Oct. 31, 1967 K. A. DUFFY 3,349,785

DRIVING MEANS CONTROL RESPONSIVE TO SPEED INCLUDING LIGHT SENSITIVE ELEMENTS

Filed March 15, 1965 3 Sheets-Sheet 1

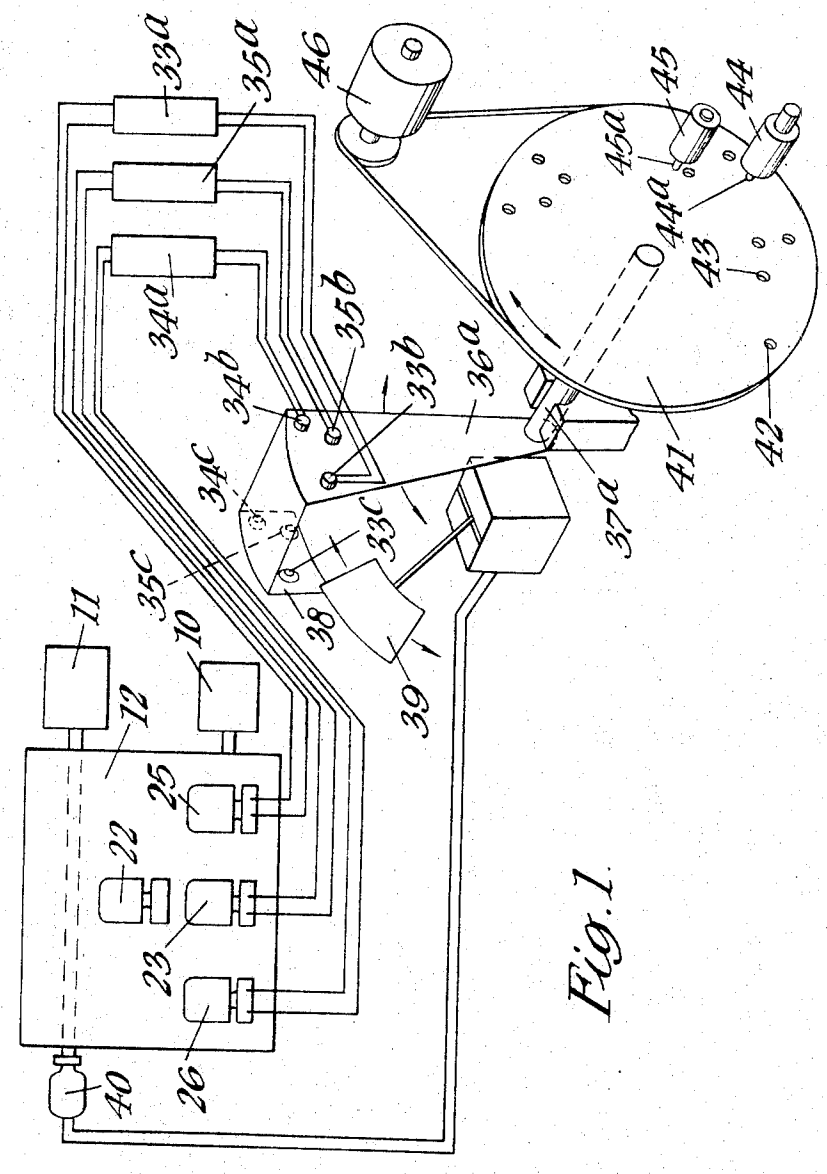


Fig. 1

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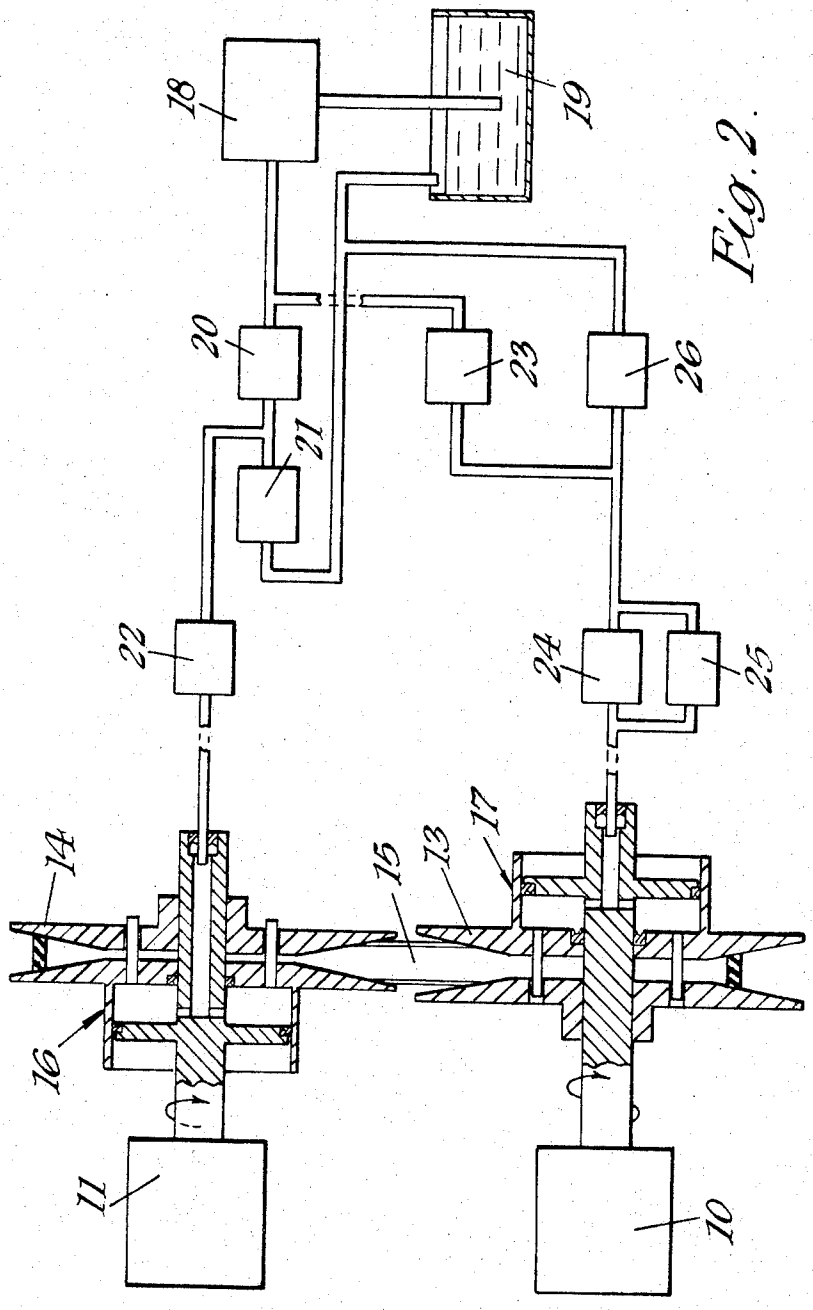


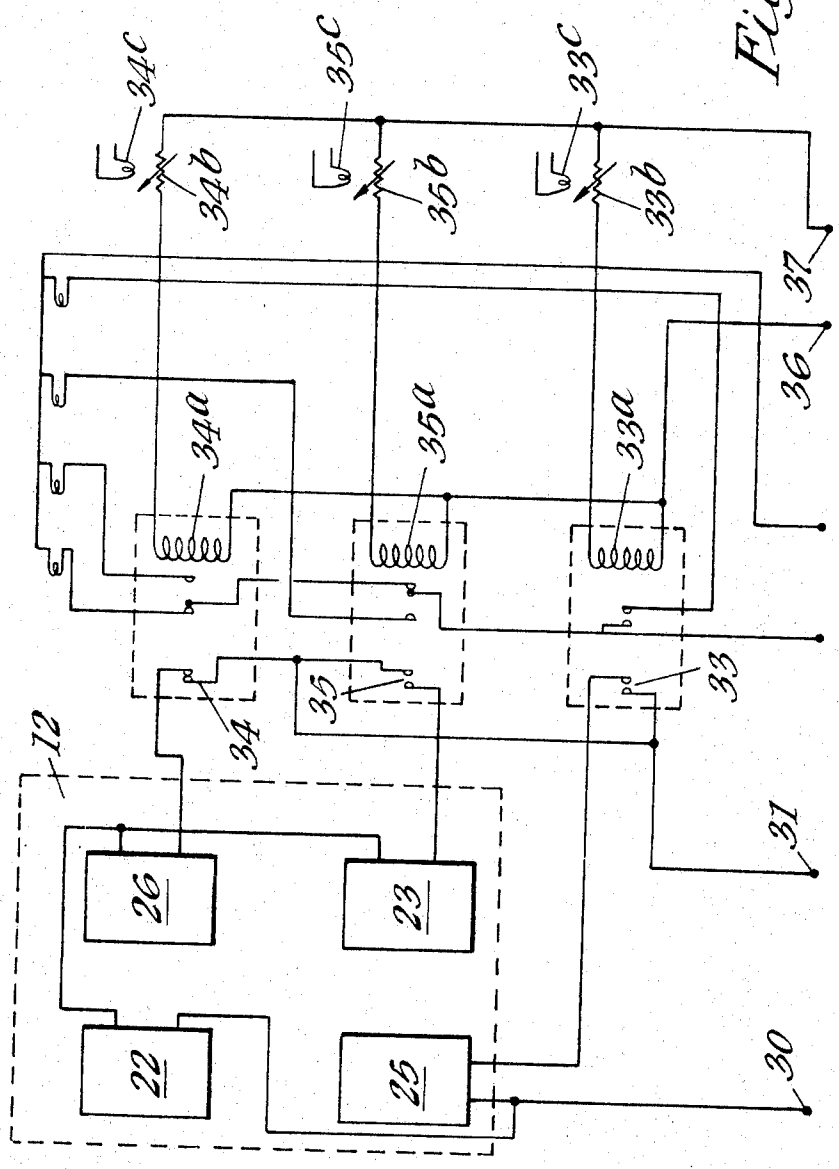
Fig. 2.

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Fig. 3.



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DRIVING MEANS CONTROL RESPONSIVE TO SPEED INCLUDING LIGHT SENSITIVE ELEMENTS

Kenneth Alfred Duffy, Rochester, England, assignor to C.A.V. Limited, London, England

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This invention relates to speed control apparatus and has for its object to provide such apparatus in a convenient form.

Speed control apparatus according to the invention comprises in combination, a driving means, a first solenoid for effecting a control to increase the speed of said driving means, a second solenoid for effecting a control to reduce the speed of said driving means, a third solenoid for effecting a control to increase the rate of change of speed in either direction, an adjustable carrier, three light sensitive devices mounted in spaced relationship on the carrier, a light source for illuminating the light sensitive devices, and a mask movable between the light source and the light sensitive devices in accordance with the speed of said driving means, said light sensitive devices being arranged respectively in electric circuits for controlling the three solenoids, the arrangement being such that, when said means is running at a speed corresponding to that for which the carrier has been preset the mask will assume an angular position so that all the solenoids are inoperative to vary the speed of said means, but departure from this speed will cause the mask to move so as to cause either the first or second solenoids to become operative to change the speed of said means in the appropriate direction, whilst further departure in the same direction will cause the third solenoid to become operative to increase the rate of change of speed of said means.

In the accompanying drawings:

FIGURE 1 is a diagrammatic view of one example of a speed control apparatus in accordance with the invention.

FIGURE 2 is a diagrammatic view of part of the apparatus shown in FIGURE 1 and

FIGURE 3 is an electrical circuit diagram of the apparatus.

Referring to the drawings, there is provided a constant speed electric motor **10** which is coupled to a liquid fuel pump or other device **11** to be tested through a variable speed transmission mechanism **12**. The transmission mechanism is shown in FIGURE 2 and comprises a pair of pulleys **13, 14** between which extend a driving belt **15**. The pulleys **13, 14** are in driving engagement with the motor **10** and the device **11** to be tested respectively and are of a variable size so that the speed ratio between the motor and device can be varied. Each pulley is formed in two halves and the relative axial setting of the halves of each pulley is controlled by a pair of fluid pressure operable piston/cylinder combinations **16, 17** respectively. Fluid under pressure is applied to the piston/cylinder combinations through passages defined within the shafts supporting the pulleys and the arrangement is such that when fluid is supplied to one combination the effective diameter of the associated pulley will be increased and the diameter of the other pulley will be decreased thereby forcing fluid from the other combination.

For supplying fluid under pressure to the piston/cylinder combination there is provided a fluid pump **18** which draws fluid from a tank **19** and delivers same through a pair of relief valves **20, 21** connected in series. The valve **20** controls the output pressure of the pump **18** to a value of the order of 80 p.s.i. and the valve **21** controls the

pressure of fluid intermediate the pair of valves to a value of the order of 40 p.s.i. Furthermore excess fluid is permitted to return from the valve **21** to the tank **19**.

A point intermediate the valves **20** and **21** is in communication with the working space of the piston/cylinder combination **16** through a passage, which passage is provided with a solenoid operable valve **22**. Furthermore, a point intermediate the pump **18** and the valve **20** is in communication with the working space of the piston/cylinder combination **17** through a further passage, and this passage is provided with a solenoid operable valve **23** to control the flow of fluid therethrough. Moreover, intermediate the valve **23** and the piston/cylinder combination **17** is a restriction **24** which can be bypassed when a solenoid operable valve **25** is operated. Moreover, fluid from a point in the further passage intermediate the valve **23** and the restriction **24** can flow back to the tank **19** when a solenoid operable valve **26** is operated.

The electrical connections of the operating coils of the solenoid operable valves are such, as will be described later, that the valve **25** can be operated independently of the other valves whilst the valve **22** is operated to allow flow of fluid therethrough whenever the valves **23** or **26** are operated, it being arranged that valves **23** and **26** cannot be operated together to allow fluid flow through the respective passages which they control.

Considering the case where the valves **22** and **23** are opened. Fluid at the higher pressure is delivered to the piston/cylinder combination **17** and the effective diameter of this pulley is increased. Since the belt **15** is of the kind which will not stretch by any substantial amount the pulley **14** is moved to reduce its effective diameter with the result that the device **11** is driven at a greater speed. During this movement of the pulley **14** fluid is displaced from the piston/cylinder combination **16** and flows to the tank **19** through the relief valve **21**. If at the same time the valve **25** is opened fluid from the pump can flow at an increased rate to the piston/cylinder combination **17** and the rate of increase in speed at which the device **11** is driven is increased.

Considering the case where the valves **22** and **26** are opened fluid at the lower pressure is delivered to the piston/cylinder combination **16** and the effective diameter of the pulley **14** is increased. In this case the pulley **13** is moved to reduce its effective diameter and fluid is displaced from the piston/cylinder combination **17** and flows to the tank. The result of this movement is that the device **11** is driven at a lower speed. If at the same time the valve **25** is opened fluid can leave the piston/cylinder combination **17** at an increased rate and consequently the rate of reduction in speed at which the device **11** is driven is increased. The apparatus so far described may be operated by operator controlled push buttons, however for convenience of use a speed control arrangement has been devised which will now be described.

Describing the electrical circuit first and referring to FIGURE 3 there are provided terminals **30, 31** for connection to a source of electric supply. Terminal **30** is connected to one end of the operating coils associated with the valves **22** and **25**. The other end of the operating coil of the valve **25** is connected to the terminal **31** through a pair of normally open relay contacts **33** which are arranged to be closed upon energisation of a relay coil **33***a*. The other end of the operating coil of the valve **22** is connected to one end of the operating coils of the valves **23** and **26**. The other end of the operating coil of the valve **26** is connected to the terminal **31** through a pair of normally closed relay contacts **34** the latter being arranged to be opened upon energisation of a relay coil **34***a*. Moreover, the other end of the operating coil of the valve **23** is connected to the terminal **31** through a pair

of normally open relay contacts **35**, the latter being arranged to be closed upon energisation of a relay coil **35***a*.

Also provided are a pair of terminals **36**, **37** for connection to a source of D.C. supply. The terminal **36** is connected to one side of each of the relay coils **33***a*, **34***a* and **35***a*, and the other sides of the relay coils are connected to the terminal **37** through light sensitive cells **33***b*, **34***b* and **35***b* respectively. Each cell has a light source associated therewith these being numbered **33***c*, **34***c* and **35***c*. Moreover, the light sources are arranged to be continuously illuminated whilst the apparatus is in use. The arrangement is such that when light from the associated source falls on one of the cells current will flow in the associated relay coil and the associated pair of contacts will be operated.

Also provided is an angularly movable carrier which comprises a plate like arm **36***a* extending radially from a supporting axle **37***a* and plate like part **38** which is mounted in parallel spaced relationship on the arm by means of an intermediate plate secured on the periphery of the arm and extending substantially parallel to the axis of movement thereof.

The light sensitive cells are mounted in angularly spaced relationship on the arm **36***a* whilst on the plate like part are mounted the light sources which serve to illuminate the cells respectively. Mounted for angular movement about the axis of the carrier is a mask **39** which is movable to prevent light from the sources falling on the cells and the position of the mask is controlled in accordance with the speed at which the device **11** is driven by means of a tachometer generator **40** arranged to be driven in synchronism with the device **11**.

The positioning of the light sensitive devices on the carrier will become apparent from the following description of operation of the apparatus. When a device is to be tested an operator sets the carrier at an angular position equivalent to the required speed of rotation of the device and connects the various sources of electric supply. Initially, all the cells will be illuminated and consequently all the relay coils will be energised with the result that the solenoids **22**, **23** and **25** will be energised to cause the transmission mechanism to effect a rapid increase in the speed at which the device is driven. As this speed increases the mask **34** will be moved and will eventually move sufficiently to obscure the cell **33***b* with the result that the solenoid **23** will be de-energised and the transmission mechanism will be caused to carry on increasing the speed at a slow rate. Eventually the mask will obscure the cell **35***b* and the solenoids **22** and **23** will be de-energised and no further change of speed will take place. If now the operator requires a further increase in speed the carrier is moved in the appropriate direction and the process will be repeated although if only a small increase of speed is required the carrier may not be moved sufficiently to uncover the cell **33***b*.

When the operator requires to reduce the speed he moves the carrier in the opposite direction and the second cell **34***b* will be obscured thereby causing the solenoids **22** and **26** to be energised which causes the transmission mechanism to reduce the speed at which the device is driven. If a substantial reduction of speed is required the cell **35***b* will be uncovered to cause the transmission mechanism to effect a rapid reduction in the speed at which the device is driven and as the mask **39** is moved in the opposite direction the cell **35***b* will be obscured to reduce the rate of reduction of speed and finally the cell **34***b* will be illuminated again to de-energise the solenoids **22** and **26** and so prevent further variation of the speed. It will be appreciated that if for any reason the speed of the output shaft alters when the solenoids are de-energised the mask will move in the appropriate direction to effect restoration of the speed to that determined by the setting of the carrier.

Conveniently the alteration of the setting of the carrier is achieved according to a pre-arranged programme

depending on the type of device being tested. For this purpose there is mounted on the axle **37***a* a peripherally grooved disc **41** which has at least one but preferably two series of angularly spaced holes punched in it. One of the series of holes **42** is arranged in accordance with the desired speed programme for increasing the speed at which the device is driven and is arranged at one radius from the axis of rotation of the disc and the other series of holes **43** is arranged in accordance with the desired speed programme for reducing the speed at which the device is driven and is arranged at another radius from the axis of rotation of the disc. Also provided are a pair of electro magnetically operable stops **44**, **45** at distances from the axis of the disc corresponding to the first and second series of holes respectively and which include spring loaded stop members **44***a*, **45***a* for engagement with the holes of the appropriate series. The disc is urged against the action of the stop members by means of a reversible electric motor **46** which is provided with a slipping friction belt drive with the disc.

The arrangement is such that when for instance it is required to increase the speed at which the device is driven, the motor **46** is driven in one direction and the appropriate stop is utilized to hold the disc **41** and when it is desired to change the speed the stop is momentarily disengaged from the hole and the disc is moved by the motor to vary the position of the carrier. The stop then engages the next hole of the series where it remains until it is again disengaged. When it is desired to reduce the speed at which the device is driven, the motor **46** is driven in the reverse direction and the other stop is utilised to determine the position of the disc. Thus by careful choice of the positions of the holes in the series a suitable programme of speeds can be arranged which are suitable for the repetitive testing of a plurality of the devices.

If desired additional sets of contacts may be provided on the relays respectively to control the illumination of lamps which indicate, when illuminated the state of the driving mechanism.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. Speed control apparatus comprising in combination, a driving means, a first solenoid for effecting a control to increase the speed of said driving means, a second solenoid for effecting a control to reduce the speed of said driving means, a third solenoid for effecting a control to increase the rate of change of speed in either direction, an adjustable carrier, three light sensitive devices mounted in spaced relationship on the carrier, a light source for illuminating the light sensitive devices, and a mask movable between the light source and the light sensitive devices in accordance with the speed of said driving means, said light sensitive devices being arranged respectively in electric circuits for controlling the three solenoids, the arrangement being such that, when said means is running at a speed corresponding to that for which the carrier has been preset the mask will assume an angular position so that all the solenoids are inoperative to vary the speed of said means, but departure from this speed will cause the mask to move so as to cause either the first or second solenoids to become operative to change the speed of said means in the appropriate direction, whilst further departure in the same direction will cause the third solenoid to become operative to increase the rate of change of speed of said means.

2. Speed control apparatus as claimed in claim **1** in which the setting of said carrier can be varied in accordance with a pre-determined programme.

3. Speed control apparatus as claimed in claim **2** in which the carrier and the mask are angularly movable.

4. Speed control apparatus as claimed in claim **3** in which the carrier is supported by a shaft, said shaft also serving to support a disc, a series of angularly spaced abutments formed on the disc, a stop for engagement

with said abutments and means for moving the disc angularly when the stop is disengaged from an abutment.

5. Speed control apparatus as claimed in claim 4 in which the disc is provided with two series of abutments there being provided two stops, one of which co-operates with one series of abutments when said means moves the disc in one direction, and the other of which co-operates with the other series of abutments when the disc is moved in the opposite direction.

6. Speed control apparatus as claimed in claim 5 in which said means comprises a reversible electric motor which drives said disc through a coupling, the coupling being of the kind which permits slip when a stop is co-operating with an abutment.

7. Speed control apparatus as claimed in claim 6 in which the position of the mask is controlled by the output signal from a generator arranged to be driven by said driving means.

8. Speed control apparatus as claimed in claim 7 in which three light sources are provided and these are mounted on the carrier so as to be movable therewith, said light sources being arranged to illuminate the light sensitive devices respectively.

No references cited.

ORIS L. RADER, *Primary Examiner.*

G. SIMMONS, *Assistant Examiner.*