United States Patent [19]

Staab

[11] **3,796,462**

[45] **Mar. 12, 1974**

[54] **MACHINERY FOR MULTIPLE GROOVING OF PAVEMENT**

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[22] Filed: **Sept. 15, 1972**

[21] Appl. No.: **289,687**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 212,253, Dec. 27, 1971, Continuation-in-part of Ser. No. 212,475, Dec. 27, 1971.

[52] **U.S. Cl.** **299/39,** 173/24, 173/52

[51] **Int. Cl.** **E01c 23/09**

[58] **Field of Search** 299/39-41; 173/24

[56] **References Cited**

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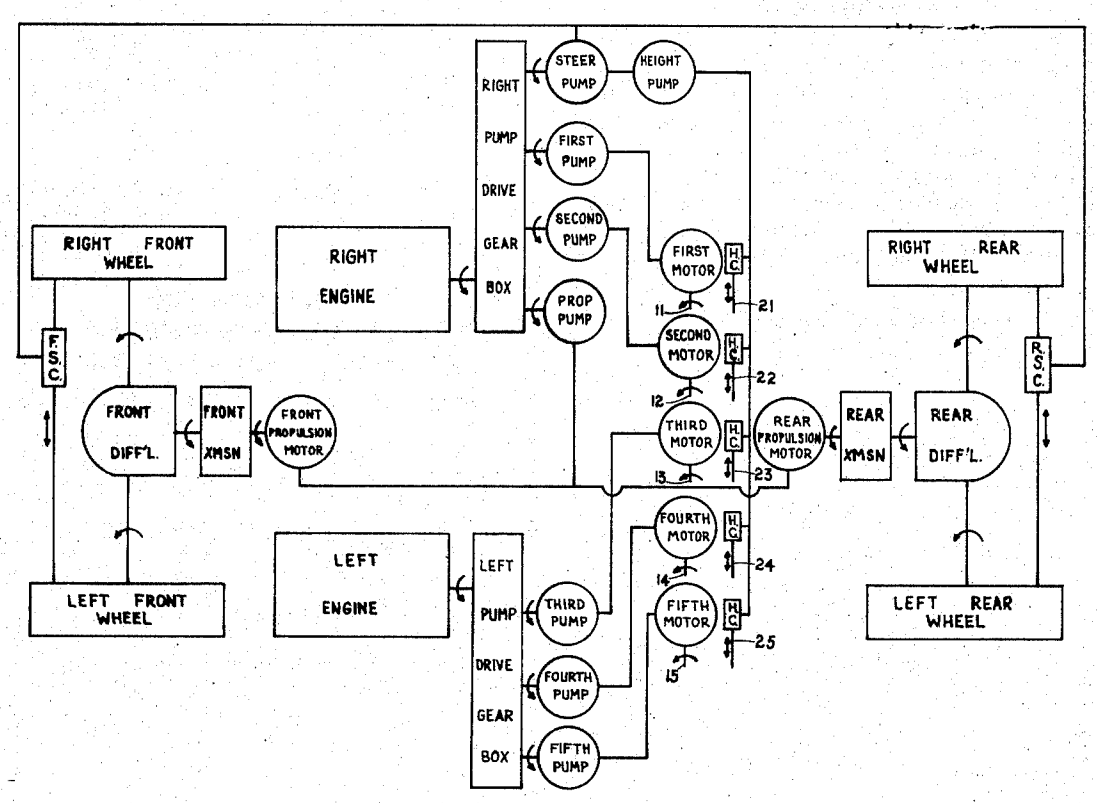
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[57] **ABSTRACT**

An hydraulic system is provided to perform the functions of vehicle propulsion and steering and of cutter rotation and height control in multiple grooving of pavement. Multiple cutter heads are controllable individually for use individually or in gangs. The load is distributed over a plurality of engines, each of which drives pumps for hydraulic motors adapted to rotate individual cutter heads separately or in unison.

14 Claims, 3 Drawing Figures



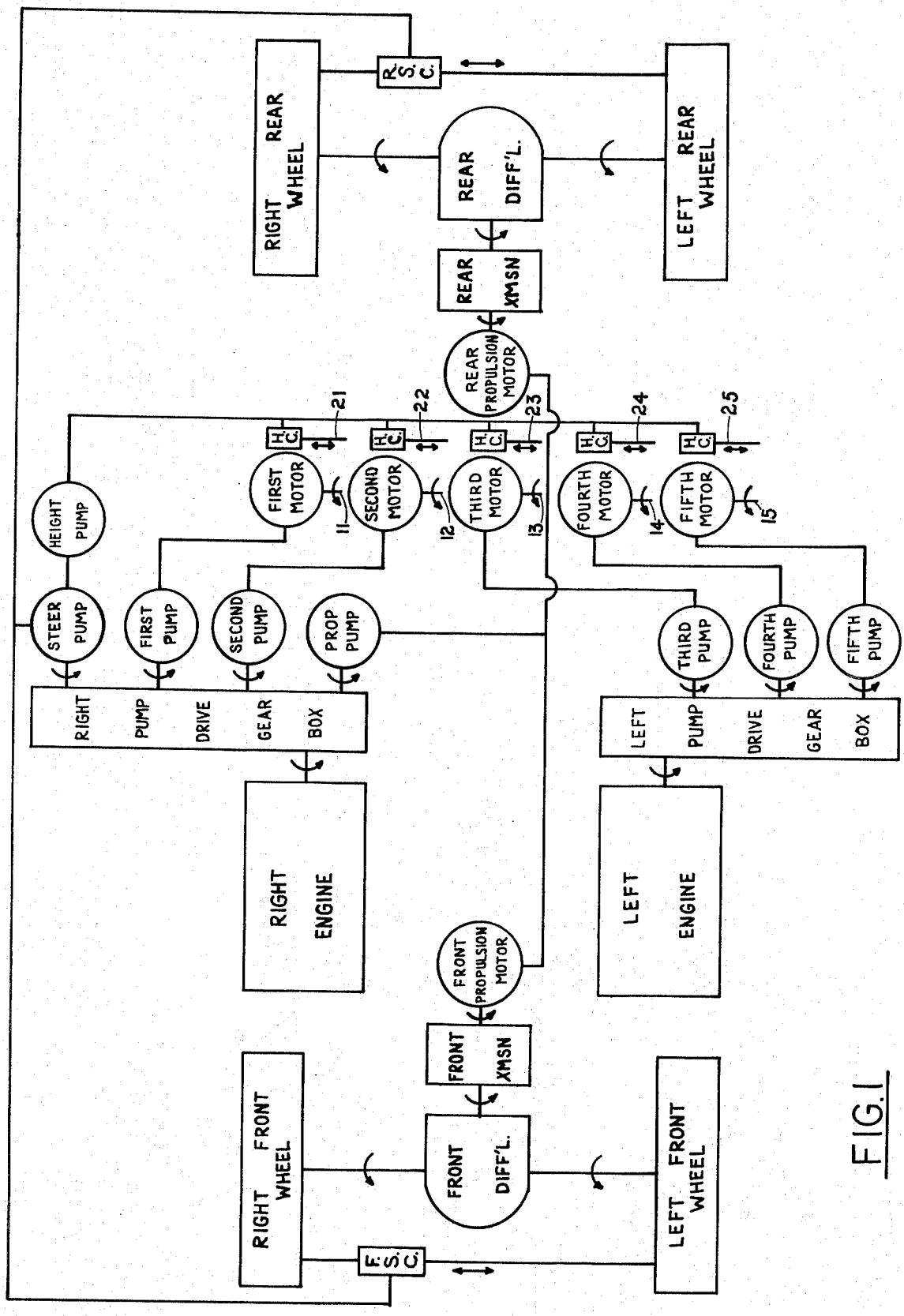

RIGHT REAR WHEEL
R.S.C.
LEFT REAR WHEEL
REAR DIFF'L.
REAR XMSN
REAR PROPULSION MOTOR
H.C.
21
22
23
24
25
FIRST MOTOR
SECOND MOTOR
THIRD MOTOR
FOURTH MOTOR
FIFTH MOTOR
11
12
13
14
15
HEIGHT PUMP
STEER PUMP
FIRST PUMP
SECOND PUMP
PROP PUMP
THIRD PUMP
FOURTH PUMP
FIFTH PUMP
RIGHT PUMP DRIVE GEAR BOX
LEFT PUMP DRIVE GEAR BOX
RIGHT ENGINE
LEFT ENGINE
FRONT PROPULSION MOTOR
FRONT XMSN
FRONT DIFF'L.
RIGHT FRONT WHEEL
LEFT FRONT WHEEL
F.S.C.

FIG. 1

FIG. 2

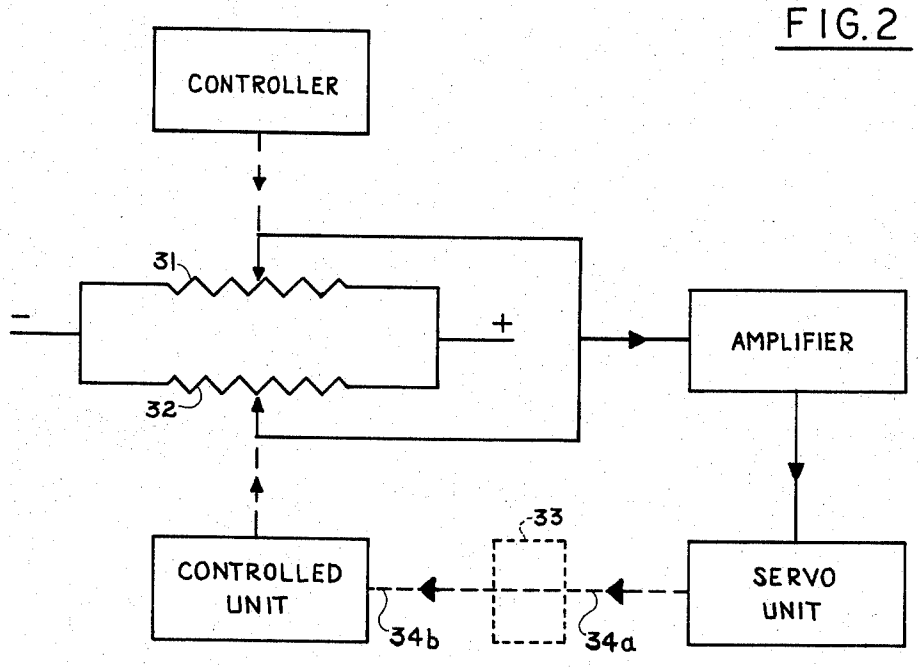
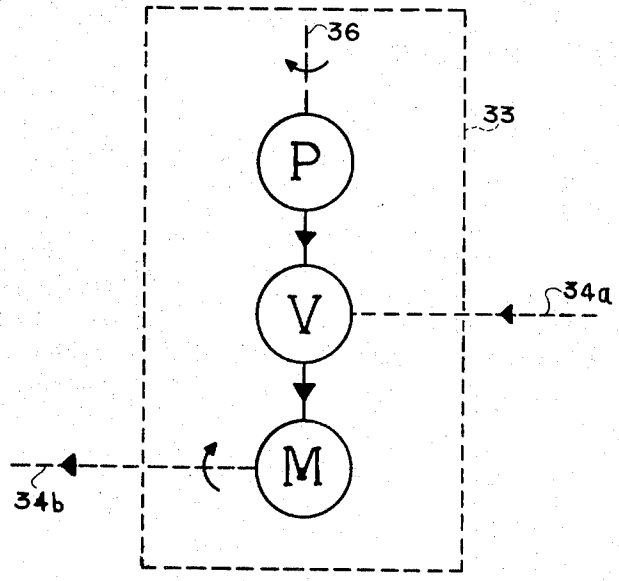

CONTROLLER
31
32
−
+
AMPLIFIER
33
CONTROLLED UNIT
SERVO UNIT
34b
34a

FIG. 3


36
33
P
V
M
34a
34b

MACHINERY FOR MULTIPLE GROOVING OF PAVEMENT

This is a continuation-in-part of my copending patent applications, Ser. Nos. 212,253 and 212,475 both filed Dec. 27, 1971.

Use of hydraulic systems to perform one or more of the functions of vehicle propulsion and steering and of cutter rotation and height control, in mutliple grooving of pavement as for imparting antiskid properties thereto, is well known. However, extension of such a system to perform all those functions or to perform some (or all) of them for multiple cutter heads has presented problems of load balancing, overloading, and related difficulties.

A primary object of the present invention is hydraulic control of operating conditions in multiple grooving of pavement.

Another object is accommodation of fractional and full loads in such a system.

A further object is provision of apparatus for accomplishing the foregoing objects.

Other objects of this invention, together with means and methods for attaining the various objects, will be apparent from the following description and the accompanying diagrams of a preferred embodiment, which is presented by way of example rather than limitation.

FIG. 1 is a diagrammatic representation of hydraulic interconnection of apparatus components useful according to the present invention;

FIG. 2 is a schematic or block diagram of control apparatus also useful according thereto; and

FIG. 3 is a further block diagram of hydraulic components useful in the apparatus of FIG. 2.

In general, the objects of this invention are accomplished, in multiple grooving of pavement, by hydraulic actuation of vehicle propulsion and steering and of cutter head rotation and height for one or more cutter heads operable individually or ganged together. More particularly, in such pavement grooving wherein a cutter head having laterally spaced cutting blades is supported adjustably in height and is adapted to be rotated about a transverse horizontal axis and to be lowered into cutting contact with pavement and wherein provision is made for propelling the cutter head along the pavement and thereby producing multiple grooves therein, the invention permits propelling the head and rotating it by separate hydraulic motor means and steering the head and controlling its height by separate hydraulic cylinder means.

FIG. 1 shows schematically hydraulic circuitry according to the present invention. Directions of movement of apparatus components actuated or controlled thereby are indicated by arrows. Directions of hydraulic flow, which can be visualized readily from identification of the respective components, are not indicated because such indication would be superfluous. Also omitted in the interest of simplification of the drawing, is any indication of the numerous valves employed in the hydraulic circuit. Suitable locations and types of valves will be readily apparent to persons ordinarily skilled in the art, as will flow volumes, return lines, reservoirs, and related components.

The four wheels designated as right and left front and rear support frame means (not shown) upon which the other apparatus components are carried. The front

wheels are driven by a front propulsion motor, which is hydraulic, through a front transmission (abbreviated "XSMN" on the drawings) and a front differential (contracted to "DIFF'L"). Similarly, the rear wheels are driven by a rear hydraulic propulsion motor through a rear transmission and rear differential.

The motive force is provided by right and left engines. Each engine drives a plurality of hydraulic pumps through its own interconnecting gearbox. A propulsion ("PROP") pump is so driven by the right engine and is interconnected by hydraulic lines to both front and rear propulsion motors to rotate them. Also driven through the right pump drive gearbox is a steering control ("STEER") pump, which is interconnected to double-acting steering cylinders: front steering cylinder ("F.S.C.") between the front wheels, and rear steering cylinder ("R.S.C.") between the rear wheels. Shown on a common shaft with the steering control pump is a height control ("HEIGHT") pump, which is interconnected to five parallel height control ("H.C.") cylinders, each shown with an extensible-retractable height control rod designated by a double-headed arrow.

For purposes of illustration, the present system is designated to accommodate five rotatable cutter heads (not shown), which may be constructed and arranged as disclosed in my aforementioned patent applications or otherwise as may be suitable. The present invention is similarly useful with other numbers, constructions, and arrangements of cutter heads, as will be readily apparent.

Also driven through the pump drive gearboxes are five pumps, one for each such cutter head. The first and second pumps are driven through the right pump drive gearbox, and the third, fourth, and fifth pumps are driven through the left pump drive gearbox. Hydraulic lines interconnect the respective pumps to their correspondingly designated hydraulic motors, each such motor having a cutter head drive shaft (with curved arrow) extending from it and being located beside one of the height control ("H.C.") cylinders.

Thus, the first pump is interconnected hydraulically to the first motor, which rotates first cutter head drive shaft **11**, and the adjacent height control cylinder, by interconnection to the height pump, is adapted to lift and lower the same cutter head (not shown) via extensible-retractable rod **21**. In like manner, second cutter head drive shaft **12** and second height control rod **22** control the second cutter head (not shown), and third cutter head drive shaft **13**, fourth cutter head drive shaft **14**, and fifth cutter head drive shaft **15** control rotation of their respective cutter heads (not shown), and the height thereof is controlled by respective third, fourth, and fifth height control cylinders **23**, **24**, and **25**.

It will be apparent that if the third, fourth, and fifth cutter heads are not to be used, as on a relatively narrow strip to be grooved by either or both the first or/and second cutter heads, the left engine need not be operated. The necessary functions of vehicle propulsion and steering and of cutter head rotation (for the first two heads) and height control are accomplished through the motive force provided by the right engine.

FIG. 2 shows schematically an electrical circuit for controlling actuation of those apparatus components whose position (as distinguished from rotation) is hydraulically controlled. Electrical interconnection is

shown in solid lines, and mechanical connection by broken lines. A controller, such as a manually actuated handle (shown in block form only) adjusts the position of the slider of first potentiometer **31** between opposing ends, which are interconnected to terminals designated + and − and maintained at given positive and negative potential, respectively. The slider of parallel second potentiometer **32** indicates the position of a controlled unit (shown in block form), which might be a steering or height component or indicator. The net potential from the pair of potentiometers is applied to an amplifier, whose output goes to a servo unit connected mechanically to the controlled unit. Any discrepancy between the desired position indicated by the controller and the actual position of the controlled unit is apparent as a potential difference to the amplifier and produces a counteracting movement of the controlled unit until such error signal is reduced to zero. The interconnecting or servo shaft has block **33**, superimposed thereon between respective incoming and outgoing connecting shaft portions **34***a* and **34***b*, and shown further in the next view.

FIG. **3** shows details of block **33** of the previous view, also schematically. Pump P, which has drive shaft **36** from one of the gearboxes, is connected hydraulically to motor M through valve V, whose setting is controlled by incoming portion **34**a of the servo shaft. Outgoing portion **34**b of the shaft is driven by motor M, whose degree (and perhaps direction) of rotation is determined by the setting of valve V.

Although a preferred apparatus embodiment of the present invention has been illustrated and described, modifications may be made therein while retaining at least some of the manifest advantages and benefits of the invention. Provisions may be made for coupling the left engine to the left pump drive gearbox so that possible loss of the right engine would not preclude propulsion, steering, and cutter head height control. Additionally, duplicate pumps for these functions may be provided and be driven from the left pump drive gearbox. Other modifications may be made also, as by adding, combining, or subdividing parts or steps, or substituting equivalents, without departing from the invention, which is defined in the following claims.

The claimed invention:

1. In multiple grooving of pavement wherein a cutter head having laterally spaced cutting blades is supported adjustably in height and is adapted to be rotated about a transverse horizontal axis and to be lowered into cutting contact with pavement and wherein provision is made for propelling the cutter head along the pavement and thereby producing multiple grooves therein, the improvement comprising propelling the head and rotating it by separate hydraulic motor means, steering the head and controlling its height by separate hydraulic cylinder means, and operating pumps to supply fluid to the foregoing hydraulic means by interconnecting some thereof to a first energy source and interconnecting others thereof to a second energy source.

2. Multiple grooving of pavement according to claim **1**, wherein a plurality of such cutter heads are individually rotatable and controllable in height, and including rotating different ones of the cutter heads via the respective energy sources.

3. Multiple grooving of pavement according to claim **2**, wherein the cutter heads are operable in ganged relation, and including raising and lowering all the cutter heads via the same one of the energy sources.

4. Multiple grooving of pavement according to claim **1**, including using a plurality of engines so to operate a plurality of cutter heads and including rotating separate pluralities of cutter heads by separate engines.

5. Apparatus for multiple grooving of pavement, comprising a plurality of individually rotatable cutter heads, each having laterally spaced cutting blades, an equal plurality of hydraulic motors connected to the respective heads to control the rotation thereof, vehicular frame means for supporting the respective cutting heads individually adjustably in height, an equal plurality of hydraulic cylinders connected to the respective heads to control the height thereof, an hydraulic motor to control vehicular propulsion, and engine means for actuating the hydraulic motors and hydraulic cylinders.

6. Multiple grooving apparatus according to claim **5**, including hydraulic cylinder means actuated by such engine means and adapted to steer the vehicular frame.

7. Apparatus for multiple grooving of pavement, comprising a plurality of individually rotatable cutter heads, each having laterally spaced cutting blades, an equal plurality of hydraulic motors connected to the respective heads to control the rotation thereof, vehicular frame means for supporting the respective cutter heads individually and together, an hydraulic cylinder adapted to steer the vehicular frame, and engine means for actuating the hydraulic motors and hydraulic cylinder.

8. Multiple grooving apparatus according to claim **7**, including an equal plurality of hydraulic cylinders connected to the respective heads and actuated by the engine means to control the height thereof.

9. Multiple grooving apparatus according to claim **7**, wherein the vehicular frame has a set of steerable wheels at the front thereof and a set of steerable wheels at the rear thereof, both sets of wheels being steerable together, and including respective hydraulic cylinder means connected to the sets of wheels.

10. Multiple grooving apparatus according to claim **7**, including hydraulic motor means, actuated by the engine means, for propelling the vehicular frame along the pavement.

11. Multiple grooving apparatus according to claim **10**, wherein the engine means includes a plurality of engines.

12. Apparatus for multiple grooving of pavement, comprising a plurality of individually rotatable cutter heads, each having laterally spaced cutting blades, hydraulic motors connected to the respective heads to control the rotation thereof, vehicular frame means for supporting the respective cutting heads individually adjustably in height, hydraulic cylinders connected to the respective heads to control the height thereof, an hydraulic motor to control vehicular propulsion, and engine means for actuating the hydraulic motors and hydraulic cylinders.

13. Apparatus for multiple grooving of pavement, comprising a plurality of individually rotatable cutter heads, each having laterally spaced cutting blades, hydraulic motors connected to the respective heads to control the rotation thereof, vehicular frame means for supporting the respective cutter heads individually and together, an hydraulic motor to control vehicular pro-

pulsion, an hydraulic cylinder adapted to steer the vehicular frame, and engine means for actuating the hydraulic motors and hydraulic cylinder.

14. Multiple grooving apparatus according to claim **13,** including hydraulic cylinders connected to the respective heads and actuated by the engine means to control the height thereof.

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