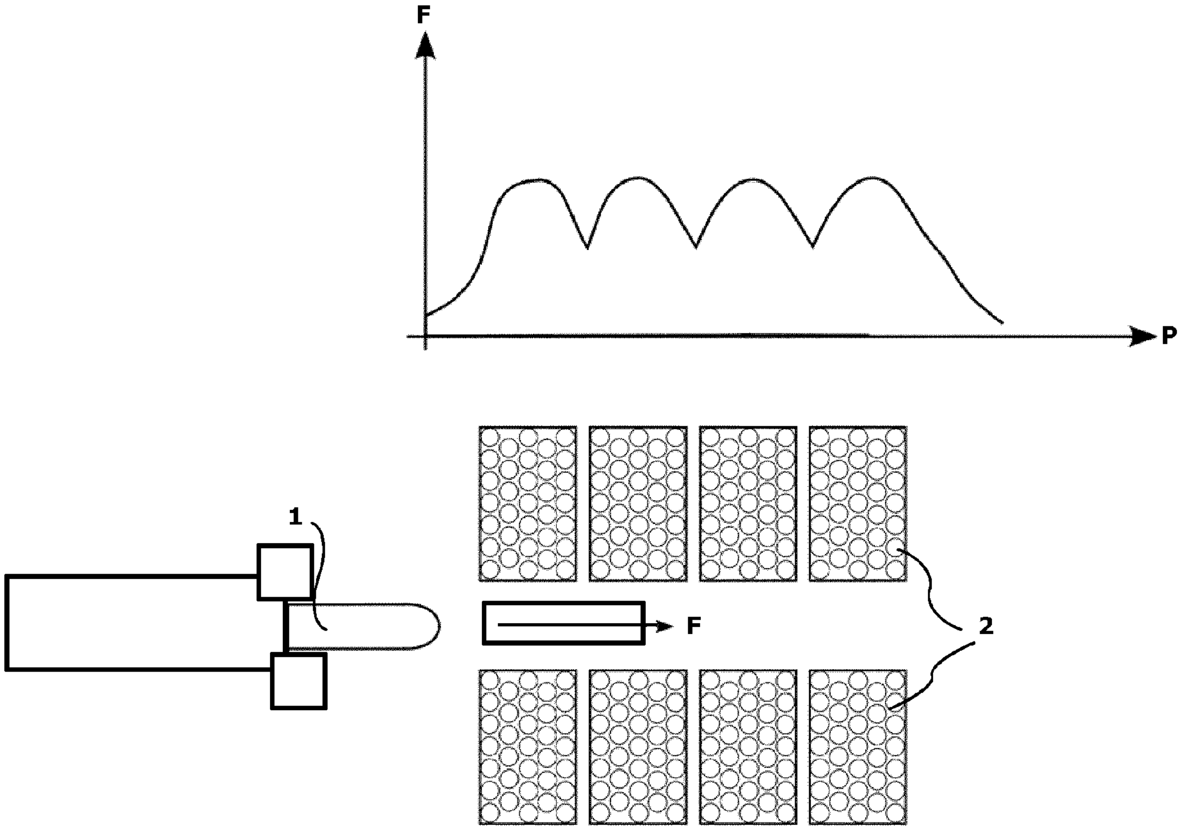

Fig. 3 (PRIOR ART - HILMAR)

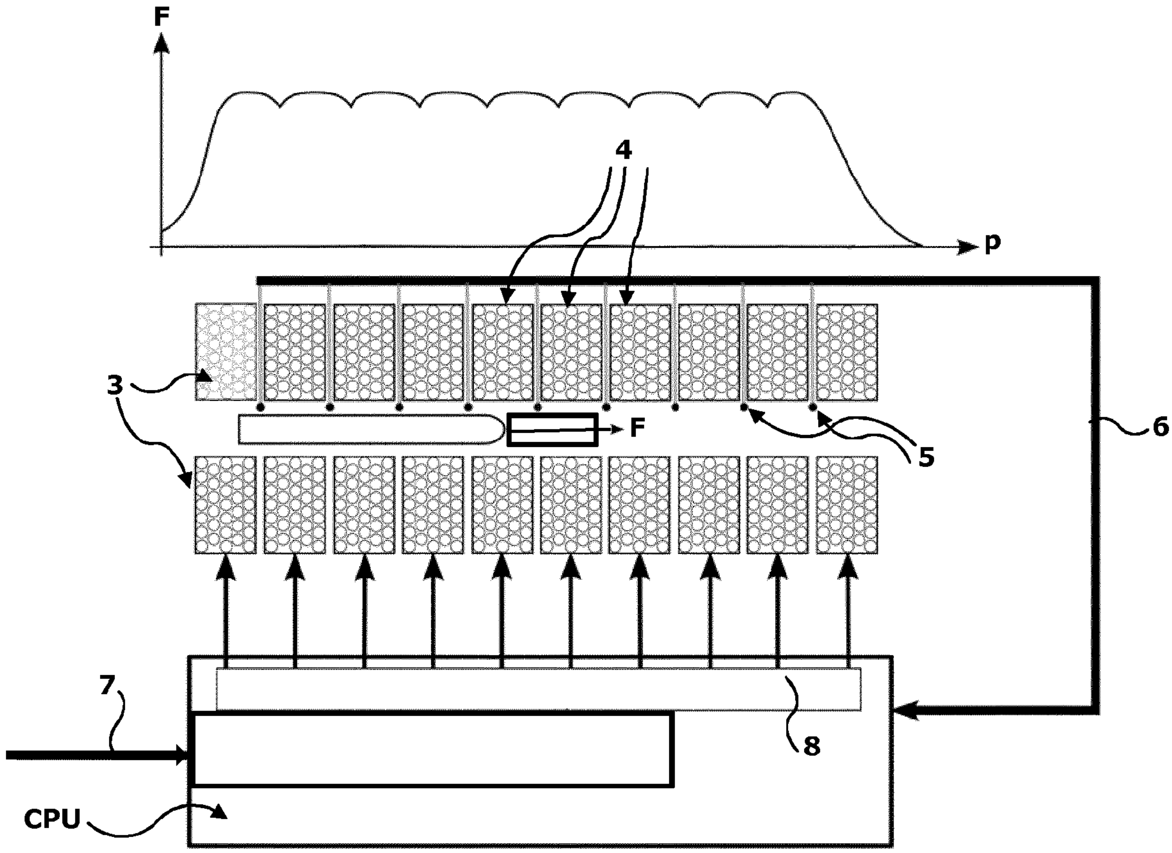

Fig. 4

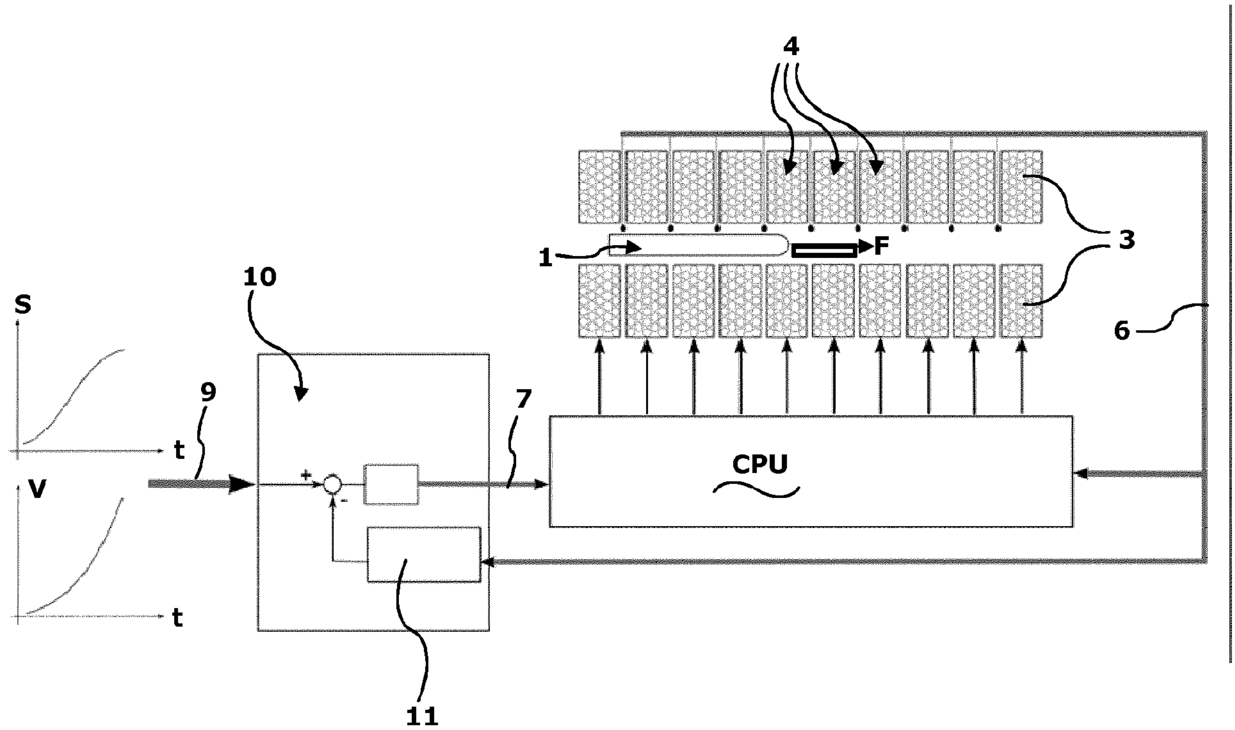

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 3198

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	DE 10 2009 019935 A1 (KONRAD HILMAR [DE]) 19 November 2009 (2009-11-19) * paragraph [0025] - paragraph [0031] * * figures 1-6 *	1-9	INV. D03D47/25 D03D49/44
A	FR 534 033 A (C BELUZE; H CAILLON; L PELOSSE) 16 March 1922 (1922-03-16) * the whole document *	1-9	
A,D	S A MIRJALILI: "Using Electromagnetic Force in Weft Insertion of a Loom", FIBRES AND TEXTILES IN EASTERN EUROPE, vol. 13, no. 3(51), 30 September 2005 (2005-09-30), pages 67-70, XP055229450, * the whole document *	1-9	
A	FR 1 318 917 A (ELECTRONICA TEXTIL S A) 22 February 1963 (1963-02-22) * claims 1, 2 * * figures 1-4 *	1-9	

TECHNICAL FIELDS SEARCHED (IPC)

D03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 July 2016	Hausding, Jan

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CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102009019935 A1	19-11-2009	NONE	
FR 534033 A	16-03-1922	NONE	
FR 1318917 A	22-02-1963	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 2003198 A **[0005]**
- JP 48445591973 B **[0008]**
- DE 102009019935 **[0013]**

Non-patent literature cited in the description

- *Fibres & Textiles in Eastern Europe,* July 2005, vol. 13 (3, 51), 67-70 **[0009]**