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(54) Benævnelse: **Landbrugsmaskine**

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The present invention relates to an agricultural machine, in particular to a mowing unit combination, with at least two workings units, which are arranged one behind the other in the direction of travel and cover neighboring travel lanes offset to one another in terms of the lane, wherein at least one of the two workings units can be adjusted relative to the one or multiple other working units transversally to the direction of travel, as well as with an electronic control device for controlling the travel lanes passed over by the working units, wherein the control device comprises a crop edge detection device for detecting the course and/or the position of a crop edge, as well as a steering angle control unit for providing a steering angle signal depending on the detected course and/or the detected position of the crop edge.

In order to achieve an as high as possible area-covering performance by large cutting widths, mowing unit combinations are often used, which include a mowing unit mounted at the front as well as mowing units mounted on the rear and arranged to protrude laterally. The individual mowing units are arranged offset in lane to one another, so that they pass over different travel lanes, wherein it is sought to dispose the individual mowing units, with respect to the lane offset, at an as large as possible distance from one another, so that the travel lanes passed over by the mowing units overlap one another as little as possible and, as far as possible, for each moving unit the maximum working width thereof is exploited in the best-possible manner. However, one possible boundary condition lies with the lane offset occurring when turning a corner, which is generated by the trailing of the rear-mounted mowing units. In the event that the moving units are fixed in such a way that their travel lanes do not have an overlap when traveling straight ahead and are essentially exactly next to one another, a travel lane strip is formed - when driving through a corner in one direction - which strip is not processed by any of the mowing units, while an increasing overlap of the travel lanes occurs when driving through a corner in the other direction.

In order to compensate this effect when driving through a corner, it has already been proposed to have at least one of the mowing units suspended in a transversally displaceable manner, and to provide a transversal drive that causes a corresponding transversal displacement when driving through a corner. For example, DE 44 09 113 C1 describes a mowing unit combination having a central front-mounted mowing unit, which is flanked by two laterally mounted lateral mowing units. The front-mounted mowing unit can be displaced transversally to the direction of travel, wherein the displacement path is controlled to be directly proportional to the steering angle. Although an improved exploitation of the maximum working widths can be achieved here, there is, however, a need for further improvement in terms of the best-possible exploitation of the working widths in this directly proportional control of the transversal displacement in relation to the steering angle. Similarly, EP 1 321 027 A1 describes a mowing unit combination with a central, front-mounted mowing unit as well as two laterally protruding, rear-mounted mowing units, wherein, depending on a given steering geometry, the rear mowing units can be adjusted laterally to prevent non-processed travel lane strips between the individual workings units. A working machine of the above-mentioned type is known from EP 14 05 556 A2, which retracts laterally displaceable mowing units when driving through a corner in order to maintain the overlap with front mowing units, wherein the corresponding transversal displacement is controlled depending on an average curve radius determined from the steering angle displacement of the differential of the carrier vehicle.

Such controls, which control the transversal displacement of individual working units fixedly depending on the steering angle and steering geometry, can, however, regularly not fully exploit the maximum working width of the working units, since deviation interferences such as a scraping of the wheels, transversal displacement by driving through slopes, etc., often occur in practice, and which have to be taken into account in the form of an additional overlap as a matter of precaution, in order to prevent non-processed travel lane strips. Moreover, excessively sharp steering movements by the machine operator lead to driving movements that impair the optimum exploitation of the working widths of the working units.

Against this background, the object underlying the present invention is to provide an improved agricultural machine of the above type, which avoids the disadvantages of the prior art and develops this prior art in an advantageous manner. Preferably, a control of the agricultural machine is to be created, which enables an optimum exploitation of the working widths of its working units.

According to the invention, this object is achieved by means of an agricultural machine having the features of claim 1. Preferred embodiments of the invention are the subject-matter of the dependent claims.

For the best-possible exploitation of the workings widths of the working units, a combination of steering aid and automatic control of the lateral and transversal displacement of the at least one transversally displaceable working unit is proposed. According to the invention, the control device includes a crop edge detection device for detecting the course and/or the position of a crop edge of the ground to be processed and/or of the crop to be processed, a steering angle control unit for providing a steering angle signal depending on the detected course and/or the detected position of the crop edge, an overlap detection device for detecting the overlap of the travel lanes of the working units, which overlap detection device measures the actual travel lane overlap of the working units by means of at least one contactless-operating overlap sensor, as well as an overlap control unit for controlling the transversal drive depending on the measured, actual travel lane overlap. Through the combination, proposed according to the invention, of a steering aid, which works depending on the detection of the crop edge to be processed and significantly improves the so-called connection method, and an automated control of the lateral displacement, the sum of the working width available of all working units can be used in the best-possible manner. On the one hand, the laterally most-protruding edge of the respective working unit is guided along the crop edge as closely as possible by the steering aid, so that no or only minimal working width is given away here. On the other hand, the control of the lateral displacement ensures that the sum of the working widths of the individual working units is always held at a maximum. It is of particular advantage here, that the lateral displacement is not controlled rigidly depending on a steering angle, but the actual overlap is detected by the detection device, so that the actual occurring overlap can in any case be held minimal irrespective of the above mentioned interfering factors such as a scraping of the edges when driving through a corner varying depending on the conditions of the ground, lateral drifting in slopes, and the like, without running the risk that a negative overlap occurs in such a way that non-processed travel lane strips remain between the working units.

In a further development of the invention, the two mentioned control units, i.e. the steering angle control unit and the overlap control unit, can be connected to one another or take each other into account, in particular in such a way that the steering angle control unit also considers the signal of the overlap detection device and/or - vice versa - the overlap control unit also considers the signals of the crop edge detection device.

In particular, in a further development of the invention, the overlap control unit may comprise a pilot control unit, connected to the crop edge detection device, for the planned control of the transverse drive depending on the detected course and/or the detected position of the crop edge. The overlap control unit, according to this configuration of the invention, thus considers both the signal indicating the course and/or the position of the crop edge, and the signal of the overlap detection device indicating the actual overlap of the working units. As a result, for example the overlap between the working units can be made larger in a predictive manner in the event that a curved course of the crop edge requires a sharper steering, which in turn requires a corresponding enlargement of the overlap. On the other hand, the overlap can also be made smaller in a predictive manner in the event that the crop edge and the steering angle therefore to be expected allow for it.

Alternatively or additionally, the steering angle control unit can also consider both signals both from the crop edge detection device and the overlap detection device, for example in such a way that a steering angle provided per se is made smaller in the event that the steering angle determined per se would result in a negative overlap of the working units. On the other hand, the steering angle unit may possibly also provide a more intense steering angle signal, which provides a stronger steering angle if the actual overlap between the working units offers reserves required to that end.

By the mutual consideration of the signals of the crop edge detection device and the overlap detection device, an overall better exploitation of the available working width can be achieved.

In a further development of the invention, the overlap control unit comprises a target value controller which controls the transverse drive of the at least one transversally displaceable working unit in such a way that the overlap between the travel lanes of the working units is controlled to a minimal overlap target value. Alternatively or additionally, the steering angle control unit comprises a target value controller, which defines the steering angle in such a way that the distance of the laterally most-protruding travel lane edge of the respective working unit from the crop edge is controlled to a minimal distance, or that the coverage of the crop edge by the travel lane of the respective working unit is controlled to a minimal coverage target value. In other words, the steering angle is determined in such a way that the most lateral working unit is guided along the crop edge in a most sharp manner, in order to achieve a maximum working width utilization.

The mentioned target value controllers of the overlap control unit or of the steering angle control unit can generally be of different design. According to an advantageous configuration of the invention, a self-learning control system is provided, in which the corresponding controllers can be configured as adaptive controllers. Alternatively or additionally, the so-called target value controllers can also be formed as fuzzy logic controllers, which define the steering angle signal and/or the control signal for the transverse drive using fuzzy logic in such a way that an overall optimum utilization of the working widths of the working units is achieved. According to another embodiment of the invention, at least one of the above-mentioned controllers can alternatively or additionally be configured as a PI controller.

The overlap detection device can basically be configured in different ways. According to the invention, it includes a contactless-operating sensor which measures the actually occurring travel lane overlap between the working units. An optically-operating sensor can be used here, for example.

The crop edge detection device can also generally be configured in different ways. In a development of the invention, it includes a likewise contactless-operating sensor, which can advantageously be formed as an acoustic sensor, which according to a possible embodiment is operated in the audible frequency spectrum and scans the crop edge to be detected with acoustic signals in the frequency range from 20 Hz to 20 kHz. A scanning of the ground with acoustic waves in the frequency spectrum audible to the human ear proved to be particularly advantageous, since different crop edges can be detected likewise precisely using this frequency range, possibly preferred sections thereof depending on the application.

In particular for the precise detection of crop cutting edges, the at least one scanning sensor and/or also a further scanning sensor can work in an upper frequency range of the audible spectrum in order to receive signal reflections from the yet uncut crop. Advantageously, the crop edge is scanned with acoustic signals in the range from 10 kHz to 20 kHz here. Preferably, the scanning sensor emits the scanning signal laterally, obliquely and/or from above on to the cutting edge. The crop edge can be detected based upon the time of flight of the signal and the signal.

Advantageously, a wide-band scanning signal is used. By the use of such wideband transmission signals, the scanning becomes sort of immune to noise from the surroundings. In order to enable a favorable signal evaluation here, a bandwidth of at least 5 kHz, preferably approximately 10 kHz, is used in a development of the invention.

According to a preferred embodiment of the invention, the at least one scanning sensor works with a scanning signal pulse from the Gaussian pulse family, wherein, in accordance with an advantageous embodiment of the invention, a second order scanning signal pulse from the Gaussian pulse family can be used here. The pulse duration can basically be selected differently, wherein preferably a pulse duration of less than 10 ms is selected. According to a preferred embodiment of the invention, the at least one scanning sensor operates with a Gaussian signal pulse with a duration in the range of 0.5 to 5 ms, in particular approximately 1 ms.

Alternatively or additionally, the scanning sensor can also be operated in a chirp mode and scan the crop edge to be detected with chirp signals. Using such chirp signals, reflections can already be achieved, depending on the frequency, at the crop cutting edge surface, so that a precise statement about the course of the cutting edge can be made. According to a preferred embodiment of the invention, chirp signals from 10 kHz to 20 kHz are used to that end.

The period of the scanning signals can generally by selected differently. In an advantageous development of the invention, the period is below one second, preferably in the range from 50 ms to 250 ms. According to a preferred embodiment of the invention, a period of approximately 100 ms is used.

Generally, the ground detection device can have multiple scanning sensors, which can operate in different frequency ranges of the audible spectrum. However, in order to achieve a cost-favorable configuration which is simple in construction, it can be provided in a development of the invention that the at least one scanning sensor can be operated in two different operating modes in an alternating manner. In particular, the scanning sensor can be operated with different forms of signals, for example on the one hand with signal pulses from the Gaussian pulse family and, on the other hand, with chirp signals. Alternatively or additionally, it can be provided that the scanning sensor can be operated in different frequency ranges, for example in order to enable an adaption to different crop edges to be scanned. For example, the scanning sensor can be used for scanning a notch in the ground in a frequency range different from that used for scanning a grass cutting edge. One and the same sensor can be adapted to different scanning tasks by the operation of the scanning sensor in different operating modes.

According to a preferred embodiment of the invention, an ultrasound sensor can be provided as the scanning sensor.

In a further development of the invention, the level of automation of the steering aid can be designed as to be differently high. In a basic version, so to say, the generated steering signal can be fed into a display device, for example in the form of a monitor, which displays the detected crop edge course or the detected crop edge position, wherein alternatively or additionally, the steering signal can be visualized, for example in the form of an arrow, which merely defines the direction of the steering wheel angle in a simple manner, but can also define the absolute value or the amount of the steering wheel angle, for example by a different size and/or different color of the respectively indicated symbol. For example, a larger steering wheel angle to be steered to can be indicated by a longer arrow in bright red color, while a smaller steering wheel angle is indicated by a shorter arrow in a paler color.

In particular, however, the steering angle control unit can also actively intervene in the controlling of the system of the agricultural machine. In a preferred development of the invention, the steering angle control unit can comprise a steering device for the automatic or semi-automatic steering of the agricultural machine depending on the generated steering signal, whereby an automatic steering angle of the agricultural machine is obtained. As the case may be, the control can be configured in a semi-automatic manner such that the machine operator, as a superior entity, so to say, can intervene in the control in order to avoid obstacles.

The invention will hereinafter be described in greater detail by means of preferred exemplary embodiments and associated drawings. The drawings show in:

Figure 1: a schematic plan view of a mowing machine in the form of a mowing unit combination with three mowing units including one front-mounted mowing unit as well as two rear-mounted, laterally protruding mowing units, and

Figure 2 a schematic plan view of a mowing machine according to a further embodiment of the invention in the form of a mowing unit combination including one front-mounted mowing unit as well as four rear-mounted mowing units arranged to be offset from another in a staggered manner.

The mowing machine 1 shown in Figure 1 can be mounted in a tractor 2 and includes one front-mounted mowing unit 3 as well as two rear-mounted mowing units 4 and 5, which, when viewed in the direction of travel, are located behind the front-mounted mowing unit 3 and are arranged offset to the right and left with respect to the travel lane of the front-mounted mowing unit 3.

As shown in Figure 1, the two laterally protruding mowing units 4 and 5 are arranged in such a way in terms of their lane that their working width or their travel lane slightly overlap with the working width or the travel lane of the front-mounted mowing unit 3 by the amounts of U1 and U2, so that it is ensured that no unprocessed lane strips remain between the mowing units 3, 4 and 5.

The rear-mounted mowing units 4 and 5 are each displaceable transversally to the direction of travel by means of a transversal drive 6 and 7, so that their position in relation to the lane of the front-mounted mowing unit 3 can be changed. For example, the mowing units 4 and 5 can be suspended on telescopic carriers 8, which can be extended and shortened by means of hydraulic cylinders 9.

The overlaps U1 and U2 of the lanes is monitored by means of an overlap detection device 10. The overlap sensors 11 and 12 are provided to that end, which measure the overlap of the trailing mowing units 4 and 5 with the lane of the mowing unit 3 running ahead. According to the drawn configuration, these overlap sensors 11 and 11 are advantageously provided on the trailing mowing units 4 and 5, but they can generally likewise be provided in the front-mounted mowing unit 3 or the tractor 2. The mentioned sensors 11 and 12 can be optical sensors, for example.

Furthermore, a crop edge detection device 13 is provided, which detects the position and/or the course of the crop edge 14 relative to the mowing unit 1. The crop edge detection device 13 can measure the distance of the mentioned crop edge 14 from one of the mowing units 3, 4, and 5 and/or measure the mowing width indicated with 15 in Figure 1 of the processing strip left (behind) by mowing unit 3 running ahead. Advantageously, the mentioned crop edge detection device 13 includes at least one crop edge sensor 16, which can be arranged on the mowing unit 3 running ahead and detects the crop edge 14 obliquely forward. Alternative or additionally, the mentioned crop edge sensor 16 can also be arranged on the trailing mowing unit 4 or 5, wherein in the embodiment of Figure 1 such crop edge sensors 16 are provided both on the mowing unit 3 running ahead and on the trailing mowing units 4 and 5, to achieve a better detection of the crop edge 14. Advantageously, such crop edge sensors 16 are provided on the right as well as on the left side, in order to be able to detect crop edges in both directions.

The sensors 11, 12 and 16 of the overlap detection device 10 or of the crop edge detection device 13 are connected to a control device 17, which can be provided on the mowing machine 1 per se, and/or on the tractor 2. The signals of the mentioned sensors 11, 12 and 16 are processed on the hand by the steering angle control unit 18, and on the other hand by the overlap control unit 19, which generate a steering angle signal for the steering of the tractor 2 on the one hand, and a signal for the transverse drives 6 and 7 of the transversally displaceable mowing units 4 and 5 on the other hand. The mentioned control units 18 and 19 in each case include target value controllers here, which depending on the detected signals determine the steering angle on the one hand, and the transversal displacement of the transversal drives 6 and 7 on the other hand in such a way that the lateral edge of the mowing unit 4 laterally protruding the farthest toward the crop edge 14 is guided at a minimal distance to the mentioned crop edge 14 on the one hand and, on the other hand, the overlap of the lanes U1 and U2 passed over by the mowing units 3, 4 and 5 becomes minimal.

Figure 2 shows a generally similar arrangement of a mowing machine 1. In addition to the embodiment of Figure 1, two further rear-mounted mowing units 40 and 50 are provided here, which are even further offset outward in lane with respect to the mowing units 4 and 5 ahead, wherein, a lane overlap U3 and U4 is provided again between the mowing units 4 and 5 ahead, on the one hand and the trailing mowing units 40 and 50 on the other hand. The trailing mowing units 40 and 50 can likewise be adjusted transversally via transversal drives 60 and 70.

The overlap detection device 10 includes further overlap sensors 16 detecting the overlap U3 and U4 between the different rear-mounted mowing units. Furthermore, the crop edge detection device 13 includes further crop edge sensors 16 on the additional mowing units 40 and 50, see Figure 2. The control device 17 controls not only the steering angle of the tractor 2 in the above-mentioned ways and manners, but also the transversal adjustment of the additional lateral mowing units 40 and 50.

Patentkrav

1. Landbrugsmaskine, især slåmaskinekombination, med mindst to arbejdsaggregater (3, 4, 5, 40, 50), der er anbragt efter hinanden i kørselsretningen og dækker naboliggende kørespor, der er sporforskudt i forhold til hinanden, hvor mindst et af arbejdsaggregaterne kan indstilles på tværs af kørselsretningen i forhold til arbejdsaggregatet eller de andre arbejdsaggregater ved hjælp af et tværgående drev (6, 7, 60, 70), og med en elektronisk styreindretning (17) til styring af køresporerne, som dækkes af arbejdsaggregaterne (3, 4, 5, 40, 50), hvor styreindretningen (17) omfatter en afgrødekant-registreringsindretning (13) til registrering af en afgrødekants (14) forløb og/eller placering og en dirigeringsvinkelstyreenhed (18) til tilvejebringelse af et dirigeringsvinkelsignal afhængigt af det registrerede forløb og/eller den registrerede placering af afgrødekanten (14), **kendetegnet ved, at** der er tilvejebragt en overlapningsregistreringsindretning (10) til registrering af overlapningen (U1, U2, U3, U4) af arbejdsaggregaterne kørespor ved hjælp af mindst en berøringsfrit arbejdende overlapningssensor (11, 12), der måler faktisk køresporsoverlapning af arbejdsaggregaterne, og en overlapningsstyreenhed (19) til styring af det tværgående drev (6, 7, 60, 70) afhængigt af den målte, faktiske køresporsoverlapning.

2. Landbrugsmaskine ifølge det foregående krav, hvor overlapningsstyreenheden (19) omfatter en forstyreenhed (19a), der er forbundet med afgrødekant-registreringsindretningen (13), til forudseende styring af det tværgående drev (6, 7, 60, 70) afhængigt af det registrerede forløb og/eller den registrerede placering af afgrødekanten (14).

3. Landbrugsmaskine ifølge et af de foregående krav, hvor dirigeringsvinkelstyreenheden (18) omfatter styremidler (18a), der er forbundet med overlapningsregistreringsindretningen (10), til påvirkning af dirigeringsvinkelsignalet afhængigt af den registrerede køresporsoverlapning (U1, U2, U3, U4).

4. Landbrugsmaskine ifølge et af de foregående krav, hvor overlapningsstyreenheden (19) omfatter en indstillingsværdiregulator (19b) til indregulering af overlapningen (U1, U2, U3, U4) til en minimal overlapningsindstillingsværdi.

5. Landbrugsmaskine ifølge et af de foregående krav, hvor dirigeringsvinkelstyreenheden (18) omfatter en indstillingsværdiregulator (18b) til indregulering af overdækningen af afgrødekanten (14) af det pågældende arbejdsaggregats (4; 40) kørespor til en minimal overdækningsindstillingsværdi.

6. Landbrugsmaskine ifølge et af de to foregående krav, hvor overlapningsstyreenhedens (19) indstillingsværdiregulator (19b) og/eller dirigeringsvinkelstyreenhedens (18) indstillingsværdiregulator (18b) er udformet som adaptiv regulator.

7. Landbrugsmaskine ifølge et af de to foregående krav, hvor overlapningsstyreenhedens (19) indstillingsværdiregulator (19b) og/eller dirigeringsvinkelstyreenhedens (18) indstillingsværdiregulator (18b) er udformet fuzzy-logic-regulator.

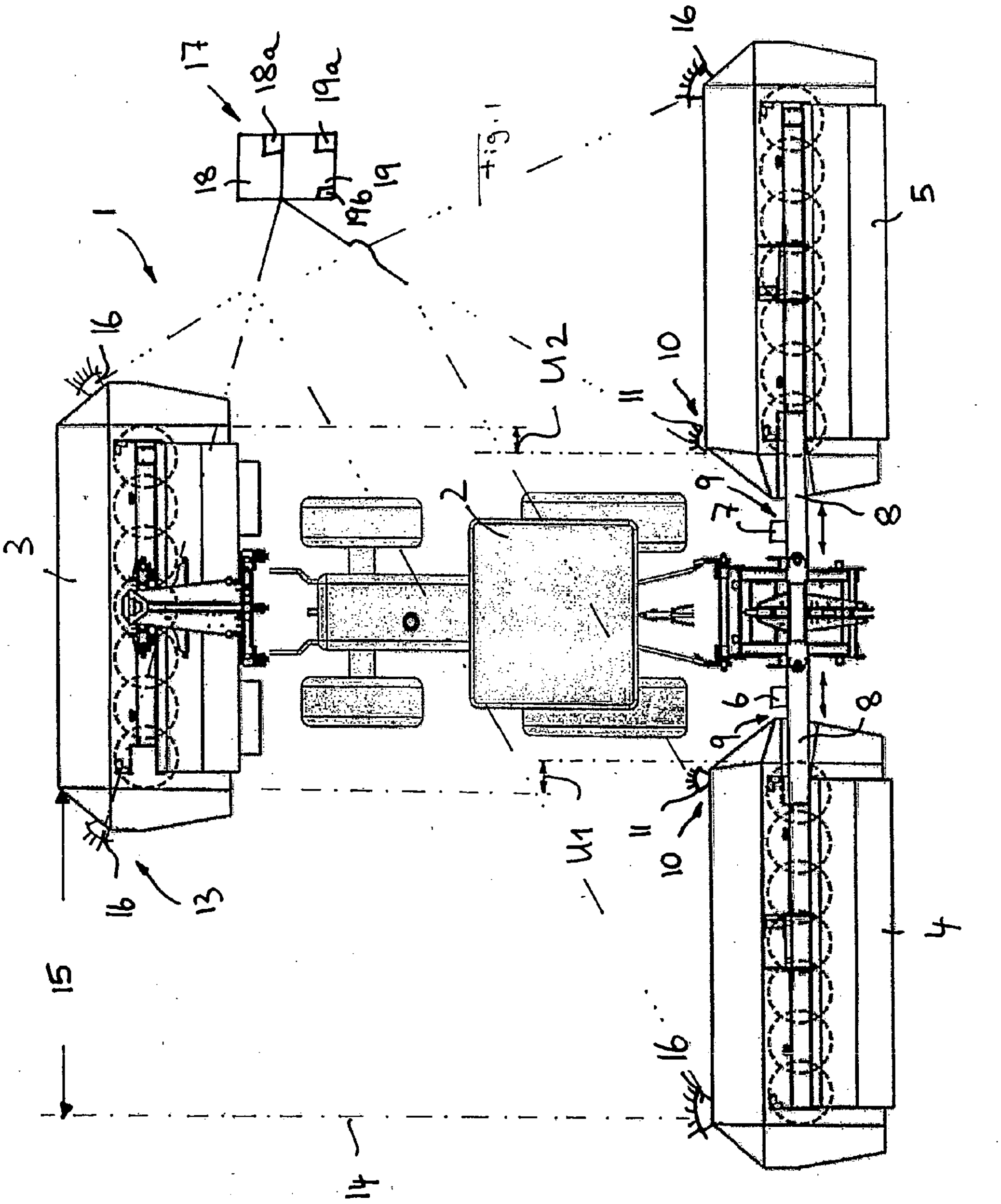
8. Landbrugsmaskine ifølge et af de to foregående krav, hvor overlapningsstyreenhedens (19) indstillingsværdiregulator (19b) og/eller dirigeringsvinkelstyreenhedens (18) indstillingsværdiregulator (18b) er udformet PI-regulator.

9. Landbrugsmaskine ifølge et af de foregående krav, hvor overlapningsregistreringsindretningen (10) omfatter mindst en optisk overlapningssensor (11, 12) til måling af den faktiske køresporsoverlapning mellem naboliggende arbejdsaggregater.

10. Landbrugsmaskine ifølge et af de foregående krav, hvor afgrødekant-registreringsindretningen (13) omfatter mindst en berøringsfrit arbejdende afgrødekantsensor (16), fortrinsvis en akustisk sensor, især en ultralydssensor, til berøringsfri registrering af afgrødekantens (14) placering og/eller forløb.

11. Landbrugsmaskine ifølge det foregående krav, hvor afgrødekantsensoren (16) er udformet som akustisk scannesensor, der arbejder i det hørbare frekvensspektrum og scanner afgrødekanten (14) i et frekvensområde på 20 Hz til 20 kHz, 10 kHz til 20 kHz.

12. Landbrugsmaskine ifølge et af de foregående krav, hvor et efterkørende, fortrinsvis bagmonterbart, arbejdsaggregat (4, 5; 40, 50) kan forskydes på tværs ved hjælp af det tværgående drev (6, 7; 60, 70).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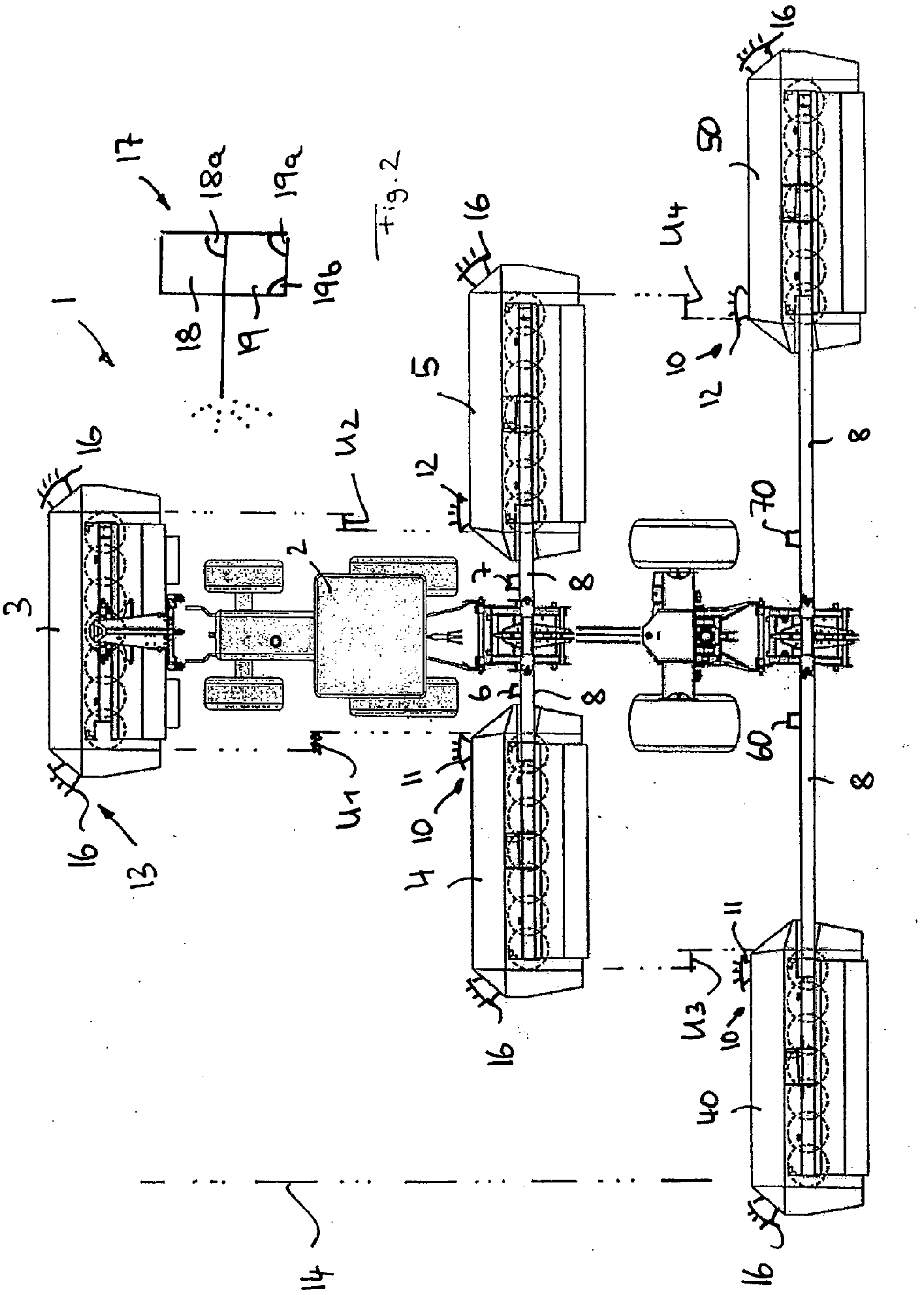
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Fig. 2