INSTRUCTION MANUAL

BRIDGE AMPLIFIER AND METER

BAM-1

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INSTRUCTION MANUAL

BAM–1

BRIDGE AMPLIFIER AND METER

APPLICABILITY

This Manual applies specifically to BAM-1's above serial number 14600. The Operating Procedure applies to essentially all BAM-1's including those made by Vishay Instruments or Ellis Associates, regardless of date of manufacture, except for Quarter Bridge hook-up and other very minor discrepancies.

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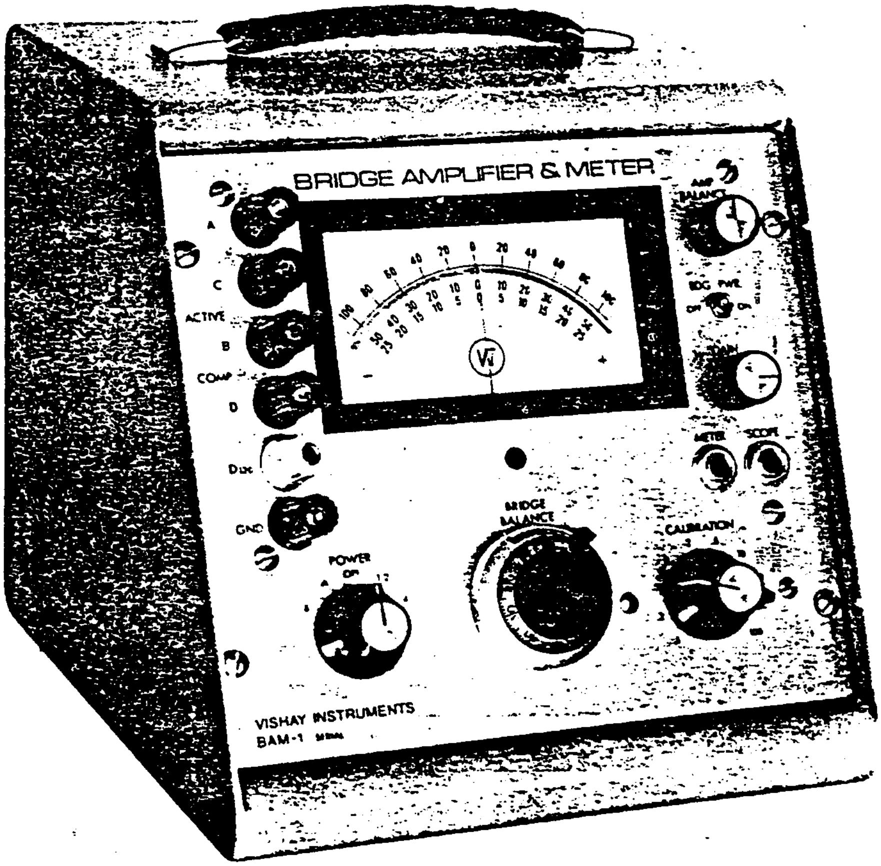


BAM-1
BRIDGE AMPLIFIER AND METER

SECTION 1
DESCRIPTION

GENERAL

1.1 The BAM-1 Bridge Amplifier and Meter is a battery-operated instrument used primarily to measure the output of resistance-type strain gages or transducers. Static outputs can be read directly on the self-contained deflection meter or an external recorder; dynamic outputs up to 20 kHz can be read on an oscilloscope.

Briefly, the BAM-1 consists of:

a) A battery to supply bridge excitation up to 12 Vdc;

b) Bridge completion and circuits to achieve initial bridge balance;

c) Shunt-calibration circuits;

d) A fixed-gain dc differential amplifier (with battery power); and

e) A linear 4½" center-zero readout meter.

1.2 The principle features of the BAM-1 include:

... Operation by self-contained batteries (115 and 230 Vac Power Packs optional).

... Ultra-stable dc amplifier with a gain of 250, flat up to 20 kHz (100 kHz in Model BAM-1B).

... Adjustable system gain from ± 100 to 15,000 $\mu\epsilon$ full scale (one active 120Ω gage).

... Built-in shunt calibration from 20 to 20,000 $\mu\epsilon$ in 10 steps (one active gage).

... Amplifier can be used independently for thermocouples, etc.

SPECIFICATIONS

1.3 All specifications are nominal or typical at 23°C unless otherwise noted, and assume full-charge batteries.

INPUTS

Strain Gage Circuits and Transducers:
Quarter, half and full bridges: 50-2000Ω.

120Ω quarter-bridge dummy resistor provided.

DC Inputs: Up to ± 25 millivolts.

BRIDGE EXCITATION

(changes with system sensitivity)
Full bridges:
120Ω: 0.53 to 6 Vdc;
350Ω: 1.4 to 9 Vdc.

Half or quarter bridge (excitation per gage):
120Ω: 0.25 to 2.5 Vdc (2 to 24 mA);
350Ω: 0.7 to 5.6 Vdc (2 to 16 mA).

BRIDGE BALANCE

(nominal, GF=2, one active gage)
Half or quarter bridge:
±40,000 $\mu\epsilon$ (±8% resistive unbalance).

Full bridge:
120Ω: ± 12,000 $\mu\epsilon$ (6 mV/V);
350Ω: ± 35,000 $\mu\epsilon$ (17 mV/V).

AMPLIFIER CHARACTERISTICS

Type: 3-stage dc solid state, differential input and output.

Input impedance: 20,000 ohms (differential).

Noise: ± 2 μV RMS referred to input.

Stability:
± 7 μV max RTI from turn-on at constant temperature;

± 1 μV/hr max RTI after ½ hour;

± 0.5 μV/°F max RTI (35-75°F or 2-24°C);

± 25 μV max RTI from turn-on, 35 to 75°F (2 to 24°C) temperature change.

	Differential Output "METER"	Single-Sided Output "SCOPE"
Gain:	250	125
Output Imp.:	250Ω	30,000Ω
Linear Range:	± 5 V into 100 kΩ; ± 0.5 mA into 1 kΩ or less	± 3 V into 500 kΩ load
Bandpass (± 5%):	dc to 10 kHz	dc to 20 kHz, min (BAM-1B: dc to 100 kHz, min)

METER

25-0-25 microamperes; approximately 3250 ohms, taut band.

4½ inch size, scale length 3.6 inches (92 mm), with mirror.

100 graduations total; marked 25-0-25, 50-0-50, 100-0-100.

Linearity: ± 1 graduation, max.

SYSTEM SENSITIVITY

(using Meter readout)
Full bridge, four active gages, GF=2

120Ω: ± 50 to 5,000 $\mu\epsilon$/gage fs (0.1 to 10 mV/V)
350Ω: ± 25 to 2,000 $\mu\epsilon$/gage fs (0.05 to 4 mV/V)

Half or quarter bridge, one active gage, GF=2

120Ω: ± 100 to 15,000 $\mu\epsilon$ fs
350Ω: ± 100 to 10,000 $\mu\epsilon$ fs

DC input: 350-5,000 μV fs

CALIBRATION

Internal shunt-calibration, 10 kΩ to 10 MΩ ± 1% (ten steps).

(In quarter or half bridge operation, shunts one leg of the 400-ohm internal half-bridge to simulate 20 to 20,000 $\mu\epsilon$ at GF=2.)

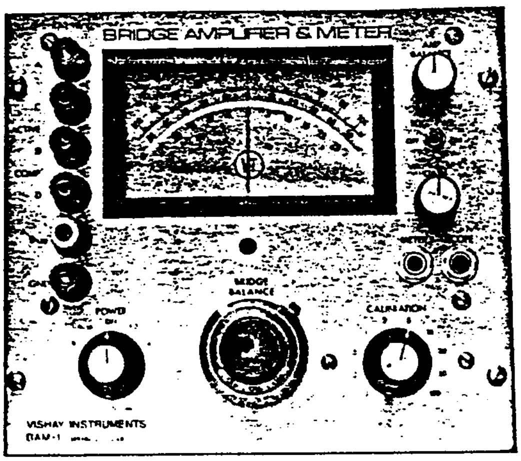
POWER — Internal batteries (standard):
2 ea. 6V, 200 hours, approx.
1 ea. 22.5V, 500 hours, approx.

AC Power Pack (optional -- replaces batteries):
115 Vac ± 10%, 60 Hz, or 230 Vac ± 10%, 50 Hz, 2 watts

SIZE & WEIGHT — Aluminum sloping-panel case, with carrying handle.

8.6 in W x 8.6 in H x 10.0 in D (218 mm x 218 mm x 254 mm).

12 lb (5.5 kg) with batteries.



CONTROLS

1.4 The following description of the panel controls is for reference only and is not intended as an operating procedure for the instrument.

Meter — This center-zero meter is the normal readout for static operation. Its range is controlled by the GAIN Control. (The Meter is disconnected when either the SCOPE or METER jack is in use.)

Binding Posts — These are the input connections for the instrument. A and B are bridge power, C and D are for bridge output (or amplifier input). A half-bridge would be connected between C, B, and D (with the common lead to B). D_{120} is used for quarter-bridges, in conjunction with C and B. GND is case ground (not connected to circuits). For details see Figure 1.

POWER Switch — OFF (center position) disconnects the batteries and shorts the Meter. (With the optional AC Power Pack, the dc outputs are disconnected, but the Power Pack remains energized until the line cord is unplugged.)

"A" checks the amplifier battery; Meter reads 23.6 Vdc fs to right.

"B" checks the bridge excitation batteries in series; Meter reads 11.8 Vdc fs to right.

"1, 2" energizes the amplifier and connects the internal half-bridge; this position is used for quarter and half-bridge measurements.

"4" energizes the amplifier; this position is used for full bridge and transducer measurements.

BRIDGE BALANCE Control — A 10-turn control (with dial) used to achieve initial bridge balance. It has a range of ± 40,000 $\mu\epsilon$ (except on full-bridge operation) with zero near center ("500"). Except in full-bridge operation, each count near center (300 to 700 on dial) represents approximately 7.5 $\mu\epsilon$; the extremes of the control are extremely non-linear.

AMP BALANCE Control — A one-turn potentiometer used to remove minor amplifier unbalance and compensate for net thermal emf's in the input wiring (see below).

BDG. PWR. Switch — A toggle switch to remove bridge power, primarily to set the AMP BALANCE Control and to check dynamic systems for noise pick-up not related to strain.

GAIN Control — This one-turn control operates two potentiometers simultaneously; when turned clockwise, one potentiometer increases bridge excitation and the other, in effect, increases amplifier gain when the Meter is used (by reducing resistance in series with the Meter). It is thus the span control used to adjust system sensitivity during calibration.

METER Jack — A differential low-impedance amplifier output used with most external recorders, but limited to 10 kHz bandpass.

SCOPE Jack — A high-impedance amplifier output used primarily to achieve maximum amplifier bandpass, especially when one output must be grounded.

CALIBRATION Switch — When this knob is *pushed*, it connects a selected shunt-calibration resistor across one arm of the bridge to simulate a given strain. In quarter or half bridge operation (one active gage, GF=2), the following strains are simulated:

.1	20 $\mu\epsilon$	5	1,000 $\mu\epsilon$
.2	40 $\mu\epsilon$	10	2,000 $\mu\epsilon$
.5	100 $\mu\epsilon$	20	4,000 $\mu\epsilon$
1	200 $\mu\epsilon$	50	10,000 $\mu\epsilon$
2	400 $\mu\epsilon$	100	20,000 $\mu\epsilon$

(For further details, see paragraph 2.14 and following.)

SECTION 2
OPERATING PROCEDURE

2.1 The user is cautioned that, for the most stable operation at high sensitivity, the BAM-1 should be maintained at a reasonably constant ambient temperature (not stored in a cold or hot location just prior to use) and should be warmed-up for up to 30 minutes, depending on sensitivity to be used. It is suggested that the POWER Switch be left on during all tests (the battery drain is minimal); for the longer rest periods during a test, the BDG. PWR. Switch may be turned OFF to conserve the bridge excitation batteries.

INPUT CONNECTIONS

2.2 Note: If it is planned to use the instrument immediately, it is suggested that the amplifier be turned on so that it will stabilize while connecting the inputs. To do this, perform steps 2.6 through 2.9 before 2.3.

2.3 Connect the input to the instrument in accordance with Fig. 1. Note that the "tension" or "compression" designation simply indicates the direction of strain at that gage position which will yield a "+" (right) deflection on the Meter or positive voltage output at the output jacks.

CAUTION: the amplifier input and output circuits operate at different dc levels. Normally, the entire instrument circuit and batteries are "floating" from the case (and GND binding post) so that an accidental or intentional ground in the input wiring will not affect operation. However, if the SCOPE or METER output jacks are used, this normally introduces a ground in the output circuit so that the *input must be ungrounded.*

2.4 To use the amplifier simply to amplify low-level (μV or low mV) signals, such as thermocouples, connect the signal at posts C and D (positive at D). The input voltage should not exceed ± 25 millivolts for linear operation of the amplifier (and inputs greater than ± 5 mV must be read with an external meter or attenuated at the input to below ± 5 mV).

WIRING CONSIDERATIONS

2.5 Certain important considerations affect wiring technique, depending on whether the purpose of the test is to measure static or dynamic data; if both may be required, observe both sets of precautions.

Dynamic Data: It is extremely important to minimize the extent to which the gages and leadwires pick up electrical noise from the test environment; this noise is usually related to the 50 or 60 Hz line power in the area:

a) *Always* use twisted multiconductor wire *(never* parallel conductor wire); shielded wire is greatly preferred, although it may prove unnecessary in some cases using short leads.

b) Shields should be grounded at one (and only one) end; normally the shield is grounded at the instrument and left *disconnected* (and insulated against accidental grounding) at the gage end. Do not use the shield as a conductor (that is, do not use coaxial cable as a 2-conductor wire).

c) The specimen or test structure (if metal) should be electrically connected to a good ground.

d) Keep all wiring well clear of magnetic fields (shields do not protect against them) such as transformers, motors, relays and heavy power wiring.

e) With long leadwires, a completely symmetrical circuit will yield less noise (e.g., a half bridge on or near the specimen will usually show less noise than a true quarter-bridge connection).

Static Data: Precise symmetry in leadwire resistance is highly desirable to minimize the effects of changes in ambient temperature on these wires.

a) In the quarter-bridge circuit, *always* use the 3-leadwire circuit shown in Fig. 1, rather than the more obvious 2-wire circuit.

b) Insofar as possible, group all leadwires in a bundle to minimize temperature differentials between leads.

c) If long leads are involved, calculate the leadwire desensitization caused by the lead resistance. If excessive in view of data accuracy required, adjust effective gage factor, increase wire size, or increase gage resistance – or all three, as best suits the situation.

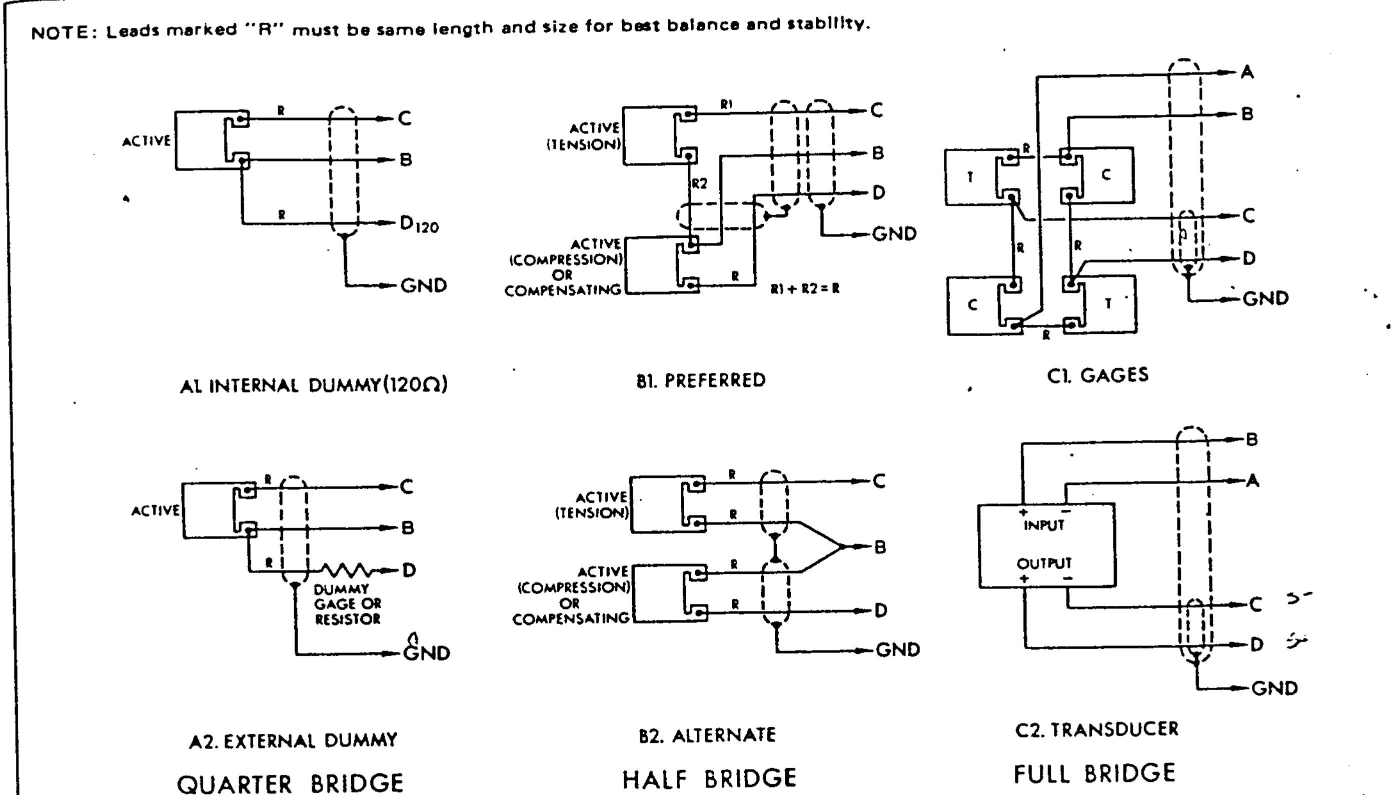


Fig. 1: Input Circuits

INITIAL ADJUSTMENTS

2.6 With the instrument off, check Meter centering: if off "0" (even slightly) adjust the recessed screw below the Meter.

2.7 Check Batteries:
Turn POWER Switch to "A"; the Meter should deflect to the right to at least 75 on the top scale (100 corresponds to approximately 23.6 V). If below 75, replace the 22.5 V amplifier battery.

Turn POWER Switch to "B"; the Meter should deflect to the right to at least 75 on the top scale (100 corresponds to approximately 11.8 V). A low reading indicates that full bridge power is not available and maximum instrument sensitivity cannot be achieved. (This test is made under a simulated load of 300 ohms.) If the reading is too low, replace the two 6 V batteries.

NOTE: If the instrument is equipped with an AC Power Pack, "A" will read around 75 and "B" around 100 – this is normal. If no reading is observed, the line cord is not energized or the Power Pack is defective.

2.8 Turn the BDG. PWR. toggle switch OFF.

2.9 Turn the POWER Switch on:
For *half* or *quarter* bridges, turn it to "1, 2".
For *full* bridges (transducers) or to use the amplifier alone (thermocouples), turn it to "4".

(Return to paragraph 2.3 if input connections have not been made.)

2.10 Turn GAIN fully clockwise. If the Meter deflects off "0", reset it using the AMP BALANCE Control. (If the range of this control is inadequate, see paragraph 3.5.)

2.11 Return GAIN to approximate midpoint.

2.12 Turn BDG. PWR. to ON.

2.13 Turn BRIDGE BALANCE Control to center Meter on "0". With a well-balanced input circuit, this should require a setting near "500" (5 turns from either end). If "0" cannot be achieved, it indicates that the input is wired incorrectly or is extremely unbalanced. The range of this control provides for an 8% unbalance of quarter or half bridges (40,000 $\mu\epsilon$ at GF=2) or ± 17 mV/V on 350Ω transducers. It is thus more probable that the wiring is incorrect or a gage defective.

CALIBRATION CALCULATIONS

2.14 Determine the desired range of operation; that is, the maximum strain or output expected during the test. (The BAM-1 can be recalibrated during a test – see paragraph 2.20 or 2.30.) If the Meter is to be used, select a full-scale reading in the 2.5-5-10 sequence (such as ± 100, ± 2,500 or ± 50,000 $\mu\epsilon$); if an external recorder or scope is to be used, choose a range appropriate to the graduations on that device.

2.15 Perform an approximate "reverse calculation" to determine the desired position of the CALIBRATION Switch (or, if N=1 and GF=2 in quarter or half bridges, see table at end of Specifications, paragraph 1.4).

Quarter or Half Bridge $$\text{CAL NO.} = \mu\epsilon_{fs} \frac{GF \times N}{400} \quad \text{(Eq. 2-1)}$$

Full Bridge $$\text{CAL NO.} = \mu\epsilon_{fs} \frac{GF \times N}{R_g} \quad \text{(Eq. 2-2)}$$

where: $\mu\epsilon_{fs}$ = Desired full scale strain reading in microinches/inch

GF = Nominal gage factor of gages

N = Number of fully active gages (see below)

R_g = Nominal gage resistance (ohms)

To read the *aggregate* strain from all gages, always use N=1, no matter how many gages are active.

To read the *average* surface strain with several gages (assuming Possion's Ratio is 0.3),

N = 1.3 using an axial and transverse gage in a uniaxial stress field.

N = 2 using two gages both axially aligned with the stress field.

N = 2.6 using two axial and two transverse gages.

N = 4 using four axial gages.

Place the CALIBRATION switch in the position *equal to or greater than* the CAL NO. calculated above.

2.16 Now perform an exact calculation for shunt calibration.

Quarter or Half Bridge $$\mu\epsilon_{CAL} = \frac{400 \times \text{CAL SET}}{GF \times N} \quad \text{(Eq. 2-3)}$$

Full Bridge $$\mu\epsilon_{CAL} = \frac{R_g \times \text{CAL SET}}{GF \times N} \quad \text{(Eq. 2-4)}$$

where: $\mu\epsilon_{CAL}$ = Simulated strain (microinches/inch)

CAL SET = Position of CALIBRATION Switch

GF = Exact gage factor of gages

N = Number of fully-active gages

R_g = Gage resistance (of arm connected between binding posts A and C)

There are possible variations on this procedure: To read directly in simple stress, multiply $\mu\epsilon_{CAL}$ by the material modulus of elasticity and calibrate to this value. Or to read load with a tension link, multiply the above value by the link cross-sectional area to obtain force. These procedures may require the selection of another CAL SET position for convenient calibration.

For dynamic measurements proceed directly to paragraph 2.24.

STATIC MEASUREMENTS WITH PANEL METER

2.17 Perform an approximate calibration:

Set the CALIBRATION Switch to the chosen CAL SET position (from prior paragraph).

With the Meter reading near "0", *push* the CALIBRATION switch knob until the Meter deflects to the right. While holding this pushed, turn the GAIN control to achieve the $\mu\epsilon_{CAL}$ reading calculated above. (This need only be done approximately at this time.) Release the CALIBRATION knob.

2.18 Refine all settings *in following sequence:*

a) AMP BALANCE: Turn BDG. PWR. to OFF; if Meter does not read exactly "0", correct it with AMP BALANCE control. Turn BDG. PWR. to ON.

b) BRIDGE BALANCE: With no load on the test structure, reset Meter to exact "0" with BRIDGE BALANCE control. (It is common for this to require an adjustment since during the calibration procedure the bridge excitation was probably changed considerably; this often has a slight effect on the bridge balance.)

c) Calibration (GAIN): Push the CALIBRATION knob and hold it in. Turn GAIN Control until the Meter reads the exact $\mu\epsilon_{CAL}$ calculated in paragraph 2.16; release knob.

2.19 The instrument is now ready to take static readings. Load the structure as desired and take the reading directly from the Meter.

2.20 Checking settings during a test:

AMP BALANCE can be checked as above at any time during a test – and should be from time to time. The structure need *not* be unloaded.

BRIDGE BALANCE can be checked as above during a test, but the structure must be unloaded.

GAIN can be checked without unloading the structure: *Record* setting of BRIDGE BALANCE. Then turn this control to bring Meter to "0". Check GAIN as above, resetting if necessary. Then *return* BRIDGE BALANCE to setting previously recorded. (If GAIN requires sizable increases each time it is checked, the two 6 V batteries are probably weak and should be replaced. An AC Power Pack would eliminate this problem.)

CALIBRATION EXAMPLE

Two gages connected as half bridge, with one active (GF=2.05) and one unstrained (used as compensating gage), highest expected reading 1500 $\mu\epsilon$ in steel.

"Reverse Calculation": $\mu\epsilon_{fs} = 1500, GF \simeq 2, N=1$
Therefore, CAL NO. = 7.5; use CAL SET =10.
Exact Calculation: As above, but use GF=2.05.
Therefore, $\mu\epsilon_{CAL}$ = 1951 microstrain.

Set CALIBRATION at 10; push knob and adjust GAIN to read 19.5 on bottom Meter scale (25-0-25); this scale now reads 50 $\mu\epsilon$/division to $\pm 2500\ \mu\epsilon$.

2.21 Offset Zero and Zero Suppression:

It is not essential that Meter "0" correspond to zero strain. Several procedures are available to improve readability of the BAM-1; all require that the strain, in a given test, be restricted to tension only, compression only, or even a narrow band of numerical readings.

a) To set Zero strain at meter left or right: Balance and calibrate as usual; finally adjust BRIDGE BALANCE to move the Meter needle to -100 (on top scale) if readings will be in tension, or +100 if readings will be in compression. This procedure, of course, doubles the range of measurement but does not improve the readability or resolution.

To maintain the same range of measurement at improved resolution, two variations are possible:

Calibrate and Balance as usual. Finally, adjust BRIDGE BALANCE to move the Meter needle to -50 (on top scale) for tension readings (or +50 for compression); then turn GAIN clockwise to read 100 on the upper Meter scale.

An alternate -- and more accurate -- procedure is to use as the CAL SET value in equation 2-3 (or 2-4) one position *smaller* than the CAL NO. calculated in equation 2-1 (or 2-2). Using this CAL SET, calibrate and balance as usual. Finally, adjust BRIDGE BALANCE to move the Meter needle to -100 or +100, as appropriate for the test.

In either of the above procedures, it will not be possible to check calibration during the test if the Meter has been set at +100 (to read compression only). This restriction could have been avoided if connections to binding posts C and D had been reversed during original hook-up; Meter deflection will now be reversed and CALIBRATION will simulate a compression strain.

b) If all readings are expected to be in a narrow band of tension (or compression) values, the CALIBRATION switch can be used to offset zero strain beyond Meter full-scale. Since the procedure is difficult to explain verbally, it is left to the skilled operator to determine the technique. If the action of the CALIBRATION operation is throughly understood, it will be realized that it can be used to simulate a value close to the anticipated values; BRIDGE BALANCE is adjusted while holding the CALIBRATION knob pushed. Two different CAL SET values are used: one to set GAIN, the other to set BRIDGE BALANCE. (Compression data requires that the leads to C and D be reversed.)

2.22 TRANSDUCER Calibration

a) If the factory calibration certificate for the transducer is available and includes shunt-calibration data: Set AMP BALANCE (with BDG. PWR. at OFF), zero Meter with BRIDGE BALANCE, apply external shunt (as specified by transducer manufacturer), and adjust GAIN to read correctly on a convenient Meter scale. (Recheck AMP BALANCE, BRIDGE BALANCE, and GAIN.) The system is now ready for use.

b) Calibration by physical transducer input: Set AMP BALANCE (with BDG. PWR. at OFF), zero Meter with BRIDGE BALANCE, and apply known load to the load cell (not necessarily anywhere near rated capacity). Adjust GAIN to read correctly on a convenient Meter scale. (Recheck AMP BALANCE, BRIDGE BALANCE, and GAIN.) Remove known load. Push CALIBRATION knob and turn it to get a Meter deflection near full scale. Record reading and position of CALIBRATION Switch. (This can be used in future rather than known load.) Now the system can be made more or less sensitive with good accuracy:

$$\frac{\text{Load (Desired)}}{\text{CAL SW POSIT (New)}} = \frac{\text{Load (Calibration)}}{\text{CAL SW POSIT (Calibration)}}$$

That is, simulated load is proportional to position of CALIBRATION switch. With this in mind, the Meter can be reset (with GAIN control) to read any range of loads (within the capacity of the transducer). For example, a 100 lb load cell can be adjusted to read 25 lb full scale.

DYNAMIC MEASUREMENTS

Since the BAM-1 is an entirely dc instrument, even static measurements can be made by this method, although it is inconvenient compared to the Meter on the instrument. Of course for dynamic measurements an external oscilloscope or oscillograph must be used.

2.23 Attach the input (using shielded wire) and balance the system in accordance with paragraphs 2.3 through 2.13, above.

2.24 Wire the scope or recorder to a standard 2-circuit ¼" diameter phone plug using shielded wire with scope ground (or low-impedance input) connected to the shield and to the "shank" of the plug and the signal lead connected to the "tip".

When a standard plug is inserted into the METER or SCOPE jack on the BAM-1, the BAM-1 case (which is usually "floating") becomes grounded to the plug "shank". In some cases (primarily to achieve maximum bandpass or to provide more flexibility in grounding methods to reduce pick-up noise) it may be desirable to use a floating differential output from the BAM-1. In this case, use a 3-circuit ¼" diameter phone plug; the two signal leads would be connected to the "tip" and "ring" using 2-conductor shielded wire -- the "shank" may be grounded (through the shield) or not, as desired. This arrangement usually is used only with the METER jack, since the SCOPE jack is not truly differential.

2.25 Center the recorder or scope (set on dc, not ac, at about 100 mV/inch) with their appropriate controls.

2.26 Plug the recorder or scope into the BAM-1.

For best frequency response into a high-impedance device (especially if one lead must be grounded), use the SCOPE jack.

For high current (low impedance) devices - such as a pen-motor without preamp or light-beam oscillograph - use the METER jack. This jack also has greater output voltage and can be used with a scope if desired.

When the plug is inserted into either jack, the panel meter on the BAM-1 becomes inoperable (except to check batteries).

2.27 When calibrating, the system gain must be adjusted. The GAIN control on the BAM-1 now simply varies gage excitation, and thus system gain. With a scope and some chart recorders, its controls can also be used to change system gain. With a pen-motor or light beam oscillograph, it is frequently desirable to insert a variable resistor between the METER output and the recorder; this is partly to adjust system gain and partly to provide the recommended source impedance to the recorder for optimum damping characteristics.

Given two controls to adjust system gain, it is generally desirable to keep the BAM-1 GAIN Control pretty far clockwise and control system gain at the scope or recorder. The advantage is that 50/60 Hz noise and pick-up in the input wiring, amplifier "white" noise, and amplifier drift become less significant. However, do not exceed safe bridge excitation and cause the gage installation to be unstable or damaged.

2.28 Determine the CAL SET value from paragraphs 2.14 through 2.16 and set the CALIBRATION switch at the chosen CAL SET position. Turn the BAM-1 GAIN control well clockwise (as discussed above). Check that the recorder reads zero (if not, adjust it with the BAM-1 BRIDGE BALANCE control).

Using the recorder attenuator controls, make a rough calibration: *push* the CALIBRATION switch knob until the recorder deflects (corresponding to "+" or tension Meter reading). While holding this pushed, turn the recorder attenuator to achieve the desired deflection corresponding to the $\mu\epsilon_{CAL}$ (calculated in paragraph 2.16). This need only be done approximately at this time. Release the CALIBRATION knob.

2.29 Refine all settings *in following sequence:*

a) Recorder centering: unplug phone plug; if recorder is not centered, make the necessary adjustment. Insert phone plug again.

b) AMP BALANCE: Turn BDG. PWR. to OFF. If recorder trace is not centered, adjust it with BAM-1 AMP BALANCE control. Turn BDG. PWR. to ON.

c) BRIDGE BALANCE: With no load on test structure, recenter recorder trace (if required) using BAM-1 BRIDGE BALANCE control.

d) CALIBRATION (system gain): Push CALIBRATION knob and hold it in. Adjust recorder attenuator to obtain exact desired deflection for calculated $\mu\epsilon_{CAL}$; release knob.

The system is now ready to record dynamic data.

2.30 Checking settings during a test:

Recorder centering and AMP BALANCE can be checked as above at any time during a test; the structure need *not* be unloaded.

BRIDGE BALANCE can be checked as above during the test, but the structure must be unloaded.

System gain can be checked without unloading the structure: *record* setting of BRIDGE BALANCE control. Then turn this control to center recorder trace. Check system gain as above, resetting if necessary. Then *return* BRIDGE BALANCE to setting previously recorded. (If system gain requires a sizable increase each time it is checked, the two 6 V batteries in the BAM-1 are probably weak and should be replaced. An AC Power Pack would eliminate this problem.)

NOISE

2.31 Especially in dynamic measurements using a scope or recorder, there is the question of how much of the indicated signal is strain and how much is extraneously picked up noise. In general, any signal indication with BDG. PWR. at OFF is noise due to wiring or instrumentation.

Noise pick-up can be of *electrostatic* nature - in this case be certain that all wiring is shielded and the shields grounded; also ground BAM-1 case (GND binding post), test structure, and scope or recorder. In grounding, it is best to tie all shields (only one end of each), cases, and an independent lead to the test structure to a single point; then tie this point to a good earth ground.

Electromagnetic fields can also introduce noise - and shields don't help. Make certain that all wires are twisted all the way from the gage to the BAM-1 binding posts; when possible, all input leads should be twisted together as a group. Keep wiring well clear of transformers, motors, and ac line cords or conduits.

SECTION 3
SERVICING DATA

The BAM-1 should require no routine maintenance other than battery replacement as required. It is recommended that, should the instrument require any other service, it be returned to the Measurements Group plant as we are fully equipped to handle calibration, service, and parts replacement. (Field repairs during the warranty period should only be done with the authorization of the Meausurements Group or their authorized representatives.)

BATTERY REPLACEMENT

3.1 If either battery reads below +75 on the upper Meter scale, it should be replaced. To replace either battery, remove the cover plate at the rear of the instrument. Remove the 22.5 V battery first, then the two 6 V batteries on either side. Replacement batteries:

22.5 V:	NEDA 710 (Eveready 763 – or Burgess 4156, but use insulated nuts from discarded Eveready battery)
6 V (2 ea.):	NEDA 920 (Eveready 2744N or Burgess F4BW)
or	NEDA 6 – shorter life (Eveready 744 or Burgess F4PI)

The two 6 V batteries plug in; no error is possible. On the 22.5 V battery, the red wire goes to +, the black wire to –. After installing the batteries (22.5 V at center), wedge about ½ inch (12 mm) of cardboard between the 22.5 V and one 6 V battery to keep them snug. Check that Meter deflects to right on "A" and "B".

TROUBLE-SHOOTING GUIDES

The following suggestions are presented as an aid in diagnosing troubles:

3.2 Meter inoperative with strain.

Check condition and polarity of batteries (Meter should deflect to right). The amplifier output goes through contacts on both jacks before going to the Meter; these contacts may be corroded or a bit of dirt may be lodged in the jack contacts.

3.3 Meter always "pegged" with POWER at "1, 2" or "4".

If condition exists with BDG. PWR. at OFF, there are one or more extraneous grounds in the circuit or the amplifier is defective.

If condition exists only with BDG. PWR. at ON, and BRIDGE BALANCE will not correct it, it is most probable that input gages are not the same nominal resistance (mixed 120 and 350Ω) or one is open or shorted.

3.4 Circuit isolation resistance:

The gage and amplifier circuits must float from case by 100 megohms minimum (no plug inserted in jacks). Poor isolation may cause instability or dc offset of the readings, especially when using a scope or recorder.

Check isolation by measuring resistance between GND and C bindings posts, then between GND and D (POWER at "1, 2", no jack plugged in). A momentary flick of the ohmmeter is normal, but then should read 100 megohms minimum. If readings are below this and there are connections to the input, remove these wires and repeat test. If readings are now good, investigate gage installation and wiring; if still poor, remove BAM-1 batteries and recheck (occasionally the battery case is electrically leaky -- wrap with electrical tape or plastic film). If problem persists and there appear to be no wires touching the chassis, disconnect 402Ω half bridge (R4 & R5).

ADJUSTMENTS

3.5 A well-adjusted BAM-1 will read near Meter "0" on either POWER "1, 2" or "4" with no input connections and the AMP BALANCE Control near center.

If this is not so, there are two screwdriver adjustments on the chassis (accessible through battery access plate at rear). With no inputs, set GAIN fully clockwise, and set AMP BALANCE at center of travel. The simplest procedure, with POWER on "4", is to first place a short between the C and D binding posts and set Meter to "0" turning BAL TRIM (the lower control). Then remove the short and zero Meter with INPUT STAB. (An alternate approach, which requires no short, is to adjust BAL TRIM on POWER "1, 2", then INPUT STAB on POWER "4", repeating as required -- the two adjustments interact somewhat.)

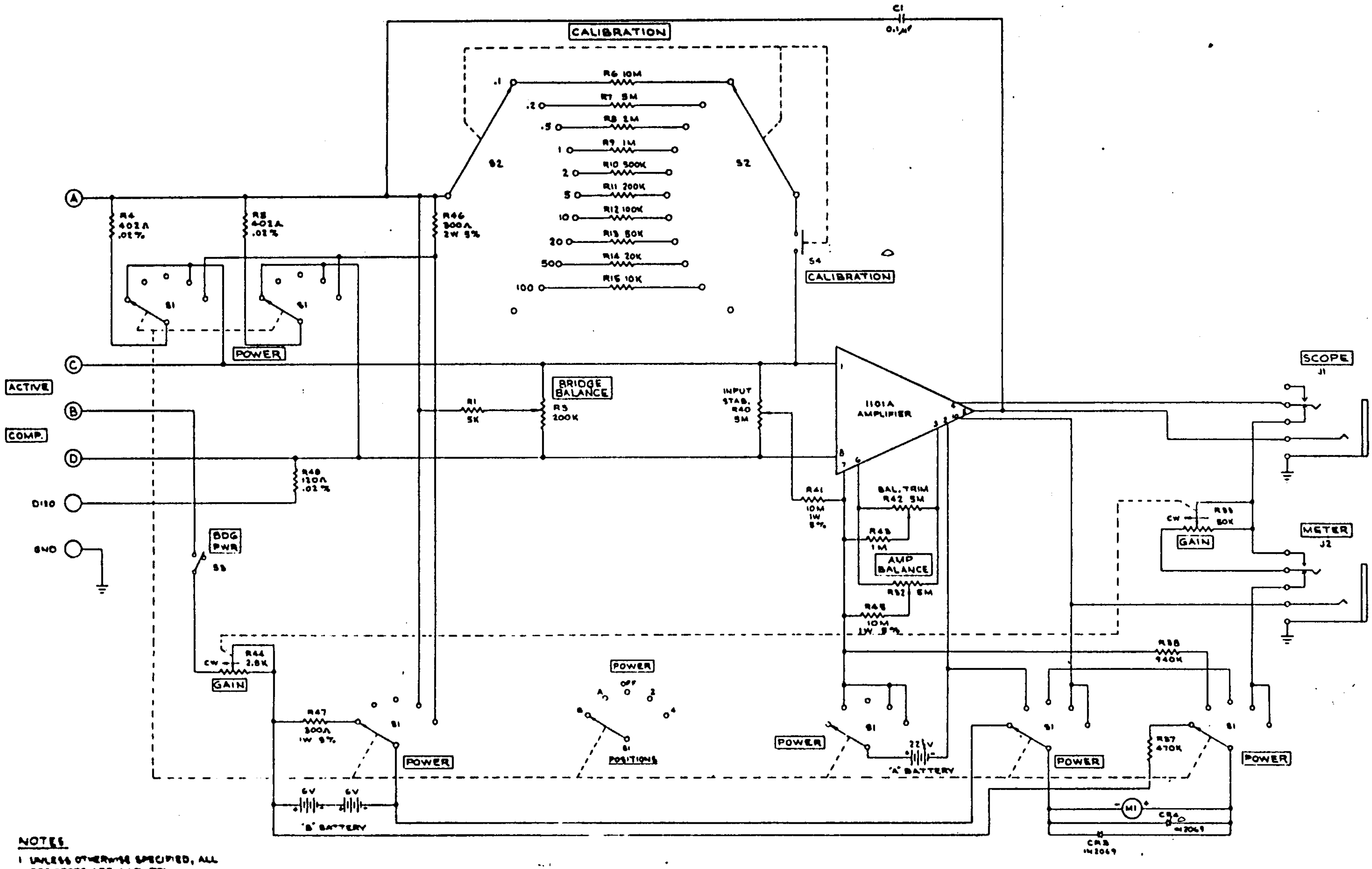
COMPONENT REPLACEMENT

3.6 It is recommended that a defective BAM-1 be returned to Measurements Group for factory service, although a qualified technician can often repair the unit in the field. All electrical and mechanical components can be obtained from stock at Vishay; some components are standard commercial items and could be bought locally. The amplifier cannot be serviced in the field (although replacements are available); depending on the failure, some are repairable at the factory.

To obtain replacement parts, specify model number, serial number, schematic symbol of part, and a fair description of part. The following is a partial parts list:

Symbol	Description	Part Number
–	1101A amplifier	200-130328
M1	Meter	200-130546
R3	BRIDGE BALANCE Pot	24X400113
R4/5	402Ω half-bridge	200-033296
R33/44	GAIN pot (dual)	100-120715
R48	120Ω dummy	15X200087
S1	POWER switch	200-130192
S2	CALIBRATION selector switch	200-130193
S4	Microswitch (CALIBRATION)	10X800076

3.7 A schematic for the BAM-1 will be found on the following page.



NOTES

1 UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE ±1% TOL

These drawings and specifications are intended to provide information for the proper utilization or maintenance or calibration or repair of the items represented. They are and shall remain the property of the Measurements Group and shall not be reproduced or copied in whole or in part as the basis for manufacture or sale of such item.

MEASUREMENTS GROUP

400-052476B

SCHEMATIC
BRIDGE AMPLIFIER & METER
BAM-1