OPERATING INSTRUCTIONS

and

TECHNICAL DATA

for

100 Kc
FREQUENCY STANDARD

TYPE MODEL

BCS – 1A

Manufactured by

BLILEY ELECTRIC COMPANY

UNION STATION BUILDING

ERIE, PENNSYLVANIA

This Manual is Furnished Specifically For
Use With BCS - 1A Frequency Standard

Serial _____

BULLETIN 41

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PURPOSE

The Bliley BCS-1A Frequency Standard was developed for the purpose of making available to laboratories and industrial organizations a frequency source which has a stability approaching that of a primary standard and at the same time will maintain this stability when used in portable or semi-portable service.

The standard is designed to maintain a stability over a twenty-four hour period of 2 parts in ten million. The long term stability is 2 parts per million over a thirty day period without resetting, and over line voltage fluctuations of plus or minus 10%. The entire instrument is constructed for rugged service conditions, such as changes in ambient temperature, air pressure, and humidity. It was constructed with long life features such as the use of high rated capacitors, resistors, transformers, and other components, and the use of red based 10,000 hour tubes in the oscillator and automatic gain control circuits.

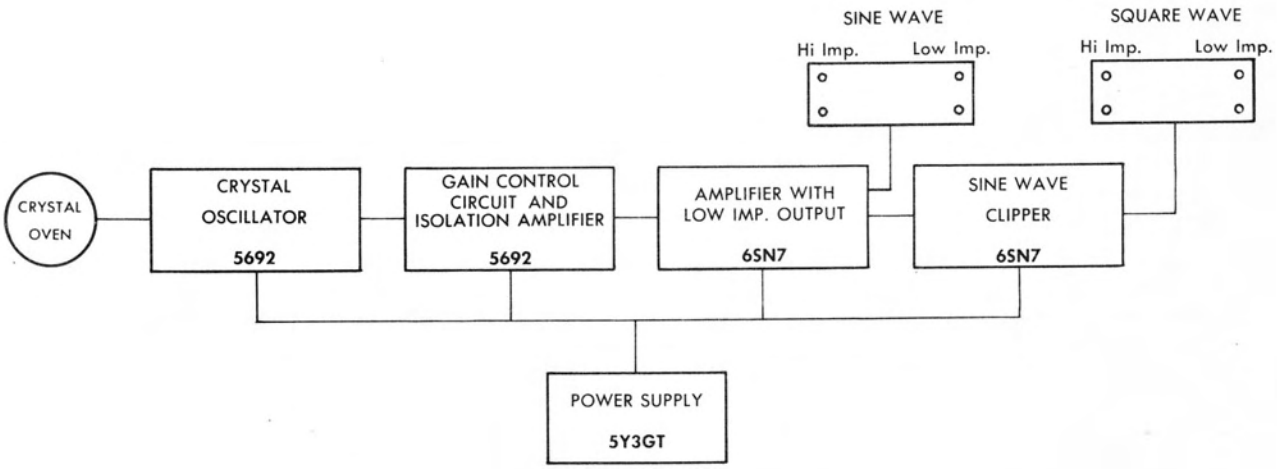

FIGURE 1. BLOCK DIAGRAM

GENERAL DESCRIPTION

A - CRYSTAL

The frequency controlling element of the Bliley BCS-1A 100 Kc. Frequency Standard is a GT cut quartz crystal which is silver plated on its faces, and rigidly clamped between resonant steel pins. The frequency temperature characteristic of this crystal is inherently very flat and special care is taken to orient and proportion the blank so that minimum frequency deviation occurs at 60°C, the temperature at which the oven operates. The holder assembly is mounted inside an evacuated metal can, which protects it from atmospheric effects, dust, corrosion, etc., and at the same time decreases the equivalent series resistance of the crystal to about 90 ohms. This low resistance, which corresponds to a "Q" of about 200,000 contributes greatly to the life and overall stability of the standard.

B - OVEN

The crystal holder is mounted inside a plug-in oven assembly whose temperature is controlled to 60 degrees centigrade by a mercury thermostat with a sensitivity of .05 degrees. Heat is applied to the oven through a 6.3 volt AC heater winding by the closing of a sensitive DC relay. Current for this relay is supplied by the 200 volt DC supply of the frequency standard through a bleeder resistor, resulting in a 10 volt drop across the relay coil. When the oven temperature reaches 60 degrees centigrade, the mercury thermostat contacts close which in turn shorts out the relay coil, causing the relay contacts to open. The DC potential across the thermostat is only 10 volts, and current flow is about 1.8 milliamperes, which assures long thermostat life.

A mechanical thermostat is also incorporated in the oven as a protective device. In the event of failure of the mercury thermostat, or sticking of the relay contacts, the mechanical thermostat will still provide reasonable regulation of the oven. These precautions are taken to give adequate protection to the oven and crystal under abnormal conditions.

C - CIRCUIT

The oscillator tube is a red based 10,000 hour twin triode type 5692, operating in a low impedance circuit. The crystal is connected into the low impedance feedback path, and oscillates very near series resonance. A variable capacitor in series with an inductance provides fine frequency adjustment around the crystal's series resonance frequency.

In order to obtain most stable operation from the oscillator stage, an automatic gain control (AGC) system is included, which serves to regulate the amplitude of oscillation. Through this arrangement the oscillator tube operates only in the linear portion of its plate curve, and produces much more stable and undistorted output than is available from an uncontrolled oscillator. One half of a second 5692 tube functions as AGC rectifier, the other half as a cathode follower buffer stage.

The third tube is a type 6SN7 GT tube which produces sine wave output at both high and low impedance. This stage is followed by a 6SN7 GT tube operating in a clipper circuit which produces square wave output at high and low impedance.

The power supply unit employs a 5Y3 tube as high voltage rectifier, and delivers 180 volts of filtered DC to the standard. Oil filled 600 volt paper condensers are used in the filter system to assure long, trouble free service. A 6.3 volt winding on the power transformer supplies heater voltage to the 5692 and 6SN7 GT tubes. A separate 6.3 volt transformer furnishes voltage for the oven heater.

D - OUTPUT

Sine wave, high impedance:	Approximately 15 volts
Sine wave, low impedance:	Approximately 2 volts
Square wave, high impedance:	Approximately 15 volts
Square wave, low impedance:	Approximately 2 volts

These voltages are peak values.

E- STABILITY

The frequency standard is operated for at least a fifteen day period before shipment which takes care of the initial "aging" of the crystal. After this fifteen day aging period, the frequency will not change more than 2 parts per million during the next thirty days of operation, and will hold within 4 parts in 10 million for periods of twenty-four hours. As the crystal ages further, stability improves until after three months of operation the frequency will not change more than 2 parts in 10 million over twenty-four hour periods, and considerably less than 2 parts per million over thirty day periods. Stability will improve further with aging, and after one year, additional aging is of an extremely low order. If the oven is shut off, for power failure, or other reason, stabilization of twenty-four hours is required before the above stability is again reached.

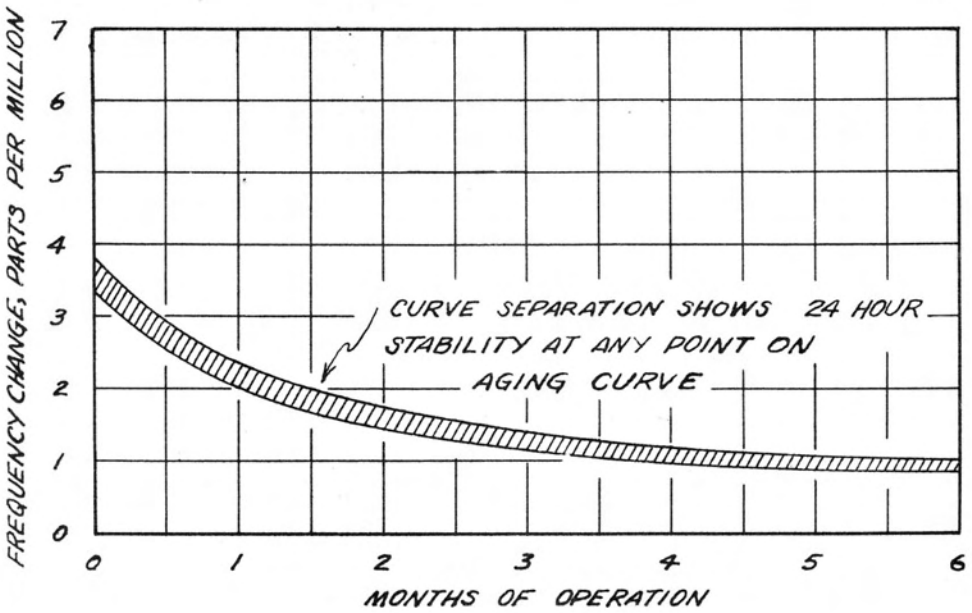

FIGURE 2. AGING CURVE

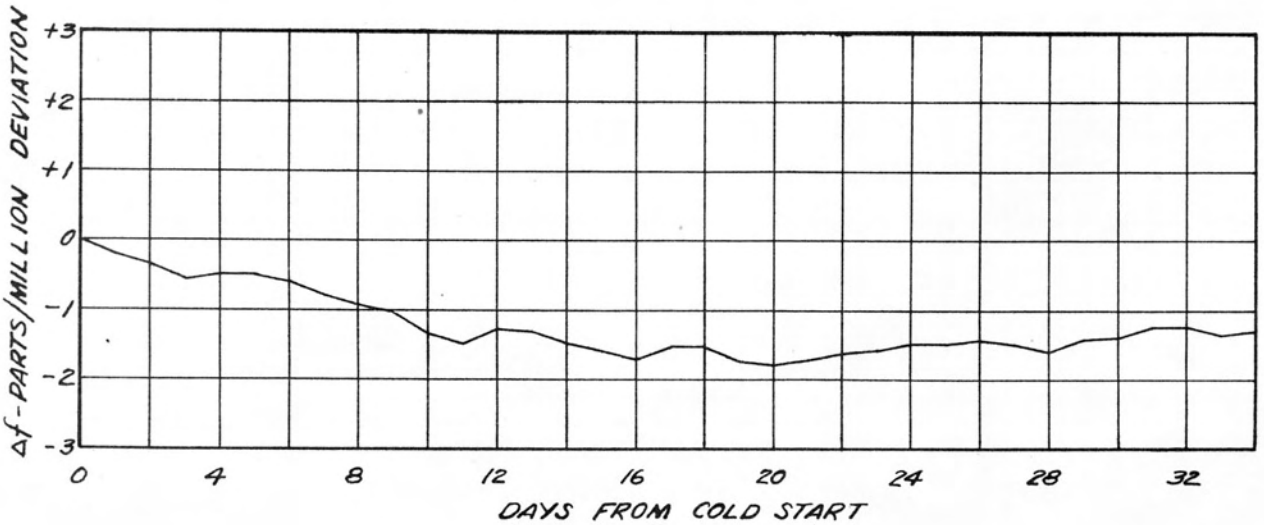

FIGURE 3. STABILITY CURVE

The effect of line voltage fluctuation on stability can be seen in Figure #4. Because of the highly stable circuits employed in the frequency standard, line voltage has a very small effect on the output frequency. As a matter of fact, regulation of either plate or heater voltages was considered unnecessary.

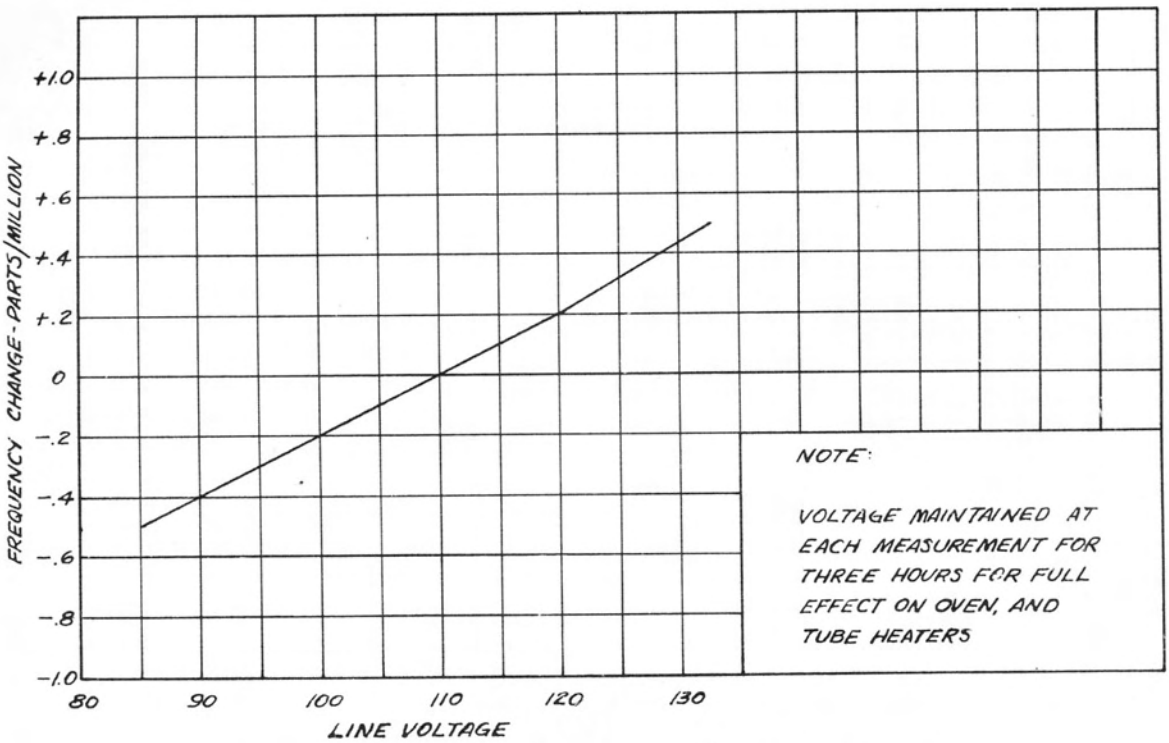

FIGURE 4. FREQUENCY SHIFT VS. LINE VOLTAGE

PRINCIPLES OF OPERATION

A - OSCILLATOR

The oscillator circuit used in the frequency standard is shown in Figure #5 along with the automatic gain control system. Triode section V_{1A} functions as an impedance matching stage, taking the voltage developed across L_2 and C_4 at a high impedance, and transferring it to a low impedance for feedback through the crystal circuit.

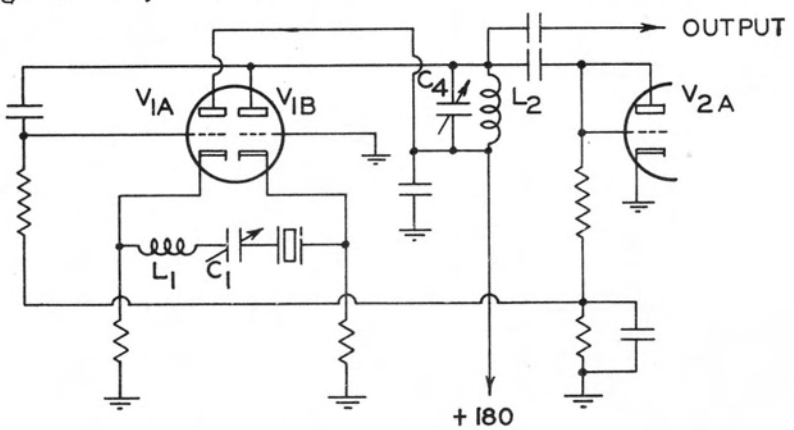

FIGURE 5. OSCILLATOR AND AGC SCHEMATIC

Section V_{1B} operates as a grounded grid amplifier with a transconductance of about 3500. Feedback voltage from the crystal is coupled into the cathode circuit, and the amplified voltage appears across the output coil L_2 which is tuned by C_4 to the crystal frequency.

Coil L_1 and capacitor C_1 are connected in series with the crystal to facilitate minor frequency adjustment. The inductance and capacitance are chosen so they are series resonant at the crystal frequency, in which case the oscillating frequency will be exactly that of the series resonant frequency of the crystal. If the capacity of C_1 is increased or decreased, a small amount of inductive or capacitive reactance is placed in series with the crystal, and the oscillating frequency will go slightly lower or higher respectively. Component values are chosen so an adjustment of plus and minus .0025 per cent is secured with the variable capacitor C_1. Exact series resonance corresponds to approximately mid-scale on the adjustment dial.

B - AUTOMATIC GAIN CONTROL

An oscillator circuit in which the tube is operated as a Class A amplifier with some form of amplitude control employed, will operate with much better stability and wave shape than if it is allowed to build up oscillations to a point where the plate curve reaches saturation. The high degree of circuit stability of the Bliley BCS-1A is achieved through the use of such a circuit.

Tube section V_{2A} is connected as a diode output rectifier which furnishes a bias voltage directly proportional to oscillator output. This voltage is used to control the gain of the triode V_{1A}. When the amplitude of oscillation increases, causing the bias voltage to increase, a point of equilibrium is automatically reached where the amplitude remains constant. Through proper proportioning of the resistance network, the point of equilibrium is chosen so that V_{1A} and V_{1B} are operating along the linear portions of their plate current curves. Under these conditions the oscillation frequency is effected to a very slight degree by changes in the oscillator circuit, such as aging, temperature and humidity effects on the oscillator tube, and other components.

C - BUFFER

The output of the oscillator is coupled to the grid of triode section V_{2B}, which acts as a cathode follower buffer stage. Its low impedance output is coupled directly into the cathode of section V_{3A} which functions as a grounded grid second buffer and amplifier. This arrangement provides a high degree of isolation between the oscillator stage and the output circuits. The plate circuit of V_{3A} supplies a sine wave output of approximately 15 volts peak, to the high impedance output terminal. A portion of its output is also coupled to the grid of tube section V_{3B} which supplies a low impedance sine wave output of about 2 volts.

D - SINE WAVE CLIPPER

The plate circuit of V_{3A} is also coupled to the grid of tube section V_{4A}. Since the sine wave voltage at the grid is about 15 V., the plate current of the stage will swing quite rapidly from cutoff to saturation, producing fairly good square wave output. Further "clipping" action by another stage will provide a steeper rise and fall of the square wave; however, single stage clipping is considered adequate for the purpose intended in the frequency standard. The

output of V_{4A} is coupled to V_{4B} which supplies high impedance output of the square wave at approximately 15 volts peak, and low impedance output at about 2 volts.

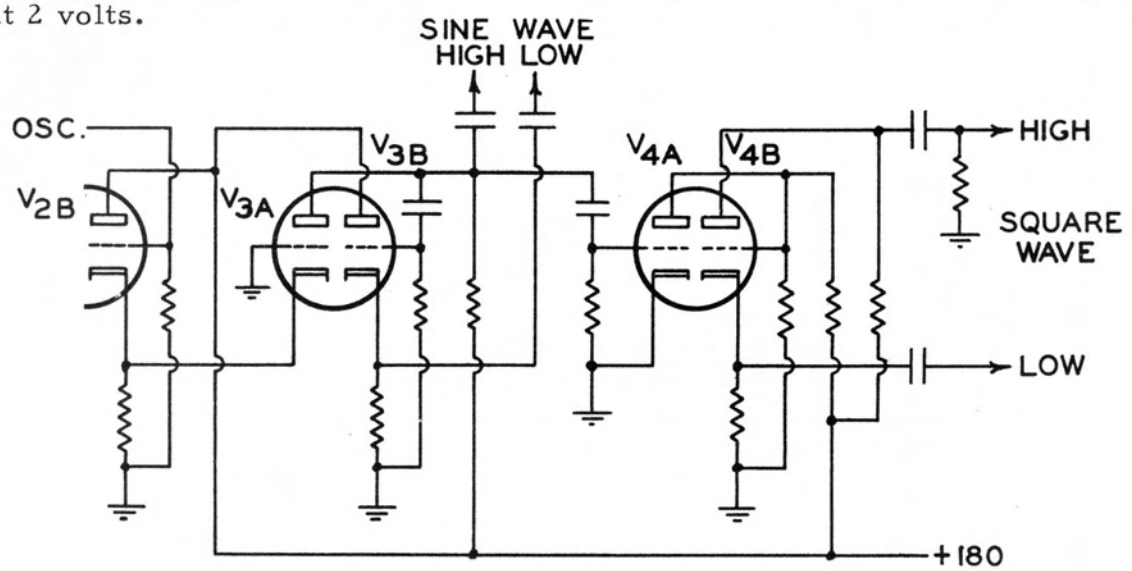

FIGURE 6. BUFFER AND CLIPPER SCHEMATIC

INSTALLATION

A - VACUUM TUBES

The Frequency Standard is shipped from the factory with all tubes in place. Tube type numbers are stamped on the chassis beside the sockets. The tube complement consists of (2) dual triodes 5692, long life series, (2) 6SN7 GT, dual triodes and (1) 5Y3 GT rectifier.

B - POWER SUPPLY

The standard model BCS-1A requires 110 volts at 50 to 60 cycles. Power consumption is 60 watts.

C - OUTPUT TERMINALS

A strip of terminals on the rear of the chassis parallels the jack block terminals on the front panel, and may be used for connecting to other equipment from the rear.

OPERATION

A - PLATE SWITCH

When the frequency standard is connected to the supply line, the tube heaters and oven heater are operating continuously. To prevent accidental interruption of the heaters, switches were eliminated. A pilot light indicates power being supplied to the standard. A plate supply switch is included on the front panel for cutting off the DC supply voltage. This switch allows the output signals to be shut off without losing temperature control in the oven. Since the stabilization aging rate of the crystal is slowed down somewhat when the plate switch is in the "off" position due to the crystal being non-operating, it is desirable to have the crystal oscillating as continuously as possible for at least the first three months of use.

B - FREQUENCY ADJUSTMENT

A screw driver slot (under snap cover), and indicator dial are provided on the front panel for setting the frequency exactly, against a known standard, such as one of the WWV Bureau of Standards Stations. A warm up period of at least one hour, (preferably two or three hours) is required from a cold start, before frequency adjustment is made. This adjustment should then be checked after several hours of operation. To assure the greatest accuracy when the frequency standard is new, it may be desirable to check the frequency at regular intervals and make any necessary adjustment as the crystal ages. After about three months of operation the crystal will reach a high degree of accuracy (2×10^{-7}), and the frequency will stay within these limits for twenty-four hours and longer without adjustment.

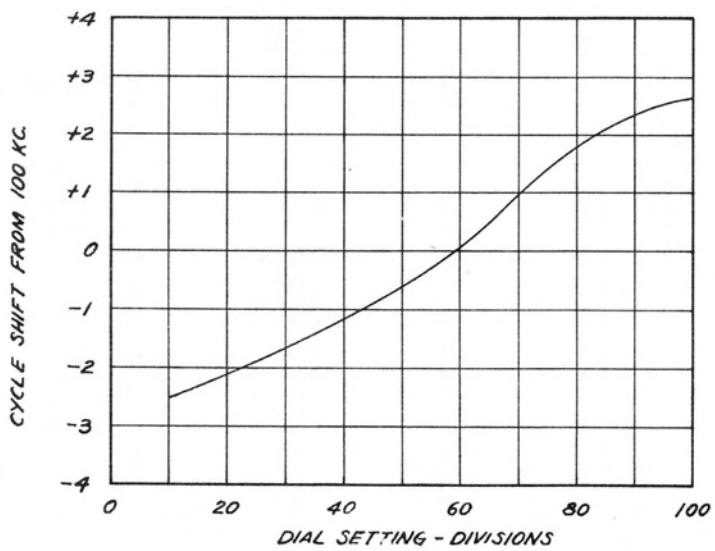

FIGURE 7. DIAL CALIBRATION CHART

C - OVEN THERMOSTAT

Proper operation of the mercury thermostat control system is indicated by a regular "on-off" cycling of the oven pilot lamp. This period will normally be from one to three minutes, after warm-up, depending considerably on the ambient temperature. If the oven pilot is either off or on all the time, the system is not functioning properly and frequency stability will be impaired.

If the oven pilot stays on continuously, it may be noted that its brilliancy changes slightly over short intervals, This condition indicates that the bi-metallic safety thermostat is controlling at about 70 degrees centigrade. This safety thermostat was incorporated in the unit simply to protect the assembly; and in case of extreme emergency still give reasonably good frequency stability. For this reason if such symptoms are noticed the mercury thermostat should be examined immediately to determine the cause of the trouble.

The major casualties in mercury thermostats occur in shipment, not from breakage but from separation of the mercury column. The oven has been mounted on shock mounts to reduce this possibility. However, due to the inertia of the mercury under certain conditions the column still may become separated.

The column may readily be joined by the simple procedure of either cooling or heating, (but exercising caution in heating) to pull the column either down completely into the well or raise it up into the small expansion chamber space at the top so as to make a continuous column when the mercury drops back down in the column. The thermostat is readily accessible through the top cover of the oven after the outside metal casing has been removed.

COMPONENT PARTS LIST

BLILEY BCS - 1A

SYMBOL	
R1, R10	22,000 ohm, 1 w
R2, R3	2,200 ohm, 1 w
R4	470,000 ohm, 1 w
R5, R15	10,000 ohm, 1 w
R6, R8	470 ohm, 1 w
R7, R9, R11, R13	47,000 ohm, 1 w
R12	330 ohm, 1 w
R14, R16	100,000 ohm, 1 w
R17	1,000 ohm, 10 w wire
R18	18 ohm, 1 w
R19	1,500 ohm, 1 w
C1	140 mmf, variable
C2	270 mmf, NPO Ceramicon
C3, C7, C8, C11, C12, C14	.001 mfd, mica, 500 volt
C4	140 mmf, air trimmer
C5, C13	100 mmf, NPO Ceramicon
C6, C22	.5 mfd, Dykanol 600 volt
C9, C23	.1 mfd, Dykanol 600 volt
C10	20 mmf, NPO Ceramicon
C15, C16	.01 mfd, mica, 300 volt
C17	.01 mfd, mica, 500 volt
C18, C19	4 mfd, Dykanol 600 volt
C20, C21	.005 mfd, mica, 500 volt
L1	8 mh, rf coil (approx.)
L2	16 mh, rf coil
T1	Power Transformer, primary, 115 volts 50-60 cycles. high voltage secondary, 250-0-250 volts @ 50 ma. filament no. 1, 5 volts @ 2 amps. filament no. 2, 6.3 volts @ 2 amps.
T2	Filament Transformer, primary, 115 volts 50-60 cycles. secondary, 6.3 volts @ 3 amps.
CH	Filter Choke, 10 henries @ 50 ma.
Tube Complement	Two 5692, Two 6SN7 GT, One 5Y3 GT

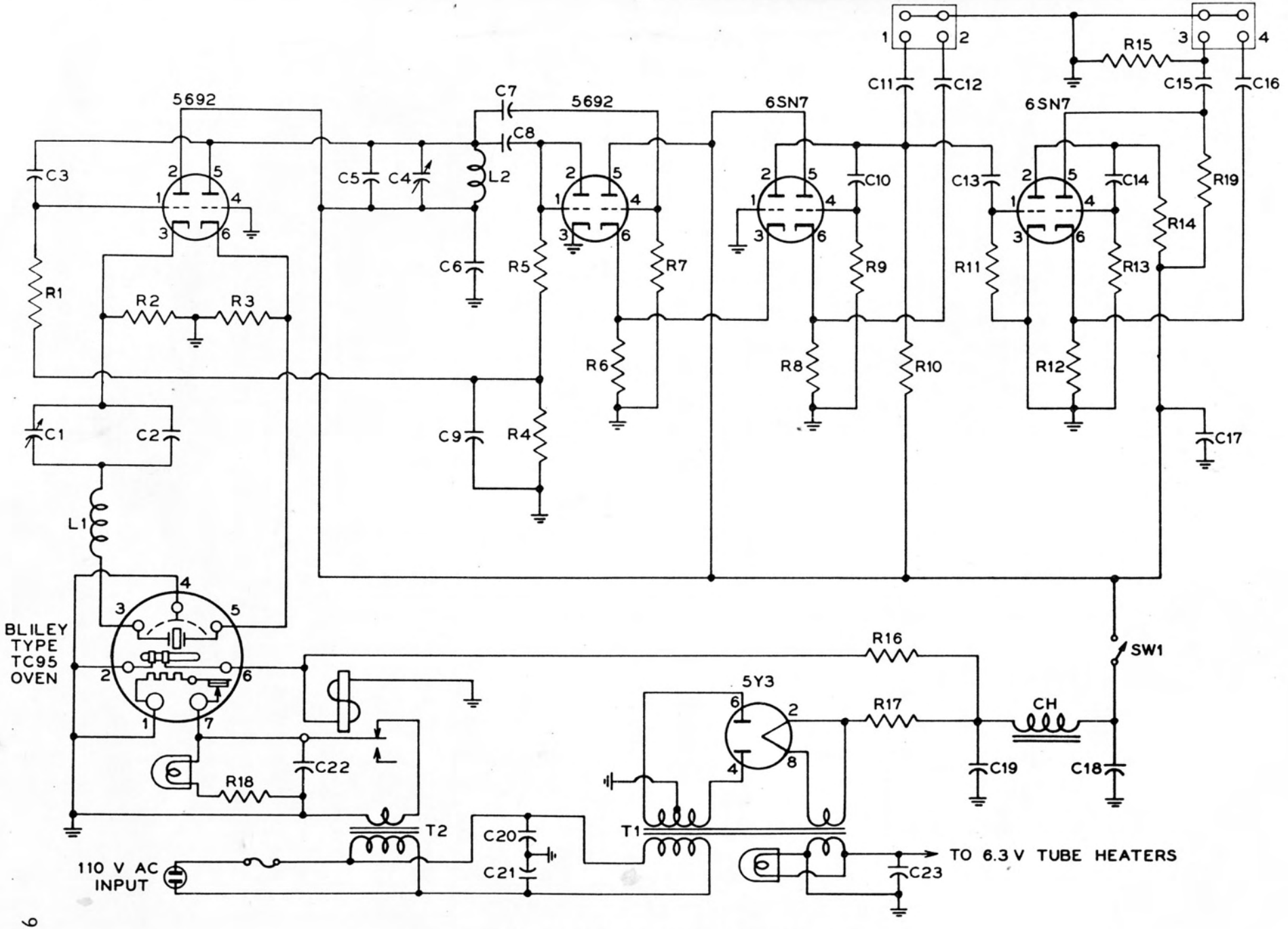

FIGURE 8. COMPLETE CIRCUIT DIAGRAM

WARRANTY

The Bliley Electric Company warrants each new BCS-1A frequency standard manufactured by it to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part in exchange for any part of any unit of its manufacture which under normal installation, use and service discloses such defect, provided the unit is delivered by the owner to us, intact, for our examination, with all transportation charges prepaid to our factory, within ninety days from the date of sale to original purchaser and provided that such examination discloses in our judgment that it is thus defective.

This warranty does not extend to any equipment which has been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation, or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory, nor to cases where the serial number thereof has been removed, defaced or changed, nor to accessories used therewith not of our own manufacture.

Any part of a unit approved for remedy or exchange hereunder will be remedied or exchanged without charge to the owner.

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of this equipment.

BLILEY ELECTRIC CO. . . . . UNION STATION BUILDING

ERIE, PENNSYLVANIA, U.S.A.