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POLYGRAPH INSTRUMENTATION AND CALIBRATION

By

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INSTRUMENTATION

The polygraph over the years has recorded three basic parameters, and though there have been many improvements in polygraph instrumentation over the last thirty years, we have in reality only discovered different and improved methods of measuring these same parameters. In the following pages we will provide a description of each of the different methods of recording these parameters in use today, and how they function.

MECHANICAL PNEUMO

Respiration is the process by which individuals absorb oxygen and give up the products of oxidation in the tissues. The lungs are entirely passive during breathing and behave as would a thin walled balloon, open to the atmosphere but otherwise enclosed in a partially evacuated space. The thoracic cavity, wherein the lungs are contained, is an airtight chamber of where the volume may be changed by the movements of the diaphragm and ribs.

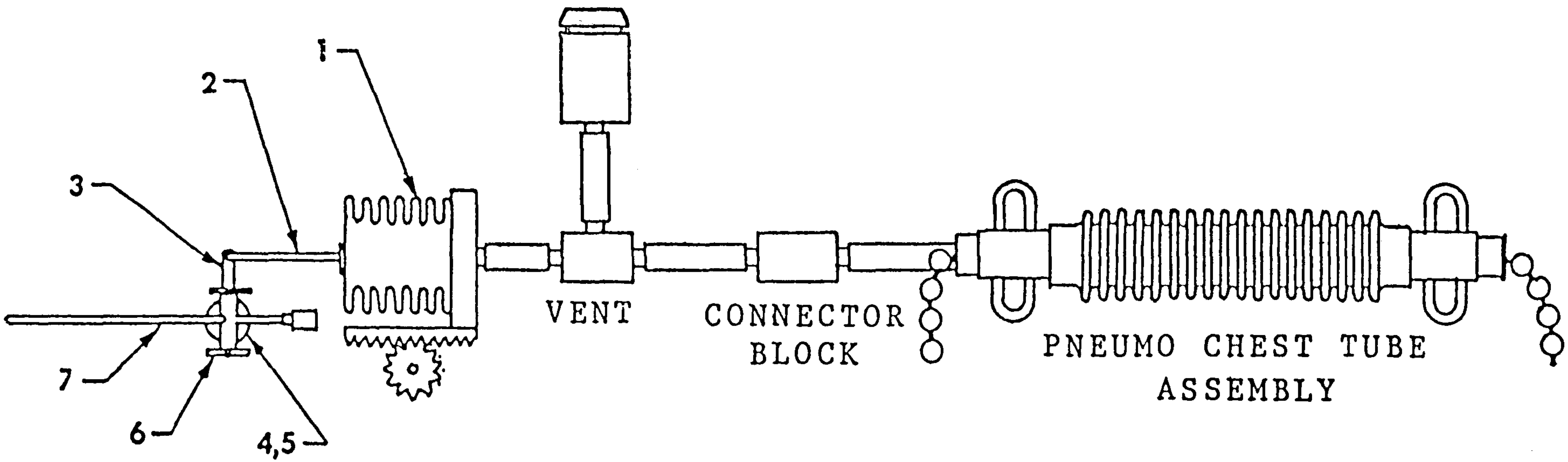
Inspiration occurs when air rushes in to occupy the extra volume made available as the floor of the thoracic cage is pulled downward during contraction of the diaphragm's muscle fibers. Expiration is the outward rush of air occurring when the diaphragm contraction ceases and the thoracic cage collapses to its resting volume. When the vigor of respiration is increased, the various movement of the ribs make an increasingly important contribution to the volume changes of the thoracic cage. As the ribs move upward and outward, the volume of the case is increased.

Simply stated, the pneumograph component records on paper a graphic display of the respiration pattern. The pneumograph channel is a low pressure (atmospheric) air tight chamber which consists of the tubular rubber bellows assembly (pneumograph), connected to the actuator assembly (pneumo channel) via rubber tubing. The bellows assembly on the actuator can be moved back and forth by the centering control located on the channel. This will permit centering of the stylus on the recording paper. (See Drawing 1)

As the chest and/or abdomen expands during inspiration, the rubber bellows also expands. This increases the volume of the bellows and since it is air tight, the air pressure inside becomes lower. At the other end of the rubber tubing the brass bellows reacts to the loss of pressure by contracting slightly.

Drawing No. 1

PNEUMOGRAPHIC COMPONENTS
(A TYPICAL TRAIN OF ENERGY)



TAMBOUR ASSEMBLY CONSISTING OF:

1. BELLOWS
2. CONNECTING LINK ARM
3. FULCRUM
4. PIVOT SHAFT
5. BEARINGS
6. PEN FORKS
7. PEN

4/85

As the stem connected between the bellows and the cradle is pulled upward, it causes the pen cradle to rotate, moving the stylus upward in the chart paper. When the chest and/or abdomen contracts, the rubber bellows also contracts causing the volume of air in the closed system to decrease which in turn causes the pressure within the system to increase. Again the brass bellows reacts to the pressure change. As the pressure increases the bellows expand and the stem pushes out against the cradle assembly causing it to rotate and move the stylus downward on the chart paper. Thus as the chest and/or abdomen expand and contract, the stylus follows and produces a graphic recording of the respiration pattern.

The cradle assembly (sometimes referred to as the pivot shaft assembly) consists of the cradle and the pivot shaft. The pivot shaft is connected to the bellows stem with a fulcrum. The pivot shaft assembly is mounted to the actuator assembly using ball bearings (Stoelting) or a bombe jewel mount (Lafeyette). Both systems are designed to give the examiner a large range of sensitivity, and both are easily calibrated. The sensitivity level is calibrated at the factory to produce a one (1) inch upwards movement of the stylus (Stoelting) or a one and a quarter (1 1/4) to a one and three quarter (1 3/4) inch movement (Lafayette), for a 1/4 inch increase in the length of the rubber convoluted chest assembly.

There are only two adjustments that should ever be attempted in the field. The first is sensitivity, which should be set so that a 1/4 inch change in the length of the convoluted tube will produce 1 inch of pen movement, and, second, the total pen sweep, which should be set for 2 1/2 inches. The adjustment for setting the sensitivity is made by moving the fulcrum in and out from the pivot shaft. As the examiner moves the fulcrum outwards from the pivot shaft the sensitivity decreases, and as the fulcrum is moved in toward the pivot shaft the sensitivity will thereby increase. (See Drawing 2)

The amount of pen travel (pen sweep) is set by the adjustment of two screws on the end of the actuator (Stoelting) or by adjusting the calibration adjustment rod on the lower portion of the pivot shaft assembly (Lafayette).

Calibration

Calibration should be done on a weekly basis, or

a. Whenever you are using an instrument that you are not sure of the last calibration date.

b. Whenever you believe that the pneumo pattern shows a lack of sensitivity.

c. Whenever you suspect there might be a leak in the system.

Note: See the Calibration Section for the calibration procedure.

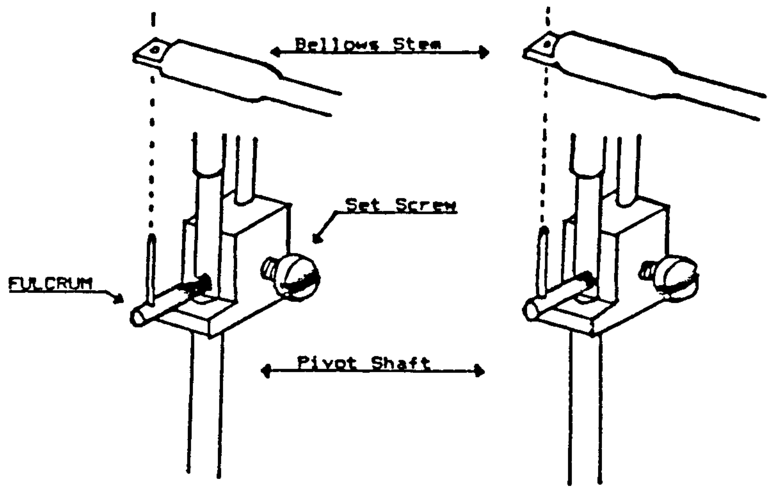
ELECTRONIC PNEUMO

The Multifunction or All Purpose Amplifier can be used in two or more modes. By selecting Pneumo with the mode selector switch, the respiration

MECHANICAL PNEUMO AND CARDIO UNITS

SENSITIVITY ADJUSTMENTS

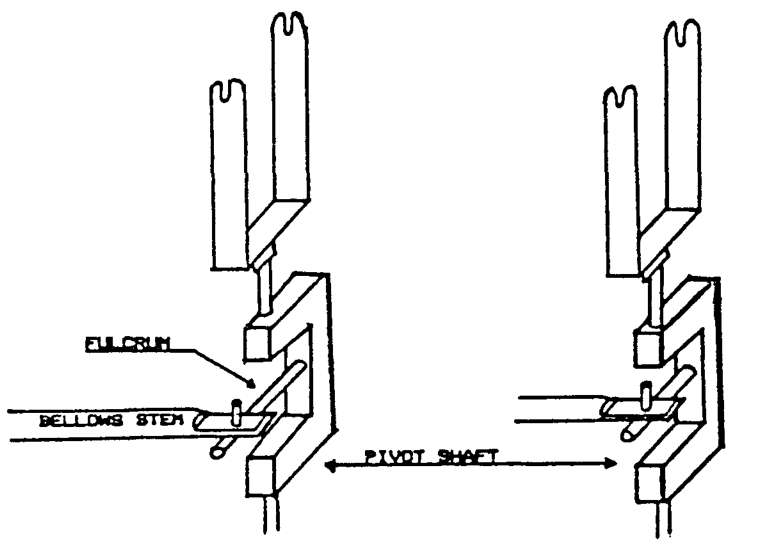
Lafayette Units



FULCRUM OUT FOR
LESS SENSITIVITY

FULCRUM IN FOR
GREATER SENSITIVITY

Stoelting Units



FULCRUM OUT FOR
LESS SENSITIVITY

FULCRUM IN FOR
GREATER SENSITIVITY

Drawing No. 2 Marshall V. Pochay 4/85

pattern of the subject will be amplified electronically and recorded on the chart paper. The heart of the Electronic Pneumo is the pressure transducer. This device senses the small variations in pneumatic pressure from the rubber pneumograph and transposes these variations to an electronical signal. These small signals are amplified and are used to drive a pen motor. The pen motor rotates the cradle and stylus to produce a graphic recording of the respiration pattern.

The Stoelting pressure transducer consists of a pair of matched silicon strain gauges bonded to a thin metal disk. This disk is secured between two heavier rings of metal and secured in an aluminum housing which is made airtight. As the pressure changes from the pneumograph appear on one side of this disk it causes the disk to flex. Due to the positioning of the strain gauges on the disk, one strain gauge will flex more than the other. Since the silicon strain gauges change resistance as they are flexed, one gauge will have a greater resistance change. There is a small amount of current flowing through the strain gauges and therefore the resistance changes from the flexing of the disk will produce a small voltage change that parallels the respiration pattern. This small voltage change will be amplified until it is large enough to drive the pen motor.

Even though the Lafayette pressure transducer differs in mechanical design and construction, the circuit design is similar and the same basic concepts are used.

As the amount of amplification is controlled by the sensitivity control, this will allow the user to set the size of the pneumo (respiration) pattern to the size he wishes to record.

Note: Since the electronic pneumo at a sensitivity of 25% for Stoelting or 2.5 for the Lafayette is equal to the sensitivity of a mechanical pneumo, care must be taken in going below 25%, or 2.5 or base line, and amplitude changes will be reduced even though the pattern looks large enough on the recording paper.

Calibration

Calibration requirements are the same as the Mechanical Pneumo.

Note: See Calibration Section for calibration procedure.

G.S.R.

In 1791 Galvani published reports of his study and experiments with animal electricity. The galvanometer was named after him, and the terms Psychogalvanic Skin Reflex or Electrodermal Response (generally referred to today as the G.S.R.) came into use. In 1888, Fere observed that when a weak constant current is applied through two electrodes attached to the skin, that the deflections which were produced on a recording galvanometer were directly influenced by a wide variety of stimuli and/or emotional states.

Instrumentation and Calibration

Electrical methods have been widely used in investigations over the years, but none of the pnenomena have a simple explanation on the basis of elementary physics and chemistry. Although there are many theories as to what causes GSR reactions, the three most commonly used are:

1. Sweat gland theory.

2. Epidermal hydration theory.

3. Or a combination of the two theories.

What we are actually recording is Skin Resistance Response (S.R.R.), though we incorrectly use the term G.S.R. This resistance is measured by passing a small current through the skin from one electrode to another. Depending on the design of the circuit, we may have either a constant current or a constant voltage as its power source. Changes in the apparent resistance of the skin are monitored by the circuitry, then amplified, and recorded on the chart paper.

Skin resistance level is the resistance of the skin when the subject is "balanced in" to the amplifier when no reaction is occurring. This basal or baseline level of resistance may vary from 20,000 ohms (20K) to 1,000,000 ohms (1 megohm) with 50,000 ohms (50K) to 200,000 ohms (200K) being typical. The phasic changes (GSR responses) may range from 100 ohms to as large as 50,000 ohms, although most of the changes are under 15,000 ohms. As the resistance of the skin decreases, the stylus on the recording chart will move upwards, and as the resistance increases, the stylus will move downward.

Circuitry

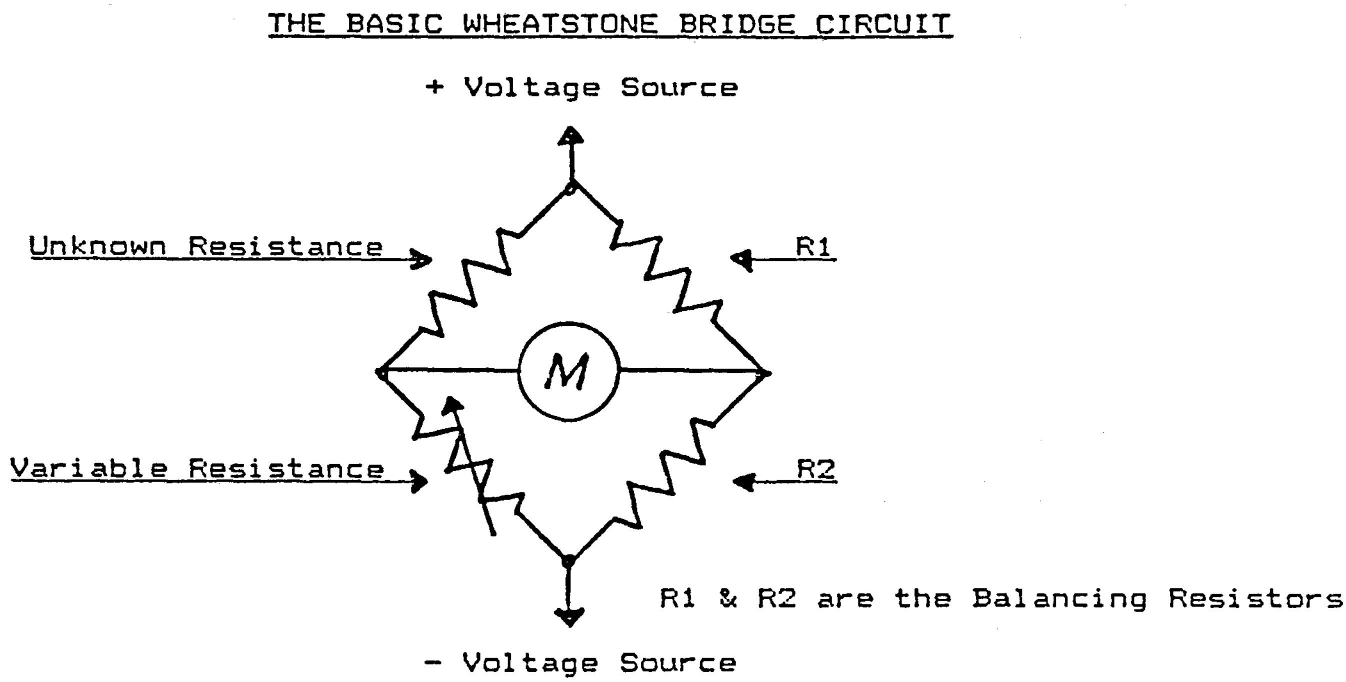
There are two types of circuitry which are presently being used in the polygraph. The Wheatstone bridge and the summing amplifier.

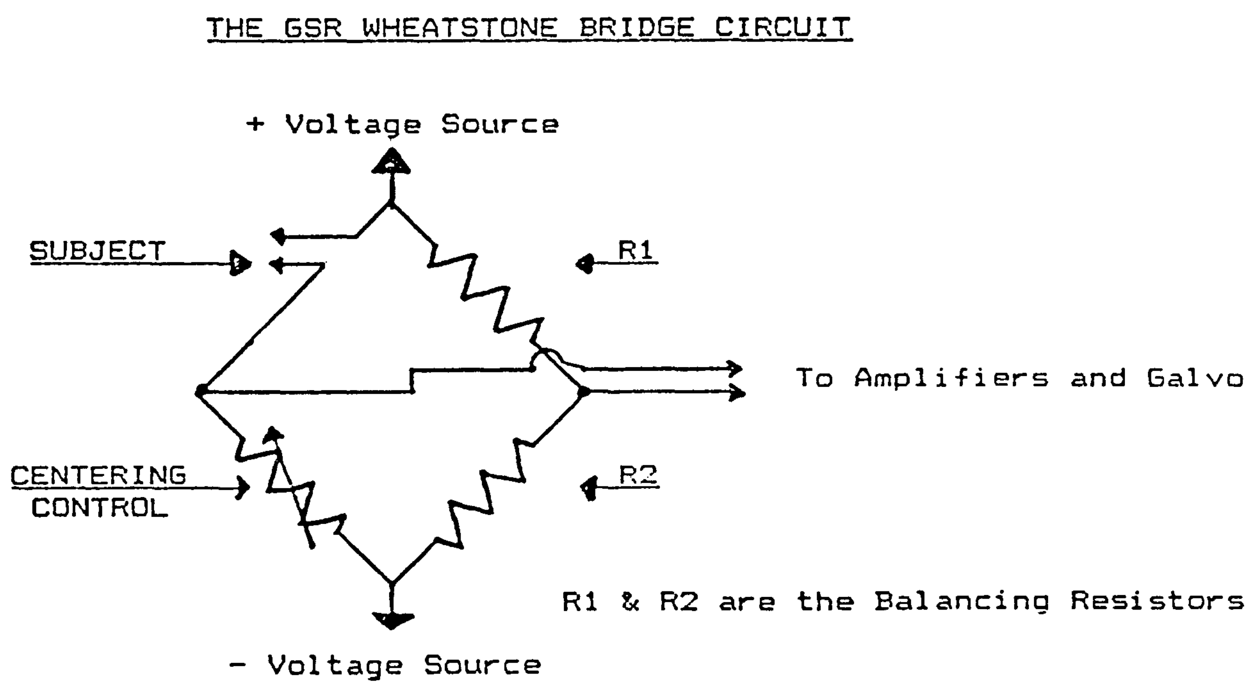
The Wheatstone bridge circuit is simply a series parallel, resistance network with a galvanometer connected between the junctions of one pair and the other. This circuit is normally used to measure an unknown resistance when the other three resistors are known. When the unknown resistance is balanced with the three known resistors, the galvanometer will indicate zero. For our application in measuring the GSR, the actual resistance value is not read. Instead, we amplify the difference in the galvanometer circuit voltage and use this amplified voltage to drive the pen motor. Thereby allowing the resistance changes of the subject to be displayed on the recording chart. (See drawing 3)

The summing amplifier circuit (Ultrascribe), has a constant current supply which causes the resistance changes at the electrodes to be fed back to the amplifier as a changing voltage. This voltage signal is presented as one of the two input signals of the summing amplifier. The subject balance control (Centering) voltage is presented as a reference voltage to the other input of the summing amplifier. This reference voltage is now constantly being compared with the subject's changing signal voltage, and the difference between these two signals are then amplified and passed on as a much larger voltage to another amplifier. Here the voltage

G.S.R.

WHEATSTONE BRIDGE CIRCUITS





Drawing No. 3 Marshall V. Pochay 4/85

is amplified again before being sent to the galvo (pen driver) amplifier. This signal (multiplied many times) now has enough power to rotate the coil in the galvo (pen motor) thereby moving the stylus on the chart paper. Thus, the constantly changing subject's resistance is graphically displayed on the chart paper.

Auto/Manual Mode

The GSR amplifier has an auto/manual switch located on the amplifier panel which provides the user with the choice of automatic or manual centering. In the automatic mode, the Stoelting Ultrascribe will return to center in about 4 or 5 seconds and the Lafayette instrument will return to center in about 7 seconds.

In manual mode, the stylus will record all instantaneous changes in the subject's resistance, including any change in the subject's basal resistance. In the automatic (auto) mode, the stylus will record between 60 and 75% of the instantaneous changes, and the stylus will automatically return to the baseline. In the older versions, the baseline in automatic operation was placed in the center and the circuitry would try to maintain the stylus on the baseline. In the new versions of both the Stoelting and Lafayette instruments, the baseline can be manually adjusted higher or lower on the recording paper and the circuitry will attempt to maintain the stylus on the desired baseline.

Recent experiments by Dr. Gordon Barland of Salt Lake City, Utah and Ron Decker of Anniston, Alabama, have shown there is a considerable loss of criteria when using the automatic mode on the GSR. These experiments show that while in the automatic mode there is a loss of 60 to 75% in the recording of duration, and a loss of 25 to 30% in the recording of degree. The studies also show, that while in the automatic mode, the GSR does not reproduce the complete reactive response of the subject. In automatic, the response known as the "saddle response," is usually displayed as only one response, though occasionally it can be viewed as two separate responses.

Duration is the amount of time from when the pen starts to move upwards until it returns to the norm.

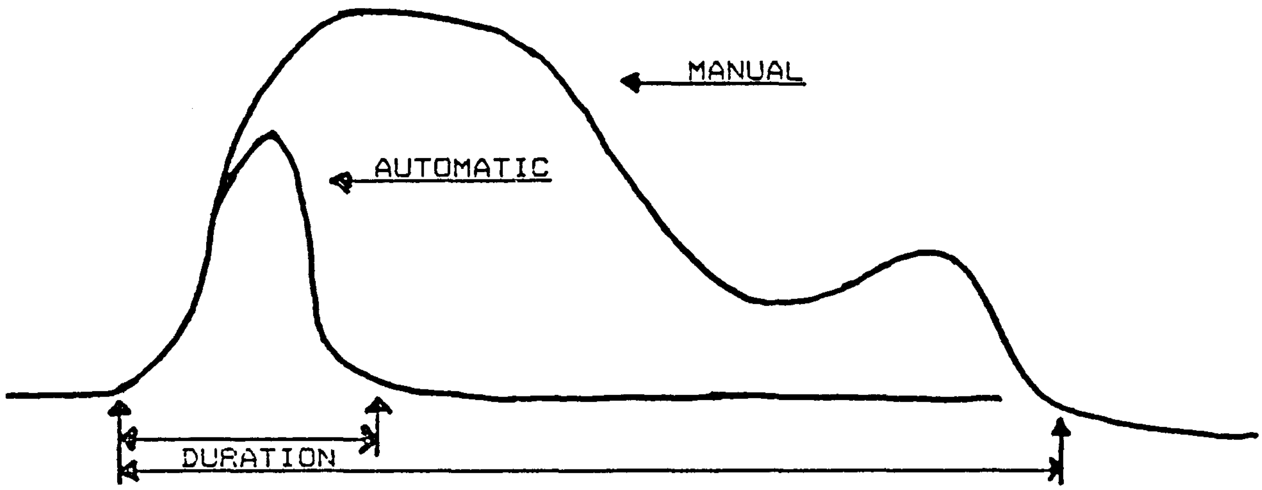
Degree is the height from the baseline to the highest point of the tracing. (See drawing 4)

1K Test Switch

Located on the panel of the G.S.R. amplifier is a small push button switch, marked "1K." This switch is designed to remove 1K (1000) ohms from the G.S.R. circuit when depressed. If the sensitivity control is turned to 100%, while in the manual mode, and the 1K button is depressed, the stylus will move upwards on the chart at least one (1) inch [1 1/4 inch is typical]. This test button can be used to check the G.S.R. circuit while testing, in that the stylus will move upwards proportionally with the sensitivity setting, *i.e.*, at 25% look for about 1/4 inch, and at 50% look for about 1/2 inch upwards movement.

G.S.R.

Manual vs. Automatic Mode



Drawing by Ronald E. Decker

<u>DURATION</u>: The amount of time from when the pen starts to move upwards, until it returns to the norm.

<u>DEGREE</u>: The height from the baseline to the highest point of the tracing.

* In the Auto Mode we lose about 25% of our <u>Degree</u>.
* In the Auto Mode we lose from 60 to 75% of our <u>Duration</u>.
* In the Auto Mode it does not reproduce complete Reactive Response.
* In the Auto Mode the return to the base line is caused by the <u>Amplifier</u> and <u>not the Examinee</u>.

Calibration

Calibration should be done on a weekly basis, or

a. Whenever you are using an instrument that you are not sure of the last calibration date.

b. Whenever you have to turn the sensitivity higher than normal, i.e., about 50% in manual mode.

c. Whenever you see little or no G.S.R. reaction.

Note: See Calibration Section for alignment and calibration procedures.

MECHANICAL CARDIO

Blood circulates through the human body in two distinct circuits: the respiratory or lesser circuit where the blood picks up oxygen in the lungs, and the systemic or greater circuit where the blood is circulated through the rest of the body organs.

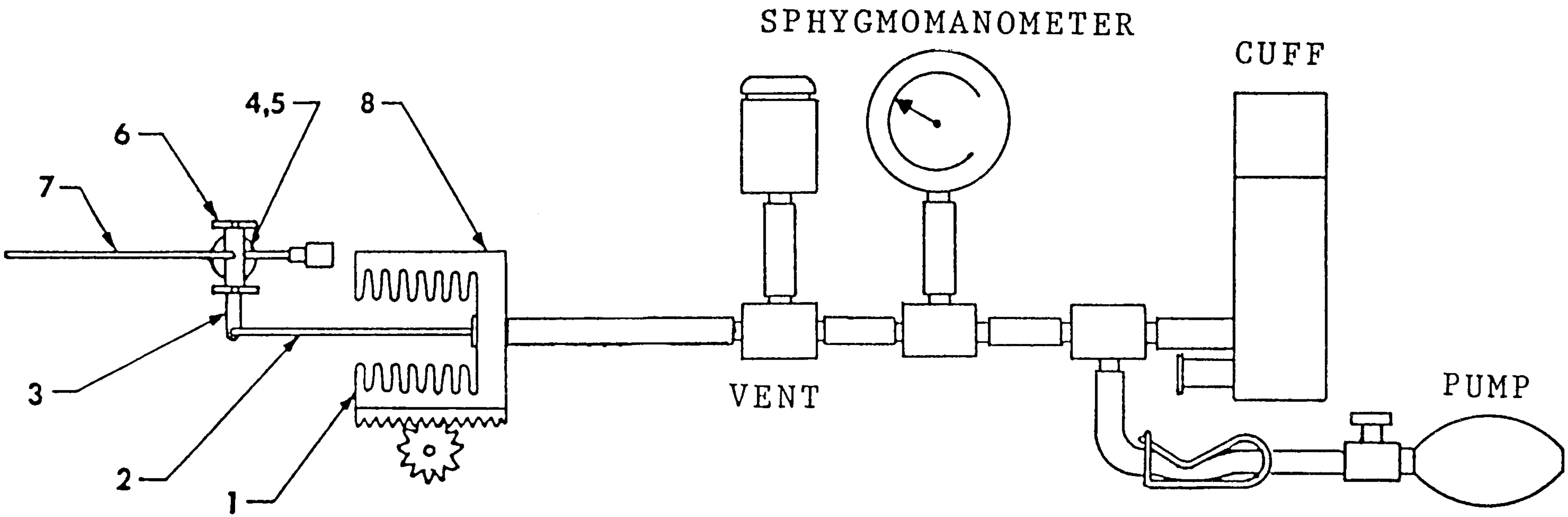
Blood being pumped through the body by the heart is continually under pressure as a result of several forces opposing its flow: the elasticity of the vessel tissues, contraction due to circular smooth muscles, and resistance to flow in the capillary beds. The strength of the pulse beat and the volume of blood ejected into the systems circulation, creates a forceful pulse wave transmission. This pressure pulse travels along the peripheral blood vessels as a wave to the skin surface where the pulse can be easily felt by simply placing a finger on an artery such as the wrist's radial artery.

The cardio component records on the chart paper a graphic display of the cardio vascular pattern of changes. The cardio channel is a high pressure pneumacic system consisting of an arm cuff which is connected to the cardio recording channel via rubber tubing. This cardio recording unit contains the actuator assembly which in turn is connected to a pressure indicating gauge (aneroid sphygmomanometer) and a small hand pump. The bellows assembly on the actuator can be moved back and forth by a centering control located on the channel to permit the centering of the system on the recording paper. (See drawing 5)

The arm cuff is wrapped firmly over the brachial artery and is inflated with the hand pump to a pressure which will provide a tracing of three quarters (3/4) to one (1) inch. The arm cuff itself is actually measuring changes in the volume of the arm and is in reality a plethysmograph. When the heart beats, the pulse wave pressure in the brachial artery increases. This pulse wave presses against the bladder of the cuff causing a decrease in volume. This decrease in volume causes an increase in pressure within the cuff and the pressure change is passed via the rubber tubing to the cardio recording channel. Due to the construction of the bellows assembly, this pressure increase forces the bellows to expand, moving the bellows stem outward. The stem then pushes the fulcrum forward causing the cradle assembly to rotate and produce an upward movement of

CARDIOGRAPHIC COMPONENTS
(A TYPICAL TRAIN OF ENERGY)

Drawing No. 5



TAMBOUR ASSEMBLY CONSISTING OF:

1. BELLOWS
2. CONNECTING LINK ARM
3. FULCRUM
4. PIVOT SHAFT
5. BEARINGS
6. PEN FORKS
7. PEN
8. AIRTIGHT CANNISTER

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the stylus. As the pulse wave passes, the pressure in the cuff decreases causing the pressure in the bellows to also decrease. This is followed by the bellows compressing, thereby causing the bellows stem to pull the fulcrum back, which in turn rotates the cradle assembly in the opposite direction moving the stylus downward, thus producing a graphic display of the blood pulse strength, rate and relative blood volume pressure changes.

The cradle (sometimes called the pivot shaft) assembly consisted of the cradle and the pivot shaft. This pivot shaft is connected to the bellows stem with a fulcrum. The pivot shaft assembly is mounted to the actuator using ball bearings (Stoelting) or a bombe jewel mount (Lafayette). Both systems are designed to give the examiner a large range of sensitivity, and are easily calibrated. The sensitivity is calibrated at the factory to produce a one (1) inch movement of the stylus (Stoelting) or a three-quarter (3/4) inch movement (Lafayette), for a two (2)mmHg change in pressure.

There are only two adjustments that should ever be attempted in the field. First the sensitivity, which should be set, so that at 90 mmHg a 2 mm change will produce 1 inch of pen movement, and, second the total pen sweep, which should be set for 2 1/2 to 3 inches, depending on your particular model.

The adjustment for setting the sensitivity is made by moving the fulcrum or sensitivity adjustment shaft in and out from the pivot shaft. As you move the fulcrum outwards from the pivot shaft the sensitivity decreases, and as you move the fulcrum in toward the pivot shaft the sensitivity will increase (See drawing 6).

The amount of pen travel (pen limits) is set by adjustment of two screws on the end of the actuator (Stoelting) or by adjustment the calibration adjustment rod on the lower portion of the pivot shaft assembly (Lafayette).

<u>Calibration</u>

Calibration should be done on a weekly basis, or

a. Whenever you are using an instrument that you are not sure of the calibration date.

b. Whenever you believe that the cardio pattern shows a lack of sensitivity.

c. Whenever you suspect there might be a leak in the system.

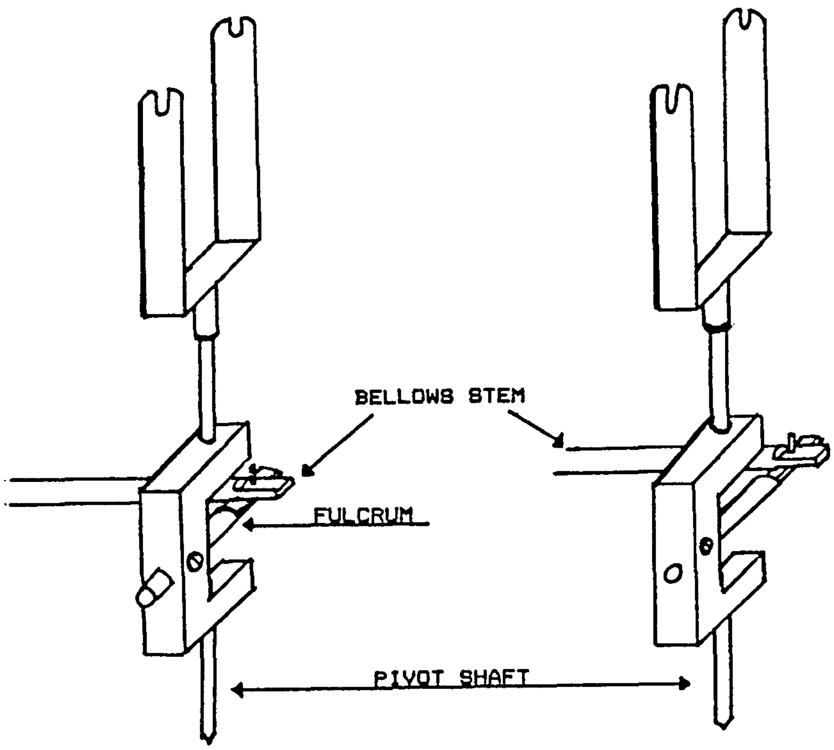
d. Whenever you see any abnormal patterns that remain consistant throughout the chart.

e. Whenever there has been a repair, adjustment or replacement of a channel.

Note: See Calibration Section for calibration procedure.

STOELTING MECHANICAL CARDIO

SENSITIVITY ADJUSTMENTS



FULCRUM IN FOR
GREATER SENSITIVITY

FULCRUM OUT FOR
LESS SENSITIVITY

ELECTRONIC CARDIO

The Stoelting Multifunction and the Lafayette Multifunction or All Purpose amplifier use two different methods to obtain the electronic amplification of the cardio vascular changes.

The Stoelting Multifunction is of the linear design. A simple description of a linear amplifier is, the signal applied to the input is amplified and adds no distortion, and therefore the output is a replica of the input only larger.

The Lafayette Multifunction and All Purpose amplifiers use selective enhancement in its reproduction and amplification of the input signal. Selective Enhancement adds additional amplification to specific portions of the input signal. Part of this additional amplification (enhancement) is designed to allow the user to vary the amount of amplification of the dicrotic notch, in order to produce a larger or smaller section of the dicrotic notch area of the recording. Another part of this additional amplification is designed to allow the user to increase or decrease the amplification of the baseline changes. With the new Auto-Ratio circuit, the adjustment of the sensitivity setting simultaneously adjusts the response enhancement. If higher sensitivity is required, the Auto-Ratio circuit lowers the response enhancement automatically. This creates a normalized tracing at below or above average cuff pressures.

The Multifunction or All Purpose Amplifiers can be used in two or more modes. By selecting the Cardio mode with the mode selector switch, the cardiovascular pattern is reproduced electronically on the recording paper. As in the Electronic Pneumo, the heart of the Electronic Cardio is the pressure transducer. This device senses the small variations in pneumatic pressure from the variations in volume within the cuff and transposes these variations to an electronic signal. These small signals are amplified and are used to drive a pen motor. The pen motor rotates the cradle and stylus to produce a graphic recording of the cardio pattern.

The Stoelting pressure transducer consists of a pair of matched silicon strain gauges bonded to a thin metal disk. A characteristic of the strain gauge, is that the electrical resistance will change if the gauge is twisted or bent. The disk is bonded around the edges between two heavier rings of metal and secured in an aluminum housing which is made airtight and tested at a pressure of 300 mmHg or more. As the pressure changes from the arm or wrist cuff appear on one side of this disk, the disk will flex with the changes. Due to the positioning of the strain gauges on the disk, one strain gauge will flex more than the other. Therefore, since the silicon strain gauges change resistance as they are flexed, one gauge will have a greater resistance change than the other.

There is a small amount of current flowing through the strain gauges and as the resistance changes from the flexing of the disk it produces a small voltage change that parallels the pressure change. These small voltage changes are amplified until they are large enough to drive the pen motor.

Even though the Lafayette pressure transducer differs in the mechanical design and construction, the circuit design is similar and the same basic concepts are used. Again the transducers are routinely tested at pressures of 300 mmHg or more.

Since the amount of amplification is controlled by the sensitivity control, the examiner can set the amplitude of the cardio pattern to the size he wishes to record.

Note: Since the electronic cardio at a sensitivity of 25% on the Stoelting is equal to the sensitivity of a mechanical cardio, care must be taken in going below 25% on the sensitivity, or the baseline changes, and the amplitude changes will be reduced even though the pattern size appears to be adequate on the recording paper. The exception of the above is the newly available Lafayette Multifunction amplifier with the Auto-Ratio circuit. This circuit will allow the baseline and amplitude sensitivity to remain nearly constant, regardless of the recording pattern size. This Auto-Ratio circuit is used only in the Cardio mode.

Calibration

Calibration requirements are the same as the Mechanical Cardio.

Note: See Calibration Section for calibration procedure.

PLETHYSMOGRAPH

Blood being pumped through the body by the heart is continually under pressure as a result of several forces opposing its flow including the elasticity of the vessel tissues, contraction due to circular smooth muscles, and resistance to the blood flow in the capillary beds.

A simple definition of plethysmograph is any defice which measures blood volume change.

Rather than define this polygraph instrumentation as a plethysmic-oximeter we have arbitrarily accepted Plethysmograph as the instrument which provides recorded information relating to relative finger blood volume, finger pulse volume, and the reflected blood color and oxygenation level of the finger.

In the field of polygraphy, there are at least two types of plethysmographs in use today:

a. Photoelectric: arbitrarily called the Plethysmograph and Heart Rate recorders.

b. Occlusion: the arm cuff, wrist cuff, thumb cuff, and the C.A.M.

In 1968, Associated Research introduced the photoelectric plethysmograph as a fourth channel in the Keeler Model 6338. In the following years, Stoelting, and later, Lafayette both produced improved versions.

Instrumentation and Calibration

In the early Stoelting version, the Transillumination method of the photoelectric plethysmograph was used to detect the varying optical opacity in the finger. A low level light source of constant intensity is introduced into the finger and as the received light intensity is changed due to volume, pulse volume, or oxygenation, a photoelectric sensor measures the changes and presents the resultant signal to be amplified and used to drive a recording galvanometer. The photoelectric sensor is positioned to receive the variations of light intensity through the tissue of the finger.

Note: This model had the pattern inverted electronically so that the reactions would be recorded in the same direction as the cardio pattern.

In the Lafayette and the latest Stoelting versions, the photoelectric plethysmograph detects the varying optical opacity by the reflection (or back scatter) method. Again a low level light source of constant intensity is used in combination with a photoelectric sensor to receive these variations and then amplifies the resultant signal so it can be used to drive a recording galvanometer. The photoelectric sensor is positioned to receive the variations of reflected light, due to the blood volume changes in the finger.

Note: Reactions theoretically will go downward.

The plethysmograph amplifier gives the examiner the choice of the DC mode (manual) or the AC mode (self-centering). In measuring blood volume changes, the baseline shifts will be large, while the amplitude changes will be smaller. Use of the DC mode will allow the user to view all the baseline shifts, and the smaller amplitude changes. There is a disadvantage in using the DC mode, you can unknowingly use too much amplification and the result will be a constant need to recenter the pen on the recording paper.

The AC mode is used in order to maintain the baseline with a minimum amount of recentering and still be able to use larger amounts of amplification for a more reliable pulse volume measurement. The Stoelting and the Lafayette versions offers the examiner a choice of different time constants in the AC mode. Using the largest time constant, will show most of the baseline shifts and still allow the examiner to use enough amplification to see the amplitude of the pulse volume variations.

HEART RATE MONITOR

One of the newer additions to the plethysmograph family is the Heart Rate Recorder. Heart rate changes have long been counted as a reaction indicator. Large changes in heart rate can be easily seen in the cardio pattern, but the smaller changes are difficult to read. With the Heart Rate Recorders, rate changes as small as 1 beat per minute can be viewed and recorded.

One of the theories that is most widely accepted by researchers provides that there is a correlation between the respiratory act and the modulation of the heart. There is a slight increase in heart rate with inspiration, and a slight decrease in heart rate with expiration.

This respiratory heart rate response can readily be identified when using one of the heart rate recorders. The Heart Rate Monitor (Lafayette) or the Cardio Tach (Stoelting) can be used as an independent monitoring device or can provide, through the polygraph a permanent recording of increase and decrease of a subject's heart rate.

Both of the systems being manufactured today use the Reflection method for detection of heart rate through volume changes. A low level light source of constant intensity is used in combination with a photoelectric sensor to receive these variations. When used as an independent monitor, the signal is sent to a counting circuit and on to a meter for visual display. When used with the polygraph, the signal is amplified within the multifunction amplifier and used to drive a galvanometer. This will allow you to record the average heart rate and the amount of change in heart rate on the recording paper. The meter display continues to function at the same time.

The Stoelting Cardio Tach has a working range of 0 to 200 beats per minute, while the Lafayette Heart Rate Monitor range is 0 to 140 beats per minute. Both of the systems are powered independently from the polygraph with a 9-volt battery. The Lafayette model gives the examiner a choice of viewing the actual heart rate or the average heart rate. Another push button switch on the Lafayette version will allow the examiner to view a 5 beat per minute calibration mode, or a battery test feature to check the condition of the battery.

C.A.M.

The cardiovascular responses recorded by the CAM are received from peripheral blood flow in the fingers. During periods of stress, blood is drawn away from the peripheral areas in order to increase the supply of blood to the larger skeletal muscles. This loss of volume will be recorded as a downward movement of the stylus on the recording paper.

In search of a method for long term monitoring of the cardiovascular activity, the U.S. Air Force, along with the Biometric Company developed the original Cardiac Activity Monitor. These units were the water actuated or "Wet" CAMS. Prototype devleopment and testing was conducted from 1968 to 1973. While the Wet CAM worked well, the initial setup was a messy and time-consuming process. In the mid 70's, Stoelting developed the present day "Dry" CAM. This improved design rapidly replaced the "Wet" CAMs in the field. By the end of 1974, the Air Force was using the dry CAM in all of its new instruments. With the instruments being manufactured today, the dry CAMs are simply referred to as CAMs and all reference to the wet CAM has been dropped.

The Stoelting or Lafayette CAM transducer utilizes the same concepts as the pressure transducer. Two silicon strain gauges are bonded to a thin metal disk, which, in turn, is bonded around the edges to a metal plate. Secured to the other side of the disk is a small rubber-like disk called the "artery feeler." The artery feeler, when placed on the thumbnail or directly on an artery, passes the changes in blood volume on to the disk. The disk flexes with the changes in volume which in turn, causes a flexing of the strain gauges. This flexing of the strain gauges produces a change in the strain gauge resistance. The small current being passed through the changing resistance of the strain gauges creates a small voltage change. The changing voltage is amplified many times, until it is large enough to drive the pen motor. The resultant movement of the stylus produces a graphic recording of the blood volume changes.

CHART DRIVE

The chart drive, also called the Kymograph, is the mechanism designed to pull the chart paper under the recording pens at a constant speed of 6 inches per minute (some laboratory models designed for research have a variable speed chart drive). The earlier models were spring powered; but the electric motor quickly replaced these spring-powered versions. On the early kymographs, the paper roller was used as a tractor feed. (Small metal teeth mounted around the ends of the paper roller would engage holes along the edges of the paper.) The chart paper would be pulled from the roll and pushed out over a small panel (writing table) and then, out over the end of the instrument. One model of the Associated Research polygraph, (Keeler Model 6348) manufactured in the mid 60's, had a 10-inch chart drive which used this sprocket drive system. In the mid 70's, friction drive became popular, and, as more of the polygraphs became 4 or more channels, the 8-inch chart drive became the standard. In 1984, Lafayette reintroduced the 10-inch chart drive using the new friction drive system. In today's polygraphs, chart drives are available for 6, 8, and 10-inch roll paper.

Today, all of the chart drives being manufactured for polygraph use are powered with either an AC or DC motor. The AC motor is of the synchronous type. The synchronous motor has a speed directly proportional to the frequency of the electric current that powers it. If the line voltage should chnage by as much as 10 or 15%, there will be no change in the speed of the motor.

The DC motor, being sensitive to voltage changes, utilizes a voltage regulator circuit to maintain a constant speed. This regulator circuit will have an adjustable resistor (usually found on the circuit board) to control the output voltage to the motor. This is used to control the speed of the DC motor. This speed control allows the chart drive to be calibrated for 50 or 60 Hz operation. The DC motor will be found in all battery powered polygraphs and on some of the newer AC powered instruments.

The friction drive motor assembly consists of a drive roller coupled to the shaft of the chart drive motor. This motor assembly is mounted under the chart drive panel and is designed to provide for easy replacement of the motor by the user. A hard rubber (or aluminum) roller wheel (pressure roller) is mounted above the panel. This pressure roller is usually spring loaded to pull it downward on top of the drive roller. The chart paper is routed up from the roll located in the paper storage area, and then between the drive roller and the pressure roller. When the motor rotates the drive wheel, the paper is pulled from the roll, pushed out across the chart drive panel and over the edge of the instrument.

CALIBRATION

GENERAL

1. Open all vents.

2. Set all sensitivity controls to zero. (Turn control knobs CCW).

3. Check mechanical pen center. This should in most cases establish your baseline for each electronic channel. The pens may need to be bent slightly to be at the true center.

4. Turn the power switch on and insure that the Chart Drive switch is off.

5. Set the GSR mode switch to manual.

6. Set the cardio lock to the lock position.

7. If equipped with electronic channels, check the mode switch for the proper mode.

8. Check your ink supply (bottles should be approximately half full.)

CALIBRATION WITH CALIBRATION FIXTURE

1. Place the pneumograph convoluted tubes, GSR finger plates (finger electrodes), and the cardio cuff in the fixture.

2. Check the chart paper.

3. Prime the pens to start the ink flowing.

4. Close all vents.

5. Turn on the chart drive.

PNEUMO SYSTEMS

Mechanical Pneumo

Check total pen travel by turning the Centering knob counter-clockwise (CCW) for bottom line, then turn clockwise (CW) for upper limit. Check for smooth movement with no signs of stickiness. Return the pen to 1/2 inch above lower pen stop.

rotates the drive wheel, the paper is pulled from the roll, pushed out across the chart drive panel and over the edge of the instrument.

CALIBRATION

GENERAL

1. Open all vents.

2. Set all sensitivity controls to zero. (Turn control knobs CCW).

3. Check mechanical pen center. This should in most cases establish your baseline for each electronic channel. The pens may need to be bent slightly to be at the true center.

4. Turn the power switch on and insure that the Chart Drive switch is off.

5. Set the GSR mode switch to manual.

6. Set the cardio lock to the lock position.

7. If equipped with electronic channels, check the mode switch for the proper mode.

8. Check your ink supply (bottles should be approximately half full.)

CALIBRATION WITH CALIBRATION FIXTURE

1. Place the pneumograph convoluted tubes, GSR finger plates (finger electrodes), and the cardio cuff in the fixture.

2. Check the chart paper.

3. Prime the pens to start the ink flowing.

4. Close all vents.

5. Turn on the chart drive.

PNEUMO SYSTEMS

Mechanical Pneumo

Check total pen travel by turning the Centering knob counter-clockwise (CCW) for bottom line, then turn clockwise (CW) for upper limit. Check for smooth movement with no signs of stickiness. Return the pen to 1/2 inch above lower pen stop.

Electronic Pneumo

To check total pen travel, turn the Sensitivity control knob to 25. This will cause the pen to go to the bottom pen limit. Turn the Centering control knob clockwise (CW) to reach the upper pen limit. Check for smooth movement of the stylus, with no signs of stickiness. Return the stylus to 1/2 inch above the lower pen limit.

Mechanical and Electronic Pneumo

Check free movement by expanding the pneumograph tube 1/4 inch, 3 or 4 times in rapid succession.

Check the sensitivity by expanding the pneumograph tube 1/4 inch. The stylus should move upwards 1 inch. Lock the pneumograph tube in this expanded position.

Check for leaks in the pneumo system. The stylus should not drop more than 1 inch in a 2 minute period. Continue on with the calibration procedure during this leakage check.

GSR

1. Remove the finger electrode connector from the amplifier and check pen travel by setting the Sensitivity control knob to 25. The stylus should fall to the bottom limit. Turn the Centering control knob clockwise until the stylus reaches the upper pen limit. Check for smooth movement with no signs of stickiness. Recenter the stylus on the baseline.

2. Increase the sensitivity to 100% (full CW position) and recenter the stylus.

3. Conduct sensitivity check by depressing the 1K button and hold. The stylus should move upward about 1 1/4 inches. Release the test switch and the stylus will return to the center baseline.

4. Set the Sensitivity control to zero. Change the auto/manual switch to automatic.

5. Turn the Sensitivity control to 10% and recenter the pen. Continue to increase the sensitivity and recenter until 100% sensitivity is reached with the pen centered.

6. Depress the 1K test button and hold for 15 seconds. The pen should rise about 3/4 of an inch and return to the baseline (+ or - 1 division). Release 1K test switch, and the pen should drop below the baseline about 3/4 of an inch and return to the baseline.

7. Return the GSR control knobs to the full counterclockwise (CCW) position and switch the auto/manual switch to manual.

8. Check the finger electrodes. Remove the finger electrode cable from the amplifier. Turn the Sensitivity control knob until the pen bottoms on the lower pen stop.

9. Recenter the pen on the recording chart paper, and continue to increase the sensitivity until the Sensitivity control is at 100% with the pen centered. Turn the Sensitivity control to zero.

10. Insert the electrode cable plug into the jack on the amplifier.

11. Short the electrodes together (hold the metal plates together). Turn the Sensitivity control to 100% and observe the pen for movement.

12. If the pen dives to the bottom of the chart, the electrodes are bad and should be replaced.

13. If the pen moves only an inch or so, the electrodes are good. Return all controls on the GSR to full counterclockwise (CCW) position.

CARDIO SYSTEMS

Install the arm cuff in the holder and inflate the cuff to 90 mmHg, massage if need to obtain a stable reading.

Mechanical Cardio

1. Place the lock/record bar in the record position.

2. Check the pen travel limits of the mechanical cardio unit by turning the Centering control knob counterclockwise (CCW) and clockwise (CW). Leave the Stylus near the lower limit.

Electronic Cardio

1. Set the electronic cardio sensitivity at 25%. This will cause the pen to fall to the bottom limit.

2. Check the travel limits of the electronic cardio unit by turning the Centering control knob clockwise (CW) and counterclockwise (CCW).

3. Position the cardio pen or pens on a reference baseline at least 1-1/2 inches from the upper limit.

4. Check free movement, by depressing the cuff button (on the cuff holder) firmly 3 or 4 times. Check for a smooth movement of the stylus.

5. Check the sensitivity of the mechanical and/or electronic cardio units by pressing down firmly on the cuff button. This should

cause a change of 2mm Hg on the spygmomanometer and an upwards movement of the stylus of about 1 inch.

6. Check for leaks in the system by leaving the lock/record bar in the record position (Mechanical Cardio) and the sensitivity at 25% (Electronic Cardio) while pressurized at 90mm Hg, for 10 minutes. If the pens do not drop more than 1/4 inch, there is no leak in the system. With the Mechanical Cardio, place the lock/record bar in the lock position. With the Electronic Cardio return the Sensitivity control to zero and then open the vents.

7. A check to determine if the chart paper moves at a constant speed of 6 inches per minute, can be ran during the leak test. Do this by placing a mark on the paper at the beginning and end of a 1 minute time period, and measuring the distance between marks.

CALIBRATION WITHOUT A CALIBRATION FIXTURE

PNEUMO SYSTEM

1. You will need to use a clipboard or the desk top, to secure the stretched pneumo tubes.

2. Check the chart paper supply.

3. Prime the pens to start the ink flowing.

4. Close all vents.

5. Turn on the chart drive.

Mechanical Pneumo

Check total pen travel by turning the Centering knob counterclockwise (CCW) for bottom limit, then turn clockwise (CW) for the upper limit. Check for smooth movement with no signs of stickiness. Return the pen to 1/2 inch above lower pen stop.

Electronic Pneumo

To check total pen travel, turn the Sensitivity control knob to 25. This will cause the pen to go to the bottom pen limit. Turn the Centering control knob clockwise (CW) to reach the upper pen limit. Check for smooth movement of the stylus, with no signs of stickiness. Return the stylus to 1/2 inch above the lower pen limit.

Mechanical and Electronic Pneumo

1. Check free movement, by expanding the pneumograph tube 1/4 inch, 3 or 4 times in rapid succession.

2. Check sensitivity by expanding the pneumograph tube 1/4 inch. The stylus should move upwards 1 inch. Secure the pneumo tubes in this expanded position.

3. Stretch the tubes about 1/4 inch (about 2 beads on the chain) to make the sensitivity and leak tests. The tubes can be secured with tape while calibrating.

4. Check for leaks in the pneumo system. The stylus should not drop more than 1 inch in a 2 minute period. Continue on with the calibration during this leakage check.

GSR SYSTEM

1. Check finger electrodes. Remove the finger electrode cable from the amplifier. Place the auto/manual switch in the manual mode. Turn the Sensitivity control knob clockwise until the pen bottoms on the lower pen stop.

2. Recenter the pen on recording chart, and continue to increase the sensitivity until Sensitivity control is at 100%, with the pen centered. Turn the sensitivity to zero (counterclockwise).

3. Insert the electrode plug into the jack on the GSR.

4. Short the electrodes together (hold the metal plates together) and turn the Sensitivity control clockwise to 100% and observe the pen for movement.

5. If the pen dives to the bottom of the chart, the electrodes are bad and should be replaced.

6. If the pen remains on or near baseline, the electrodes are good.

7. Turn the Sensitivity control to zero (full CCW) and remove the finger electrodes from the amplifier connector.

8. Turn the Sensitivity control slowly to 10 and recenter the stylus on baseline.

9. Check free movement and pen limits. (About 2 1/2 inches total). Rotate the Centering control knob clockwise and counterclockwise. Observe the pen for smooth movement.

10. While still in the manual mode, increase the Sensitivity control to 100% and continue to maintain the pen on the baseline with the Centering control.

11. Depress the 1K push button switch. The pen should move upwards 1 to 1 1/4 inches. Release the test button and the pen should return to baseline.

12. Turn the Sensitivity control to zero (CCW), and switch the

auto/manual mode switch to auto. Slowly turn the Sensitivity control to 100% while maintaining the pen on the baseline with the Centering control.

13. Depress the 1K push button switch. Hold for 10 to 15 seconds and release. The pen should swing upwards about 3/4 of an inch and return to the baseline (+ or - 1 division). When the 1K switch is released, the pen should swing below the baseline about 3/4 of an inch, and slowly return to the baseline.

CARDIO SYSTEM

1. Wrap the arm cuff around a firm object of 3 or more inches (a bottle or can will do).

2. Inflate the cuff to about 110mm Hg and massage the cuff. If pressure is below 90mm Hg after the massage, reinflate to 110mm Hg and repeat the massage to obtain a stable reading on the gauge.

3. Electronic cardio: Set the Sensitivity knob to 10% and recenter the pen on the baseline.

4. Electronic or Mechanical cardio: Lower the cuff pressure to 90mm Hg and center the pen. Pressure should read 88 to 92mm Hg.

5. Electronic cardio: Set the Sensitivity to 25% and recenter the pen on the baseline.

6. *Electronic or Mechanical cardio: Check the travel limits of the* cardio unit by rotating the Centering control knob clockwise (CW) and counterclockwise (CCW). While checking the pen limits, observe the pen for smooth movement with no signs of stickiness.

7. Squeeze the cuff for a 2mm Hg change on gauge, release and repeat 2 or 3 times. The pen should move upward 3/4 to 1 inch on the chart.

8. Mechanical cardio: Check for leaks by leaving the lock/record bar in the record position for 10 minutes. If the cardio pen does not drop more than 1/4 of an inch, then the cardio system is to be considered good.

9. Electronic cardio: Check for leaks by leaving the Sensitivity control at 10% for 10 minutes. If the cardio pen does not drop more than 1/4 of an inch, then the cardio system is considered to be good.

10. Mechanical cardio: At the end of the test set the record/lock bar to the lock position and open the vent.

11. Electronic cardio: Return the Sensitivity to zero. Turn the Centering knob to the full counterclockwise position and open the vent.

SPECIFICATIONS

Lafayette. Ambassodore and Diplomat

Mechanical Pneumo: Model 76473-G
A 1/4 inch change in the pneumograph will produce a 1 1/4 to 1 3/4 inch change in pen position.

Electronic Pneumo: Model 76476-G/76477-G
At a sensitivity setting of 5, a 1/4 inch change in the pneumograph will produce a 1 1/4 inch change in pen position.

GSR: Model 76475-G, 76480-G
At a sensitivity of 10, a 1000 ohm change will produce a 1 inch change in pen position.
Model 76475-F Total Pen Travel of 4 inches.
Model 76480-G Total Pen Travel of 6 inches.

Mechanical Cardio: Model 76474-G
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

Electronic Cardio: Moden 76476-G/76477-G
Cardio 1 Mode.
At a sensitivity of 5 with 60mm Hg of pressure, a 2mm Hg change will produce a 1 1/4 inch change in pen position.
Total Pen Travel 3 inches.

Lafayette Thermal Models 76163 & 76164

Electronic Pneumo:
At a sensitivity of 5, a 1/4 inch change in the pneumograph will produce a 1 1/4 inch change in pen position.

GSR:
At a sensitivity of 2.5, a 1000 ohm change will produce a 1/4 inch change in pen position.

Electronic Cardio:
At a sensitivity of 5, with 60mm Hg of pressure, the built-in simulator will produce a 1 1/4 inch change in pen position.

Stoelting Ultrascribe 80000 Series

Mechanical Pneumo:
A 1/4 inch change in the pneumograph will produce a 1 inch change in pen position. Total pen travel of 2 1/2 inches.

Electronic Pneumo:
At a sensitivity setting of 25%, a 1/4 inch change in the pneumograph will produce a 1 inch change in pen position.
Total pen travel of 2 1/2 inches.

Stoelting Ultrascribe 80000 Series (cont.)

GSR:
At a sensitivity setting of 100%, a 1000 ohm change will produce a 1 to 1 1/4 inch change in pen position. Total pen travel of 4 1/2 inches.

Mechanical Cardio:
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 to 1 inch change in pen position. Total pen travel of 2 1/2 inches.

Electronic Cardio:
At a sensitivity setting of 25% with 90mm Hg of pressure, a 2mm Hg will produce a 3/4 to 1 inch change in pen position. Total pen travel of 2 1/2 inches.

Stoelting Emotional Stress Monitor 22600 Series

Stoelting Executive Polygraph 22532/22533 Series

Mechanical Pneumo:
A 1/4 change in the pneumograph will produce a 1 inch change in pen position.

GSR:
At a sensitivity of 100%, a 1000 ohm change will produce a 1 inch change in pen position.

Mechanical Cardio:
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

Electronic Cardio:
At a sensitivity setting of 25% with 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

Stoelting Deceptograph 22500 Series

Mechanical Pneumo:
A 1/4 inch change in the pneumograph will produce a 1 inch change in the pen position.

GSR:
At a sensitivity of 100%, a 1000 ohm change will produce a 1 inch change in pen position.

Mechanical Cardio:
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

Associated Research

Keeler Models 6303 & 6308

Mechanical Pneumo:
A 1/4 inch change in the pneumograph will produce a 1 inch change in the pen position.

GSR:
Use the built in calibrator. With a sensitivity of 5 and the resistance dial at 50, the pen should be on the baseline.

Mechanical Cardio:
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

ELECTRONIC ALIGNMENT

Lafayette Multifunction and All Purpose Amplifier

Note: See drawing 7 of Model 76477A-PCB.

LO CAL CHECK:

1. With the AC power off, check all pens for mechanical center. Reposition cradle or straighten pens if needed to obtain the center baseline.

2. Check that all Centering controls and Sensitivity controls are fully counterclockwise. Set Response control to Norm (12 o'clock) and the Notch to full counterclockwise position. Place the Vent in the open position. Turn AC power on and allow a 5 minute warm up.

3. Slowly turn Sensitivity control to the maximum (clockwise) position, while maintaining the pen on the baseline with the Centering control.

4. Slowly turn the Centering control about 1 turn counterclockwise. The pen should now move from pen stop to pen stop with just a small movement of the Centering control.

5. If the pen is not in the active range at the 1 turn CCW from the full CW position, then adjust the LO CAL trimpot on the printed circuit board to bring the pen to the mechanical center (baseline).

6. Turn the Sensitivity control to zero (CCW), and return the Centering control to the full counterclockwise (CCW) position.

Associated Research

Keeler Models 6303 & 6308

Mechanical Pneumo:
A 1/4 inch change in the pneumograph will produce a 1 inch change in the pen position.

GSR:
Use the built in calibrator. With a sensitivity of 5 and the resistance dial at 50, the pen should be on the baseline.

Mechanical Cardio:
With 90mm Hg of pressure, a 2mm Hg change will produce a 3/4 inch change in pen position.

ELECTRONIC ALIGNMENT

Lafayette Multifunction and All Purpose Amplifier

Note: See drawing 7 of Model 76477A-PCB.

LO CAL CHECK:

1. With the AC power off, check all pens for mechanical center. Reposition cradle or straighten pens if needed to obtain the center baseline.

2. Check that all Centering controls and Sensitivity controls are fully counterclockwise. Set Response control to Norm (12 o'clock) and the Notch to full counterclockwise position. Place the Vent in the open position. Turn AC power on and allow a 5 minute warm up.

3. Slowly turn Sensitivity control to the maximum (clockwise) position, while maintaining the pen on the baseline with the Centering control.

4. Slowly turn the Centering control about 1 turn counterclockwise. The pen should now move from pen stop to pen stop with just a small movement of the Centering control.

5. If the pen is not in the active range at the 1 turn CCW from the full CW position, then adjust the LO CAL trimpot on the printed circuit board to bring the pen to the mechanical center (baseline).

6. Turn the Sensitivity control to zero (CCW), and return the Centering control to the full counterclockwise (CCW) position.

HI CAL CHECK:

1. Close the Vent and set the pressure at 150mm Hg. Massage the cuff to obtain a stable reading of 150mm Hg.

2. Rotate the Sensitivity control slowly to its maximum (CW) position.

3. Rotate the Centering control 1/2 turn clockwise. The pen should now be able to swing from pen stop to pen stop with a very small movement of the Centering control. If it does not, adjust the HI CAL trimpot on the printed circuit board, so that the pen is placed on the baseline.

4. Turn the Sensitivity control to zero (CCW). Turn the Centering control to the counterclockwise (CCW) position.

Note: Adjusting the HI CAL trimpot clockwise should raise the pen. Turning the pot counterclockwise should lower the pen.

SET GAIN OF CARDIO 1

1. Adjust the pressure to 60mm Hg and massage the cuff to obtain a stable reading of 60mm Hg.

2. Adjust the Sensitivity to 5 and adjust the Centering control to place the pen on the baseline.

3. Depress and release the Cardio test button (if using a calibrator) or squeeze the cuff to produce a 2mm Hg change in pressure (repeat this step 2 or 3 times). This should produce a minimum of 1 1/2 inch upward pen movement.

4. If pen movement is less than 1 1/2 inches, adjust the Cardio Trimpot on the printed circuit board to obtain the 1 1/2 inch change.

Note: The Drift test should be performed in the Cardio 2 mode, after a 5 or 10 minute warm up. With the pressure at zero, the Sensitivity at maximum, center the pen with the Centering control. Turn on the Chart Drive and observe the Cardio pen tracing. The pen should not drift more than 1/4 inch in a 1 1/2 minute period of time.

ELECTRONIC PNEUMO

1. To check the sensitivity, close the vent, adjust the Sensitivity control to 5 and center the pen on the baseline.

2. Stretching the pneumograph tube 1/4 inch should produce a 1 1/4 inch upward pen movement.

3. If pen does not move 1 1/4 inch, adjust the Pneumo trimpot on the printed circuit board for the proper amount of movement.

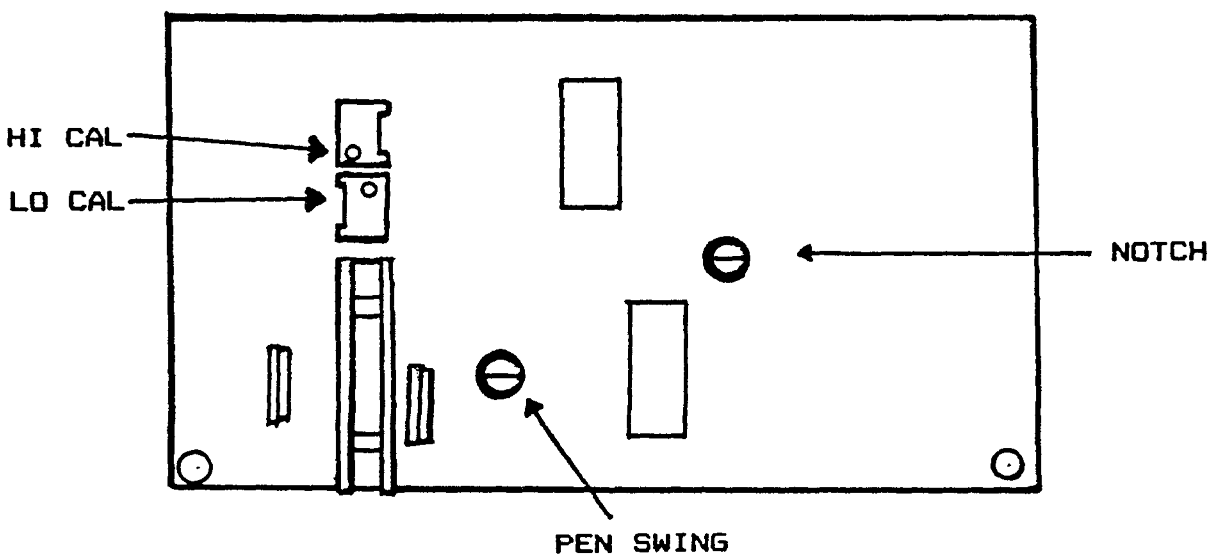
LAFAYETTE

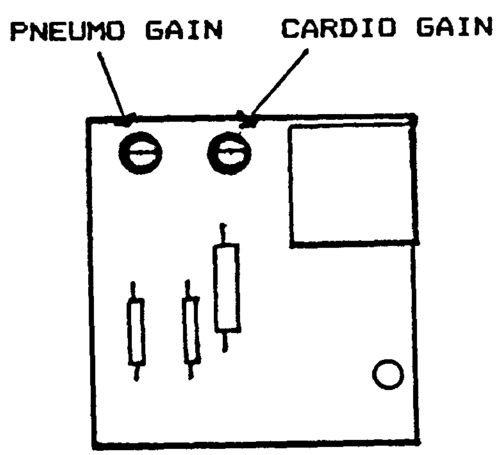
MULTIFUNCTION AMPLIFIER

AND

ALL PURPOSE AMPLIFIER CALIBRATION

MODEL 76477-PCB





Drawing No. 7 Marshall V. Pochay 4/85

Note: If the trace is not as high in amplitude as it should be, and/or looks flat topped, the LO CAL trimpot should be adjusted to increase the Pneumo range, and/or eliminate the flat top.

Stoelting Ultrascribe 80000 Series

See drawing 8.

Note: Do NOT adjust control pot R4. This is a factory adjustment, and tampering with this control pot will void the warranty, and could cause damage to the transducer. The Multifunction channel is calibrated in the Cardio mode. The new versions of this channel have an additional control pot for the calibration of the Pneumo section. This Pneumo sensitivity control pot is located underneath and slightly to the right of the input connector, very close to the location of the R4 Transducer control pot.

SENSITIVITY ADJUSTMENT

1. With the AC power off and the power cord removed, remove the two channels located next to channel you are going to align. This will give you access to the PC board with all of the connections in place.

2. Install the AC power cord and turn on the AC power. Allow the instrument to warm up for at least 5 minutes before starting the alignment procedure.

3. Install the arm cuff into the calibration fixture. If no calibration fixture is available, wrap the arm cuff around a firm object of at least 3 inches in diameter. Close the vent.

4. Inflate the arm cuff to about 120mm Hg and massage the cuff until the pressure is stable. Then lower the pressure to 90mm Hg. If the pressure is below 90mm Hg after the massage, reinflate to 120mm Hg and repeat the massage. As the Velcro settles, it will appear as a slow leak in the system. To minimize this effect, always lower the pressure in the system down to the operating pressure, after the massage.

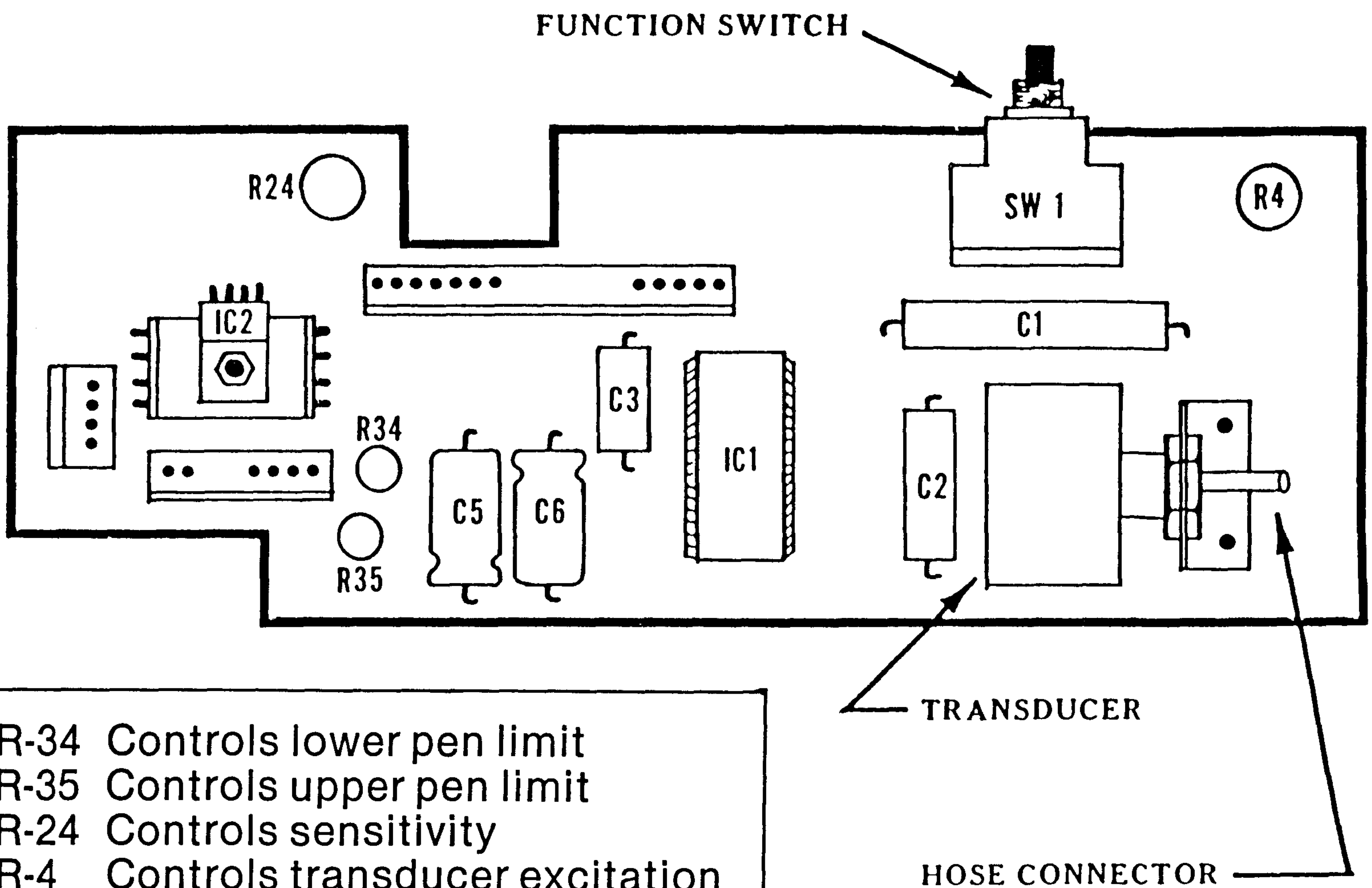
5. Slowly increase the Sensitivity control until the pen moves to the bottom pen stop.

6. Recenter the pen on the baseline with the Centering control and then increase the sensitivity to 25, while maintaining the pen on the baseline with the Centering control.

7. Depress the test button on the cuff fixture (or squeeze the arm cuff if the calibrator is not being used) for a 2mm Hg increase in pressure. Repeat two or three times and observe the amount of pen movement on the chart paper.

8. Adjust control pot R24 to obtain a 1 inch pen movement for a 2mm Hg change in pressure. Turning the control pot clockwise (CW)

Drawing No. 8



R-34 Controls lower pen limit
R-35 Controls upper pen limit
R-24 Controls sensitivity
R-4 Controls transducer excitation

4/85

MULTI-FUNCTION PRINTED CIRCUIT BOARD

will increase the sensitivity and counterclockwise (CCW) will decrease the sensitivity.

9. If pen limits have to be adjusted, go to step 4 in the pen limit adjustment section.

10. Turn the Sensitivity control to zero and turn the Centering control to the full counterclockwise position. Release the pressure from the arm cuff. Lock the vent open, and turn the AC power off. Remove the AC power cord. Replace the channels you have removed. Be sure that all cable and hose connections are secure before securing the channels in the instrument.

PEN LIMIT ADJUSTMENTS

1. With the AC power off and the power cable disconnected, remove the channels located next to the channel to be aligned. This will give you access to the PC board.

2. Turn on the AC power and allow the unit to warm up for at least 5 minutes before starting the alignment.

3. Slowly increase the Sensitivity control until the pen is just about to the lower pen stop.

4. Recenter the pen on the baseline with the Centering control and then increase the sensitivity to 25 while maintaining the pen on the baseline with the Centering control.

5. Rotate the Centering control clockwise until the pen reaches the upper pen stops. Adjust control pot R35 to obtain a total of 1.1 inch pen movement above the baseline. Rotate the pot clockwise to increase the pen travel, and rotate the pot counterclockwise to decrease the pen travel.

6. Check the total pen movement and if the lower pen limit needs adjusting then rotate the Centering control counterclockwise to place the pen on the lower pen stop. Rotate the control pot R35 to obtain a total pen sweep of 1.1 inches below the baseline. Rotate the control pot clockwise to increase the pen travel, and counterclockwise to decrease the pen travel.

7. Rotate the Centering control to move the pen from pen stop to pen stop. Total pen travel should not exceed 2.5 inches.

8. Turn the Sensitivity control to zero and turn the Centering control to the full counterclockwise position. Turn the AC power off. Remove the line cord from instrument and then replace the channels you have removed. Be sure that all cables and hose connections are secure before securing the channels in the instrument.

GSR ALIGNMENT

Lafayette 6 inch

See drawing 9. Model 76480-PCB.

1. With the Auto/Manual switch in Manual, the Sensitivity set at 2.5, center the pen on the baseline with the Centering control.

2. Depress the 1K Test button and hold. Adjust the Gain pot on the printed circuit board (PCB) for 1/4 inch upward pen movement.

3. Release the 1K Test button and recenter if needed.

PEN LIMITS ADJUSTMENT

1. With the Auto/Manual switch still in the Manual position, and the Sensitivity still at 2.5, turn the Centering control counterclockwise to move the pen to the lower pen stop.

2. Adjust the Lower control pot on the printed circuit board to move the pen 3 inches below the baseline.

3. Turn the Centering control clockwise to move the pen to the Upper pen stop.

4. Adjust the Upper control pot on the PCB for 3 inch movement above the baseline.

5. Vary the Centering control and check for a 6 inch total pen movement from pen stop to pen stop.

6. Turn the Sensitivity control to zero. Turn the Centering control fully counterclockwise. Turn off the AC power switch.

Stoelting Ultrascribe WideTrac

See drawing 10.

Note: Control pots R2 and R24 are factory adjustments. Any attempt to make adjustments with these control pots will Void the Warranty and could cause damage to the GSR amplifier.

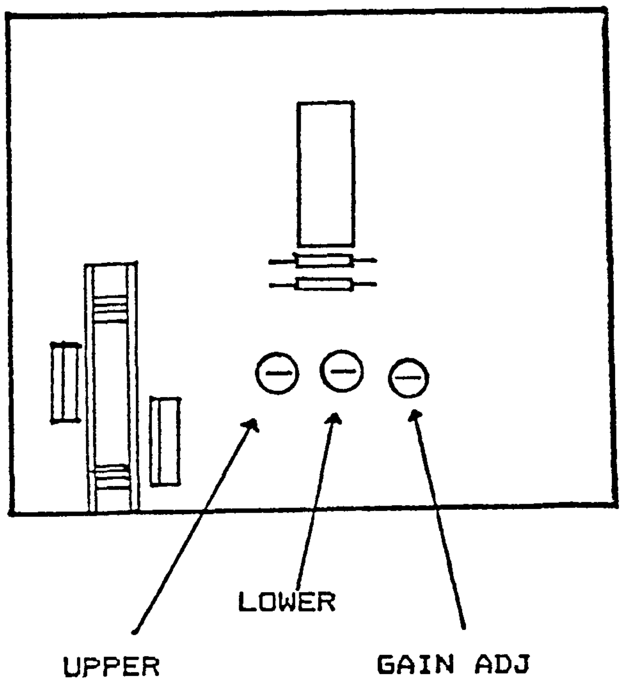
SENSITIVITY ADJUSTMENTS

1. With the AC power off and the power cord disconnected from the instrument, remove the electrodes from the input connector on the GSR channel. Remove the channel or channels below the GSR amplifier for easy access to the GSR PC board.

2. Locate R14 (marked 1K Set on some models) on the amplifier PC board.

LAFAYETTE
GSR AMPLIFIER CALIBRATION

MODEL 76480-PCB



Drawing No. 9 Marshall V. Pochay 4/85

3. Connect the power cord and turn on the AC power. Allow a 5 minute warm up before starting the GSR adjustments.

4. Place the Auto/Manual switch in the Manual position. Slowly increase the sensitivity until the pen is almost on the lower pen stop.

5. Recenter the pen with the Centering control.

6. Slowly increase the sensitivity to 100% while maintaining the pen on the baseline with the Centering control.

7. With the sensitivity at 100% and the pen on the baseline, press and release the 1K test button on the top panel of the GSR amplifier.

8. Check the amount of deflection. The total pen deflection should not be less than 1 inch or more than 1 1/4 inch.

9. With the 1K test button depressed, adjust R14 to obtain the proper deflection. Turn the control clockwise to increase the sensitivity and turn counterclockwise to decrease the sensitivity.

10. Release the 1K test button and check the pen for its return to the proper location on the baseline.

11. Depress and release the 1K test button several times, while observing the repeatability of the pen sweep.

12. When the sensitivity check meets the 1 to 1 1/4 inch requirement, check the pen sweep limits by rotating the Centering control knob to move the pen from upper pen stop to the lower pen stop. If the pen travel limits are ok, go on to the next step. If the pen stops need adjustment go to the Pen Sweep Adjustment section and continue.

13. Rotate the Sensitivity control to zero. Rotate the Centering control knob to its full counterclockwise position.

14. Turn off the AC power and remove the power cord from instrument. Place a drop of fingernail polish on all of the control pots you have adjusted. This will keep it from accidentally moving. Replace the channel or channels you have removed.

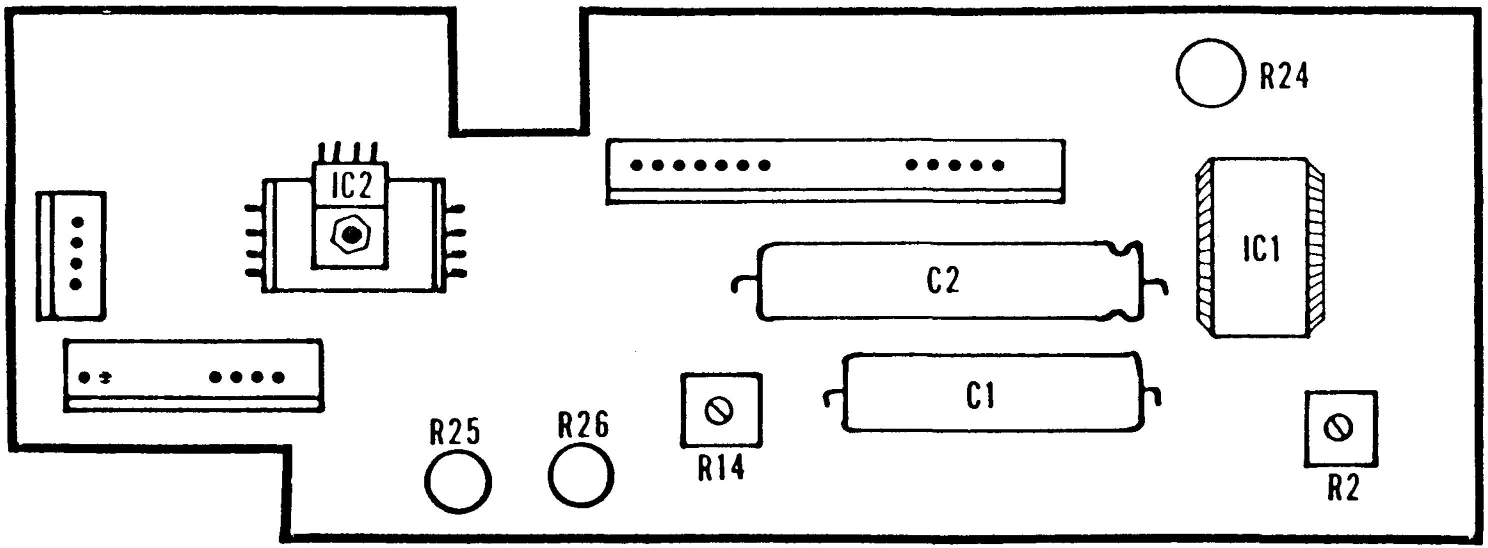
15. Be sure that all cable and hose connections are in place and secure before the final installation of the channels in the instrument.

PEN SWEEP ADJUSTMENT

1. Pen sweep (or pen travel) is adjusted by the control pots R25 and R26. One controls the upper pen limits and the other controls the lower pen limits. There are a couple of different versions

Drawing No. 10

GALVANOGRAPH PRINTED CIRCUIT BOARD



R-25 & R-26 Varies the overall range of pen sweep
R-14 Varies sensitivity or test size
R-24 Voltage bias
R-2 Subject current

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of this PC board and the location of R25 and R26 can be interchanged so the identification of which pot controls the upper stop, and which controls the lower stop, has to be made at the time of the adjustment.

2. Turning the control pot clockwise will increase the pen travel while turning the control pot counterclockwise will decrease the pen travel.

3. Increase the Sensitivity control knob until the pen is near the lower pen stop.

4. Recenter the pen with the Sensitivity control knob.

5. Set the Sensitivity control knob to about 25% and move the pen with the Centering control knob from pen stop to pen stop.

6. The total pen travel should be between 4 1/4 and 4 1/2 inches from pen stop to pen stop.

7. If adjustment is needed, move the pen to the upper pen stop and rotate R26 clockwise. Check to see if the pen moved upwards. If no movement of the pen is observed, move the pen to the lower pen stop and turn the control counterclockwise and check to see if the pen now moves upward from the power pen stop. Once you have determined which control pot controls the upper and lower pen stop, adjust as needed to obtain the proper pen travel limit.

8. Repeat the adjustment with the other control pot until you obtain the desired amount of pen travel.

9. When the adjustments are complete, rotate the Sensitivity control knob to zero, and rotate the Centering control knob to its full counterclockwise position.

10. Turn off the AC power, remove the power cord from the instrument. Place a drop of fingernail polish on the edge of the control pots you have used to make any of the adjustments. This will prevent them from moving accidentally.

11. Replace the channel or channels that you removed. Make sure that all of the required cable and hose connections are in place and secure before the final installation of each channel.

Stoelting Emotional Stress Monitor 22600 Series
(U.S. Army Model AN/USS-2F)

Stoelting Executive Polygraph 22532/22533 Series

Stoelting Amplifier Model SA-779, SA727 & SA769

See drawing 11.

1. With power on and electrodes removed from unit, maintain the pen on baseline and advance the sensitivity to 100% in the manual mode.

2. Switch to the auto mode. If the pen remains stable, (within 1 division of baseline) the GSR alignment is OK, go to step number 7.

3. With the power off, remove the amplifier from the top panel.

4. Place the amplifier on the top panel with the power supply side up.

5. Refer to drawing 11 for location of the components. Turn on the AC power and allow the amplifier to warm up for 10 minutes.

6. Set the sensitivity at 100% in Auto mode and adjust R-8 to recenter the pen on baseline.

7. Switch to the manual mode and recenter if required, to place the pen on baseline.

8. Recheck the pen position in auto mode, and repeat step number 6 if required.

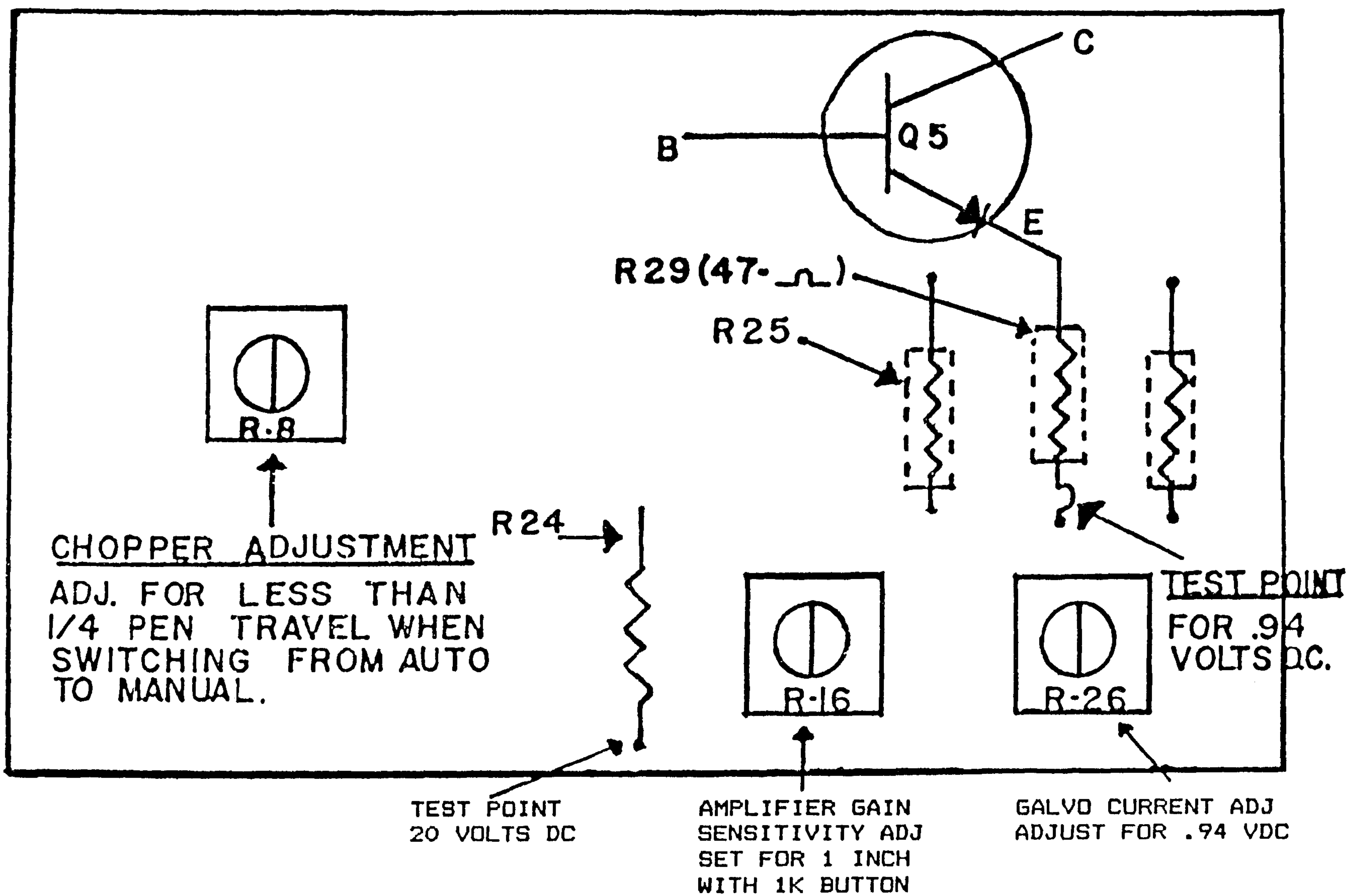
9. Switch to the manual mode at 100% sensitivity and with the pen on the baseline, depress the 1K test button.

10. If pen raises 1 inch from baseline, release the button and go to step number 12.

11. If pen raises more or less than 1 inch (+ or - 1/8 inch), from baseline adjust R-16 (while holding the button depressed), adjust for 1 inch deflection.

12. Return sensitivity to zero, turn the power off and re-install the amplifier in the top panel.

GSR PRINTED CIRCUIT BOARD



Drawing No. 11

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Stoelting Deceptograph 22500 Series
(U.S. Army Model AN/USS-2D)

Stoelting Amplifier Model SA-17

See drawing 12.

1. Turn the AC power on, and remove the electrodes. Allow the unit to warm up for 15 minutes. With the sensitivity at zero, observe the pen position on the chart paper.

2. If the pen remains on the baseline (+ or - 1/8 inch), go to step number 6.

3. If the pen drifts off of the baseline, go to step number 4.

4. With the power off, (AC line cord removed) loosen the screws on the amplifier and lift out of the case. Position the amplifier on an angle in the case. Turn on the power and let the amplifier warm up for 10 minutes.

5. Refer to drawing number 12 for the location of the components. With the auto/manual switch in the manual position and at zero sensitivity, adjust R-3 to position the pen on the baseline.

6. Adjust the sensitivity to obtain 100% while maintaining the pen on the baseline.

7. Still at 100% sensitivity, switch to the auto mode. If the pen remains within + or - 1/8 inch of the baseline, go to step number 10.

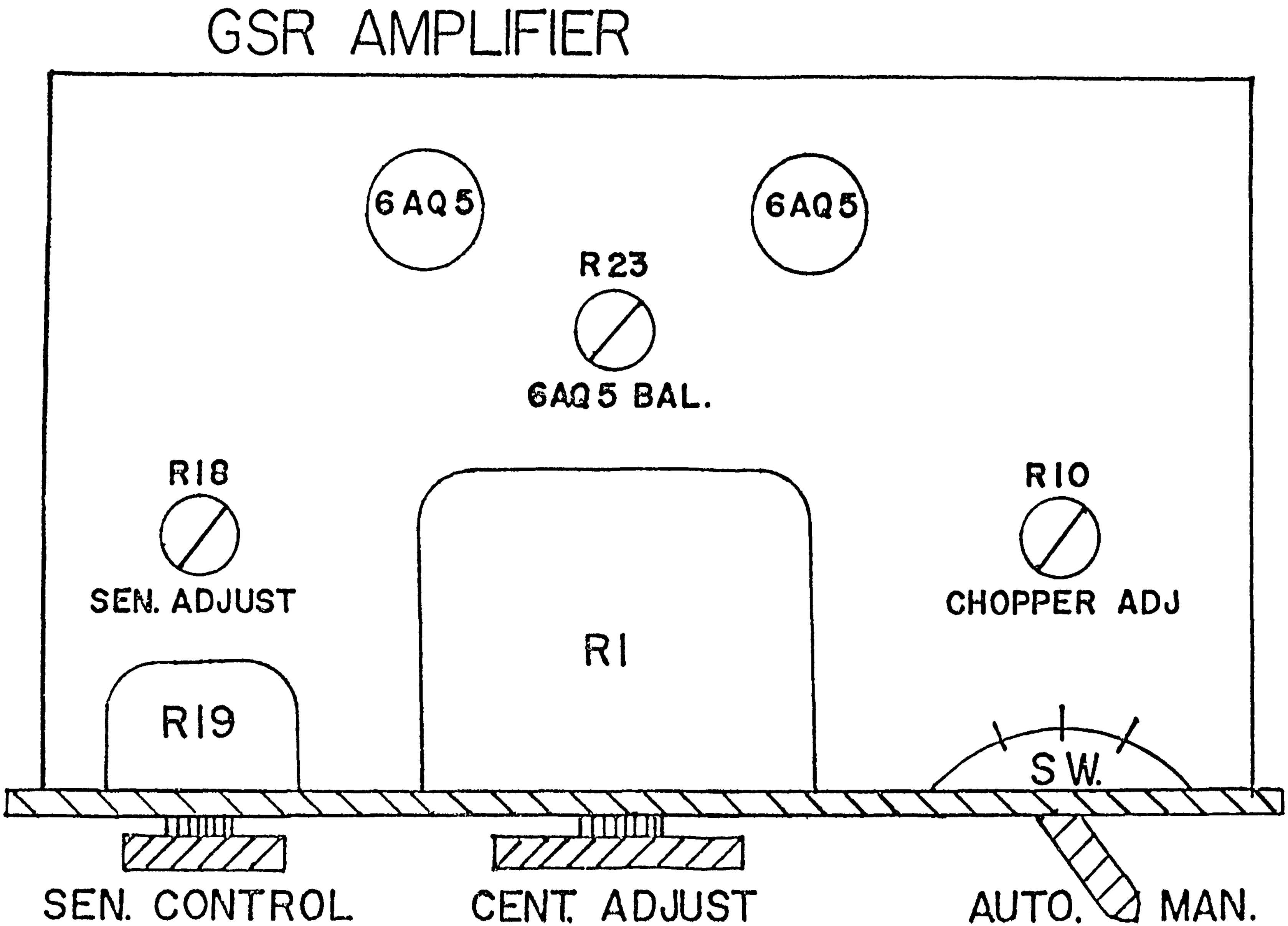
8. If the pen drifts up or down from the baseline, adjust R-10 to return the pen to the baseline.

9. Switch to the manual mode and recenter if required. Go to step number 7 and repeat steps 7 and 8. Then, if the pen remains on the baseline when switching between automatic and manual mode, return the sensitivity to zero and continue.

10. Connect electrodes to a dummy subject or a resistance decade box. Switch to the manual mode and increase the sensitivity to 100% while maintaining the pen on the baseline.

11. Decrease the resistance by 1000 ohms. The pen should move upwards 1 inch. If not, adjust R-18 to obtain the 1 inch per 1000 ohm change.

12. Return the sensitivity to zero and turn the power off. Disconnect the electrodes and reinstall the amplifier in the case. Tighten the mounting screws.



GSR AMPLIFIER
6AQ5
6AQ5
R23
6AQ5 BAL.
R18
SEN. ADJUST
R10
CHOPPER ADJ
R1
R19
SW.
SEN. CONTROL
CENT. ADJUST
AUTO.
MAN.

TROUBLESHOOTING

GENERAL

When you first receive a new instrument, always inspect the package for damage before you open it. If damage is noticed, Do Not Open It. Notify the shipping company and the manufacturer first. If no damage is notived to the container, open the package, and inspect the instrument and attachments for any possible damage. If the instrument appears to be damage free, then perform a calibration check on the instrument. Be sure to adjust the pen weights as they are normally shipped from the factory with the weights screwed down. If the new unit will not hold air pressure, look for a disconnected hose, as they sometimes will work loose during shipment. Remember to first look for the obvious. Is the power cord connected at both ends? Is the AC switch turned on? Are all of the attachments connected to the instrument?

The troubleshooting comments below should be applied to an instrument that has been performing normally and suddenly develops a problem. Again as in the paragraph above, remember to look for the obvious answer to the problems. On electronic channels, be sure the switches are in the right position.

When you encounter an abnormal pattern and believe that the channel is at fault always run a calibration test pattern to determine if there is a problem with the channel. If there is a malfunction in the channel, then examine the components above the top panel before you remove them. A visual check above or below the top panel will sometimes locate the source of the problem. Check the pen weights and make sure that they are not set too heavy (refer to your owner's manual). Then examine the pneumograph or arm cuff and its related tubing. After a visual check, read over the section pertaining to the channel that you are having a problem in. Before you remove the section or top panel, be sure you remove the pens and ink well (or ink bottles). If possible try to leave the rubber tubing connected as you examine the unit.

PNEUMO

Most of the problems encountered in the Pneumo system, will be found in the pneumograph. The easiest way to check the pneumograph is to substitute a unit that is known to be good for the suspect one.

If the same problem still persists with a different pneumograph installed, you can probably rule out the external components. Look for breaks on the edges of the convoluted tube. They have a tendency to crack or break within the first inch or so of either end. If the leak is not found with a visual check, submerge the pneumograph in water and with a slight pressure blown into the pneumograph, watch for bubbles to indicate the exact location of the leak. Sometimes, you can make a temporary repair in a pneumograph by placing a small amount of rubber cement on the area where the leak is located. Check the pen weights (refer to your owner's manual). A pneumo pen weight that is turned in too far (too heavy), can decrease the sensitivity by as much as 30%.

With a mechanical pneumo channel look for ink and/or dirt at the pivot shaft and fulcrum junction. (Note: Refer to the Pneumo Sensitivity drawing 2.) If you find the junction area is dirty, you can clean it by washing it in hot water. Do not attempt to make any adjustments unless the unit is clean. Cleaning a dirty or ink-caked pivot shaft will restore the original sensitivity to the channel without any adjustment. Disconnect the rubber tubing and hold the channel by the top panel and place the junction area under a hot water faucet. Run the hot water until the area is clean. Air dry and then reinstall the channel and run a test pattern with it.

GSR

About 90% of the problems encountered in the GSR system will be found in the finger electrode cables. If you believe that you have a GSR problem, always check the finger electrodes cable first. Be sure and check both the cable connections at the plates, and at the connector end.

Be aware, that with the electronic instruments (or the GSR in a mechanical instrument) strong RF signals (nearby radio transmitters) can overload the system, and will usually cause the pens to quiver or jump to the upper pen stop. The instruments are designed to reject the RF signals they would be expected to be exposed to, but stronger than normal signals will still cause interference. If RF interference is suspected, notify the factory to obtain modifications to resolve the problem. If there is any problem or question, notify the factory immediately.

In the older GSR systems, the automatic mode does not allow the user to select the baseline. In this version whenever the pen is resting with the AC power off, that point will be the baseline for the GSR in the automatic mode. If the automatic mode is more than 1/8 inch from this point, refer to the GSR alignment section for your instrument.

CARDIO

The problems encountered with a cardio system will be either a loss of pressure or a loss of amplitude (reduced or no signal) on the chart. If the problem seems to be a loss of pressure, then, examine the cuff and its related tubing. An easy way to check the cuff is to wrap the cuff around a solid object of at least 3 inches in diameter. Then pressurize the cuff to about 90mm Hg, center the pen on the baseline and clamp the tubing close to the top panel connector. You can then run a leak test. You can also substitute a unit that is known to be good for the suspect one. If the same problem still persists with a different arm cuff installed, you can probably rule out the external components. Check the pen weights (refer to your owner's manual). A cardio pen weight that is turned in too far (too heavy), can cause a loss of the dicrotic notch and can also decrease sensitivity as much as 30%.

About 90% of the leaks in the cardio system will be found to originate in the cardio vent. These type of leaks will usually appear as a slow loss of pressure during a test. First remove, and clean or replace the vent stem. If the vent requires repeated cleaning to stay leak free, there may be some foreign material in the tubing. Remove and replace the rubber tubing on the cardio module and clean the vent body.

Another source for a slow leak is the manifold connector which provides a connection between the bellows, vent and the input connector. A rapid loss of pressure may be caused by a hose slipping off of the bellows connector or the vent assembly underneath the top panel.

Under pressure, the velcro lock on the cuff will slip or creap as it sets up. With the electronic cardio, this will look like a slow leak in the cardio system. One way to detect this creepage is to inflate the system to 120mm Hg, massage until stable, and then lower the pressure to 90mm Hg. Check for downward pen movement over a period of time. Usually the system will stablize after a 15 minute period of time. To counteract this creepage inflate the system to 120mm Hg and then after massaging of the cuff, lower the presure to the operating pressure. If after the massage the cuff pressure is below 90mm Hf, reinflate to 120mm Hg and repeat the massage. It is important that you lower the pressure at least 15mm Hg and not just massage the cuff down to the operating pressure. The idea is to set the velcro at a higher pressure and then when you lower the pressure to run the test, any creepage will show up as a slight upwards pen movement.

Drift in the electronic cardio systems can also be mistaken for a leak in the system. Drift can be checked by setting the sensitivity at 25% with zero pressure and the pen should not drop more than 2 divisions in 1 minute.

Ink getting into the fulcrum and spacer area will cause a loss of sensitivity and could cause the cradle to freeze in place. Look for ink and/or dirt at the pivot shaft and fulcrum junction. (Note: Refer to the Cardio Sensitivity drawing 5). Do not attempt to make any adjustments unless the unit is clean. If you find the junction area is dirty, you can clean it by washing it in hot running water. Disconnect the rubber tubing and hold the channel by the top panel and place the junction area under a hot water faucet. Run the hot water until the area is clean. Air dry and then reinstall the channel and run a test pattern with it.

If a visual check shows the area to be clean or if after cleaning the channel still has a malfunction, then with the cradle centered (the pen, if installed, would be on the baseline), check to see if the stem is correctly aligned. With the cradle straight, the connecting block (the aluminum block portion of the pivot shaft, where the fulcrum adjustment screw is located) should be aligned so that it is facing in the same direction as the cradle (Refer to the Cardio drawing 5). If it is not aligned, loosen the screw on the pen cradle, realign and then retighten the screw.

Note: If a malfunction exists which you cannot locate or repair, contact a qualified repairman or notify the factory repair department.

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