ABSTRACT

A dual marine gear installation includes three remote controls, one of which is a master control. Each control has control levers for positioning signal potentiometers providing input control signals to an engine governor throttle actuator and to a valve of a hydraulically actuated variable clutch. Each clutch lever also actuates a forward drive switch, a reverse drive switch and a brake release switch. A transistor diode logic circuit is connected to the forward and reverse drive switches and includes a selected control relay for each control and a transfer relay. A main selection switch only at the master control selectively energizes one of the control relays to condition the circuit for transfer of control. The transfer relay is controlled by the energization of the control relays and by the logic circuit to permit transfer only if the next selected control is in the same drive condition as the controlling station or in neutral. The master control includes the start switches and must initially be in control with the clutch lever in neutral to start the engines.

Operation can be transferred to a different control only at the master control but the master can retake control at any time subject to limitation of the setting of the clutch levers.
ELECTRICAL CONTROL APPARATUS FOR AN ENGINE AND VARIABLE TRANSMISSION APPARATUS

BACKGROUND OF THE INVENTION

The invention relates to an electrical control apparatus for remote control of an engine driven propulsion means and including the throttle setting for an engine and the connection of the engine to the driven means or device to provide forward, reverse and neutral driving connections. The present invention is particularly applicable to marine propulsion apparatus and off-highway vehicles, wherein the drive apparatus is provided with a first control for establishing the engine speed through the setting of its governor and a second control for a transmission means Arnold, variably couple the engine to the drive elements and thereby adjust the propulsion speed. The present invention has been particularly applied to such marine gear apparatus and is therefore described accordingly even though it may be applied to off-highway vehicles and the like where similar controls are desired.

A highly satisfactory marine gear control for providing forward, neutral and reverse drive of a boat propeller shaft is shown in the co-pending application of Richard C. McRoberts and Bruce C. Arnold, Ser. No. 32,914, filed Apr. 29, 1970, now U.S. Pat. No. 3,613,469 and entitled "Power Transmission of the Hydraulically Actuated, Friction Clutch Type." As more fully disclosed therein, the engine speed is preset to a selected speed and a variable coupler is hydraulically actuated from a remote marine gear control having a throttle element and a clutch control element controlling a plurality of directional control valves for selectively operating of the hydraulic apparatus. The control valves selectively supply fluid to the apparatus for a forward or a reverse direction drive of the propeller shaft in accordance with the setting of the corresponding marine gear or clutch element. Additionally, the opening of the clutch valve is directly related to the energization level thereof which in turn is controlled by the position of the clutch control element from a neutral position. The system provides an unusually satisfactory infinite speed control over a given range.

In marine propulsion applications, a plurality of remotely located control stations, each having a suitable control unit, are desirably provided to permit remote control of the propulsion means from any one of such several stations. For example, the bridge control will normally provide a main or master remote control location. A sheltered remote station may be conveniently provided below the bridge in a weather protected area and an unprotected or exposed remote control may be provided on the deck.

Generally, the several remote controls have previously been interconnected to each other and to the engine and marine gear coupler or transmission in the engine room through mechanical or pneumatic control systems. In the mechanical system, the several control elements in the control stations and in the engine room are interconnected by suitable Bowden type cables such that movement at any station results in a corresponding movement at the other remote stations and in the engine room. Although mechanical systems have been widely employed, they are generally limited to marine units of less than 75 feet in length.

Above 75 feet in length, a pneumatic system has generally been employed wherein an air control system provides interconnection between the several remote stations and the engine controls. An air supply valve selectively supplies air to only one of the remote controls and thereby determines the unit in control. Generally, the pneumatic systems are substantially more expensive than mechanical systems and thus are not employed for shorter length boats. Although such systems have been satisfactorily employed, they have certain distinct disadvantages and generally are not readily adapted to the provision of the interlocking means for selectively transferring control to the several stations. Thus, the mechanical systems have the usual wear associated with moving mechanical elements and there is not actually a transfer between the several control stations as a result of the physical interlocking of the controls to each other. Both stations might attempt to operate the controls and thereby create a hazardous condition. Generally, the mechanical and the pneumatic system which employ air or other compressible like fluid also include slight time response delay which may be under certain conditions requiring instantaneous controlled movement of the boat, undesirable or unacceptable.

SUMMARY OF THE INVENTION

The present invention provides an electrical control system for interconnecting of a plurality of remote control units or stations to the drive which preferably includes an engine throttle adjustment and a separate variable transmission control, with interlocking means to selectively restrict the operating control to a single control unit or station and to provide transfer of control only under appropriate predetermined setting of a controlling station and a next selected control station. Generally, in accordance with the present invention, the several control stations include switch means or other signal forming means establishing electrical signals related to the position of corresponding drive control elements and interconnected through a logic circuit means with each other to restrict transfer between the several control stations to prespecified related positions between the control elements. One of the stations is provided with a selection means for determining which station is to take control. Each of the control elements in turn includes an electrical signal generator or signal forming means to produce an output signal related to the position thereof for selectively varying drive, as by separately adjusting the engine speed and the coupling between the engine and the driven element. The present invention thus provides an electrical control system which will produce essentially instantaneous signal transfer for controlling of the marine gear equipment as well as instantaneous transfer between the several control stations in response to appropriate corresponding conditions at the respective stations. The electrical system with the appropriate logic readily permits various interlocking means to restrict operation of the over-all system for maximum safety and efficiency of operation.

Generally in accordance with a most important aspect of the present invention, the selected master control station, which will normally be in the bridge of a ship or the like, is provided with a main control selection switch means for determining which control sta-
tion is to have control and to provide the initial system energization. The logic system conditions the controls in accordance with the master control setting to permit transfer only under predetermined conditions. For marine gear, the next selected station must be in neutral or the same drive position as the then controlling station. If the station in control is in neutral, the receiving station must correspondingly be in neutral to transfer. If the station in control is in a drive position, the station to receive control must be set in the same drive position or in neutral to transfer. The master control station can always retain control from any other remote station, subject only to the previous two conditions relating to the setting of the several control elements. Each other remote station may be provided with an acknowledgement switch which must be momentarily actuated as a condition of transfer to insure that an operator is present at the specific time the master station initiates a transfer.

In accordance with a particularly practical aspect of the present invention, the position of the several marine gear control elements is recorded by suitable cam actuated switches mounted adjacent to and actuated by cams secured to rotating marine gear control elements. The switches include a forward drive switch and a reverse drive switch respectively closed whenever the control element is moved in a corresponding control direction. The neutral position is indicated by the simultaneous opening of both switches. This provides a binary logic input into the logic control system. The logic control system thus detects the switch condition and controls the energization of a plurality of selected control means and a transfer means such as relays or other similar switching devices. The selected control relays are interconnected to the master control station and selectively energized in accordance with the setting of the stations selection means to condition the transfer circuit relay for transferring of the control between the various control stations or controls. Thus, the master control station will actually energize the respective relays to condition the system for transferring of control, but the transfer control relay can only respond to the actuating of the related relays if the logic system establishes an appropriate signal to such transfer relay noting that the stations are in a proper condition for transfer.

The logic system as such preferably is a suitable solid state transistorized circuit having a separate channel for each of the forward and reverse switches of the master control and a separate third channel for all other forward switches and a fourth channel for all other reverse switches. The outputs of the logic circuit transistor channels are connected through suitable logic gates to control a switching circuit for selectively controlling the energizing and de-energizing of the transfer relay. For example, the transfer relay can be selectively energized through a first transistor having an input circuit interconnected to the selected master station relay and the logic gates with an interlocking transistor connected to the several selected remote station control relays. The logic interlock is connected to over-ride the control relay inputs to the transfer relay circuit, with the over-riding control transistor responsive to the output of the logic gates to insure transfer only under the selected appropriate conditions.

In a system employing a master control station and a plurality of remote control stations the logic system is preferably provided with an interlock whereby if the several relays for the remote stations are simultaneously energized, control is automatically transferred back to the master control station. This can be readily provided in the relay system through contacts on the several remote station relays providing a series connection in the ground circuit of the transfer relay circuitry. As both relays are actuated, the ground circuit is broken and the transfer relay automatically resets the system to the master control station.

In accordance with still a further aspect of the present invention, the system is interlocked to restrict initial starting of the engine and insertion of the power to the circuit from the master control station and is such that the marine gear control element must be set in neutral. As applied to the previously described control, a master station relay is in series with a logic transistor of the logic circuit which determines if the marine gear control element at the master station is in neutral. The master station relay contacts insure that the master station is in control and the logic transistor insures that the variable marine gear element is in neutral.

In accordance with still further aspect of the present invention as applied to a multiple drive system, completely separate controls are provided for each engine and the associated marine gear coupler. A single power supply is provided having a first switching means actuated from the master control for establishing 'on' power to the various relays and logic elements. The power circuit is constructed to provide an unregulated DC control voltage line for operating the relays and power components and a transient protected voltage line for supplying power to the logic control system. Thus relays and similar elements will not be adversely affected by transient signals nor will they malfunction in response to such signals. In contrast, solid state logic control components may well respond adversely to transient signals and/or may be damaged by such signals.

As applied to separate engine and clutch controls, similar signal generating means may be incorporated into the control system to proportionately actuate the engine and clutch. Thus, a variable throttle potentiometer having a rotating input is connected to an engine speed lever and a second variable clutch potentiometer is connected to the marine gear control levers at each control. The throttle potentiometers are selectively connected as the input to a closed loop throttle positioning, a master system for in turn, actuating a suitable engine throttle. The clutch potentiometer is connected to provide a variable signal to a marine gear clutch control means.

The power supply to the engine throttle position control advantageously includes a constant output voltage for varying input voltages and load currents up to a maximum value. Current above the limiting value in the regulating circuit automatically drops the voltage to reduce the input to the motor and prevent establishing of adverse currents to demagnetize the motor. In addition to the normal current limit control, limit switches can be provided in the motor drive circuit to further reduce the current setting upon approaching a predetermined actuator position.
The present invention thus provides an electrical engine and coupling control system for providing a rapid and reliable control of several drive elements and the selective and positive transfer between the plurality of control stations only under appropriate conditions for transfer.

These and other objects and advantages of the present invention will appear hereinafter as this disclosure progresses, reference being had to the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a diagrammatic view of the engine and marine gear control system as applied to a dual engine propulsion unit in accordance with the teaching of the present invention;

FIG. 2 is a fragmentary view of a master control station head with parts broken away to illustrate certain details of construction;

FIG. 3 is an end view of FIG. 2 illustrating the position and movement of the several control elements;

FIG. 4 is a sectional view taken on line 4—4 of FIG. 2, and illustrating a cam switch assembly for establishing logic signals in accordance with the setting of the marine gear control element;

FIG. 5 is a sectional view taken generally on line 5—5 in FIG. 2 and more clearly illustrating a second control cam shown in FIGS. 2 and 4;

FIG. 6 is a schematic circuit diagram of the control at the master station and incorporating the cam switches shown in FIG. 2 and further showing a common power connecting circuit for supplying logic and control power to the remote control, operating circuits and components;

FIG. 7 is a schematic circuit diagram of the logic circuit showing the interconnection between the transfer means and the logic cam switches of FIG. 2;

FIG. 8 is a diagrammatic view of the engine throttle control loop for actuating the engine governor;

FIG. 9 is a schematic diagram of the engine throttle control loop including a preferred operational amplifier circuit and a regulated and current limited power supply forming a part of the engine governor loop;

FIG. 10 is a view similar to FIG. 6 illustrating the schematic circuit of a remote control station; and

FIG. 11 is a schematic illustration showing an engine shut down actuator which may be incorporated in the engine governor control for certain engines.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring to the drawings and particularly to FIG. 1, the present invention is shown applied to control the drive of a pair of marine propulsion drive elements such as the shaft and propeller assemblies 1 and 2 for a boat or ship (not shown). In the illustrated embodiment of the invention, the propellers 1 and 2 are separately driven. A first engine 3 is coupled through a marine gear transmission and clutch coupler 4 to the shaft of propeller 1. A second engine-marine gear drive 5 is similarly coupled to drive the propeller 2. Generally, the drive 5 for the propeller 2 is identical to that for the propeller 1 and consequently, the control system for a single marine gear installation is hereinafter described in detail as applied to engine 3 and coupler 4. A corresponding control would provide duplication of the components hereinafter described for the propeller 2 except where otherwise specifically noted.

Generally, the engine 3 and the coupler 4 are controlled from a plurality of remote control stations shown as including a master control station 6 a sheltered remote control station 7, and a simplified or exposed remote control station 8. The master control station 6 will normally be located in the bridge. The sheltered remote station 7 will be located within a second enclosure or shelter which is remote from the bridge and the exposed remote station 8 is designed as a weather-tight element for deck mounting or the like. The exposed remote station 8 must thus conform to the coastguard regulation for water-tight equipment and in general must be constructed to prevent leakage from the surrounding environment into the control under the conditions specified in the coastguard regulations.

The several control stations 6—8 are generally similarly constructed to permit separate control of the speed of the engine 3 and the direction and degree of coupling provided by coupler 4 between the engine 3 and the propeller 1. The master control station 6 has additional over-riding control functions and is therefore described in detail with its corresponding elements appearing at stations 7 and 8 in FIG. 1 being similarly numbered for simplicity and clarity of explanation.

The master control station 6 includes a station control selection unit 9, shown as a key actuated lock means rotatable between a central master control position, shown in full line in FIG. 1. a sheltered remote control position, shown to the left, and an exposed remote position, shown to the right. The lock unit 9 is actuated by a suitable key 10 as diagrammatically shown. As more fully developed hereinafter, only the master control station 6 has this selection control means and it determines which station is conditioned for and can operate the engine 3 and the coupler 4. The master control station 6 also includes a main power control switch 11 which controls and provides for the application of power for operating all of the control stations and the interconnection of operational components for the engine 3 and the coupler 4. A main start control switch 12 is also provided and connected directly to an engine starter 13 at engine 3 for remotely starting of the engines 3 and 5 only from the master control station. A separate engine shut-down actuator 14 is provided and connected through an engine room junction box 15 to the corresponding control junction box at the master station 6. The several operating components are connected into the control station through a junction box at the control station for selective connection to the several remote controls and the master control as hereinafter described. A stop button or switch unit 16 is also provided only at the master control station for actuation of the engine shut-down actuator.

The present invention is preferably employed with a separate engine speed control and a variable coupling such as shown in the previously identified application. The engine 3 is therefore provided with an engine throttle control 17 which is interconnected to a servo system to selectively adjust the setting of the engine throttle in accordance with a signal generated by the positioning of a throttle control lever 18 at the master control station. Similar control levers 18 are provided...
in each remote control with only one control and associated lever coupled into the circuit in accordance with the setting of switch unit 9.

As described in the above application, a hydraulic modulating valve 19 selectively adjusts the degree of coupling established by a friction clutch, not shown, between the engine 3 and the propeller 1 through selective energization of the valve 19 in response to the setting of a marine gear coupler control element 20 at the master control station. The remote control stations are provided with corresponding elements 20 to provide for the simultaneous control of the engine 3 and the coupler 4 from each of the several stations. The coupling is further controlled by a plurality of solenoid valves which interconnect the output of the modulating valve 19 to the clutch for selectively providing forward and reverse drive of the propeller 1. Thus the solenoids include a forward drive solenoid 21 and a reverse drive solenoid 22 as well as a brake solenoid 23. An optional two speed transmission solenoid 24 is included in the illustrated embodiment of the invention. The several solenoid valves are controlled by the positioning of the element 20 which is connected into the circuit through the selection switch unit 9, and a related logic control circuitry. The solenoid valve 21 obviously provides for a forward drive condition and the reverse solenoid 22 correspondingly provides for a reverse drive position. The brake solenoid 23 provides release of a holding brake in synchronism with the energization of the forward or reverse drive solenoids 21 and 22. The two speed optional transmission solenoid 24 is selectively controlled at a particular setting of the control element 20 as hereinafter described to permit transfer between the two speed coupling as an optional feature in this type of a hydraulic control system.

A tachometer 25 includes a magnetic pick-up or the like for sensing the actual rotational output speed of the propeller 1 and provides a signal back to the master control station 6 which is provided with a readout meter 26 calibrated to read the percentage wheel revolutions per minute for the settings of the control element 20. This provides a continuous indication of the setting of the drive or marine gear coupling control element 20 then connected into the circuit.

Various conventional auxiliary equipment can, of course, be provided. For example, an oil sensor 27 may be provided having various switch means for sensing abnormal pressure, temperature or level of the oil in the hydraulic marine gear coupler 4. The output of the sensor 27 is shown coupled through the junction box 15 to the several controls to provide corresponding illumination to a plurality of lamps 28, labelled to indicate the corresponding condition. Thus, if the oil temperature should rise to an abnormal level, the associated lamp 28 would be turned on at each of the control stations to provide an immediate indication of the condition. Similarly, the engine room will normally be provided with an instrument control and indicating panel 29 which will provide for certain engine controls such as shut down as well as an indication of the coupling oil temperature and pressure.

In addition, each of the control stations is provided with a bank of three lamps 30, 31 and 32 respectively related to indicate which control station is in control. The three lamps are shown positioned adjacent the selection unit 9 and identified by appropriate labels such as R, M and S and preferably will be different colored lamps.

The control and operating circuitry is energized from a suitable low voltage direct current power source such as a 24 volt DC supply line 33. This will allow highly reliable operation of the system without the necessity of a functioning alternator or the like. Obviously, any other suitable AC or DC power supply can be employed within the broadest aspects of the present invention.

As noted above, the sheltered remote station 7 and the exposed remote station 8 are similarly constructed except that they are not provided with means for starting or shutting down of the engine and of course, do not have the selection control unit 9. Generally, the sheltered remote station 7 may also be provided with a tachometer output reading meter whereas the exposed remote station 8 will not include such an element.

FIG. 1 illustrates a dual control system wherein similar throttle and marine gear levers 18' and 20' are mounted to the opposite side of the control 6 to provide a similar control for the engine-coupler unit 5.

The control apparatus at the master station 6, which would be duplicated at the other stations, is partially shown in FIGS. 2-5. Referring particularly to FIG. 2, the throttle control lever 18 is secured to a pivot shaft 34 mounted in the wall of a suitable enclosure. A throttle control signal means or generator 35 such as a potentiometer unit is mounted upon a suitable mounting bracket 36 and coupled to the shaft 34 for simultaneous and corresponding positioning. A similar shaft 37 is rotatably mounted immediately above shaft 34 and connected to the coupler lever 20. A valve control signal generator 38 which may also be a rotating potentiometer is mounted to the bracket 36 and similarly coupled to the shaft 37 for positioning in accordance with the positioning of the lever 20.

In accordance with the present invention, a pair of cam plates 39 and 40 are interconnected to a bearing hub 41 coupled to rotate with the control shaft 37. The cam plates 39 and 40 are located to selectively control a plurality of control switch including a forward drive control switch 42, and a reverse drive control switch 43 mounted to opposite sides of the cam plate 39 as shown in FIGS. 2 and 4. The switches are operable to actuate the forward drive solenoid valve 21 and the reverse solenoid valve 22 in response to proper movement of the control lever or element 20 as more fully described hereinafter. A similar pair of switches 44 and 45 are mounted in alignment with the cam plate 40, as most clearly shown in FIG. 5, for selective actuation and corresponding energization of the brake solenoid valve 23 and the optional two speed transmission solenoid valve 24 of FIG. 1.

The cam plate 39 further controls a neutral start switch 46 to limit starting of the engines 3 and 5 to the positioning of the corresponding control element 20 in the neutral position. In the illustrated embodiment of the invention, the neutral start switch 46 is shown mounted to the casing of the valve control potentiometer 38. The cam plate 39 is provided with an opening 47 which is aligned with the switch unit 46 with the lever 20 in the neutral position and only with the lever in the neutral position. A spring loaded shaft 48 is slideably mounted in alignment with the switch 46 and the cir-
The brake release switch 44 and the two speed transmission switch 45 are mounted in similar alignment
with the switches 42 and 43, respectively, and with the related followers engaging the periphery of the cam 40,
as shown in FIGS. 4 and 5. The cam plate 40 is located in alignment with the cam plate 39 as shown in FIG. 4
and is provided with cam operating projections or surfaces as most clearly shown in FIG. 5. Thus, the cam
plate 40 includes raised constant radius switch actuating portions spaced from the cam switch follower in the
neutral position. In particular, the forward drive related cam surface includes the initial cam portion 58 spaced
from the follower 59 of switch 44 by an angle of 10° and thus in alignment with the cam surface 54 of cam
plate 39. Thus the counter-clockwise rotation of the cam plates results in a simultaneous closure of the
brake release switch 44 with the closure of the forward drive cam switch 42.

The reverse drive cam portion includes an initial cam surface 60 to the opposite side of the cam follower 59
and similarly spaced in a counter clockwise direction ten degrees from the follower 59. Consequently, the
clockwise rotation of the cam plates 39 and 40 results in the simultaneous actuation of the brake release
switch 44 and the reverse drive switch 43.

The cam switch actuating large diameter portions of the cam plate 40 extend from the initial surfaces 58 and
60 through an angle somewhat greater than 90° and terminate in respective trailing cam surfaces 61 and 63
which move inwardly to the reduced diameter portion. This maintains the brake release switch 44 closed to
release the brake during the complete operative movement of the clutch control lever 20 from the neutral
position to the full forward drive engagement with stop 52 as well as the full reverse drive engagement with
the stop 53 as shown in FIG. 3. The trailing portions 61 and 63 are similarly formed and correspondingly spaced
from the two speed transmission control switch 45. In particular, the surfaces 61 and 63 are located with
respect to the switch 45 to engage and actuate the switch with the control lever 20 located 10 degrees from
the corresponding stops 52 and 53. Thus, with the optional two speed transmission circuit provided, the
switch 45 will be energized as the lever 20 is moved 80° from the neutral position in the illustrated embodiment
of the invention.

The several cam switches are connected at the master control station circuit as schematically shown in
FIG. 6 and into the logic control circuit of FIG. 7 for selective energization of the control valves 21 through
24.

Referring particularly to FIG. 6, the schematic circuit for the master control station 6 and the intercon.
ecting main power supply circuitry is disclosed. The master control station circuit generally includes the
several control switches and indicating lamps previously described with respect to the diagrammatic illustration
of FIG. 1. The tachometer meter 26 is provided with a pair of leads connected into the output of the
tachometer of FIG. 1. Similarly, the oil condition indicating lamps 28 are individually connected into the
oil sensing circuit 27 of FIG. 1 through suitable interconnecting leads. A buzzer or audible alarm 64 may be
provided and connected to energize whenever any one of the lamps 28 is energized. A test switch 65 is pro-
vided for directly applying power to the three lamps 28 for checking the operation thereof. The shut-down switch 16 is shown as a double pole single throw switch to provide separate circuits for establishing a shut-down signal as hereinafter described and for energizing of a shut-down lamp 66 to provide a visual indication that the engine is being shut-down at each of the remote stations.

The throttle control potentiometer 35 and the valve control potentiometer 38 are connected into the circuit as more fully described hereinafter.

The main power switch 11 is shown in FIG. 6 as a double pole single throw switch having a set of normally open contacts 68 which are momentarily closed and a set of normally open contacts 69 which remain closed in response to actuation of the switch 11 to the on position. The momentary contacts 68 are connected into the shut down actuator circuit to insure initial reset of the engine actuator upon first applying of the power as more fully developed hereinafter in the description of FIG. 11. The contacts 69 are interconnected into the circuit to energize a main power relay 70 of a power supply circuit for interconnecting of the main power lead 33 to the several control stations and the inter-related operating components. Thus, the contacts 69 are connected in a common ground lead 72 to the one side of the relay 70. The opposite side of the relay 70 is connected directly to the incoming power lead 33. The relay 70 includes a set of normally open contacts 70-1 which when closed provide power from lead 33 through a circuit breaker 73 to an unprotected DC power lead 74. The lead 74 is connected to operate relays and similar elements which can be operated without adverse affect from the result of superimposed transient signals and the like. Power is also supplied through breaker 73 to a protected DC supply circuit 75 including an inductance-capacitive filter 76 which is paralleled by a free wheeling diode 77. A clamping diode 78 is also connected in parallel with the filter circuit and the free wheeling diode 77 between the circuit breaker 73 and a common or return line 79. The circuit is connected as an ungrounded supply and consequently, the lead 79 is defined hereinafter as the low voltage line. The protected output is taken across the paralleled circuitry including the filter 76 and appears at the DC protected line 80. The lead or line 80 is particularly connected into the logic and other control circuitry employing solid state elements which might be subject to damage by transient voltages or the like. The filter network and clamping diode will remove the transient signal and insure reliable and long-life operation of the control circuitry.

Thus, the closing of the switch 11 and the related contact 69 energize relay 70 to provide power to the operating circuitry.

The closing of the relay contact 70-1 also supplies power via a lead 81 to the start control switch 12 for permitting starting of the engine. The lead 81 includes a set of interlocking normally open contacts 82-1 of a start relay 82. One side of the relay 82 is connected to the common power supply ground line 79 and the opposite side is interconnected to positive power through the logic circuit of FIG. 7 to permit starting of the engine only with the master control station 6 in control and the control lever 20 in neutral. Thus referring to FIGS. 6 and 7, the common lead 83 connects the one side of the relay 82 to the collector of a control transistor 84. The emitter of which is interconnected to the protected supply line 80 through the normally open contacts 85-1 of a master station selected control relay 85.

The one side of the relay 85 is connected directly to the unprotected power lead 74. The opposite side of the relay 85 is interconnected to the circuit through the key operated selection switch unit 9 through a connecting lead 86. Thus, referring particularly to FIG. 6, the selection switch unit 9 is shown as a single pole, three position switch having a common contact arm 87 connected to the logic low line 79 of the power supply. The contact arm 87 is selectively engageable with a master station contact 88 located centrally of a remote station contact 89 and a simplified remote station contact 90. The master control station 88 is connected to the lead 86. With the master switch unit 9 in the full line position shown, the contact 88 and consequently the lead 86 is connected to the low power line 79. Consequently, the corresponding side of the relay 85 of FIG. 7 is grounded and the relay is energized. This closes the contacts 85-1 and interconnects the protected power lead 80 to the emitter of the transistor 84. If the transistor 84 is conditioned to conduct, power is consequently applied via the lead 83 to the start relay 82 which closes its contacts and provides power to the start button and thus to the engine starting circuit 13 of FIG. 1.

A lead 91 from line 74 is connected in common to the one side of the station lamps 30, 31 and 32 and the opposite side of the lamps are selectively and individually connected into the circuit through the master control switch unit 9, as shown in FIG. 7. Thus, the master control indicating lamp 31 is connected to a lead 92 which in turn is connected to the lead 86 from the master control contact 88 in FIG. 7. The actual circuit connection is made in the logic circuit of FIG. 7 with all of the corresponding lamps 31 of the three stations 6, 7, and 8 similarly connected to the lead 86 which provides completion of the circuit to the master station selected relay.

Thus, with the master switch unit 9 connected in the position shown, the relay 85 is energized and the lamp 31 at each of the stations is illuminated to indicate that the master station is in control and if the engines are not started, that they may be started from the master control station, assuming that the master control station is in the neutral position and permitting conduction of the transistor 84. The setting of the cam switches 42 and 43 of the master control station indicate whether the circuit is in neutral as follows.

A transfer relay 93 is connected in an energizing circuit through a set of normally closed contacts 85-2 of the master station selected relay 85. Energization of the relay 85 opens this circuit to the relay 93 which resets the relay to a master position and in particular, places the associated plurality of contacts in the full line position shown in FIG. 7. The contacts of the relays 85 and 93 as well as other illustrated relays include a plurality of double throw, common poles such that each defines a pair of circuit contacts which are separately numbered by the relay number and an associated separate identifying number. The relay 93 includes a first set of
normally closed contacts 93-1 connected to the low power line 79 and to the one side of the relay 85 in common with lead 86. This latches relay 85 in the circuit independently of the setting of the master control switch unit 9 and holds the master station 6 in control until a positive transfer to a remote control station 7 or 8 is desired and a proper condition is established to permit such control.

The energization and latching of relay 85 also provides power through the now closed contacts 85-1 in FIG. 7 to a cam switch power lead 94 which is connected to the corresponding lead in FIG. 6 for energizing of the cam switches 42-45 of the master control station 6. Each of the switches 42 through 45 is similarly constructed as a single pole, double throw switch and corresponding elements of each switch will be correspondingly numbered and referred to by corresponding numbers. Referring particularly to the forward drive switch 42, a common contact arm 95 selectively engages a normally closed contact 96 connected to the common low line 79 and a normally open contact 97 connected in common with all of the other corresponding contacts of switches 43-45 to the power lead 94. The contact arms 95 are individually connected into the logic control circuit. The contact arm 95 of switch 42 is connected via a lead 98 to the anode side of a steering diode 99 in FIG. 7. The opposite side of the diode is connected through a set of normally closed contacts 93-2 of the transfer relay 93 to a forward drive solenoid line 100. The output of which is connected directly to the forward drive solenoid valve 21 of FIG. 1. Thus, with the cam switch 42 in the full line position shown in FIG. 6, the lead 98 is connected to the low side of the power supply and through the circuit just described and provides a corresponding low voltage connection to the solenoid valve 21 holding it de-energized. When the cam switch 42 however, is actuated, the contact arm 95 engages contact 97 and transfers positive power through the above described circuit to energize the solenoid valve 21 and thereby establish the coupling for forward drive, with the actual degree of coupling controlled by the valve 19. The contact arm 95 of the brake release switch 44 is connected by a lead 101 in series with a diode 102 and a set of normally closed contacts 93-3 of the transfer relay 93 to a brake release solenoid energizing line 103. Thus upon actuation of the switch 44, the brake release solenoid 23 of FIG. 1 is energized. As previously noted, this occurs simultaneously with the actuation of the forward or reverse drive switches 42 to 43 to provide a corresponding drive and release connection.

The reverse drive cam switch 43 similarly has its contact arm 95 connected by a lead 104 in series with a diode 105 and contacts 93-4 of the transfer relay 93 to the reverse solenoid energizing line 106.

The two speed transmission cam switch 45 similarly has its common arm 95 connected by a lead 107 in series with a diode 108 and a fifth set of normally closed contacts 93-5 of transfer relay 93 to the corresponding energizing line 109. Thus, with selected cam switches actuated and the transfer relay 93 in a de-energized state, power is supplied to the respective solenoids to provide the desired operative connection of the pre-set speed engine 3 to the propeller 1 with the degree of coupling controlled by the valve 19.

The cam switches 42 and 43 are also connected into the logic circuit to provide inter-related control which as previously noted, includes a first condition for starting; namely, that the coupler control lever 20 be positioned in the vertical or neutral position. This condition is established and responded to in the illustrated embodiment of the invention by interconnecting of the related cam switches lead 98 and 104 directly to the logic leads 110 and 111 in FIG. 7, which in turn are connected through isolating transistors 112 and 113 to the first and second channels of logic decoder circuit consisting of four channels, each of which includes a transistor 114, 115, 116, and 117, respectively. Each of the transistors 112 and 113 are similarly shown as NPN transistors having the input bases connected to the respective signal lines 110 and 111. The output circuit of the transistors are connected between the positive logic protected power line 80 and the common low line 79. With the transistors 112 or 113 turned off, the collector is at the relatively positive potential of line 80. When the transistor 112 is turned on, its collector drops to the low potential of line 79. The input signal at the base with the cam switch actuated drives the transistor 112 on and thus provides a step change from the high to the low voltage levels. This binary logic signal appears at an output line 118 connected between the collector of the transistor 112 and the input or base of the transistor 114 of the decoder circuit. The output lead 118 is also connected via a steering diode 119 to the input circuit of the main power conditioning control transistor 84 for controlling the initial starting of the engine, as follows.

The input circuit to the transistor 84 includes a control transistor 120 having its input circuit connected to a voltage dividing network 121 between the power connection to the emitter of transistor 84 and the common return line 79. The diode 119 is connected in the voltage dividing network and particularly to the base junction for the control transistor 120. Thus, with the logic decoding transistor 112 off, the positive potential at line 118 back biases the diode 119 and the voltage dividing network applies an appropriate turn-on power signal to the transistor 120 and to the inter-related connection to the transistor 84 permitting normal conduction. If the lever 20 at the master control station however, is not in neutral, but in a forward drive position, the cam switch 42 is actuated to supply power to turn on the transistor 112 and consequently, the line 118 is at the relatively low potential. This provides a relatively low voltage to the base of the transistor 120, thereby turning the transistor 120 off and preventing conduction of the transistor 84. This consequently prevents the starting of the engine through the circuit previously described.

The reverse cam switch 43 is similarly connected to the transistor 113, the output of which appears as a collector connected line 122 which is also connected through a diode 123 to the base of the transistor 120 in the same manner as the connection for diode 119. The output lead 122 is also connected to the input base connection of the second channel or stage transistor 115 of the decoder circuit to provide inter-related transfer control as more fully developed. Thus, with the circuit as described to this point, the master control station 6 is interconnected to control the operation of the
system in response to the starting of the engine from the master control station and the movement of the throttle lever 18 and the clutch control lever 20.

In this position, the potentiometers 35 and 38 of FIGS. 2 and 6 are connected into the circuits to control the engine throttle actuator 17 and the energization of the valve 19 as follows.

Referring particularly to FIG. 6, the potentiometer 38 for the controlling of valve 19 is shown including a center tapped resistance element 124, the opposite ends of which are interconnected to each other to form a common input connection. Power is applied between a common input connecting line 125 and the center tap line 126 from a regulated constant voltage source 127 connected across the protected power lines 80 to 79. The illustrated regulator 127 is a known series regulator which in essence looks like a highly constant voltage Zener diode. Generally, a transistor 128 is connected in series with the line 125 to the line 80. The bias input network is connected between the line 80 and the common 79 and line 125 with a Zener reference 129 connected between the low power line 79 and the base, to establish the reference voltage. The conductivity of the transistor 128 will vary to maintain a constant voltage at the positive lead 61 and thereby establish a constant voltage and provide a true linear position responsive potentiometer output at the tap 130 in FIG. 6. The polarity of the signal is identical for both forward and reverse movement of the control lever 20 as a result of the interconnection of the opposite ends of the resistor element 64, which produces an output with respect to the center tap lead 126. The tap 130 is connected via the lead 131 through a set of normally closed contacts 93-6 of the transfer relay 93 to a current regulating response lead 132 to establish a corresponding potential input signal to a current regulator 133 in FIG. 6. One side of the valve 19 is connected directly to the protected power supply lead 80.

The opposite side is connected to the low line 79 through the series current regulator 133. The illustrated regulator or control 133 includes a Darlington triplet transistor circuit interconnected to establish a high current gain equivalent transistor shown in the illustrated embodiment as an NPN equivalent. The wiper lead 132 is connected as the input signal to the base of the first stage of the amplifying stage. As a result of the high current gain, and the high input impedance presented to the lead 132 the emitter will be driven to essentially the same potential with a variable current through a series resistance branch including a variable resistor 134. Thus for any given voltage signal on the potentiometer, a selected related constant current supply is established through the resistors for energization of the valve connected between the line 80 and the low valve side connection line 136. The potentiometer 134 permits adjustment of the relative current change for any given input voltage change for various valve characteristics and the like.

A protective diode 137 is connected across the line 80 and 136 to permit discharge of the inductive energy in the winding 138 of the valve 19, in the event there is a sudden change in the setting of the current, without adversely affecting or applying damaging voltages to the network.

The engine speed or governor throttle control potentiometer 35 is connected into a motor control circuit, as follows. Referring particularly to FIG. 6, the potentiometer 35 is shown as including a center tapped resistance element 140 having the opposite ends thereof individually connected to opposite sides of a power supply as shown and described hereinafter in connection with FIG. 9. The output signal is taken between the center tap lead 141 and the adjustable tap 142 which is coupled to be moved with the throttle control lever 18 and connected in circuit through a lead 143. The potentiometer 35 is connected as an input signal to a closed loop engine governor position control unit for actuation for operating the engine governor throttle actuator of FIG. 1. Generally, the closed loop block diagram is shown in FIG. 8 with the potentiometer 35 connected to a summing point 144 of a servo amplifier 145, the output of which is coupled to actuate a DC motor 146 of a motor gear train drive assembly. A linear mechanical actuator 147 is mechanically coupled to the output of the motor 146 and provides a mechanical positioning of a throttle lever 148. A feed back potentiometer 149 is coupled to the output of the motor 146 in common with actuator 147 to provide an electrical feedback signal related to the actual position of the actuator 147 and therefore the throttle lever 148. The output of potentiometer 149 is fed back and summed with the output of the potentiometer 35 at the summing point 144. Thus, the actuator will be driven until the two signals reach a predetermined relationship or balance at which time the actuator 147 will be held in the commanded position. As shown in FIG. 8, a current limit and constant voltage supply 150 is connected to the servo amplifier 145 for driving the motor 146 to prevent damaging currents from being applied to the unit with the throttle driven to a full open or full closed limit position.

A preferred schematic circuit of a closed loop motor control system is schematically shown in FIG. 9 where the corresponding elements of FIG. 8 are similarly numbered for purposes of description. Referring particularly to FIG. 9, the motor 146 is schematically shown as a permanent magnet drive motor having an armature 151 coupled to drive the actuator 147 and potentiometer 149, in accordance with the energization of a winding 152. Potentiometer 149 is similar or identical in construction to the throttle element control potentiometer 35 and is energized from the corresponding fixed supply with a movable tap 153 providing a feedback signal for balancing the corresponding voltage signal established on the tap 142 of the potentiometer 35. As is well known, with both sides of the winding 152 connected to a corresponding potential, the permanent magnet motor 146 will be energized. The winding 152 is energized from the servo amplifier 145 with the opposite sides of the winding connected to an "H" connected output amplifier 153 to provide a holding torque as required by the servo commanded input. The movement of the motor is related to the energization level of the winding 152 and the polarity of the potential applied thereto. The illustrated servo amplifying circuit includes the "H" connected amplifier 153 with a Darlington quad connection driven by a pair of integrated operational amplifiers 154 and 155.
The operational amplifier 154 is connected to summate the output signals of the station control potentiometer 35 and the actuator motor driven feedback potentiometer 149. A logic circuit lead 157 is connected through a resistive summing network to the inverting input of the operational amplifier 154 and via a set of normally closed contacts 93–7 in the logic circuit of FIG. 7 to the potentiometer tap lead 143 of the potentiometer 35, shown in FIG. 6. The tap 142 provides a correspondingly polarized signal with respect to the neutral position or center tap winding line 141 of potentiometer 35 which as shown, is connected to the non-inverting input of the operational amplifier 154. The motor actuated potentiometer 149 has its tap 153 connected in series with a variable potentiometer 156 to the resistive summing network and thus to the inverting input of the operational amplifier 154. The potentiometer 156 provides a proportional adjustment to relate the angular movement of the engine governor throttle lever 18 with the desired rotational positioning of the throttle motor 146. Thus in a practical application, the throttle lever 18 is moveable between 120° as previously noted. The motor 146 however moves through 70° to provide a corresponding full open and idle positioning of the throttle. The setting of potentiometer 156 establishes corresponding related scaled signals as well as compensating for various governor manufacturers' tolerances and input motion from zero through the full throttle angles.

The output of the operational amplifier 154 is therefore an error signal related to the desired position and the actual position of the throttle actuator 17. This signal is sent through a high gain power amplifying stage 158 which is connected directly to one side of the motor winding 152, the opposite side of which is connected in the circuit by amplifier 155, which is driven via line 159.

The operational amplifier 155 has its non-inverting input connected directly to the output of the operational amplifier 154 and thus is driven out of phase in accordance with the error signal generated by the operational amplifier 154. The opposite side of the amplifier is connected to the common lead 141. The output of the operational amplifier 155 is similarly amplified through a high gain power amplifier 160 and produces an output at line 161 which is connected to the opposite side of the permanent magnet motor winding 152.

The circuit is established such that with corresponding related inputs from the logic circuit line 157 and the motor potentiometer tap 153 the operational amplifier 154 provides an output signal of a selected level. This signal of course drives the amplifier 155 to provide a corresponding output at line 161. The two output signals applied to the opposite sides of the motor winding 152 position the motor in the desired position in accordance with the usual error signal between potentiometers 35 and 148. If an error signal is generated by moving of the engine throttle control element 18 or the like, a corresponding signal is generated at the output of the amplifier 154. The inverted output applied to the input of amplifier 155 results in an opposite or inverted signal at its output. Consequently, the output potentials at lines 159 and 161 move in the opposite direction providing a corresponding energization of the winding 152 which then is driven to reposition the motor potentiometer 149 until a balanced error signal is again established.

The motor 146 and the operational amplifier power circuit is driven from a regulated voltage supply 162 which is interconnected to the 24 volt protected supply line 80 through the current limit circuit 150 to establish a desired regulated voltage at the output line 163. For example, in a practical application of the 24 volt protected input, a fifteen volt regulated output is generally required to operate the several circuit components.

The voltage regulator 162 is a known type circuit employing a Zener diode reference 164 connected across the input power lines 80 and 79. The Zener 164 is connected in series with the emitter circuit of a control transistor 165 and the base circuit of an amplifying stage shown as a Darlington pair 166 connected to the collector 165. A voltage sensing branch 167 shown as a resistive branch including a temperature compensating diode and a potentiometer having a tap 168 connected to the base of the control transistor 165 and thereby driving the transistor in accordance with the output voltage sensed by the tap 168 with respect to the Zener voltage of Zener diode 164. Thus any change from the desired 15 volts will vary the conductivity of the control transistor 165 to correspondingly control the conductivity of the Darlington pair 166 and thus provides the desired regulation in the well known manner. The input to the Darlington pair is through the current limit circuit 150 which includes a control transistor 169 having its input base circuit connected to the power lines 79 and 80, with a Zener diode 170 in series with a current limit setting potentiometer 171 connected across the base to the emitter circuit. The output of the transistor 169 provides a current supply at the collector line 172 which is connected to the base of the Darlington pair 166 and to the output collector circuit of the transistor 165. The transistor 165 thereby provides a variable diversion of the current from the base circuit to control the conductivity of the Darlington pair and the regulated supply as previously discussed. Generally, the circuit operates in accordance with the known current limit function with the current supply being fixed until a selected current limit is established at which time the current supplied by the current limit circuit will be reduced to limit the drive and thereby cause the voltage to reduce from the desired regulated voltage. Thus if the current should tend to rise above an undesirable or dangerous level as set by the potentiometer 171, the voltage to the motor is automatically reduced thereby reducing the current and preventing de-magnetization damage to the permanent magnet of the motor. If desired, an auxiliary resistor 173 may be selectively connected in circuit in series with the potentiometer 171 in the input base network. The resistor is normally by-passed by a pair of normally closed cam actuated switches 174 and 175 such that the circuit will normally operate as if the resistor 173 were not present. The cam switches 174–175 are coupled to the motor 146 to close at selected limit positions such as full throttle and shut-down or idle.

Opening of either one of the cam switches 174 or 175 inserts the resistor 173 which reduces the maximum current supply; further reducing and insuring back-off of the voltage applied to the motor 146 for positively
preventing excessive current and torque and possible over-drive against a stop or the like.

Thus the circuit as described above is set with the master control station 6 in control such that the engine can be started and the engine speed set by proper positioning of the throttle lever 18. The movement of the boat is controlled by the control lever 20 to move in a forward or reverse direction in accordance with a corresponding positioning through the actuation of the logic switches 42 and 43 and the setting of the potentiometer 38, which sequentially establishes energization of the proper solenoids 21 through 24 and a proportionate energizing of the valve 19 to produce the desired movement. The control by the master station 6 is indicated at all stations by illumination of the corresponding lamps 31, 31', and 31''. The wheel speed is indicated by the output of the tachometer viewer 26 at the master control station and also at the remote station 7. As previously noted, the exposed station 8 is not provided with this means and consequently, the information is not transmitted thereto.

If during the operation of the boat, it is desired to now transfer control to either the sheltered remote 7 or the exposed remote 8 or if control has previously been at a remote station and is to be transferred to the master, the selection must be made and signaled by the master control unit 6 by appropriate operation of the key lock selection unit 9.

As a transfer is essentially identical to or from either station unit 7 or 8, the transfer from and to station 7 and the required circuitry will now be described in detail with reference made to the opposite or exposed station 8 only where necessary to show the inter-relationship and interlocks provided.

The remote stations 7 and 8 are generally identically constructed except that the exposed remote 8 does not include the tachometer and each station generally includes duplicates of many of the components as shown for the master station in FIG. 6. Consequently, a schematic for only the sheltered remote station 7 is shown in FIG. 10 and the components which correspond to the components at the master station are identified by the same numbers and distinguished therefrom by double primes for simplicity and clarity of explanation. The circuits will be clearly distinguished by providing distinct numbering for certain interconnections as presently described to maintain the proper description.

The interconnection and transfer between the several stations in response to the actuation of the station control selection means 9 at the master station 6 is reflected in the operation of the logic circuit shown in FIG. 7. In the illustrated embodiment of the invention, a pair of remote selected station or control relays 176 and 177 are provided, for each of the corresponding control units 7 and 8. The circuit connection for relay 176 for station 7 is described and in accordance with the above, it will be understood that the relay 177 is similarly interconnected and functions for controlling of relay station 8 with the interlocks described for relay 176, similarly being provided for relay 177 through contacts of relay 176.

The relay 176 has one side of its winding connected directly to the unprotected power supply line 74 in common with the one side of the master control relay winding 85 and the opposite side connected through the lead 178 to the remote station contact 89 of the selection switch unit 9 as shown in FIG. 6. Thus, the movement of the selection switch unit 9 interconnects the low side of the relay 176 to the power low line 79, energizing the relay 176 and conditioning relay 85 for deenergization to permit transfer.

Relay 177 for control unit 8 is similarly connected in circuit to the contact 90 of selection switch unit 9 through a corresponding lead 179. Thus the movement of the switch unit 9 to either one of the contacts provide a corresponding energization of the relay 176 or 177 to affect a transfer in response to conditions as presently described for the transfer to the remote station 7.

Energization of the relay 176 closes a set of normally open contacts 176-1 which interconnects the protected power supply line 80 to a cam switch control power line 180 which in turn is interconnected to the cam switches of the remote control stations as shown in FIG. 10. The circuit connection between power line 80 and the cam switch power line 180 is through a set of normally closed contacts 177-6 of relay 177 to provide an interlocking control between the two remote relays. In the condition assume, the contact 177-6 will be closed and provide a power circuit connection described to the cam switch units of FIG. 10.

The remote station includes a main power switch 181 having a first set of contacts 181-1 connected in the line 180 to prevent transfer to the cam switches in the absence of a positive action or response at the remote station.

Each remote station 7 and 8 may also advantageously be provided with a momentary contact push button switch 182 connected through a suitable lead 182a to actuate a set-reset relay 183 in the transfer logic circuit of FIG. 7. The switch 182 actuates the relay to open a set of contacts 183-1 establishing an interlock signal to the logic circuit for permitting transfer from the master station 6 to the corresponding remote station 7 or 8, as subsequently described. A second set of contacts 181-2 of switch 181 is ganged with the contacts 181-1 and interconnected to provide direct energization of an "on" signal lamp 184 at the remote station 7. Thus with the switch 181 closed, the power transfer is established to the cam switches 42'-45' which respond to the clutch control element 182 in the same manner as the action described with respect to the master control cam switches 42-45 as shown in FIG. 6. The normally closed contacts of the cam switches 42'-45' of the remote unit 7 which are connected at the master station unit 6 directly to line 79, are similarly connected to a common logic line 10 through a common lead 186 to the center tap line 126 of the clutch control potentiometer 38' in common with the other station potentiometer.

The conditioning of the circuits for operation by the remote station 7 is indicated at all stations by illumination of the remote station indicating lamps 30, 30' and 30'' at the several locations. Thus, the relay 176 includes a second set of contacts 176-2 which interconnect a corresponding lamp ground line 187 to the common logic circuit ground 79. The lead 187 is connected to the several lamps at all three of the stations to provide a corresponding illumination. The opposite sides of the lamps are of course connected directly to the necessary positive power supply.
The relay 176 further includes potentiometer tap connecting contacts 176-3 and 176-4 connected respectively to the throttle control potentiometer tap line 188 connected to tap 142" of FIG. 10 and clutch control tap line 189 connected to the potentiometer tap 130" of FIG. 10. The opposite side of contacts 176-3 is connected by a line 190 to a set of normally open contacts 93-8 of the transfer relay 93 for selected connection to the operational input amplifier throttle line 157. Thus upon closure of contacts 176-3 and 93-8, the potentiometer tap 142" of the remote control station is connected into the operational amplifier to provide the necessary input control signal. The contacts 176-4 similarly connect the clutch control tap line 189 to a line 191 which is connected to the clutch control signal line 132 through normally open contacts 93-9 of the transfer relay. Thus, energization of the relay 176 conditions the circuit for transfer of the potentiometer tap signals from the remote station into the control circuit, but actual transfer is not established until the transfer relay 93 is energized. The transfer relay 93 is connected into the circuit to require a corresponding positioning of the clutch control levers 20 and 20" to selectively permit transfer from one station to another. The relay 93 includes a ground return line 192 connected to the low line 79 through contacts 176-5 of relay 176 in parallel with corresponding contacts 177-5 of relay 177. This particular interlock insures that the transfer relay 93 cannot be energized if both relays 176 and 177 should for some reason be energized simultaneously. This ground circuit connection is also interconnected to the corresponding lamp lines 187 for the remote station relays to provide a similar interlock for the indicating means as shown in FIG. 7.

The interlock ground return line 192 is connected to the low side of the relay 93 by a transfer control transistor 193, the base of which is connected directly to the normally closed contacts 85-2 of the master station relay 85. The base of transistor 193 is selectively connected to the common line 192 by a control transistor 194 to hold the transfer relay 93 off under certain conditions. Transistor 193 will be turned on if transistor 194 is off and the contacts 85-2 are closed to provide a power input connection from line 80. The base circuit of the transistor 194 is connected via a line 195 to the protected logic power line 80 in series with normally closed contacts 176-6 of relay 176 and normally closed contacts 177-6 of relay 177. With both of the transfer relays 176 and 177 de-energized and indicating the connection of the selection switch unit 9 to the master control, the transistor 194 is biased to conduct and prevents energizing of transfer relay 93. When relay 176 is energized, it opens the circuit and de-energizes transistor 194 and energization of relay 93 is now under the control of a logic control signal line 196. The relay 85 is of course still energized through the latch circuit to contacts 93-1 and prevents the energization of the relay 93 through the contacts 85-2.

The logic interlock line 196 is connected via the contacts of relay 93 to a pair of logic circuit decoders, a first of which controls transfer from a remote to a master station and the second of which controls transfer from the master to the remote.

The logic circuit for controlling the transfer from remote unit 7 to master unit 6 is first described, as follows. A set of normally open contacts 93-10 of the transfer relay 93 connects the line 196 to a steering diode 197 of the remote to master transfer logic decoder which in turn is connected through the logic transistor 114 through 117 to sense the condition of the clutch control levers 20 and 20" at the master station unit 6 and at the selected remote control station unit 7. The diode 197 has its anode connected directly to the positive logic power line 80 and is normally biased to conduct and transfer a positive turn on signal to the interlock line 196 and thus the base of transistor 193. This provides a holding signal to hold relay 93 energized and control at a remote control unit 7 or 8, depending upon energization of the relay 176 or 177. Transfer to the master 6 can be established only by opening the path through diode 197, as follows. A logic control transistor 198 is connected between the anode and ground common logic low line 79 and when biased to conduct holds the anode at the low potential thereby preventing transfer of the signal via diode 196 and permitting transfer back to master unit 6. A cut off control transistor 199 is connected into the base circuit of transistor 198 which is normally biased "on" to selectively control energization of transistor 198 and thereby remove the signal from line 196 and transfer of the turn off signal to transistor 193 if the logic conditions indicate a proper condition for transfer from the remote back to the master. The transistor 199 is connected into separate parallel biased networks for sensing forward and reverse conditions through a diode 200 in parallel with a diode 201 to the power line 80. Either circuit biases transistor 199 on or holds transistor 198 off. A first condition sensing bank of three diodes 202 are shown with their anodes connected in common to the circuit of diode 200 and a similar bank of three diodes 203 are connected to the bias network of diode 201 to selectively connect the corresponding bias network to common low and cut off energization of the transistor 199. Only when both circuits are off, is the transistor 199 off, which turns on the transistor 198, thereby permitting the desired transfer. In the bank of diodes 202, the top illustrated diode is connected via the line 204 to the collector side of the logic transistor 114. This transistor, as previously described, is interconnected through the line 118 and transistor 112 to respond to the condition of the forward drive cam switch 42 in the master control station 6. When the switch 42 is closed, a positive signal is applied to the connecting line 98 to turn on transistor 112 and turn off transistor 114. This would provide a back bias to the top diode in the bank of diodes 202. Conversely, if the lever 20 is in the neutral position, and the switch 42 is open, the transistor 112 is off and the transistor 114 is turned on. This grounds the line 204 and permits diode 202 to conduct thereby grounding the input of diode 200 providing a first possible cut-off condition.

The second diode in the bank of diodes 202 is connected to the previously described lead 122 which is interconnected to the base of the transistor 115 and thus to the collector of the transistor 113. As noted previously, the transistor 113 senses the condition of the reverse cam switch 43 at the master control station 6 through the interconnection of lead 111 and cam switch line 104 to the master control station 6. Thus, if the switch 43 is closed by lever 20, transistor 113 is
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turned on to ground the line 122 providing corresponding grounding to the input circuit of the logic circuit 199. Conversely, if the switch is in the normally open position as shown, transistor 113 is cut off providing a positive back biasing signal to the corresponding diode 202 and permitting turn on of the transistor 199.

The third diode in the bank of diodes 202 is connected to a lead 205 through the third stage of the logic circuit which constitutes an input to the base circuit of the transistor 116 and the collector circuit of a related transistor 208 for sensing of the condition of the remote station forward cam switch 42" as hereinafter described.

The bank of diodes 203 are similarly connected into the logic circuit with the uppermost illustrated diode connected to the top side of the second stage logic transistor 115 via a lead 206 to sense the condition of the reverse cam switch 43 at the master station. The second diode in the bank of diodes 203 is connected directly to the logic line 118 from transistor 112 to sense the condition of the forward cam switch 42 of the master station. The third diode 203 is connected via a lead 207 to the base of the fourth stage transistor 117 and connected to indicate the condition of remote control reverse switch 43".

The logic signal appearing at line 205 and applied to the third diode in the first bank 202 is responsive to the condition of the forward drive switch 42" at the selected remote station as follows. The coupling transistor 208 has its output connected to the base of the third transistor 116 to selectively supply power thereto to establish conduction or to ground the input circuit to prevent the conduction. A lead 209 connects the base of the transistor 208 to the corresponding side of a pair of diodes 210 and 211, the opposite sides of which are connected respectively via leads 212 and 213 to the remote control stations 7 and 8. The connection to the remote control station unit 7 is shown via the lead 212 in FIG. 10. If the remote control station unit 7 is in neutral, the related cam switch 42" will be connected to ground thereby affectingly applying ground to the anode of the diode 210 to prevent the transfer of a turn on signal to the transistor 208. As a result, the logic line 205 will be at the high level providing correspondingly back biasing on the diode 202. On the other hand, if the cam switch 42" is actuated, to a forward drive position, a positive or "on" logic signal is applied via the signal line 212 from cam switch 42" to the transistor 208 causing it to conduct and provide a logic low to the line 205 which permits the related diode 202 to conduct thereby by-passing the base circuit diode 200 and preventing turn on current to the transistor 199.

As noted, the cam switch diode 211 similarly connects the related cam switch (not shown) of the remote station unit 8 into the circuit of transistor 208. However, that cam switch of unit 8 will be de-energized regardless of the position of the clutch lever 20", because power is not supplied thereto unless the relay 177 is energized.

The top illustrated diode in bank 203 is connected to the lead 206 and in turn to the collector of transistor 115. This transistor 115 is controlled by the signal at lead 122 which as noted immediately above, indicates the opened or closed condition of the cam switch 43 at the master station unit 6. Thus the top diode of 203 indicates or is biased in the opposite direction from the second diode in the first bank. The second diode in the bank 203 is similarly connected to the lead 118 to sense the condition of the forward drive cam switch 42 and is oppositely biased from that of the first diode in the bank 202 which is connected to lead 204 and to the opposite side of the transistor 114 from that of lead 118. Similarly, the third diode in the bank 203 is connected to the lead 207. The latter diode 203 senses the logic condition of the transistor 117 through the interconnection of a control transistor 214 which responds to the condition reverse cam switches 43" and 43'" of units 7 and 8 similar to the action of transistor 208 for the related forward switches 42" and 42'". A lead 215 connects the base of the transistor 214 to the common side of a pair of diodes 216 similarly connected via leads 217 and 218 to the reverse drive cam switches 43" and 43'" of the remote station units 7 and 8. The line or lead 217 is shown in FIG. 10 connected to the common contact arm of the reverse drive cam switch 43". Thus, with the remote control switch 7 supplied with power as a result of the energization of relay 176 and the closure of the related power switch 181, the signal line 217 provides an off signal in accordance with whether or not the cam switch 43" has been operated. This provides a signal in the same manner as the forward drive cam switch 42" does through line 212.

Thus the diode banks 202 and 203 sense the condition of the clutch control levers 20 and 20'" to turn off the transistor 199 only if the lever 20'" of the remote station unit 7 in control is in the same drive position as the master station lever 20 or alternatively, the latter is in neutral. Any other condition, will maintain a turn on path from one of the bank of diodes 202 or 203 and maintain the turn-on power to the transistor 199. Consequently, transistor 199 is held on, transistor 198 is held off and a turn-on signal is transferred to and held on the transfer relay 93 via the diode 197. If the above described conditions however are met, both of the bank of diodes 202 and 203 will be conducting through at least one diode and turn on power is removed from the base of transistor 199 which turns off and allows completion of the input circuit to transistor 199. Conduction of transistor 198, as a result of the above, grounds the anode of the diode 197 and opens the circuit through normally open contacts 93-10, which are closed when the station 7 is in control, and lead 196 to the base of the transistor 193, turning it off and providing de-energization of the relay 93. The relay 93 will then actuate its associated contacts to return to the normally closed position shown and actually effect the transfer of power from the remote control station to the master control station. De-energization of the relay 93 opens the latch contacts 93-11 to relay 176 and consequently, results in the dropping of this relay. The ground line 79 is connected through the contacts 93-11 to an interlock lead 219 which is connected via relay contacts 176-7 in a lead 220 to the ground side of relay 176. Thus, the transfer affected by de-energization of relay 93 opens this ground latching circuit to relay 176 whereby it is energized again dependent upon the position of the master control station selection switch unit 9.
A timing capacitor 221 is connected to the lead 196 and the low logic line 79. Thus, with the operation of the circuit under the remote control station, contacts 93-10 were closed. Upon transfer of power through the diode 197, capacitor 221 is charged. When relay 93 is de-energized to open the signal circuit, the capacitor will discharge through the transistor 193 to provide a holding current. This circuit is primarily employed in the transfer from the master to the remote unit which requires energizing of relay 196. Capacitor 221 insures a holding signal to permit the transfer of the several contacts and the latching of the relay 176 and relay 93 through contacts 85-2 as hereinafter described.

Referring particularly to FIGS. 10 and 7, the cam switch 42" of unit 7 is connected into the circuit via the lead 212 and diode 210. The cam switch is transferred to the forward drive solenoid line 100 via a set of normally open contacts 93-12 of the transfer relay 93. The reverse drive cam switch 43" is similarly connected through lead 217 and diode 216 and a set of normally open contacts 93-13 of the transfer relay to the reverse drive solenoid line 106. The brake release solenoid switch 44" is similarly connected via lead 222 and a diode network and contacts 93-14 to the brake release line 103. The two speed transmission control cam switch 45" is similarly connected via steering diodes and lead 223 to the normally open contacts 93-15 which are now closed and connected to the two speed transmission control line 109. The above conditions are established to complete the transfer to the remote control station 7 which is solely in control and will remain in control as long as the selection switch unit 9 is maintained with contact 87 engaging contact 89. If the selection switch movable contact 87 is moved from contact 89, it breaks the circuit to the selection circuit to relay 176 and transfer it to the relay 85 or 177. This will result in a corresponding energization of the related station relay, but it will not automatically affect transfer from the remote station even to the master station as a result of an interlocking signal applied to the lead 196 of transfer control relay transistor 193 as described above.

With the transfer relay 93 de-energized, the contacts 93-10 to the lead 196 open and a set of normally closed contacts 93-16 close transferring the control to the master station 6 with the lead 196 connected to the logic decoder circuit via a control lead 224 including a steering diode 225 connected to the power logic protected power line 80. Transfer of power via diode 225 to the lead 196 and thus to transistor 193 is controlled by the second logic decoder circuit which prevents back-biasing of the diode 225 and establishing the latching signal only when the clutch control element 20 at the master control station unit 6 is in the position corresponding to the clutch control element 18" at the remote control station unit 7, or the control element 18" is in neutral.

The transfer from the master station to a remote unit 7 in response to the energization of relay 176 as previously described can only occur if diode 225 conducts. A cut off transistor 226 is connected to ground the power line 80 with respect to the anode of diode 225 and thereby selectively prevent and permit conduction. The transistor is normally connected in an on condition through a pair of paralleled biased diodes 227 and 228.

The bias circuits are selectively by-passed by a control transistor 229 connected to the diode 227 and a similar control transistor 230 connected to the diode 228. The master to remote control logic circuit is similar to that previously described for the remote to master control and includes a first set or bank of three diodes 231 connected to control the conductivity of transistor 230 and connected to the output of the logic transistor circuitry. A second bank of three diodes 232 is similarly connected to the output of the logic circuit to control the conductivity of transistor 229.

The 231 and 232 are connected into the logic circuitry with a polarity which is the opposite of banks 202 and 203 and provide an opposite response to that defined by the diodes 202 and 203. Thus when the diodes 202 and 203 are back-biased, the related diodes 231 and 232 will be forward biased to provide a corresponding turn on signal to the transistors 229 and 230. Thus the second logic circuit provides a similar response indicating when the remote control station unit 7 is set to the drive position of the controlling master station unit 6 or is in a neutral position.

Thus only when the cam switches 42"-43" at the remote station provide an indication that the remote station 7 to receive control is in the same position as the master station 6, or is in a neutral position, with the transistors 229 or 230 be cut off, thereby providing a turn off signal to the transistor 226 to remove the low from the positive side of the diode 225 and permit transfer of a holding signal to the relay transistor 193 to permit transfer to the remote control unit 7.

If the required conditions are met, at least one of the diodes in banks 231 and 232 will conduct to turn on the transistors 229 and 230. This connects both of the diodes 227 and 228 to the common low line 79 and turns off transistor 226. Consequently, the low connection to diode 225 is removed and a positive signal is transmitted via the diode 225, line 224 and the normally closed contacts 93-16 to line 196 which drives transistor 193 on to energize relay 93. This transfers the contacts of relay 93 to the alternate positions as previously described to insert control unit 7.

Further, as previously noted, the remote station 7 includes the acknowledgement switch 182 connected to actuate relay 183. The contacts 183-1 of relay 183-1 are shown connected through a suitable diode 232a to the base circuit of transistor 226. Switch 182 must be actuated to open contacts 183-1 and thus remove this source of bias current to permit cut-off of transistor 226 and transmission of a transfer signal via diode 225, line 224 and contacts 93-16 of relay 93 to turn on transistor 193 and energize relay 93.

When transfer is established, relay 93 actuates a further set of contacts 93-17 which actuates relay 183 to reset the relay and again close contacts 183-1 and resetting the circuit. Of course, relay 93 has also closed contacts 93-10 to latch the relay 93 in the remote station control position. The requirement of the acknowledgement signal would insure that an operator was at the remote station at the specific time at which transfer to this remote station was initiated from the master control station, or if this response was not received, control would remain with the master control station.
The capacitor 221, as previously noted, discharges through transistor 193 to hold the relay energized until the latching circuits are established to complete the transfer. If either condition does not exist however, one of the bank of diodes 231 or 232 will be cut off, thereby turning off the associated transistor 230 or 229. This then permits a turn on signal through either diode 227 or 228 to drive transistor 226 on and preventing diode 225 from conducting the transfer signal to transistor 193. This of course prevents the completion of the circuit to the relay transistor 193 and the energization of the relay 93, thereby holding all of the contacts of the relay 93 in the full line position and holding control at the master station unit 6 until the drive position conditions are properly related.

To transfer power to the sheltered remote station 8, the selection switch unit 9 is rotated to engage the contact arm 87 with the contact arm 90 as shown in FIG. 6 providing power via the lead 179 to energize relay 177 and thereby establishing a circuit condition identical to that responsive to energization of relay 176. The same sequence must be followed as previously described with respect to relay 176, and is previously noted if for any reason relay 176 and 177 are simultaneously energized, the corresponding contacts 176-5 and 177-5 will open thereby breaking the ground connection from the transfer line 192 to the common logic low 79. As a result, the circuit to the relay 93 is opened and the relay 93 will return to the full line position shown transferring control immediately back to the master control station 6 independently of any other conditions.

Shut-down of the engines and the control system is also affected by an electrical control system including a shut-down switch 16 at the master control station shown in FIG. 6. A shut-down means, not shown, may also be provided in the engine room or the like.

In the illustrated embodiment of the invention, the shut-down switch 16 is shown as a double pole, single throw switch 235 having a first set of contacts 235-1 connected at the master station to illuminate the lamp 66 and indicate the shut-down condition. A second set of contacts 235-2 of the switch 235 are connected via a suitable lead 238 in a suitable shut-down control. Although any suitable shut-down means may be employed, certain engines require rotation of the governor throttle control beyond the idle position. For example, certain engines employing the 70° rotational command, require an additional 20° below the idle position upon a separate command to shut down engine operation. The motor actuator must then rotate the 70° under the command of the control potentiometer 35 and have still an additional 20° of rotation available to move to shut down upon input of a separate command signal. A suitable shut-down circuit for certain governors having a separate shut-down shaft is shown in FIG. 11.

In FIG. 9, the shut-down switch contacts 235-2 connect a potentiometer 236 to the summing point 144 through a series summing resistor 237. When contacts 235-2 close a signal is impressed upon the amplifier 154 to drive the motor 151 to shut down. Thus, the engine governor may be provided with a main input shaft coupled to motor 146 of FIG. 9 and a second shut down input shaft coupled to an auxiliary drive motor 239. As shown in FIG. 11, the auxiliary drive motor 239 is coupled to the second control shaft of the governor and includes a drive winding 239a which is adapted to drive the motor from the zero or idle degree position an additional twenty degrees to shut down the engine and then to reset the circuit to permit normal operation in response to the initial engine start up. As previously discussed, the start switch 11 includes a set of momentary contacts 68 which provide a momentary pulse signal into the shut down circuit of FIG. 11 to reset the optional motor shut down unit, for those governors with a separate shut down shaft, to the zero setting if it is not at zero condition upon the initial start power application. This resets the inter-connected motor driven potentiometer with respect to the throttle tap 142 prior to actual engine initiation.

The illustrated shut down circuit includes a control relay 240 shown as a known set-reset relay having a reset winding 241 and a shut down winding 242. The windings are connected to correspondingly position a pair of contact arms 243 and 244 between a zero or reset position and a minus 20° or other angle, or a shut down position. The contacts 243 and 244 selectively supply operating power to the winding 239 to first drive it between the 0° and 20° positions as follows. Assuming that the motor 239 has stopped at other than the balanced or zero angle, the contact arms 243 and 244 will be engaged with the minus 20° contacts 245 and 246, respectively. The winding 241 has one side connected to 24 volt low line 79. The opposite side is connected to the momentary pulse contacts 68 of the start switch 11 via a lead 247. Thus upon turning on the main power switch 11, the relay winding 241 is energized and resets the contacts 243 and 244 disengaging the 20° contacts 245 and 246 and moving them into engagement with 0° contacts 248 and 249. This establishes the following power circuit to the winding 239a, from the plus 24 volt line 74, a normally closed cam operated switch 250, contact 248 and contact arm pole 243 of relay 240, the lower end of winding 239, through the winding and the contact arm 244 and now engaged contact 249 of relay 240 to the 24 volt low line 79.

The normally closed cam operated switch 250 is coupled to the motor 239 as diagrammatically illustrated at 251. The contacts are normally closed for all positions of the motor gear from 0 to a minus 45 or other angle setting. They are opened at 0°. Thus, the motor winding 239a is energized to drive the motor 239 back to zero or balanced zero output position at which time the cam switch 250 opens, breaking the circuit to the motor winding 239a and holding it in the open position.

When shut down is desired, the switch 16 is actuated to close the contacts 235-2. This provides an input power signal to the stop line 238 which is connected to the top side of stop winding 242 of relay 240, the opposite side of which is connected to the logic low line 79. Energization of the relay winding 242 sets the switch contacts 243 and 244 into engagement with the minus 20° angle contacts 245 and 246. This establishes a shut down power and supply to the winding 239a as follows: From positive power line 74 directly to the contact 246 and via the contact 244 to the top side of the winding 239a. Power thus flows downwardly through the winding 239a to the contact arm 243 and
through contact 245 to the low line 79. This will then drive the motor 239 in the direction to affect shut down of the engine in accordance with the required mechanical input. A second set of normally open contacts 252 are coupled to the cam unit 251 of motor 239 and are closed when the cam unit rotates or moves to the minus 20° position. At that time, the engine will have shut down and the closure of contacts 252 will energize the relay reset winding 241 to automatically reset the servo motor unit 239 to zero, as follows. The positive power line 74 is connected in series with the contacts 252 to the start line 238 and thus provides power to the winding 241 to reset the relay unit 240 in the same manner as a start signal from the master control station. This will reset the contact poles 243 and 244 to the zero motor position and provide power in the same manner as momentary pulse from the start unit previously described. Thus, normally the shut down unit is automatically reset upon shut down and the momentary start signal applied to the winding 241 upon application of power is then of no particular consequence. However, if for any reason the engine should become shut down with the motor in an intermediate position between 0° and the 20° reapplication of power would not automatically reset the circuit. Thus, the contacts 252 would be open and break the automatic reset circuit. The pulse signal input via the momentary contacts 68 would then automatically insurge rapid resetting of the system and permit proper and normal operation.

In governs without the optional shut down feature, a proper angle error signal may be connected through an input potentiometer to the servo amplifier as in FIG. 9.

The transfer of control from one station to another is, as previously noted, restricted to preselected positioning of the clutch controls. The logic system provides an indication of the setting of each control and this information may be transferred through a visual indicating system to the controls to assist the receiving station in positioning its clutch lever in correspondence with the controlling station. For example, lights or other indicators may be provided at the master station for each remote station and at each remote station for the master control. The receiving station operator can then immediately determine the required setting for his clutch control lever to establish the required correspondence and permit rapid transfer.

The present invention thus provides a completely electrical marine gear control which can advantageously be applied to a separate engine governor throttle control and a separate variable coupling or transmission assembly hereinafter broadly called as a coupling member or coupling means. However, if desired, the throttle control could of course be incorporated into the coupling control to provide a single lever type system. As previously noted, the invention has been applied to the dual engine coupling control and in particular, wherein the coupling was in infinitely variable hydraulic coupling such as shown in the previously referred to co-pending application. The electrical input preferred by the logic control circuit permits interconnection of any number of remote control stations with the desired selection control and the positive interlock to insure that control is made only when desired and under proper conditions. In the illustrated embodiment of the invention, a single master control station has been provided. Obviously, if desired, the logic control system would permit additional remote control stations with or without master selection control concepts or functions. The electrical control system of this invention provides maximum versatility and permits interconnection and selection of the controls and application to the various different types of engine drive systems which have been employed in marine and off-vehicle controls. The use of the solid state controls provides a compact reliable and long-life assembly which can be readily adapted to the requirements of marine applications and the like.

We claim:

1. An engine-transmission operating apparatus for adjusting a propulsion means and having a plurality of remote control units, each of which includes an adjustable engine speed setting and drive control input means for an actuating circuit means operable to control the transmission means between the engine and propulsion means and the speed setting for the engine, comprising control signal forming means coupled one to each of said control input means to establish a position signal corresponding to a selected speed setting, second control signal forming means coupled to one to each control input means to establish directional control signals, electrically actuated transfer means for selectively connecting said signal forming means in said actuating circuit means, control selection means at one of said control units for selectively conditioning the transfer means to connect one of said control units into said actuating circuit means, and logic circuit means connected to said second control signal forming means and to said transfer means to restrict transfer between said control units to preselected directional control signals at a control unit in control and the control unit selected to take control.

2. The engine-transmission operating apparatus of claim 1 wherein said logic circuit means is a binary logic circuit means and said second signal forming means includes a forward drive switch and a reverse drive switch, said input means includes a drive control element coupled to said switches and movable in opposite directions from a selected control position to close said switches and establish signals related to the forward and reverse positions and to actuate said first signal forming means to control the propulsion means speed.

3. The engine-transmission operating apparatus of claim 1 wherein each of said second signal forming means includes a forward switch and a reverse switch, said input means actuating the forward switch to establish a forward drive and actuating the reverse switch to establish a reverse drive and establishing a neutral drive with both switches in the non-actuated condition, said logic circuit including a selected switch means for each of said control units, said selection means including switch means connected to actuate said selected switch means, a transfer switch means connected to said selected switch means and to said logic circuit means, said logic circuit means connected to said forward and reverse switches at each of said control units and responsive to actuating said switches to permit operation of the transfer switch means to transfer control to a next selected control unit.
only with the switches of said next selected control unit non-actuated or actuated in correspondence with the control unit in control.

4. The engine-transmission operating apparatus of claim 1 wherein the control unit including said selection means is a master control unit, all other control units other than said master control unit having an acknowledgement switch connected to control operation of the transfer means and permit transfer to the corresponding control unit only with a preselected operation of the acknowledgement switch.

5. The engine-transmission operating apparatus of claim 1 wherein said selection means includes a separate operating means for each control unit connected to said transfer means, the operating means for each control unit other than the control unit having said selection means having interlock means connected to actuate said transfer means to transfer control to said control unit having said selection means in response to simultaneous operation of a plurality of the interlock means.

6. The engine-transmission operating apparatus of claim 1 having engine start means at the control unit having said selection means, and start interlock means coupled to said corresponding input means and to said selection means to require control by the corresponding input means and a preselected adjustment of said input means.

7. An engine-transmission operating apparatus for adjusting a propulsion means and having a master control unit at least one remote control unit, each of said control units including an engine throttle control element to adjust an engine speed through the throttle setting of an actuator and a transmission control element to control a transmission actuator for varying the coupling of the engine to the propulsion means, comprising control signal forming means coupled one to each of said engine control elements, second control signal forming means coupled one to each transmission control element, electrically actuated transfer means for selectively connecting said signal forming means to the corresponding actuator, a control selection means at said master control unit for selectively conditioning the transfer means to connect the master control unit and the remote control units for actuating said engine actuator and said transmission actuator, signal means coupled to each of said transmission control elements to establish electrical signals related to forward, reverse and neutral drive positions of said corresponding transmission control element, and logic circuit means connected to said signal means and to said transfer means to restrict transfer of control between said controls to preselected drive positions of the transmission control elements.

8. The engine-transmission operating apparatus of claim 7 wherein said logic circuit means is responsive to establishing said preselected drive positions before and after conditioning of the transfer means to establish transfer to a control unit.

9. The engine-transmission operating apparatus of claim 7 wherein said signal means includes a forward switch and a reverse switch actuated in response to a corresponding movement of the transmission control element to establish signals related to the forward and reverse positions and conjointly establishing a neutral position with both switches in the non-actuated position.

10. The engine-transmission operating apparatus of claim 9 wherein said transmission includes a continuously adjustable clutch and said transmission control element is a clutch control lever pivotally mounted for movement in opposite directions from a neutral position, a clutch cam secured to pivot with the lever and having oppositely located cam portions aligned with and similarly spaced from said forward switch and said reverse switch, a second cam secured to pivot with the lever and having a pair of spaced cam portions, and a brake release switch means aligned with said second cam centrally between said spaced cam portions to simultaneously actuate said brake release switch means and one of forward and reverse switches.

11. An engine-transmission operating apparatus of claim 7 wherein said engine actuator includes an engine governor throttle actuator, a feedback means positioned in accordance with the actuator, a servo-opera-
tor coupled to said actuator and said feedback means and having a summing input means connected to said first signal forming means and said feedback means to correspondingly drive said actuator.

12. The operating apparatus of claim 11 wherein said servo-operator includes a motor having a torque control winding energized in accordance with the setting of said control element and a shut-down actuator energized from a down circuit, said shut-down circuit including a signal responsive switch means and a limit switch means coupled to said actuator, said signal responsive Set-Reset switch means having first contacts to drive said actuator to a starting position and second contacts to drive said servo to a shut-down, and pulse responsive means to selectively close said first and second contacts, said limit switch means having start position contacts connected in circuit with said first contacts and stopping said actuator at said starting position, and said limit switch means having shut-down position contacts connected to energize said pulse responsive means to close said first contacts and reset said servo-operator to the starting position.

13. The engine-transmission apparatus of claim 11 wherein said servo-operator includes a permanent magnet motor, a regulated voltage supply connected to said motor and said summing point to operate said motor, and a current limit means connected to said voltage supply and responsive to a selected motor load to reduce said regulated voltage to limit current to prevent demagnetizing the permanent magnet motor for sudden reversals of control inputs.

14. The engine-transmission apparatus of claim 13 having motor driven limit switches coupled to said motor and connected in said current limit means to reduce said regulated voltage in response to actuating of said limit switches.

15. The engine-transmission operating apparatus of claim 7 wherein each of said signal means includes a forward switch and a reverse switch and means coupled to the transmission control element to actuate the forward switch to establish a forward drive and actuating the reverse switch to establish a reverse drive, said logic circuit including a master station selected switch means and remote station selected switch means and a neutral sensing switch means, said selection means being con-
connected to selectively actuate one of said station selected switch means, said logic circuit means connected to said forward and reverse switches and responsive to actuation of either of said switches at the master control unit to prevent operation of the neutral sensing switch means, said start means for said engine, and said start means being connected in a start circuit in series with said master station selected switch means and said neutral sensing switch means.

16. The engine-transmission operating apparatus of claim 15 wherein said station selected switch means are relay means, said master station relay means having normally open contacts connected in said start circuit and having a set of normally closed contacts, said selection means including a transfer relay means, a transistor switch means connected in circuit through said normally closed contacts and in circuit with said transfer relay means, said transfer relay means having a plurality of first contacts connecting said logic circuit means to the forward and reverse switches of the master control unit and a second plurality of contacts connecting said logic circuit means to the forward and reverse switches of the remote control unit.

17. The engine-transmission apparatus of claim 16 wherein said first plurality of contacts are normally closed contacts and second plurality of contacts are normally open contacts, and start control interlock means to de-energize said transfer relay means when starting the engine.

18. The engine-transmission operating apparatus of claim 7 wherein said transmission control elements are levers and said first signal forming means are potentiometers with a tap connected to a corresponding lever, said transfer means including a two position switch means having first and second alternately closed contacts, said tap of said master control unit being connected to said first contacts for selective connection to said control, said tap of said remote control being connected to the second contacts for selective connection to said logic circuit means.

19. The engine-transmission operating apparatus of claim 18 wherein said selection means includes selectively actuated switch means for each of said control units, said switch means for said remote control units having contacts connected to the taps of the corresponding units and to said second contacts of said transfer means for selective connection to said engine and transmission actuators.

20. The apparatus of claim 7 including a plurality of remote control units controlled from said master control unit, said selection means having operating means for each control unit and connected to said transfer relay means and responsive to simultaneous energization of said operating means for said plurality of remote control units to actuate said transfer means to transfer control to the master control unit.

21. The engine-transmission operating apparatus of claim 7 wherein control units have dual control elements for controlling a pair of engines and related variable transmission, a common power source connection means, a main power switching means at the master control unit connecting said power source connection means to a start engine line for supplying power to start the engines, a start relay having contacts in said start engine line and connected to said logic circuit means for energization, said logic circuit means having first means responsive to connection of the master control unit to the engine and coupling actuators and second means responsive to establishing a neutral position of the transmission control element, said first and second means being connected in circuit with said start relay to selectively control energization of each start relay.

22. The apparatus of claim 21 wherein said first means includes normally open contacts and said second means includes a neutral transistor having output means connected in series with said open contacts, said logic circuit means including at least four binary logic channels, one channel being connected to respond to the forward drive setting of said coupling control element, a second channel being connected to respond to the reverse drive setting of said coupling control element, and said first and second channels being correspondingly connected to the input of said neutral transistor to cutoff said neutral transistor if the transmission control element is in either a forward drive or a reverse drive position.

23. The engine-transmission operating apparatus of claim 7 wherein said logic circuit means includes a plurality of input means connected to said signal means of said several control units, said signal means establishing binary control signals related to a forward drive and a reverse drive setting of each transmission control element, a binary logic decoder connected to said input means and having a pair of binary logic gate means, said first gate means being connected to said transfer means and controlling transfer from said master control unit to a remote control unit and said second gate means connected to said transfer means and controlling transfer from a remote control unit to the master control unit.

24. The engine-transmission operating apparatus of claim 23 wherein said logic gate means selectively establishes latch circuits to said transfer means, said first logic gate means establishing a first latch circuit holding said transfer means in a master control state until said master control unit and a selected remote control unit are in corresponding drive settings or said selected remote control is in neutral setting, said second logic gate means holding said transfer means in a remote control state until a controlling remote control unit and the master control unit are in a corresponding drive or said master control unit is in a neutral setting, and a transfer interlock means at each of said remote control units to selectively prevent transfer to a remote control unit.

25. The engine-transmission operating apparatus of claim 23 wherein said logic gate means selectively establish latch circuits to said transfer means, said first logic gate means establishing a first latch circuit holding said transfer means in a master control state until said master control unit and a selected remote control unit are in corresponding drive settings or said selected remote control is in neutral setting, said second logic gate means establishing a second latch circuit holding said transfer means in a remote control state until a controlling remote control unit and the master control unit are in a corresponding drive or said master control unit is in a neutral setting, a transfer acknowledgment means for said remote control unit, said selection means selectively setting said transfer
means to condition a remote control unit to accept control is response to release of said first latch circuit and operation of said transfer acknowledgment means and setting said transfer means to condition said master control unit to accept control in response to release of said second latch circuit.

26. The engine-transmission operating apparatus of claim 25 wherein said transfer means includes a master selected relay, a first remote selected relay, a second remote selected relay, and a transfer relay, said selected relays being connected to said selection means to selectively energize one of said selected relays, a transistor switching circuit having a power transistor connected to said transfer relay for energizing of said transfer relay and a control transistor connected to said power transistor for de-energizing said transfer relay, said master relay having normally closed contacts connected to said power transistor on, said transfer relay having a plurality of contacts including first contacts connecting said engine and coupling signal forming means of said master control unit to said engine and transmission actuators and second contacts for connecting said engine and coupling signal forming means of said remote controls to said engine and coupling actuators, said first and second selected remote relays having contacts connecting said second contacts to the signal forming means of said remote controls, said transfer relay having logic signal contacts connected to said logic signal means and to said decoder, said first logic gate being connected to said power transistor to establish said first latch circuit, said second logic gate being connected to said power transistor to establish said second latch circuit.

27. The engine-transmission apparatus of claim 26 wherein said decoder includes a master forward logic transistor, a master reverse logic transistor, a remote forward logic transistor and a remote reverse logic transistor, said signal means being switch means connecting a signal supply to a corresponding logic transistor, said first gate means including a first latch transistor connecting a bias supply to said power transistor first and second AND gates connected to control said first latch transistor, OR gates being connected to said logic transistors to operatively control said AND gates to actuate said first latch transistor, said second gate including a second latch transistor connecting a bias supply to said power transistor and having a pair of OR gates connected in parallel to control said second latch transistor.

28. The engine-transmission apparatus of claim 26 wherein said power transistor and said control transistor have a common supply line, said remote selected relays having contacts connected in said common supply line to open said power transistor circuit in response to simultaneous energization of said relays to connect said master station control unit to the engine and transmission actuators.

29. The engine-transmission apparatus of claim 7 wherein said logic circuit means includes a master forward logic switching means, a master reverse logic switching means, a remote forward logic switching means and a remote reverse logic switching means, said signal means includes binary logic signals and supplying first binary logic signals to a corresponding logic switching means in response to operation of a corresponding transmission control element to a corresponding forward and reverse drive position and an opposite second binary logic signal in the neutral position, and said logic circuit means including a pair of gate means connected to said logic switching means and to said transfer means, one of said gate means establishing control from the master control unit to a remote control unit to said preselected drive positions, and the second of said gate means establishing control from the remote control unit to the master control unit to said preselected drive positions.

30. The engine-transmission apparatus of claim 7 wherein said logic circuit means includes a master forward logic switching means, a master reverse logic switching means, a remote forward logic switching means and a remote reverse logic switching means, said signal means including switch means for connecting a signal supply to a corresponding logic switching means, and said logic circuit means including a gate means connected to said logic switching means and to said transfer means to restrict the transfer of control between said control units to said preselected drive positions.

31. The engine-transmission apparatus of claim 30 wherein said selection means includes a master selected relay and a first remote selected relay for a corresponding first remote control unit, said transfer means includes a transfer relay having first drive signal contacts connected to said signal forming means of said master control unit and second driving signal contacts, said remote selected relay having drive signal contacts connected to the corresponding signal forming means and said second drive signal contacts, said master selected relay having contacts connected to energize said transfer relay, said remote selected relay having contacts connected to de-energize said transfer relay, and said gate means being connected to prevent said energization or de-energization in the absence of said preselected drive positions.

32. The engine-coupling apparatus of claim 30 wherein said selection means includes a master selected switch means and a first remote selected switch means for a corresponding first remote control unit, said transfer means including switch means having drive signal contacts connected to said signal forming means of all said control units and to said actuators, said remote selected switch means having drive signal contacts connected to the corresponding signal forming means and drive signal contacts of said transfer means, and said master and remote selected switch means having contacts connected to control energization of said transfer means.

33. The engine-transmission apparatus of claim 32 having a second remote control unit, said selection means having a second remote selected switch means having contacts connected to the signal forming means of said second remote control unit and to the drive signal contacts of said transfer means in common with said first remote selected switch means.

34. The engine-transmission apparatus of claim 30 wherein said selection means includes a master selected relay for insertion of the master control unit and a first and a second remote selected relay for insertion of a first or second remote control unit, said transfer means includes a transfer relay means con-
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37. The engine-transmission apparatus of claim 34 wherein said signal means of each control unit includes a forward drive switch and a reverse drive switch, said transfer relay having fifth contacts connected to the forward drive switch of the master control unit and a forward drive line to said transmission actuator and having sixth contacts connected to the reverse drive switch of the master control unit and a reverse drive line to said transmission actuator, and said transfer relay having seventh contacts connected in common to the forward drive switches of the remote control units and said forward drive line and having eight contacts connected in common to the reverse drive switches of the remote control units and said reverse drive line.

38. The engine-coupling apparatus of claim 33 wherein said first and second remote control units having interlock contacts correspondingly connected to said electronic switch means to actuate said transfer means for transfer of control to the master control unit in response to simultaneous operation of said remote selected switch means.

39. The engine-coupling apparatus of claim 30 wherein said selection means includes a master selected relay and a first and a second remote selected relay, said transfer means includes a relay having a plurality of contacts including first contacts connected to the first signal forming means of the master control unit and to an engine control line to said engine actuator, second contacts connected to the second signal forming means of the master control unit and to a transmission control line to said transmission actuator, said first and second remote selected relays each having coupling contacts connected to the corresponding first and second signal forming means of the master control unit and to a transmission control line to said transmission actuator, said first and second remote selected relays each having coupling contacts connected to the corresponding first and second signal forming means, said transfer relay having third contacts connected to said engine control line and the corresponding contacts of said remote selected relays, said transfer relay having fourth contacts connected to said transmission control line and the corresponding contacts of said remote selected relays.

40. The engine-transmission operating apparatus of claim 1 having an engine throttle position control including a permanent magnet motor, a regulated voltage supply, a closed loop circuit connecting said supply to said motor in accordance with the output of said first signal forming means, said voltage supply including a
current limit means to reduce the voltage in response to a current output above a selected energizing level.

41. The engine-transmission operating apparatus of claim 40 including switch means responsive to limit positions of said governor input angle control to reduce the maximum current setting of said current limit means.

42. The engine-transmission operating apparatus of claim 1 wherein said engine and coupling signal forming means are potentiometers having a center tap and an adjustable output tap, a voltage regulator connected to energize said potentiometers, a coupling current source including a high current gain transistor amplifier for varying the current supply to said transmission actuator in accordance with the setting of tap of the signal potentiometer.

43. The engine-transmission operating apparatus of claim 40 wherein said logic circuit means includes interlock means preventing transfer from the master control unit to a remote control unit, and each of said remote control units includes acknowledgement means connected to said logic circuit means to actuate said interlock means to permit transfer to a remote control unit.

44. The engine-transmission operating apparatus of claim 43 wherein said acknowledgement means includes a momentarily actuated switch and said interlock means includes a set-reset relay having contacts connected to selectively permit transfer to a remote control unit.