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## (54) Title: PASS PREDICTOR FOR AGRICULTURAL HARVESTING MACHINES

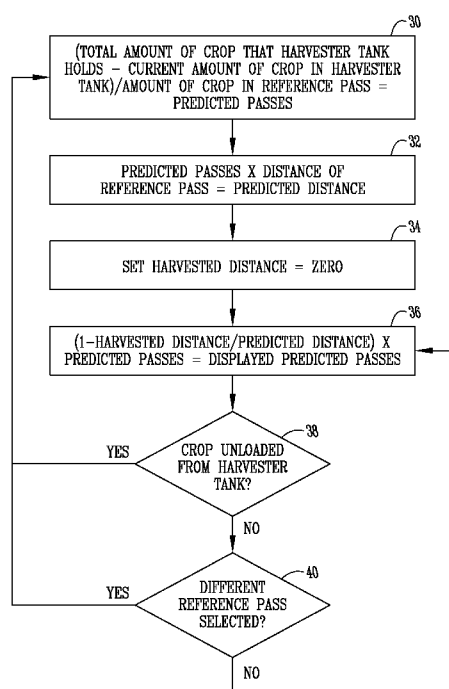


Fig.3

(57) Abstract: A method of predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine includes determining a reference pass, the reference pass having a reference pass amount of crop, an optional reference pass distance, and a reference pass spatial location. The method further includes determining an amount of crop in the grain tank of the harvesting machine. The method further includes calculating a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop and displaying the number of predicted passes.



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**TITLE: PASS PREDICTOR FOR AGRICULTURAL HARVESTING MACHINES**

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**CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims priority under 35 U.S.C. § 119 to provisional application Serial No. 61/470,258 filed March 31, 2011, herein incorporated by reference in its entirety.

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**FIELD OF THE INVENTION**

The present invention relates to agricultural harvesting machines. More particularly, the present invention relates to pass prediction for agricultural harvesting machines.

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**BACKGROUND OF THE INVENTION**

The adage "time equals money" rings true for farmers at harvest time. Bad weather alone can make a few extra days the difference between a profit and a cash flow crunch. Farmers are always on the look-out for ways to increase harvest efficiency.

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Harvest efficiency diminishes when a full grain tank stops a combine from harvesting; therefore, farmers try to provide enough labor and machinery to unload combine harvesters on-the-go. FIG. 1 is an example of a grain cart unloading a combine on-the-go. FIG. 1 illustrates a field 10. Within the field 10 there is an unharvested area 12 and a harvested area. A harvesting machine or combine 16 with a grain tank 18 is shown which is unloading grain into a grain cart 22 being pulled by a tractor 20. One way to keep combines harvesting is to predict the passes the combine can complete without unloading its grain tank.

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The passes a combine can complete without unloading will vary throughout the course of harvesting a field. A combine operator can harvest passes in the most efficient order if the operator knows the passes that can and cannot be fully completed. For example, if the operator knows the combine will have to be unloaded midway through a long pass and the grain cart will not make it back before the combine's tank fills; the operator may choose to harvest shorter passes. Shorter passes take more time to harvest because of frequent turns, which gives the grain cart more time to get back to the combine.

This makes better use of the combine's time compared to waiting for the grain cart in a longer pass.

Sometimes fields are harvested in 'lands.' The combine operator strikes through the field in certain spots so they can harvest with their unloading auger always on the harvested side of the field and harvesting in a counter-clock-wise motion. This allows the grain cart to stay close to the combine allowing for more efficient harvesting. FIG. 2 shows a combine 16 starting a new land within a field. Notice the un-harvested crop 12 on both sides of the machine. Combine operators need to pick a pass they know they can make all the way through when opening a land. If the combine gets full before the end of the pass, the combine will have to waste time backing up to the beginning of the pass to unload.

It is also useful for the grain cart operator to know whether or not the combine can make it through its current pass. If it can't, the grain cart operator knows to unload the combine on-the-go on the current pass.

Two main factors are needed to predict passes. First, the amount of grain that can be added to combine grain tank and second, the amount of grain in the next pass. Various systems have been used to indicate volume within a combine tank. For example, U.S. Patent No. 6,216,071 to Motz discloses a volume indicating system for the combine tank. U.S. Patent No. 8,032,255 to Phelan et al. also discloses a system to monitor bin level of a combine tank. U.S. Patent No. 7,756,624 to Diekhans discloses a system that reconciles a crop material quantity stored in the combine grain tank. What is needed is a method of determining amount of grain that can be added to combine tank.

U.S. Patent No. 6,216,071 discloses a control system that determines an expected time and location at which harvested crop will reach a predetermined desired level in a combine tank. U. S. Patent No. 7,756,624 discloses using expected crop material yield to determine the expected unloading point or unloading point in time or remaining distance at which the crop material quantity must be unloaded from the combine. What is needed is a method for determining expected crop yield or how to predict which passes the combine can harvest without unloading. Knowing remaining distance and expected time is useful to a combine operator but it does not resolve the problem of which passes can be completed without unloading.

What is needed is a method and system for predicting the number of passes that can be harvested before the combine tank becomes full and needs unloading.

## SUMMARY OF THE INVENTION

5 Therefore it is a primary object, feature, or advantage to improve over the state of the art.

It is a further object, feature, or advantage to predict the number of passes that can be harvested until the harvester tank becomes full.

10 It is a still further object, feature, or advantage to display the number of passes that can be harvested until the harvester tank becomes full to an operator.

A further object, feature, or advantage is to determine whether a particular pass within a field can be completed before the combine tank becomes full and needs unloading.

A still further object, feature, or advantage of the present invention is to determine where a pass begins and ends.

15 One or more of these and/or other objects, features, or advantages will become apparent from the description and claims that follow. No single embodiment need meet all objects, features, or advantages.

According to one aspect, a method of predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the  
20 harvesting machine is provided. The method includes determining a reference pass to use, the reference pass having a reference pass amount of crop and determining an amount of crop in the grain tank of the harvesting machine. The method further includes calculating a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop within the grain tank of the harvesting machine, and the amount of crop  
25 associated with the reference pass. The method further includes displaying the number of predicted passes on a display associated with the harvesting machine.

According to another aspect, a system for predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine is provided. The system includes an intelligent control, a global  
30 positioning system receiver operatively connected to the intelligent control, a memory operatively connected to the intelligent control, the memory adapted to store previous pass information including amount of crop, and a display operatively connected to the

intelligent control. The intelligent control is configured to perform steps of (1) determining a reference pass from the previous pass information, the reference pass having a reference pass amount of crop, (2) determining an amount of crop in the grain tank of the harvesting machine, (3) calculating a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop. The display is configured to display the number of predicted passes.

According to one aspect, a method of predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine is provided. The method includes determining a reference pass, the reference pass having a reference pass amount of crop, a reference pass distance, and a reference pass spatial location. The method further includes determining an amount of crop in the grain tank of the harvesting machine. The method further includes calculating (a) a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop, (b) a predicted distance from the number of predicted passes and the reference pass distance, and (c) a displayed predicted passes from a harvested distance, the predicted distance, and the number of predicted passes. The method also provides for displaying the displayed predicted passes on a display associated with the harvesting machine.

According to another aspect of the present invention, a system for predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine is provided. The system includes an intelligent control, a global positioning system receiver operatively connected to the intelligent control, a memory operatively connected to the intelligent control, the memory adapted to store previous pass information including amount of crop, pass distance and spatial location for each previous pass, and a display operatively connected to the intelligent control. The intelligent control is configured to perform steps of (1) determining a reference pass from the previous pass information, the reference pass having a reference pass amount of crop, a reference pass distance, and a reference pass spatial location, (2) determining an amount of crop in the grain tank of the harvesting machine, (3) calculating (a) a number of predicted passes from a capacity of the grain tank of the harvesting

machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop, (b) a predicted distance from the number of predicted passes and the reference pass distance, and (c) a displayed predicted passes from a harvested distance, the predicted distance, and the number of predicted passes. The display is configured to  
5 display the displayed predicted passes.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a harvesting machine unloading into a grain cart in a field.

FIG. 2 illustrates a harvesting machine cutting a land in a field.

10 FIG. 3 is a flow diagram illustrating one example of a method for predicting the number of passes that can be harvested before a harvester tank becomes full.

FIG. 4 illustrates an example of a harvesting machine traveling through a field.

FIG. 5 is a diagram of one example of a system for performing pass prediction.

FIG. 6 is one example of a screen display for conveying predicted pass information  
15 to a user.

## DETAILED DESCRIPTION

The present invention provides for predicting the number of passes that can be harvested before a harvester tank (or grain tank) becomes full, or whether a particular pass  
20 can be completed before harvester tank must be unloaded.

The number of predicted passes can be calculated based on the capacity of the grain tank of the harvesting machine, the amount of crop within the grain tank, and the amount of crop associated with a reference pass.

25 FIG. 3 illustrates one example of a method used for predicting the number of passes that can be harvested before a harvester tank becomes full. In step 30 the number of predicted passes is determined by:

PREDICTED PASSES = (TOTAL AMOUNT OF CROP THAT HARVESTER TANK  
30 HOLDS – CURRENT AMOUNT OF CROP IN HARVESTER TANK)/AMOUNT OF CROP IN REFERENCE PASS

At this point, now that the number of predicted passes has been calculated, this result may be displayed to a user to indicate a number of predicted passes. However, additional steps 32, 34, 36 may be performed.

In step 32 a predicted distance of travel is determined by:

$$\text{PREDICTED DISTANCE} = \text{PREDICTED PASSES} \times \text{DISTANCE OF REFERENCE PASS}$$

In step 34 the harvested distance is set to zero.

In step 36 the number of predicted passes which may be displayed is calculated. The displayed predicted passes may be determined as follows:

$$\text{DISPLAYED PREDICTED PASSES} = (1 - \text{HARVESTED DISTANCE} / \text{PREDICTED DISTANCE}) \times \text{PREDICTED PASSES}$$

After the number of displayed predicted passes has been calculated in step 38 a determination is made as to whether crop is unloaded from the harvester tank. If it is, then the process returns to step 30 and the number of predicted passes is re-calculated. If not, then in step 40, a determination is made as to whether a different reference pass is selected. If it is, then the process returns to step 30 and the number of predicted passes is re-calculated. If not, the process returns to step 36 and the displayed predicted passes is recalculated.

Steps 32, 34, and 36 are optional. These steps allow the system to factor out variation in yield throughout the pass as the combine harvests. Including these steps eliminates inflated or deflated pass prediction while harvesting higher or lower yielding parts of the pass.

To assist in performing the method, note that a reference pass may be used. The system may store the total amount of crop, total distance, and spatial location of every harvested pass within the field. This information may be used in predicting whether other passes may be completed without unloading the harvester tank.

FIG. 4 illustrates one example of a harvesting machine 16 as it is making a pass through a field. Note that the field shown includes a harvested area 14 and unharvested area 12.

FIG. 5 illustrates one example of a system that predicts the number of passes that can be harvested until the harvester tank becomes full. As shown in FIG. 5 an intelligent control 52 is shown which may be a microcontroller, microprocessor, or other type of intelligent control. A memory 54 is operatively connected to the intelligent control 52. The memory 54 is a machine readable storage medium on which information such as the total amount of crop, total distance and spatial location of every harvested pass within the field may be stored.

A Global Positioning System (GPS) receiver may be operatively connected to the intelligent control 52 to provide spatial location information which may be used in defining or recording the position of a pass or its start and end points within a field. User controls 58 are also operatively connected to the intelligent control 52. The user controls 58 may include buttons, a touch screen interface, or other types of user controls. The user controls 58 may be used by a user to select a harvested pass to use as a reference pass.

Header position sensor(s) 62, bin level sensor 66, and grain flow sensor(s) 64 may also be operatively connected to the intelligent control 52. The bin level sensor 66 may be used to determine the amount of crop in the harvest tank of the harvesting machine. The grain flow sensors and/or the header position sensors may be used to assist in determining the start point and end point for a pass through a field. Where the header position is raised and the grain flow sensors indicate no grain is flowing may indicate that one pass is over. This information may also be combined with position information or heading information from the GPS receiver 56 to assist the intelligent control in determining the start point and the end point of a pass through the field. In addition, field boundaries, and information about other passes may be used in determining pass start points and end points.

A display 60 is also operatively connected to the intelligent control 52. The display may be used to display predicted pass information as well as other information which is conventionally associated with a yield monitor of a harvesting machine. FIG. 6 illustrates one example of a screen display 70 which may be displayed on the display 60. As shown in FIG. 6, the number of predicted passes which may be harvested before unloading is shown. It should further be appreciated that other information may be present on the

display at the same time. This may include yield monitoring information, field mapping, or other information. In addition to the number of predicted passes, the level of the bin or tank may be displayed or other related information.

Returning to the system 50 of FIG. 5, the system may be used to store the total amount of crop, total distance, and spatial location information for every harvested pass within the field. The information on each may be used as reference passes. The reference passes may be selected by any of a number of different methods. A reference pass may be determined manually or automatically. One method of automatically selecting a reference pass is to use the last pass harvested. Another method to automatically select a reference pass is to use an adjacent harvested pass nearest to the selected (unharvested) next pass. Another method of automatically selecting the reference pass is to select the nearest adjacent pass that has one or more properties in common with the selected next pass. This may include the same variety or type of seed, the same fertilizer, the same pesticide, the same length or other properties.

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What is claimed:

1. A method of predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine, the  
5 method comprising:  
determining a reference pass to use, the reference pass having a reference pass amount of crop;  
determining an amount of crop in the grain tank of the harvesting machine;  
calculating a number of predicted passes from a capacity of the grain tank of the harvesting  
10 machine, the amount of crop within the grain tank of the harvesting machine, and  
the amount of crop associated with the reference pass; and  
displaying the number of predicted passes on a display associated with the harvesting machine.
- 15 2. The method of claim 1 wherein the reference pass further having a reference pass distance and a reference pass spatial location.
3. The method of claim 2 wherein the step of calculating the number of predicted passes uses a predicted distance.  
20
4. The method of claim 1 wherein the reference pass is a most recent pass by the harvesting machine through the field.
5. The method of claim 1 wherein the reference pass is selected by a user of the  
25 harvesting machine.
6. The method of claim 1 wherein the reference pass is an adjacent harvested pass.
7. The method of claim 1 wherein the reference pass is an adjacent harvested pass  
30 with one or more properties the same as a next pass.

8. The method of claim 5 wherein the one or more properties include at least one of crop variety, fertilizer applied, pesticide applied, and length.

9. The method of claim 1 wherein the step of determining a reference pass is  
5 determining the reference pass from a set of stored reference passes on a machine readable storage medium.

10. The method of claim 9 further comprising identifying passes and storing the passes as stored reference passes.

10  
11. The method of claim 10 wherein the step of identifying the passes comprising determining a start of each of the passes and determining an end of each of the passes.

12. The method of claim 11 wherein the determining of the start of each of the passes  
15 and determining the end of each of the passes is performed by using at least one of header height status changes, GPS readings, grain flow status changes, field boundaries, and other completed passes.

13. A method of predicting the number of passes a harvesting machine can complete  
20 within a field without unloading grain from a grain tank of the harvesting machine, the method comprising:

determining a reference pass, the reference pass having a reference pass amount of crop, a reference pass distance, and a reference pass spatial location;

determining an amount of crop in the grain tank of the harvesting machine;

25 calculating (a) a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop, (b) a predicted distance from the number of predicted passes and the reference pass distance, and (c) a displayed predicted passes from a harvested distance, the predicted distance, and the number of  
30 predicted passes; and

displaying the displayed predicted passes on a display associated with the harvesting machine.

14. A system for predicting the number of passes a harvesting machine can complete within a field without unloading grain from a grain tank of the harvesting machine, the system comprising:

an intelligent control;

5 a global positioning system receiver operatively connected to the intelligent control;

a memory operatively connected to the intelligent control, the memory adapted to store previous pass information including amount of crop;

a display operatively connected to the intelligent control;

wherein the intelligent control is configured to perform steps of (1) determining a reference

10 pass from the previous pass information, the reference pass having a reference pass amount of crop, (2) determining an amount of crop in the grain tank of the harvesting machine, (3) calculating a number of predicted passes from a capacity of the grain tank of the harvesting machine, the amount of crop in the grain tank of the harvesting machine, and the reference pass amount of crop; and

15 wherein the display is configured to display the number of predicted passes.

15. The system of claim 14 wherein the intelligent control is further configured to calculate the number of predicted passes using a predicted distance from the number of predicted passes and a reference pass distance.

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16. The system of claim 14 wherein the reference pass is a most recent pass by the harvesting machine through the field.

17. The system of claim 14 wherein the reference pass is selected by a user of the  
25 harvesting machine.

18. The system of claim 14 wherein the reference pass is an adjacent harvested pass.

19. The system of claim 14 wherein the reference pass is an adjacent harvested pass  
30 with one or more properties the same as a next pass.

20. The system of claim 19 wherein the one or more properties include at least one of crop variety, fertilizer applied, pesticide applied, and length.

21. The system of claim 14 wherein the intelligent control is further configured for  
5 identifying reference passes and storing the passes in the memory.

22. The system of claim 21 wherein the identifying the passes is performed by determining a start of each of the passes and determining an end of each of the passes.

10 23. The system of claim 22 wherein the determining of the start of each of the passes and determining the end of each of the passes is performed by using at least one of header height status changes, GPS readings, grain flow status changes, field boundaries, and other completed passes.

15 24. The system of claim 14 further comprising a bin level sensor operatively connected to the intelligent control and wherein the intelligent control determines the amount of crop in the grain tank of the harvesting machine using the bin level sensor.

25. The system of claim 14 further comprising a grain flow sensor operatively  
20 connected to the intelligent control.

26. The system of claim 14 further comprising a header position sensor operatively connected to the intelligent control.

25 27. The system of claim 14 further comprising user controls operatively connected to the intelligent control and wherein the system is configured to allow a user to select a reference pass using the user controls.

28. A system for predicting the number of passes a harvesting machine can complete  
30 within a field without unloading grain from a grain tank of the harvesting machine, the system comprising:  
an intelligent control;

a global positioning system receiver operatively connected to the intelligent control;  
a memory operatively connected to the intelligent control, the memory adapted to store  
previous pass information including amount of crop, pass distance and spatial  
location for each previous pass;

5 a display operatively connected to the intelligent control;

wherein the intelligent control is configured to perform steps of (1) determining a reference  
pass from the previous pass information, the reference pass having a reference pass  
amount of crop, a reference pass distance, and a reference pass spatial location, (2)  
determining an amount of crop in the grain tank of the harvesting machine, (3)  
10 calculating (a) a number of predicted passes from a capacity of the grain tank of the  
harvesting machine, the amount of crop in the grain tank of the harvesting machine,  
and the reference pass amount of crop, (b) a predicted distance from the number of  
predicted passes and the reference pass distance, and (c) a displayed predicted  
passes from a harvested distance, the predicted distance, and the number of

15 predicted passes; and

wherein the display is configured to display the displayed predicted passes.

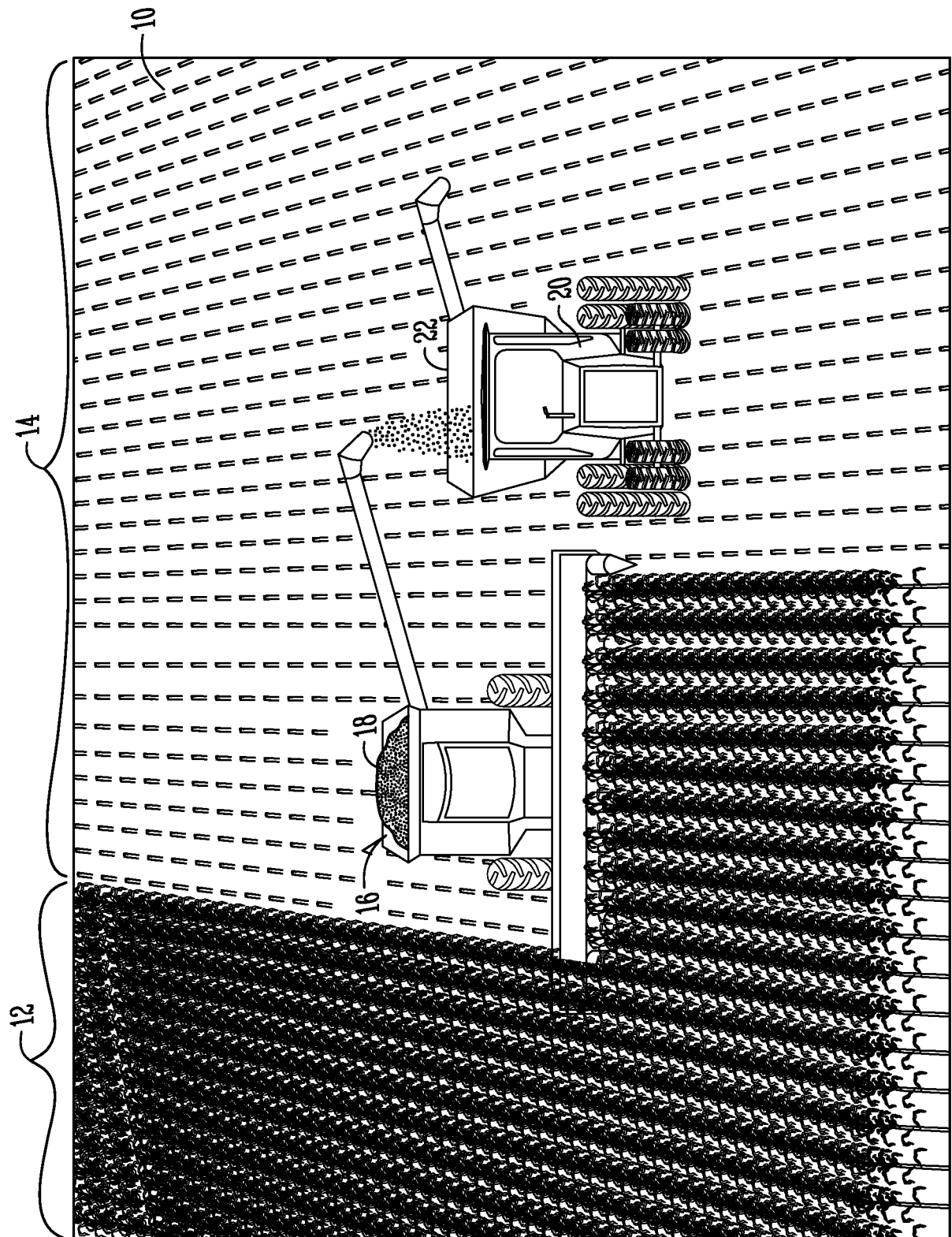


Fig. 1

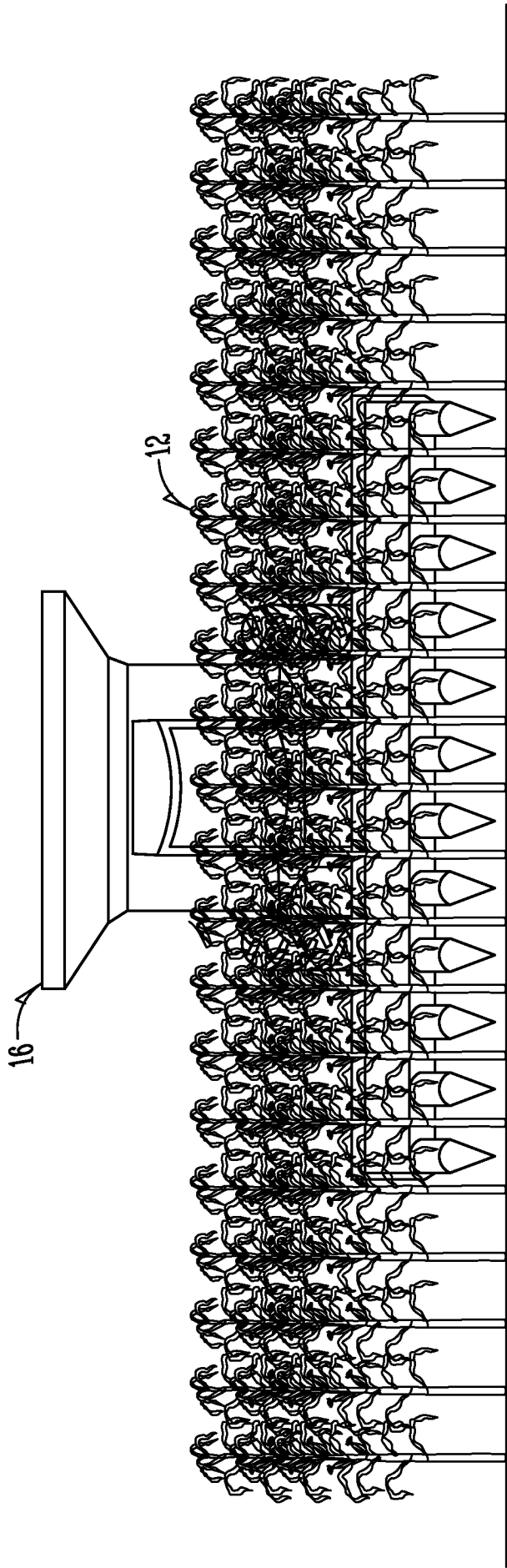
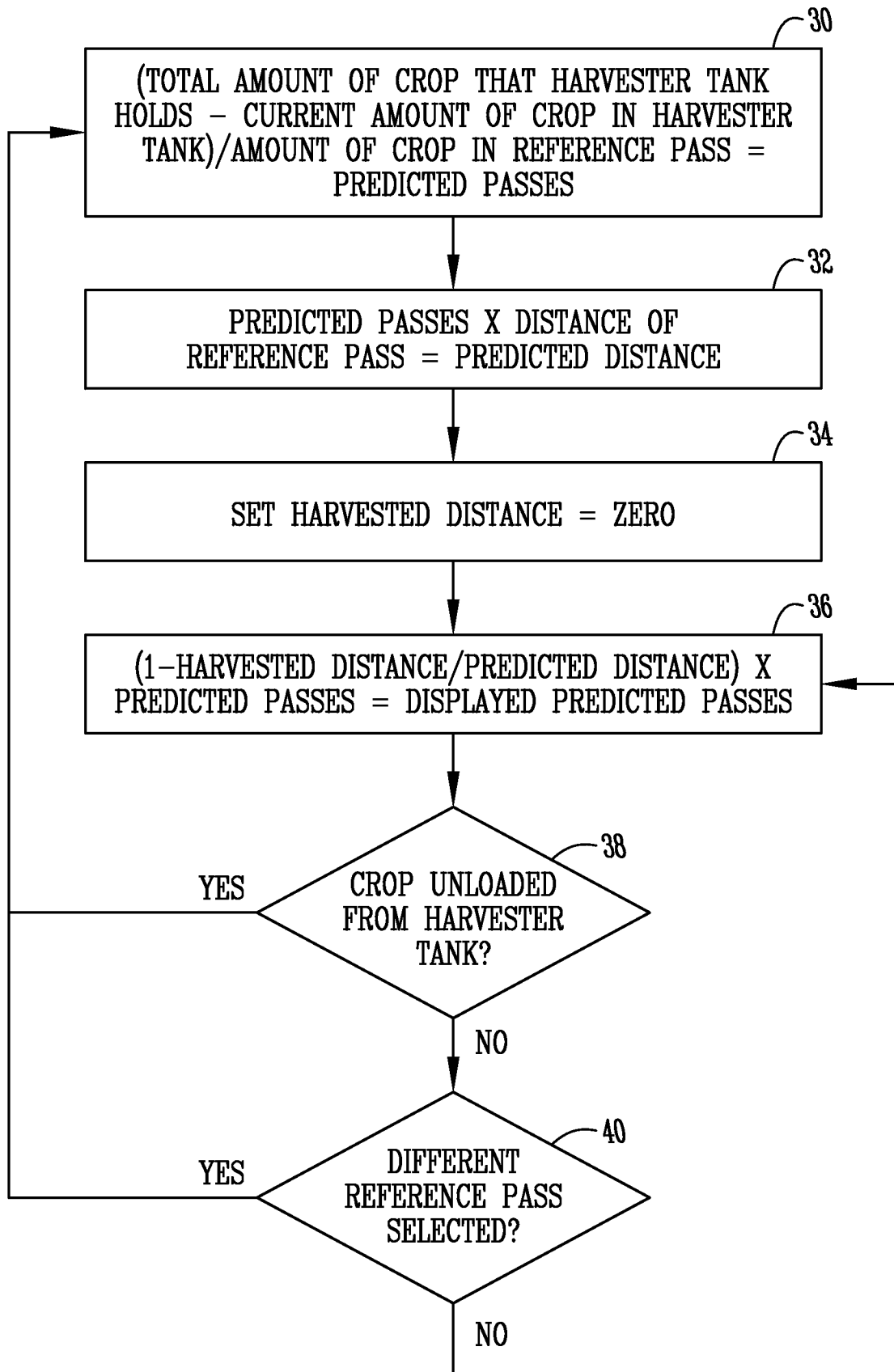


*Fig.2*

**3/5****Fig.3**

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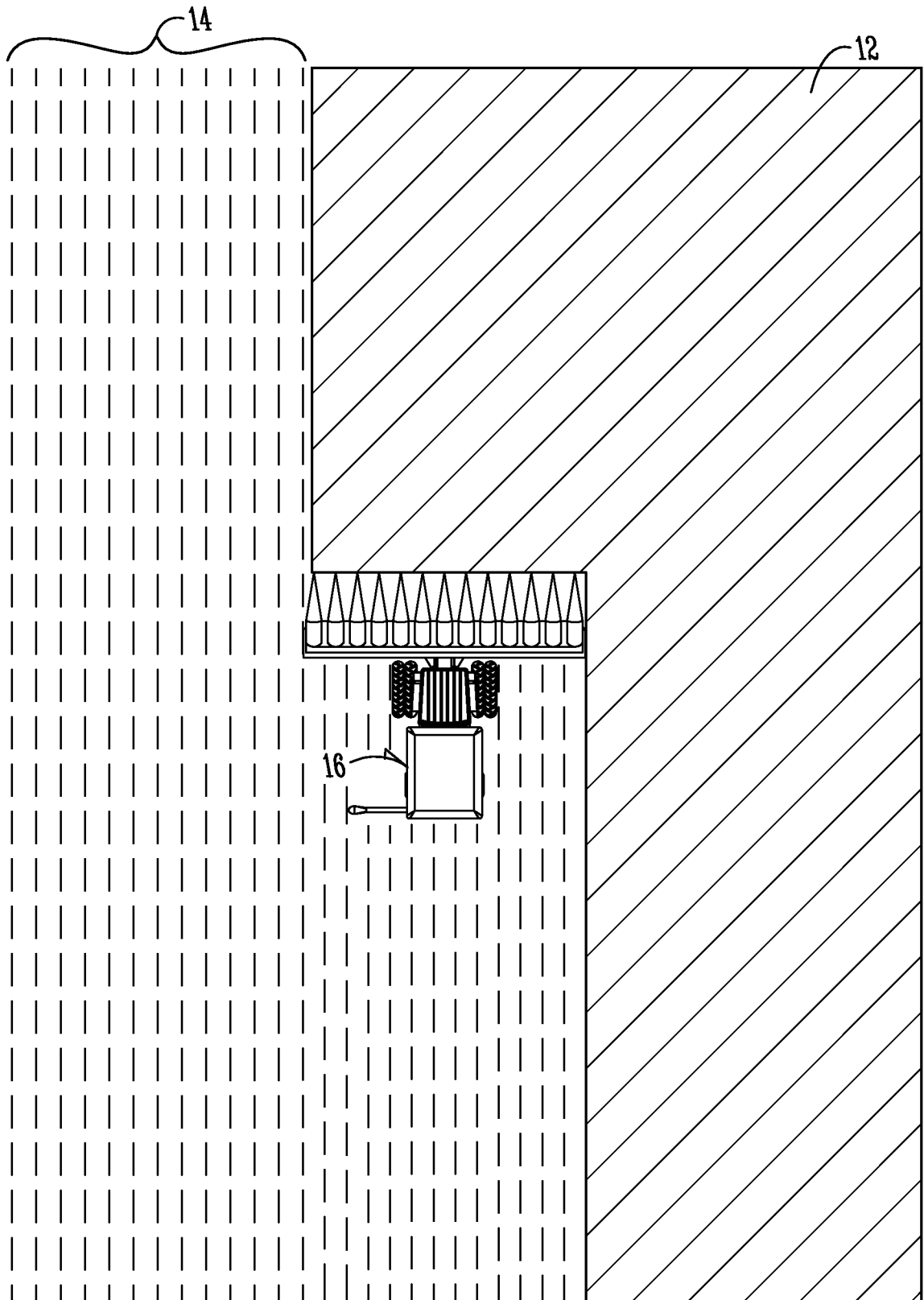
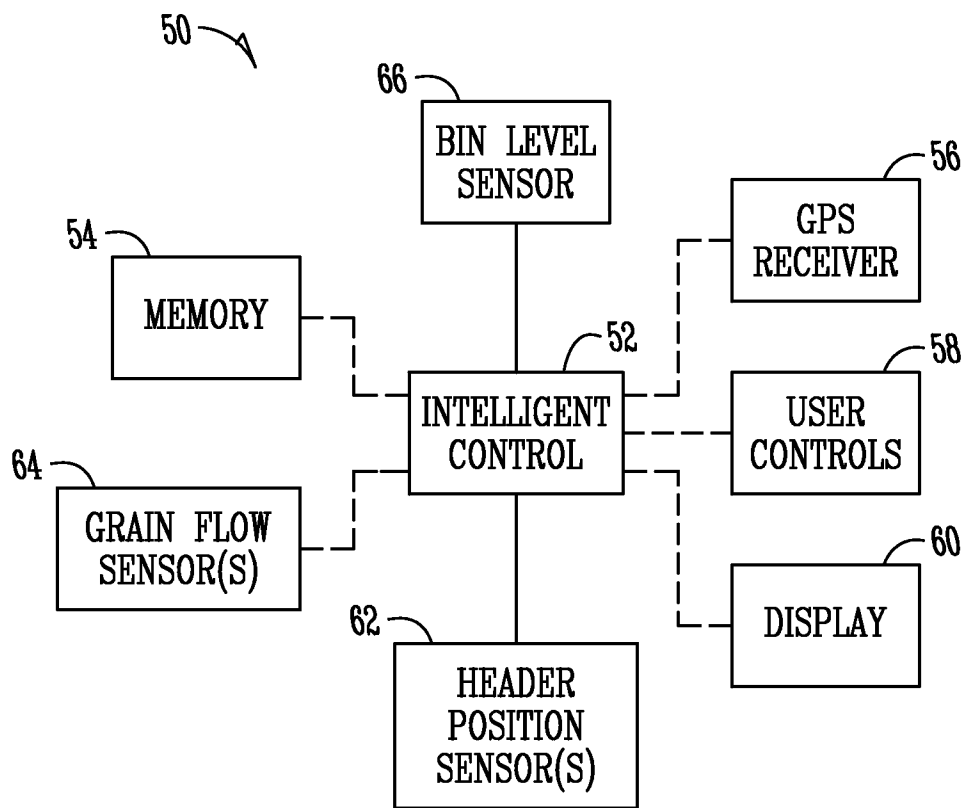
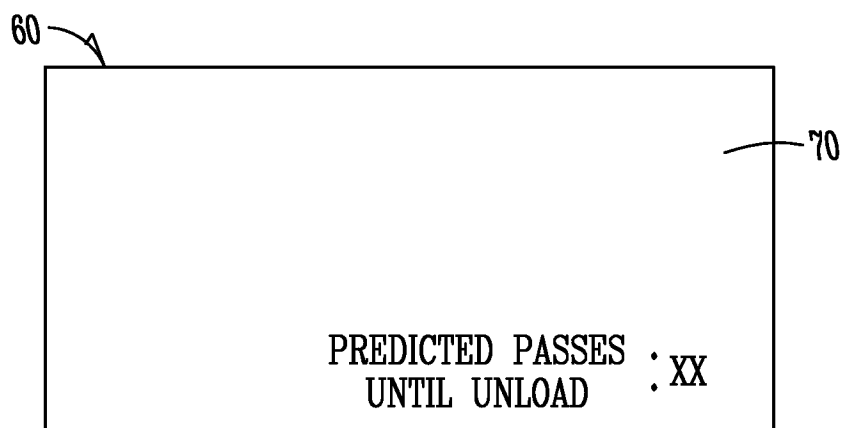


**Fig.4**

**5/5****Fig.5****Fig.6**