Echometer Operating Manual

Model D with Compact Gas Gun

REV A

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PRECAUTIONS

1. Read Manual before operating equipment.

2. Operate the equipment safely at all times.

3. Securely connect Echometer gas gun assembly to the casing annulus opening. Clean threads if necessary. Tighten securely so the Echometer wellhead will not become dislodged by casing pressure and/or shock from the discharged pressure wave.

4. The gas valve should be in the open position when the gas gun is installed on a well. The gas gun pressure gauge will indicate casing pressure when the casing valve is opened. Open valve to pressure **slowly.** For safety, open valve a slight amount until gas begins to flow. Do not open the valve any more until the pressure equalizes. Then, fully open valve.

5. Wellhead Pressure Rating.

Working Pressure	1500 PSI
Test Pressure	4000 PSI

The working pressure ratings on the Echometer wellhead, fittings, nipples, etc., apply to like-new condition. The ratings must be lowered if wear or corrosion has occurred.

6. Usually the gas gun volume chamber pressure is less than the working pressure of the fittings on the well. However, if the gas gun volume chamber pressure exceeds the working pressure rating of the connections on the well, do not discharge the gas in the gas gun into a closed valve as a dangerous pressure may result.

7. Clean wellhead attachment every 500 shots, monthly, or whenever dirty, whichever occurs first. Inspect and replace any worn or bad parts.

8. When assembling the wellhead, install Microphone **after** installing the Housing Cap. See Page VIII.

9. Do not breathe excessively high concentrations of CO_2 or N_2 gas.

10. Recharge battery when voltage drops in yellow arc, or once a month, whichever occurs first.

11. Package properly for shipment. Remove all heavy objects from amplifier-recorder case.

PRINCIPALS OF ACOUSTIC LIQUID LEVEL MEASUREMENT

A pressure pulse is generated from a wellhead attachment that is connected to the surface casing annulus valve. The pressure pulse travels down the casing annulus gas and is reflected by collars, liquid level, and other obstructions. A microphone in the wellhead attachment converts the pressure pulses into electrical pulses which are amplified, filtered and recorded on a strip of paper. The chart shows the number of tubing collars to the liquid level. The depth is determined by multiplying the number of tubing collars by the average tubing length.

THE ECHOMETER

The Echometer is a precision instrument for determining the depth to liquid in a well. It is the most advanced instrument available regardless of price. The upper collars, deep collars, or the liquid level can be accented for maximum accuracy. Yet, it is simplified for easy operation by the labeling of controls to indicate the functions performed.

ECHOMETER SCHOOL

Echometer Company offers schools on the use and applications of the Echometer. You are invited to attend free of charge. A list of the schools which are located throughout the U.S. and Canada will be sent upon request.

Echometer Company has an excellent service policy. If we can be of service, please contact us. Thank you.

COMPUTER & SPECIAL APPLICATION

A portable laptop computer is available for calculating bottomhole pressures. Also, the distance to an anomaly or liquid level can be calculated from accoustic travel time when gas properties are known. Contact us for additional information.

GENERAL DESCRIPTION OF THE ECHOMETER

A. AMPLIFIER-RECORDER

The amplifier-recorder receives the signals from the microphone, amplifies these signals, filters the signals to accent desired information, and records the information on heat sensitive paper. The controls and their functions follow:

AMPLIFIER POWER SWITCH

Units built after June 1, 1985. Momentarily placing the switch in the "On" position energizes the amplifier circuit for four to five minutes. Turning on the chart drive energizes the amplifier circuit for an additional four to five minutes. Additional battery life will be obtained if the amplifier power switch is momentarily placed in the "Off" position immediately after the record is completed.

Units built before June 1, 1985. A toggle switch controls power to the amplifier. Turn the switch to "On" and allow ten seconds for stabilization. As a safety precaution, a safety switch will automatically turn off the power when the lid is closed.

SENSITIVITY

Two sensitivity controls are located on the panel. The higher knob is the COLLAR sensitivity control, and it controls the sensitivity when the filter is in UPPER COLLARS or DEEP COLLARS. The lower knob controls the sensitivity when the filter is in LIQUID LEVEL.

FILTER

The Echometer uses a very effective filter system. The filter is labeled UPPER COLLARS, DEEP COLLARS and LIQUID LEVEL. The various filter positions tune the system to record the type of signal desired. UPPER COLLARS tunes the amplifier to high frequency signals which result in the collars being recorded as sharp, distinct "kicks". DEEP COLLARS passes medium band signals and records these signals similar to smooth sine waves. DEEP COLLARS accents deep collars for greater accuracy in deep wells. LIQUID LEVEL tunes the system to the low frequency signals found from the liquid level in deep, low pressure wells.

The UPPER COLLARS filter position is used on shallow wells (less than 4000 feet), high pressure wells, dirty wells, and wells with irregular length tubing. The collars are recorded as "sharp" kicks.

The DEEP COLLAR filter position is recommended for most low pressure, deep wells below 4000 feet. With normal conditions, the upper collars are strong and distinct, and the liquid level is strong and distinct, but the lower collars are weak and they become indistinct. The DEEP COLLAR filter position will accent these signals while removing undesired background noise and result in the recording of lower collars. This is a more accurate record than a record without the lower collars recorded.

PRESSURE SWITCH (Only on units built before June 1, 1985)

The pressure switch reduces the signals from the microphone to the amplifier when operated in the HIGH position. This switch is used in the LOW position with the gas gun, since the response from the microphone can be controlled by the size of the charge from the gas gun.

MICROPHONE CABLE

A shielded cable connects the amplifier-recorder to the microphone. When installing and removing the cable, hold to the cable connector only. DO NOT PULL ON THE FLEXIBLE CABLE BODY. Cable length can be in excess of 50 feet if desired for special conditions with negligible loss of signals. The shielded cable prevents stray kicks generated by overhead power lines and other electrical disturbances. Echometer cable is superior to standard coaxial cable and should be used for best results.

TEST OUTPUT

See Section VII

RECORDER AND PAPER DRIVE

The chart drive and electrical writing pen are activated by the toggle switch near the chart drive. Turn ON the chart drive when ready to record. Approximately 12" of paper discharge is necessary for the pen to heat. The chart paper is replaced by removing the galvanometer plate (push back and lift) and then removing the used paper roll. Place the paper in the chart drive with the printed side up. Replace the pen cover plate. Be careful not to damage the pen.

THE GALVANOMETER AND PEN REPLACEMENT

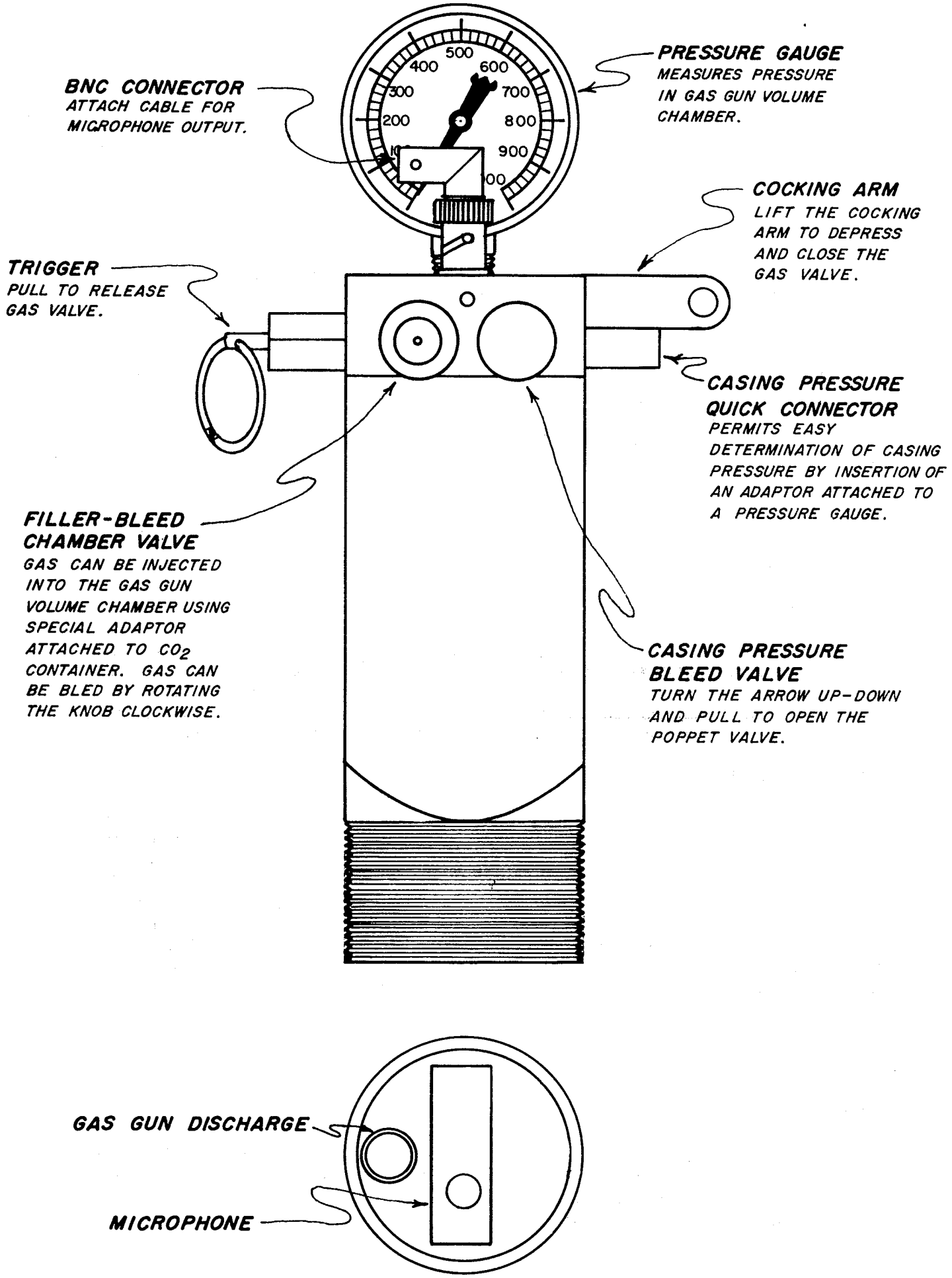
The galvonometer does not require maintenance except for pen replacement and adjustment. The pen is replaced by removing the galvanometer cover plate. The plate should be pushed back and lifted. Remove the two screws holding the pen leads and the screw holding the pen body. Remove the pen and insert a new one. The pen tension on the paper support should be about 5 grams to get adequate writing darkness and proper pen response. Turn the pen tension screw 90° clockwise after the pen touches the paper support roller (no paper installed) to obtain approximately 5 grams pen tension. Connect the red wire on the pen to the terminal block having a red wire attached as before. Reconnect the black wire. Be sure that the tabs on the pen are bent up to prevent the tabs from restricting pen movement.

VOLTMETER

See Section VI "Battery Information" for details of battery operation.

TIMER SWITCH (Manufactured after July, 1984)

A timer places a mark on the chart at the initial pulse generation & each second thereafter. The mark should be on the printed side of the chart if the initial wave is a compression wave, and on the opposite side when the initial wave is a rarefaction wave. The timing marks can be generated manually by depressing the Timer switch.


BNC CONNECTOR
ATTACH CABLE FOR MICROPHONE OUTPUT.
PRESSURE GAUGE
MEASURES PRESSURE IN GAS GUN VOLUME CHAMBER.
COCKING ARM
LIFT THE COCKING ARM TO DEPRESS AND CLOSE THE GAS VALVE.
TRIGGER
PULL TO RELEASE GAS VALVE.
CASING PRESSURE QUICK CONNECTOR
PERMITS EASY DETERMINATION OF CASING PRESSURE BY INSERTION OF AN ADAPTOR ATTACHED TO A PRESSURE GAUGE.
FILLER-BLEED CHAMBER VALVE
GAS CAN BE INJECTED INTO THE GAS GUN VOLUME CHAMBER USING SPECIAL ADAPTOR ATTACHED TO CO_2 CONTAINER. GAS CAN BE BLED BY ROTATING THE KNOB CLOCKWISE.
CASING PRESSURE BLEED VALVE
TURN THE ARROW UP-DOWN AND PULL TO OPEN THE POPPET VALVE.
GAS GUN DISCHARGE
MICROPHONE

B. WELLHEAD ATTACHMENT

The wellhead attachment consists of two parts: the microphone and the gas gun.

The microphone converts acoustical signals into electrical signals. Do not permit the electrical receptacle to become damaged or wet. Do not change pressure rapidly.

The gas gun consists of a 10 cubic inch volume chamber with a ¼" outlet valve. The outlet valve will open rapidly when the trigger is pulled. This generates a pressure pulse. If the pressure is greater in the volume chamber than the casing annulus, a compression (or positive) pressure pulse is generated. If the pressure is greater in the casing annulus than the volume chamber, a rarefaction (or negative) pressure pulse is generated.

A discussion of the parts on the gas gun will be beneficial in operating the equipment. See the gas gun drawings.

PRESSURE GAUGE

The pressure gauge measures the pressure in the gas gun volume chamber. If the gas gun valve is open, the gauge indicates the pressure between the gas gun and the casing annulus valve. If the casing annulus valve is open, the gauge indicates the casing pressure.

CASING PRESSURE QUICK CONNECTOR

A casing pressure quick connector is located on the side. A lower range pressure gauge with a mating adaptor will fit into the casing pressure quick connector to enable the operator to obtain the casing pressure when greater accuracy at low pressures is needed. The pressure gauge and adaptor simply push into the casing pressure quick connector.

COCKING ARM

The cocking arm is lifted to depress and close the gas valve.

CASING PRESSURE BLEED VALVE

The casing pressure bleed valve is a poppet type valve to bleed the casing pressure. To open the valve, turn the knob until the arrow is up - down and pull out the knob. The discharge from the gas valve is sudden. Be careful not to blow sand or debris which could injure personnel.

The casing pressure bleed valve can be used to generate the initial pressure pulse. Rapidly open the casing pressure bleed valve and allow it to remain open and bleed gas from the well until the record is obtained. Do not close the casing pressure bleed valve before the reflection from the liquid level is obtained. Closing the casing pressure bleed valve will result in another pulse being generated and multiple reflections will be obtained from down the well.

FILLER-BLEED CHAMBER VALVE

The filler-bleed chamber valve is used to pressurize the gas gun volume chamber or to remove gas from the chamber. Gas is added to the gas gun volume chamber by insertion of a mating quick connector attached to a pressurized gas source into the filler-bleed chamber valve. Gas is bled from the chamber by rotating the knob clockwise. Clockwise rotation of the filler-bleed chamber valve results in depression of the valve core and hence bleeding of the volume chamber thru the filler-bleed chamber valve.

TRIGGER PAWL

The trigger pawl is pulled to release the gas valve. If sufficient pressure exists in the volume chamber or on the end of the gas valve, the gas valve will open.

MICROPHONE

The microphone is a twin-disc pressure-sensitive device that is vibration cancelling.

C. ACCESSORY COMPONENTS

The standard accessories include recording paper, eleven point dividers, a choice length microphone cable, a 110 VAC automatic recharger, a 12 VDC automobile cigar lighter recharger, and an operating manual. A gas supply cylinder is necessary on low pressure wells. Three 7.5 ounce CO_2 containers with quick connect filler connector, a refill adaptor and scales are standard unless the optional 5# bottle with hose and quick connect filler connector are specified. Extra manuals are free.

Operation of the Echometer with Compact Gas Gun Wellhead

The compact gas gun is to be operated in the Explosion or Implosion mode depending upon the casing pressure. Use the Explosion technique when the casing pressure is less than approximately 100 PSI. Use the Implosion technique when the casing pressure is sufficient to obtain a good record.

A. EXPLOSION of compressed gas from the Echometer gas gun can be used to generate the pressure pulse. The pressure pulse is positive. (Use with less than 100 PSI casing pressure).

1. Securely attach Echometer gas gun to casing valve.
2. Close Casing Pressure Bleed Valve and Filler-Bleed Chamber Valve. Open casing valve slowly.
3. Pull trigger ring and measure casing pressure. (Use precision pressure gage with adaptor if desired).
4. Lift cocking arm to close gas valve.
5. Fill volume chamber with gas (CO_2 or N_2) to 150 PSI. Use a higher pressure only if the liquid level response is not distinct. Less pressure should be used if satisfactory records are obtained at lower pressures.
6. Turn amplifier ON and allow 10 seconds for stabilization while connecting cable.
7. Select type of collar response desired and increase collar sensitivity until pen response is ⅛". (Reduce well noise if necessary).
8. Turn chart drive ON and run 12 inches of chart paper.
9. Generate pressure pulse by pulling trigger ring.
10. Turn amplifier OFF after operation.

B. IMPLOSION of compressed gas from the casing annulus into the Echometer gas gun is used to generate the pressure pulse. The pressure pulse is negative. (Use when the casing pressure is between 100 PSI and the working pressure rating of 1500 PSI. Use at lower pressures if satisfactory records are obtained).

1. Securely attach Echometer gas gun to casing valve.

2. Close Casing Pressure Bleed Valve and Filler-Bleed Chamber Valve and very slowly open casing valve. Do not allow pressure to increase over 500 PSI per second. Damage to the microphone can result when rapid pressure changes occur.

3. Pull trigger ring and measure casing pressure. (Use precision pressure gage with adaptor if desired.)

4. Lift cocking arm to close gas valve.

5. Bleed gas gun pressure through Filler-Bleed Chamber Valve by rotating knob clockwise until the gas gun pressure has been decreased to approximately 200 PSI below the casing pressure. Use greater or lesser differential pressure if greater or lesser response is desired.

6. Turn amplifier ON and allow 10 seconds for stablization while connecting cable.

7. Select type of collar response desired and increase collar sensitivity until pen response is ⅛". (Reduce well noise if necessary).

8. Turn chart drive ON and run 12 inches of chart paper.

9. Generate pressure pulse by pulling trigger ring. The generated pressure pulse is negative. Chart response direction will be reversed.

10. Turn amplifier OFF after operation.

Comments

1. Before removing the gas gun from the casing valve, bleed gas by opening the casing pressure bleed valve. The casing pressure bleed valve is the solid ¾" knurled knob. Turn arrows up-down. Be careful. If sufficient pressure exists behind the poppet valve, the valve will open itself. If the pressure is low, pull the valve open.

2. On deep wells, the filter should be in DEEP COLLAR position. DEEP COLLAR position accents the lower collars.

3. On shallow wells or if the upper collars are not distinct on a deep well, set the filter to UPPER COLLARS.

4. **If the fluid level is not recorded**, (especially on deep, low pressure wells), after step 7 above, place filter in LIQUID LEVEL position and increase the lower sensitivity knob until pen response is ⅛". Then set filter to collar position. After generating the pressure pulse, note the pen response carefully. When collar response has diminished to ⅛" background noise, switch the filter to LIQUID LEVEL so that the amplifier will be tuned to the response from the LIQUID LEVEL.

5. All pen responses will be reversed in the IMPLOSION technique since the pressure is negative in comparison to the normal positive pressure pulse.

6. If a larger liquid level response is desired, use a greater differential pressure between the gas gun volume chamber pressure and the casing annulus gas pressure. Do not use a larger differential pressure unless needed.

7. Operating the gas gun at 300 PSI requires twice as much gas as operating at 150 PSI. Only one-half as many shots will be obtained from a cylinder. When using CO_2 gas above 300 PSI (at normal temperatures), liquid may form in the gas gun which will result in considerably more gas being used per shot.

8. When using nitrogen gas, use a regulator so that the pressure cannot exceed the working pressure rating of 1500 PSI.

DETAILS OF OPERATION

Attach Echometer wellhead to casing valve. The Echometer microphone should be as near as possible to the casing annulus, preferably within 5 feet. Short lengths of pipe can mask the desired downhole signals. Longer lengths will give multiple reflections which are hard to distinguish from collar reflections. Use a minimum of 90° ells and tees and direct the blast directly into the well if possible. Two inch connections are preferable but one inch connections are generally satisfactory if the length of 1" pipe is held to a minimum. The amount and number of unfavorable conditions which can be tolerated are determined by the difficulty of the well. If the well is easy to test, then a few unfavorable conditions can be tolerated. If the well is difficult, the unfavorable surface conditions may prevent a satisfactory record. Normally, unfavorable surface connections interfere more with collar than with liquid level response.

Proper sensitivity setting is very important. Increase sensitivity until pen response is ⅛". The setting indicates the background well noise level. Background noise is caused by surface vibrations, leaking gas connections, downhole gas "popping" out of liquid, and other unstable conditions. This background noise is not a part of the signals that result when the pressure wave is generated. Do not increase the sensitivity after the pressure wave is generated or background noise will be recorded.

Background noise must be considered. The pressure wave travels down the well and is reflected by collars and the liquid level. The top collar reflections are strong, and the lower collar reflections become much weaker. The liquid level reflection varies from a strong signal in a shallow high-pressure well to a very weak signal in a deep low-pressure well. Only signals stronger than background noise can be recorded. It is obvious that strong background noises must be reduced if the recording of lower collars and liquid level is obtained in a deep, low pressure well. More background noise can be tolerated in high pressure, shallow wells because the desired signals are stronger. In general, a background noise sensitivity setting of 3-5 is sufficient on shallow and higher pressure wells, while a setting of 5-10 may be required for satisfactory results on a deep low-pressure well.

Background noise can be classified as surface noise or down-hole noise. The source of the noise can be easily determined by increasing the sensitivity until pen movement is obtained. Then close the casing valve between the microphone and the casing annulus. If the random pen movement reduces, the noise is originating from the other side of the valve which would be down-hole noise or noise caused by surface gas leakage on the other side of the valve. If the pen movement remains the same, then the noise is either surface vibrations or noise caused by gas leakage from extraneous lines connected on the same side of the casing valve as the wellhead. Surface noise generally originates from surface vibrations. The microphone is shock mounted, but if the wellhead attachment vibrates, signals are generated. Wellhead Vibrations should be stopped for better records on deep low-pressure wells. Vibrations result from running gas engines, chattering check valves, and other operating surface equipment. Other possible surface noises include leaking gas connections, leaking valves, and operating regulators. Close all other lines leading from the casing annulus.

The main source of downhole noise is gas "popping" out of a gaseous column. When pen movement occurs at sensitivity settings of less than 5, always check for a gaseous column. See "Analyzing Well Performance" in the appendix. Downhole noise can also result from tubing & casing leaks.

The filter can be used to remove background noise in many cases. Try all 3 filter positions if necessary. The filter position which has the highest sensitivity settings for ⅛" pen response often gives best results.

Generally, the downhole noise can be reduced in relation to the desired reflected signals by increasing the casing pressure. Continue to pump the well with the gas vent valves closed. At low pressures, an increase of 10 PSI casing pressure almost always improves the record and depresses a solid liquid column about 30 feet.

If the liquid level signal is not obtained due to excessive surface noise or downhole noise, a larger signal from the liquid level can be obtained by generating a larger initial pressure pulse.

Increasing the Sensitivity above the background noise level makes interpretation much more difficult and is not recommended.

INTERPRETATION

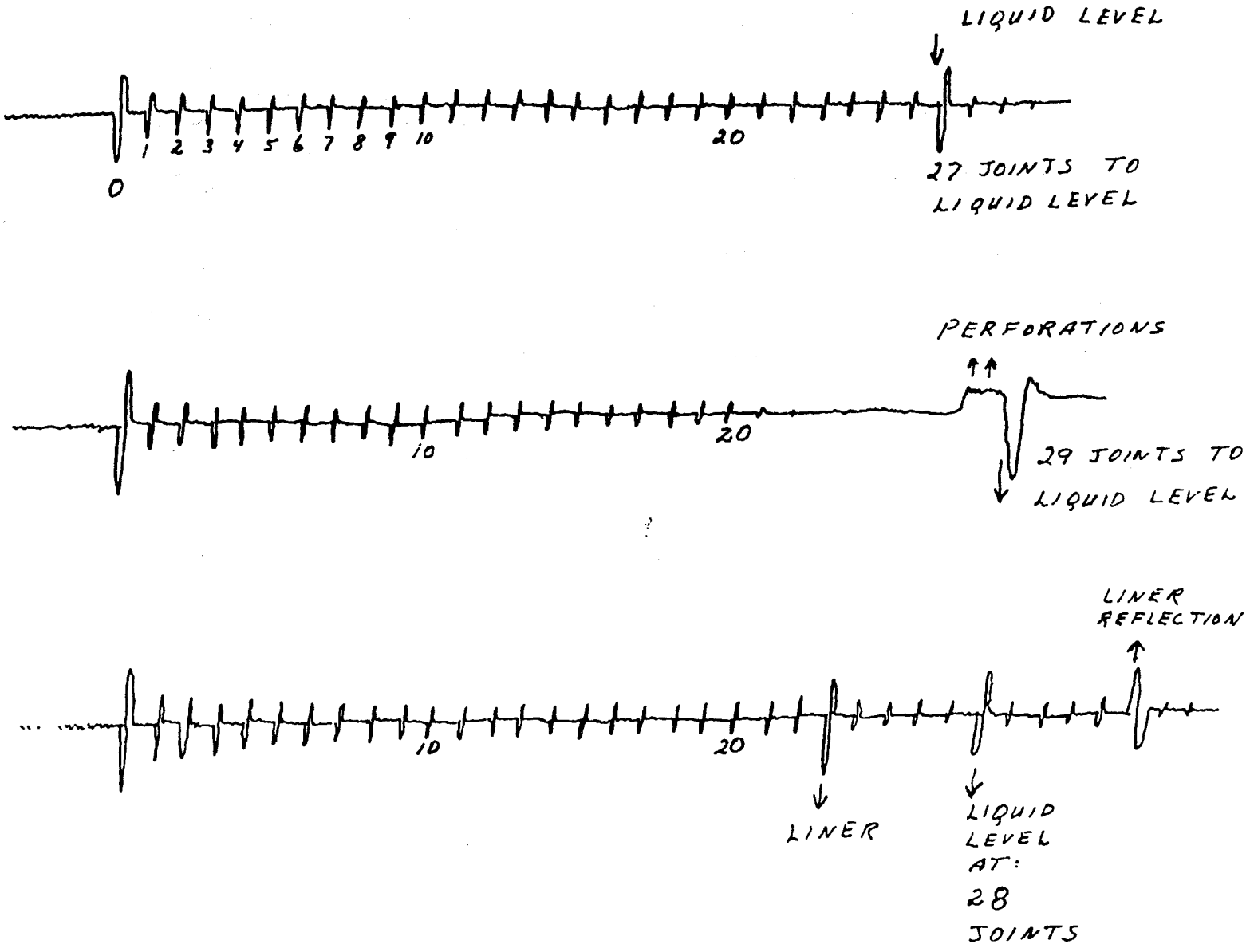
The normal chart has a kick at the beginning of the run signifying the initial pressure pulse, a series of small evenly spaced kicks indicating the collars, and the large kick indicating the liquid level. On some charts, the collars can be distinguished from the top of the chart to the liquid level and each collar can be counted. The spacing divider can be used if desired. On other charts, the collars cannot be distinguished clearly all the way down the chart to the liquid level kick. In such cases, count the collars down to the last distinguishable collars. Then, extrapolate to the liquid level using the spacing dividers set with the same spacing as the last distinguishable collars. Often the collars near the top of the chart are closer together than those in the lower portion of the chart on wells which are not venting gas from the casing annulus. The change is caused by heavier gas settling in the lower portion of the well. Sound travels slower in a heavy gas. The collars become closer together near the bottom of the hole when gas is being vented at the surface and the bottomhole temperature is higher than the surface temperature. The higher temperature causes an increase in the velocity of sound. Be sure to count the collars as accurately as possible down to the last distinguishable collars. In some cases, the collars are indistinct. Set the spacing divider for the same spacing as shown by the best collars and count from the instant of "blast" to the liquid level using this spacing.

The liquid level depth can also be determined by measuring the travel time and knowing the acoustic velocity from gas property data. Acoustic velocity charts are available. Also, a portable computer can be used. Information is available on request.

On an average well, the following events will be recorded on the chart. A kick will show the initial blast. A series of small kicks will indicate the collars, and then the liquid level kick will be recorded. If the chart is allowed to run, another kick will often occur below the liquid level kick. This reflected liquid level kick is caused by the blast which travels down the well, is reflected by the liquid level back to the surface, is again reflected by the casing head back down the well; and again it is reflected by the liquid level back to the surface. The distance from the initial blast to the first liquid level kick will be equal to the distance between the first liquid level kick and the second reflected level kick. Multiple liquid level reflections on shallow liquid levels can be misinterpreted.

The direction of kick indicates enlargement and reductions in the cross sectional area of the annulus. Objects which reduce the cross-sectional area of the annulus result in compression waves and are recorded as downward kicks (toward the printed side of the chart) when the top of the chart is to the left. Such objects would be liners, tubing anchors, paraffin deposits or liquid level. Conditions increasing the cross sectional area of the annulus result in rarefaction waves and are recorded as upward kicks. Such conditions are perforations, "shot" holes, parted casing, or parted tubing. If the Implosion technique is used, the direction of pen response will be reversed.

The liquid level is recorded as a downwarn kick. (See chart below). If the liquid level is 20 feet or so in a "shot" hole, the pen would first kick upward then down as the sound wave was reflected from the liquid level. Recording the liquid level below a liner would show a downward kick at the liner, and downward kick at the liquid level, and an upward kick. The distance between the liner kick and the liquid level kick is equal to the distance between the liquid level kick and the liner reflection kick. The liner reflection kick results when the liquid level reflection signal is travelling upward and passes the liner increase in cross-sectional area. This generates a rarefaction wave which returns to the bottom and then travels to the surface where it is recorded.



PROBLEM WELLS

The problem of obtaining a good record is generally caused by excessive surface vibrations, excessive downhole noise (gaseous liquid columns), improper wellhead connections, dirty microphone and electrical connections, or low casing pressure.

Excessive surface vibrations and downhole noise should be reduced. The SENSITIVITY permits an actual measure of extraneous noise. See Section III - Details of Operation.

The wellhead attachment should be attached directly to the casing valve, and all other valves should be closed to obtain the best records. Attaching the Echometer wellhead over 5 feet from the casing can cause misleading reflections from the collar response.

Keep the microphone cable connectors clean and dry. Stray signals will result when the connectors are dirty. Also, keep the microphone clean.

Gaseous liquid columns caused by gas bubbling through oil can be a problem. Increasing gas pressure by closing the surface casing valves will generally result in a liquid level reflection. Only a small discharge of gas is necessary to form a gaseous column in a small annulus completion. Larger quantities are necessary to cause gaseous columns in large casing, small tubing completions. Any well venting gas to the atmosphere, venting gas to the flow line, or using casing gas to operate an engine should be checked. The amount of liquid present in a gaseous column can be determined by a casing presure build-up test. Another technique is compression of the gaseous column with casing pressure to determine the gaseous columns gradient. See "Analyzing Well Performance" in the appendix.

The best way to verify a liquid level in a producing well from other "kicks" (such as liners) is to cause the liquid level to move. The liquid level is the only "kick" that can move in a well and such a movement verifies a liquid level. A high level can be depressed by increasing the casing pressure. An increase of 10 PSI in the casing pressure will depress the liquid level approximately 30 feet. The liquid level will rise when a producing well is shut-down. See Rate of Fillup Graph for the amount of time required for liquid level rise.

If numerous "kicks" are recorded on a chart which are difficult to interpret, another test should be taken and compared to the first test. All "kicks" should be duplicated on each chart. If "kicks" are not duplicated, stray noises caused them and these stray noises should be stopped as described above.

The effect of pressure is very important. Stronger signals are returned in high pressure wells. Increasing the casing pressure by 10 PSI is beneficial in deep, low-pressure wells. Atmospheric pressure and vacuum wells do not return strong signals from down the annulus and a large "blast" may be necessary.

On rare occasions, paraffin deposits, dirty tubing or other conditions can result in downhole conditions which make the counting of collars or the determination of the liquid level difficult. In extreme conditions, it may be necessary to clean the tubing and casing to remove foreign material.

BATTERY INFORMATION

A sealed, rechargeable, lead cell, 2.5 amp hour, 12 volt battery is used in the amplifier-recorder. The battery is similar to the new, sealed, 12 volt automobile battery.

The Echometer will operate from the self contained rechargeable battery or from a power cord which is plugged into the automobile cigar lighter.

A 110 VAC charger permits charging of the Echometer battery from a common 110 VAC power outlet. Approximately 14 hours is required to charge a discharged battery. The 110 VAC charger will charge the battery at a 250 ma rate until the battery voltage reaches about 15 volts which indicates the battery is almost fully charged. Then the charger will trickle charge at a 25 ma rate. The red light on the charger is ON when the charger is charging at high rate. When the charger is in trickle charge, the light is OFF. The charger whould be left connected to the battery until the red light goes out and ceases to turn ON and OFF. Then the battery is almost fully charged. The battery should be recharged at a temperature of approximately 70°F (20°C). Continuous charging does not damage the battery.

When operating with the cigar lighter power cord, the battery will be partially charged by an operating automobile system in 5 to 15 minutes, and will be completely charged if the car is driven for 8 hours. Attaching the power cord to the cigar lighter with the engine running for a short time will charge a low battery sufficiently for a few tests. The power cord can be permanently attached to the car battery if desired.

The battery should be charged when the operating voltage drops to approximately 11.3 volts which is the top of the yellow arc. The battery can be charged more often if desired.

Best operating performance will be obtained with battery temperatures of 0°F to 120°F (-15°C to +50°C). The battery has less capacity and voltage at lower temperatures. Failure is indicated if the test procedure given in Section VII does not produce the desired results.

Temperature		Battery Life*
°F	°C	Hours
104	40	4
77	24	3.5
32	0	3
-4	-20	2

* Amplifier and chart drive ON: battery fully charged.

A fully charged battery operating at 70°F has sufficient energy to test 1000 wells which requires about 25 rolls of paper. Turning ON the amplifier only will discharge the battery in 24 hours.

Excessive storage periods without charging will severely reduce service life. A fully charged battery will discharge without use in 15 months at 77°F (25°C), in 6 months at 113°F (45°C), or in 50 months at 23°F (-5°C). A discharged battery deteriorates rapidly. Experience has indicated that the battery should be recharged at least monthly with the 110 VAC charger.

VOLT-AMP METER

The VOLT-AMP meter has 3 functions. The switch does not control whether the battery is being charged or not. The volt-amp meter only measures the battery voltage, or the battery charge, or the battery drain. The functions of each position follows:

VOLTAGE

The voltmeter reads battery voltage from 10 to 16 volts.

The approximate percent charge of the battery can be estimated by measuring the battery voltage. The battery should be about 70°F (20°C) and the amplifier ON and chart drive OFF or the following chart does not apply.

Battery Voltage	Percent Charge
12.5+	60+
12.2	40
12.0	20
11.8	0

With the amplifier and chart drive ON, the yellow arc indicates when charging should be performed. The red arc indicates that an unstable condition will probably exist. VOLTAGE is the normal operating mode because battery condition is indicated.

CHARGE

The CHARGE position measures the current which is supplied through the charging adaptor to the instrument. The meter measures from 0 to 2.5 amps. The amplifier and motor switches must be OFF to read the current to the battery.

The 110 VAC charger initially charges at 250 ma rate, which is the first mark to the right of zero, until the battery is charged and then drops to 25 ma.

The auto cigar lighter power cord will have a charge rate depending upon the condition of the battery.

DRAIN (OR OPERATE)

This position indicates the current used by the instrument. This meter measures from zero to 1 amp. Approximate current requirements are:

Item	**Current, ma.**
Amplifier ON	120
Amplifier, chart motor & pen ON	550 - 750

Charging Procedure

1. Turn OFF amplifier and chart drive.
2. Place VOLT-AMP meter switch in CHARGE position.
3. Attach either 110 VAC charger or cigar lighter power cord.
4. Observe meter.
   A. The 110 VAC charger will charge at a 250 ma rate until the battery is almost fully charged and then trickle charge at a 25 ma rate. Approximately, 14 hours is required to charge a fully discharged battery. If the battery is partially discharged, but a 250 ma charge rate is not indicated, check the EXTERNAL POWER fuse. If the fuse is open, replace the fuse.
   B. The cigar lighter will charge at a rate depending upon the condition of the Echometer battery. The charge rate will decrease as the Echometer battery becomes charged. The charge current can be over 3 amps when charging a fully discharged Echometer battery. When charging a very low Echometer battery from a cigar lighter, excessive currents may blow the fuse. If the fuse blows, replace the fuse and try charging with the automobile engine not running until the current drops below 1.25 amp. Then, run the car engine to increase the charge rate. If the Echomter battery is extremely low, the 110 VAC charger may have to be used to prevent blowing the fuse.

      A very small charge will be indicated if the Echometer battery is already fully charged.

External Power Fuse

A 3 amp fuse protects the charging circuit from excessive currents. Check the fuse if a charge is not indicated when it should be.

Battery Sulfanation

A very deeply discharged battery may not accept a charge normally. The red light does not come ON when using the 110 VAC charger, nor is a charge current indicated when using the cigar lighter charger. To recharge the battery, use the 110 VAC charger. At first, the red light will not be ON, but after a period of time up to 6 hours, the red light will come ON indicating the battery is accepting a charge. Then after about 14 hours, the red light will go out indicating the battery is charged.

IMPORTANT INSTRUCTIONS FOR RECHARGEABLE BATTERIES

1. Charge before using. Read your equipment manual for charging instructions. Use only the charger that comes with your equipment.

2. When not in use remove from equipment and store in cool dry place.

3. Do not short circuit battery terminals. Some batteries are protected with internal self-resetting fuses, but short circuits may still cause severe damage to the battery.

4. Keep away from fire and do not incinerate when disposing of the battery ... it may explode.

5. Under no circumstances should you attempt to open the battery case.

6. Do not expose battery to moisture or rain.

7. Do not drop, hit or abuse the battery ... it will break and may release electrolyte as well as expose cell contents which are corrosive.

SOME NOTES ON BATTERY USE

1. It is perfectly normal for the battery to become warm to the touch during charging and discharging.

2. Running time depends on the power demanded. Statements such as "2-hour" battery refer to laboratory tests of simple non-stop use of the equipment. Use of special features and accessories demands extra power and shortens run time. In the case of laptop computers features which use extra power and shorten battery run time include disc drives, hard drives, programs which use audio dialogue or music, as well as the intensity of your backlit screen.

3. The life of the battery under normal conditions may be as long as 1,000 charge-discharge cycles.

4. New batteries may require four or five charge-discharge cycles before they achieve their designed capacity.

5. Nickel cadmium batteries may be stored as long as 2 to 3 years without harm. However, for best results they should be charged periodically and stored in a cool dry place.

6. Sealed lead acid batteries may be stored as long as 12 to 18 months without harm. However, for best results they should be charged after every 8 months of storage and stored in a cool dry place.

7. It is normal for a battery to "self-discharge" itself during storage. Always fully charge your battery before you use it after it has been stored for over 1 week at a time.

Low Voltage Indicators

Amplifier-recorder units, having a serial number above 326, have an audible alert for indicating low voltage to the operator. Units, having a serial number below 327, use a low voltage protector which consists of a circuit breaker to disconnect the battery from the amplifier and chart drive.

Serial Number Above 326

When the voltage drops to approximately 11 volts, an audible alert indicates that the battery is at a minimum charge condition for satisfactory operation. The battery should have sufficient energy for a few more tests, but recharging the battery should be accomplished as soon as possible.

A BATTERY fuse is used to protect the amplifier and chart dirve circuits. The fuse is located to the right and below the meter. Use a 1.5 amp fuse. The voltmeter does not indicate battery voltage if the BATTERY fuse is blown.

Serial Number Below 327

A Low Voltage Protector is used to prevent damage to the battery which can result when operating the battery below 10.6 volts. The Low Voltage Protector circuit breaker is located to the right and below the voltmeter. The circuit breaker and control electronics will disconnect the battery from the amplifier and chart drive when the battery voltage drops below 10.6 volts.

The voltmeter will read zero volts if the Low Voltage Protector circuit breaker is open:

If the Low Voltage Protector circuit breaker disconnects the battery from the instrument.

1. turn OFF the amplifier and chart drive,
2. push in the red shaft on the Low Voltage Protector circuit breaker,
3. charge the battery with the 110 VAC charger or the cigar lighter power cord, and
4. check voltage, if the reading is not obtained, push in the Low Voltage Protector circuit breaker.

TESTING THE ECHOMETER

1. To test the amplifier-recorder and cable:
   A. Check battery voltage, recharge if needed.
   B. Attach the cable to the INPUT and TEST connectors.
   C. Turn amplifier ON.
   D. See Sensitivity controls to 6.
   E. Depress TEST button, then release button. Pen should respond ½" or greater (see sample charts). Test in UPPER COLLARS, DEEP COLLARS and LIQUID LEVEL to insure correct response in all three filter positions.

   If pen does not respond, try another cable.

2. To test the Microphone:

   A. Perform above test to prove condition of amplifier-recorder and cable. Clean wellhead including microphone.
   B. Attach cable to INPUT and Microphone.
   C. Attach test bulb. Close gas valve by lifting cocking arm. Close casing pressure bleed valve.
   D. Turn amplifier ON.
   E. Set filter to LIQUID LEVEL.
   F. Set the LIQUID LEVEL sensitivity to 1.
   G. Depress rubber bulb sharply, delay, then release bulb suddenly.
   H. Pen response should be in excess of ½". (See sample chart).

The microphone could have a resistance in excess of 10 megohms and a capacitance in excess of 0.02 microfarads.

Do not attempt to repair the amplifier unless familiar with complex, low frequency, high gain transistorized amplifiers. The warranty is voided if repairs are performed by an unauthorized repair station without prior permission.

ECHOMETER TEST RECORDS

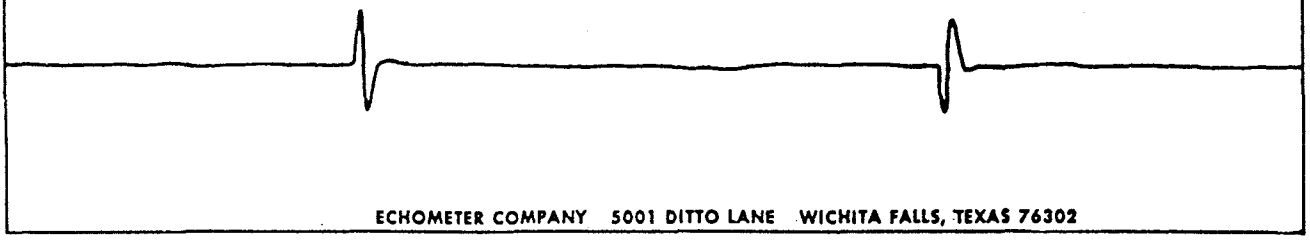
AMPLIFIER - CABLE TEST

PRESS TEST BUTTON

RELEASE TEST BUTTON

UPPER COLLARS

SENSITIVITY = ___ APPROXIMATELY 7



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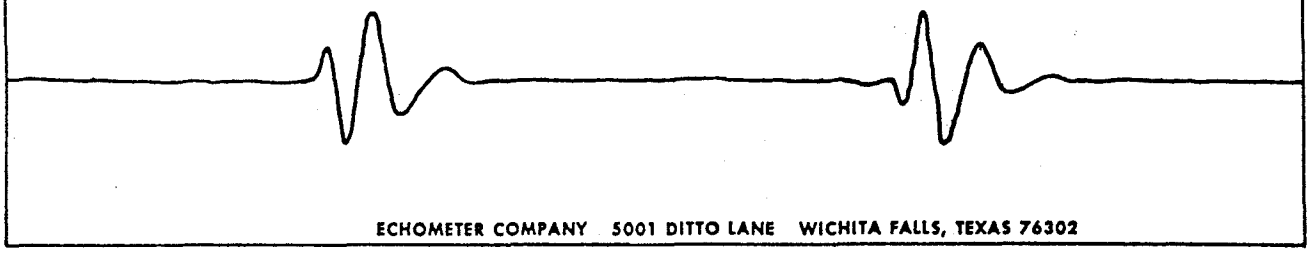
DEEP COLLARS (Normal on Model B-1)

SENSITIVITY = ___ APPROXIMATELY 6



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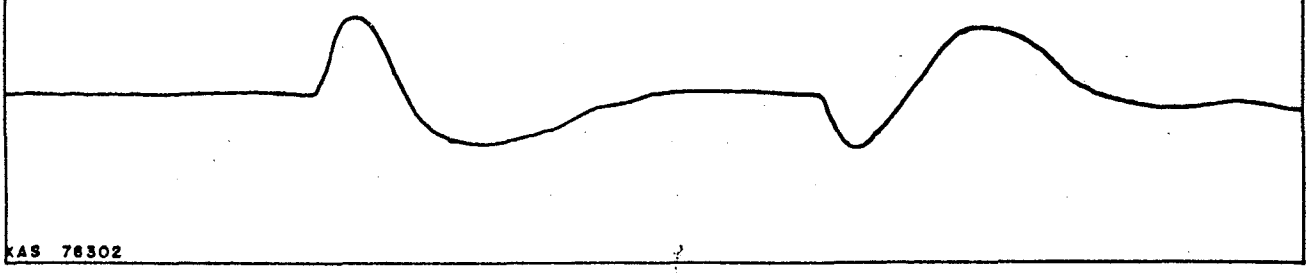
FLUID LEVEL

SENSITIVITY = ___ APPROXIMATELY 6



XAS 76302

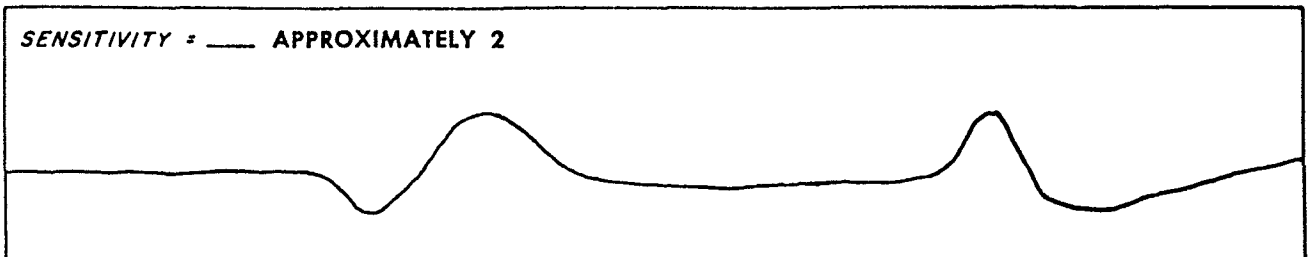
MICROPHONE TEST

FLUID LEVEL POSITION

PRESS BULB

RELEASE BULB

SENSITIVITY = ___ APPROXIMATELY 2



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D.C.M.

AUGUST, 1968

MAINTENANCE

The Echometer amplifier-recorder should be clean. Keep proper pen tension described in Section II. Charge the battery when the voltage drops into the yellow arc or monthly, whichever occurs first. Do not jar unit.

The gas gun should be cleaned every 500 shots or monthly, whichever occurs first. Be sure to check all threads, the moving gas valve, and all other pieces thoroughly. If any signs of wear or deterioration exist, replace before using. Replace the o-rings when any sign of wear or deterioration exists. Lubricate the gas valve and all O-rings with light oil before assembly.

The microphone is located at the lower end of the gas gun. The microphone can be removed by unscrewing a 10-32 x 1¼" cap screw. Be sure the O-rings are installed before replacing the microphone or installing a new microphone.

SPECIAL PRECAUTION

When the gas gun is disassembled, always remove the microphone first. Assemble Housing Cap to Housing with 4 bolts before installing microphone. Improper assembly can cause damage to the Microphone Electrical Wire Tube.

PARTS LIST

Part No.	Description
MS139	Chart Paper, 125'/Roll (Usually supplied 50 rolls to the case)
RE140	Battery
RE395	Writing Pen, 12 VDC
MS175	Eleven Point Dividers
MS200	Supply Box
	Cables:
MS115	5' Length
MS120	10' Length
MS125	25' Length
GG334	Microphone Test Bulb
GG301	Set of O-Rings
MS195	Owners Manual (D with Gas Gun)
Compact Gas Gun	See Drawing in this Section
CO_2 Containers	See Drawings at end of CO_2 Information in Appendix

USE OF RATE OF FILLUP GRAPH

The accompanying graph is very useful in liquid level work. The graph indicates the initial rate of fill up between casing and tubing in a well for a certain producing rate after the well is shut-in.

The chart is read as follows: If the well produces less than 100 BPD, find the point on the bottom scales corresponding to the producing rate, read straight up until intersecting the line indicating the pipe sizes, then read to the left to find fill up rate. For over 100 BPD, find the point on the top scale corresponding to the producing rate, read down until intersecting the line indicating the pipe sizes, then read to the right to find fill up rate. Note that the top and right scales are ten times the lower and left scales. For over 1000 BPD rates, divide the producing rate by 10, 100, 1000, etc., to locate the rate on the upper scale, then multiply this figure times the fill up rate obtained on the right scale.

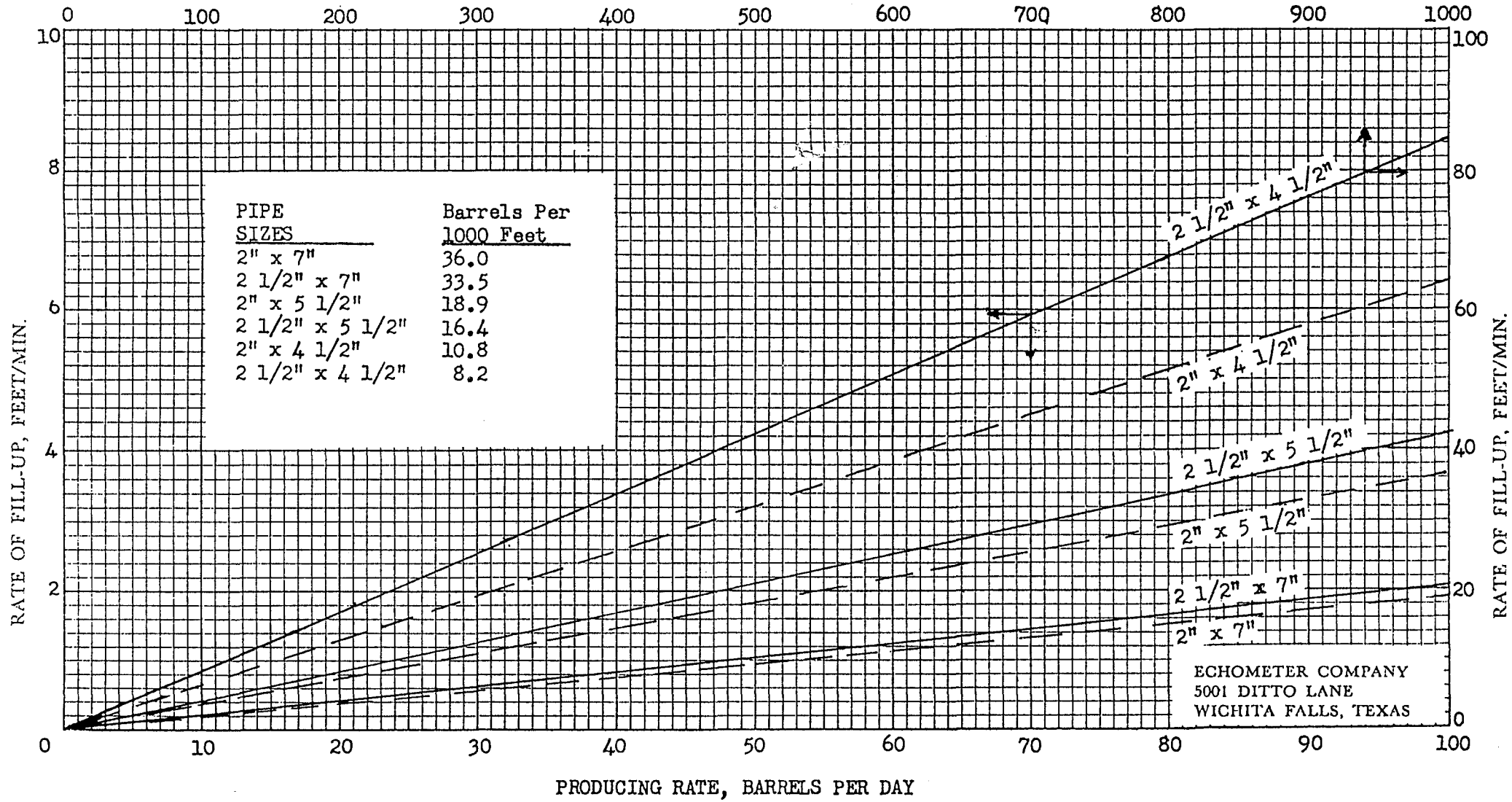
For example, if a well which has 2" tubing and 5½" casing is producing 60 BPD, the initial fill up rate is 2.2 feet per minute. A well with 2½" tubing and 4½" casing, producing at 700 BPD will have an initial fill up rate of 59 feet per minute.

USE OF RATE OF FILLUP INFORMATION

If a well is shut down for ten minutes for surface connection work prior to a liquid level shot and the initial fill-up rate is only 1.3 feet per minute, then the maximum error would be only 13 feet due to the shut in time. However, if the fill up rate is 35 feet per minute, the maximum error could be as high as 350 feet.

The fill-up rate found in the chart is the initial rate at which liquid will fill the casing annulus. This rate decreases as the pressure in the well bore approaches the static reservoir pressure. For example, if the static reservoir pressure is 1000 PSI, the reservoir pressure will support approximately 2500 feet of liquid (assuming low casing pressure), so the fill-up rate found on the chart would be within 10% for the first 600 feet or so. However, if the static reservoir pressure would support only 900 feet of liquid, then the fill-up rate would be reduced to one-half by the time the well had filled with 600 feet of liquid.

RATE OF FILL-UP



Technique for Determining Chart Speed

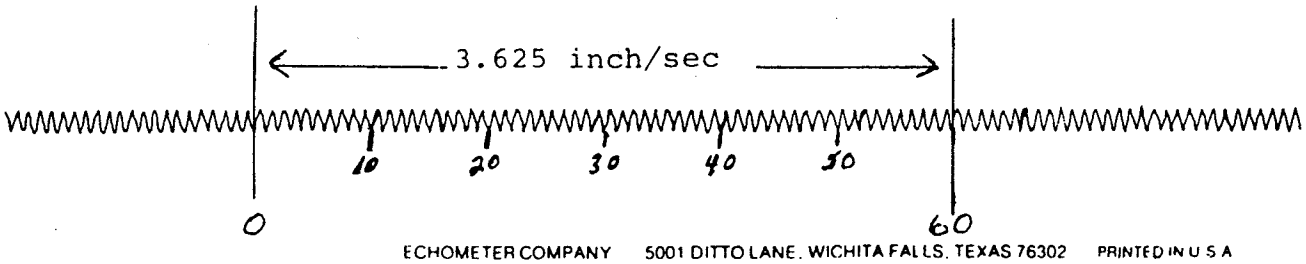
Introduction

60 hertz energy is present around electric equipment, electric lines, and lights. The 60 hertz signal can be fed into the Echometer amplifier and recorded on the chart. Then, 60 cycles can be measured and marked on the chart. The length of 60 cycles is measured and the length indicates actual chart speed/second since a frequency of 60 cycles per second is used in the United States.

Procedure

1. Straighten a paper clip or locate a short piece of small wire about 6" long.
2. Insert wire into the gold connector in the amplifier INPUT.
3. Turn amplifier POWER ON.
4. Place filter in UPPER COLLARS.
5. Increase Sensitivity until 1/8" pen response is obtained.
6. Turn chart drive ON and run chart 6-8 inches.
7. Count 60 cycles.
8. Measure the length of 60 cycles.
9. The length represents chart speed per second.

Example



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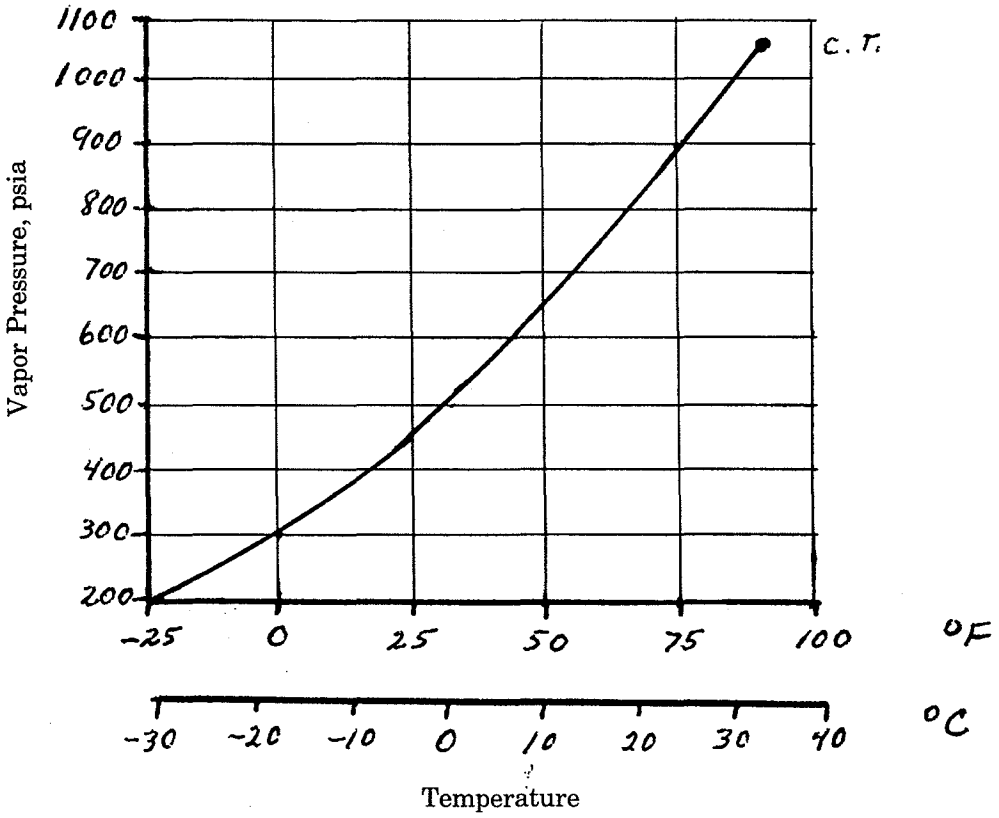
CARBON DIOXIDE INFORMATION (CO_2)

Carbon dioxide is a nonflammable, colorless, ordorless, slightly acid gas. It is approximately one and one-half times as heavy as air. It is commonly available.

CO_2 is used in the carbonation of soda pop, as an inert agent in fire extinguishers, in refrigeration, in canned food products, and many other applications.



VAPOR PRESSURE VS. TEMPERATURE

Below 88°F, confined CO_2 liquid and gas are in equilibrium at a vapor pressure shown on the above graph. For example, a container of CO_2 liquid and gas at 70°F has a pressure of 840 PSIA. As gas is removed from the cylinder, the liquid vaporizes into a gas which maintains the vapor pressure. When all the liquid has been vaporized, the gas pressure will reduce as gas is withdrawn from the cylinder.

Above 88°F, CO_2 becomes a fluid. Liquid will not be present. The pressure in the tank is an indication of the volume of CO_2 fluid present in the tank.

The amount of CO_2 in a cylinder is determined by weighing the cylinder having the CO_2 in it and then subtracting the weight of the empty cylinder.

CO_2 CAUTION

Do not overfill a container or dangerous pressures can result.

CO_2 is heavier than air and may collect in confined, unventilated areas. Do not permit a leaking cylinder in a closed automobile. CO_2 is the regulator of the breathing function, and an increase in the CO_2 inhaled will cause an increased rate of breathing. In high concentrations, CO_2 can paralyze the respiratory system. The normal concentration of CO_2 in the air is 300 p.p.m. Do not breathe air having excessive amount of CO_2.

HANDLING PRECAUTIONS

Never drop cylinders or permit them to strike each other violently.

Do not discharge CO_2 in confined, poorly ventilated areas, since displacement of air can cause asphyxiation and/or increased breathing rate.

Spillage of liquid CO_2 on the skin can cause frostbite. Wear protective clothing and gloves when handling liquid CO_2.

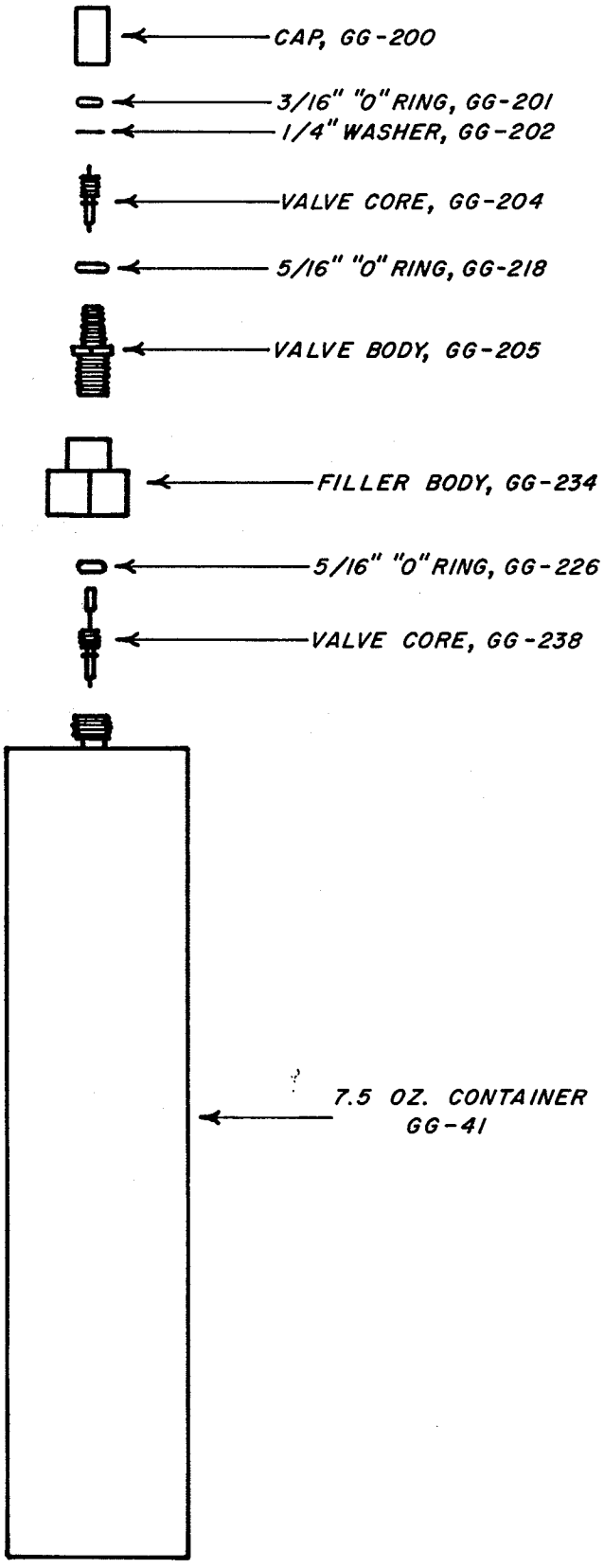
Do not store CO_2 cylinders in sub-surface or closed areas. CO_2 is heavier than air and leaking gas could cause suffocation.

CO_2 leaks can be detected by painting suspected areas with soap solution, or by holding a squeeze bottle containing aqueous ammonia in the area (leaks will be indicated by formation of a white ammonium carbonate cloud). See your local gas supply dealer for other precautions. See additional instructions on container if present.

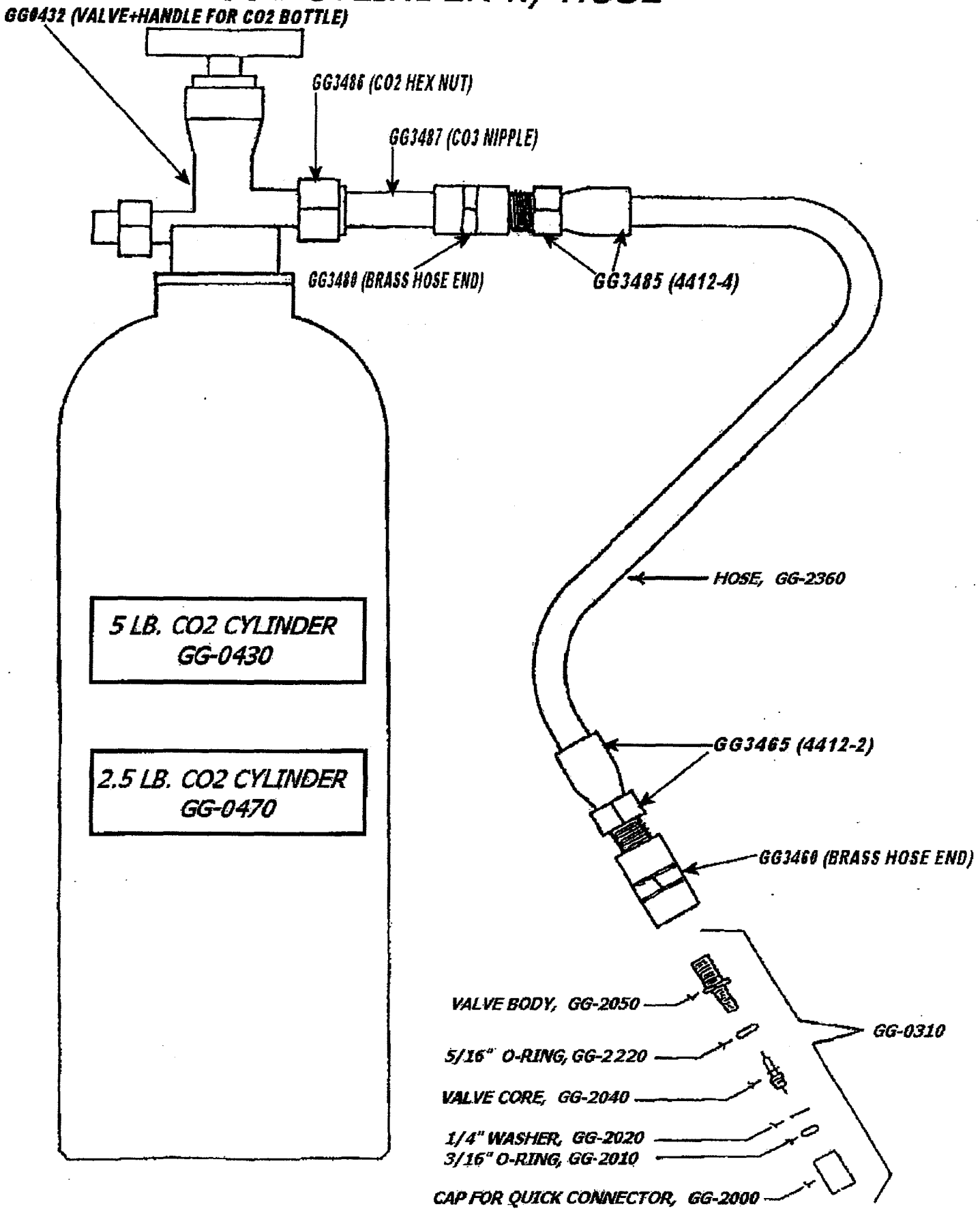
PHYSICAL CONSTANTS

Vapor Pressure @ 70°F.	830 p.s.i.g.
Density, Gas @ 70°F., 1 atm.	0.1146 lb./cu. ft.
Critical Temperature	87.8°F. (31°C)
Critical Density	0.468 g./ml.
Critical Pressure	1072 PSIA (73 atm.)
Specific Gravity	1.53
Specific Volume @ 70°F., 1 atm	8.76 cu. ft./lb. or 15,000 cu. in./lb. or 950 cu. in./oz.

7.5 OZ. CO_2 CONTAINER



CO2 CYLINDER w/ HOSE



NITROGEN INFORMATION (N_2)

Nitrogen comprises approximately 79% by volume of the air. It is found chemically combined in many forms in nature. Nitrogen will not burn and will not support combustion. Nitrogen is normally available in cylinders compressed to 2200 PSI.

Nitrogen is used as an inert gas in electrical systems, the chemical industry, and in the food packaging industry. Nitrogen also finds extensive use as an inert atmosphere and in the filling of some incandescent lamps.

Nitrogen is nontoxic but can act as an asphyxiant by displacing the necessary amount of air to sustain life.

HANDLING PRECAUTIONS

Never drop cylinders or permit them to strike each other violently.

Never tamper with safety devices in valves or cylinders. See your local gas supply dealer for other precautions.

PHYSICAL CONSTANTS

Molecular Weight	28.016
Density @ 70°F., 1 atm	0.17247 lb./cu. ft.
Critical Temperature	-232.87°F. (-147.15°C.)
Critical Pressure	492.45 PSIA (33.5 atm.)
Specific Volume, @ 70°F., 1 atm.	13.8 cu. ft./lb. or 31,000 cu. in./lb.