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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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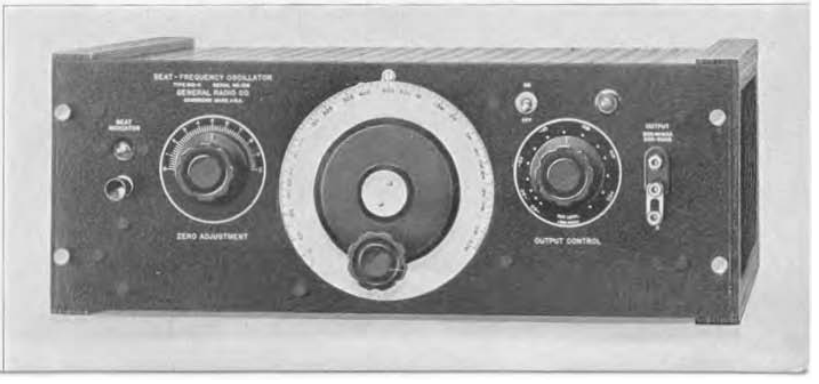
BRINGING THE BEAT-FREQUENCY OSCILLATOR UP TO DATE

● OF THE THREE COMMON TYPES OF AUDIO-FREQUENCY OSCILLATOR — the tuned circuit, the beat-frequency, and the degenerative or resistance-tuned—each has certain inherent advantages which make it preferable to other types for certain applications, while each has also certain disadvantages which must be eliminated as far as possible in a practical design.

The beat-frequency oscillator, in particular, is characterized by the relative simplicity with which the frequency can be changed over a wide range by varying a single control. Furthermore, with reasonable design precautions the output of such an oscillator can be made substantially constant as the frequency is varied. These two characteristics make the beat-frequency oscillator well suited for measuring the frequency response of amplifiers, filters, and other communication networks, and, for this application, it has almost completely superseded the older tuned-circuit type.

On the other hand, the beat-frequency oscillator has certain inherent disadvantages which must be overcome in any satisfactory design. In the first place, since the output frequency is obtained by heterodyning

FIGURE 1. Panel view of the TYPE 913-A Beat-Frequency Oscillator.



two higher-frequency oscillators, any given percentage drift in one of these oscillators with respect to the other will cause a much higher percentage drift in the output frequency. For instance, assuming that the high-frequency oscillators are operating around 100,000 cycles and one of them drifts 0.1%, or 100 cycles, the drift is then equivalent to 100% for an output frequency of 100 cycles. This was not an uncommon occurrence in earlier types of beat-frequency oscillators during the warming-up period.

The second troublesome characteristic of the beat-frequency circuit is the "pulling-in" effect. As the beat frequency is lowered, any direct coupling between the two high-frequency oscillators becomes more serious, since one oscillator tends to pull the other into step with it. At frequencies above that at which the oscillators actually lock in together, this pulling in causes a serious distortion in the beat waveform.

A third disadvantage of the beat-frequency oscillator is that the beat frequency is generally obtained at a fairly low level and must be amplified. If the oscillator is to compete with other low-distortion types, such as, for instance, the degenerative, the design of the amplifier itself is an important problem.

In older designs these factors seriously limited the performance of the oscillator, but the tools available to the modern designer, such as improved circuit elements, new mixer tubes, and low-distortion amplifier circuits, have made it possible to eliminate them in the design of the new TYPE 913-A Beat-Frequency Oscillator.

This instrument was developed particularly with the idea of providing the best-balanced design possible at the present time, and in operating characteristics it bears little resemblance to the ordinary type of beat-frequency oscillator. Among its important features are convenience and ease of frequency control, constant output voltage, a high de-

FIGURE 2. Rear view of the oscillator with dust cover removed. Note that tubes and fuses are easily accessible.

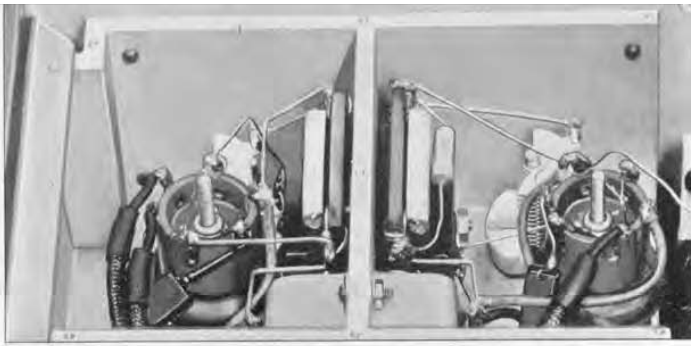


FIGURE 3. View of the cast-metal oscillator housing with cover removed to show the two oscillator circuits. The use of duplicate parts and the symmetry of construction about the center shield help to equalize the temperature coefficients of the two oscillators.

gree of stability, and low distortion. It is well adapted for running frequency characteristics (with a recorder, if desired) and also for all normal types of distortion measurements.

Since price and size are also of importance in instrument design, no attempt was made to utilize temperature control or other awkward, expensive systems for maintaining stability. Instead, the circuit elements themselves were designed to have minimum temperature coefficients. This necessitated first a new design for the oscillator coils. In these coils the dust core is supported by a continuous threaded rod, which is supported in the same manner at each end of the coil form. Hence any differential expansion between the coil form itself and the rod produces equal and opposite forces, so that the relative position of the core does not shift.

The fixed condensers are of the silvermica type and are mounted directly on opposite sides of a shield separating the oscillator compartments. The two condensers are thus maintained at substantially the same temperature. The oscillator circuits are contained in adjacent sections of a cast-metal shield, so that their temperatures remain approximately the same. This is important, since it is relative drift between the two oscillators, and not the actual drift of either one, which changes the beat frequency.

Finally, in order to reduce so far as possible any remaining drift, each oscillator is checked in the calibration laboratory throughout a warming-up cycle, and a temperature-compensating condenser is added to the circuit to cancel out so far as possible any residual temperature drift. The result is that the TYPE 913-A Oscillator will, on the average, drift only a few cycles between the time it is turned on and the time it has reached equilibrium, when operating at normal ambient room temperature. For most purposes the drift is so slight that no readjustment of the calibration whatsoever is required. In stability, therefore, the TYPE 913-A Oscillator is second among commercially available types only to the best of degenerative oscillators* and for most purposes the stability of this beat-frequency oscillator is more than adequate.

In the past beat-frequency oscillator designs have included buffer amplifiers between the oscillator and the mixer or modulator, in an attempt to prevent pulling in. In the TYPE 913-A use has been made of one of the newer pentagrid converter tubes, which, when combined with suitable grid-bias circuits to provide the proper square-law characteristic, gives substantially distortionless heterodyning action and at the same time good isolation between the oscillator circuits. The circuit used in the TYPE 913-A is a considerable simplification over previous low-distortion beat

*Low-priced degenerative (resistance-tuned) oscillators, while useful for many purposes, do not, in general, have either the stability or low distortion which might be expected in view of the type of circuit used and which is characteristic of more expensive types.

oscillators, and yet provides substantially better performance.

To provide the required output voltage and power a highly degenerative amplifier is used. It includes a vacuum-tube phase inverter and a push-pull output stage, feeding a high-quality output transformer. Distortion in the amplifier is considerably less than 0.05% throughout most of the frequency range. The output impedance is 550 ohms. This value was chosen so that the oscillator could be used equally well with 500-ohm and 600-ohm equipment.

Other circuit refinements include plate voltage regulation, a constant-impedance volume control calibrated directly in output power in terms of db with respect to the standard reference level of 1 milliwatt into 600 ohms, and a simplified zero-beat indicator consisting essentially of a small gas-filled tube. The instrument is also equipped with a gear-drive dial, which can be connected readily to recording equipment when so required.

—H. H. Scott

SPECIFICATIONS

Frequency Range: 20 to 20,000 cycles.

Frequency Control: The main control is engraved from 20 to 20,000 cycles per second and has a true logarithmic frequency scale. The total scale length is approximately 12 inches. The effective angle of rotation is 240°, or 80° per decade of frequency.

Frequency Calibration: The calibration can be standardized within 1 cycle at any time by setting the instrument to zero beat. The calibration of the frequency control dial can be relied upon within ±2%±1 cycle after the oscillator has been correctly set to zero beat.

Zero Beat Indicator: A neon lamp is used to indicate zero beat.

Frequency Stability: Improved design of the oscillator circuits and the use of temperature-compensated capacitors and inductances result in an unusually high degree of stability.

Output Impedance: The output impedance is 550 ohms, either grounded or balanced-to-ground, and is essentially constant regardless of the output control setting. With load impedances of 2000 ohms or less, the output is balanced for all settings of the output control. With higher load impedances, unbalance may occur at low settings of the output control.

Output Power: 0.3 watt maximum.

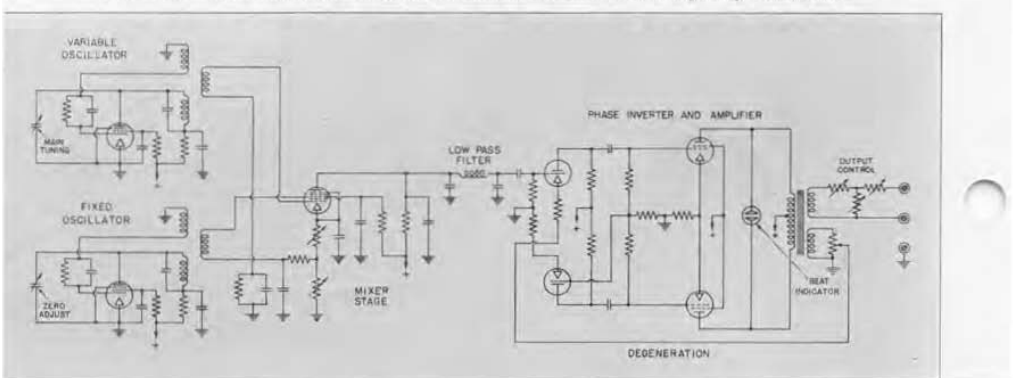
Output Voltage: Approximately 25 volts open circuit. For a matched resistive load the output voltage varies by less than ±0.25 db between 20 and 20,000 cycles.

Output Control: The output control is calibrated in db referred to 1 milliwatt into 600 ohms. The total range is from +25 to −25 db.

Waveform: When the oscillator is operating into a matched load or a load of higher impedance, the total harmonic content is approximately 0.2% from 150 to 7000 cycles. Below 150 cycles the harmonic content increases slightly, reaching about 2% at 50 cycles. With the volume control turned fully on, the harmonic content is approximately doubled when the oscillator is operated into an extremely low impedance. If, however, the volume control is turned 3 db or more below the maximum setting, the load impedance has no effect upon the waveform.

A-C Hum: The a-c hum is less than 0.05% of the output voltage at a line frequency of 60

Figure 4. Schematic circuit diagram of the Type 913-A Beat-Frequency Oscillator.



cycles, and is less than 0.1% at 42 cycles. Since the volume control is in the output circuit, the hum percentage does not increase for low output voltages.

Temperature and Humidity Effects: Large changes in ambient temperature and humidity necessitate a readjustment of the zero-beat setting. High temperatures and humidity cause a slight increase in distortion and a slight decrease in output.

Terminals: Jack-top binding posts with standard ¾-inch spacing are provided on the panel. A Jones socket and plug provide duplicate output terminals on the back of the instrument for relay-rack installation.

Mounting: The panel is designed for mounting on a 19-inch relay rack, but removable wooden ends are supplied so that it may be used equally well on a table.

Power Supply: 105 to 125 volts, 40 to 60 cycles ac. A simple change in the connections to the power transformer allows the instrument to be used on 210 to 250 volts. The total consumption is about 100 watts. Since the oscillator circuits are equipped with voltage regulators, the change in output with power-supply voltage is negligible.

Tubes:

2 — type 6SK7
1 — type 6SA7
2 — type 6SF5
2 — type 6V6-GT
2 — type 6X5-G
2 — type VR-150-30
1 — 139-949 Neon Lamp

All are supplied with the instrument.

Accessories Supplied: A seven-foot connecting cord, a multipoint connector, and spare fuses and pilot lamp are supplied.

Dimensions: 19⅜ x 14¼ x 7½ inches, over-all.

Net Weight: 35 pounds.

Type		*Code Word*	*Price*
913-A	Beat-Frequency Oscillator	CAROL	$260.00

*This instrument is licensed under patents of the American Telephone and Telegraph Company solely for utilization in research, investigation, measurement, testing, instruction, and development work in pure and applied science.

RECENT PRIORITY ORDERS OF INTEREST TO BUYERS OF GR EQUIPMENT

QUARTZ CRYSTALS

● ON MAY 18 the Director of Industry Operations of the War Production Board issued General Conservation Order No. M-146 because of the shortage of quartz crystals which has been brought about by increasing demands for crystals and other forms of quartz in connection with the National Defense. Paragraph (g) of this order, given below, indicates the restrictions which have been placed on the sale and use of quartz by this Conservation Order and contains the certification which must be furnished to us before delivery of equipment containing manufactured forms of quartz crystals can be made.

Section 1218.1 General Conservation Order No. M-146:

"(g) *Restrictions on Use.* After the effective date of this Order, except as specifically authorized by the Director of Industry Operations, no Person shall consume or process Quartz Crystals except in the manufacture of:

(1) Radio oscillators and filters or other products for use in Implements of War,

(2) Radio oscillators and filters for use in radio systems to be owned, used, and operated by Federal Agencies, or by commercial airlines,

(3) Telephone resonators,

(4) Optical parts for use in Implements of War;

and no Person shall purchase or accept delivery of manufactured forms of Quartz Crystals except for use for purposes for which manufacture thereof is permitted under the foregoing provisions of this paragraph (g). Any Person who consumes or processes Quartz Crystals as aforesaid, shall require before the manufactured forms of Quartz Crystals leave his possession that the purchaser or transferee thereof make and

deliver to him, or endorse on the purchase order a certificate, manually signed by the purchaser or transferee or a responsible official thereof, in substantially the following form, to wit:

The undersigned hereby certifies that he is familiar with the terms of Conservation Order M-146; and that the manufactured forms of Quartz Crystals covered by the accompanying Order of even date shall be used only for purposes permitted by the terms of said Order M-146.

Dated . . . . . .

Name . . . . . .

By . . . . . .

Such certificate shall constitute a representation by the purchaser or transferee to the consumer or processor and to the War Production Board of the facts stated therein. The consumer or processor of Quartz Crystals shall be entitled to rely on such representation unless he knows or has reason to believe it to be false."

Several instruments which General Radio manufactures, such as the TYPE 736-A Wave Analyzer, TYPE 620-A Heterodyne Frequency Meter, CLASS C-21-H and CLASS C-10 Frequency Standards, and other frequency monitors, use crystals as filters or oscillators. Accordingly it is necessary for our customers ordering these instruments to comply with the restrictions of M-146 and to furnish us with a signed certification before shipment can be scheduled.

END USE

Priorities Regulation No. 10 established an Allocation Classification System which has been designed to provide a means of identifying the ultimate uses and users of various products and materials as well as a means of transmitting such identifications down through industry to original suppliers. With the information so obtained it will be possible for the War Production Board to allocate materials more wisely and to reduce the rules and forms which now must be used for allocation purposes. *The Regulation provides that all purchase orders or contracts, other than retail, placed after June 30, 1942, must have indicated on them the appropriate Allocation Classification Symbol and Purchaser's Symbol.* Furthermore, all orders, regardless of when placed, which call for delivery after July 31 must also carry these symbols. Customers who have already placed orders for delivery after July 31 must, before that date, notify the supplier of the appropriate symbols applying on such orders.

For the convenience of our customers we are listing below the various Allocation Classification Symbols, with a short description of material covered.

ALLOCATION CLASSIFICATION

(NOTE: The symbol numbers have no relation to order of importance.)

Allocation Symbol	MILITARY
1.00	CLASS 1.00 — AIRCRAFT — PRODUCTION AND MAINTENANCE (complete except for armament and ammunition — as approved by the Joint Aircraft Committee)
	CLASS 2.00 — SHIPS, PRODUCTION AND MAINTENANCE (complete except for armament and ammunition)
2.10	Battleships
2.20	Aircraft carriers
2.31	Escort vessels (aircraft), combat, loaded transports, and combat loaded cargo ships
2.32	Patrol vessels
2.33	Landing craft including the following types: APM, ATL, YTL, tank lighters, artillery lighters, landing boats, support landing boats
2.40	Light cruisers
2.50	Destroyers including escort vessels
2.60	Submarines
2.70	All other types of naval craft
2.80	Repairs to all naval vessels
2.90	Ships for Maritime Commission

CLASS 3.00 — VEHICLES — PRODUCTION AND MAINTENANCE (complete except for armament and ammunition)

3.10 Tanks and armored vehicles — all types
3.20 Vehicles, except rail — all other military types

CLASS 4.00 — ARMAMENT AND WEAPONS — PRODUCTION AND MAINTENANCE (complete mounts and related equipment)

4.10 Aircraft
4.20 Anti-aircraft, barrage balloon equipment, A. A. searchlights
4.30 Artillery including railway and seacoast
4.40 Fire control, all types
4.50 Machine guns — ground, hand arms
4.60 Naval, all types
4.70 Tanks and anti-tank
4.90 Weapons of all other types

CLASS 5.00 — AMMUNITION — PRODUCTION AND MAINTENANCE (complete items)

5.10 Ammunition 20 mm. and above
5.20 Ammunition, small arms below 20 mm.
5.30 Bombs, depth charges, mines, and torpedoes
5.40 Propellants, chemicals, explosives
5.50 Pyrotechnics

CLASS 6.00 — WAR EQUIPMENT AND SUPPLIES — PRODUCTION AND MAINTENANCE (complete with related equipment)

6.10 Chemical warfare equipment and supplies
6.20 Clothing, general supplies, and subsistence
6.30 Mapping, map reproduction, and photographic equipment
6.40 Medical equipment and supplies
6.50 Military field construction equipment
6.60 Military radio and wire communications, and Radar or electronic equipment — all types
6.70 Military railway including rail vehicles and bridge equipment
6.80 Supplies and equipment — all other military types
6.90 Supplies and equipment — all other

CLASS 7.00 — WAR FACILITIES — CONSTRUCTION AND/OR MAINTENANCE

7.10 Air fields, bases, camps, coast defense, depots, forts, navy yards, posts, stations — Continental U. S. A.
7.20 Air fields, bases, camps, coast defense, depots, forts, navy yards, posts, stations — outside Continental U. S. A.
7.30 Munitions manufacturing facilities and proving grounds — government owned
7.40 Panama Canal
7.50 Shipyards and ship repair facilities — government owned

INDUSTRIAL AND CIVILIAN

CLASS 8.00 — RAW MATERIALS, PRODUCTION, AND PROCESSING OF

8.10 All metals, production (including mining), smelting, and processing of
8.20 All chemicals, production, and processing of
8.90 All other raw materials, production, and processing of

CLASS 9.00 — POWER, LIGHT, AND HEAT

9.10 Electricity
9.20 Petroleum
9.30 Coal and coke
9.40 Gas

CLASS 10.00 — TRANSPORTATION

10.10 Railroad including urban and interurban
10.20 Automotive
10.30 Roads, streets, etc., construction and maintenance of
10.40 Water transportation, including construction of privately owned shipyards
10.50 Air transportation
10.90 All other transportation

CLASS 11.00 — COMMUNICATION

11.10 Telephone
11.20 Radio
11.30 Telegraph
11.90 All other communication

CLASS 12.00 — PUBLIC HEALTH AND SAFETY

12.10 Sanitary and health systems and facilities
12.20 Health equipment and supplies including personal care
12.30 Public safety equipment and supplies
13.00 CLASS 13.00 — AGRICULTURAL EQUIPMENT AND SUPPLIES
14.00 CLASS 14.00 — INDUSTRIAL FOOD PROCESSING
15.00 CLASS 15.00 — WEARING APPAREL
16.00 CLASS 16.00 — EQUIPMENT AND SUPPLIES FOR HOUSEHOLD USE

CLASS 17.00 — EDUCATION AND INFORMATION

17.10 Printing and publishing
17.20 Education
18.00 CLASS 18.00 — RECREATION AND AMUSEMENT
19.00 CLASS 19.00 — EQUIPMENT AND SUPPLIES FOR OFFICE USE

CLASS 20.00 — MACHINERY AND EQUIPMENT FOR INDUSTRIAL USE

20.10 Metal working machinery
20.20 All other — including mine, construction, special and general industrial

CLASS 21.00 — NEW BUILDINGS, CONSTRUCTION OF

21.10 Buildings for manufacturing and commercial purposes, construction of

(*Continued on page 8*)

21.20 All types of dwellings, construction of
21.90 All other types of building, construction of
22.00 CLASS 22.00 — OPERATING SUPPLIES AND BUILDING REPAIR AND MAINTENANCE
23.00 CLASS 23.00 — ALL OTHER END USES (excludes all sub-assemblies and parts going into finished products coming with the other classes)

Five different Purchaser's Symbols are used to indicate the end user of the material. They are:

United States Army ..... USA
United States Navy ..... USN
(Including Maritime Commission)
Lend-Lease LL
Other Foreign Purchasers ..... FP
Domestic Purchasers ..... DP

These symbols must be passed on from supplier to his suppliers, etc., even though the Allocation Classification Symbol may change. A complete copy of the Regulation, together with detailed information on the various symbols to be used by different users and industries, has been reproduced by the Chamber of Commerce of the United States in Washington under the title, "Allocation Classification System."

— MARTIN A. GILMAN

MISCELLANY

● **THE ABILITY TO SEE HUMOR** in the difficulties of doing business these days is rare, but refreshing. An instance of this turned up recently in one of the printing trade publications. According to this item a purchasing agent wrote to some of his regular sources of supply, requesting new catalogs, with the complaint that the last issues were out of date. He expressed the hope that, if no new catalogs were available, he might be given some schedule by which he could figure prices from the catalogs he had. A few of the replies that he received are quoted below :

"We are glad to advise the illustrations in our catalog are still O.K., only we have discontinued most of the items. If we sent you the whole list of what we are not making, our catalog would be useless."

"Forget the prices. Also forget the descriptions. By the time you get this letter we do not know ourselves how or what we will be making the stuff out of."

"Thank you for your note indicating you still have one of our complete catalogs. Please return it at once. You ought to see the prices we are receiving here for our waste paper."

"After reading your inquiry we are afraid you are thinking of sending us an order. It looks suspicious to us. Nevertheless, we will gladly meet you halfway by showing you how to calculate costs, if you will promise to send the order to some one else."

"The only part of that catalog we are still certain about is the line that says, 'Established in 1885.' All other information and prices have been withdrawn."

"We will answer your question if you will first answer one for us: What do you want with a price on things we do not have and cannot get?"

GENERAL RADIO COMPANY
30 STATE STREET - CAMBRIDGE A, MASSACHUSETTS
BRANCH ENGINEERING OFFICES
90 WEST STREET, NEW YORK CITY
1000 NORTH SEWARD STREET, LOS ANGELES, CALIFORNIA