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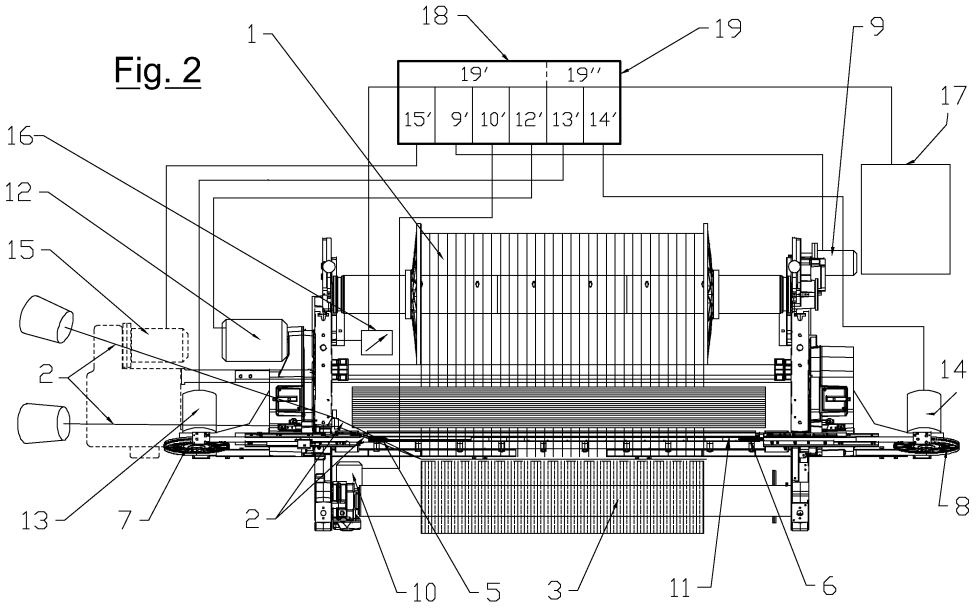
(54) **Modular drive system for weaving machines**

(57) A modular drive system (18) for weaving machines, adapted to realise an individual actuation of each mechanism belonging to a set of mechanisms which intervene in the weft insertion cycle and, consequently, in the formation of the fabric, with variable mutual phasing between one actuation and the other, according to the technological weaving needs, and possibility of individual variation of the motion diagram of each servo-mechanism; the drive system (18) comprises a series of control devices, each of which is composed of two parts, of which one operates individually on the assigned drive device, while the second part is integrated inside one common base (19) with the other control devices, regarding the shareable functions of the machine, which can be the system of power supply, communication, management and control, energy recovery or electrical flywheel, and braking for safely stopping the machine, etc.

Fig. 2



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Description

[0001] The present invention refers to a modular drive system for weft and warp weaving machines.

[0002] More specifically, the invention regards an integrated drive and control system for the individual actuation of each mechanism of a set adapted to carry out the insertion cycle of the weft, which, sequentially repeating, leads to the formation of the fabric in a weaving machine.

[0003] The formation process of a weft and warp woven fabric fundamentally consists of inserting weft threads transverse to warp threads, which, with the aid of eyes or heddles in which a thread is inserted in each, are appropriately separated in positions arranged on different levels so to form a shed wherein a weft thread is introduced which is beat by a reed against the edge of the fabric being formed.

[0004] After the beating, the heddles close, aligning themselves so to reopen in an analogous manner to that previously described but according to a different order, determined by the type of fabric weave which it is desired to produce.

[0005] Other mechanisms, beyond those described, intervene in the so-called "insertion cycle of the weft", which, sequentially repeating, leads to the formation of the fabric in a weaving machine; in general, the fundamental parts necessary for carrying out the above-described operations are the following:

- mechanisms adapted to feed warp threads at controlled speeds and tensions;
- drive mechanisms of the position of the warp threads for forming a shed;
- insertion mechanisms of the weft shed so to weave it with the warp threads;
- beat-up mechanism, which by means of a reed, sequentially draws close the wefts weaved with the warp threads;
- mechanism of leading the fabric with a predetermined ratio of advancing and rolling up outside the machine.

[0006] It is known from the state of the art of the weaving machines that each of the above-mentioned elements is actuated by specific drive devices, which can be mechanical or electronic, and for the insertion of the weft, mechanical or fluid-mechanical. All the actuation must be synchronised in the context of the sequence of the weft insertion cycles; moreover, the mutual phasing between one actuation and the other is not fixed, but variable as a function of the fabric in production, according to parameters theoretically defined and experimentally optimised.

[0007] Types of weft and warp threads, weft/warp weave, cover factor of the fabric, and width of the fabric are some of the characteristics which require specific adjustments of the machine in order to optimise its productivity in every application; such adjustments, nevertheless, must be made when the machine is stopped, before starting, and involve a waste of time and resources which penalise the weaving costs.

[0008] Object of the present invention is therefore that of realising a system of modular drives for weaving machines, which permit driving and controlling the individual actuation of each mechanism which intervenes in the formation process of the fabric, simplifying and improving the adjustment problems mentioned above.

[0009] Another object of the invention is to realise a modular drive system for weaving machines which permits driving and controlling the individual actuation of each mechanism which intervenes in the insertion cycle of the weft, with variable mutual phasing, according to the technological needs of the weaving, with the possibility of individual variation of the motion diagram of each servomechanism connected with the related mechanism and with devices adapted to obtain the energy recovery in the pulsating course of the typical drive torques of the weaving cycle.

[0010] Further object of the invention is that of realising a modular drive system for weaving machines which is of easy, compact, rational construction and of reduced size with respect to the prior art, adapted for functioning at high speeds, thus improving the machine's productivity.

[0011] Not last object of the invention is that of realising a modular drive system for weaving machines, as well as an integrated control system for the individual actuation of the fabric formation mechanisms, which permits utilising the machine for any type of weft and warp thread and/or fabric, intervening with quick and easy adjustments for every fabric to be produced, at the start or during the weaving.

[0012] Such objects are achieved by realising a modular drive system for weaving machines, according to the attached claim 1.

[0013] Other technical characteristics are mentioned in the subsequent claims.

[0014] Advantageously, each of the controls of the servo-drives, respectively associated with the formation mechanisms of the fabric, is composed of two parts, one of which operates individually regarding the needs of the drive device to which it is assigned, while the second is integrated in a common base with the other controls regarding all shareable functions, which can be the power supply system, the communication system, the management and control system, the energy recovery system, the braking system for emergency stopping, etc.

[0015] The system can be advantageously applied to every type of weaving machine, such as rapier looms or machines and/or air jet looms.

[0016] Further characteristics and advantages of a modular drive system for weaving machines according to the present invention will be more evident from the following description and from the attached drawings, provided as exemplifying but not limiting, wherein:

- Figure 1 shows a front schematic view of a weaving machine, in particular of rapier type, equipped with the modular drive system, object of the present invention;
- Figure 2 is a schematic top, plan view of the rapier weaving machine of figure 1, according to the invention;
- Figure 3 is a schematic plan view of an air jet weaving machine, equipped with the modular drive system, object of the invention.

[0017] With particular reference to the mentioned figure 1, the warp threads entering the rapier weaving machine (loom) are generically indicated with 1, the weft threads are generically indicated with 2, while the fabric forming at the exit of the rapier weaving machine according to the present invention is indicated with 3.

[0018] Moreover, a device for the formation of the warp shed is indicated with 4, a series of eyes or heddles are indicated with 4', in each of which a thread is inserted, adapted to separate the warp threads 1 into positions, the left hand gripper is indicated with 5, the right hand gripper is indicated with 6 and indicated respectively with 7 and 8 are a drive gear of the left hand gripper 5 and a drive gear of the right hand gripper 6; the left hand 5 and the right hand 6 grippers slide adjacent to the reed 11 of the sley.

[0019] The weaving machine also comprises a drive motor 9 for feeding the warp threads, a drive motor 10 for advancing the fabric 3, a drive motor 12 of the sley, a drive motor 13 of the left hand gripper 5, a drive motor 14 of the right hand gripper 6 and a drive motor 15 for the formation of the warp shed.

[0020] With reference in particular to the attached figure 2, finally, a reference and signalling device of the cycle phase is indicated with 16, an electric control box of the entire weaving machine is indicated with 17 and the modular control system, according to the invention, is indicated with 18 which comprises a common base 19, with the possibility of being subdivided in turn into modules which, in the example of the attached figures, are two and consist of the modules 19' and 19''.

[0021] The modular control system 18 includes, in addition to the common base 19, the servo-drive 9' of the drive motor 9 for the feeding of the warp 1, the servo-drive 10' of the drive motor 10 for the advancement of the fabric 3, the servo-drive 12' of the drive motor 12 of the sley, the servo-drive 13' of the drive motor of the left hand gripper 5, the servo-drive 14' of the drive motor 14 of the right hand gripper 6 and the servo-drive 15' of the drive motor 15 for the formation of the warp shed.

[0022] In particular, in figure 3, in which an air jet weaving loom is illustrated and the same devices of the figures 1 and 2 are indicated with the same reference numbers, the devices used for the insertion of the weft in the air jet loom are likewise indicated with 20 and 21.

[0023] The functioning of the weaving machine and related modular drive system, according to the present invention, is substantially the following.

[0024] The warp threads 1 advance, powered by the drive motor 9, while the formation device of the shed 4 positions such warp threads 1 up high or low, so to form a shed, which permits weaving the warp threads with the weft threads 2 transversely inserted with the alternate motion of the left hand 5 and right hand 6 grippers (in the case of rapier looms) or by means of the devices consisting of pre-feeders and nozzles 20 and 21 (in the case of air jet looms), in order to realise the fabric 3; in the case of the rapier looms, the grippers 5, 6 are driven by respective drive gears 7,8, by the independent servo-drives 13', 14' integrated in the modular control system 18, and by the respective drive motors 13, 14.

[0025] The present invention realises a system of individual drives of the basic devices of the weaving machine (loom), integrated in a platform which groups together all of the technically shareable functions, with advantages in terms of cost reduction, high processing potentialities of the control programs, optimal capacities of compensating the pulse power flows and reducing the energy consumption, and finally with the possibility of putting the machine in a safe position in case of emergency.

[0026] The set of servo-drives 9', 10', 12', 13', 14', 15', integrated in the modular control system 18 and of the respective drive motors 9, 10, 12, 13, 14, 15, can operate in a closed-loop control system, synchronised by means of signals coming from the reference device 16 and/or from position or velocity transducers situated on the drive motors 9, 10, 12, 13, 14, 15, or a closed-loop system of "sensorless" type, synchronised by means of signals generated by the modular control device 18, or in an open-loop control system.

[0027] The drive of the sley is a direct drive between the drive motor 12 and sley mechanism 11, and the related servo-drive 12' can actuate the mechanism at constant or modulated rotation speed, as a function of the technological needs of the fabric to be produced.

[0028] The servo-mechanism of the formation mechanism of the warp shed, composed of the drive motor 15 and by the related servo-drive 15', can actuate the heddles 4 with phasing and motion laws adjustable in real time, as a function of the technological characteristics of the threads and fabric 3.

[0029] The insertion of the weft 2 can occur by means of fluid-mechanical devices (not indicated in the attached figures), actuated by means of pressure timing and control systems, or by means of the grippers 5 and 6, actuated by servo-mechanisms, respectively consisting of the drive motors 13 and 14 and the related servo-drives 13' and 14'; the aforesaid servo-mechanisms, of compact structure and lacking complex and costly mechanical components, can be of position control type or of speed control type in electric gear or electric cam with other members of the machine.

[0030] The motion laws of the grippers 5 and 6, determined by the technological needs of the weaving proc-

ess, in addition to that of the mechanical functionalities of the set, deriving from the dynamic loads due to the running and acceleration progressions of the various machine parts, are realised by means of software programs, with appropriate algorithms which make said laws adaptable, in a versatile manner, to the objectives of the present invention.

[0031] Moreover, according to the invention, on the common base 19, possibly subdivided into the sub-modules 19' and 19" of the modular control system 18, the unwinding system of the warp 9 and the leading system 10 of the fabric 3 are integrated, which have control servo-drives 9' and 10', specific for the parts necessary for the specific functions assigned to the them, while they use the potentialities of the common base 19 of the modular control system 18 for the functions which they can share with the other servo-drives 12', 13', 14' and 15'.

[0032] From the above description the characteristics of the modular drive system for weaving machines, which is object of the present invention, as with its advantages are clear. In particular, they regard the following aspects:

- simple, compact structure, with reduced size, lacking complex and/or costly mechanical components;
- high processing potentialities of the control programs;
- capacity to compensate the pulse power flows and reduce the energy consumption, with the possibility of placing the machine in a position of safety in case of emergency;
- possibility of realising an electrical power supply system of the servo-drives, consisting of a single bus in continuous current, which permits recovering the braking energy of a motor in deceleration phase for the benefit of other motors in acceleration or constant speed phase;
- possibility of realising a network energy recovery system during the phases of slowing and braking, with continuous control of the absorption capacities of the electrical power supply network;
- possibility of realising a variable mutual phasing of the formation mechanisms of the fabric, according to the technological needs of weaving;
- possibility of realising an individual variation of the motion diagram of each servo-mechanism;
- realisation of an integrated control system for the individual actuation of each formation mechanism of the fabric.
- possibility of realising appropriate software control programs of the motion laws of the grippers, so to adapt them in a versatile manner to the objectives of the invention.

[0033] Finally, it is clear that numerous other variants may be made to the modular drive system for weaving machines in question, without departing from the principles of novelty inherent in the inventive idea, thus as it is clear that, in the practical actuation of the invention, the materials, forms, and sizes of the details illustrated can be of any type according to needs and the same can be substituted with other technically equivalent elements.

Claims

1. Modular drive system (18) for weaving machines, adapted to realise an individual actuation of single mechanisms belong to a set, which intervenes in the insertion cycle of the weft and consequently in the formation of the fabric, in a weaving machine, **characterised in that** said drive system (18) comprises a plurality of control devices, each of which composed by at least two parts of which at least one first part operates individually on at least one assigned drive device, and at least one second part is integrated inside at least one common base (19) with the other control devices, regarding the shareable functions of the machine.

2. Modular drive system (18) as in claim 1, **characterised in that** said shareable functions of the weaving machine include one or more among at least one electrical power supply system, at least one communication system, at least one management and control system, at least one energy recovery system and/or at least one emergency stopping system.

3. Modular drive system (18) as in claim 1, **characterised in that** said base (19), common with the other control devices, can be subdivided into at least two modules (19', 19'').

4. Modular drive system (18) as in claim 1, **characterised in that** said drive system (18) includes a plurality of servo-drives (9', 10', 12', 13', 14', 15') of respective motors (9, 10, 12, 13, 14, 15), of rotational type or of another type, actuating said formation mechanisms of the fabric.

5. Modular drive system (18) as in claim 1, **characterised in that** said formation mechanisms of the fabric can be used, in particular, in rapier weaving machines or in air jet weaving machines.

6. Modular drive system (18) as in claim 5, **characterised in that** said rapier weaving machines, in addition to comprising at least a first drive motor (9) for feeding the warp threads (1), at least a second drive motor (10) for the advancement of the fabric (3), at least a third drive motor (12) of the sley, and at least a fourth drive motor (15) for the formation of the warp shed, can also comprise at least a fifth drive motor (13) of a left hand gripper (5) and at least a sixth drive motor (14) of a right hand gripper (6).

7. Modular drive system (18) as in claim 4, **character-**

ised in that said servo-drives (9', 10', 12', 13', 14', 15') integrated inside the modular system (18) and the respective drive motors (9, 10, 12, 13, 14, 15) can operate in a closed-loop control system, synchronised by means of signals coming from the reference device (16) and/or from position or velocity transducers situated on said drive motors (9, 10, 12, 13, 14, 15).

8. Modular drive system (18) as in claim 7, **characterised in that** it can operate in a closed-ring control system of "sensorless type", synchronised by means of signals generated by the modular control device (18).

9. Modular drive device (18) as in claim 7, **characterised in that** it can operate in an open-loop control system.

10. Modular drive system (18) as in claim 6, **characterised in that** said third drive motor (12) of the sley is connected to at least one related servo-drive (12'), adapted to actuate a beat-up mechanism (11) at constant rotation speed or at modulated speed.

11. Modular drive system (18) as in claim 6, **characterised in that** said sixth drive motor (15) of the formation mechanism of the shed is connected with at least one servo-drive (15'), adapted to actuate a plurality of heddles (4) with phasing and motion laws adjustable in real time.

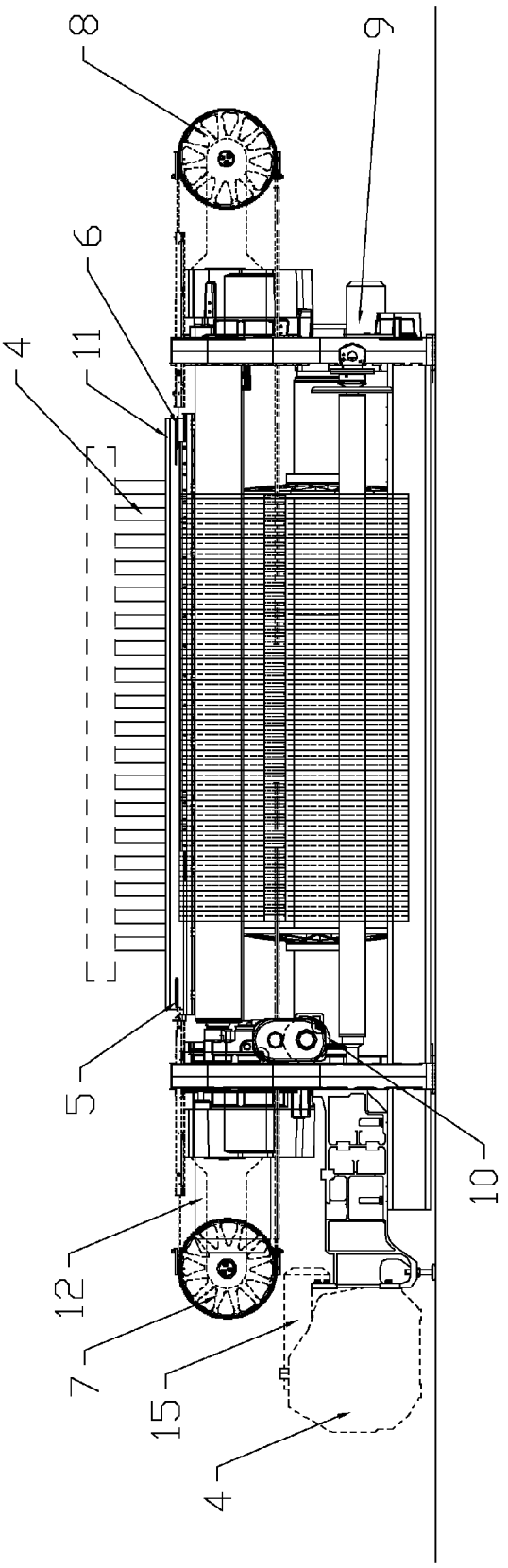
12. Modular drive system (18) as in claim 6, **characterised in that** said fifth drive motor (13) and said sixth drive motor (14) for the movement of the left hand (5) and right hand (6) grippers of the rapier weaving machine are connected to respective servo-drives (13', 14'), independent from each other.

13. Modular drive system (18) as in claim 2, **characterised in that** said electrical power supply system can be considered a type of electrical flywheel, since it is capable of transferring energy from one or more servo-mechanisms, when there is excess energy, to others which require energy.

14. Modular drive system (18) as in claim 11, **characterised in that** the electrical power supply system and/or electrical flywheel system can be realised by means of a single power supply bus in continuous current, with the possibility of realising an energy recovery system in the network.

15. Modular drive system (18) as in claim 1, **characterised in that** it is adapted to offset the pulse energy flows, with the possibility of placing the machine in a position of safety, in case of emergency.

Fig. 1



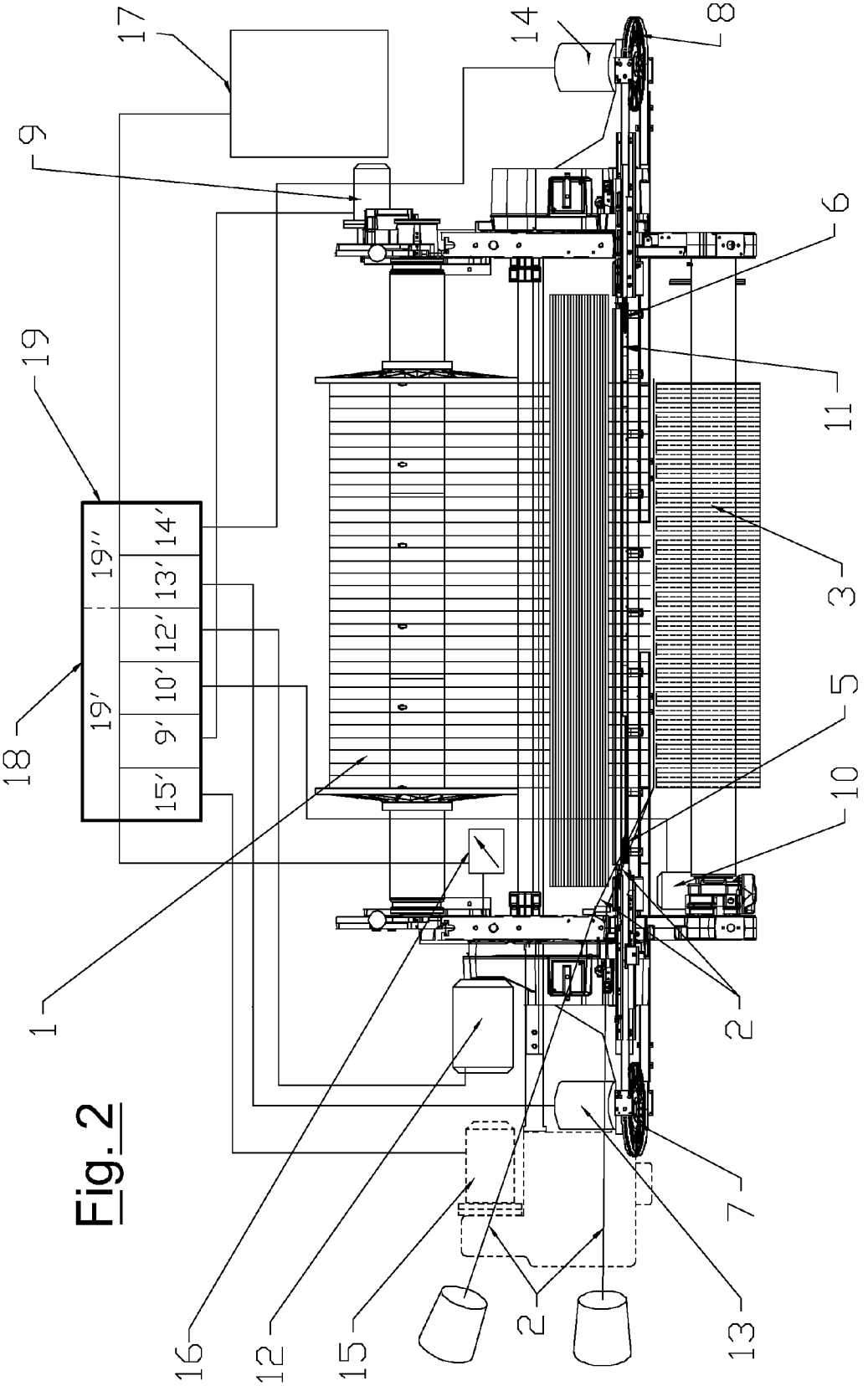


Fig. 2

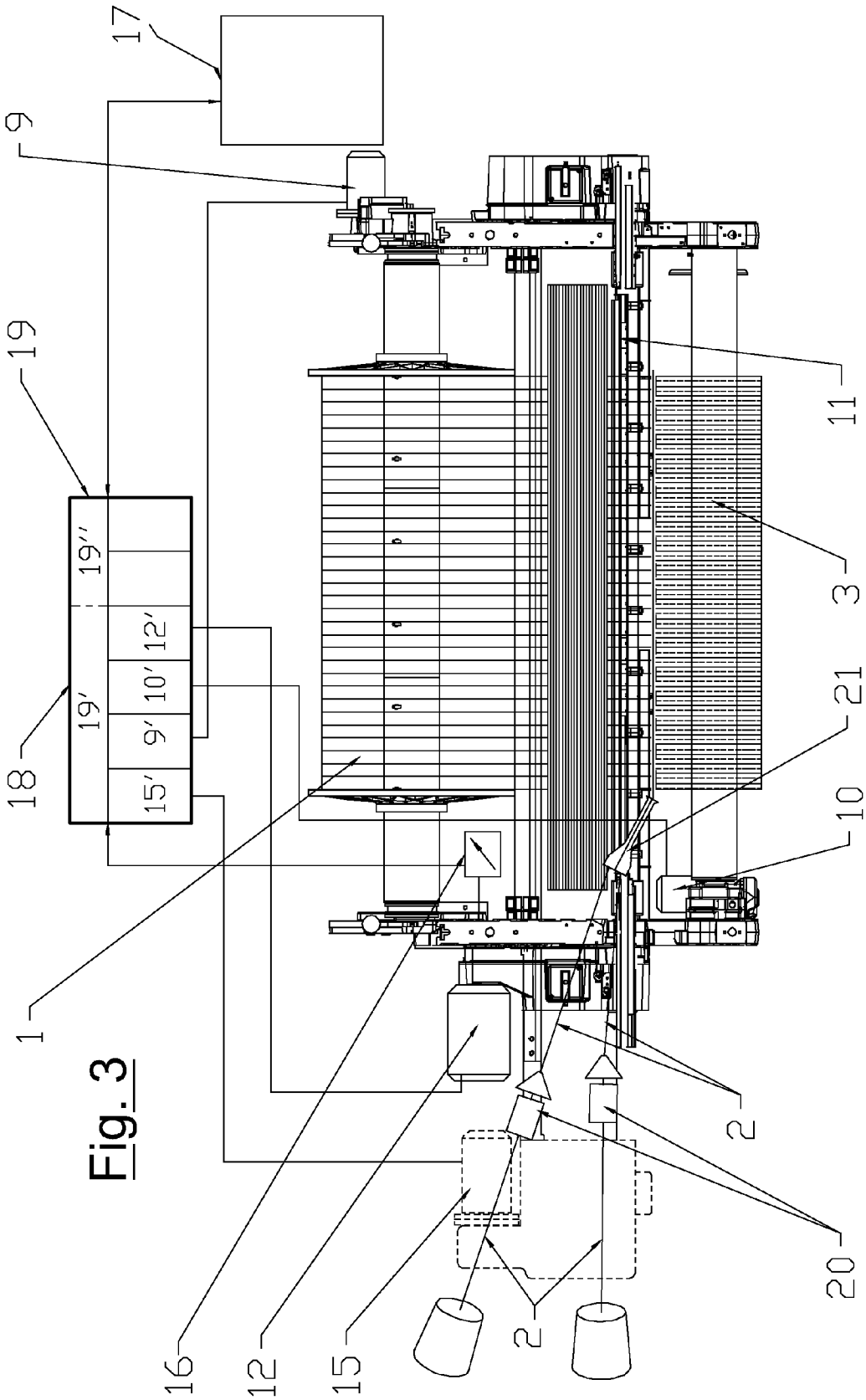


Fig. 3