PRACTICAL
ON 3/4 METER

AN OPTICAL WAVE RECEIVER SYSTEM

Figure 8. The B.-K. receiver with an audio frequency amplifier and loudspeaker attached for picking up ¾-meter transmissions

Continuing the
with constructional details
and reflecting antenna
wavelengths

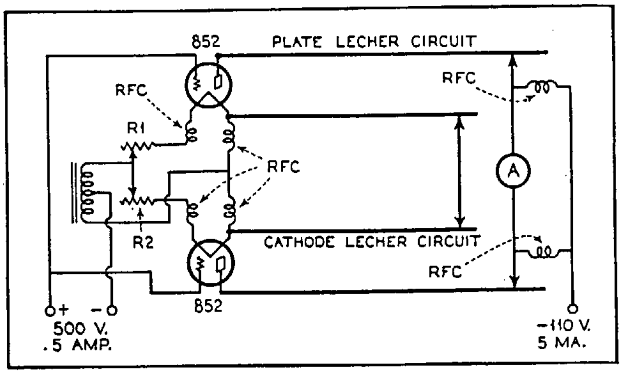
By James

THE optical characteristics of ultra-short-wave radio transmission become pronounced only on wavelengths shorter than 5 meters. While it is justifiable to consider any wavelength shorter than 10 meters in the quasi-optical region by virtue of the fact that communication is usually limited to visual distances, the "shadows" are erratic and transmission and reception can be effected by conventional circuits. A wavelength of 5 meters perhaps marks the borderline where circuit differentiation becomes more than mere modification of the usual arrangements, and Barkhausen-Kurz and Gill-Morell hobnob with our familiar friends, Armstrong and Colpitts. But even at 56 megacycles the superheterodyne (RADIO NEWS for August, 1932) is the most efficient receiver yet developed, the super-regenerator is still very effective, while the tourmaline crystal-controlled transmitter is more reliable than the magnetron oscillator.

However, still farther down, the picture changes more definitely. The old principles are still recognizable, but apparatus, technique and application are entirely new. While it is by no means as hopeless as Dante's Inferno, we may take liberties with the Florentine poet and declare, "Abandon old ideas, all ye who enter here!"

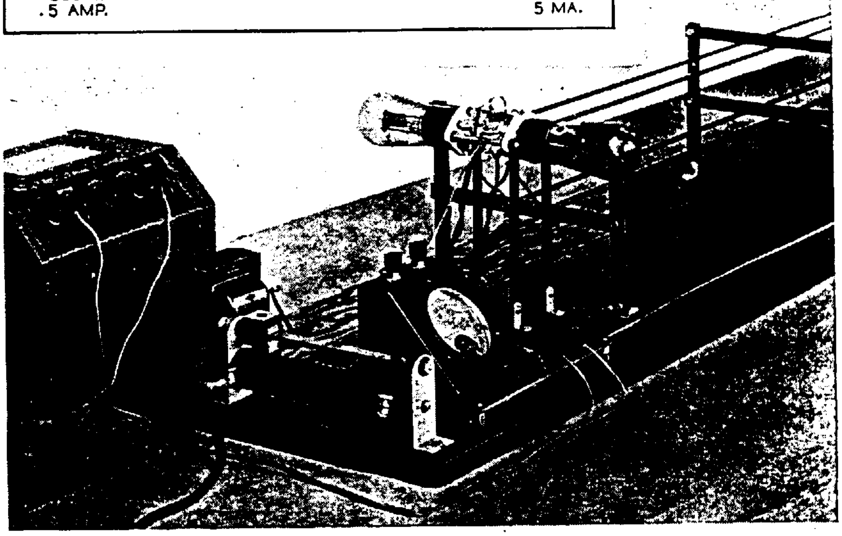
In the "misty mid-region" of centimeters, the phenomena are markedly quasi-optical, and it is suggested that the experimenter review the first two articles (RADIO NEWS, June and July) in this series, which consider the basic principles and characteristics.

As we shall describe a ¾-meter transmitter and receiver in this article, we shall limit ourselves for the present to 75-centimeter considerations, bearing in mind, however, that the optical phenomena predominate more and more as the wavelength is shortened still further. Communication at 75 centimeters is believed to be limited to between points in a direct line of vision with each other. Even small obstacles, such as trees, cast pronounced "shadows." The wavelength is sufficiently short to permit the use of simple parabolic reflectors, at both transmitting and receiving stations, whereby the signals can be concentrated in accordance with the familiar optical law.



CONSTRUCTION DATA

Figure 1, at left, shows circuit diagram of a Kozanowski oscillator. Figure 3, below, experimental Kozanowski oscillator for type -27 tubes



The experimenter who has studied the introductory articles in this series will appreciate that at frequencies above 300 megacycles (300 megacycles equals 300,000,000 cycles per second or a wavelength of 1 meter—just to remind you) the period of the circuit approaches the limitations imposed by the rapidity with which the electrons can circle about in the tube. The velocity of the electron and the geometric spacing of the tube elements, rather than the capacity and inductance of the circuit, may be the deciding factors as to frequency. Such is the case with the Barkhausen-Kurz oscillator, and by varying the accelerating charge on the grid (which, of course, affects the velocity of the electron stream) the wavelength can be controlled over a considerable range, practically independent of the circuit constants. Such a circuit necessarily results in the very unconventional arrangement in which the grid is highly positive and the plate negative.

B-K oscillations can be extended well down in the centimeter region, but are of lesser value for transmitting purposes

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WORKING DATA

TRANSMISSION

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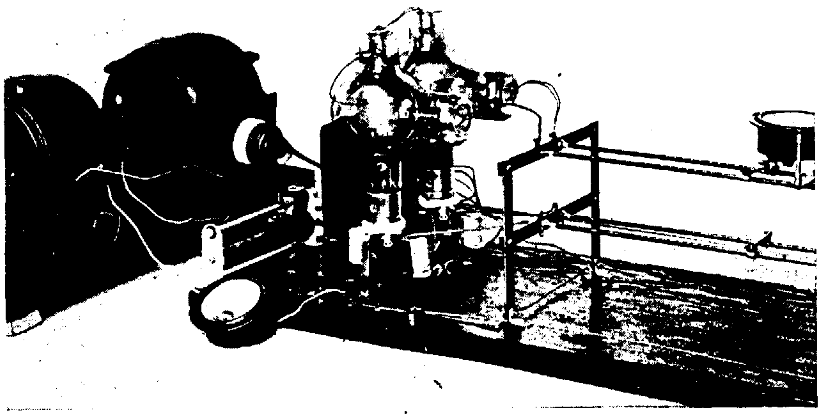
below 1 meter, due to low output and lack of stability—the frequency often swinging as much as several megacycles! The lack of stability, however, suggests that the system has possibilities as a receiver, where signal swinging would merely be evidenced as broad tuning. Barkhausen-Kurz oscillators are considered in detail in the June and July articles to which reference has already been made.



FINAL EXPERIMENTAL SET-UP FOR 852 TUBES

Figure 2. This transmitter is capable of generating five to six watts of 75 centimeter radiation and is tuned by Lecher wire antennas

It was in an effort to improve the output of the B-K system that Kozanowski developed his oscillator, which departs even farther from the familiar way of things by tuning the plate and filament circuits rather than the plate and grid circuits. Kozanowski's investigation into a modified Barkhausen-Kurz oscillator indicated that the oscillations were the result of the space-charge fluctuating geometrically (not in potential) about the grid. In other words, the vibratory phenomena pivots about the grid, the filament and plate being the high-potential sides of the oscillating system. Such a theory would suggest an improved output with the filament and plate circuits balanced or tuned—an assumption thoroughly justified by further experimentation.

The Kozanowski oscillator circuit used by the author in ¾-meter experiments is shown in Figure 1, while the photograph, Figure 2, provides a clear idea of the mechanical arrangement. The plate and filament circuits are tuned by individual Lecher wire systems. The wavelength at which the oscillator functions is determined by the length of the plate Lecher system. It must not be assumed, however, that we have here merely a modified oscillator operating on the tuned-plate principle. It is, of course, a bona fide electronic oscillator, as is evident by the reversed potentials on grid and plate, and the fact that the wavelength is almost exactly equal to the length of the plate Lecher system as measured from the plates of the tubes to the terminating ammeter, quite independently of concommitant inductance and capacity.

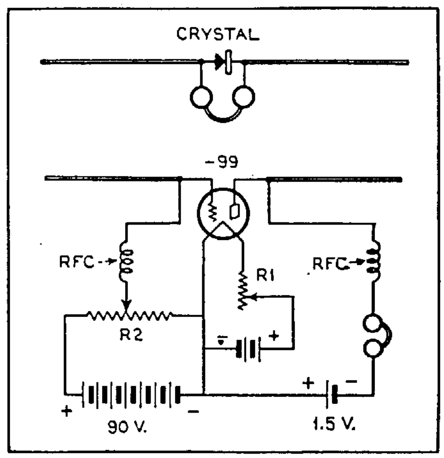
From considerations outlined above, it is evident that the power output can be controlled by varying the length of the cathode Lecher system, which has practically no effect on frequency. The oscillating power generated by the Kozanowski circuit is considerably greater than that obtained by a B-K oscillator. The best output reported from Barkhausen-Kurz circuits at 75 centimeters has been a fraction of a watt, whereas the circuit in Figure 1, employing the tubes and potentials indicated, can be pushed to well over 5 watts, at this wavelength, with good stability.

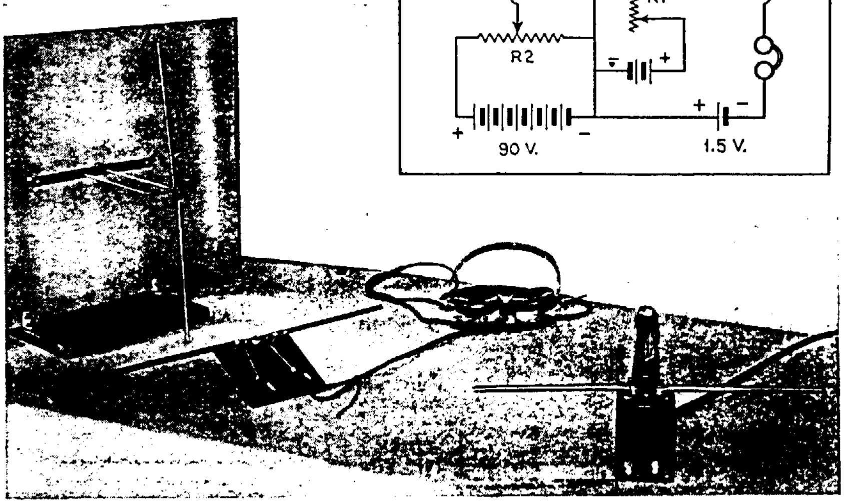
The 852 type tube is admirably suited to oscillations of this character. Original experiments carried on with the type -27 tubes (Figure 3) showed that our old ultra-high-frequency standby will not provide satisfactory results in this circuit. While oscillations were present, they did not exhibit the proper characteristics. The plate circuit showed practically no frequency control, and the length of the cathode circuit had a negligible effect on the power output. Oscillations ceased when a plate potential of more than a few volts negative was applied. The circuit was apparently functioning as a Barkhausen-Kurz oscillator, and increasing the grid potential up to the point where the grid ran white-hot did not improve matters.

However, upon substitution of the type 852 tubes, as shown in Figure 2, the circuit settled down and operated strictly in accordance with Hoyle—or, rather, Kozanowski. It was necessary to apply at least 200 volts to the grids before the power output became sufficiently great to light a small flashlight bulb.

RECEIVER CIRCUITS

Figure 4, below, shows resonating crystal and tube receivers. Figures 6 and 7, at right, show the crystal receiver and the simple tube receiver, respectively





With the accelerating potential increased to 500 volts it was possible to obtain a power output between 5 and 6 watts. With this voltage applied to the grids, the filament circuit of each tube should be adjusted, by means of R1 and R2, to limit the grid current to about 250 milliamperes per tube. Careful matching of tubes is unnecessary when provision is made for this adjustment. The negative plate potential should be about 110 volts. The plate current varies from 5 to 6 milliamperes, while the oscillatory current in the plate Lecher circuit is about 2.5 amperes at no load.

Needless to say, the grids of the tubes become extremely hot, but since the filament emission is not excessive, the life of the tubes should not be materially shortened.

It will be found that the negative plate voltage, for best output, is rather critical, and that as the plate voltage is increased from the optimum value, the power output decreases proportionately. This condition suggests that the circuit is readily amenable to modulation, which can be effected most economically due to the fact that the power required is only about 6 watts. The usual straight-line considerations are involved, and the steady plate voltage should be set midway between the optimum value and the point at which oscillations cease.

Construction Details

The constructional details are well illustrated in the photographs. The Lecher wires are made of ¼-inch copper rods, supported rigidly by isolantite and R-39 insulating material. The filament choke coils consist of 15 turns of No. 12 double-cotton-covered wire, wound with a ¾-inch diameter. The plate-circuit chokes can be the same, or, if more convenient, of 20 turns of No. 18 enameled wire, with a diameter of ½ inch, and stretched, spring fashion, until they are two inches long.

Once the oscillator is functioning satisfactorily, there remains the problem of providing a suitable antenna system and of coupling it to the plate Lecher circuit. The most interesting features of ¾-meter experimentation are, perhaps, the miniature radiating systems and the sharp directional effects which they can be made to produce.

The simplest antenna consists of a 15-inch piece of copper rod (Lecher wire material), one end of which is clipped to the plate Lecher circuit. Any desired amount of coupling can be obtained by clipping the rod antenna at different points along the plate circuit. While a simple radiator of this description will work fairly well, it is definitely inferior in efficiency to the reflector systems shown in Figures 4 and 5. The antenna is a current-fed doublet and is located in the focus of a semi-parabolic reflector. The feeder system is one wavelength long and is inductively coupled to the plate Lecher circuit. The mechanical degree of coupling can be ascertained by reference to Figure 5. A reflector of this type will concentrate the radiation in a fairly sharp beam which will be many times more powerful than that emanating from an open antenna system.

Antennas and Feeders

A later version of the reflector, which gave improved results, was similar to the above described arrangement with the exception that the feeder system, three-quarters of a wavelength long, was clipped directly to the Lecher system. It is probable that this voltage-feed method is to be preferred, as it is rather difficult to obtain satisfactory inductive coupling to the Lecher circuit because of its shape.

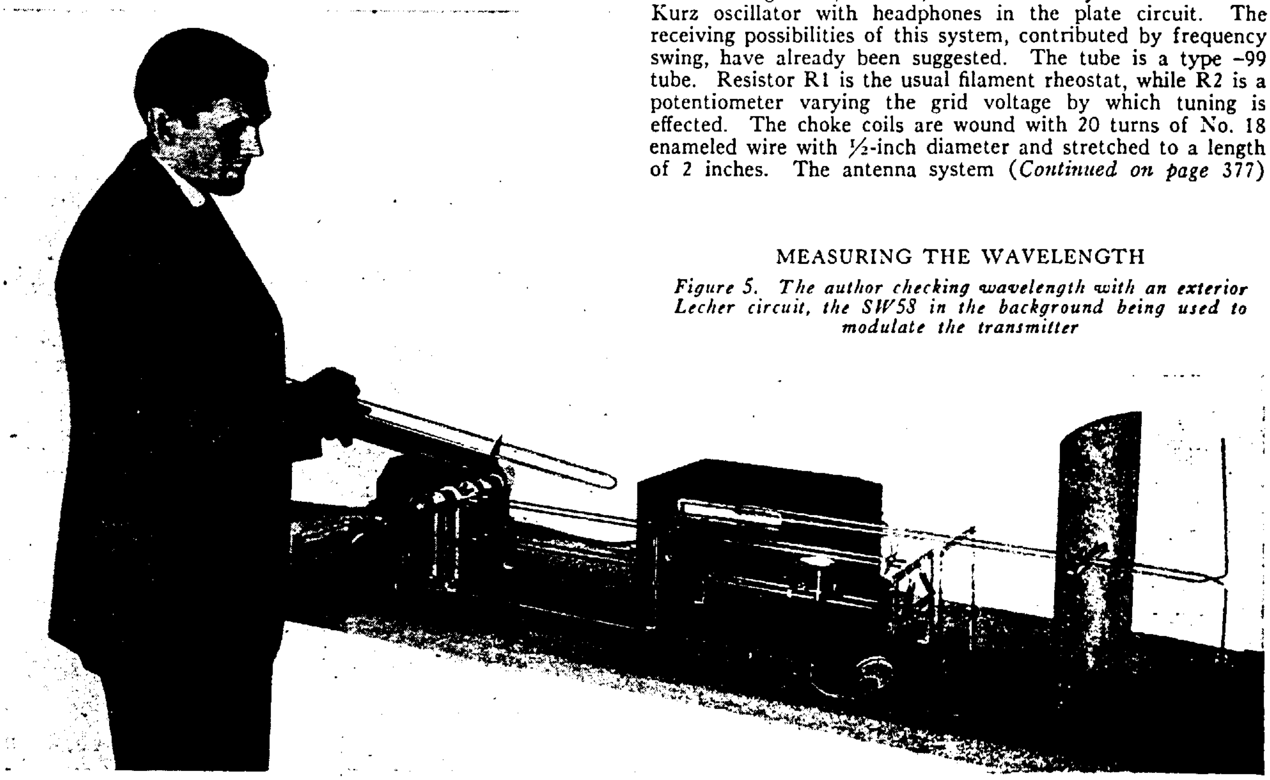
The wavelength of the radiated wave may be measured on an independent Lecher system if desired, as shown in Figure 5. The slide may be either a sensitive microammeter, a small flashlight bulb (when relatively high powers are being radiated) or a simple short-circuiting bar, resonance being indicated in the latter case by a variation in the plate Lecher oscillatory current. However, checking in this way is hardly essential, because, as already explained, the radiated wavelength is equal (with negligible error) to the measured distance between where the Lecher wires connect to the plates (within the tubes) and the terminating bridge.

Before extensive experiments can be carried out, it is essential to have some form of receiver. The simplest is the crystal unit diagrammed in Figure 6 and photographed in Figure 4. This consists of an iron pyrite crystal detector connected between two 7-inch lengths of rod—the overall length approximating 15 inches or ½ wavelength at 75 centimeters. The headphones are connected directly across the detector.

This arrangement, while insensitive, is extremely useful in checking modulation, the directional effects of different radiators, etc., due to the fact that its low sensitivity permits its use in the immediate field of the transmitter. An interesting phenomenon will be observed in a preliminary search with this receiver. When the antenna rods of the receiver are parallel with those of the transmitter, the received signal will be strong; at right angles the signal cannot be heard—demonstrating the sharply polarized nature of the radiated wave.

Receiver Equipment

A receiver more practical for communication purposes is shown in Figures 7, 8 and 4, which essentially is a Barkhausen-Kurz oscillator with headphones in the plate circuit. The receiving possibilities of this system, contributed by frequency swing, have already been suggested. The tube is a type -99 tube. Resistor R1 is the usual filament rheostat, while R2 is a potentiometer varying the grid voltage by which tuning is effected. The choke coils are wound with 20 turns of No. 18 enameled wire with ½-inch diameter and stretched to a length of 2 inches. The antenna system (*Continued on page* 377)



MEASURING THE WAVELENGTH

Figure 5. The author checking wavelength with an exterior Lecher circuit, the SW58 in the background being used to modulate the transmitter

On ¾ Meter Transmission

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has the same overall dimension as that employed in the crystal receiver.

The B-K receiver can be used either in an oscillating or stable state, depending on whether cw or a modulated signal is being received. Oscillations are suppressed by increasing the plate voltage slightly, in which condition it functions as a relaxation period tuner—a signal being favored, or tuned, the frequency of which corresponds to the relaxation period of the electron stream as governed by the grid potential. Oscillations are actually induced by the incoming wave—which, of course, is also favored by the dimensions of the pick-up system.

The output of this receiver can be readily amplified in conventional circuits—a combination receiver and amplifier being shown in Figure 8. With such a receiver, the transmitter described can be heard with good volume for several hundred feet. Under favorable conditions, communication has been established over a distance of several miles with this apparatus. Such results, however, are not easy to duplicate, and the experimenter may be gratified if he can pick up a good signal ¼-mile from the transmitter.

It is obvious that plenty of room exists for further development of the receiver. The addition of super-regeneration should result in greatly improved sensitivity. While the advantages accruing from the use of this system will not be so great as in the 5-meter band, experimentation along this line will be amply justified.

To the experimenter planning a thorough investigation into the possibilities of transmission and reception under 1 meter, a variation of the super-heterodyne principle, as applied to both transmitter and receiver, is also recommended. The transmitter oscillator is modulated at some super-audible frequency, say 175 kilocycles. The receiver input may consist of the B-K arrangement described above, with the output circuit tuned to the modulating frequency. The ¾-meter signal passing through the Barkhausen-Kurz circuit will be demodulated at the intermediate frequency, which can then be amplified through a conventional 175 kc. amplifier to any desired degree, to be followed by a second detector and the requisite amount of af. amplification. If the second detector is operated in conjunction with a beat frequency oscillator a very steady cw signal is available. Also the 175 kc. signal at the transmitter can be voice modulated, which will be demodulated in turn by the second detector.

Learn the Code

(*Continued from page* 339)

from a receiver. Messages taken from the air may be recorded and later copied at a slower speed. Also, if the operator happens not to be present during the sending of press, the message can be recorded and transcribed later.

The amateur can record the signals received from his friends or correspondents and show them how they are sending. Another use for the amateur is to record a call or a CQ on a tape and paste the ends together. The headphone can be held near a small microphone and thus he can modulate his transmitter automatically. Messages can be recorded on a tape previous to their transmission and this tape could then be run off at any desired speed when the desired party has been contacted on the air.