GENERAL DESCRIPTION of the WAGNER SERIES 50 AUTOPILOT

The WAGNER SERIES 50 AUTOPILOT is a complete automatic steering control system featuring proportional rate control and incorporates the latest solid-state components. The basic system consists of a control unit, a magnetic compass with a course sensor, and a hydraulic pumpset or a mechanical drive unit. The autopilot system operates from either 12 VDC, 24 VDC, or 32 VDC and must be specified when ordering.

The control unit has wide range controls and uses proportional, integral and differential circuits. SEA STATE (damping) control with a maximum sensitivity of 0-1 degrees optimizes course accuracy in all sea conditions. RUDDER control alters the amount of rudder applied in response to sea and boat speed changes. A built-in counter rudder circuit senses the rate of change of the course heading and varies the amount of rudder applied accordingly. Automatic rudder trim counteracts persistent course errors due to side winds, waves, current, or imbalance of the vessel. Port and starboard indicator lights assist course setting and display steering activity.

Two sizes of axial piston pumpsets and a mechanical drive unit are available to drive the steering system. The adjustable flow pumpsets can be "tuned" to a wide range of sizes of hydraulic steering actuators. The mechanical drive unit can easily be matched to any steering system within its capacity. The units operate only when demanded by the autopilot or operator and in direct proportion to the sensed change resulting in very low power consumption and extremely precise rudder control.

Options include a permanently mounted remote course setting station and a hand-held remote course setting station, both include a 'DODGER' switch. A wind vane steering control system for sailboats is also available as well as an interface to Loran, Decca and Satnav receivers with the standard format NMEA 0180 output signal.

All cables are terminated with coded, splashproof plug and socket connections for easy installation.

SECTION I: AUTOPILOT CONTROLS

SEA STATE
This control adjusts the response time of the autopilot. Decrease SEA STATE in calm seas to optimize course accuracy. Increase SEA STATE in rough seas to prevent unnecessary rudder corrections. This control also features an "ON/OFF" function in the extreme CCW* position. Turning to the "OFF" position disconnects all rudder power to the autopilot.

RUDDER
This control adjusts the amount of correcting rudder applied. Decrease at high speeds by turning CCW to prevent oversteering. Increase by turning CW* at low speeds, or when operating in following seas, on heavy displacement vessel, etc. This control also features a SET function in the extreme CCW position - see following description for COURSE SETTING. After the course is set, the knob may be removed CW beyond the SET detent in order to activate the RUDDER.

The RUDDER control knob has a third function, enabling it to actjvate the remote control (if installed) by pulling the knob outward - see following description for OPERATING of REMOTE COURSE-SETTING STATIONS.

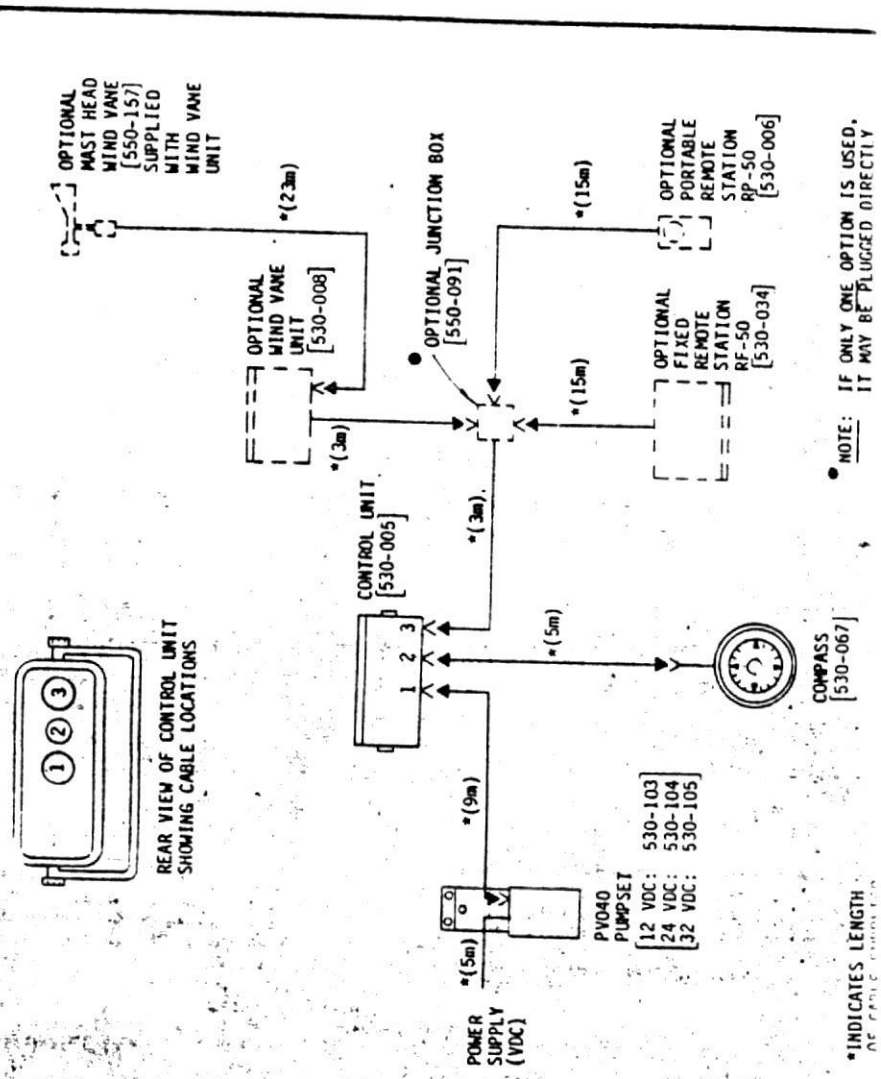
COURSE SETTING
With SEA STATE at "OFF" (fully CCW), turn RUDDER TO "SET" (fully CCW). Then switch the unit "ON" by turning SEA STATE in a clockwise direction. Steer the vessel to the desired heading and rotate the course setting dial until the red and green lights above the dial are both out. (NOTE: Both lights will go out on the desired heading as well as on a 180 degree opposite course. Check the magnetic compass card if in doubt.) Activate the pilot by rotating RUDDER in clockwise direction. Adjust SEA STATE and RUDDER to suit the vessel and the sea conditions. To change course, simply turn the course dial to the new heading.

OPERATION of REMOTE COURSE-SETTING STATIONS
With the autopilot steering the vessel and SEA STATE and RUDDER in their adjusted positions, pull the RUDDER control outward. This will disable the autopilot. Go to the remote station, select the desired heading and switch to "ON". To change course, simply turn the course dial on the remote station to the new heading. To dodge an object in the water, press and hold the spring-centered DODGER switch to "PORT" or "STBD" as required. The autopilot will return the vessel to the remote station course dial heading when the switch is released.

To return steering to the control unit, switch the remote station "OFF". Go to the control unit, select the course heading, push the RUDDER control inward and autopilot control is returned to the control unit. (NOTE: The remote station must be turned "OFF" when not used for remote course setting, otherwise it will adversely affect the operation of the autopilot. However, the remote station (in the "OFF" position) may be used as a DODGER when steering with the control unit. The autopilot will return the vessel to the control unit course dial heading when the DODGER switch is released.)

A remote course-setting station may also be used as a non follow-up (jog) controller by turning RUDDER on the control unit to the "SET" position and simply operating the DODGER switch. (The remote station does not need to be switched "ON".) The autopilot will not function and the rudder will remain at its immediate position when the DODGER switch is released.

CW - clockwise
CCW - counterclockwise



SERIES 50 PROPORTIONAL CONTROL AUTOPILOT CABLING DIAGRAM (WITH PV040)

WAGNER ENGINEERING LTD.
40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M 3G2
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	RE
DRAWN	A-9-283	
02.		

SECTION II: INSTALLATION PROCEDURE

A. MOUNTING BASIC COMPONENTS

1. WAGNER COMPASS - The autopilot compass may be used as the main steering compass or it may be remotely located in a position of minimum magnetic interference for best steering accuracy.

   To ensure course setting dial accuracy, the compass lubber line must be carefully aligned with the fore-aft line of the vessel.

   (NOTE: The compass must not be mounted close to any engines, tanks, motors, speakers, transmitting antennas, etc.)

   Minimum safe mounting distances are:

   2 to 3 metres (6 to 9 ft.) from electric winches, engines, radars, electric motors, large iron masses or electric meters (particularly ammeters and their connecting wires).

   1.5 to 2 metres (4 to 6 ft.) from steering compasses, depth sounders, radiophones, etc.

   1 metre (3 ft.) from any steel structure, structural support or large fastener.

   After installation, the compass should be checked for accuracy and, if necessary, corrected by a qualified compass adjuster.

2. CONTROL UNIT - This unit should be mounted close to the helm and away from direct sea spray.

   Consideration should be given to ease of cable installation and access for future maintenance when mounting this unit.

3. PV040 PUMPSET - This unit should be mounted where convenient connection can be made to the steering lines and where the cable supplied (#10 awg) can be run directly to the batteries. A warm, dry location such as the engine room is usually suitable. Also, it should be mounted on a resilient base to isolate vibration and hydraulic noise from the hull of the boat.

   * The output of the pumpset is easier to adjust before securing it to a mounting surface. Refer to the chart in SECTION VI: HYDRAULICS for the correct settings.

   The unit should be electrically bonded to the vessel's ground or frame for R.F. shielding purposes. This must be negative or neutral ground.

4. REMOTE STATIONS - Optional remote course setting stations are mounted where convenient for installation and service, and where protected from direct rain or sea spray.

B. INTERCONNECTING CABLES (Refer to DWG. No. A-9-283)

All interconnecting cables are supplied with the autopilot system and are of the plug-in type. Standard lengths are indicated on the drawing. Custom lengths of cable are available upon special order; however, the customer is advised to attempt to accommodate the standard cables to avoid delivery delays and extra cost.

SECTION III: TESTS and ADJUSTMENTS

A. DOCKSIDE TESTS (TO BE COMPLETED IN THE ORDER LISTED)

- In cases of problems, refer to SECTION V: SERVICE

1. VISUAL CHECKS - All wiring and component mounting must be carefully inspected to avoid possible damage from vibration, chafing, strain, overheating and short circuits from loose wires.

2. POLARITY CHECK - Polarity protection is built in. If the autopilot will not turn on and power is available, the power supply connections may be reversed. RED is POSITIVE. BLACK is NEGATIVE. (Never manually close the relay contact if a power connection reversal is suspected, as severe damage will result.)

3. RUDDER SPEED - Before any of the following adjustments are made, it is advisable to continue moving the steering gear from hardover to hardover until the steering gear responds instantly. (i.e. Most of the air must be purged from the system.)

   Turn the autopilot "ON" with the SEA STATE control knob. Turn the RUDDER control knob to the extreme clockwise position. Examine the magnetic compass heading and turn the course dial to the same heading until the "null position" is found. Both port and starboard lights will be out in the null position. By moving the course knob to approximately 30 degrees either side of this null position, the steering gear can be made to go from hardover to hardover. The rudder speed can be timed during this maneouver and, if necessary, adjusted to obtain the optimum flow setting of 9 seconds hardover to hardover.

   See SECTION VI: HYDRAULICS for the correct adjustment procedure in order to set the flow rate of the pumpset for the steering cylinder installed.

4. INITIAL TEST - Centre the rudder using manual steering. Select the "SET" position on the RUDDER control. Switch the unit "ON" by turning SEA STATE in a clockwise direction. Rotate the course setting dial slowly until both the RED and GREEN lights go out. This will occur at two places (180 degrees apart). One heading will be within 5 degrees of the required course. This is the correct dial setting. Note that the dial must be turned clockwise to extinguish the red light and counterclockwise to extinguish the green.

   The compass Index Mark (lubber line) should be forward, if not, the indicated course will not be correct.

   Rotate the course setting dial for a GREEN (starboard) light (about 30 degrees from the course heading) e.g. - if the compass heading is 090, then turn the dial to 120 degrees.

Switch to pilot by turning RUDDER in a clockwise direction. The GREEN light will go on and the rudder will move approximately 10 degrees to starboard with RUDDER at minimum; further if RUDDER is increased. The GREEN light will remain on and the rudder will 'creep' further to starboard (automatic trim action).

IF THE RUDDER MOVES TO PORT - SHUT THE PILOT OFF AND REVERSE THE PUMPSET ROTATION BY FLIPPING SWITCH SW-1 ON THE PRINTED CIRCUIT BOARD IN THE CONTROL BOX AND REVERSE THE TACHOMETER CONNECTIONS AT THE CIRCUIT BOARD PUSH-ON PINS. Refer to the Motor Control component layout for location of SW-1 and the push-on pins.

When the rudder is moving in the correct direction, check that the rudder will move both ways by setting courses about 30 degrees off the compass heading to port and starboard.

B. SEA TESTS

These tests should be done in an area free of obstacles and where large course changes and steering corrections may be made. Start with a slow vessel speed.

1. COURSE SETTING - Switch the autopilot to 'SET' and adjust the course setting dial to the heading being hand steered (both-lights-out condition) REMEMBER, turn the dial clockwise to extinguish the red light and counterclockwise to extinguish the green.

2. OPERATION CHECK - Activate the pilot by rotating RUDDER in a clockwise direction. The autopilot should try to hold the vessel on course. If the vessel goes hardover, recheck that a 180 degree opposite heading was not selected. If necessary, repeat the dockside tests. If the course is set correctly and the rudder still goes hardover, repeat DOCKSIDE TEST A. 4.

The autopilot course holding can be improved by adjusting SEA STATE and RUDDER - see SECTION I: AUTOPILOT CONTROLS.

The SEA STATE control should be adjusted for minimum steering corrections with best course accuracy. This sets the autopilot response time to the sea conditions. In rough weather, SEA STATE is increased so that the autopilot is not constantly working. In calm seas, SEA STATE is decreasec

The RUDDER control adjusts the amount of correcting rudder applied. If the vessel is moving slowly or operating in following seas, a large rudder movement may be necessary to return to course, therefore, increase RUDDER. If the vessel is travelling at high speed, only a small rudder movement is required and RUDDER should be decreased. Due to wide range adaptive circuits in the autopilot, it may not be necessary to adjust this control for different conditions once an optimum setting has been determined.

Try the autopilot ar varying vessel speeds and different courses to develop a 'feel' for adjusting the controls.

The pounding motion of a high speed boat in rough water may cause the gimballed compass to swing violently or even tumble 360 degrees, resulting in very erratic autopilot performance. Some form of gimbal restriction should be considered such as foam rubber, if this is a normal operating condition. A non-gimballed compass could also be considered, in which case the factory should be consulted.

3. INTERNAL SETTINGS - a dual two-position rocker type COUNTER RUDDER switch is mounted on the control unit circuit board. Refer to the Control Unit Component Layout for the location of this switch.

A. Displacement Hulls - use 'low' switch position.
B. Planing Hull - use 'high' switch position.

All units are shipped with this switch in the 'low' position.

Most owners will be able to classify their boats and therefore determine the correct switch setting. However, some semi-planing boats are very sensitive to rudder movement and may tend to oversteer (hunt) with the RUDDER control set at mid-position or less. If this is the case, the switch must be turned to the 'high' position.

CAUTION: THIS SWITCH IS LOCKED IN THE 'LOW' POSITION. TO CHANGE POSITION THE LOCK MUST BE REMOVED, BOTH SECTIONS OF THE SWITCH ROTATED AND THEN LOCKED TOGETHER AGAIN.

The compass gain is factory preset and should only be reset by a competent technician using the proper test equipment. Normally, adjustment is required only when the compass is not supplied with the autopilot.

To reset the compass again:

a) Measure the voltage at U5 - pin 7 with respect to pin 19 of the terminal strip (V Reference) in the control unit and rotate the synchro (course setting dial) to the null position (0 volts - both lights out).

b) Rotate the synchro (or compass) 30 degrees to PORT or STBD and adjust RT1 in the control unit for a 3 volt reading. Both sides of null should be checked (PORT: -3 volts, STD: +3 volts).

SECTION IV: TECHNICAL DESCRIPTION

The Series 50 Autopilot, although simple in appearance, employs very sophisticated electronic circuitry. We recommend that internal parts replacement and service be performed by factory authorized technicians if the following circuit theory and details are not fully understood.

Replacement of an entire unit, assembly, or circuit board will generally result in faster and more economical field servicing.

A. COMPASS SENSOR

The Wagner compass sensor is a toroidal magnetic flux detector. It is mounted on the underside of the compass bowl. The compass itself is a standard externally gimballed type.

Signals generated in the compass sensor by the magnetic field of the compass card are transmitted to a synchro receiver. This synchro receiver is directly connected to the course setting dial in the control unit and the remote stations. The output signal of the synchro is phase detected to give an error signal proportional to the difference between the compass card heading and the synchro position. With the RUDDER control in the 'SET' position, this signal is used to switch the RED and GREEN course setting lights. When the autopilot is activated, this signal is used to steer the vessel.

B. CIRCUITRY

1. CONTROL UNIT (Refer to DWG. No. B-4-240-04: Schematic and B-4-264: Test point Waveforms) - The regulated +8 VDC supply from the motor control box is split by R37 and R38 and buffered by U2, C16, C17, C18 and C31, to provide a signal reference of +4VDC.

Integrated circuit, U1, is an oscillator/binary divider providing 420 Hz (Test Point A) and 840 Hz (Test Point C) square waves (± 10%). The 420 Hz feeds integrator, U2-section B, giving a triangle wave (Test Point B) which is buffered and inverted by dual, high current amplifiers in U3. The complementary outputs (Test Points E and F) provide the primary excitation voltage for the sensor coil, 3 - 4 volts peak to peak.

The second harmonic signal pulses (Test Points G and H) generated in the three phase secondary winding of the sensor have varying amplitudes from one to another, corresponding to the sine of the angle of the magnetic field from the compass (and therefore the earth's magnetic meridian). This three phase signal is converted to single phase in the synchro and then to a DC voltage on C8 by gating the signal pulses at 840 Hz (second harmonic) with U4.

C8 voltage varies ± 0.5 volts (with respect to V Reference) with synchro or compass rotation being maximum at 90 degrees and null at 0 degrees and 180 degrees.

This signal amplified by U5-section B, is set by gain potentiometer, RT1, to ± 3V (with respect to V Reference) for 30 degree synchro (or compass) rotation off null.

This compass error signal goes to the SEA STATE control and the RED/GREEN (port/starboard) light circuit. U2-section D turns on the appropriate ligh through Q1 and Q2 when the compass error is greater than ± 300 - 400 mV or approximately 3.5 degrees off null in the 'SET' mode and 3 degrees differen between course selected and rudder angle with the autopilot activated. The lights facilitate course setting before activating the drive unit and also provide a "steer-by-lights" feature when manually steering a desired headin

When the autopilot is activated, the lights indicate when large rudder corrections are necessary to hold a course. The automatic trim circuit makes corrections for small, persistent course errors over a period of 1 to 3 minutes gradually extinguishing the light as the error diminishes.

The SEA STATE circuit consists of RV1 and C11 and averages course error signals over a time selectable between 100 milliseconds and 6 seconds, reducing rudder movements in heavy seas while maintaining excellent average course holding accuracy.

The compass signal then goes to the COUNTER RUDDER circuit, comprised of U5-section A, R25 - R30, C12, C13 and dual switch SW1. This circuit is a differentiator with a DC gain of 1 and switch selectable gain of 5 and 10 for AC signals at a rate of change greater than the RC time constants. Bot sections of the switch are locked together on the "high" or "slow" speed settings according to the vessel's hull type. See SECTION III, B. SEA TEST part 3. INTERNAL SETTINGS.

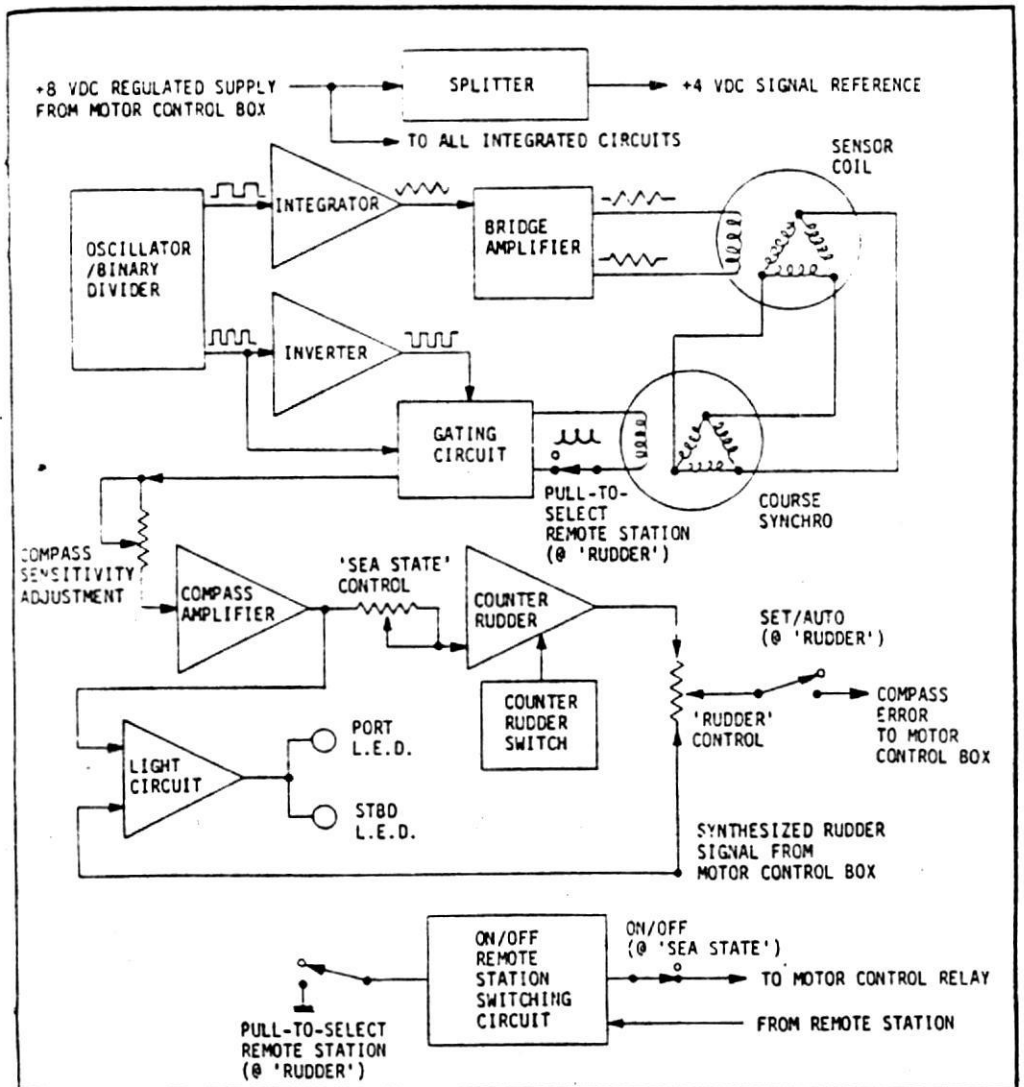
This circuit varies the amount of rudder applied in proportion to the rate of change of heading and provides opposing rudder to eliminate overshoot.

This conditioned signal then goes to the rudder ratio potentiometer, RV2, through limiting resistor, R31, which with R33 from the synthesized rudder (see SECTION IV, B.2.- MOTOR CONTROL BOX) output, provides a rudder angle versus compass error ratio variable between 3:1 (i.e. 3 degrees compass err calls up a 1 degree rudder correction) and 1:3 (i.e. 1 degree compass error calls up a 3 degree rudder correction).

All leads to and from the control unit circuit board are bypassed by ceramic capacitors for R.F.I. and E.M.I. immunity. These capacitors also prevent interference with other electronic navigation equipment.

H.F. or V.H.F. Transmitters will not affect the course unless their antennas are mounted very close to the autopilot, and/or are grossly mismatched in their antennas.

The remote station switching circuit consists of SW3, SW4, Q3, R35, R36, C1 C15, D1, D2 and D3. This circuit allows the autopilot to be turned off at the control unit and on again at a remote station.



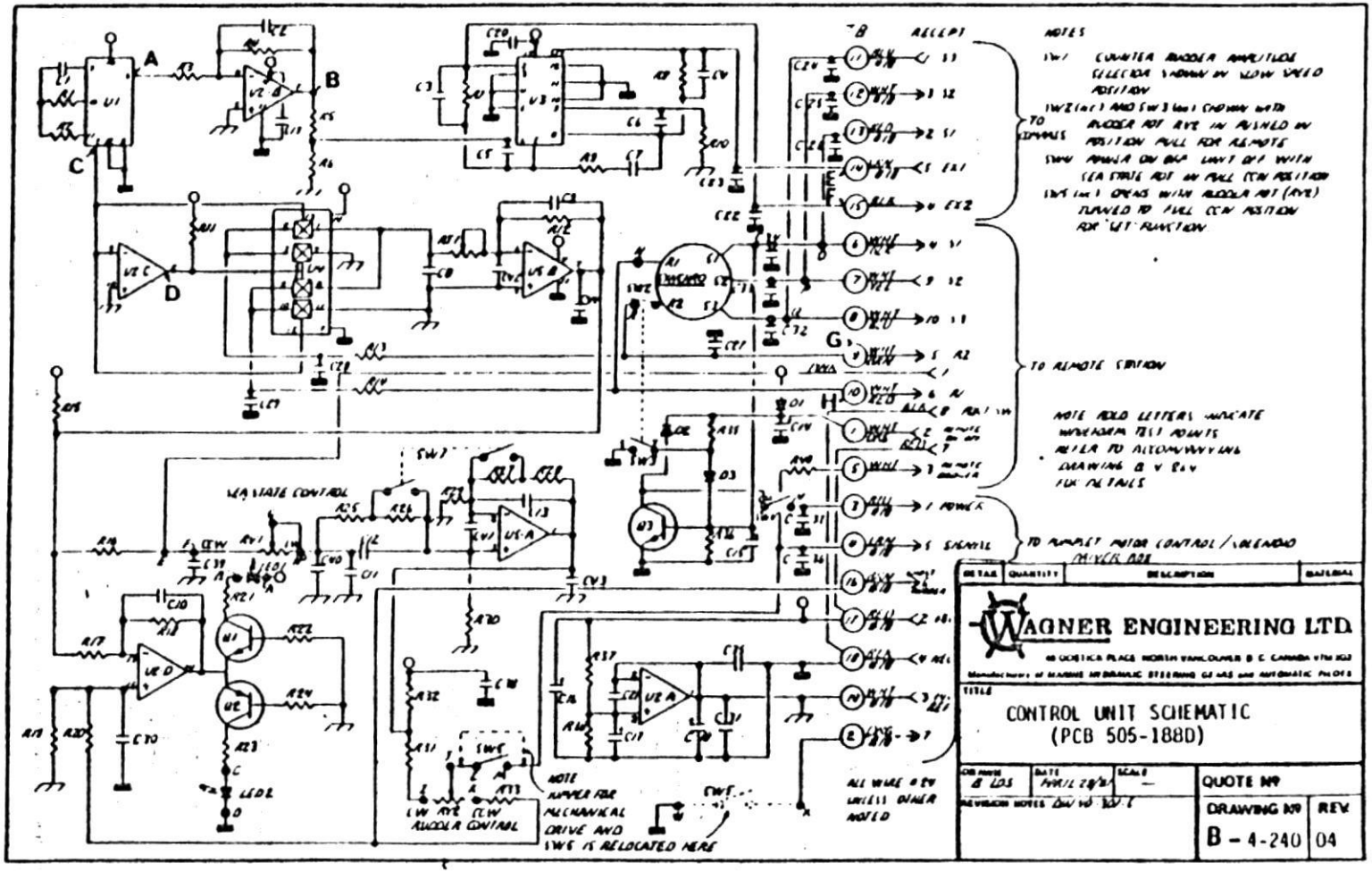
CONTROL UNIT BLOCK DIAGRAM FOR S50 AUTOPILOT

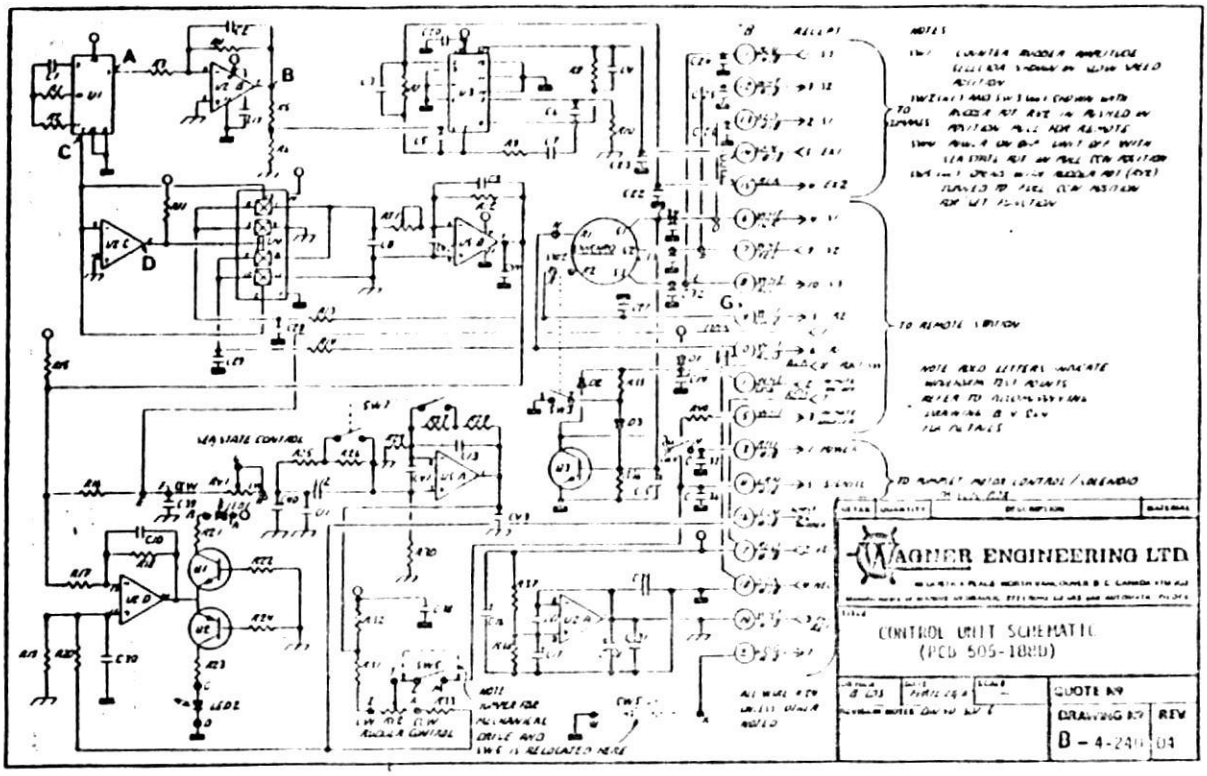
WAGNER ENGINEERING LTD.
40 GOSTICK PLACE, NORTH VANCOUVER, B C CANADA V7M3G2
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
JUNE / 80	A-4-265	
DRAWN		

COMPONENTS LIST FOR S50 CONTROL UNIT

COMPONENT	VALUE	PART NO.	COMPONENT	VALUE	PART NO.
C1	.001 mfd/100V	400-029	R6	470/¼w	115-038
C2	.047mfd/100V	400-001	R7,8,11,12,16,36	100K/¼w	115-051
C3, 4	47pfd/500V	400-030	R9,10,22,24	10K/¼w	115-045
C5, 6, 13	470pfd/500V	400-028	R13, 14	10K/¼w	115-039
C7, 8, 11	1mfd/100V	400-004	R15	5K6/¼w	115-044
C9, 19 - 21, 24 - 44	.1mfd/50V	400-024	R18	68K/¼w	115-050
C10	.1mfd/100V	400-002	R19, 31, 33, 35	4K7/¼w	115-042
C12	.47mfd/100V	400-022	R20	22K/¼w	115-046
C14	10mfd/35V	401-035	R21, 23	180/¼w	115-036
C15	22mfd/16V	401-027	R25, 28	2M2/¼w	100-014
C16	470mfd/16V	401-025	R26, 27	2M7/¼w	115-056
C17, 18	22mfd/15V	401-013	R29, 30	470K/¼w	115-054
C22, 23	.01mfd/50V	400-010	R37, 38	1K/¼w(1:)	114-003
D1, 2, 3	1N4005	300-003	R40	2K7/¼w	115-061
LED 1	PCE 200-BG	300-003	RT1	10K pot	130-021
LED 2	PCE 200-BR	300-002	RV1	5M pot	131-002
Q1, 3	2N4401	310-006	RV2	10K pot	131-005
Q2	2N4403	311-004	SW1	DIP switch	213-001
R1	27K/¼w	115-047	SYNCHRO	Size 11	470-016
R2	270K/¼w	115-053	TB	WIBA 8180/20	430-027
R3, 17	33K/¼w	115-048	U1	CD4060	360-011
R4,	680K/¼w	115-055	U2, 5	LM324	350-005
R5, 32	3K9/¼w	115-041	U3	LM1877N-9	350-010
			U4	CD4066	360-012


WAGNER ENGINEERING LTD.
CONTROL UNIT SCHEMATIC
(PCB 505-188D)
DRAWING NO B – 4-240
REV 04
QUOTE NO
NOTES
TO REMOTE STATION
TO RUDDER MOTOR CONTROL / SOLENOID
SEA STATE CONTROL
NOTE JUMPER FOR MECHANICAL DRIVE AND SW5 IS RELOCATED HERE
ALL WIRE #24 UNLESS OTHER NOTED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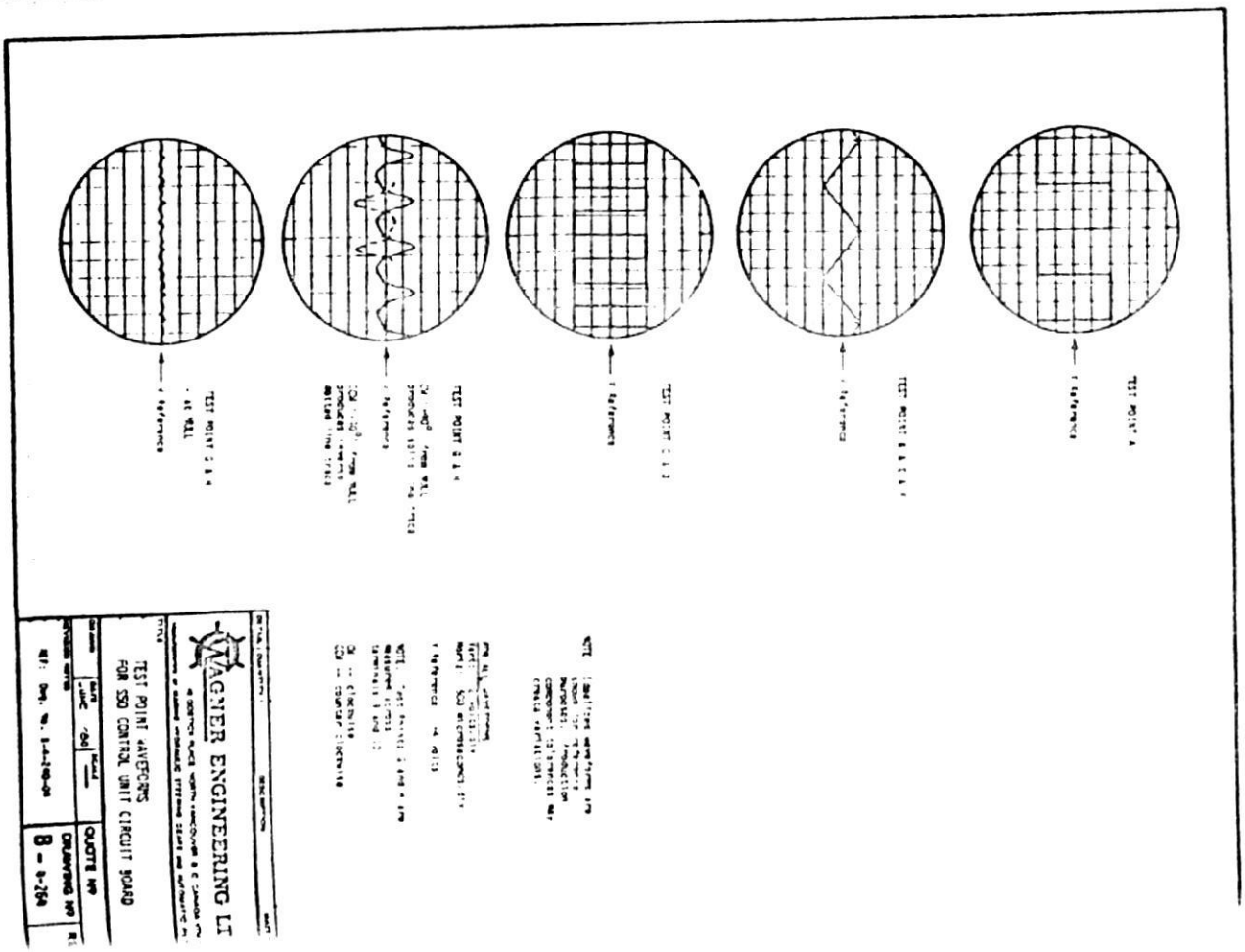
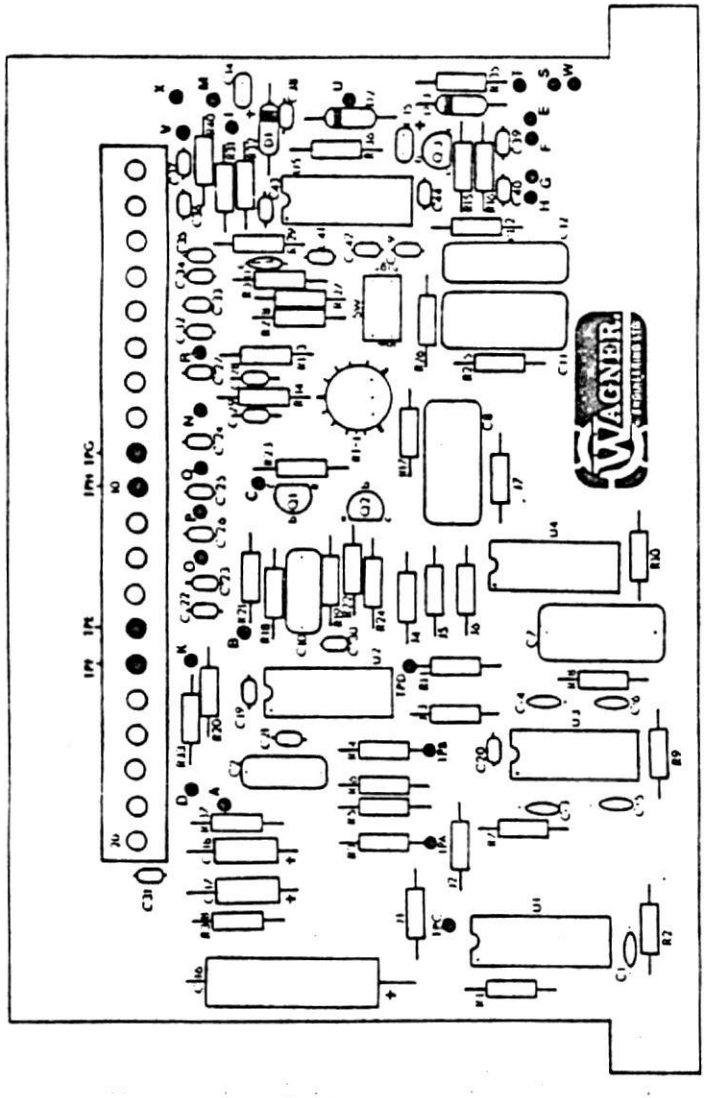

WAGNER ENGINEERING LT
TEST POINT WAVEFORMS
FOR 550 CONTROL UNIT CIRCUIT BOARD
QUOTE №
DRAWING №
B – 4-264



CONTROL UNIT COMPONENT LAYOUT

2. PV040 MOTOR CONTROL BOX

(The following description refers to Block Diagram A-9-228-01, Schematics C-9-225-03, C-9-226-04 and C-9-227-04 and the Motor Control Component Layout drawing.)

Overcurrent protection for the drive motor is provided by a circuit breaker and electronic current limiting. The breaker is an automatic resetting type. The 12VDC model trips at 20 amps and the 24VDC and 32VDC models trip at 10 amps. The breakers are the automatic resetting type and reset in approximately 10 seconds.

The pilot power is turned on by the circuit board mounted relay RL-1, controlled by the ON/OFF switch on the control unit front panel.

The battery voltage is fed directly to Q3, Q7, Q8, and Q9. These power switching transistors control the speed and direction of the pumpset motor. The voltage regulator U5 provides a stable supply voltage to all the other signal processing circuits and is factory preset by RV-2 to 8 Volts, ± 50 millivolts.

Transistor Q1 is provided for mechanical drive applications to switch the electric clutch or bypass solenoid. It can only be activated by a specially wired Series 50 control unit, P/N 530-044.

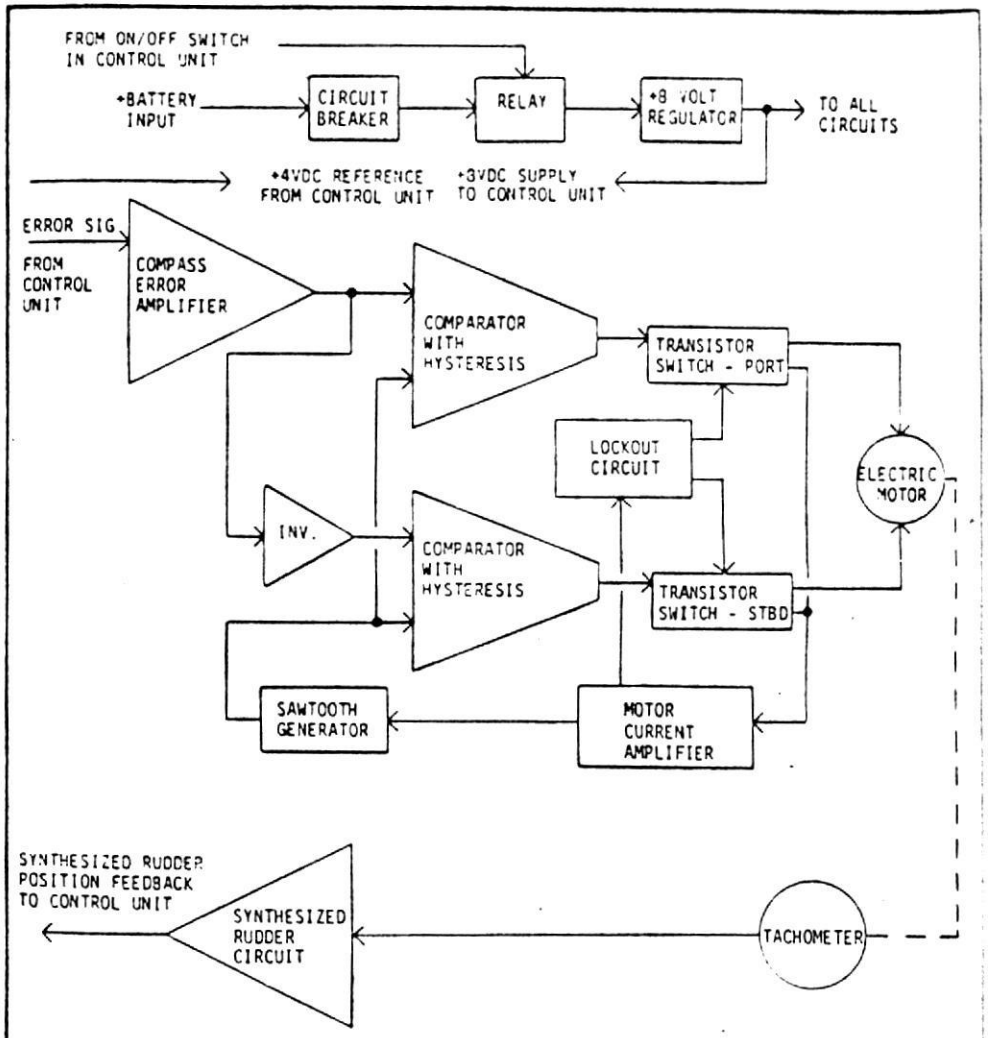
The compass error signal from the control unit is amplified by U1A and fed directly to comparator U1D and through inverter U1B to comparator U1C.

These two comparators switch from output low (0V) to high (+6.5V) to turn on the output transistors. The switching point is controlled by a sawtooth generator U3B and U3A. The waveform shown on Dwg. No. A-9-232 feeds the non-inverting inputs of the two comparators (through positive feedback resistor networks). This circuit combination provides pulse-width proportional control of pumpset speed and direction.

Amplifier U3C senses the motor current through a low value resistor etched from the circuit board copper. The output voltage is factory calibrated by RV-1 and controls two circuit functions.
The first is motor current limiting through the sawtooth generator. When the output of this current amplifier exceeds the 4V ref. (plus 0.7V drop across D4), the sawtooth waveform output from E3A shifts downward, driving the fully on comparator and its respective transistor switch into variable pulse width current limiting. The secondary function of the current sensing amplifier is control of the base drive current to the output transistors in proportion to the current drawn by the motor. This is accomplished by feeding the U3C output voltage to the base of the darlington current sourcing transistors Q3 or Q4 through D2, D3, and Q6 in proportion to motor current. The emitter follower configuration of Q3 and Q4 transforms the base input voltage to a proportional current through resistors R3 and R45. This proportional current feeds the bases of the respective output transistor pair, Q2 and Q8 or Q7 and Q9. The variable base drive keeps power dissipation and heat low when the pumpset is lightly loaded but provides increased base drive when heavily loaded. Insufficient base drive at high currents is a primary cause of power transistor failure.

A tachometer generator is mounted on the back end of the motor. This tachometer generator provides a bipolar analog signal proportional to motor speed. This signal is fed back to the input error amplifier for servo loop stabilization and to integrator U2 to provide the synthesized rudder position feedback signal to the control unit.

This synthesized rudder circuit replaces the rudder angle transmitter found in conventional autopilots reducing installation and maintenance costs and eliminating a common source of system failure.



MOTOR CONTROL BLOCK DIAGRAM FOR S50 AUTOPILOT

WAGNER ENGINEERING LTD.
40 GOSTICK PLACE NORTH VANCOUVER B C CANADA V7M3G2
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
OCT/84	A-9-228	01
DRAWN O.B.		

COMPONENT LIST FOR 12VDC MOTOR CONTROL

(24 VDC & 32 VDC AT BOTTOM OF NEXT PAGE)

COMPONENT	VALUE	PART NO.
C1,2,5,7,9,11,12	0.1 mfd/50v	400-024
C3,13	0.047 mfd	400-011
C4,8	100 pfd	400-026
C6	22 mfd/16v	401-027
C10	1 mfd	400-004
C16	1000 mfd/16v	401-004
C17	4700 mfd/25v	401-003
C19	0.001 mfd	400-026
D1,2,3,6,12	IN4005	300-003
D4	IN914	300-001
D8,9,10,11	IN5402	300-019
J1-9	0 ohm	115-060
Q1	TIP 146	313-012
Q2,7	TIP 35	312-005
Q3,4	TIP 140	312-016
Q5	2N4400	310-002
Q6	2N4402	311-003
Q3,9	TIP 36	313-013
R1,2,4,7,8,26,30,38,41,42	1k/¼w	115-039
R3,45	0.5 ohm/5w	106-014
R5,16,17	4k7/¼w	115-042
R6,9,28,35,36	220k/¼w	115-052
R10	22m/¼w	115-059
R11,12	220 ohm/¼w	100-017
R13,31,34,37	10k/¼w	115-045
R15,18,19,22	10k/¼w	115-045
R25	10m/¼w	115-058
R21	33k/¼w	115-048
R23,24	1m8/¼w	100-062
R29	47k/¼w	100-060
R27	470k/¼w	115-054

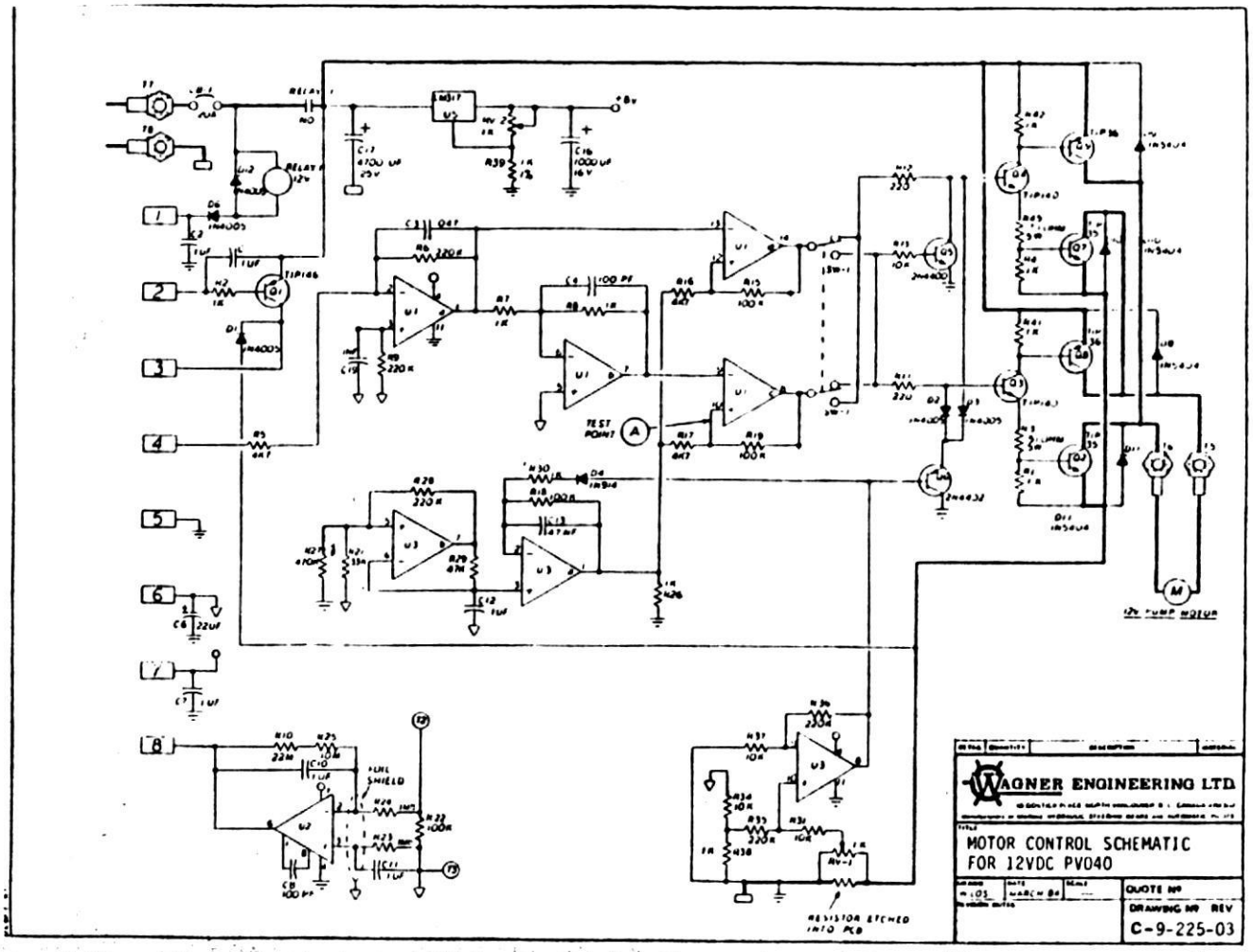
COMPONENT	VALUE	PART NO.
R39	1k/¼w/1%	114-003
RV-1, RV-2	1k	130-040
Relay-1	P&B 12V	450-045
U1,3	324	350-005
U2	308	350-001
U5	LM317	315-012
SW-1	GRAY HILL	213-009
T1	WIBA 8 TERM	430-026
Circuit Breaker	20A	420-711

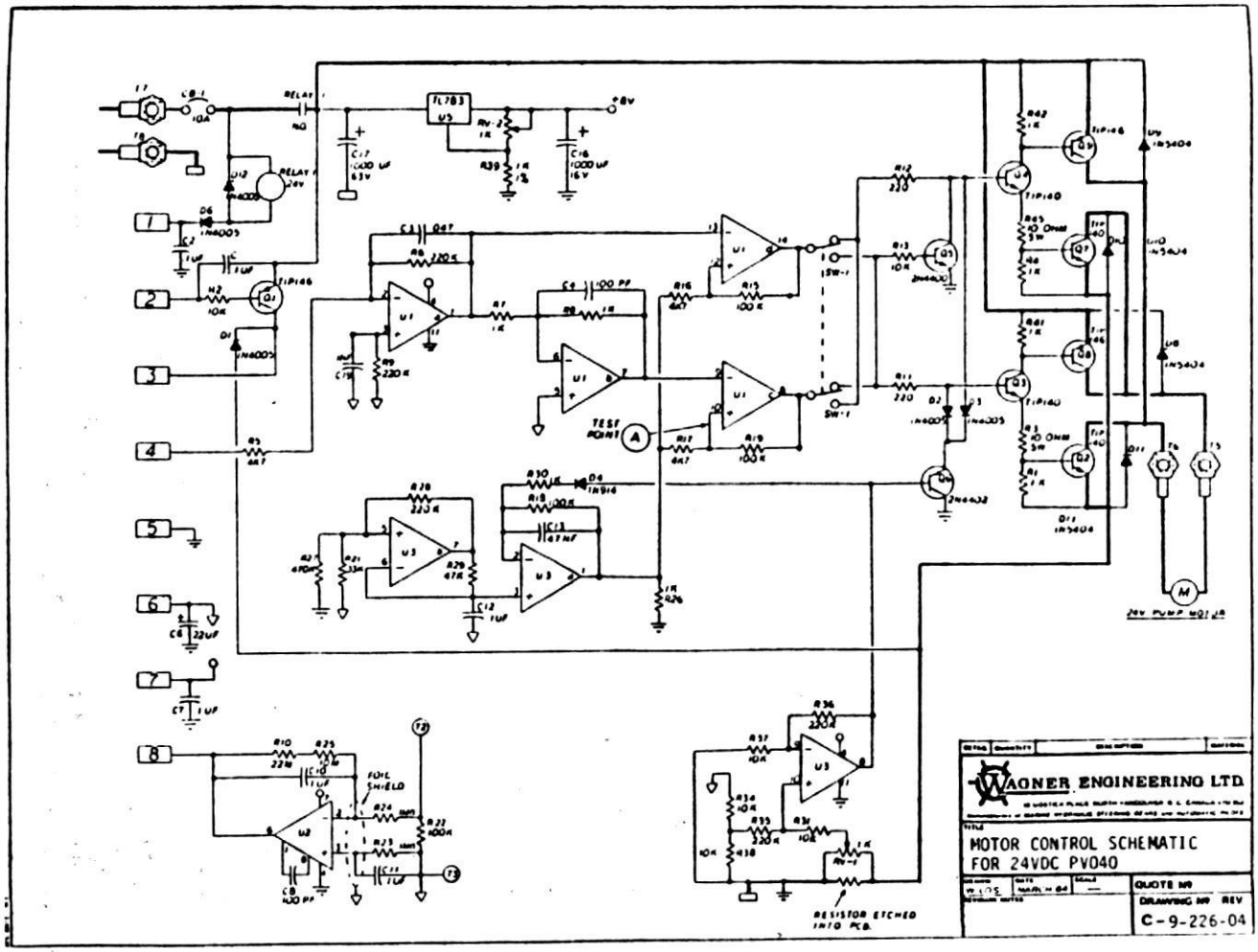
24VDC MOTOR CONTROL has the following components in place of those listed above:

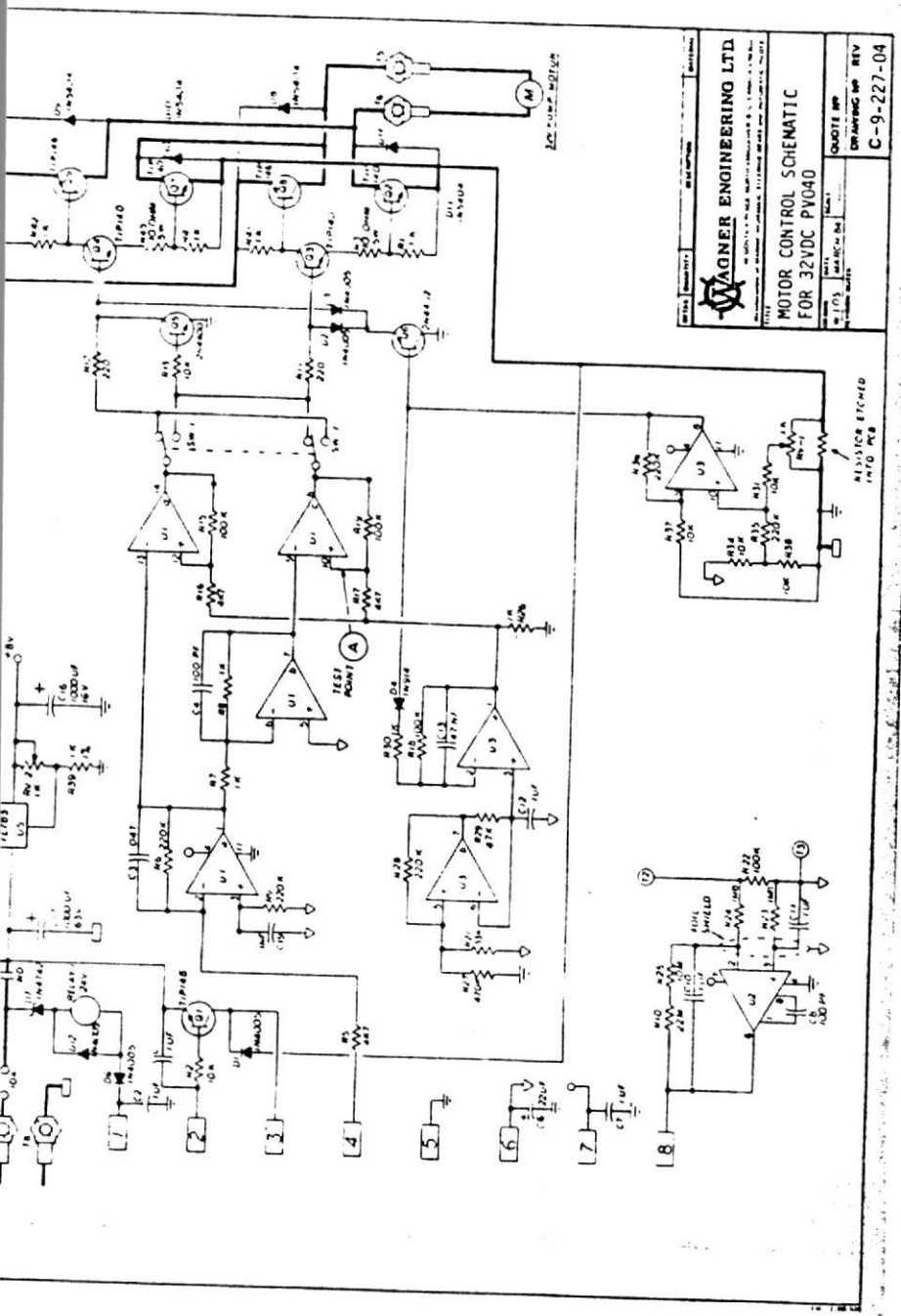
C17	1000 mfd/63v	401-036
Circuit Breaker	10 A	420-703
Q2,7	TIP 140	312-016
Q8,9	TIP 146	313-012
R2,38	10k/¼w	115-045
R3,45	10 ohm/5w	106-006
Relay-1	P&B 24v	450-046
U5	TL783	315-010

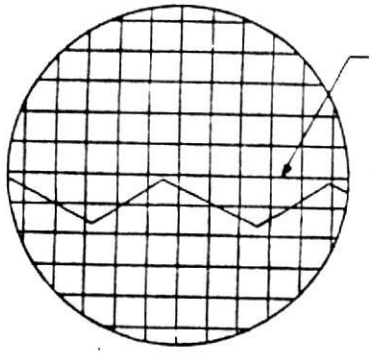
32VDC MOTOR CONTROL has the following components in place of those listed above:

C17	1000 mfd/63v	401-036
Circuit Breaker	10 A	420-703
D7	IN 4742	302-029
Q2,7	TIP 140	312-016
Q8,9	TIP 146	313-012
R2,38	10k/¼w	115-045
R3,45	10 ohm/5w	106-006
Relay-1	P&B 24v	450-046
U5	TL 783	315-010


WAGNER ENGINEERING LTD
MOTOR CONTROL SCHEMATIC
FOR 12VDC PV040
C-9-225-03
TEST POINT A
FUEL SHIELD
RESISTOR ETCHED INTO PCB


WAGNER ENGINEERING LTD
MOTOR CONTROL SCHEMATIC
FOR 24VDC PV040
C-9-226-04
TEST POINT A
FUEL SHIELD
RESISTOR ETCHED INTO PCB





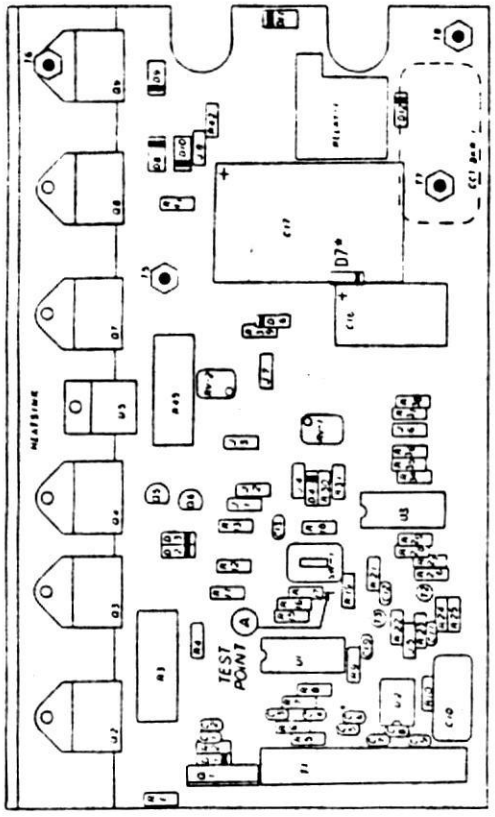
Vert: .5 volt/div.
Horiz: .5 milliseconds/div.

NOTE: Idealized waveforms are shown for reference purposes. Production component tolerances may create variations.

TEST POINT WAVEFORMS FOR S50 MOTOR CONTROL CIRCUIT BOARD (FOR PF040)

WAGNER ENGINEERING LTD.
40 GOSTICK PLACE, NORTH VANCOUVER B C CANADA V7M 3G2
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
MARCH/8/81		
DRAWN		
W. LOS	A-9-232	



*D7 IS REPLACED BY J9 on 12VDC AND 24VDC CIRCUIT BOARDS

MOTOR CONTROL COMPONENT LAYOUT

SECTION V: SERVICE

A. ROUTINE MAINTENANCE

The Series 50 Autopilot is all solid state construction and no routine electrical maintenance is required other than periodic performance checks.

B. TROUBLE SHOOTING

The following test procedure is confined to external checks due to the sophisticated nature of the electronic circuitry. The schematic diagrams accompanying the TECHNICAL DESCRIPTION will allow a competent technician to diagnose any internal component problem. FIELD SERVICE SHOULD ONLY BE ATTEMPTED IF THE OPERATIONAL CHARACTERISTICS OF THE AUTOPILOT ARE FULLY UNDERSTOOD AND ONLY AFTER THE EXTERNAL CHECKS ARE PERFORMED. If all external operations and voltages appear normal yet the autopilot does not function properly, carefully repeat all installation and test procedures in SECTIONS II and III.

NOTE: A good quality voltmeter will be necessary to assure the reliability of required measurements.

1. Turn RUDDER control to "SET" position (fully CCW).
2. Turn SEA STATE control to "ON" position (rotate CW).
3. Rotate the course setting dial through 360 degrees - the RED (port) lamp should be on for 180 degrees of the rotation and the GREEN (starboard) lamp for the remaining 180 degrees.
4. If neither lamp goes on, check the following:
   a) The battery voltage with the electric motor operating. MINIMUM is 11 vdc for a 12 volt system and 22 VDC for a 24 volt system.
   b) The regulated voltage (across 016 in the control unit). THE READING SHOULD BE 7.6 - 8.4 VDC.
   c) The V Reference voltage (across C18 in the control unit). THE READING SHOULD BE ONE-HALF OF REGULATED VOLTAGE MEASURED IN b) above.

If the regulated voltage is not correct, the problem is most likely a defective integrated circuit, U6, in the motor control box. If either the regulated voltage or the V Reference voltage is not correct, refer to a qualified technician for servicing.

5. If one lamp remains illuminated for more than 180 degrees of the dial or both lamps go out at several places on the dial, check the following:

   a) The compass cable and sensor are properly plugged in.

   b) The cable is not damaged.

   c) The sensor is properly mounted to the underside of the compass. A very close mounting of the sensor to a powerful compass may cause this. Refer to the factory.

   d) The synchro windings or slip rings are not open circuit or intermittent.

6. If the autopilot appears to operate but follows the wrong course, check the following:

   a) The compass is mounted with the lubber aligned parallel to the fore-aft line of the vessel.

   b) The sensor fore-aft line is aligned with the compass lubber line. The 'F' (fore) mark on the sensor must be forward.

   c) The compass dial or synchro mounting is not loose or misaligned.

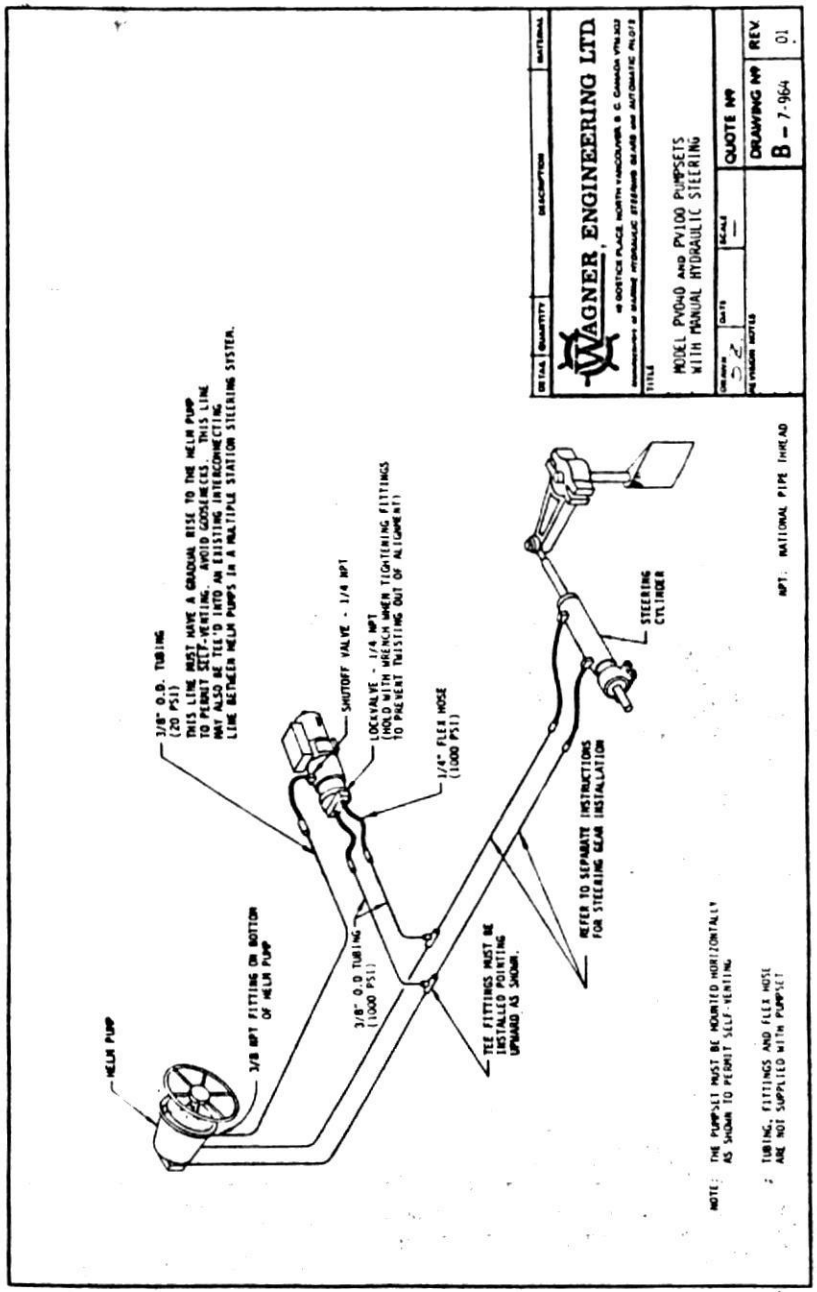
   d) The rudder turns in a direction to steer the vessel to starboard when the GREEN lamp is on.

   e) The desired course is being set correctly. See SECTION I: AUTOPILOT CONTROLS.

7. If the drive unit (pumpset) does not operate or rotates only in one direction after the preceding checks have been made, the fault is in signal or drive circuits in the motor control box or the connections to it.

   a) Check that the cable from the control unit is not damaged and that it is properly plugged in at both ends. Inspect the wires from the control box to the motor.

8. If none of the above problems are found and proper operation cannot be restored, it is best to diagnose and repair the fault by replacement of the sub-assembly or circuit board with a known good unit.



SECTION VI: HYDRAULICS

A. DESCRIPTION OF THE PV040-XX-PC UNIT (Refer to Drawing A-2517 for overall dimensions and Drawing C-2-304 for parts information).

The Model PV040 is a proportional rate hydraulic pumpset. The package contains a 1/4 HP direct current electric motor coupled to a variable volume bi-directional axial piston pump.

The electric motor operates only during course changing or when correction is required and then only in an amount directly proportional to the error sensed. The autopilot system continually samples the course signal and, therefore, only small increments of correction or pump operation are required. This results in a very low average power consumption.

Two models of pumpset are available - the PV040 and the PV100 - both very similar in appearance. Be certain that the correct pumpset has been specified and supplied because a pumpset which is too small will not provide satisfactory performance. The PV040 pumpset is used with equal displacement steering cylinders of 20 cu.in. (330 cc) or less. The PV100 pumpset is used with equal displacement steering cylinders of 70 cu. in. (1150 cc) or less, (down to the PV040 range). The model of the pumpset is indicated on the top of the pumpset electronic connection box. (The displacement of an equal displacement cylinder is determined by: area of cylinder bore minus area of piston rod times total stroke of the piston rod.)

The steering cylinder must be an equal displacement type in order to obtain the same rudder speed when moving in both the port and starboard directions.

1. ADJUSTING THE PUMPSET - The pump is normally adjusted to achieve hardover to hardover rudder speed of approximately 9 seconds. This adjustment (if necessary) is easiest to perform before the pumpset is secured to its mounting surface. Check the chart on the adjoining page to ensure an adjustment is required, and if so, the correct number of turns.

   To adjust the pump output, remove the plastic plug from the access port on the side of the pump. (Refer to Drawing A-2517.) Rotate the pumpset shaft until the coupling setscrew is pointing directly upward. A socket head capscrew will now be visible through the access port. A hexagonal wrench (Allen key) of 5/32" (4 mm) across the flats is required to fit this capscrew to make the adjustment. Turning the capscrew clockwise decreases the pump output.

   The pumpset is shipped from the factory set at an output of 0.4 GPM. If the steering cylinder is not a Wagner, refer to the CYLINDER DISPLACEMENT column on the chart to determine the correct number of adjustment turns required.

CYLINDER DISPLACEMENT (IN^3)	WAGNER CYLINDER MODEL	NUMBER OF TURNS ON PUMPSET ADJUSTING SCREW
20	- T3 -	3/4 CCW
19	- N50-190 -	1/2 CCW
18		1/2 CCW
17		1/4 CCW
16		1/4 CCW
15	- TWIN N40-120 -	1/4 CCW
14		NO ADJUSTMENT
13		NO ADJUSTMENT
12	- N40-190 -	1/4 CW
11		1/4 CW
10	- 1½ X 7* -	1/4 CW
9		1/2 CW
8	- 1½ X 9* -	1/2 CW
7	- N40-120 -	3/4 CW
6	- 1½ X 7* -	3/4 CW
5		3/4 CW

The pumpset is factory preset at 0.4 GPM when shipped.

CW - clockwise
CCW - counter clockwise

* indicates a 700 Series cylinder

CHART FOR ADJUSTING PV040 PUMPSET

2. READJUSTING THE PUMPSET - If the exact position of the adjusting capscrew cannot be determined or is forgotten, turn the capscrew clockwise as far as it will turn. Then adjust 1 3/4 turns counter clockwise to regain the starting point - the original factory setting of 0.4 GPM. Ensure that the plastic plug is put back into the access port before filling the system with oil.

The hardover to hardover rudder speed should have been obtained fairly accurately by the initial adjustment. However, if it is necessary to readjust the rudder speed after the system is filled with oil, the following procedure must be followed:

a) Close the pumpset reservoir shutoff valve by turning the handle fully clockwise.

b) Carefully remove the plastic plug from the access port. (A rag should be placed below the access port as a small quantity of oil will drain from the pump when the plug is removed.)

c) Adjust the capscrew as previously described referring to the chart for the correct number of turns.

d) Replace the plastic plug in the access port and open the pumpset shutoff valve by turning fully counter clockwise.

A lockvalve is manifolded to the end of the pump. This lockvalve isolates the pumpset from the hydraulic steering system.

Preset (and not adjustable) relief valves provide over-pressure protection of the pumpset. They are set at 1000 psi. The relief valves are only required when the pump output is adjusted to less than 0.3 GPM because this high pressure range is only potentially obtainable at lower pump outputs.

The pumpset is protected for pump outputs above 0.3 GPM by current limiting circuitry. Additional protection is provided by a thermal circuit breaker. This breaker has an automatic reset feature with a delay at approximately 10 seconds. Trip points are 20A for a 12 VDC system, 12A for 24 VDC and 10A for 32 VDC.

8. INSTALLATION (Refer to Drawings A-2517 and B-7-964-01)

This section of the manual deals specifically with the installation of the hydraulic portion of the Series 50 autopilot system. It is assumed that the hydraulic steering system has been previously installed. If this autopilot was purchased at the same time as the steering system, the steering should be installed first (but not filled with oil). The tee fittings for the connection of the pumpset should be put in place during the installation of the steering lines.

1. PIPING THE SYSTEM - Keep working conditions as clean as possible. Contamination of any form must be prevented from entering the system. Some common contaminants are Teflon tape, pipe fitting compound, metal

filings, any form of dust, and pieces of wiping rags. It is essential that all hydraulic tubing is clean inside before starting the installation. Teflon tape or pipe fitting compounds, commonly used to seal threaded NPT joints, must be used sparingly and applied only to the male threads. The first two threads of the fitting should not be covered. If it is necessary to remove a fitting for any reason, the female thread must be cleaned before reinstalling the fitting.

Soft refrigeration-type copper tubing is recommended and should be at least 3/8" outside diameter and capable of the working pressures as indicated on Drawing B-7-964-01. Long lengths of flexible hose must not be used in place of the recommended tubing as it will adversely affect the performance of the system.

The tubing should be installed with lengths as straight as possible. Bends should be as gradual as possible. Goosenecks (a vertical bend resembling an inverted drain trap, commonly used on the waste drain of a wash basin) must be avoided, otherwise vent plugs must be installed at the high point of the bend to provide a means for removing entrapped air.

Flare-type fittings are recommended for problem-free connections rather than in-line compression-type fittings. When tightening the fittings into the PVO40 pumpset, the lockvalve MUST BE HELD SECURELY WITH A WRENCH to prevent it from twisting out of alignment.

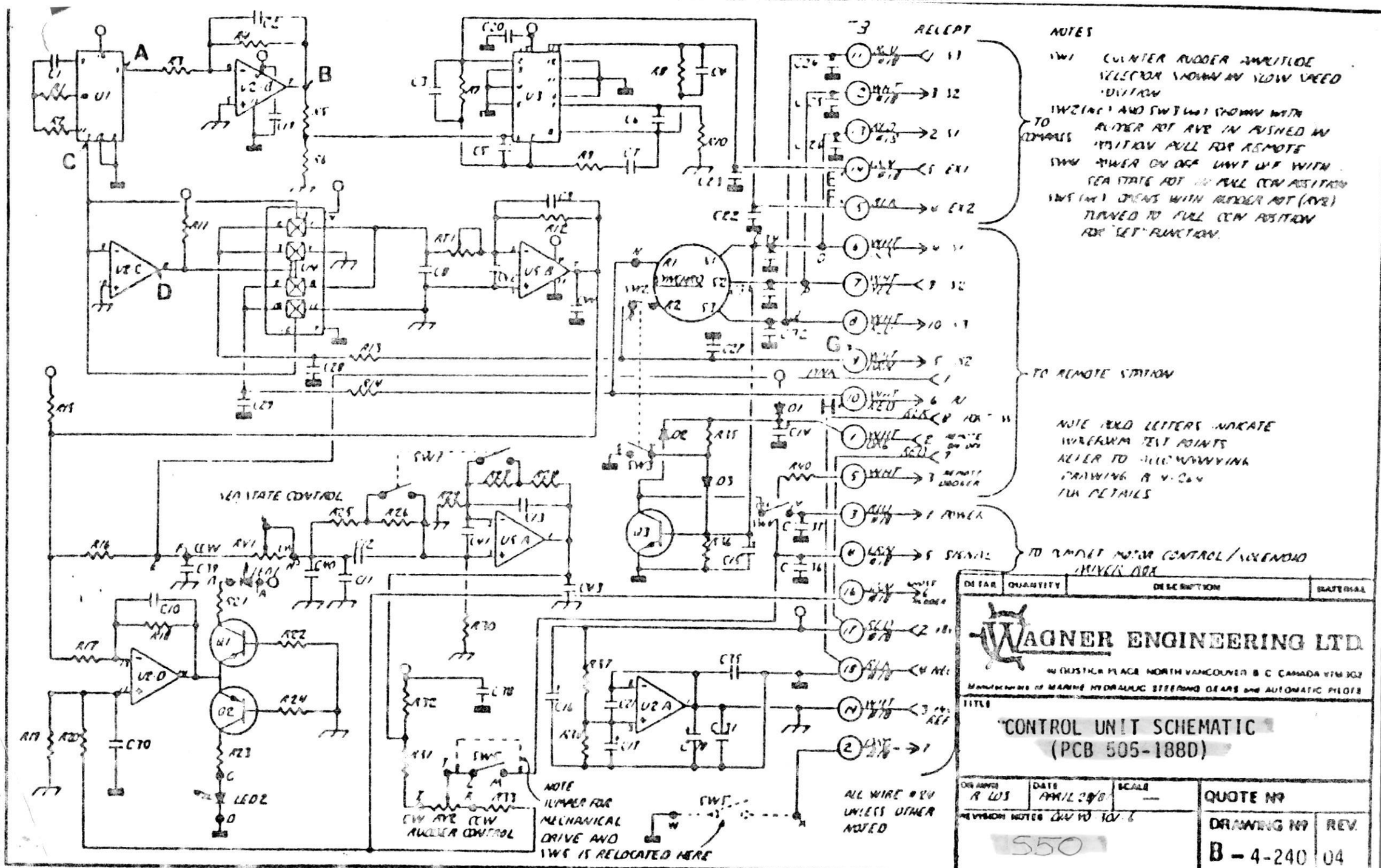
2. RECOMMENDED OILS - Any oil suitable for hydraulic winch drives is acceptable, but the following listed oils are preferred due to their superior qualities.

CHEVRON:	AW Machine 32, EP Hydraulic MV
ESSO :	Nuto H32
GULF :	Harmony AW32, Harmony HVI 36
MOBILE :	DTE 24, DTE 13
SHELL :	Tellus 32, Tellus T37
TEXACO :	Rando HD32, RANDO HD AZ

DO NOT USE BRAKE FLUID

3. FILLING THE SYSTEM - The main steering lines between the helm pump(s) and the steering cylinder must be filled first. The highest (or only) helm pump in the system is also the filler/reservoir and vent for the system and should contain a dipstick. The filler hole on all other helm pumps must be closed with a pipe plug.

Pour oil slowly into the filler tube and begin turning the wheel at this highest (or only) helm pump steadily in one direction only, checking the oil level periodically to prevent pumping air, until the system begins to feel solid. If the steering system is a type N with bleed fittings at the cylinder ports, one fitting can be opened slightly (on the side being filled) to purge entrapped air from the lines quickly. If the system does not contain these fittings, the cylinder tubing fitting can be backed out slightly, but wiping rags must be placed under the cylinder to contain the expelled oil.


NOTES
SW1 COUNTER RUDDER AMPLITUDE SELECTOR SHOWN IN NORM POSITION
SW2 (SW1) AND SW3 (SW2) SHOWN WITH RUDDER POT AXE IN PUSHED IN POSITION PULL FOR REMOTE
SW4 POWER ON OFF UNIT UP WITH SEA STATE POT IN FULL CCW POSITION
SW5 (SW4) OPENS WITH RUDDER POT (AXE) TURNED TO FULL CCW POSITION FOR "SET" FUNCTION
TO REMOTES
TO REMOTE STATION
NOTE BOLD LETTERS INDICATE INTERCONN TEST POINTS REFER TO ELECTRONICS DRAWING B 4-240 FOR DETAILS
TO RUDDER MOTOR CONTROL / SOLENOID VALVES ASSY
SEA STATE CONTROL
NOTE NUMBER FOR MECHANICAL DRIVE AND SW5 IS RELOCATED HERE
CW AXE CCW RUDDER CONTROL
ALL WIRE #20 UNLESS OTHER NOTED
LED2
PART NO. | QUANTITY | DESCRIPTION | MATERIAL
WAGNER ENGINEERING LTD.
40 GOSTICK PLACE NORTH VANCOUVER B.C. CANADA V7N 3G3
MANUFACTURERS OF MARINE HYDRAULIC STEERING GEARS AND AUTOMATIC PILOTS
TITLE
"CONTROL UNIT SCHEMATIC (PCB 505-188D)
DRAWN R WS
DATE APRIL 28/80
SCALE —
REVISION NOTES DRAWING NO. 550
QUOTE NO
DRAWING NO B-4-240
REV. 04