50X1-HUM

[redacted]

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Title: TRANSLATIONS FROM THE BOOK "RADIO ENGINEERING: TRANSPORT COMMUNICATIONS" (USSR) (F. N. Ramlau)

Source: Radiotekhnika: Transportnaya Svyaz' [redacted]

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I. The Radio Station ZhR-1

Radio communications between the operators of marshalling ~~switching~~ yards and the ~~locomotive~~ engineers of marshalling locomotives is now used at most ~~switching~~ yards. The use of radio communications in the marshalling ~~switching~~ yard cuts down the time for rolling stock turnover by 15-25%, increases the productivity of yard engines by 15%, and cuts down idle time of the cars by 3%. For this type of radio communications, a special radio station, the ZhR-1, has been devel- oped which permits direct establishment of ~~one to enter~~ into communication ~~directly and to maintain~~ [illegible] communi- cations without retuning.

For the development of the ZhR-1, the following were awarded the Stalin Prize: N. M. Mikhalenko, director of the work, P. F. Karro-Est, O. P. Sitnikov, and S. V. Khubayev, engrs of the Plant imeni Kozitskiy, and N. A. Metass, engr of the Ministry of Transportation.

The construction of the ZhR-1 is as follows: the transmitter, receiver, and rec- tifiers are mounted on one common chassis enclosed in a hermetically-sealed iron cabinet. When the cabinet is closed, the tuning controls cannot be reached. The cabinet is installed in the right side of the locomotive.

The control panel, which contains the dynamic loudspeaker, a microphone with a [illegible] ~~supporting car~~, and the supply knife switch, is suspended from the roof of the engineer's cab.

The type ZhR-1 radio station is also used in large railroad junctions for com- munication between the engineers of the switching locomotives ~~engine~~ and the switching dispatcher, which provides operational control of the locomotives ~~engines in~~ any section of the station ~~yard~~.

Recently, the radio station ZhR-1 has also come to be used between engineers on a run and the train dispatcher in order to see that the time-table is observed and to avoid ~~provide movement without~~ holding up through trains.

When the number of radio communications is increased, a greater wave band must be occupied in order to eliminate mutual interference. Simultaneous operation of several score radio stations ~~in~~ within a limited area without mutual interference is possible only in the ~~maximum~~ ultrashort-wave band. Conversion to ultrashort waves is the coming thing in ~~[illegible]~~ railroad transport.

Each ZhR-1 radio station is designed for operation on two possible wavelengths between 114 and 142 m, the wavelengths differing by a frequency of 456 kc. The master oscillator of the transmitter and the local oscillator of the receiver are both crystal-controlled so that the frequency will remain constant over wide changes of the ambient temperature. Since because of operating conditions the receiver on the locomotive and at the dispatcher's office must remain on at all times, the receiver has a device which blocks receiver output in the absence of ~~a useful~~ effective signal if ~~interference~~ noise with a level lower than that of the ~~useful~~ effective signal enters the input.

Figure 322 shows a block diagram of the ZhR-1 radio station. There are four possible types of operation, any one of which may be used, as shown in Table 1?.

No of Type of Operation	I	II	III	IV
Transmitter Frequency	f_1	f_2	f_1	f_2
Local Oscillator ~~Frequency~~	f_1	f_2	f_2	f_1
Radio Station Operating	Duplex		Simplex	

Types of operation III and IV are characterized by the fact that one of the crystals, having a frequency of either f_1 or f_2, is used to control the master oscillator of the transmitter G, while the other is used to control the local oscillator of the receiver. In these types of operation, the transmitter is connected up in a three-stage circuit with grid modulation in the last stage. Two radio ~~xxxxx~~ stations designed for operation on the same communications line must have identical crystals. When two radio stations ~~operate in simplex~~ use type of operation III or IV, ~~communication is obtained by the simplex method~~ simplex operation is obtained. When the microphone switch is pressed, ~~the plates of~~ [illegible] supplied to the tubes in the preliminary stages of the transmitter ~~are supplied~~ and ~~the plate supply of~~ power [illegible] from the receiver tubes ~~is removed~~. . . . .

During reception, the microphone switch must be released, in order to supply power to the ~~plates of~~ the receiver tubes and ~~disconnect~~ remove it from the transmitter ~~supply~~.

~~Communication~~ In simplex operation, the same wavelength, ~~which~~ corresponded to the frequency f_1 or f_2, is ~~accomplished~~ used at both ends ~~on~~. The frequency difference $|f_1 - f_2| = f_3$ is equal to the intermediate frequency of 456 kc.

Types of operation I and II are characterized by the fact that the local oscillator of the receiver is used as the master oscillator of the transmitter. In these types of operation, the master oscillator G is switched over to auxiliary excitation, so that the transmitter then has four stages. Types of operation I or II are used in the duplex system of communication. In the duplex ~~system~~ operation, transmission is on one wavelength at one end of the line and on the other wavelength at the other end, i.e., the radio station must be in type of operation I at one end and type of operation II at the other end. In duplex operation, the transmitter is switched on with the microphone switch during transmission, while the receiver remains on all the time so that a communication can be sent without waiting until transmission ends from the other end of the line.

The schematic diagram of the ZhR-1 transmitter is shown in Figure 323.

The first stage (tube L_1) is an electron-coupled oscillator.

In the plate circuit of the second stage (L_2), the choke coil L_a is used as a plate load instead of the usual tuned circuit in order to cut down the number of elements requiring readjustment when the transmitter is to be changed from one frequency f_1 to the other f_2. The third output stage L_3 is inductively coupled with the antenna. The tube L_4 is used for af amplification. The resistors r_1 and r_2 form the negative feedback circuit. The loading coil L with variable inductance is used to tune the antenna to resonance. When changing from one wavelength to another, along with changing the crystals, the capacitors C_1 and C_2 must be interchanged in order to tune the plate circuits of the first and third stages into resonance at the wavelength generated. The transmitter circuit for simplex operation is shown in Figure 323; in duplex operation, the master oscillator stage (tube L_1) becomes an amplifier of the oscillations generated by the local oscillator as shown in Figure 324.

For the transmitting antenna, a wire 7-8 m long on the locomotive and 10-12 m long at the stationary point is used. The power delivered by the transmitter to the locomotive antenna is about 2 w, and to the stationary antenna, about 5 w.

Because of the limited dimensions of the locomotive antenna ($h \approx 2$ m, $b = 6$ m), its efficiency is low.

The effective height of the antenna is

$$h_g = h\left(1 - \frac{h}{2(h+b)}\right) = 2\left(1 - \frac{2}{2(2+6)}\right) = 1.75 \text{ m.}$$

The radiation resistance of the antenna, assuming $\lambda = 118$ m, is

$$R_\Sigma = 160\pi^2\left(\frac{h_g}{\lambda}\right)^2 = 160\pi^2\left(\frac{1.75}{118}\right)^2 = 0.353 \text{ ohm.}$$

The natural wavelength of the antenna is

$$\lambda_0 = (4 \div 5)(h+b) = (4 \div 5)(2+6) = 35 \text{ m.}$$

The loss resistance is

$$R_l = A\frac{\lambda}{\lambda_0} = 7\,\frac{118}{35} = 23.6 \text{ ohms.}$$

Thus, the efficiency of the antenna is

$$\eta_A = \frac{R_\Sigma}{R_\Sigma + R_l} = \frac{0.353}{0.353 + 23.6} = 0.0147 \approx 1.5\,\%$$

The ~~radiation power~~ effective radiated power is

$$P_\Sigma = P_A \eta_A = 2 \cdot 0.0147 = 0.03 \text{ w.}$$

The field intensity created by the locomotive radio station can be calculated approximately from the following relationship:

$$E_{\mu v/m} = 3\,10^5 \frac{\sqrt{P_{\Sigma\,kw}}}{d_{km}}\,S,$$

where $$S = \frac{2 + 0.3\rho}{2 + \rho + 0.6\rho^2}\,;\quad \rho = \frac{\pi}{6 \cdot 10^{12} \cdot \sigma}\,\frac{d_{km}}{\lambda^2_{km}}.$$

Assuming a soil conductivity σ of $\gamma\,10^{-13}$, we find the greatest distance within the range of a marshalling yard is d = 6 km:

$$\rho = \frac{\pi}{6 \cdot 10^{12} \cdot 10^{-13}}\,\frac{6}{0.118^2} = 2.26.$$

$$S = \frac{2 + 0.3 \cdot 2.26}{2 + 2.26 + 0.6 \cdot 2.26^2} = 0.346$$

The field intensity is therefore:

$$E_{\mu v/m} = 3 \cdot 10^5 \frac{\sqrt{0.03 \cdot 10^{-3}}}{6}\ [illegible] = [illegible]\ \frac{\mu v}{m}$$

The receiver circuit for the ZhR-1 radio station is shown in Figure 325. The input ~~unit~~ circuit, which is inductively coupled with the antenna, consists of two tuned circuits very ~~weakly~~ loosely coupled, which ~~weakens~~ reduces the coupling between the transmitting antenna and the amplification stages of the receiver in duplex operation of the radio station.

The tube L_1 is used for rf amplification. The cathode and the first two grids of tube L_2 act as the oscillator triode, which is crystal-controlled. In retuning the receiver from one wavelength to another, the crystal is changed, as are the capacitors C_1 and C_2 of the tuned circuits ~~in the~~ input ~~unit~~ and the capacitor C_3 in the plate circuit of the rf amplifier. As a result of applying an alternating voltage of frequency f_1 (or f_2) to the first grid of the tube L_2 and an alternating voltage ~~of~~ of the oscillations received ~~with a~~ of frequency f_2 (or f_1) to the fourth grid, a current of the difference frequency $f_3 = |f_1 - f_2|$, equal to 456 kc, will flow in the plate circuit. The load for this ~~if~~ i-f current in the plate circuit of tube L_2 is the i-f transformer I. The control grid of the mixer tube L_2 (terminal 3) is connected with the control grid of tube L_1 of the transmitter for duplex operation. The following stage L_3 is an i-f amplifier with the i-f transformer II as a plate load.

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Diode 1 of tube L_4 is used as a detector, diode 2 for delayed automatic volume ~~gain~~ control, and the triode section for amplification of ~~the~~ signals from the detector. The last stage L_5 is a power amplifier.

We now consider the principle of operation of the delayed automatic volume control. A positive direct ~~direct~~ voltage e is applied to plate 2 (the plate of diode 2) from part of the potentiometer r_1 and thus a direct current i will flow from the filament to the plate. This direct current will produce a voltage drop across the resistor r_2, so that the voltage between ~~the~~ plate and ~~the~~ filament will be

$$e_a = e - ir_2.$$

When there is no signal to the receiver input, e_a will be positive. This positive voltage will be applied to the control grids of the tubes L_1, L_2, and L_3 and thus grid currents will flow in these tubes. When these grid currents flow, the transfer constant of the input circuit ~~device~~ K_{in} and the amplification factor of the rf amplifier K_1 and mixer K_2 will be relatively small. For a low voltage at ~~in~~ the receiver input, the voltage U_1 at the detector input will also be relatively small. The voltage U_1 is fed through the capacitor C_4 to the plate of diode 2. If $U_1 < e_a$, there will be no detection effect in ~~the~~ diode 2. Detection will not occur in diode 1 either, since for a low voltage on the receiver input $U_1 < |E_g|$, the potential on plate 1 ~~the first anode~~ will be continuously negative. Thus, for a low voltage on the receiver input, there will be no af voltage at the receiver output and the receiver will be blocked. If, on the other hand, the voltage at the receiver input is sufficiently great, U_1 will be larger than e_a, the detection process will begin in diode 2 and the current i will increase. With an increase of i, the quantity

$$e_a = e - ir_2$$

will decrease, as a result of which the coefficients K_{in}, K_1, and K_2 will increase, and thus the voltage U_1 at the detector input will also increase. The increase of U_1 will continue until the voltage e_a reaches a negative value for which the coefficients K_{in}, K_1, and K_2 are ~~reaches a~~ maximum. With the greatest high amplification in the first three stages of the receiver, the voltage U_1 will become larger than the bias $|E_g|$, the detection process will begin in diode 1, and a alternating ~~variable~~ af voltage will appear at the receiver output. Thus, the receiver will start to operate only when the input voltages exceed a definite level; consequently, interference entering the receiver input in the absence of effective ~~useful~~ signal will not be received, if its level is below that of the ~~useful~~ effective signal. The voltage level at the receiver ~~input~~ input for which the receiver will start to operate ~~minimum will be higher, the higher~~ is proportional to the voltage e taken from the potentiometer r_1.

~~The tubes~~ L_1, L_2, and L_3 ~~have variable transconductance~~ are variable-mu tubes and therefore when ~~with~~ because of a sharp increase of the input voltage the voltage e_a determining the grid bias of these tubes becomes highly negative, the amplification of these tubes decreases so that the voltage at the receiver output remains ~~almost unchanged~~ practically constant. The dependency of the amplification factor of the receiver K upon the voltage at the input U_{in} is shown in Figure 326 (for different values of e taken from the potentiometer).

The receiving antenna on the locomotive is a wire 4-5 m long and a wire 6-7 m long at the stationary equipment. The output power of the receiver is about 1.5 w. A schematic diagram of the power pack for the ZhR-1 radio station is shown in Figure 327.

The primary winding of the transformer has taps for connections to either a 40, 110, or 220 v ac line. The first ~~primary~~ secondary winding of the transformer is used to supply the rectifier ~~which~~ delivering +400 v ~~is fed to~~ to the plate and screen grid of the output stage of the transmitter. The second winding supplies the rectifier which delivers +220 v to the plates of the rest of the transmitter and receiver tubes. This rectifier is also used to supply the microphone and the potentiometer r_1.

The third (secondary) winding supplies the bias rectifier for the last stage of the transmitter. The filament winding ~~of~~ supplying this ~~rectifier~~ [illegible] is also used for the filaments of all tubes except the output tube of the transmitter, for the supply of which there is a separate secondary transformer winding.

An overall circuit of the radio station ZhR-1 is shown in Figure 328. If the transfer switch P is set in the first ~~m~~ (I) or second (II) positions, the radio station is connected up for duplex operation; the third (III) and fourth (IV) positions correspond to simplex operation. In the tuned rf circuits of the transmitter and receiver, there is a semi-variable capacitor connected in parallel with the main capacitor for fine tuning. The tuning indicator U is used to observe~~d~~ the ~~magnitude~~ value of ~~the~~ current in the antenna when ~~tuning~~ adjusting the latter to resonance [with the loading coil]. The plate voltage is fed to the transmitter and receiver through the contacts of relay R. The winding of relay R must be ~~mag~~ energized in order to apply voltage to the transmitter. Current will flow through the winding of relay R if either ~~the~~ switch T_1 of the microphone on the control panel or switch T_2 of the headset on ~~microtelephone tube of~~ the portable unit VU is pressed.

During tuning of the radio station, the headset ~~can also be connected by the~~ with its switch can be connected into jacks 1, 2, 3, or 4 of the control plug (kol). The winding of relay R can be ~~connected into the~~ energized during tuning of the radio station without using the switch by setting the tumbler switch T in position 2.

When the receiver is set for the highest possible sensitivity, the switch K in the detector circuit is opened. The copper-oxide meter KV is used to check the voltages in the supply circuit on locomotive radio stations. The small lamp L_3 is used as a voltage indicator in stationary radio stations. The neon lamps L_1 and L_2 indicate power off and on to the transmitter and receiver.

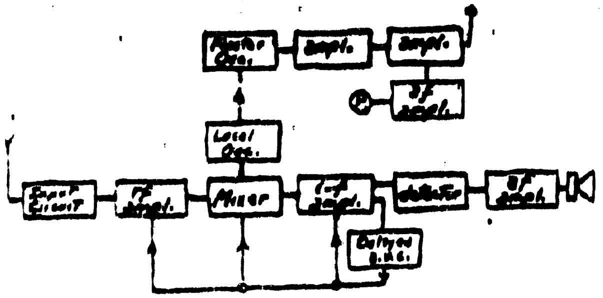
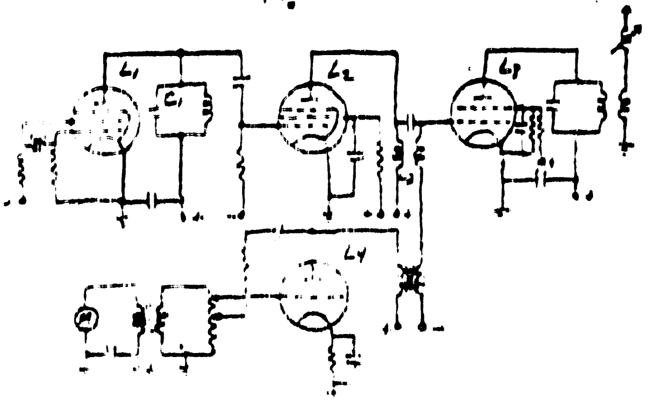


Figure 322



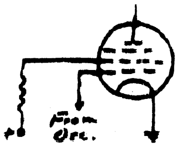


Figure 324

Figure 323

[Figures 325 and 326 are on the following page].

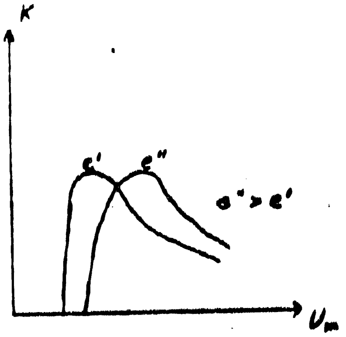


Figure 326

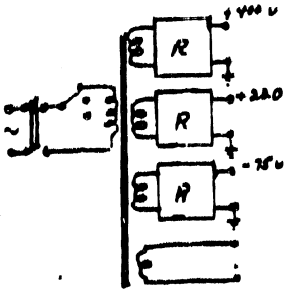
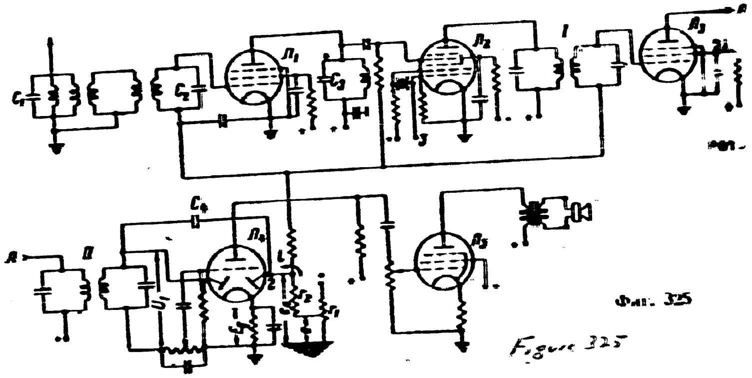
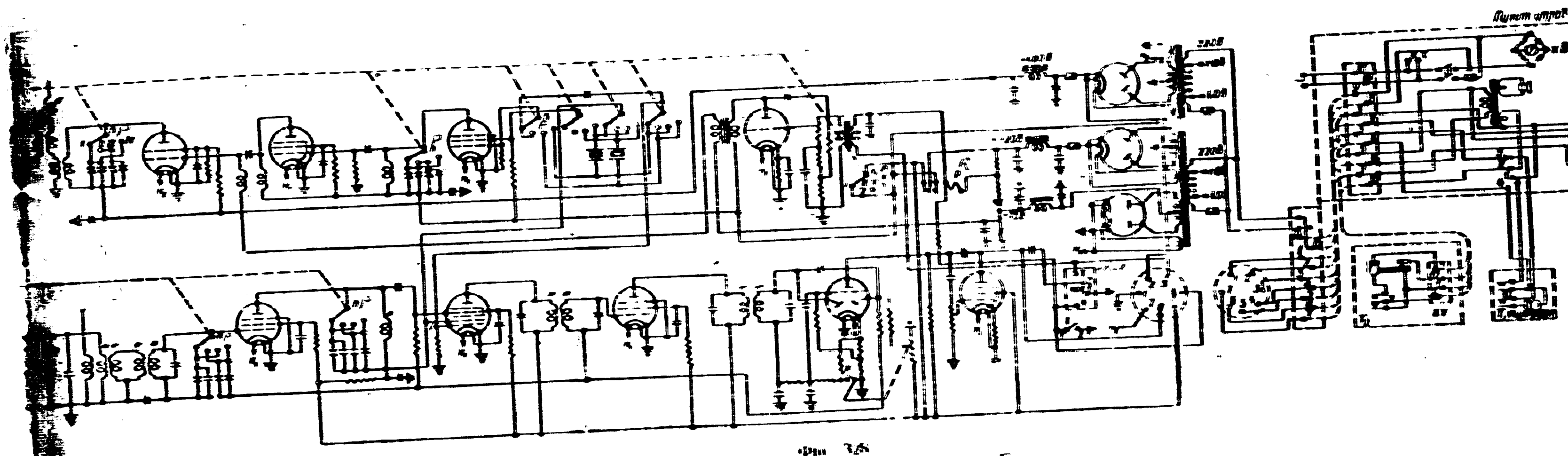


Figure 327



Фиг. 325

Figure 325



Фиг 326

Figure 325

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[illegible] UHF Triode Oscillators

The problem of generating oscillations becomes more complex as the wavelength is made shorter. With an increase in frequency, the [illegible] capacitances connected in parallel (particularly ~~the leakage caused by~~ the capacitance of circuit wiring [illegible]) and inductances connected in series (~~the~~ inductances ~~of connecting~~ leads [illegible] particularly) [illegible]. Therefore, special small tubes with low interelectrode capacitance and low inductance [illegible] leads are used for the generation of [illegible] superhigh frequencies. In using [illegible] tubes, we must keep in mind that the interelectrode capacitance and lead inductances [illegible] are [illegible], proportional ~~vary approximately linearly with a change~~ [illegible] dimensions [illegible], while the saturation current and permissible plate [illegible] the dimensions of the [illegible] [illegible] when all the linear dimensions of the tube are made smaller.

[illegible] oscillator with consideration for the interelectrode capacitances and lead inductances (Figure 337) is made up of three coupled circuits. To simplify control of the circuit, the coupling between circuits should be made as [illegible] as possible. For this purpose, one of the circuits (I or II) [illegible] shorted, making [illegible] (Figure 338) or $L_{p-f} = \infty$ (Figure 339), respectively. [illegible] (Figure 338 and III) will be [illegible] and $L_c < L_g$, the coupling between circuits II and [illegible] between circuits I and III (Figure 339), and consequently the circuit shown in Figure 339 should be more efficient. By connecting in the plate circuit an inductance L in series with a blocking capacitor C_b and a choke coil L_g in the grid circuit, we obtain the bridge circuit shown in Figure 340.

In ~~[illegible]~~ this circuit, the capacitance of the oscillatory circuit for obtaining waves as short as possible is determined only by the capacitance of the tube itself.

The ~~[illegible]~~ condition governing bridge balance is the equality:

$$\frac{C_{p-g}}{C_{p-f}} = \frac{L_f + L_c}{L_g}$$

When this equality holds, the current i_a flowing ~~[illegible]~~ in the plate circuit in one diagonal does not develop a potential difference U_g across the grid-filament terminals in the other diagonal.

In other words, when the bridge is balanced, there is no feedback in the circuit, self-excitation is impossible, and the circuit can be used to generate oscillations if independent excitation is used. The feedback necessary for self-excitation can be obtained by making the proper change in the inductance of the grid choke coil L_g. If we do not show the elements of the circuit found within the tube itself, the circuit shown in Figure 340 takes the form shown in Figure 341, where the plate circuit inductance L is taken care of by a short lead connecting the plate of the tube with the blocking capacitor C_b. Sometimes the inductance connected between the grid and plate is taken care of by a short-circuited two-conductor feeder (Figure 342). The feeder is short-circuited for rf current through the capacitance C_b in order that the plate circuit will be isolated from the grid circuit for the dc voltage. By moving the capacitance C_b along the feeder, we can change the length of the feeder l_2. Correspondingly, we change the inductance of the plate circuit L:

[illegible] $= Z_{l_2} = -j \frac{1}{Z_0} \cot \alpha l_2$

and the wavelength of the oscillations generated. In order to cut down losses in the two-conductor feeder circuit in the plate-grid circuit, this type of feeder is replaced by a concentric cable. In order to obtain the shortest possible waves, the capacitance of the oscillatory circuit must be made minimum. This capacitance is determined by the capacitance between the tube electrodes, which has a definite value for a given tube type, and the capacitance of the tube electrodes with respect to ground. The plate has the highest capacitance with respect to ground.

If one end of the filament is grounded, the plate-to-ground capacitance $C_{p\text{-ground}}$ will be actually connected in parallel with the plate-to-filament capacitance, thus increasing the total capacitance of the oscillatory circuit. In order to eliminate the capacitance $C_{p\text{-ground}}$ from the oscillatory circuit, the filament must be isolated from ground for the rf current, and that is why a choke coil (Figure 342) is used in the filament circuit.

In order to obtain high power, we can use a push-pull circuit, in which the two conductors connecting the plates and grids of the tubes can be considered as a two-conductor feeder (Figure 343). The plate and grid choke coils are connected in this circuit to points of the feeder at which a voltage node will appear. Another variation of the push-pull circuit is shown in Figure 344, where the feeder ~~jumpers~~ shorting bars 1 - 1 and 2 - 2 serve respectively for changing the wavelength and regulating feedback.

The design of a triode ultrashort-wave oscillator should take into account the fact that at superhigh frequencies ~~the duration of~~ the period of oscillations becomes comparable with the transit time. The maximum velocity of an electron in the filament-plate space is

$$V = 6\cdot 10^5 \sqrt{E_a}\ \frac{m}{sec}.$$

The average velocity is

$$V_{av} = \frac{1}{2} V = 3\cdot 10^5 \sqrt{E_a}.$$

If an alternating voltage $u = U_g \cos \omega t$ is applied to the grid of the tube, the alternating component of the plate current will ~~change~~ vary according to the relationship

$$i_a = I_1 \cos[\omega(t - t_1)] = I_1 \cos[\omega t - \phi],$$

where $\phi = \omega t_1$ is the angle by which the plate current lags the grid voltage and t_1 is the transit time.

The time t_1 is related to the radius of the plate r_a (with the length of the electron trajectory) by the following equation:

$$t_1 = \frac{r_a}{V_{av}}$$

Thus the angle of lag is

$$\phi = \omega \frac{r_a}{V_{av}} = \frac{2\pi}{T}\frac{r_a}{V_{av}} = \frac{2\pi}{\lambda}\frac{c\, r_a}{V_{av}} = \frac{2\pi}{\lambda}\frac{3\cdot 10^8 r_a}{3\cdot 10^5\sqrt{E_a}} = 1000\,\frac{2\pi}{\lambda}\frac{r_a}{\sqrt{E_a}}$$

or, expressing the angle ϕ in degrees,

$$\phi^\circ = \frac{360}{2\pi}\phi = \frac{360\cdot 10^3 r_a}{\lambda\sqrt{E_a}}$$

where r_a and λ are given in meters and E_a is the plate voltage in volts.

A phase shift ϕ between the alternating component of the plate current I_1 and the alternating grid voltage I_g can obviously occur only if there is reactance in the ac circuit. Consequently, the plate resistance of the tube for superhigh frequencies should be considered to be the complex impedance

$$Z_i = R_i + jX_i$$

in which the reactive part depends on the angle ϕ:

$$\tan\phi = \frac{X_i}{R_i}$$

The equivalent circuit of a vacuum-tube oscillator for superhigh frequencies (Figure 345) is determined by the dependency of the plate current upon grid voltage:

$$I_1 = \frac{\mu U_g}{Z_i + Z}$$

Multiplying both sides of the equality by Z and remembering that $U_a = I_1 Z$, we obtain:

$$\frac{U_g}{U_a} = D\left(1 + \frac{Z_i}{Z}\right).$$

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If in the first approximation we disregard losses in the circuit elements determining feedback, the ratio $\frac{U_g}{U_a}$ should be a real number. For this, the ratio $\frac{Z_i}{Z}$ should also be a real number, i.e., the circuit must be tuned relative to the frequency of the first harmonic of the plate current, so that

$$Z = R + jX$$

where

$$\frac{X}{R} = \frac{X_i}{R_i}$$

Thus, the voltage at the terminals of the circuit will lead the current I_1 by an angle ϕ, so that the useful power is

$$P_1 = \frac{1}{2} U_a I_1 \cos\phi .$$

The shorter the wave length the greater ϕ and consequently the less useful power P_1 obtained from the tube and the lower the efficiency of the vacuum-tube oscillator. The triode can be used for the generation of superhigh frequencies in the meter and decimeter wave bands.

Example. Calculate an oscillator for a wavelength of $\lambda = 1$ m, using a G-464 tube. The parameters of the tube are:

$E_a = 500$ v, $E_{g_0} = -100$ v,

$S = $ [illegible], $D = 0.0312$, $R_i = 11,400\ \Omega$, $P_a = 50$ w

$I_s = $ [illegible] ma, radius of plate $r_a = 2.25$ mm, radius of cathode $r_k = 1.35$ mm

We assume the maximum pulse plate current as

$$I_{max} = 0.4 \text{ a}$$

We select an operating angle $\theta° = 90°$. We find the functions of the operating angle:

$$\alpha_1 = 0.5,\ \alpha_0 = 0.318,\ \alpha_i = 2$$

The amplitude of the first harmonic of the plate current is

$$I_1 = I_{max}\,\alpha_1 = 0.4 \cdot 0.5 = 0.2 \text{ a}$$

Considering the sharp rise in losses ~~in the~~ circuit at superhigh frequencies, we assume a circuit impedance of

$$|Z| = 1,000\ \Omega .$$

The amplitude of the plate voltage is

$$U_a = I_1 Z = 0.2 \cdot 1000 = 200 \text{ v.}$$

The coefficient of utilization of the plate voltage is

$$\xi = \frac{U_a}{E_a} = \frac{200}{500} = 0.4$$

The phase shift angle between the plate current and the grid voltage is

$$\phi° = \frac{360 \cdot 10^3\, r}{\lambda \sqrt{E_a}} ,$$

where $r = r_a - r_k = 2.25 - 1.35 = 0.9$ mm is the distance between plate and cathode and thus

$$\varphi^\circ = \frac{360\cdot10^3\cdot0.9\cdot10^{-3}}{1\sqrt{500}} = 14.5^\circ.$$

The active component of the given plate resistance is

$$R_i' = R_i\alpha_i = 11,400\cdot2 = 22,800\ \Omega.$$

The reactive component is

$$X_i = R_i'\tan\varphi = 22,800\cdot\tan 14.5^\circ = 5,900\ \Omega.$$

Thus, the plate impedance of the tube is

$$|Z_i'| = \sqrt{R_i'^2 + X_i^2} = \sqrt{22,800^2 + 5,900^2} = 23,600\ \Omega$$

The excitation voltage is

$$V_g = DI_1(Z_i' + Z) = 0.0312\cdot0.2(23,600+1,000) = 153\ V.$$

The grid bias is

$$E_g = -V_g\cos\theta - D(E_a - E_{g_0} - V_a\cos\theta) =$$
$$= -0.0312(500-100) = -12.5\ V.$$

The dc component of the plate current is

$$I_0 = I_{max}\alpha_0 = 0.4\cdot0.315 = 0.127\ a.$$

The applied power is

$$P = E_aI_0 = 500\cdot0.127 = 63.5\ W$$

The useful power is

$$P_1 = \frac{1}{2}V_aI_1\cos\varphi = \frac{1}{2}200\cdot0.2\cos14.5^\circ = 19.3\ w.$$

The plate ~~losses are~~ dissipation is

$$P_a = P - P_1 = 63.5 - 19.3 = 44.2\ w.$$

We check whether these ~~losses are~~ dissipation is permissible for the tube type selected:

$$P_a \leq P_0;\ 44.2 < 50.$$

Specially-designed triodes can be used to obtain wavelengths down to 10 cm.

Ultrashort-wave triode transmitters are used in transport for communication between the switching engine and the dispatcher and between the locomotive and caboose.

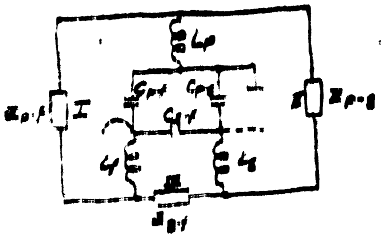

Figure 337

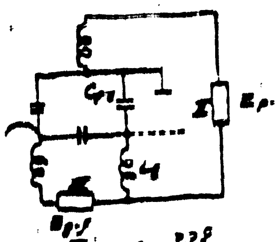

Figure 338

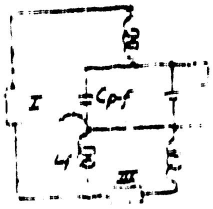

Figure 339

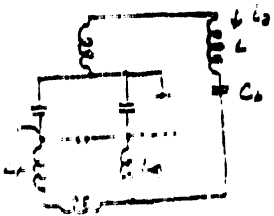

Figure 340

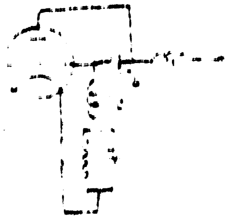

Fig...

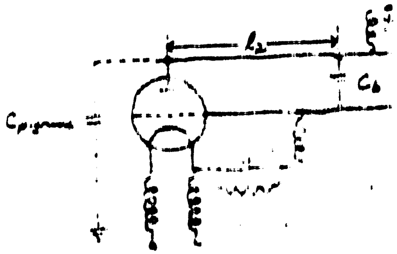

Figure 342

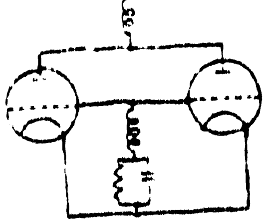

Figure 343

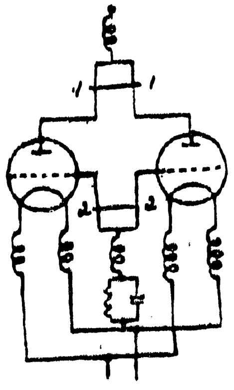

Figure 344

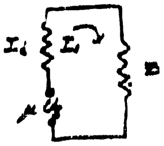

Figure 345