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(54) ACTUATOR DRIVE CONTROL SYSTEM IN CONSTRUCTION MACHINE

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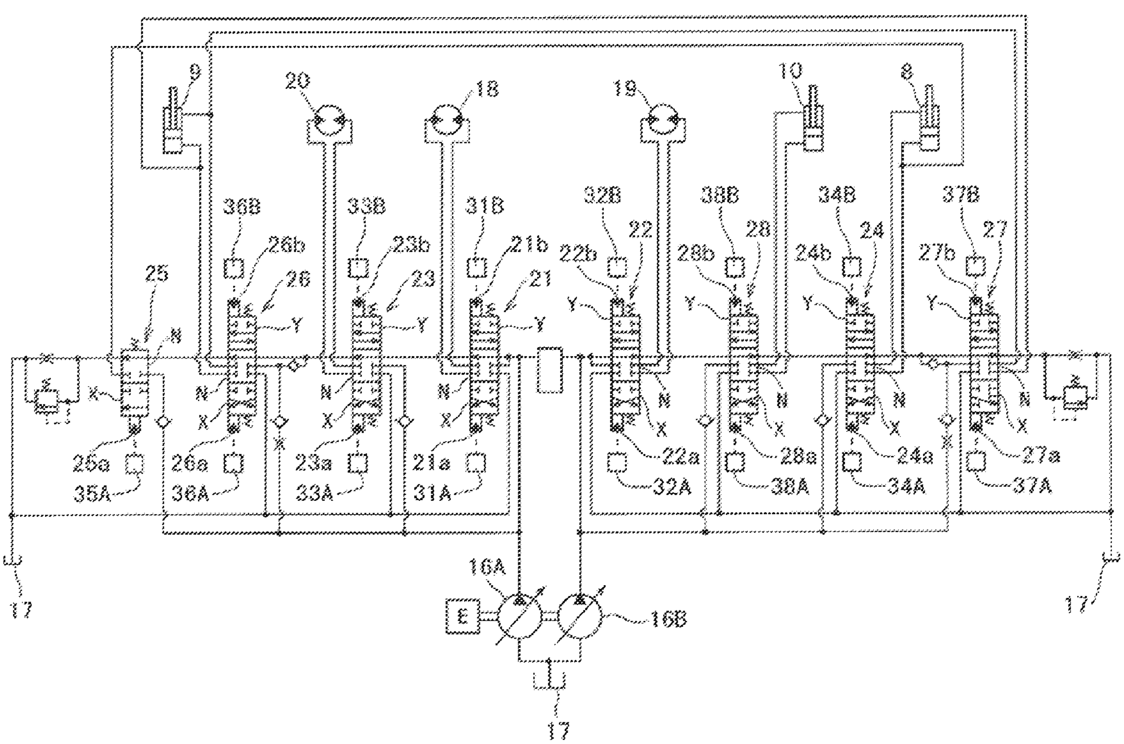
(57) **ABSTRACT**

Drive control of an actuator is performed by using an operation amount versus control value map so that the actuator can be driven at a speed corresponding to an operation amount of an operation member, even if there is difference in load conditions or the like or deterioration over time. An operation amount control unit that determines an operation amount to be input into the operation amount versus control value map is provided. Said operation amount control unit is provided with a speed requirement computing unit that determines a speed requirement from an operation detected value of the operation member, a main map for determining an operation amount from a speed requirement, a sub-map for correcting an operation amount based on influencing factors that have an influence on drive speed of the actuator, and main map updating means for updating main maps, and sub-map updating means for updating sub-maps so as to decrease the speed difference between actual speed and speed requirement of the actuator, and is configured to determine an operation amount by using updated main map and sub-map.



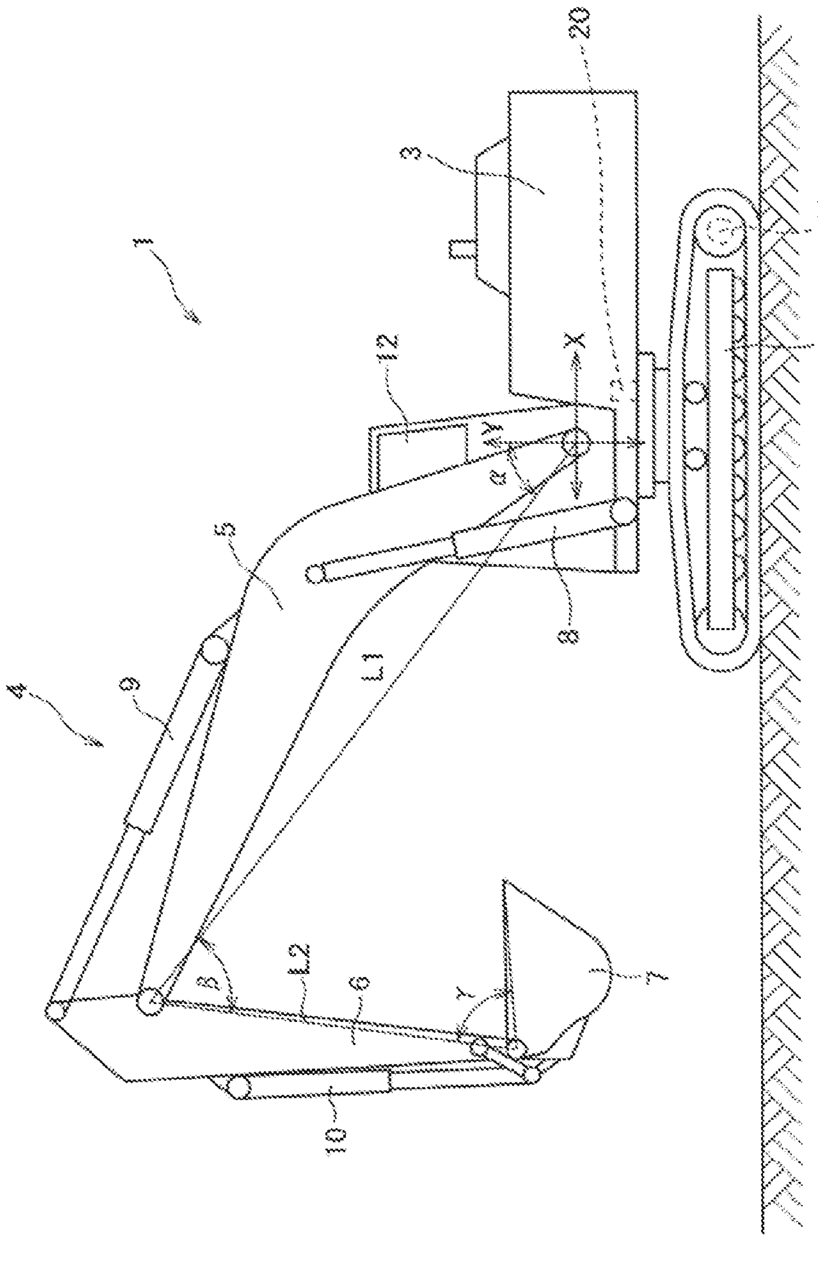


FIG. 1

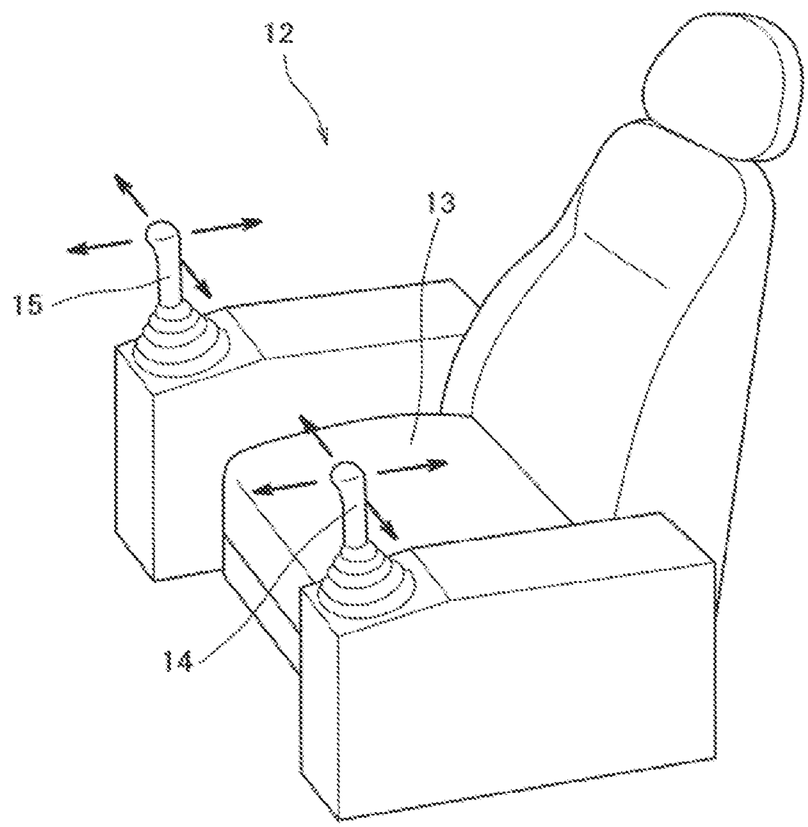
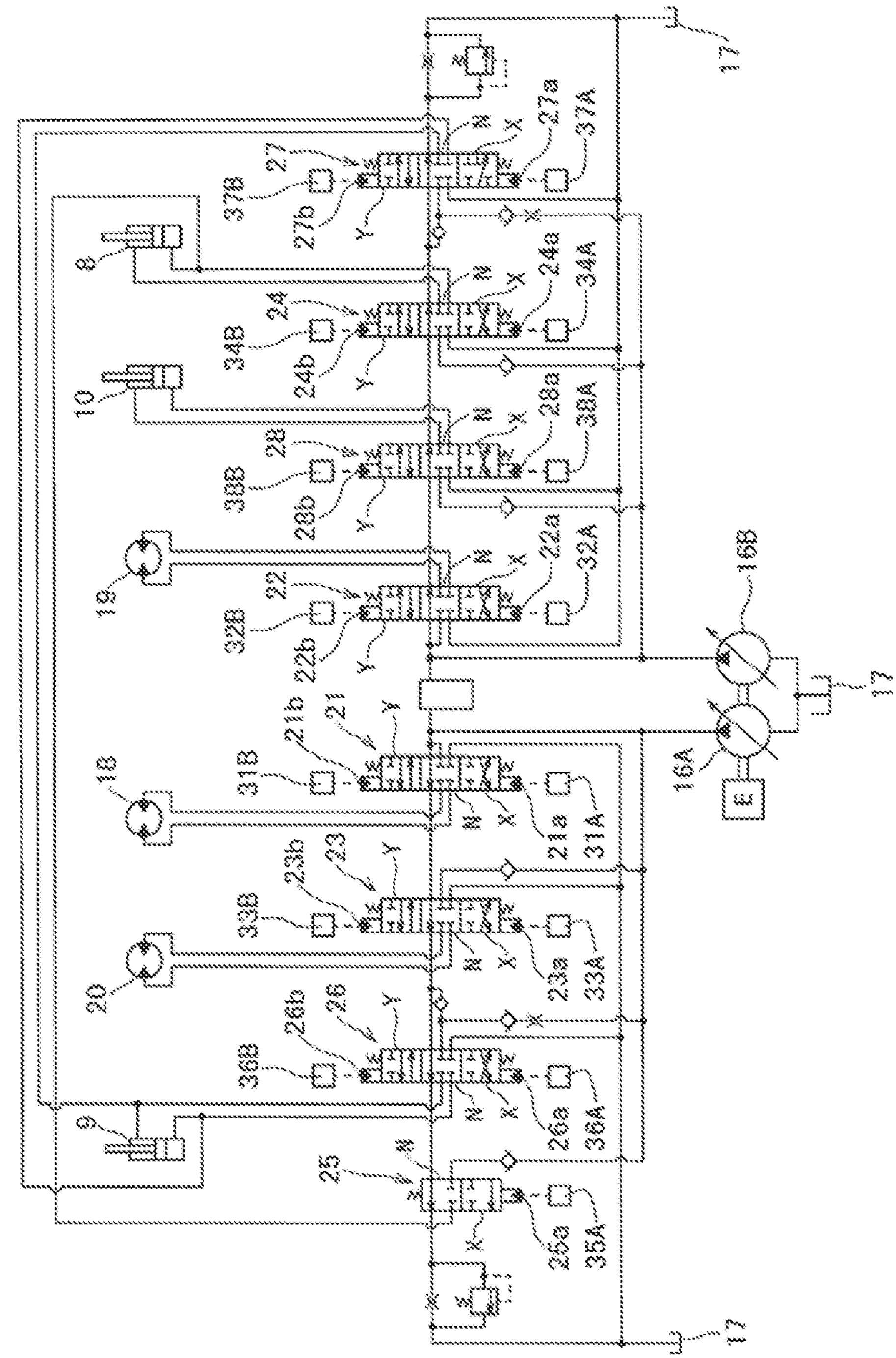


FIG. 2



17
27
27a
27b
37A
37B
8
24
24a
24b
34A
34B
10
28
28a
28b
38A
38B
19
22
22a
22b
32A
32B
16A
16B
E
21
21a
21b
31A
31B
18
23
23a
23b
33A
33B
20
26
26a
26b
36A
36B
9
25
25a
35A
N
X
Y

FIG. 3

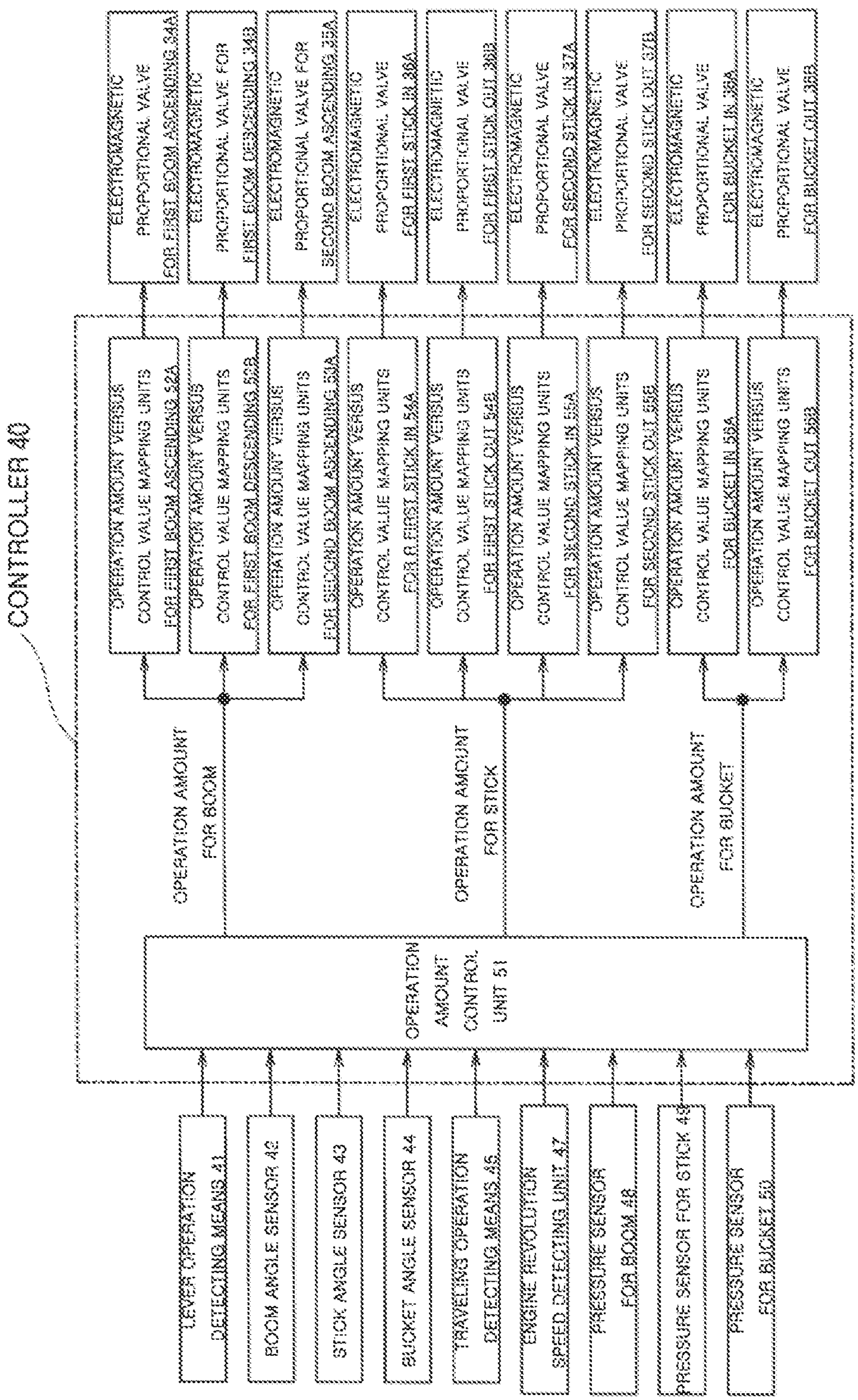

CONTROLLER 40
LEVER OPERATION DETECTING MEANS 41
BOOM ANGLE SENSOR 42
STICK ANGLE SENSOR 43
BUCKET ANGLE SENSOR 44
TRAVELING OPERATION DETECTING MEANS 46
ENGINE REVOLUTION SPEED DETECTING UNIT 47
PRESSURE SENSOR FOR BOOM 48
PRESSURE SENSOR FOR STICK 49
PRESSURE SENSOR FOR BUCKET 50
OPERATION AMOUNT CONTROL UNIT 51
OPERATION AMOUNT FOR BOOM
OPERATION AMOUNT FOR STICK
OPERATION AMOUNT FOR BUCKET
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR FIRST BOOM ASCENDING 52A
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR FIRST BOOM DESCENDING 52B
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR SECOND BOOM ASCENDING 53A
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR S FIRST STICK IN 54A
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR FIRST STICK OUT 54B
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR SECOND STICK IN 55A
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR SECOND STICK OUT 55B
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR BUCKET IN 56A
OPERATION AMOUNT VERSUS CONTROL VALUE MAPPING UNITS FOR BUCKET OUT 56B
ELECTROMAGNETIC PROPORTIONAL VALVE FOR FIRST BOOM ASCENDING 34A
ELECTROMAGNETIC PROPORTIONAL VALVE FOR FIRST BOOM DESCENDING 34B
ELECTROMAGNETIC PROPORTIONAL VALVE FOR SECOND BOOM ASCENDING 35A
ELECTROMAGNETIC PROPORTIONAL VALVE FOR FIRST STICK IN 36A
ELECTROMAGNETIC PROPORTIONAL VALVE FOR FIRST STICK OUT 36B
ELECTROMAGNETIC PROPORTIONAL VALVE FOR SECOND STICK IN 37A
ELECTROMAGNETIC PROPORTIONAL VALVE FOR SECOND STICK OUT 37B
ELECTROMAGNETIC PROPORTIONAL VALVE FOR BUCKET IN 38A
ELECTROMAGNETIC PROPORTIONAL VALVE FOR BUCKET OUT 38B

FIG. 4

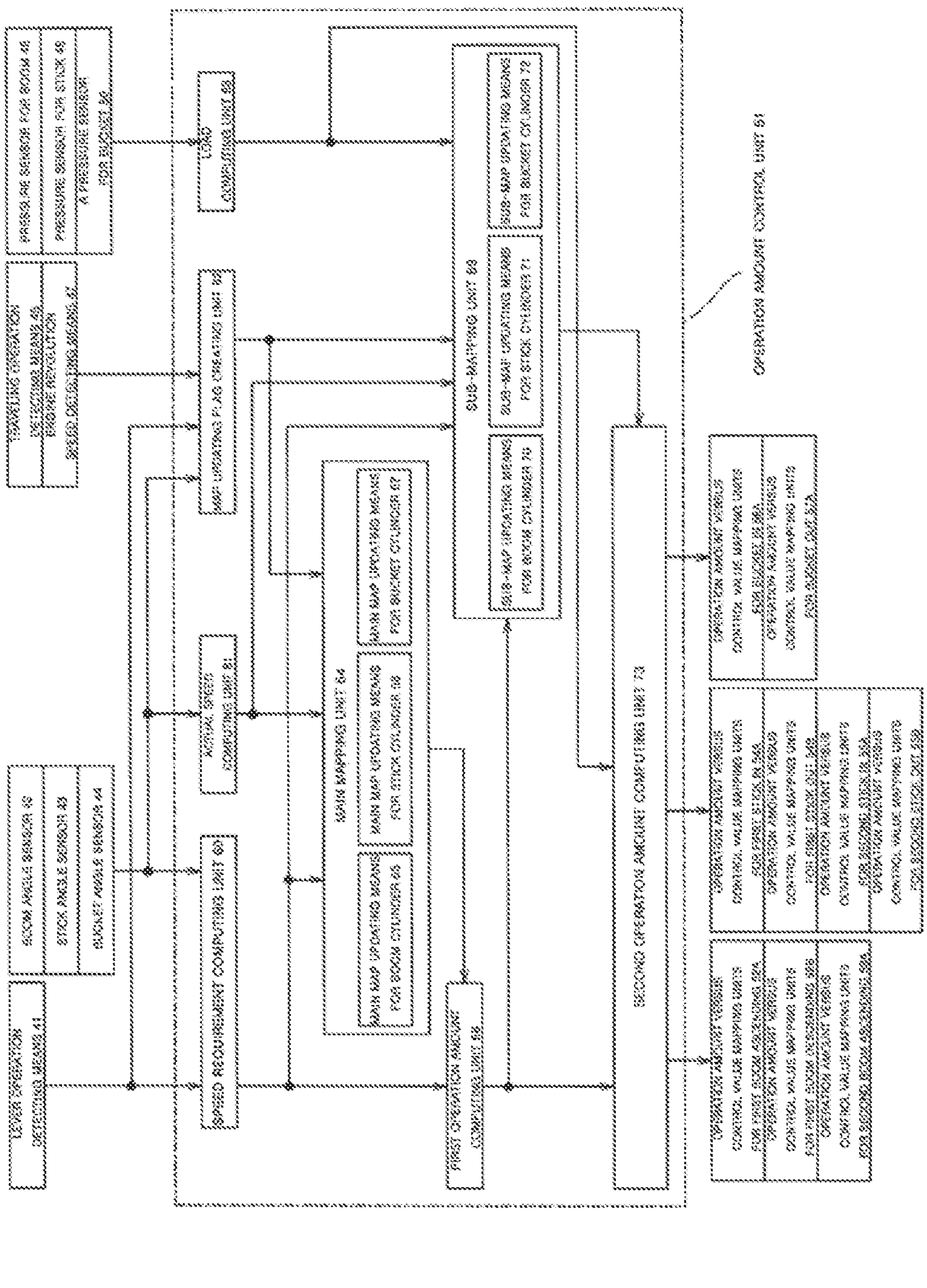

LEVER OPERATION DETECTING MEANS 41
BOOM ANGLE SENSOR 42
STICK ANGLE SENSOR 43
BUCKET ANGLE SENSOR 44
SPEED REQUIREMENT COMPUTING UNIT 60
ACTUAL SPEED COMPUTING UNIT 61
MAP UPDATING FLAG CREATING UNIT 62
LOAD COMPUTING UNIT 63
MAIN MAPPING UNIT 64
SUB-MAPPING UNIT 68
FIRST OPERATION AMOUNT COMPUTING UNIT 59
SECOND OPERATION AMOUNT COMPUTING UNIT 73
OPERATION AMOUNT CONTROL UNIT 51

FIG. 5

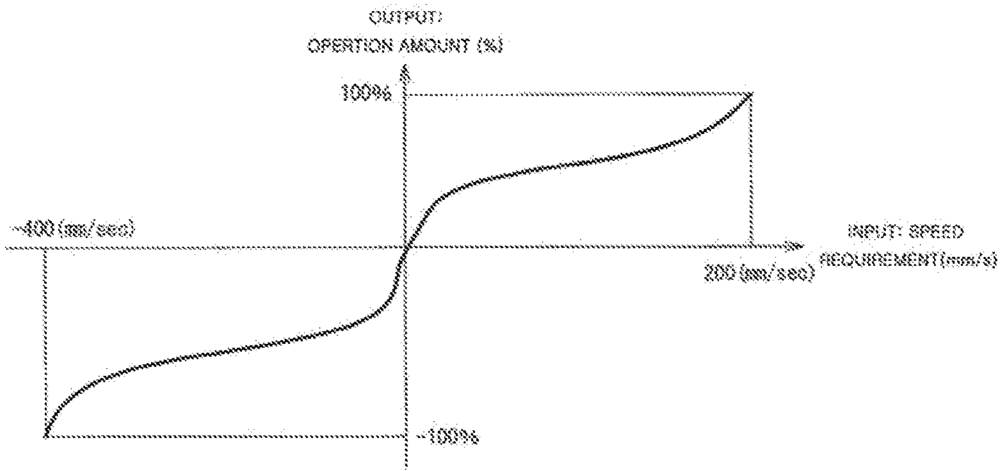


FIG. 6A

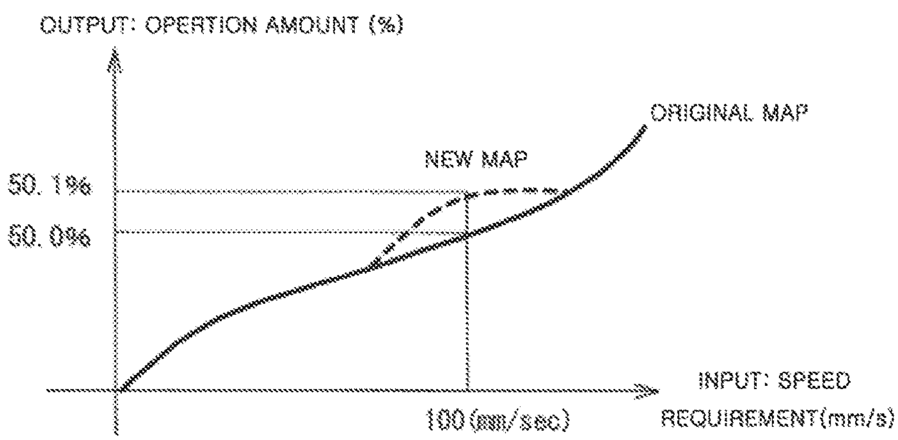


FIG. 6B

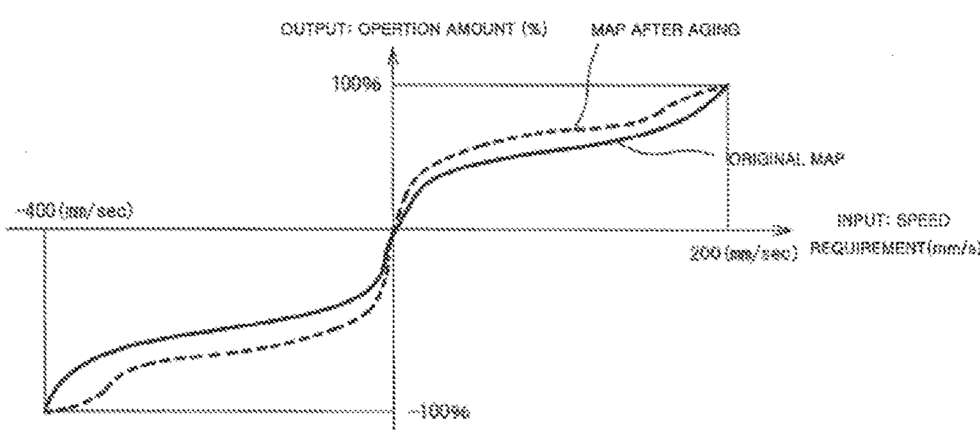


FIG. 6C

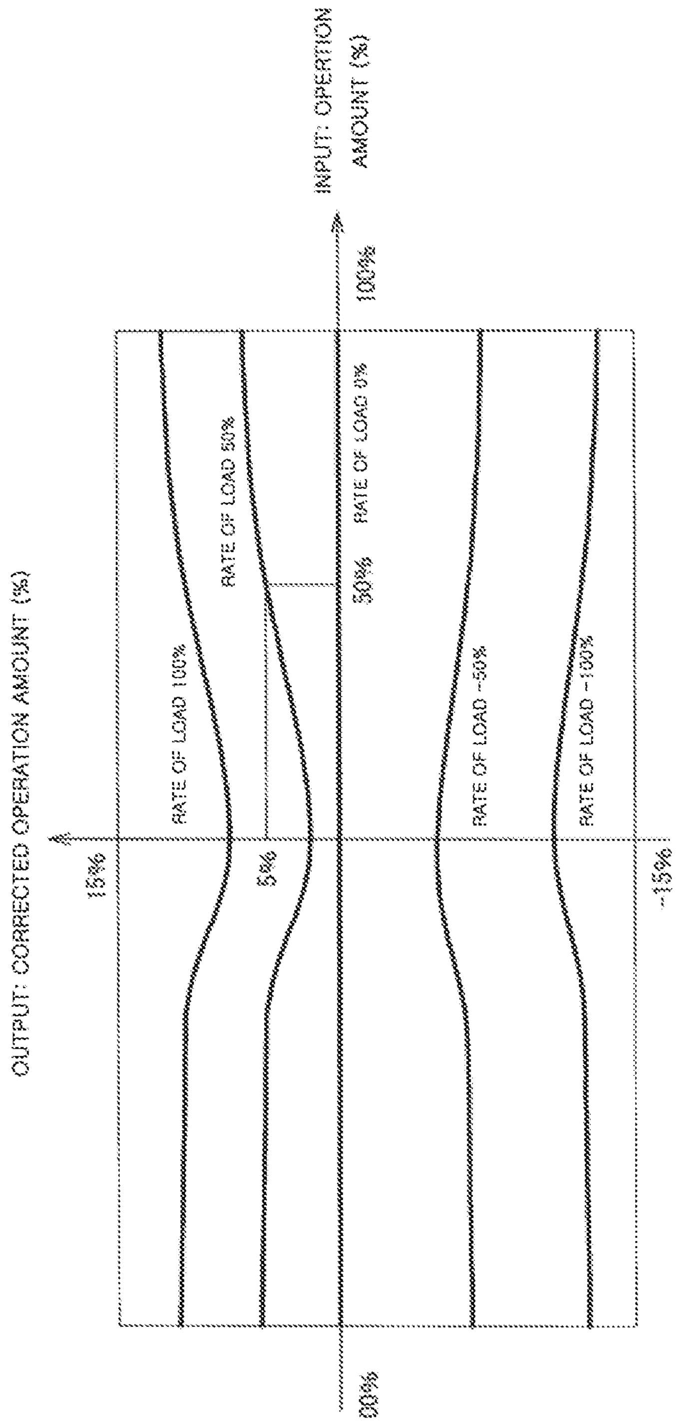

OUTPUT: CORRECTED OPERATION AMOUNT (%)
INPUT: OPERTION AMOUNT (%)
100%
-100%
15%
5%
-15%
50%
RATE OF LOAD 100%
RATE OF LOAD 50%
RATE OF LOAD 0%
RATE OF LOAD -50%
RATE OF LOAD -100%

FIG. 7

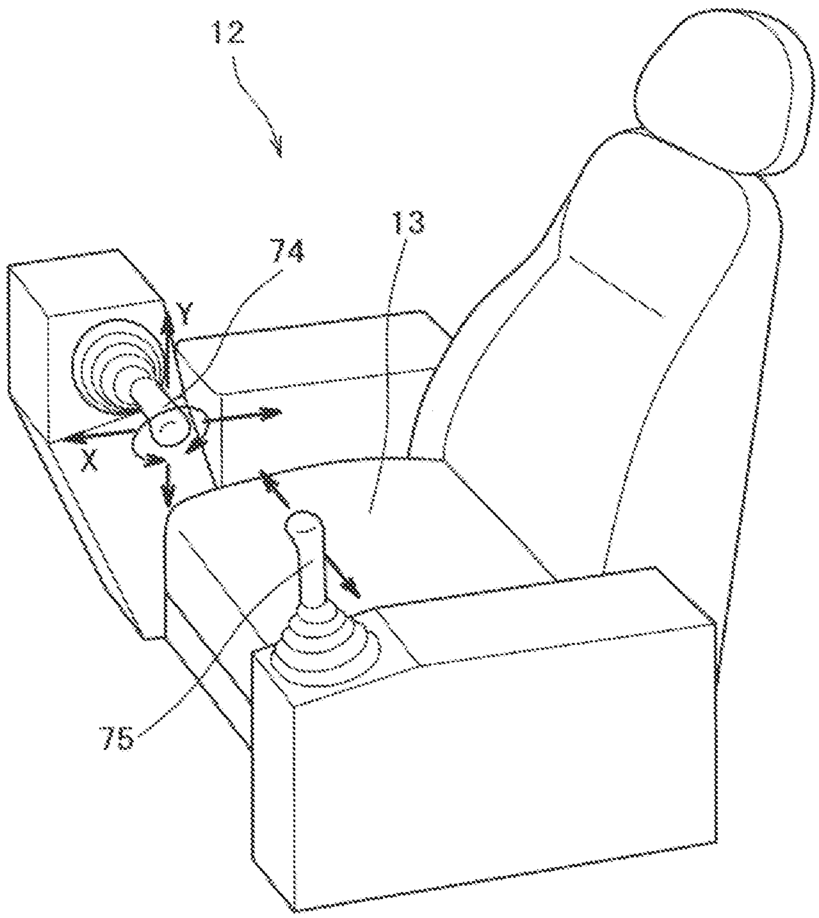


FIG. 8

ACTUATOR DRIVE CONTROL SYSTEM IN CONSTRUCTION MACHINE

TECHNICAL FIELD

[0001] The present invention relates to a technical field of an actuator drive control system in a construction machine for performing drive control of an actuator such as a hydraulic cylinder, in a construction machine such as a hydraulic shovel.

BACKGROUND ART

[0002] Generally, a construction machine such as hydraulic shovel is provided with a plurality of actuators for driving a work device, and operation members operated so as to drive these actuators. For example, a hydraulic shovel is provided with a front working machine including a boom, a stick, a bucket, as well as a plurality of hydraulic actuators (boom cylinder, stick cylinder, and bucket cylinder) for operating these boom, stick, and bucket, and operation members (operation levers) for driving these hydraulic actuators, and is configured to perform various types of works such as excavation, by performing combined operation of the hydraulic actuators by the operation members. In the hydraulic shovel, in controlling drive speeds of respective hydraulic actuators, presetting an operation member operation amount versus control value map that represents correlations between operation member operation amounts (lever strokes) detected by an operation member detection unit, and control values (e.g., target supply flow rate values to the hydraulic actuators, command values to control valves for hydraulic actuators) for controlling the drive speeds of the hydraulic actuators, and performing drive control of the hydraulic actuators based on the control values that are output from the operation member operation amount versus control value map constitutes a conventional practice that is commonly performed.

[0003] However, in case of using the operation member operation amount versus control value map that is preset such as the one described above, even if operation member operation amounts to be detected by the operation member detection unit are the same, the drive speeds of the actuators are not always equal to each other. For example, in the hydraulic shovel, generally pressure oil is supplied to a plurality of hydraulic actuators from one hydraulic pump. For this reason, in case combined operation is performed, a discharge flow rate of the one hydraulic pump will be shared and thus the hydraulic actuators will be influenced with each other, and the speeds of the hydraulic actuators may be slower than in case individual operation is performed. Also, even in case of the same operation, for example, of raising the boom, various factors such as difference in load conditions such as presence or absence of gravels within the bucket, high and low engine revolution speeds, or individual difference between machines, deterioration over time of hydraulic equipment, climate conditions, high and low oil temperatures exert influence on the drive speed of the boom cylinder. In other words, even when operation amounts of the operation members are the same, the drive speeds of the hydraulic actuators will be eventually increased or decreased depending on individual operation/combined operation, loads acting on the hydraulic actuators, or various factors such as the ones described above. For this reason, there was a problem in that it is difficult to accurately control, for example, ascending speed or descending speed of the boom, or a position of the bucket displaced by the drives of the boom cylinder and the stick cylinder.

[0004] Thus, conventionally, a technology is known for enabling command electric current versus control amount characteristics used for the drive control of the hydraulic actuators to be corrected by learning correction processing performed by actually driving the plurality of hydraulic actuators in learning correction mode (see Patent Literature 1, for example).

[0005] Further, a technology is also known for enabling a reference speed of operation speed to be learned based on an operation history performed on the operation unit, and output characteristics of the actuators according to the operation amounts to be changed, depending on correlations between the reference speed thus learned and change speed of the operation amounts (see Patent Literature 2 for example).

PRIOR ART LITERATURES

Patent Literatures

[0006] [Patent Literature 1] Japanese Patent Application Laid-open No. H11-350536

[0007] [Patent Literature 2] Japanese Patent Application Laid-open No. 2010-7264

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0008] However, the technology disclosed in the above-described Patent Literature 1 has a problem in that, because of a configuration of making a correction by switching to a learning correction mode, in performing correction of the command electric current versus control amount characteristics, and actually operating the hydraulic actuators in the learning correction mode, the correction may or may not be appropriate correction in regards to various operations or conditions other than operations actually performed. Furthermore, there is also a problem in that time and labor for executing the learning correction mode are needed, and the learning correction mode must be implemented on regular basis, in order to cope with performance decline of the hydraulic equipment due to, for example, deterioration over time.

[0009] Further, the technology disclosed in the Patent Literature 2 is a technology for selecting either map from among a plurality of maps preset, in correcting an output characteristics map of actuators with respect to operation amounts, and has problems with the inability to perform correction of maps other than the preset maps, besides the inability to perform correction corresponded to various factors such as individual operation/combined operation, loads acting on the hydraulic actuators such as described above, since this correction was only correction relating to responsiveness of the hydraulic actuators with respect to operations, and there are issues to be solved by the present invention in these problems.

Means for Solving Problems

[0010] The present invention has been created with the aim of solving these issues, in view of actual circumstances as described above. The invention of claim **1** relates to an actuator drive control system in a construction machine wherein, in a construction machine provided with an actuator, an operation member configured to be operated so as to drive said actuator, and an operation amount versus control value map for outputting a control value for controlling a drive speed of the actuator based on an input of an operation amount, and configured to perform drive control of the actuator based on said control value output from said operation amount versus control value map, a control system configured to determine an operation amount input into the operation amount versus control value map is provided, and said control system is provided with an operation detecting means for detecting an operation of an operation member, a speed requirement computing unit for computing a speed requirement of the actuator based on a detected value from said operation detecting means, a main map for representing correlations between speed requirement and operation amount in order to determine an operation amount from the speed requirement of the actuator, an actual speed computing unit for computing a current drive speed of the actuator, a main map updating means for updating, at any time, a main map based on a speed difference between the speed requirement of the actuator and the current drive speed of the actuator, a sub-map for correcting an operation amount based on influencing factors that have an influence on the drive speed of the actuator, and a sub-map updating means for updating, at any time, the sub-map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, and is configured to determine an operation amount by using the main map and the sub-map updated by the main map updating means, and the sub-map updating means.

[0011] The invention of claim **2** relates to the actuator drive control system in a construction machine according to claim **1**, wherein the main map updating means, in updating the main map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, makes the weighting of the speed difference to the speed requirement to be small, and updates the main map so as to decrease said small-weighted speed difference.

[0012] The invention of claim **3** relates to the actuator drive control system in a construction machine according to claim **1** or claim **2**, wherein the sub-map updating means, in updating the sub-map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, makes the weighting of the speed difference to the speed requirement to be small, and updates the sub-map so as to decrease said small-weighted speed difference.

[0013] The invention of claim **4** relates to the actuator drive control system in a construction machine according to claim **3** citing claim **2**, wherein the weighting of the speed difference in updating of the sub-map is set greater than the weighting of the speed difference in updating of the main map.

[0014] The invention of claim **5** relates to the actuator drive control system in a construction machine according to any one of claim **1** to claim **4**, wherein an influencing factor for use in correction of an operation amount in the sub-map is at least either one out of a load acting on the actuator, individual operation/combined operation in case a plurality of actuators is provided, and an engine revolution speed.

[0015] The invention of claim **6** relates to the actuator drive control system in a construction machine according to any one of claims **1** to **5**, wherein a construction machine is provided with a bendable articulated working arm composed of a plurality of arms, a work attachment attached to the distal end portion of said working arm, as well as provided with a plurality of hydraulic cylinders for arms for driving the plurality of arms respectively, and a hydraulic actuator for the work attachment serving as actuators.

[0016] The invention of claim **7** relates to the actuator drive control system in a construction machine according to claim **6**, wherein a construction machine is provided with right and left operation members operable in front-back, and right-left directions serving as operation members for a working arm, and an operation mode selecting means selectable by an operator, wherein in case an attachment position control mode for controlling a work attachment position by operations of the right and left operation members by said operation mode selecting means is selected, the control system computes a desired work attachment position based on detected values from an operation detecting means for detecting operations of the right and left operation members, and computes speed requirements of a plurality of hydraulic cylinders for arms respectively in order to control the work attachment position based on said computation result, wherein a main map and a sub-map are provided in correspondence to each hydraulic cylinder for arm respectively.

[0017] The invention of claim **8** relates to the actuator drive control system in a construction machine according to claim **6**, wherein a construction machines is provided with one operation member operable in front-back, and up-down directions serving as an operation member for a working arm, wherein the control system computes a desired work attachment position based on detected values from the operation detecting means for detecting an operation of the operation member, and computes speed requirements of a plurality of hydraulic cylinders for arms respectively in order to control the work attachment position based on said computation result, and wherein the main map and the sub-map are provided in correspondence to each hydraulic cylinder for arm respectively.

Advantageous Effects of the Invention

[0018] According to the invention of claim **1**, drive speed control of an actuator can be performed with a high accuracy by using a main map and a sub-map, and the similar operation accuracy to that during an initial service stage can be retained, even when characteristic of a machine body has been changed due to deterioration over time, because the main map and the sub-map can be updated at any time, as well as the need for calibration job of the maps can be eliminated.

[0019] According to the invention of claim **2**, updating of the main map is less influenced by protruding data of current drive speeds of an actuator, which may be temporarily, accidentally generated like noises.

[0020] According to the invention of claim **3** of the invention, updating of the sub-map is less influenced by protruding data of current drive speeds of an actuator, which may be temporarily, accidentally generated like noises.

[0021] According to the invention of claim **4** of the invention, updating of the main map can be performed effectively on characteristics that change little by little in a long period of time like deterioration over time of hydraulic components, and on the other hand, correction to short-term speed difference generated by influencing factors that have an influence on the drive speed of the actuator, can be performed promptly by updating the sub-map.

[0022] According to the invention of claim **5** of the invention, drive speed control of the actuator corresponding to loads acting on the actuator, individual operation/combined operation, or engine revolution speeds can be performed.

[0023] According to the invention of claim **6** of the invention, positional control of a work attachment attached to the distal end portion of an articulated working arm can be performed accurately.

[0024] According to the invention of claim **7** of the invention, in the control system configured to control the work attachment position by operations of right and left operation members when an attachment position control mode is selected by an operator, the work attachment position can be controlled accurately.

[0025] According to the invention of claim **8** of the invention, in the control system configured to control the work attachment position by operation of one operation member, the work attachment position can be controlled accurately.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is a schematic side view of a hydraulic shovel.

[0027] FIG. **2** is a view illustrating the interior of a driver's cab.

[0028] FIG. **3** is a hydraulic circuit diagram of a hydraulic shovel.

[0029] FIG. **4** is a block diagram illustrating input/output of a controller.

[0030] FIG. **5** is a control block diagram of an operation amount control unit.

[0031] FIG. **6**A is a diagram illustrating a main map, FIG. **6**B is an explanatory diagram of updating of the main map, and FIG. **6**C is a diagram illustrating long-term change of the main map.

[0032] FIG. **7** illustrates a sub-map.

[0033] FIG. **8** illustrates the interior of the driver's cab in a second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Herein below, embodiments of the present invention will be described with reference to the drawings. FIG. **1** is a side view illustrating a hydraulic shovel **1** as an example of a construction machine embodying the present invention. Said hydraulic shovel **1** is constituted of a crawler type lower body **2**, an upper slewing body **3** slewably supported above said lower traveling body **2**, a front working machine **4** fit to said upper slewing body **3** and other components. Furthermore, said front working machine **4** is constituted of a boom **5** swingably supported in an upward-downward direction by the upper slewing body **3** at a base end portion, a stick **6** swingably supported in a front-back direction at a distal end portion of said boom **5**, a bucket **7** swingably attached at the distal end portion of said stick **6**, and other components, and further is provided with a boom cylinder **8**, a stick cylinder **9**, and a bucket cylinder **10** for swinging the boom **5**, the stick **6**, and the bucket **7** respectively, and right and left travel motors **18**, **19**, for traveling the lower traveling body **2**, a slewing motor **20** for slewing the upper slewing body **3**, and other components. The boom **5** and the stick **6** correspond to a plurality of arms constituting a bendable articulated working arm of the present invention, and the bucket **7** corresponds to a working attachment of the present invention. Furthermore, the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** corresponds to actuators of the present invention, and the boom cylinder **8** and the stick cylinder **9** correspond to hydraulic cylinders for arm of the present invention, and the bucket cylinder corresponds to a hydraulic actuator for working attachment of the present invention.

[0035] FIG. **2** is a view illustrating the inside of an driver's cab **12** mounted on the upper slewing body **3**, and in the inside of said driver's cab **12**, joystick type right and left operation levers (corresponding to operation members of the present invention) **14**, **15** operable in front, back, right and left directions are disposed on both front right and left sides of the driver's seat **13** with an operator being seated thereon. Furthermore, an operation mode selecting means (not illustrated) described below, operation members for traveling (traveling lever and traveling pedal) to be operated for performing traveling, various switches and dials, monitoring device and others are disposed within the driver's cab **12**, but their illustrations will be omitted.

[0036] The operation mode selecting means is incorporated in the monitoring device, and is provided as switch and dial, but said operation mode selecting means allows the operator to arbitrarily select operation modes of the right and left operation levers **14**, **15**. In other words, in the present embodiment, any of "standard control" mode and "attachment position control" mode can be selected by the operation mode selecting means, in the "standard control" mode, but respective operations in front-back direction, and in right-left direction of the right and left operation levers **14**, **15** are set so as to correspond to respective drives of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, and the slewing motor **20**. For example, the stick cylinder **9** is set to be driven in correspondence to an operation in front-back direction of the left-side operation lever **14**, the slewing motor **20** is driven in correspondence to an operation in right-left direction of the left-side operation lever **14**, the boom cylinder **8** is set to be driven in correspondence to an operation in front-back direction of the right-side operation lever **15**, and the bucket cylinder **10** is set to be driven in correspondence to an operation in right-left direction of the right-side operation lever **15**. In addition, two or more of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, the slewing motor **20** can be simultaneously driven by combined operations (operations in forward-leftward, forward-rightward, backward-leftward, backward-rightward directions of the right and left operation levers **14**, **15**, or simultaneous operation of the right and left operation levers **14**, **15**) of the right and left operation levers **14**, **15**.

[0037] On the other hand, in an "attachment position control" mode, the fact that an operation in the right-left direction of the left-side operation lever **14**, and an operation in the right-left direction of the right-side operation lever **15** correspond to the drives of the slewing motor **20**, the bucket cylinder **10** respectively are similar to the "standard control" mode, but an operation in forward-backward direction of the left-side operation lever **14** and the right-side operation lever

15 is set to drive the boom cylinder **8** and the stick cylinder **9** in order to move the bucket **7** position (being an attachment position of the bucket **7** swingably attached to the distal end portion of the stick **6**, and corresponding to the working attachment position of the present invention) in correspondence to that operation. In the present embodiment, an operation in forward-backward direction of the left-side operation lever **14** is set to correspond to movement in forward-backward direction (X direction illustrated in FIG. **1**) of the bucket **7** position, and an operation in forward-backward direction of the right-side operation lever **15** is set to correspond to movement in upward-downward direction (Y direction illustrated in FIG. **1**) of the bucket **7** position.

[0038] FIG. **3** illustrates a hydraulic circuit provided in the hydraulic shovel **1**. As illustrated in FIG. **3**, the hydraulic circuit comprises first, second hydraulic pumps **16**A, **16**B driven by an engine E, an oil tank **17**, right and left traveling motors **18**, **19**, a slewing motor **20**, the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**. Further, the hydraulic circuit further comprises control valves **21** to **28** for right and left traveling, for slewing, for the first boom cylinder, for the second boom cylinder, for the first stick cylinder, for the second stick cylinder, for the bucket that perform oil supply- and discharge-control respectively to the right and left traveling motors **18**, **19**, the slewing motor **20**, the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**. These respective control valves **21** to **28**, at a neutral position N in which pilot pressure is not input to pilot ports **21***a*, **21***b* to **28***a*, **28***b*, are positioned at neutral position N in which oil supply- and discharge-control to the corresponding hydraulic actuators **18**, **19**, **20**, **8**, **9**, **10** is not performed, but are configured to be switched to operating positions X, Y at which oil supply- and discharge-control to the corresponding hydraulic actuators **18**, **19**, **20**, **8**, **9**, **10** is performed based on the pilot pressure being input to the pilot ports **21***a*, **21***b* to **28***a*, **28***b*.

[0039] In FIG. **3**, electromagnetic proportional valves **31**A, **31**B to **38**A, **38**B are provided for left traveling forward, for left traveling reverse, for right traveling forward, for right traveling reverse, for left slewing, for right slewing, for first boom ascending, for first boom descending, for second boom ascending, for first stick IN, for first stick OUT, for second stick IN, for second stick OUT, for bucket IN, and for bucket OUT. These respective electromagnetic proportional valves **31**A, **31**B to **38**A, **38**B are configured to output pilot pressures to respective pilot ports **21***a*, **21***b* to **28***a*, **28***b* of the control valves **21** to **28** for right and left travelling, for slewing, for the first boom cylinder, for the second boom cylinder, for the first stick cylinder, for the second stick cylinder, for the bucket, based on control signals from the controller **40** described below. In this case, pilot pressures output from the electromagnetic proportional valves **31**A, **31**B to **38**A, **38**B are increased or decreased according to control values output from the controller **40**, and movement strokes of the respective control valves **21** to **28** are increased or decreased according to the increase or decrease of said pilot pressures, such that supply flow rates to the corresponding hydraulic actuators **18**, **19**, **20**, **8**, **9**, and **10** are increased or decreased, thereby controlling the drive speeds of the hydraulic actuators **18**, **19**, **20**, **8**, **9**, and **10**.

[0040] The controller **40**, as described above, outputs control signals to the electromagnetic proportional valves **31**A, **31**B to **38**A, **38**B, in order to control the drive speeds of the hydraulic actuators **18**, **19**, **20**, **8**, **9**, and **10**. However, in the present embodiment, because the present invention is actually implemented for the drive control of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, when a portion relating to the drive controls of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, out of the controls performed by the controller **40** is described, as illustrated in the block diagram of FIG. **4**, a lever operation detecting means (corresponding to the operation detecting means of the present invention) **41** for detecting operations of the right and left operation levers **14**, **15**, a boom angle sensor **42**, a stick angle sensor **43**, a bucket angle sensor **44** for detecting a boom angle α (swing angle of the boom **5** relative to the machine body (see FIG. **1**)), a stick angle β (swing angle of the stick **6** relative to the boom **5** (see FIG. **1**)), a bucket angle γ (swing angle of the bucket **7** relative to the stick **6** (see FIG. **1**)) respectively, a traveling operation detecting means **45** for detecting operations of an operation member for traveling, an engine revolution speed detecting means **47** for detection engine revolution speeds, a pressure sensor for boom **48**, a pressure sensor for stick **49**, and a pressure sensor for bucket **50** for detecting pressures of head-side oil chambers rod-side oil chambers of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** respectively are connected to an input side of the controller **40**, and the electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B for the first boom ascending, for the first boom descending, for the second boom ascending, for the first stick IN, for the first stick OUT, for the second stick IN, for the second stick OUT, for the bucket IN, and for the bucket OUT are connected to an output side of the controller **40**. In addition, the controller **40** is provided with an operation amount control unit (corresponding to the control system of the present invention) **51**, and respective operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B for first boom ascending, for first boom descending, for second boom ascending, for first stick IN, for first stick OUT, for second stick IN, for second stick OUT, for bucket IN, for bucket OUT. Then, the operation amount control unit **51** determines operation amounts in a manner described below based on input signals from the detecting unit or sensors to be input to the controller **40**, and outputs the operation amounts determined by said operation amount control unit **51** to operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B. Said operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B each store therein an operation amount versus control value map in which correlations between the operation amounts and the control values to the respective electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B have been preset, and by using said operation amount versus control value map, the operation amount control unit **51** outputs control values to the respective electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B based on the operation amounts determined by the operation amount control unit **51**. Then, by the control values output to said electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B, the drive speeds of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** are controlled as described above.

[0041] Then, when the operation amount control unit **51** is described in detail based on the control block diagram of FIG. **5**, said operation amount control unit **51** is configured to include a speed requirement computing unit (corresponding to a speed requirement computing means of the present invention) **60** described below, an actual speed computing unit (corresponding to an actual speed computing means of the present invention) **61**, a map updating flag creating unit **62**, a load computing unit **63**, a main mapping unit **64**, a main map updating means for boom cylinder **65**, a main map updating means for stick cylinder **66**, a main map updating means for bucket cylinder **67**, a first operation amount computing unit **68**, a sub-mapping unit **69**, a sub-map updating means for boom cylinder **70**, a sub-map updating means for stick cylinder **71**, a sub-map updating means for bucket cylinder **72**, a second operation amount computing unit **73**, and other components. In the present embodiment, the present invention is implemented when an "attachment position control" mode is selected by the operation mode selecting means. Herein below, the control of the operation amount control unit **51** when the "attachment position control" mode is selected will be described.

[0042] The speed requirement computing unit **60** computes a current position of the bucket **7** (attachment position of the bucket **7** at a distal end portion of the stick **6**), based on a boom angle α, a stick angle β input from the boom angle sensor **42**, and the stick angle sensor **43**. Furthermore, the speed requirement computing unit **60**, based on operation amounts (lever strokes) of the forward-backward operation (the operation of moving a position of the bucket **7** in front-back direction (X direction illustrated in FIG. **1**) of the left-side operation lever **14** and the forward-backward operation (operation of moving a position of the bucket **7** in the up-down direction (Y direction illustrated in FIG. **1**)) of the right-side operation lever **15** input from the lever operation detecting means **41**), determines a ratio (XY ratio) of the left-right direction (X direction illustrated in FIG. **1**) to the vertical direction (Y direction illustrated in FIG. **1**) of the position of the bucket **7** to be moved, and computes a desired position of the bucket **7** from said XY ratio. Then, the speed requirement computing unit **60** computes the respective speed requirements Vr of the boom cylinder **8** and the stick cylinder **9** based on differences between computed current positions of the bucket **7** and desired positions of the bucket **7**. The data (boom length L**1**, stick length L**2**, etc. illustrated in FIG. **1**) necessary for said computation is stored in advance on a memory (not illustrated) provided in the controller **40**. Furthermore, the speed requirement computing unit **60** computes a speed requirement Vr of the bucket cylinder **10**, based on an operation amount (lever stroke) of the leftward-rightward operation of the right-side operation lever **15**. Then, the speed requirement computing unit **60** outputs the computed speed requirements Vr of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** to the main mapping unit **64**, the first operation amount computing unit **68**, and the sub-mapping unit **69**.

[0043] Further, the actual speed computing unit **61** computes current actual speeds Vp of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** respectively, based on change amounts of the boom angle α, the stick angle β, and the bucket angle γ input from the boom angle sensor **42**, the stick angle sensor **43**, and the bucket angle sensor **44**. Then, the actual speed computing unit **61** outputs the computed current actual speeds Vp of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** to the main mapping unit **64** and the sub-mapping unit **69**.

[0044] Furthermore, the map updating flag creating unit **62** creates ON/OFF flags of map updating, based on a boom angle α, a stick angle β, and a bucket angle γ to be input from the boom angle sensor **42**, the stick angle sensor **43**, and the bucket angle sensor **44**, and traveling operation, slewing operation (the leftward-rightward operation of the left-side operation lever **14**), engine revolution speed to be input respectively from the traveling operation detecting means **45**, the lever operation detecting means **41**, and the engine revolution speed detecting means **47**. Said map updating flags are created in such a manner that, in case traveling operation or the slewing operation is performed (during traveling or during slewing), OFF flag is created in either case of the case in which the engine revolution speed is lower than the set revolution speed that is preset, and the case in which the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** reach the cylinder end (at the time of maximum extending or maximum contracting), and ON flag is created in neither case. Then, the map updating flag creating unit **62** outputs said created ON/OFF flags of the map updating output to the main map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket cylinder of the main mapping unit **64** described below and the sub-map updating means **70**, **71**, and **72** for boom cylinder, for stick cylinder, and for bucket cylinder of the sub-mapping unit **69**. The OFF flag to be output by the boom cylinder **8** reaching the cylinder end is output only to the main map updating means **65** and the sub-map updating means **70** for boom cylinder, and the OFF flag to be output by the stick cylinder **9** reaching the cylinder end is output only to the main map updating means **66** and the sub-map updating means **71** for stick cylinder, and the OFF flag to be output by the bucket cylinder **10** reaching the cylinder end is output only to the main map updating means **67** and the sub-map updating means **72** for bucket cylinder.

[0045] Furthermore, the load computing unit **63** computes rates of loading (%) acting on the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, based on pressures of head-side, rod-side oil chambers of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** to be input from the pressure sensor for boom **48**, the pressure sensor for stick **49**, and the pressure sensor for bucket **50**. Said computation is performed in such a manner that, data for computations is created in advance, for example, assuming differential pressure between the head-side oil chamber and the rod-side oil chamber of the boom cylinder **8** when the bucket **7** is fully loaded to be the rate of loading (100%), assuming differential pressure between the head-side oil chamber and the rod-side oil chamber of the boom cylinder **8** when the bucket **7** touches the ground to be the rate of loading (0%), and assuming differential pressure between the head-side oil chamber and the rod-side oil chamber of the boom cylinder **8** when the bucket **7** is strongly pressed against the ground surface to be the rate of loading (−100%), and rates of loading (%) of the boom cylinder **8** are computed by using said data for computation. Then, the load computing unit **63** outputs said computed rates of loading (%) of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** to the sub-mapping unit **69**, and the second operation amount computing unit **73**.

[0046] Furthermore, the main mapping unit **64** stores therein the main maps for the boom cylinder, for the stick cylinder, and for the bucket, and is provided with the main map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket for updating the main maps at any time.

[0047] The main map for boom cylinder, as illustrated in FIG. 6A, is a map representing correlations between speed requirements Vr and operation amounts (%) of the boom cylinder **8**, and is used to determine an operation amount (%) from the speed requirement Vr of the boom cylinder **8** computed by the speed requirement computing unit **60**, in the first operation amount computing unit **68** described below. In the present embodiment, the maps are created, assuming speed requirement Vr, operation amount (%) on an extending side (ascending side of the boom **5**) of the boom cylinder **8** to be (+), and assuming speed requirement Vr, operation amount (%) on a contracting side (descending side of the boom **5**) of the boom cylinder **8** to be (−).

[0048] Further, the main map for the stick cylinder is a map representing correlations between speed requirements Vr and operation amounts (%) of the stick cylinder **9**, and the main map for the bucket cylinder is a map representing correlations between speed requirements Vr and operation amounts (%) of the bucket cylinder **10**, and these main maps for the stick cylinder, and for the bucket cylinder, similar to the main map for the boom cylinder, are used to determine the operation amount (%) from the speed requirement Vr in the first operation amount computing unit **68**. These main maps, though an initial main map (original main map) is mounted at the time of the shipment of products, are updated at any time by the main map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket.

[0049] The main map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket, based on speed requirements Vr of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** computed by the speed requirement computing unit **60**, and current actual speeds Vp of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** computed by the actual speed computing unit **61**, update the main maps at any time in order to decrease the speed differences between these speed requirements Vr and actual speeds Vp. In this case, the weighting of the speed difference to the speed requirement Vr is made small, and the main map is updated so that said small-weighted speed difference is decreased. By this weighting of the speed difference, updating of the main maps is less influenced by protruding data of the actual speeds Vp temporarily, accidentally generated like noises, and is effectively performed on characteristics (differences) that change little by little in a long period of time like deterioration over time of hydraulic components. Then, updating of the main map is performed only when the map updating flag is ON. In other words, the main map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket are configured such that updating of the main maps for boom cylinder, for stick cylinder, and for bucket not to be performed, in either case of a case in which traveling operation or slewing operation is being operated (during traveling or during slewing), a case in which the engine revolution speed is lower than the set revolution speed that has been preset, a case in which the boom cylinder **8** reaches the cylinder end in the main map updating means **65** for boom cylinder, a case in which the stick cylinder **9** reaches the cylinder end in the main map updating means **66** for stick cylinder, and a case in which the bucket cylinder **10** reaches the cylinder end in the main map updating means **67** for bucket cylinder. Then, the latest main maps that have been updated by the main map updating means **65**,**66**, and **67** for boom cylinder, for stick cylinder, and for bucket are designed to be output to the first operation amount computing unit **68**.

[0050] Now, updating of the main map will be specifically described, based on FIG. 6B, taking the main map for boom cylinder as an example. For example, a speed requirement Vr of the boom cylinder **8** computed by the speed requirement computing unit **60** is assumed to be (100 mm/sec), and an actual speed Vp of the boom cylinder **8** computed by the actual speed computing unit **61** is assumed to be (90 mm/sec). In this case, in the main map before updating, an operation amount is (50%) when the speed requirement Vr is (100 mm/sec), but in case the actual speed Vp is slower than the speed requirement Vr, the main map will be updated to increase an operation amount (%) in order to increase the actual speed Vp. For example, new main map is obtained by rewriting in such a manner that the operation amount for the portion of the speed requirement Vr (100 mm/sec) be increased from (50%) to (50.1%). In FIG. 6B, the amount of an increase of the operation amount is displayed in an enlarged size for easy recognition.

[0051] In determining a value of the operation amount in the new main map, in order to make smaller the weighting of the speed difference to the speed requirement Vr, in the present embodiment, the weighting to the actual speed Vp is set smaller than weighting to the speed requirement Vr and are weighted-averaged to obtain an operation amount by using said weighted average value. For example, in case a ratio of the weighting of the actual speed Vp to that of the speed requirement Vr is set at a ratio (1/100):(99/100), when the speed requirement Vr is (100 mm/sec), and the actual speed Vp is (90 mm/sec), the speed requirement Vr and the actual speed Vp are weighted-averaged in a manner as given in the following formula (1).

$$(100\ [\text{mm/sec}]\times 99+90\ [\text{mm/sec}]\times 1)/100=99.9\ [\text{mm/sec}] \quad (1)$$

Then, an operation amount (%) when the speed requirement is (100 mm/sec) in the new map is determined, in a manner as given in the formula (2) by using the above-described weighted average value.

$$50[\%]\times 100\ [\text{mm/sec}]/99.9\ [\text{mm/sec}]\approx 50[\%] \quad (2)$$

[0052] In this manner, the new map is updated so that an operation amount when the speed requirement is (100 mm/sec) to be (50.1%).

[0053] Furthermore, updating on as-required basis illustrated in FIG. 6B described above is performed successively, and thereby the main map will be changed for a long period of time as illustrated in FIG. 6C. Then, even if performance is deteriorated due to deterioration over time of the machine body, through such a long-term change of the main map, an operation amount (%) corresponding to the speed requirement Vr is always obtained.

[0054] In determining a value of an operation amount in the main map, in order to make smaller the weighting of the speed difference to the speed requirement Vr, in the present embodiment, as described above, the weighting to the actual speed Vp is set smaller than the weighting to the speed requirement Vr and the actual speed Vp and the speed requirement Vr are weighted-averaged, to obtain an operation amount by using said weighted average value. However, this computation method is by way of one example. For example, the weighting to the speed difference is set smaller than the weighting to the speed requirement Vr, and a percentage of said weighted-smaller speed difference to the speed requirement Vr is computed, thereby enabling a value of an operation amount in a new main map to be determined by using said percentage.

[0055] On the other hand, the first operation amount computing unit **68** determines operation amounts (%) for boom, for stick, and for bucket from the speed requirements Vr for the boom cylinder **8**, for the stick cylinder **9**, and for the bucket cylinder **10** input from the speed requirement computing unit **60**, by using the latest main maps for boom cylinder, for stick cylinder, and for bucket input from the main mapping unit **64**. Then, the first operation amount computing unit **68** outputs said operation amounts (%) for boom, for stick, and for bucket, to the sub-mapping unit **69**, and the second operation amount computing unit **73**.

[0056] Furthermore, the sub-mapping unit **69** stores the sub-maps for boom cylinder, for stick cylinder, and for bucket, and is provided with the sub-map updating means **70**,**71**, and **72** for boom cylinder, for stick cylinder, and for bucket for updating these sub-maps at any time.

[0057] These sub-maps for boom cylinder, for stick cylinder, and for bucket are maps for correcting operation amounts (%) for boom, for stick, and for bucket obtained by the first operation amount computing unit **68** in correspondence to loads acting on the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10**, individual/combined operations, engine revolution speeds, or the like. For example, when the sub-map for the boom cylinder is taken as an example in case of correction in correspondence to a rate of loading (%) of the boom cylinder **8** computed by the load computing unit **63**, and is illustrating in FIG. **7**, then, in said sub-map of FIG. **7**, corrected operation amount (%) can be obtained based on an operation amount (%) for boom obtained by the first operation amount computing unit **68**, and a rate of loading (%) of the boom cylinder **8** computed by the load computing unit **63**. For example, when an operation amount for boom obtained by the first operation amount computing unit **68** is (50%), and a rate of loading of the boom cylinder **8** is (50%), corrected operation amount (5%) is obtained from the sub-map in illustrated in FIG. **7**. In FIG. **7**, two-dimensional sub-map only in a case of the correction in correspondence to a rate of loading (%) for easy recognition is illustrated. However, significant factors that can influence the driving speeds of the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** include individual operation/combined operation (e.g., combined operations of the boom cylinder **8** and the stick cylinder **9**), and engine revolution speeds. Thus, in the present embodiment, though not illustrated, three- to four-dimensional sub-maps that are set so that they can respond to said individual operation/combined operations, engine revolution speeds. Although initial sub-maps (original sub-maps) are attached at the time of shipment of products, for these sub-maps for boom cylinder, for stick cylinder, and for bucket, they will be updated at any time by the sub-map updating means **65**, **66**, and **67** for boom cylinder, for stick cylinder, and for bucket.

[0058] The sub-map updating means **70**, **71**, and **72** for boom cylinder, for stick cylinder, and for bucket, based on the speed requirements Vr for the boom cylinder **8**, for the stick cylinder **9**, and for the bucket cylinder **10** computed by the speed requirement computing unit **60**, and the current actual speeds Vp for the boom cylinder **8**, for the stick cylinder **9**, and for the bucket cylinder **10** computed by the actual speed computing unit **61**, update the sub-maps at any time, in order to decrease the speed differences between these speed requirements Vr and the actual speeds Vp. In this case, the weighting of the speed difference to the speed requirement Vr is made small, and the sub-map will be updated so as to decrease said small-weighted speed difference, but the weighting of the speed difference in said sub-map is set greater than the weighting of the speed difference in the above-described main map. By this weighting, corrections to the speed difference between the speed requirement Vr and the actual speed Vp generated by differences in short-term conditions such as loads acting on the cylinders **8**, **9**, and **10** and individual operation/combined operations, engine revolution speeds and the like can be performed promptly. Then, updating of the sub-map is performed only when the map updating flag is ON, similarly to updating of the main map. In other words, when traveling operation or slewing operation is being performed (during traveling or during slewing), and an engine revolution speed is lower than the set revolution speed that has been preset, the sub-map updating means **70**,**71**, and **72** are configured in a manner that updating of the sub-maps for boom cylinder, for stick cylinder, and for bucket not to be performed in either case of a case in which the boom cylinder **8** reaches the cylinder end in the sub-map updating means **70** for boom cylinder, a case in which the stick cylinder **9** reaches the cylinder end in the sub-map updating unit **71** for stick cylinder, and a case in which the bucket cylinder **10** reaches the cylinder end in the sub-map updating means **72** for bucket cylinder. Then, the latest sub-maps that have been updated by the sub-map updating means **70**,**71**, and **72** for boom cylinder, for stick cylinder, and for bucket will be output to the second operation amount computing unit **73**.

[0059] Now, updating of the sub-map will be specifically described, taking the sub-map for boom cylinder as an example, as illustrated in FIG. **7** described above. For example, when an operation amount for boom obtained by the first operation amount computing unit **68** is (50%), and a rate of loading of the boom cylinder **8** is (50%), in the sub-map before updated, corrected operation amount (5%) will be obtained as described above. At this time, however, a speed requirement Vr of the boom cylinder **8** computed by the speed requirement computing unit **60** is (100 mm/sec), and an actual speed Vp of the boom cylinder **8** computed by the actual speed computing unit **61** is (90 mm/sec), because the actual speed Vp is slower than the speed requirement Vr, updated to increase the corrected operation amount (%) in order to increase the actual speed Vp. A new sub-map is obtained, for example, by rewriting in such a manner as to increase from (5%) to (5.6%) the corrected operation amount of the part where an operation amount for boom is (50%), and the rate of loading is (50%).

[0060] In determining a value of an operation amount in the new sub-map, in order to make small the weighting of the speed difference to the speed requirement Vr, in the present embodiment, the weighting to the actual speed Vp is set smaller than the weighting to the speed requirement Vr, and the actual speed Vp and the speed requirement Vr are weighted-averaged, thereby determining the operation amount by using said weighted average value. In this case, in order to make the weighting of the speed difference in the updating of the sub-map greater than the weighting of the speed difference in the updating of the main map, a ratio of the weighting of the actual speed Vp to that of the speed requirement Vr is set greater than a ratio when the main map is updated described above. For example, in case a ratio of weighting of the actual speed Vp to that of the speed requirement Vr is set at (1/10):(9/10), the speed requirement Vr and the actual speed Vp are weighted-averaged in such a manner as given in the following formula (3), when the speed requirement Vr is (100 mm/sec), and the actual speed Vp is (90 mm/sec).

$$(100\ [\text{mm/sec}]\times 9+90\ [\text{mm/sec}]\times 1)/10=99\ [\text{mm/sec}] \quad (3)$$

Then, a corrected operation amount (%) in the new map is determined as given in the following formula (4), by using the above weighted average value.

$$\{(50[\%]+5[\%])\times 100\ [\text{mm/sec}]/99\ [\text{mm/sec}]\}-50[\%]=5.6[\%] \quad (4)$$

[0061] In this manner, the new map is updated in such a manner that corrected operation amount at the time of operation amount (50%), and the rate of loading (50%) for the boom becomes (5.6%).

[0062] In determining a value of the corrected operation amount in the new sub-map, another computation method may be used, similarly to the case of the main map described above.

[0063] On the other hand, the second operation amount computing unit **73** determines corrected operation amounts (%) by using the latest sub-maps for boom cylinder, for stick cylinder, and for bucket input from the sub-mapping unit **69**, and adds said corrected operation amounts (%) to operation amounts (%) for boom, for stick, and for bucket input from the first operation amount computing unit **68**. Then, the second operation amount computing unit **73** determines operation amounts (%) for boom, for stick, and for bucket for use with operation amount versus control value map. Then, operation amounts (%) for boom, for stick, and for bucket obtained by said second operation amount computing unit **73** are configured to be output from the operation amount control unit **51**, and are input respectively into the above-described operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B for first boom ascending, for first boom descending, for second boom ascending, for first stick IN, for first stick OUT, for stick IN, for second stick OUT, for bucket IN, and for bucket OUT, and to be converted into control values to the electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B for first boom ascending, for first boom descending, for second boom ascending, for first stick IN, for first stick OUT, for second stick IN, for second stick OUT, for bucket IN, and for bucket OUT in said operation amount versus control value mapping unit **52**A, **52**B to **56**A, **56**B, and to be output to the electromagnetic proportional valves **34**A, **34**B to **38**A, **38**B.

[0064] The second operation amount computing unit **73** is conditioned such that, when operation amounts (%) for boom, for stick, and for bucket to be input from the first operation amount computing unit **68** are zero, directly outputs a value of operation amount (%) zero to each of the operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B, without performing correction by the sub-maps.

[0065] In the present embodiment configured as described above, the hydraulic shovel **1** is provided with the boom cylinder **8**, the stick cylinder **9**, and the bucket cylinder **10** serving as actuators, the operation levers **14**, **15** operated to drive these actuators, and the operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B that output control values for controlling drive speeds of the actuators based on the input of operation amounts. The drive control of the actuators will be performed based on the control values output from said operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B. However, operation amounts input into the operation amount versus control value mapping units **52**A, **52**B to **56**A, **56**B are obtained by the operation amount control unit **51**, and said operation amount control unit **51** is provided with the speed requirement computing unit **60** that computes the speed requirements of the actuators based on detected values from the lever operation detecting means **41** for detecting operations of the operation levers **14**, **15**, the main mapping unit **64** that stores therein the main map representing correlations between the speed requirements and the operation amounts so as t determine operation amounts from the speed requirements of the actuators, the actual speed computing unit **61** that computes current drive speeds of the actuators, the main map updating means **65**, **66**, and **67** for updating the main map at any time based on the speed difference between the actuator speed requirement and the current actuator drive speed, the sub-mapping unit **69** that stores therein the sub-map that corrects operation amounts based on the influencing factors that influence the drive speeds of the actuators, and the sub-map updating means **70**, **71**, and **72** for updating the sub-maps at any time based on the speed differences between speed requirements of the actuators and current drive speeds of the actuators. Then, the operation amount control unit **51** will determine operation amounts by using the main maps and the sub-maps updated by the main map updating means **65**, **66**, and **67**, and the sub-map updating means **70**, **71**, and **72**.

[0066] In other words, operation amounts obtained by the operation amount control unit **51** will be used, rather than detected values of the lever operation detecting means **41** for detecting operations of the operation levers **14**, **15**, for operation amounts used for the control of drive speeds of the actuators (for the boom cylinder **8**, for the stick cylinder **9**, and for the bucket cylinder **10**). In said operation amount control unit **51**, however, there are provided two kinds of maps: the main maps representing correlations between speed requirements and operation amounts of the actuators computed based on the detected values of the lever operation detecting means **41**, and the sub-maps for correcting operation amounts based on the influencing factors that influence the drive speeds of the actuators, such as loads acting on the actuators, and the like. Thus, operation amounts are obtained according to detected values of the lever operation detecting means **41**, by the main maps, and operation amounts are corrected based on the influencing factors such as loads acting on the actuators, by the sub-maps, and thus control of the drive speeds of the actuators will be performed with high accuracy. In addition, these main maps and sub-maps will be updated at any time based on the speed requirements of the actuators and the current drive speeds of the actuators. As a result, even when output characteristics of the engine or the hydraulic pump are changed due to secular changes, and even when the quantity of leaked oils is changed due to wear and tear or the like at cylinder piston sections or sliding sections of various types of valves, operational accuracy similar to that during service initial stage will be able to be held by using the main maps and the sub-maps updated at any time. Furthermore, since updating of these main maps and sub-maps can be performed at any time, based on the speed differences between the speed requirements of the actuators and the current drive speeds of the actuators, time and labor for updating is not required, and calibration work for map adjustment, which was conventionally necessary in order to respond to secular changes, becomes unnecessary, making it possible to significantly contribute to the simplification of maintenance job. In addition, influences of characteristics of machine bodies or deterioration over time of machine bodies can be easily grasped, by viewing the shapes of updated main maps and sub-maps, which can be utilized for troubleshooting of these machine bodies. Further, highly accurate drive control of the actuators can be performed continuously by the updating of the main maps and sub-maps, and as a result, they are also suitable for automatic driving.

[0067] Furthermore, in the operation amount control unit **51**, the main map updating means **65**, **66**, **67** and the sub-map updating means **70**, **71**, **72** are configured to update the main maps and sub-maps, in such a manner that the weighting of the speed difference to the speed requirement is made small, and said small-weighted speed difference be decreased, in updating the main maps and sub-maps based on the speed differences between the speed requirements of the actuators and the current the drive speeds (actual speeds) of the actuators. Therefore, the updating of the main map and the sub-maps becomes less influenced by the protruding data of the current drive speeds of the actuators generated temporarily, accidentally like noises, and thus stable drive control of the actuator s can be performed.

[0068] Furthermore, the weighting of the speed difference in the updating of the sub-maps is set to be greater than the weighting of the speed difference in the updating of the main map, such that the updating of the main maps can be effectively performed to characteristics (difference) that change little by little in a long period of time like deterioration over time of hydraulic components. On the other hand, the updating of the sub-maps enables correction to short-term speed difference generated by the influencing factors that have an influence on the drive speeds of the actuators, including loads acting on the actuators and individual operation/combined operations, the engine revolution speeds, and the like to be performed promptly.

[0069] Then, in this manner, by updating the main maps and the sub-maps by making the weighting of the main maps and the sub-maps different to the speed difference between the speed requirements of the actuators and the actual speeds, adequate speed correction will be performed immediately to the speed difference occurring in a short-term due to the influencing factors while keeping the drive of the actuators properly, and map adjustment can be performed slowly to long-term change due to deterioration over time of the hydraulic components, or the like, and accordingly the actuators will be able to be driven at a speed which is intended by an operator in the entire life cycle of construction machine.

[0070] Further, the influencing factors to be used for the correction of the operation amounts in the sub-maps, in the present embodiment, are supposed to include loads acting on the actuators, and individual operation/combined operations, and the engine revolution speeds when a plurality of the actuators is provided. In construction machines like the hydraulic shovel **1**, however, loads acting on the actuators significantly fluctuate depending on work contents, and drive speeds of the actuators are increased or decreased depending on individual operation/combined operations and the engine revolution speeds. As a result, highly accurate drive control of the actuators can be performed by correcting operation amounts based on these influencing factors.

[0071] Then, the present invention, in the present embodiment, is implemented on a construction machine (the hydraulic shovel **1**) provided with a bendable articulated working arm that is constituted of a plurality of arms (the boom **5** and the stick **6**), and the work attachment (the bucket **7**) attached to the distal end portion of said working arm, as well as provided with the hydraulic cylinders for a plurality of arms (the boom cylinder **8**, the stick cylinder **9**) and the hydraulic actuator for the work attachment (the bucket cylinder **10**) for driving the above plurality of arms respectively as actuators. However, positional control of the work attachment attached to the distal end portion of such an articulated working arm requires drive-speed control of a plurality of arms to be performed with a high accuracy, and as a result, positional control of the work attachment can be performed with a high accuracy by implementing the present invention on such a actuator drive control of construction machines.

[0072] Further, in the present embodiment, the right and left operation levers **14**, **15** operable in front, rear right and left directions serving as operation members for the working arm, and the operation mode selecting means selectable by the operator are provided, by said operation mode selecting means in case an attachment position control mode for controlling a work attachment position (position of the bucket **7**) by operations of the right and left operation levers **14**, **15** is selected, the operation amount control unit **51** computes a desired work attachment position based on detected values from the lever operation detecting means **41** for detecting the operations of the right and left operation lever **14**, **15**, and computes respectively the speed requirements of the hydraulic cylinders for a plurality of arms (the boom cylinder **8**, and the stick cylinder **9**) in order to control the work attachment position based on said computation results. The main maps and the sub-maps are provided respectively, in correspondence to the hydraulic cylinders for arms. Then, when the attachment position control mode is selected by the operator in this manner, the work attachment position can be controlled with a high accuracy by implementing the present invention on the configuration for controlling the work attachment position by operations of the right and left operation members.

[0073] Of course, the present invention is not limited to the embodiment (first embodiment). In the first embodiment, the bright and left operation levers **14**, **15** operable in right and left front, rear directions are provided as the operation members for the working arm. On the other hand, as in the second embodiment illustrated in FIG. **8**, one working machine operation lever (corresponding to operation members of the present invention) **74** operable in front-back, and up-down directions as the operation members for the working arm may be provided. In other words, the working machine operation lever **74** of the second embodiment is attached substantially parallel to the floor of the driver's cab **12** and is designed to be operable in front and rear, up and down directions, and is further constituted in a manner that the forward-downward operation thereof corresponds to the front-back direction (X direction illustrated in FIG. **1**) of the work attachment position (position of the bucket **7**), and the upward-downward operation thereof corresponds to movement in the up-down direction (Y direction illustrated in

FIG. **1**) of the work attachment position. By this configuration, a displacement direction of the working machine operation lever **74** and a movement direction of the work attachment position can be matched with each other. Then, by implementing the present invention, with the operation amount control unit **51** being constituted to compute a desired work attachment position based on detected values from the operation detecting means that detects operations of the working machine operation lever **74**, as well as to compute respectively the speed requirements of the hydraulic cylinders (for the boom cylinder **8**, for the stick cylinder **9**) for a plurality of arms in order to control the work attachment position based on said computed results, and with the main maps and the sub-maps being provided respectively in correspondence to the hydraulic cylinders for respective arms, then the work attachment position can be controlled accurately.

[0074] The above working machine operation lever **74** is constituted to be turned in a direction around the machine axis, and by turning said working machine operation lever **14** forward in a direction around the machine axis, the bucket cylinder **10** is drive-controlled in order to swing (the bucket OUT) the bucket **7** forward. On the other hand, by turning backward in a direction around the machine axis, the bucket cylinder **10** is drive-controlled in order to swing (the bucket IN) the bucket **7** backward. In FIG. **8**, reference numeral **75** denotes a slew operation lever, and said slew operation lever **75** is attached in a vertical direction relative to the floor of the driver's cab **12**. By rightward-leftward operation of said slew operation lever **75**, the slewing motor is drive-controlled so that slewing in right-left direction of the upper slewing body **3** is performed

[0075] Furthermore, in the present invention, without limiting to the above-described loads acting on the actuators, individual operation/combined operations, engine revolution speeds as the influencing factors for use with the correction of operation amounts in the sub-maps, the sub-maps can be created by using, for example, high or low oil temperatures for the drive of the actuators, difference in work contents performed by construction machines as the influencing factors.

[0076] Also, needless to say, the present invention can be implemented on various types of construction machines, without limiting to the hydraulic shovels.

INDUSTRIAL APPLICABILITY

[0077] The present invention can be utilized for drive control of actuators such as hydraulic cylinders provided in construction machines such as the hydraulic shovel.

DESCRIPTION OF REFERENCE NUMERALS

[0078] **1** hydraulic shovel
[0079] **5** boom
[0080] **6** stick
[0081] **7** bucket
[0082] **8** boom cylinder
[0083] **9** stick cylinder
[0084] **10** bucket cylinder
[0085] **52**A, **52**B to **56**A, **56**B operation amount versus control value mapping unit
[0086] **14**, **15** right and left operation levers
[0087] **51** operation amount control unit
[0088] **60** speed requirement computing unit
[0089] **61** actual speed computing unit
[0090] **63** load computing unit
[0091] **64** main mapping unit
[0092] **65** main map updating means for boom cylinder
[0093] **66** main map updating means for stick cylinder
[0094] **67** main map updating means for bucket cylinder
[0095] **69** sub-mapping unit
[0096] **70** sub-map updating means for boom cylinder
[0097] **71** sub-map updating means for stick cylinder
[0098] **72** sub-map updating means for bucket cylinder
[0099] **74** working machine operation lever

1. An actuator drive control system in a construction machine wherein, in a construction, machine provided with an actuator, an operation member configured to be operated so as to drive said actuator, and an operation amount versus control value map for outputting a control value for controlling a drive speed of the actuator based on an input of an operation amount, and configured to perform drive control of the actuator based on said control value output from said operation amount versus control value map, a control system configured to determine an operation amount input into the operation amount versus control value map is provided, and said control system is provided with an operation detecting means for detecting an operation of an operation member, a speed requirement computing unit for computing a speed requirement of the actuator based on a detected value from said operation detecting means, a main map for representing correlations between speed requirement and operation amount in order to determine an operation amount from the speed requirement of the actuator, an actual speed computing unit for computing a current drive speed of the actuator, a main map updating means for updating, at any time, a main map based on a speed difference between the speed requirement of the actuator and the current drive speed of the actuator, a sub-map for correcting an operation amount based on influencing factors that have an influence on the drive speed of the actuator, and a sub-map updating means for updating, at any time, the sub-map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, and is configured to determine an operation amount by using the main map and the sub-map updated by the main map updating means, and the sub-map updating means.

2. The actuator drive control system in a construction machine according to claim L wherein the main map updating means, in updating the main map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, makes the weighting of the speed difference to the speed requirement to be small, and updates the main map so as to decrease said small-weighted speed difference.

3. The actuator drive control system in a construction machine according to claim **1**, wherein the sub-map updating means, in updating the sub-map based on the speed difference between the speed requirement of the actuator and the current drive speed of the actuator, makes the weighting of the speed difference to the speed requirement to be small, and updates the sub-map so as to decrease said small-weighted speed difference.

4. The actuator drive control system in a construction machine according to claim **3**, wherein the weighting of the speed difference in updating of the sub-map is set greater than the weighting of the speed difference in updating of the main map.

5. The actuator drive control system in a construction machine according to claim **1**, wherein an influencing factor for use in correction of an operation amount in the sub-map is at least either one out of a load acting on the actuator, individual operation/combined operation in case a plurality of actuators is provided, and an engine revolution speed.

6. The actuator drive control system in a construction machine according to claim **1**, wherein a construction machine is provided with a bendable articulated working arm composed of a plurality of arms, a work attachment attached to the distal end portion of said working arm, as well as provided with a plurality of hydraulic cylinders for arms for driving the plurality of arms respectively, and a hydraulic actuator for the work attachment serving as actuators.

7. The actuator drive control system in a construction machine according to claim **6**, wherein a construction machine is provided with right and left operation members operable in front-back, and right-left directions serving as operation members for a working arm, and an operation mode selecting means selectable by an operator, wherein in case an attachment position control mode for controlling a work attachment position by operations of the right and left operation members by said operation mode selecting means is selected, the control system computes a desired work attachment position based on detected values from an operation detecting means for detecting operations of the right and left operation members, and computes speed requirements of a plurality of hydraulic cylinders for arms respectively in order to control the work attachment position based on said computation result, wherein a main map and a sub-map are provided in correspondence to each hydraulic cylinder for arm respectively.

8. The actuator drive control system in a construction machine according to claim **6**, wherein a construction machines is provided with one operation member operable in front-back, and up-down directions serving as an operation member for a working arm, wherein the control system computes a desired work attachment position based on detected values from the operation detecting means for detecting an operation of the operation member, and computes speed requirements of a plurality of hydraulic cylinders for arms respectively in order to control the work attachment position based on said computation result, and wherein the main map and the sub-map are provided in correspondence to each hydraulic cylinder for arm respectively.

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