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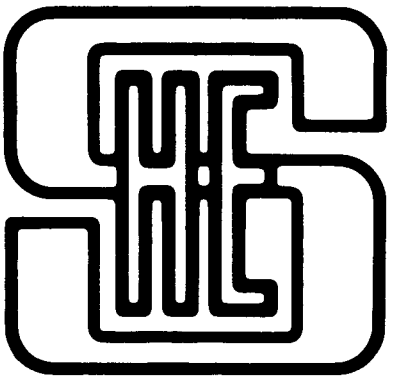
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Electronics



INSTRUCTION MANUAL

RLM MEASURING SYSTEM

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CRYOGENIC INSTRUMENTS AND SYSTEMS
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INSTRUCTION MANUAL

RLM MEASURING SYSTEM

Table of Contents

I. Description. 1
II. Specifications 3
III. Model RBU Low Level AC Impedance Bridge. 6
IV. Model BPD Biphase Detector 19
V. Instruction For Rack Mounting. 22

I. Description

The SHE RLM (resistance, self and mutual inductance) Measuring System is a cryogenic, low impedance ac bridge in which a superconducting quantum interference device (SQUID) is employed as a null detector. The exceptional sensitivity of the SQUID enables high resolution measurements of resistance and inductance to be made at extremely low power dissipation levels. The system allows for considerable inductance in resistive elements and for considerable losses in inductive elements.

The various components of the RLM system are indicated with their interconnections in Figure 1. The components include: a low temperature "SQUID probe", Model MFP or RMP; the electronics units required to operate the SQUID sensor, Model 300 RF Head and Model 30 Control Console; a precision bridge unit, Model RBU; and a sensitive two-phase null indicator, Model BPD.

The lower end of the probe, which contains the SQUID sensor itself, must be cooled to about 4.2K by contact with a bath of liquid helium, as described in the appropriate probe instruction manual. The resistance or inductance element to be measured is connected to the terminals on the terminal board of the SQUID probe. Again, details are given in the probe manual.

This manual describes specifically the Model RBU bridge and the Model BPD null detector. The SQUID probe and System 330 electronics are considered in separate manuals.

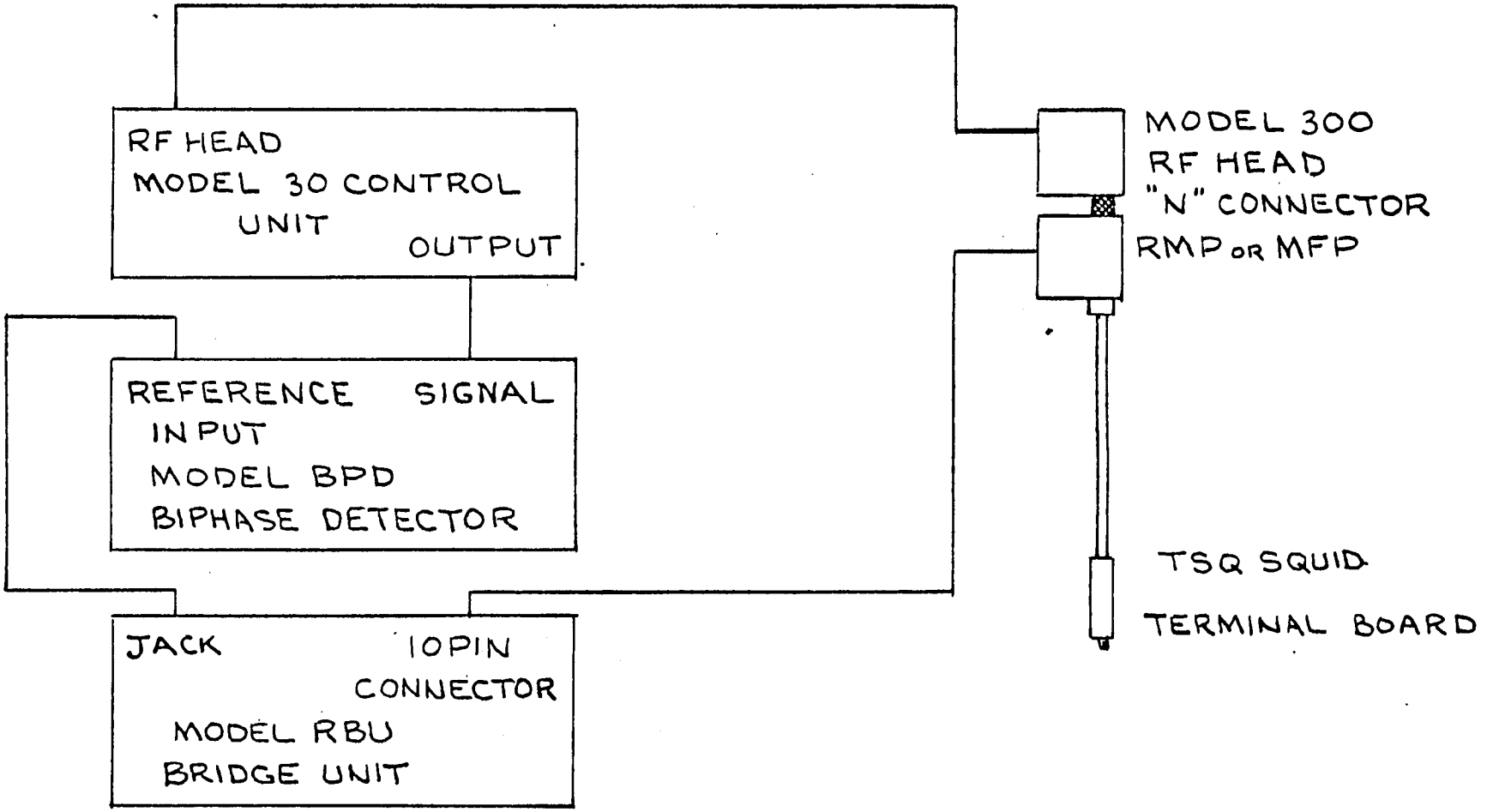


FIGURE 1

MATERIAL	TOLERANCES SPECIAL SYMBOLS	TITLE COMPONENT CONNECTION OF RLM MEASURING SYSTEM	
FINISH			
DRN. BY S DATE 9-27-76		S.H.E. CORPORATION SAN DIEGO, CALIFORNIA	
APPV'D BY DATE	DIMENSIONS		
SCALE	SHEET 1 OF 1	ASSY. DWG.	DWG. NO. A3000-006 REV.

SYM.	REVISION DESCRIPTION	BY	DATE

II. Specifications

- Excitation Frequency: The internal oscillator in the RBU bridge unit operates at four switch selectable angular frequencies of 100, 200, 500, and 1000 radians/sec, corresponding to 16, 32, 80, and 160 Hz. The frequency accuracy is ± 10%.

- Detection Bandwidth: The BPD synchronous null detector has six switch selectable detector integrating time constants of 0.03, 0.10, 0.30, 1, 3, and 10 sec. These time constants τ result in an effective noise bandwidth ENBW=$1/4\tau$.

- Measurement Range: The scale factor on the RBU bridge unit is continuously adjustable by means of the precision RANGE ratio transformer along with the MULTIPLY/DIVIDE switch. The useful range is limited by the accuracy and sensitivity requirements.

- Balance Sensitivity: The balance sensitivity of the RLM system is limited inherently by Johnson noise in the resistive components of the unknown (including any resistance in the "potential" connections to the unknown) and by noise in the SQUID sensor itself. Assuming the unknown is at 4.2K and the maximum specified SQUID noise, the following minimum balance sensitivities are obtained at maximum oscillator output and at an exicta-tion frequency of 80 Hz and a 1 sec time constant, corresponding to an effective noise bandwidth ENBW of 0.25 Hz.

  R (resistance);

  0.001% for 7.7×10^{-5} Ω to 0.013 Ω
  0.01% for 1.8×10^{-5} Ω to 0.64 Ω

  L (self inductance):
  0.001% for 1.4×10^{-8} H to 1.7×10^{-4} H
  0.01% for 1.4×10^{-9} H to 1.7×10^{-3} H

  M (mutual inductance);
  0.001% for mutual inductances greater than 5.8×10^{-7} H, assuming the self inductance of the secondary is less than 10^{-4} H.

- Accuracy: The value of the balancing mutual inductance in the SQUID probe, a quantity entering directly into the equations for the unknown resistance or inductance, is known with an accuracy of 1%. This places a lower limit on the absolute accuracy of all measurements made with the RLM system. Assuming the SQUID sensor is at 4.2 K with maximum specified SQUID noise, an excitation frequency of 80 Hz and a 1 sec time constant, the Model RBU bridge will introduce an additional inaccuracy of less than 1% in the following ranges:

  R (resistance): 1.4×10^{-8} Ω to 1 Ω
  (the lower limit assumes the unknown is at 4.2 K)

  L (self inductance): 1.4×10^{-11} H to 10^{-3} H

  M (mutual inductance): 2.0×10^{-11} H to 10^{-3} H
  (the lower limit assumes the self inductance of the secondary is less than 10^{-6} H)

- Linearity: Departure from linearity in the IN-PHASE component will be less than 0.02% of the reading plus 0.04% of the QUADRATURE dial setting.

- Stability and Reproducibility: The long term stability and reproducibility of the system is better than 0.01% in the INDUCTANCE mode and better than 0.1% in the RESISTANCE mode. Short term stability is 0.001% and 0.01% respectively.

- Maximum Quadrature Component: A large quadrature component in the unknown reduces the precision with which the in-phase value can be determined. Writing $Z = X+jY$, the effect of the quadrature component can be considered in terms of $\tan \delta = Y/X$. If $\tan \delta$ falls within the range of values given below, then there is no extra limitation on the resolution of the in-phase balance.

  160 Hz: $-0.1 < \tan \delta < 0.9$
  80 Hz: $-0.05 < \tan \delta < 0.45$

32 Hz: $-0.02 < \tan\delta < 0.18$

16 Hz: $-0.01 < \tan\delta < 0.09$

When tan δ falls outside these ranges, a bridge balance can still be obtained, but with reduced resolution.

- Power Dissipation: The sine wave oscillator output V_o is variable in ten discrete steps (1-2-5 sequence) from zero up to 5.0 volts peak-to-peak, V_o=5 Vp-p.

When measuring a resistance in the RESISTANCE mode:

$$P = \left(\frac{V_o}{5\ \text{Vp-p}}\right)^2 \frac{1.25\times10^{-15}\ \text{watt}\ \Omega}{R} \quad \text{for } R > 10^{-3}\ \Omega$$

$$P = \left(\frac{V_o}{5\ \text{Vp-p}}\right)^2 1.25\times10^{-9}\ R\ \frac{\text{watt}}{\Omega} \quad \text{for } R < 10^{-3}\ \Omega$$

When measuring an inductance in the INDUCTANCE mode;

$$I = \left(\frac{V_o}{5\ \text{Vp-p}}\right) \frac{1.77\times10^{-10}\ \text{amp henry}}{L} \quad \text{for } L > 10^{-6}\ \text{H}$$

$$I = \left(\frac{V_o}{5\ \text{Vp-p}}\right) \frac{1.77\times10^{-10}\ \text{amp henry}}{M} \quad \text{for } M > 10^{-6}\ \text{H}$$

$$I = \left(\frac{V_o}{5\ \text{Vp-p}}\right) 1.77\times10^{-4}\ \text{amp} \quad \text{for } L, M < 10^{-6}\ \text{H}$$

III. Model RBU Low Level ac Impedance Bridge

The SHE Model RBU Low Level ac Impedance Bridge takes advantage of the sensitivity of a SQUID as a null detector to permit the user to make measurements of ac resistance, self-inductance, and mutual inductance with a resolution of 0.001%. The measurement frequencies may be selected to be 16, 32, 80 or 160 Hz. A simplified schematic is presented in Fig. 2.

Before connecting the Model RBU to the ac power line, check that the power supply is properly set at 120 or 240 Vac. The unit will run on either 50 or 60 Hz. The actual voltage set may be determined by looking through the clear plastic door by the power cord receptacle on the rear panel. There a power supply "wafer" can be seen, on the upper left surface of which are the numerals 120 or 240; the number displayed should correspond to the ac line voltage to be used. If the correct voltage is not indicated, it may be easily changed. First slide open the plastic door to expose the fuse and power supply wafer. Next, remove the fuse by pulling the lever marked FUSE PULL. Now the wafer may be pulled out; it is helpful to use a needle nose pliers to grab the fiberglass wafer. The top surface of the wafer has the two numbers 120 and 240. Simply rotate the wafer until the correct number is on the upper left side, and then push the wafer back in. If one of the two numbers, 120 or 240 is not visible on the upper left side of the wafer, then the instrument will not work. Once the wafer is installed so that the proper number is displayed, and the fuse has been reinserted, slide the clear plastic cover to the right and insert the power cord. The fuse used for both power settings is rated at 1/4 amps, 240 volt, "slo-blow".

The cable connecting the Model RBU to the SQUID probe, either a Model MFP/MFPC or Model RMP/RMPC, attaches to the multipin connector on the rear of the bridge unit and to the AUXILIARY INPUTS connector on the SQUID probe. The Model RBU schematic is at the end of this manual and Figs. 3 and 4 are wiring schematics for the SQUID probes. Leads E and F go to the primary of the balancing mutual inductor. The switch labeled FORWARD/REVERSE on the front panel of the Model RBU reserves the connection of leads E and F; a balance will only be possible in one position, which is determined empirically. Coming from the Model RBU, the excitation current for the impedance to be measured is available through leads A and B or through leads G and H: the selection is made via the front panel switch

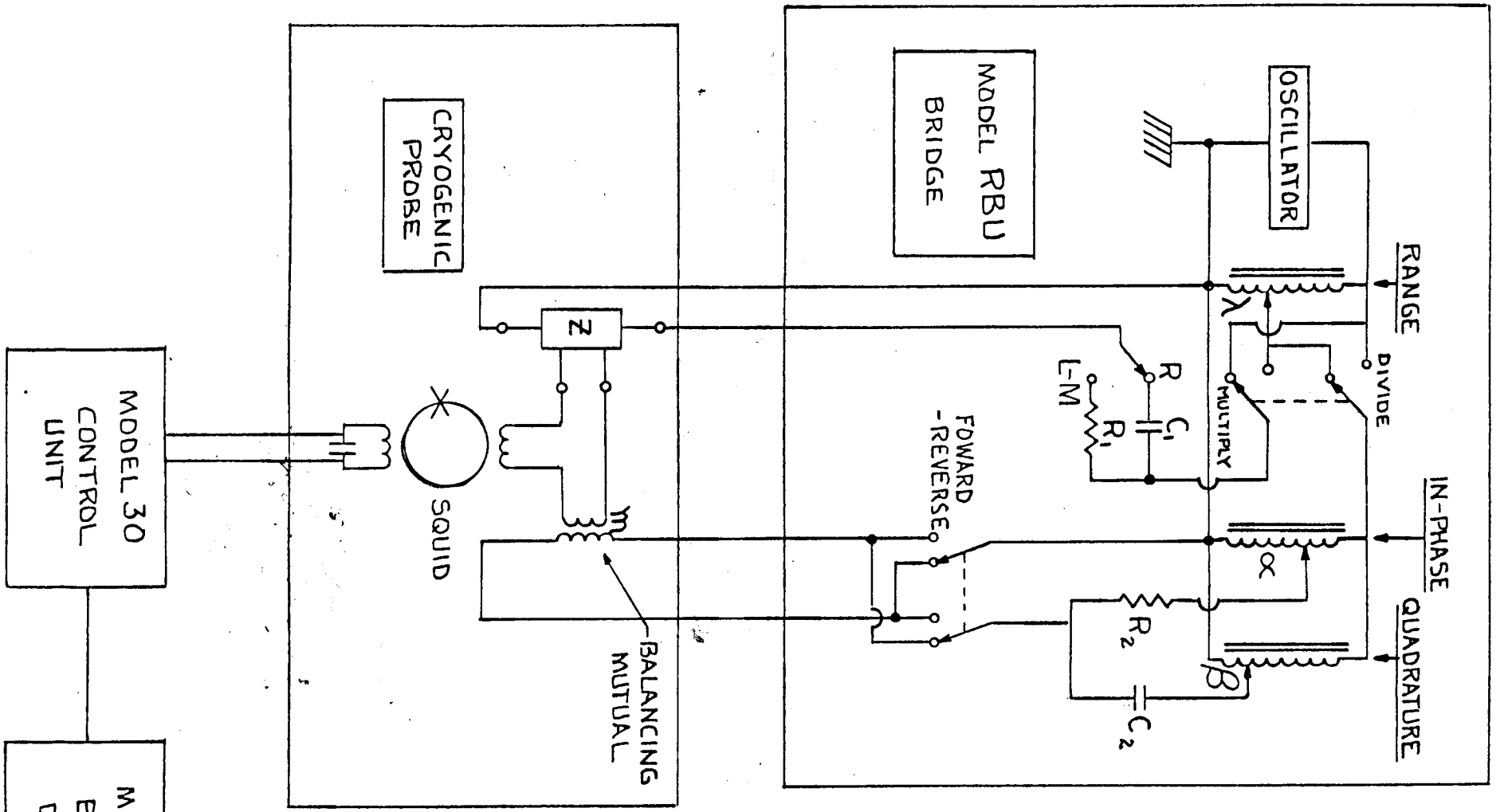


FIGURE 2

MATERIAL —	TOLERANCES SPECIAL SYMBOLS —	TITLE SIMPLIFIED CIRCUIT DIAGRAM R L M MEASURING SYSTEM	
FINISH —			
DRN. BY DATE 9-23-76		S.H.E. CORPORATION SAN DIEGO, CALIFORNIA	
APPV'D BY DATE 9-29-76	DIMENSIONS —		
SCALE —	SHEET 1 OF 1	ASSY. DWG.	DWG. NO. A3000-007 / REV.

SYM.	REVISION DESCRIPTION	BY	DATE

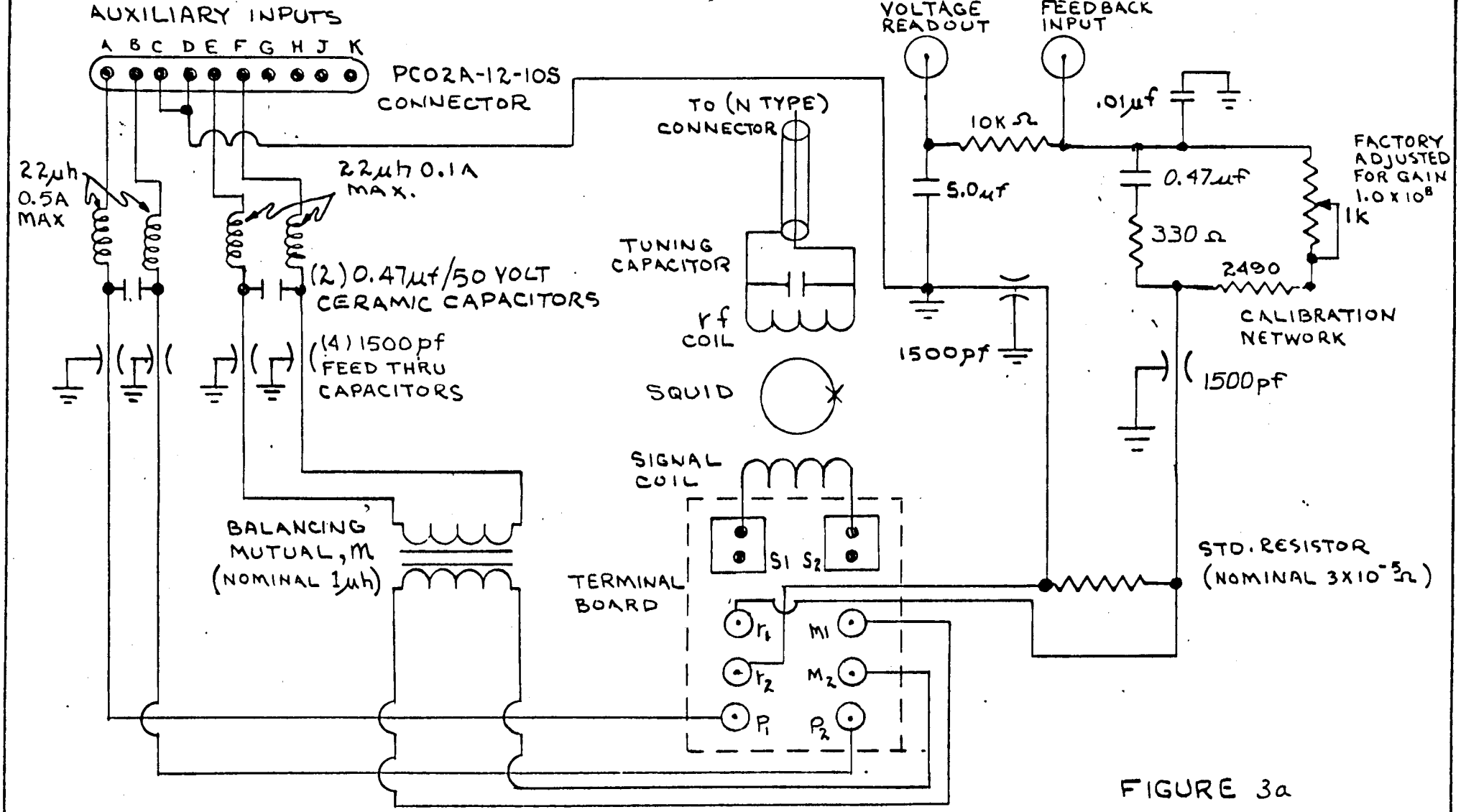


FIGURE 3a

MATERIAL —				TOLERANCES SPECIAL SYMBOLS —	TITLE: WIRING DIAGRAM MODEL MFP/MFPC SERIES MULTI-FUNCTION PROBES
FINISH —					S.H.E. CORPORATION SAN DIEGO, CALIFORNIA
DRN. BY JS DATE 2-20-76					
B	REVISED	JS	1-31-79	APPV'D BY KTC DATE 2-27-79	DIMENSIONS —
SYM.	REVISION DESCRIPTION	BY	DATE	SCALE —	SHEET 1 OF 1

ASSY. DWG.	DWG. NO.	REV.
	A3000-001	B

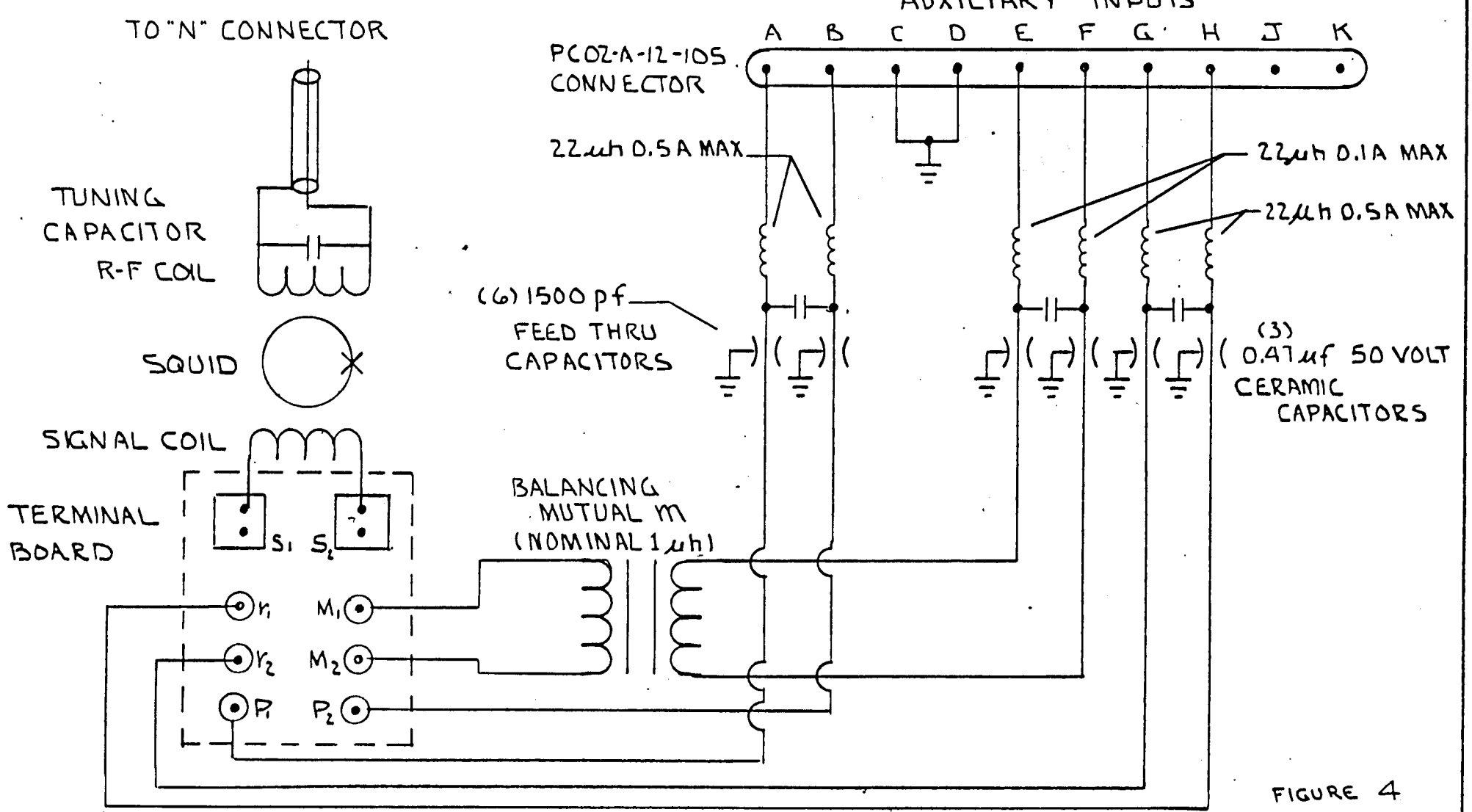


FIGURE 4

-6-

MATERIAL				TOLERANCES SPECIAL SYMBOLS	TITLE WIRING DIAGRAM MODEL RMP/RMPC SERIES
FINISH					
DRN. BY JP	DATE 1-30-78				S.H.E. CORPORATION SAN DIEGO, CALIFORNIA
APPV'D BY	DATE			DIMENSIONS	
SCALE —				SHEET 1 OF 1	ASSY. DWG. / DWG. NO. A 3000-002 / REV. B

SYM.	REVISION DESCRIPTION	BY	DATE
B	REVISED & REDRAWN	RJ	3-28-77

on the Model RBU labeled Z1/Z2. Using leads A and B, the Z1 position, Fig. 5a shows how an unknown would be connected to the terminal board on the SQUID probe. For comments on the techniques of connecting to SQUID probes, refer to the SQUID probe manual. As is the case for the cable provided with the Model RBU, the cable connecting the bridge to the probe should have individually shielded pairs of conductors for each drive signal. Each pair of leads is grounded in the Model RBU and must not be grounded elsewhere.

> CAUTION: Whenever checking for grounds or for continuity with an ohm meter, the cable to the RBU should be disconnected to avoid possibly damaging the decatran ratio transformers.

Model RMP/RMPC probes are wired so that the primary, or current, leads may be leads A and B and/or leads G and H: see Fig. 4. This allows the possibility to measure two unknown impedances: the secondary, or voltage, leads are connected in series and the primary, or current, leads are switched between the two impedances. Fig. 5b shows how the two impedances would be connected to the terminal board. Note that if two impedances are connected, the balance sensitivity will be lower than for either impedance alone: the sum of the two resistances or the two self-inductances or the two secondary inductances will be the determining factor (see Sec. II).

Because of the presence of a standard resistor, see Fig. 3, the Model MFP/MFPC probes cannot be directly used for dual impedance measurements. However, with some simple modifications this type of dual measurement is possible. A small amount of rewiring is required, and also one of the primary, or current, leads must be shared by the two impedances. These modifications are discussed in the SQUID probe manual. After the rewiring, Fig. 5c shows how the two impedances would be connected to the terminal board.

To realize the full sensitivity of the system, a biphase detector such as the SHE Model BPD should be used. The latter is a lock-in amplifier referenced to the operating frequency of the bridge — refer to Sec. IV in this manual. It presents separately the in-phase and quadrature out-of-balance signals appearing at the output of the SQUID control console. The ratio transformers on the RBU are adjusted to produce a simultaneous null in both components of the signal.

FIGURE 5a

A	REDRAWN	P	3-17-77	APPV'D BY RTC	DATE 3/17
SYM.	REVISION DESCRIPTION	BY	DATE	SCALE	

MATERIAL –

FINISH –

DRN. BY 3 DATE 2-20-77

TOLERANCES SPECIAL SYMBOLS –

DIMENSIONS –

SHEET 1 OF 1

TITLE TERMINAL BOARD ARRANGEMENT
A-C IMPEDANCE MEASUREMENT
MFP/MFPc & RMP/RMPc PROBES

S.H.E. CORPORATION
SAN DIEGO, CALIFORNIA

ASSY. DWG.	DWG. NO.	REV.
	A3000-003	A

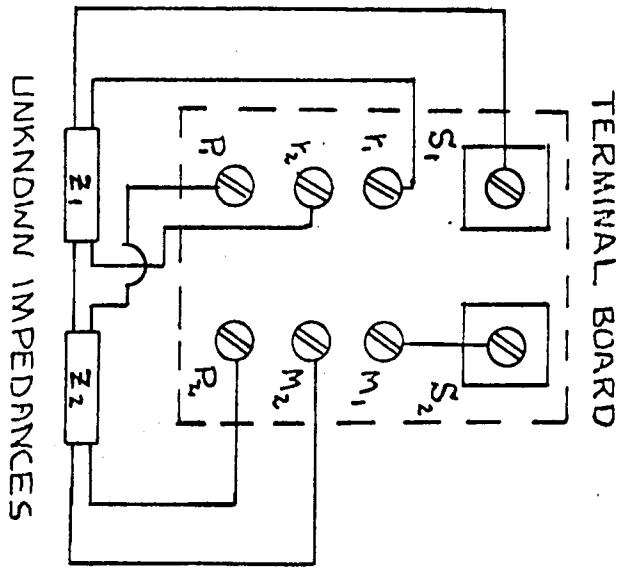


FIGURE 5b

MATERIAL —	TOLERANCES SPECIAL SYMBOLS —	TITLE DUAL A-C IMPEDANCE MEASUREMENTS RMP/RMPC PROBES			
FINISH —		S.H.E. CORPORATION SAN DIEGO, CALIFORNIA			
DRN. BY J DATE 3-17-77					
APPV'D BY RTC DATE 3/17	DIMENSIONS —	ASSY. DWG.	DWG. NO. A3000-030	REV.	
SCALE —	SHEET 1 OF 1				

SYM.	REVISION DESCRIPTION	BY	DATE

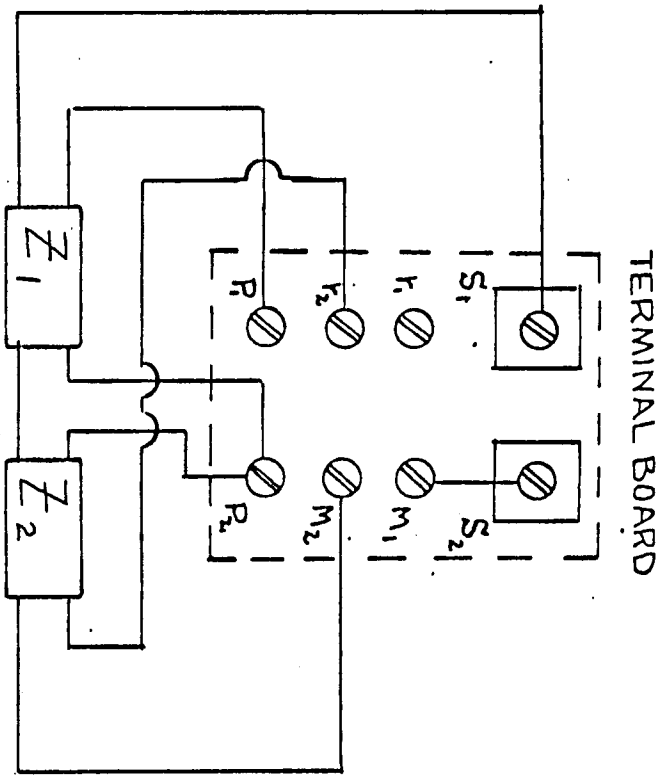


FIGURE 5c

MATERIAL —	TOLERANCES SPECIAL SYMBOLS —	TITLE DUAL IMPEDANCE MEASUREMENTS WITH MFP/MFPC PROBES	
FINISH —		S.H.E. CORPORATION SAN DIEGO, CALIFORNIA	
DRN. BY J DATE 3-17-77			
APPV'D BY RYC DATE 4/3	DIMENSIONS —	ASSY. DWG. —	DWG. NO. 3000-047 REV.
SCALE —	SHEET 1 OF 1		

SYM.	REVISION DESCRIPTION	BY	DATE

The range DIVIDE/MULTIPLY switch allows the high sensitivity range of the bridge to be greatly expanded by dividing down, in a precise and accurate way, the drive voltage fed to either the unknown (DIVIDE) or the balancing mutual inductor (MULTIPLY) relative to the other. Although the DIVIDE mode is always usable, maximum sensitivity may necessitate going to the MULTIPLY mode. The following table indicates the optimum position of the DIVIDE/MULTIPLY switch.

	DIVIDE	MULTIPLY
RESISTANCE	$> 10^{-3}\ \Omega$	$< 10^{-3}\ \Omega$
INDUCTANCE	$> 10^{-6}$ H	$< 10^{-6}$ H

Impedance Determination: The bridge components R_1 and R_2 shown in Figure 2 are precision wirewound resistors with a value of 10 kΩ to an accuracy of 0.01%. Components C_1 and C_2 are highly stable 0.1 μF polystyrene capacitors with an accuracy of 0.1%. When both the in-phase and quadrature out-of-balance signals have been nulled, there are three ratio transformer numbers as indicated on Figure 2.

$\lambda \equiv$ RANGE with a value between 0.00000 and 1.00000
$\alpha \equiv$ IN-PHASE with a value between 0.00000 and 1.00000
$\beta \equiv$ QUADRATURE with a value between -0.10000 and 0.90000

The other quantity which enters into the impedance determination is m, the value of the balancing mutual inductor in the SQUID probe. For each SQUID probe, m is specified to an accuracy of 1% and is nominally 1 μ H. Specifying the unknown impedance as $Z = R + jX$, the balance conditions are given in the attached table.

Initial Balance: When initially trying to balance the system when connected to an unknown impedance, the following procedure is recommended.

X = Reactance

$j = \sqrt{-1}$ 90° comp.

BALANCE CONDITIONS

$$Z = R + jX$$

λ = RANGE

α = Fuphase

β = QUADRATURE

MODE		R	X
INDUCTANCE	MULTIPLY	$-10^{-9}\lambda\beta\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD./SEC}\right)^2\Omega$	$10^{-6}\lambda\alpha\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD/SEC}\right)\Omega$
	DIVIDE	$-10^{-9}\frac{\beta}{\lambda}\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD/SEC}\right)^2\Omega$	$10^{-6}\frac{\alpha}{\lambda}\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD/SEC}\right)\Omega$
RESISTANCE	MULTIPLY	$10^{-3}\lambda\alpha\left(\frac{m}{1\mu H}\right)\Omega$	$10^{-6}\lambda\beta\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD/SEC}\right)\Omega$
	DIVIDE	$10^{-3}\frac{\alpha}{\lambda}\left(\frac{m}{1\mu H}\right)\Omega$	$10^{-6}\frac{\beta}{\lambda}\left(\frac{m}{1\mu H}\right)\left(\frac{\omega}{1\,RAD/SEC}\right)\Omega$

1. Connect all the system components as shown in Figure 1. Select an excitation frequency on the RBU and set the biphase detector to the same frequency.

2. Put the MULTIPLY/DIVIDE switch in the DIVIDE mode and set all three ratio transformers (α, β, and λ) to zero. Set the excitation voltage on zero.

3. Tune up the SQUID electronics according to the System 330 instructions.

4. Set the Model 30 SQUID Control Console on the X1 range in the SLOW mode with the INT FB button pushed in.

5. On the RBU, put the RESISTANCE/INDUCTANCE switch in the appropriate position. If both a resistance and an inductance are present, the mode switch indicates which of the two will be determined by the IN-PHASE dial.

6. Set the excitation voltage at its lowest nonzero value, 0.01 Vp-p. Push the RESET button on the Model 30 to insure that the SQUID is operating properly. Set the null detector gain as high as is reasonable for the noise present. Increase the RANGE ratio transformer λ until an easily observable meter deflection is obtained.

7. Adjust the IN-PHASE and QUADRATURE dials, α and β, so as to null both meters. This may necessitate switching the FORWARD/REVERSE switch. If increased power dissipation is acceptable, increase the drive voltage further to improve the sensitivity of the balance.

8. Use the above formulas with the null values of α, β, and λ to evaluate the unknown impedance.

Now the sensitivity and accuracy can be optimized. Using the table at the beginning of this section, the DIVIDE or MULTIPLY mode can be selected based on the value of the in-phase impedance. To select the RANGE, the choice depends on whether accuracy or precision is most important. If accuracy is most important, select the RANGE λ such that the IN-PHASE α is approximately equal to λ. If precision is most important, as when small impedance changes are to be monitored, then it is most desirable to have α close to 1.0. In

the latter case, the assumption is that λ will be set and seldom changed, since changing λ requires both changes in α and changes in β to again obtain a null condition.

Once the DIVIDE or MULTIPLY mode has been selected and the RANGE λ chosen, then α and β should be put in approximately the correct position — all based on the initial balance obtained in step 8 above. To again obtain a balance, start with the excitation voltage at 0.01 Vp-p, its lowest nonzero level, push the RESET button on the Model 30, and then adjust the IN-PHASE and QUADRATURE dials for null. Increase the excitation and refine the balance to the maximum excitation acceptable.

The 8 step procedure presented above should provide a straight-forward means of balancing the system when connected to an unknown impedance. However, if there are difficulties, the following alternate approach may prove helpful. This alternative is slightly more complex, but better illustrates the functioning of the SQUID as a null detector. Instead of observing the out-of-balance signal on the BPD, the "triangle pattern" associated with SQUID operation is monitored.

To observe triangles requires an oscilloscope connected to the Model 30 console. Connect the DETECTOR jack, on the back panel, to the scope vertical and trigger the scope using the SYNC jack, also on the back panel. Initially disconnect the RBU from the SQUID probe and tune up the SQUID electronics, following the System 330 manual. When completed, triangles should appear on the scope when the SET 1 button on the front of the Model 30 is pushed in. These triangles should be approximately 60-120mV in amplitude and have a period of approximately 20 μ sec. With the RBU disconnected, the triangle pattern should be stable, indicating no time varying signal into the SQUID.

Now the RBU can be connected. Set the RESISTANCE/INDUCTANCE switch as in step 5 of the previous procedure. Also put the RBU in the DIVIDE mode until an initial balance is obtained. Set the excitation level at 0.01 Vp-p. In an off-null condition, the triangle pattern will oscillate horizontally at the oscillator frequency set on the RBU. Since the system is not balanced, a signal is being fed into the SQUID at the oscillator frequency. The amplitude of the oscillations indicates the magnitude of the out-of-balance.

By adjusting the three ratio transformers, α, β, and λ, the horizontal oscillation of the triangle pattern can be eliminated — possibly this will necessitate switching the FORWARD/REVERSE switch. Once a stable triangle pattern has been obtained, the balance should be close enough to proceed with the BPD and with the Model 30 in the X1 and SLOW mode to obtain a final balance.

IV. Model BPD Biphase Detector

The SHE Model Biphase Detector contains two phase-sensitive detectors operating at the same frequency but locked 90° out-of-phase with respect to each other. The Model BPD is specifically designed to operate with the SHE Model RBU Precision Low Level AC Impedance Bridge and is not meant to be a general purpose two phase lock-in amplifier.

The front panel features:

ANGULAR FREQUENCY switch - must be matched to the operating frequency of the RBU bridge.

GAIN switch - sets the amplification of the error signal in ten steps having a 1-2-5- sequence. The gain is the same for both channels.

TIME CONSTANT switch - selects the detector integrating time for both channels. Six possibilities are provided from 0.03 sec to 10 sec.

PHASE switch and potentiometer - adjusts the phase of the reference signals relative to the input signal. The phase is switch selectable at 0°, 90°, 180°, 270° with continuous linear adjustment of ± 50° within each switch setting.

IN-PHASE AND QUADRATURE meters - indicate the in-phase and quadrature outputs of the synchronous detectors. A null balance is indicated by a zero reading on both meters.

IN-PHASE OUTPUT - jack in parallel with the IN-PHASE meter, for use with a recorder, etc. Full scale deflection corresponds to ± 10 volts. The source impedance is 10 k Ω.

The rear panel contains the following:

SIGNAL jack - a floating BNC connector for attaching the input signal. The input signal is obtained from the Model 30 SQUID Control Console OUTPUT.

SIGNAL OUTPUT MONITOR, IN-PHASE and QUADRATURE - these jacks are parallel to the meters on the front panel and are available for use with a recorder, etc. Full scale deflection corresponds to ± 10 volts. The source impedance is 10 k Ω.

REFERENCE OUTPUT MONITOR, IN-PHASE and QUADRATURE - presents the reference in-phase and quadrature signals shifted as controlled by the fine PHASE control on the front panel. The in-phase and quadrature signals are locked at 90° separation. These are available for analytical or troubleshooting purposes.

REFERENCE INPUT - connects to the reference source in the Model RBU bridge unit.

Power cord socket, fuse, line voltage selector card - Before connecting the Model BPD to the ac power line, check that the power supply is properly set at 120 or 240 Vac. The unit will run on either 50 or 60 Hz. The actual voltage set may be determined by looking through the clear plastic door by the power cord receptacle on the rear panel. There a power supply "wafer" can be seen, on the upper left surface of which are the numerals 120 or 240; the number displayed should correspond to the ac line voltage to be used. If the correct voltage is not indicated, it may be easily changed. First slide open the plastic door to expose the fuse and power supply wafer. Next, remove the fuse by pulling the lever marked FUSE PULL. Now the wafer may be pulled out; it is helpful to use a needle nose pliers to grab the fiberglass wafer. The top surface of the wafer has the two numbers 120 and 240. Simply rotate the wafer until the correct number is on the upper left side, and then push the wafer back in. If one of the two numbers, 120 or 240 is not visible on the upper left side of the wafer, then the instrument will not work. Once the wafer is installed so that the proper number is displayed, and the fuse has been reinserted, slide the clear plastic cover to the right and insert the power cord. The fuse used for both power settings is rated at 1/4 amp. 240 volt, "slo-blow".

Setting the Phase Control:

To set the phase controls on the BPD properly, the following procedure is recommended.

1. Turn the BPD GAIN control to a low setting and manipulate the IN-PHASE and QUADRATURE balance controls on the Model RBU bridge unit to bring both meters on the BPD into a null condition.

2. Off-set the IN-PHASE balance control on the RBU enough to cause a full-scale deflection of the IN-PHASE meter on the BPD. Be careful not to introduce such a large error signal that the SQUID system saturates. Saturation is indicated by seemingly random motion of the meter needles. If saturation occurs, increase the gain setting on the BPD such that a smaller error signal produces full-scale deflection.

3. If the phase of the BPD is set correctly, no deflection of the QUADRATURE meter will have occured in step 2. Otherwise, adjust the PHASE switch and potentiometer on the BPD to bring about a null in the QUADRATURE meter.

4. Now rebalance the IN-PHASE component. The IN-PHASE meter should now only respond to the IN-PHASE balance control, and the QUADRATURE meter to the QUADRATURE balance control.

The BPD gain setting may now be increased for increased sensitivity in determining the balance condition. In general, the higher the GAIN setting and the lower the TIME CONSTANT, the more noise there will be on the null meters. Hence, these two settings should be chosen to give the most sensitivity consistent with reasonable measurement times. At this maximum signal level, the independence of the IN-PHASE and QUADRATURE signals should again be checked as in steps 2 and 3 above, and the PHASE setting trimmed to remove any interdependence. The system is now fully aligned for greatest simplicity in taking a large number of readings. Depending on the measurements being made, it may be advantageous to check the phase setting periodically. If for some reason the excitation frequency is changed, then the phase should be reset.

V. Instructions for Rack Mounting SHE Electronic Instruments

SHE electronic equipment may easily be modified for mounting in 19" (48 cm) panel width electronic enclosures. The 17" (43.2 cm) width units (such as the Model RBU and Model BPD) need only have mounting brackets installed on the side panels at the front of the unit. The half-rack width units (such as the Model PCB and Model 30) have a width of 8.5" (21.6 cm); any two these units may be bolted side-by-side, have mounting brackets installed, and thus be rack mounted. Alternatively, a single half-rack width unit may be rack mounted using a half-rack mounting kit. This kit and also the mounting brackets are available from SHE.

The mounting brackets are easily installed. On each side of each electronic unit are two blue filler panels. The panel near the front of the unit is 25 mm wide x 78 mm (or 121 mm) high. The screw holding this small panel in place should be removed, and the panel taken off. The mounting bracket has a ridge which fits into a groove on the exposed side rail; it may then be fastened in place using the two 10-32 (UNF) screws supplied. The holes on the other leg of the mounting bracket are then suitable for rack mounting, using the 10-32 (UNF) machine screws provided.

The half-rack mounting kit includes two mounting brackets which are first mounted to the half-rack width unit as described above. Then a 214 mm x 88 mm blank panel porvided is mounted flush with one of the mounting brackets using the 86 mm x 37 mm x 6 mm mounting plate containing four threaded holes. Now the unit is ready for rack mounting using the mounting bracket on one side and the two holes in the blank panel on the other side.

If two of the half-rack width units are to be bolted side-by-side, then the 78 mm x 297 mm and the 25 mm x 78 mm blue filler panels should be removed from both units on the mating sides. To join the units it is necessary to unscrew and slide off the blue cover plate on top of the unit. Disconnent the power line cord to prevent any possibility of electrical shock. The units may be bolted together using 6-32 (UNC) or M 3.5 screws and nuts, using the 4 mm diameter holes in the side rails. At least four screws spaced over the side rails should be used to firmly join the units. Lock washers on each side are recommended. The screws should not be longer than necessary.

Owing to the circuit layout inside the electronic units, certain orientations

are recommended to minimize the possibility of interference of one unit's performance by the adjoining unit. Model 30 and Model ARB units should always be mounted to the left of another unit, when looking at the front panels. The Model PCB should always be mounted to the right.

For all units except the Model 30, four well-spaced easily accessible 4 mm diameter holes are readily available for bolting the units side-by-side. In the case of the Model 30, which should be mounted to the left of other units as noted above, the access to suitable 4 mm holes is limited by the location of the power supply board mounted to the right side rail. Disconnect the power line cord before proceeding. It is recommended that the two 6-32 (UNC) screws which hold the board to the side rail via the stand-off posts be replaced by longer screws which will then pass thru the adjacent side rails of the two instruments, thus fastening them together. Similarly, the two 6-32 (UNC) screws holding the power supply heat sink to the side rail may also be replaced by longer screws for the same purpose.

CAUTION: When following the above procedure, the power supply board will be unsupported and free to move during the interchange of screws. Be careful to avoid damaging either it or the main circuit board during this process.

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