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Title: Frequency Meters as Master Oscillators
Author: Commander E.H. Conklin, W3JUX

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Frequency Meters as Master Oscillators

An Easily-Constructed Amplifier for Use with Surplus Units

BY COMMANDER E. H. CONKLIN,* USNR, W3JUX

There is an old saying that if you want a really good frequency standard — oscillator or crystal — don't make it drive a transmitter, too. This saying has its value, to be sure, but from time to time new developments make it possible to get some usable power out of a frequency standard. For example, many Navy-transmitter master oscillators perform every bit as well as many crystal stages, once set on the right frequency, and the Navy's best shipboard frequency meter — Model LR — produces several watts of power.

A less-complicated frequency meter, the Navy's Model LM series and the Army's Type SCR-211, has occasionally served as a master oscillator by driving an amplifier with its normal output. This model has already appeared in the surplus market at a price around $20 (without calibration). The meter is being handled by Hoffman Radio Corp., 1601 East 16th Street, Los Angeles 25, California, and by Hallicrafters in Chicago, as agents for the RFC, at somewhat higher prices (subject to service discounts), but comes complete with instructions and book of individually-calibrated dial settings.[1] Large quantities appear in the Navy's allowances of radio material for Naval Reserve members. It has a crystal-controlled calibrator oscillator to provide check-points, and a tunable oscillator with tone modulator to interpolate between check-points, all built into a nice unit approximately 8-inches cube, weighing 11½ pounds.

Some of these units are operated from an aircraft power supply, while others are mounted in a battery case or are provided with a 110-volt a.c. power supply. In the absence of the latter, it is necessary to provide only ¾ ampere at 12-volts a.c. or d.c. for the heaters and 10 ma. at 180 to 475 volts for the plates — the first readily obtainable from a small filament transformer and the second from a receiver. If the less-expensive meter without the power supply is purchased, Type CQC-20104A power units can be obtained separately at only $7.50 as Item G2F-1 on the surplus list of Communications Measurements Laboratory, 120 Greenwich Street, New York 6, New York.[1]

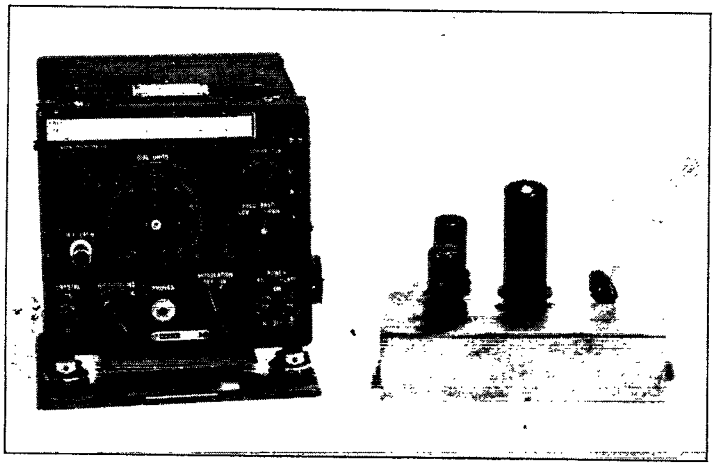
The tunable oscillator uses a Type 77 tube, the crystal oscillator and harmonic generator uses a 6A7, and the tone modulator a 76. The 2000–4000-kc. output for driving an external amplifier is taken from the arm of a potentiometer connected between the tunable-oscillator plate blocking condenser and ground.

A Choke-Coupled Amplifier

An amplifier that will permit controlling a transmitter from the output of the frequency meter, based on a circuit furnished by Lt. Col. Byron E. Hargrove, W9LFU (who spent his Army career in the Bureau of Ships, Navy Department, after leaving the Signal Corps labora-

* Conklin Radio Co., 6800 Clarendon Road, Bethesda 14, Md.

[1] According to information at the time of writing. Changes in the surplus picture may modify these prices considerably.



The amplifier described in the text alongside the Model LM frequency meter which drives it. It is built on a chassis 8 inches wide, 4 inches deep, and 2 inches high. Parts layout is not critical, since only the last stage operates as a tuned amplifier.

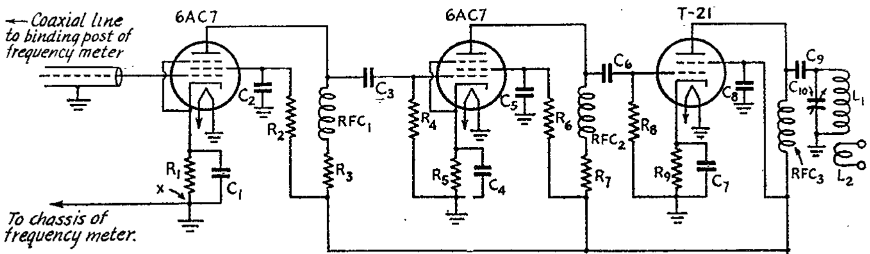


Fig. 1 — Circuit diagram of the amplifier unit for boosting the frequency-meter output to a level suitable for driving the ex-crystal-oscillator tube in a transmitter.

C_1 to C_9, inc. — 500- to 1000-μμfd. ceramic, 600 volts.
C_{10} — 100-μμfd. variable.
R_1, R_5 — 300 ohms, 2 watts.
R_2, R_6 — 60,000 ohms, 2 watts.
R_3, R_7 — 1000 ohms (or higher), 2 watts.
R_4, R_8 — 0.1 megohm, ½ watt.
R_9 — 500 ohms, 2 watts.
L_1, L_2 — 3.5-Mc. coil with link, such as a junior transmitting coil or receiver-type plug-in coil. Suitable dimensions for a 1½-inch diameter coil form are 50 turns of No. 22 enameled, closewound, for L_1, and 5 or more turns of the same wire for L_2.
RFC_1, RFC_2, RFC_3 — 2.5-mh. r.f. choke.

tories at Fort Monmouth) is shown in the photograph. The wiring diagram differs from Lt. Col. Hargrove's circuit chiefly in the use of r.f. chokes instead of simple resistance coupling in the plate circuits of the two 6AC7 amplifiers. The Taylor T-21 output stage is used on the 3.5–4.0-Mc. band, although it could operate at 1.7–2.0 Mc. as well. The latter range will be preferred where it is intended to drive an existing 3.5-Mc. crystal stage as an unneutralized doubler.

For break-in, the key should be connected between the bottom of R_1 and ground (point "X" on schematic), opening the d.c. cathode circuit of the first 6AC7. The coaxial cable from the frequency meter to the first amplifier tube is desirable to reduce radiation which might be picked up by the station receiver when operating break-in on the transmitter frequency. However, its capacity by-passes some of the r.f. input to the first amplifier and, therefore, it should be kept reasonably short. If the shielded coax is omitted, a common ground should connect the frequency meter and the amplifier in order to provide an r.f. return.

The resistor and capacitor values were found to be not at all critical. Inasmuch as no grid current flows in the grid leaks of the second and third stages when plate and screen voltages are applied and when cathode-bias resistors are used, the grid-leak values are selected purely to avoid loss of r.f. and not for operating bias. Grid chokes in series with them were found to cause a modest improvement in gain, as measured by the grid current of the next stage when no plate and screen voltages are applied to it, but not enough to justify their cost. So long as the grid-leak resistors are not by-passed, the use of grid chokes does not increase the tendency for the amplifier to oscillate at a parasitic frequency as a tuned-plate tuned-grid oscillator, with the chokes forming the inductances.

The by-pass and coupling condensers used are actually 680-μμfd. axial-lead ceramic capacitors, plus or minus 180 μμfd., which are available for a few cents from a mail-order radio supply house. They are shorter than a ½-watt resistor and can be mounted directly on the socket terminals in an extremely-compact arrangement with very short leads. The reactance of a by-pass circuit is probably less with these condensers than it is with common 0.1-μfd. paper by-pass condensers which cost several times as much.

The use of radio-frequency chokes instead of plate resistors increased the stage gain very much — at least a third — without losing any plate voltage in the resistors which otherwise would happen. With Type 6AC7 tubes in the first two stages, there was no tendency toward oscillation in the second and third stages through the r.f. chokes but later, when trying other types of tubes, this form of oscillation occurred. It is deemed to be desirable, therefore, to insert resistors of 1000 ohms or more in series with the chokes. These resistors are in series with the tuned circuits of the parasitic oscillations through the chokes and, therefore, suppress the tendency completely.

Link-coupled output is used, although normally it will be more convenient to locate the amplifier reasonably close to the former crystal-oscillator stage of the transmitter and to feed the latter capacitively, operating the stage as a doubler unless it is a pentode or tetrode, with no tendency toward oscillation when worked straight through as an amplifier.

A voltage of only 300 was used on this unit, although it is recognized that a higher voltage may be used, with adjustment of the screen and plate resistors to the necessary higher values. It will then be necessary also to increase the cathode

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Frequency Meters as Oscillators

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resistor in the final amplifier to provide the bias voltage necessary to hold the plate current of this tube within its rating.

At 300 volts, a 6V6 produces nearly as much output as a T-21 or 6L6, but the latter are to be preferred for higher plate voltages. Triodes and tetrodes were also tried in the untuned stages, with good results but with reduced voltage gain. The 6V6 and 6J5 required an increase of the cathode resistor to 500 ohms to hold the plate current within the ratings. It is evident that this amplifier can be built up from almost any triode, tetrode, or pentode tubes that are on hand and which have fair power-handling ability.

Operation

The presence of the r.f. amplifier attached to the output of the frequency meter does not in any way detract from the value of the latter for its originally-intended purpose. Whether used as such or to drive the transmitter, the operating procedure is the same although, with well-shielded leads, it is necessary to clip a wire on to the frequency-meter output or even to couple it to the receiving antenna, to check the frequency of an incoming signal.

After the frequency meter has warmed up, the dial on the tunable oscillator should be set at the nearest check-point. The crystal oscillator in the meter is then turned on, and the "corrector" is adjusted until the tunable oscillator is in zero beat with a harmonic of the crystal frequency which provides the check-point, while listening with headphones that are plugged into the frequency-meter 'phone jack. If low audio beat frequencies cannot be heard, the exact dial setting of zero beat can be estimated with satisfactory accuracy by noting the dial settings on each side which produce the same low-frequency audio tone, the midpoint of these two settings being used. The crystal oscillator is then turned off, and the tunable-oscillator dial is returned to the desired setting between check-points.

The accuracy of this type of frequency meter depends upon the accuracy of the crystal oscillator and its harmonics which serve as check-points, and upon the ability of the tunable oscillator to retain a calibration between the check-points. Under severe changes of temperature, humidity, tubes and so on, the cumulative error should be well within 0.01 per cent at any point, which is 100 cycles per megacycle. It should be very much better at the check-points, which generally fall at the edges of the amateur bands. In practice, the errors will be compensating to some extent, so that a frequency can be determined within a few hundred cycles. The tunable oscillator was not built to maintain this accuracy under large temperature or humidity changes, while warming up, or for long periods of time, without being

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rechecked against the crystal harmonics and, therefore, it falls short of the performance of the best Navy-transmitter master oscillators. However, it will compare very favorably with almost any similar piece of equipment constructed by amateurs at a similar cost, and at much more trouble.

About the Author

• Commander Elmer H. "Bill" Conklin, W3JUX, admits his best claim to fame is being the husband of W9SLG/3! That is, when he isn't devoting his time to conducting u.h.f. columns for magazines such as the prewar *Radio*, working on the development of u.h.f. antennas, talking 44 miles on crystal-controlled 'phone on frequencies above 5000 Mc., or serving in the Fleet Technical Section, Chief of Naval Communications, Navy Dept., Washington, D. C. A graduate of Northwestern University with a B.S. degree, "Bill" has been licensed since 1922, his first call being W9DBF. He holds WAC and RCC certificates.

Happenings

(*Continued from page 40*)

tunity for members to put their representation in the hands of a member of their own choosing. Full Members are urged to take the initiative and file nominating petitions immediately.

For the Board of Directors:

K. B. WARNER,
Secretary

June 1, 1946

Propagation Predictions

(*Continued from page 46*)

9 of the article are from the report IRPL-D15. The charts in the article by E. H. Conklin in January, *QST*, "The Bright New World — of Sunspots," are also from IRPL reports.

The CRPL hopes that in making available to the general public the radio wave propagation information and techniques which were so widely and so successfully used by the Army and Navy during the war, the radio amateur's understanding of propagation conditions and his enjoyment of the time he is on the air will be significantly increased.

Strays

"KC," writing in *APCO Bulletin*, says "A short time ago I heard one station ask: 'WX?,' and the queried station cracked back: 'It's dark here.'"