UNIT-2
AM TRANSMITTERS

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SYLLABUS(Topics to be covered)

UNIT – II

AM Transmitters: Classification of Radio transmitters, Carrier Frequency Requirements, Master Oscillator, frequency Synthesizers, Harmonic Generators, Radio Broadcast Transmitters,

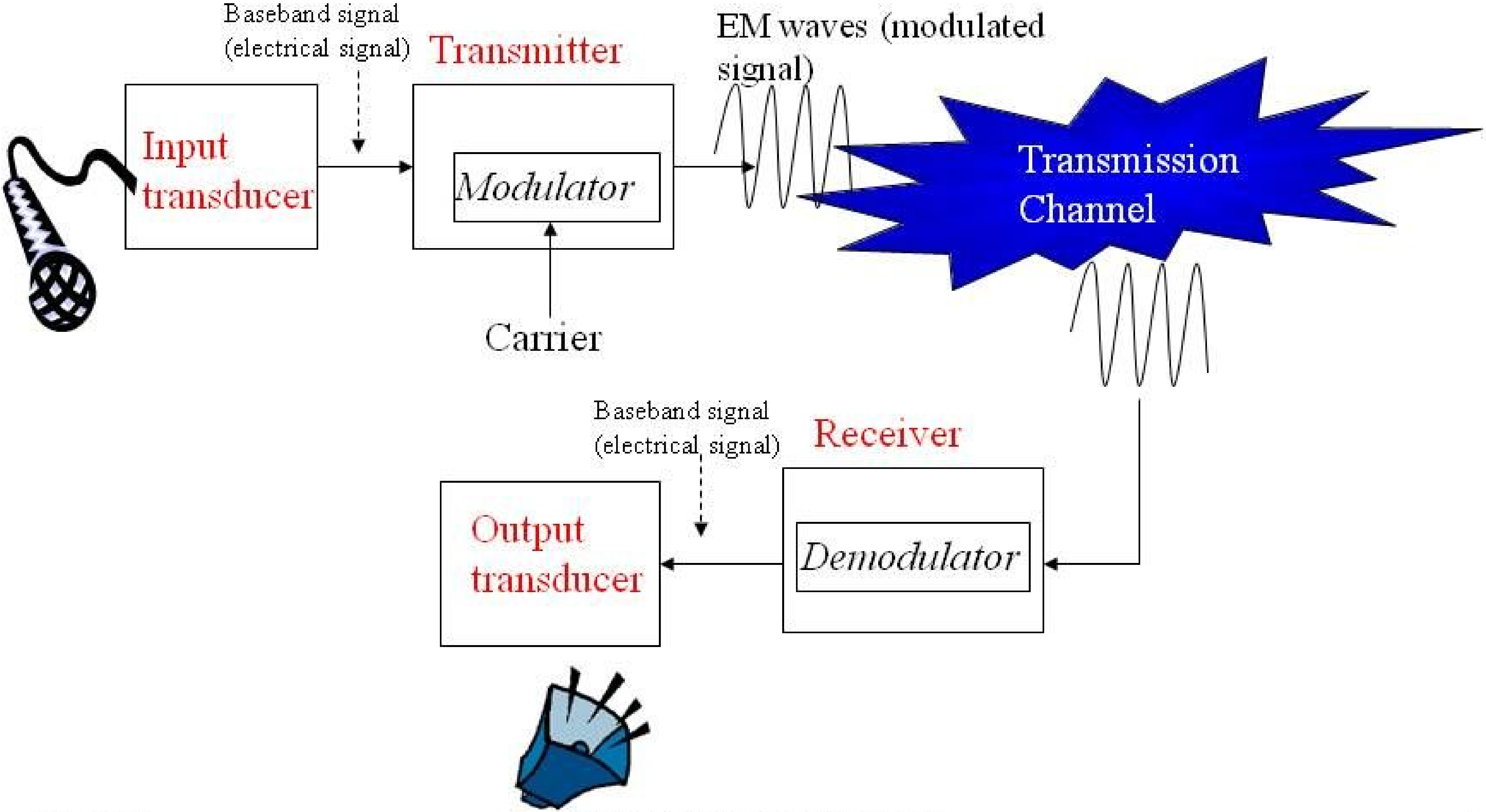
Radio Telephone Transmitters, Peak Limiters, Peak Clippers, Volume Compressors, VODAS, Privacy

Devices in Radio Telephony, Broad band Techniques,

FDM and TDM Hierarchy, SSB Transmitters,

Suppression of Radiation from Radio Transmitters.

Basic analog communications system



RADIO TRANSMITTERS

CLASSIFICATION OF RADIO TRANSMITTERS:

Classified according to following methods:

1. According to type of modulation used.
2. According to type of service involved.
3. According to the frequency range involved.

1.CLASSIFICATION ACCORDING TO THE TYPE OF MODULATION USED:

1.1. AMPLITUDE MODULATION TRANSMITTER:

In AM Transmitter , the modulating signal amplitude modulates the carrier.

USES:-

- *For Radio Broadcast on Long, Medium, Short waves.*
- *For radio telephony on short waves.*
- *For radio telegraphy on short waves.*
- *For Television picture broadcast on very short waves or ultra short waves*

1.2. FREQUENCY MODULATION TRANSMITTER:

In FM transmitter, signal voltage frequency modulates the carrier.

- *For Radio Broadcast on VHF & UHF range.*
- *For Television sound broadcast in VHF & UHF range.*
- *For Radio telephone communication in VHF & UHF range over short distances*

Contd.

1.3. PULSE MODULATION TRANSMITTER:

In this signal voltage alters some characteristic of pulses such as pulse width, pulse position, pulse amplitude, pulse code etc

Uses: Radio telegraphy, telephony etc.

2. CLASSIFICATION BASED ON THE TYPE OF SERVICES INVOLVED:

2.1. RADIO TRANSMITTER:

2.2. TELEVISION TRANSMITTER: 2 Txrs one for picture using AM Txr, other for using sound using FM Txr

2.3 RADAR TRANSMITTER: PULSE RADAR & COUNTINUOUS RADAR

2.4 NAVIGATIONAL TRANSMITTER: For sea & air navigations

2.5. RADIO TELEGRAPHY TRANSMITTER:

2.6 RADIO BROADCAST TRANSMITTER:

3. CLASSIFICATION ACCORDING TO THE CARRIER FREQUENCY:

3.1 **LONG WAVE TXR:** operates on long wave i.e frequency below 300 hz

Use: broadcasting

3.2 MEDIUM WAVE TXR: 550 to1650 khz

Use: broadcasting

3.3 SHORT WAVE TXR: 3- 30 mhz

Use: broadcasting

3.4 VHF &UHF TXR: VHF OR UHF ranges

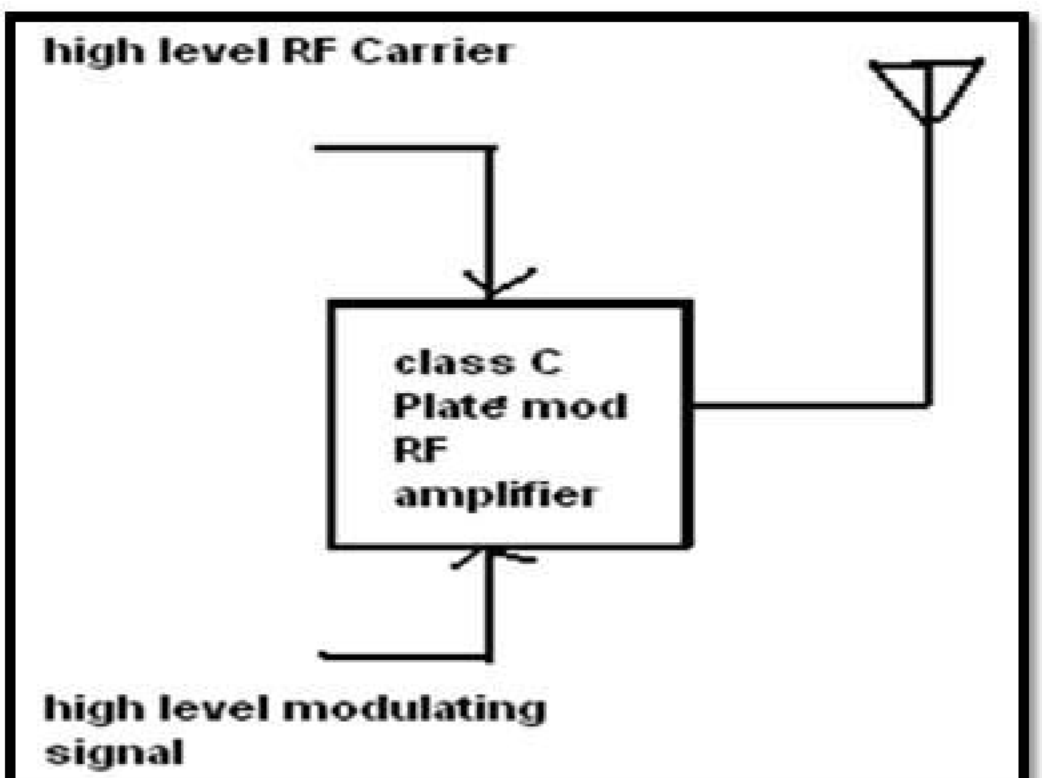
Use: broadcasting

3.5 MICROWAVE TXR: microwave frequencies , freq beyond about 1000 MHz

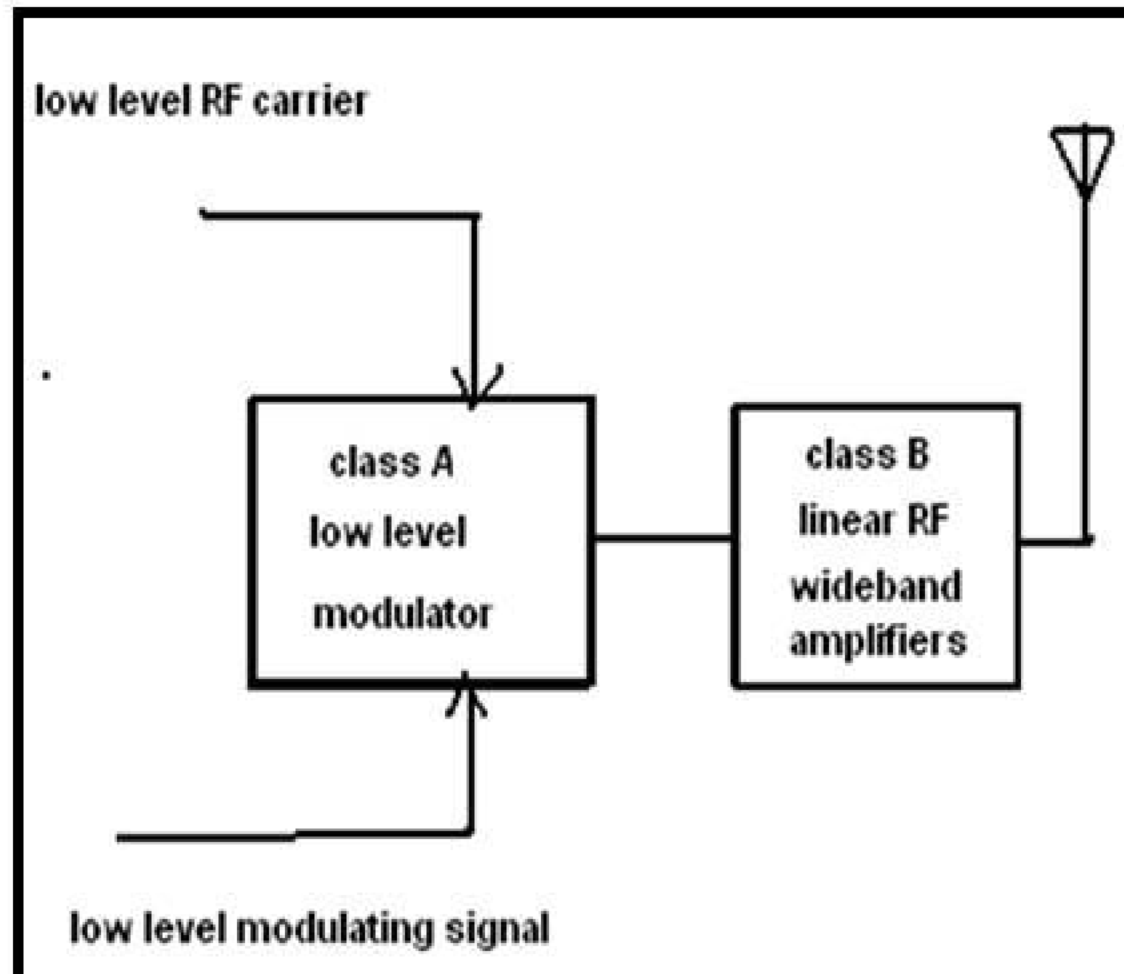
use: microwave link between two adjacent places

AM TRANSMITTERS:

✓ **HIGH LEVEL MODULATION SYSTEM:** *Radio transmitter using modulation at high level of power level of the carrier.*



✓ **LOW LEVEL MODULATION SYSTEM:** *Radio transmitter using modulation at low level of power level of the carrier.*



HIGH LEVEL TRANSMITTERS

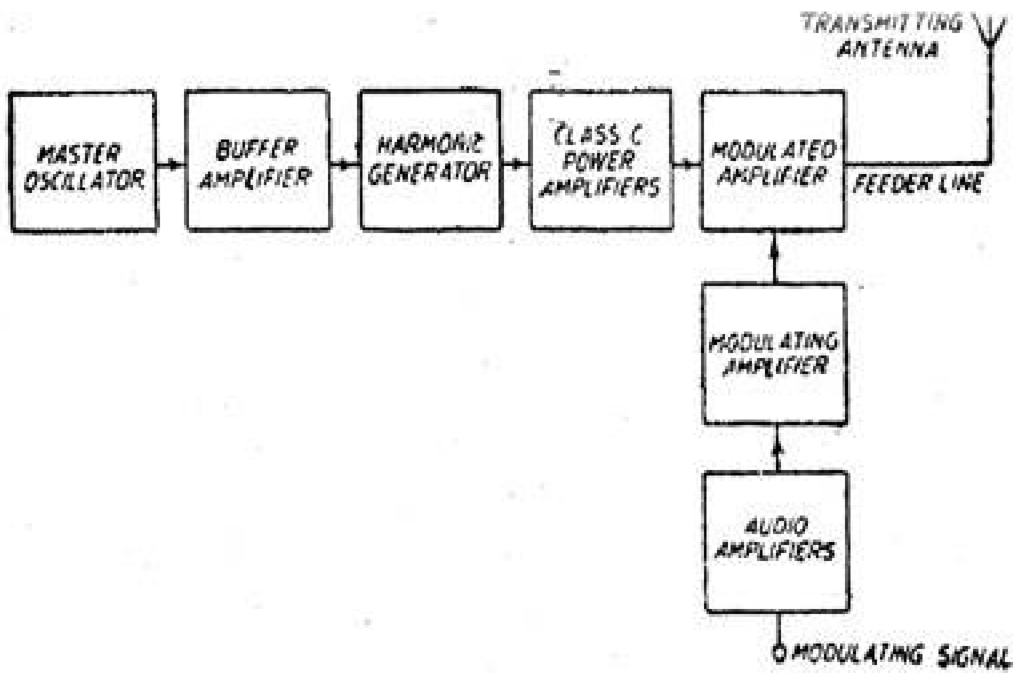


Fig. 6.1. Block diagram of amplitude modulation radio transmitter using modulation at high carrier power level.

LOW LEVEL TRANSMITTERS

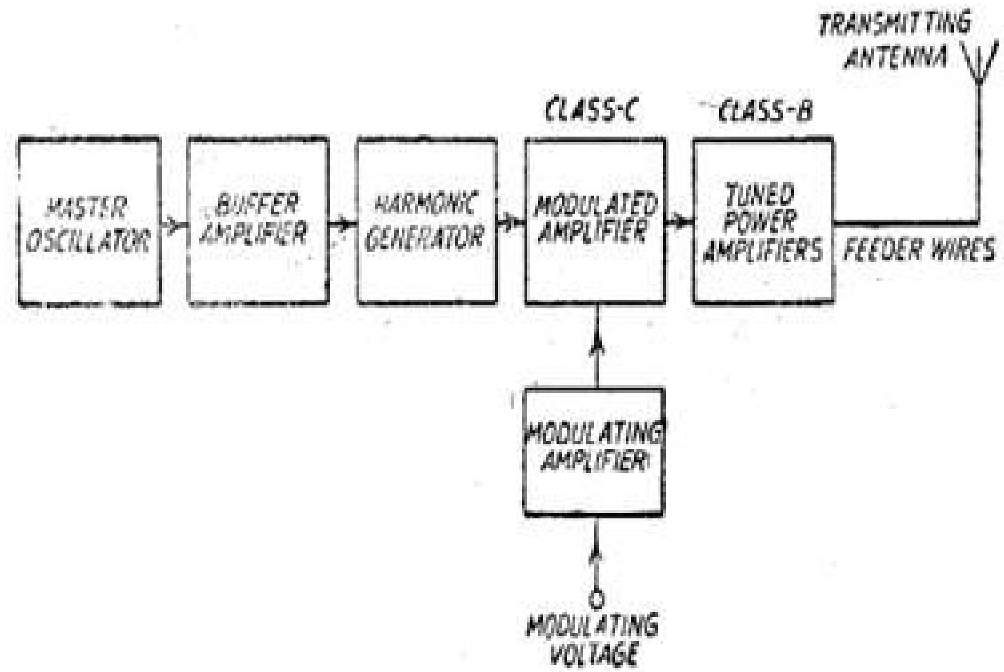


Fig. 6.2. Block diagram of a radio transmitter using low power level modulation system.

Explanation of fig. 6.1 & 6.2

The transmitter shown in Fig. 6.1 uses the so called *high power level modulation system* in which the carrier voltage is modulated at the highest power level. An alternative system called the *low power level modulation system* consists in modulating the carrier at low power level and the carrier power is subsequently raised to the desired level in class B tuned power amplifiers as shown in Fig. 6.2. Such tuned power amplifiers cannot use class C operation because class C operation cannot reproduce the variation in the amplitude of the carrier voltage since plate current in class C amplifier flows in the form of pulses. Such low power level modulation system was extensively used in the early stages of development of radio communication but has now been almost completely replaced by high power level modulation system.

The function of each constituent stages of block diagram in brief:

1. **Master oscillator**: generates oscillations of desired frequencies.

2. **Buffer amplifier**: low-gain, high input impedance linear amplifier, to isolate the oscillator from high power amplifier.

3. **Harmonic generators**: basically are class c amplifiers which generates desired harmonic frequency.

4. **RF power amplifiers**: RF voltages generated by the has usually very low power so power level is raised to final level.

1. **Modulated amplifiers**: to combine the modulating signal with the carrier frequency.

5. **Modulating amplifiers**: feeds audio power to the modulation amplifiers

Q. Compare low level and high level modulation???

PARAMETERS	LOW LEVEL MODULATION	HIGH LEVEL MODULATION
POINTS AT WHICH MODULATION TAKES PLACE	*At initial stages of amplification*	*At final stages*
POWER LEVEL	*Low power*	*High power*
COMPLEXITY	*Simple*	*Quite complex*
PRIME FACTORS IN DESIGN	*Simplicity*	*High efficiency and low distortion*
AUDIO POWER	*Low audio power required*	*High*
DESIGN REQUIREMENT OF AMPLFIER STAGES	*Sufficient bandwidth handling amplifiers*	*Not the case*
AMPLIFIER USED	*Linear amplifiers class A*	*Class C amplifiers*
EFFICIENCY	*Low*	*High*
APPLICATIONS	*Some times used in tv broadcast*	*AM broadcasting*

Generally, negative feedback is provided in AM transmitters. This negative feedback reduces the distortion in a class C modulator system. It also linearizes the output of class C modulator. Fig. 2.21 shows the negative feed back circuitry.

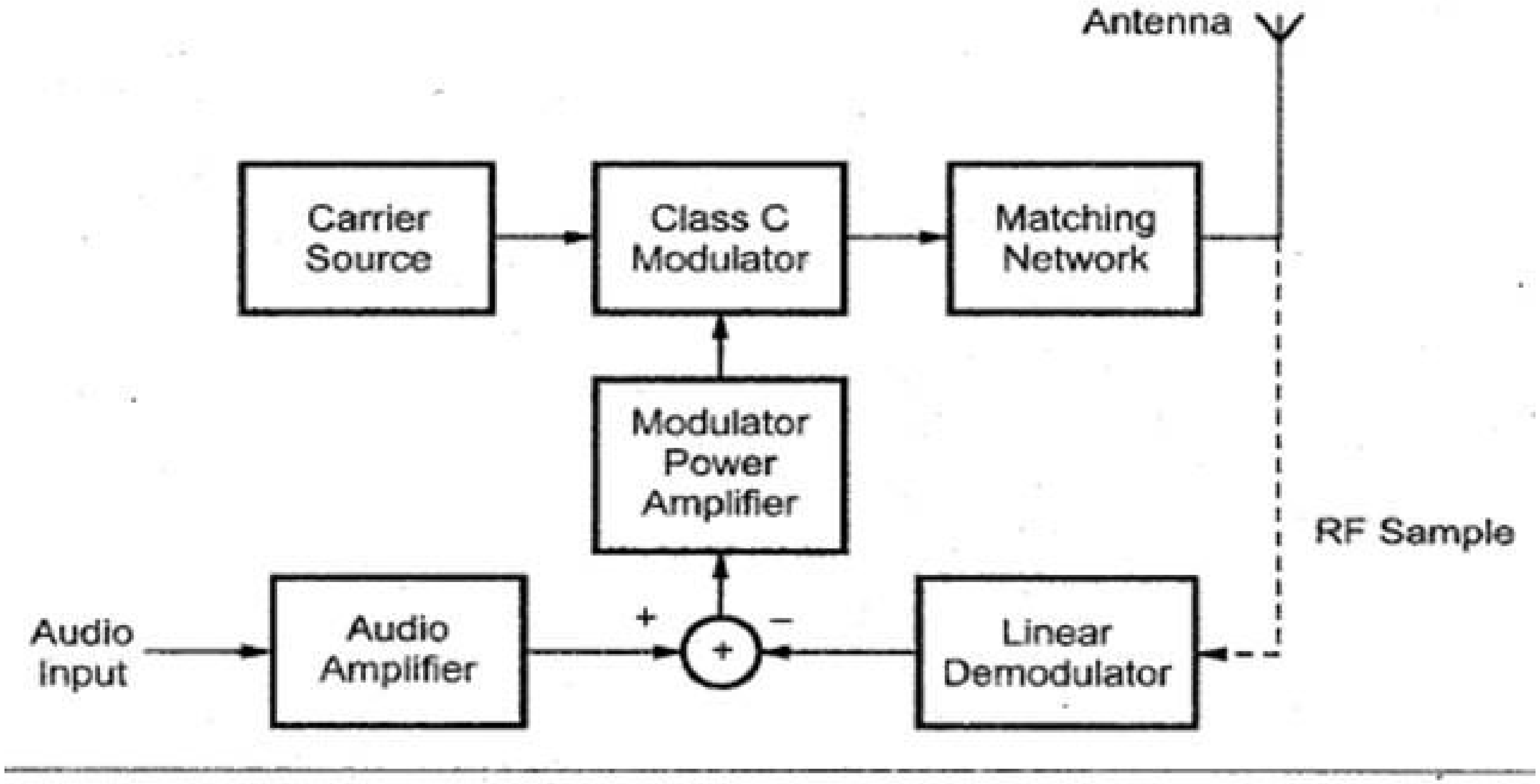


Fig. 2.21 Negative feedback circuitry

The negative feedback circuitry samples the RF signal sent to the antenna. sampled signal is demodulated by linear demodulator to produce feedback signal.

Carrier frequency requirement of Radio transmitter

There are three main requirements of a radio transmitter regarding the carrier frequency:

1. *Generated carrier frequency must be exactly at specified value.*
2. *Carrier freq. must be readily adjustable.*
3. *Frequency drift and frequency scintillation must be extremely small.*

- ✓ **FREQUENCY DRIFT** :It means slow variation in frequency with time

  The maximum frequency drift permitted in radio transmitters is

  ± 20 hz for medium wave txr

  And ± 0.002 % for short wave and UHF txr
- ✓ **FREQUENCY SCINTILLATION**: It means abrupt changes in frequency caused mostly by abrupt variations in load on the master oscillator.

- <u>To avoid scintillation</u>, the master oscillator should be made to drive buffer amplifier adjusted to draw little power from the master oscillator thereby producing little loading of the master oscillator

- <u>Frequency drift</u> : in any oscillator the frequency of oscillation is close to the resonant freq. of the tank circuit but the exact value of freq of oscillation is influenced by the following factors :-

1. Resistances & reactance coupled into the tank circuit by the load.

2. Effective "Q" of the tank circuit.

3. Voltage acting on the electrodes of the oscillator tube or transistor.

4. Harmonics generated .

Note : *these factors produce small phase shift between the exciting voltage & the output voltage of the oscillator transistor(tube)*

In order to cancel these phase shifts the oscillator has to operate slightly off the resonant freq of the tank circuit

MASTER OSCILLATORS

An LC oscillators may be used as Master oscillator for most purposes provided that optimum care is taken in the design and operation of the oscillators to reduce frequency drift and scintillation.

Necessary Precautions are as follows:

1. *Oscillators should be enclosed in constant temperature chamber so that the values of tank circuit L and C inter electrode capacitances do not vary with temperature*
2. *Stablized power supply should be used so that electrode voltages do not vary*
3. *Effective Q of the tank circuit should be kept as high as possible.*
4. *Master oscillator should operate at sub-harmonic of the carrier frequency.*
5. *Master oscillator should be followed by multistage power amplifier whose first stage has to be buffer amplifier.*
6. *Operating conditions should be adjusted so that the harmonic generation is minimum.*
7. *So on.........*

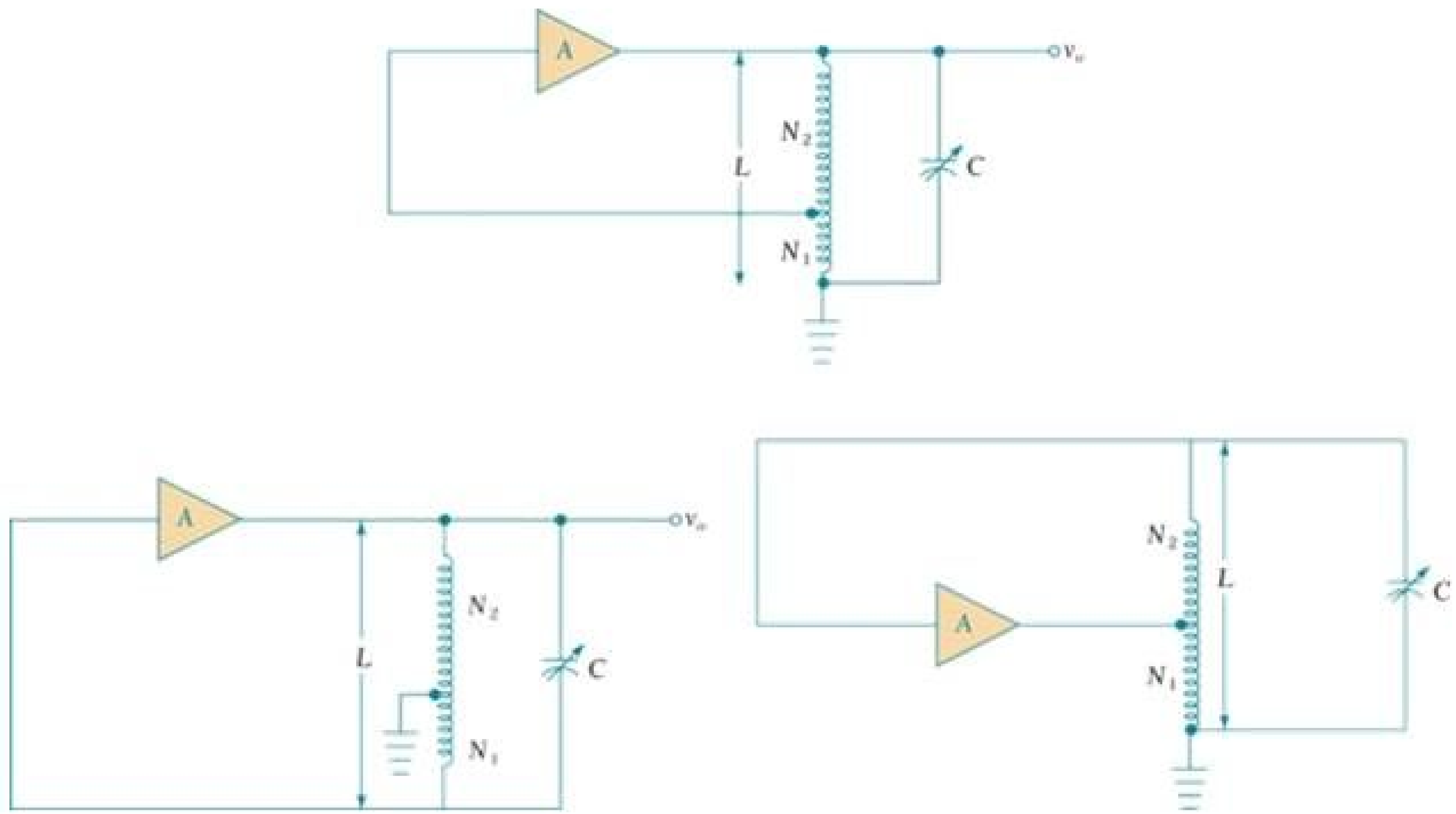
Radio-Frequency Oscillators

- RF oscillators do not differ in principle than other oscillators but practical circuits are quite different
- Any amplifier can be made to oscillate if a portion of the output signal is fed back to the input
- The *Barkhausen criteria* establishes the requirements for a circuit to oscillate

LC Oscillators

- Practical RF circuits whose frequency is controlled by a resonant LC circuit are:
  - Hartley Oscillator
  - Colpitts Oscillator
  - Clapp Oscillator

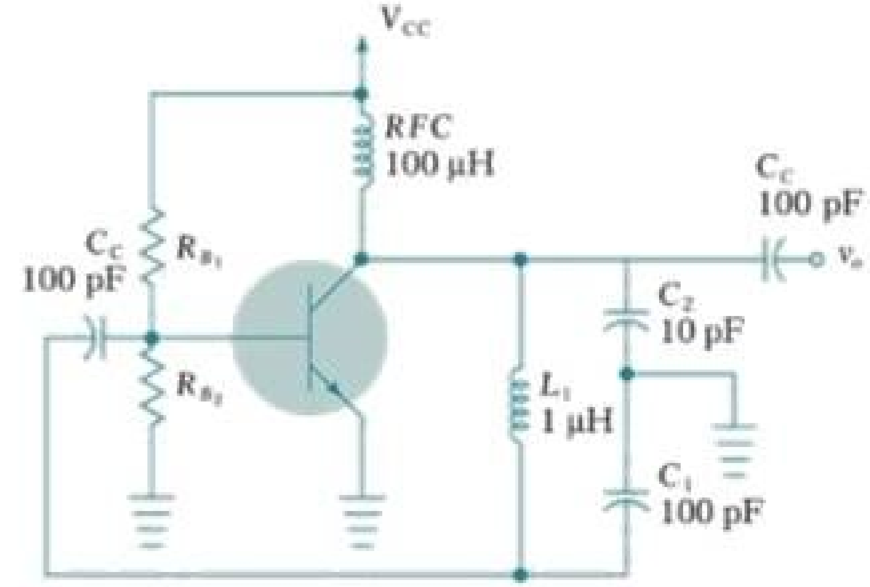
Hartley Oscillator

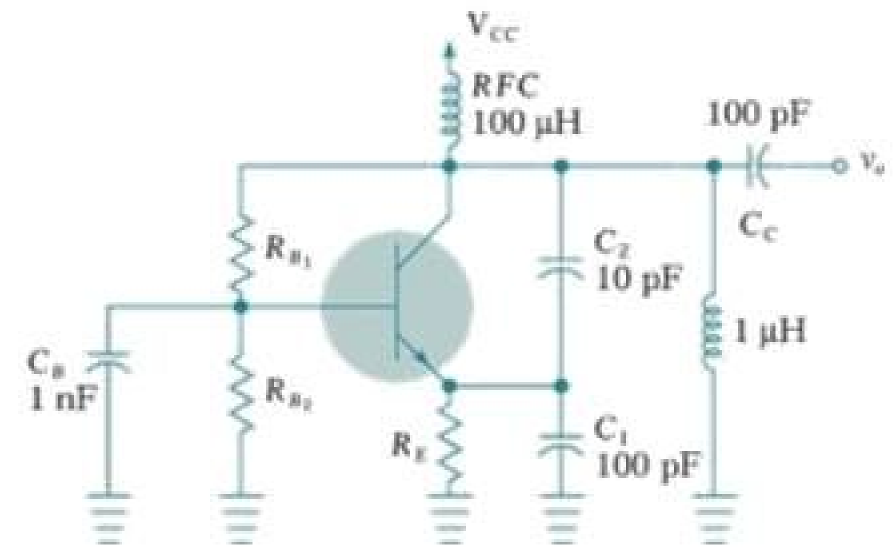


- Common configurations for a Hartley Oscillator

Colpitts Oscillator

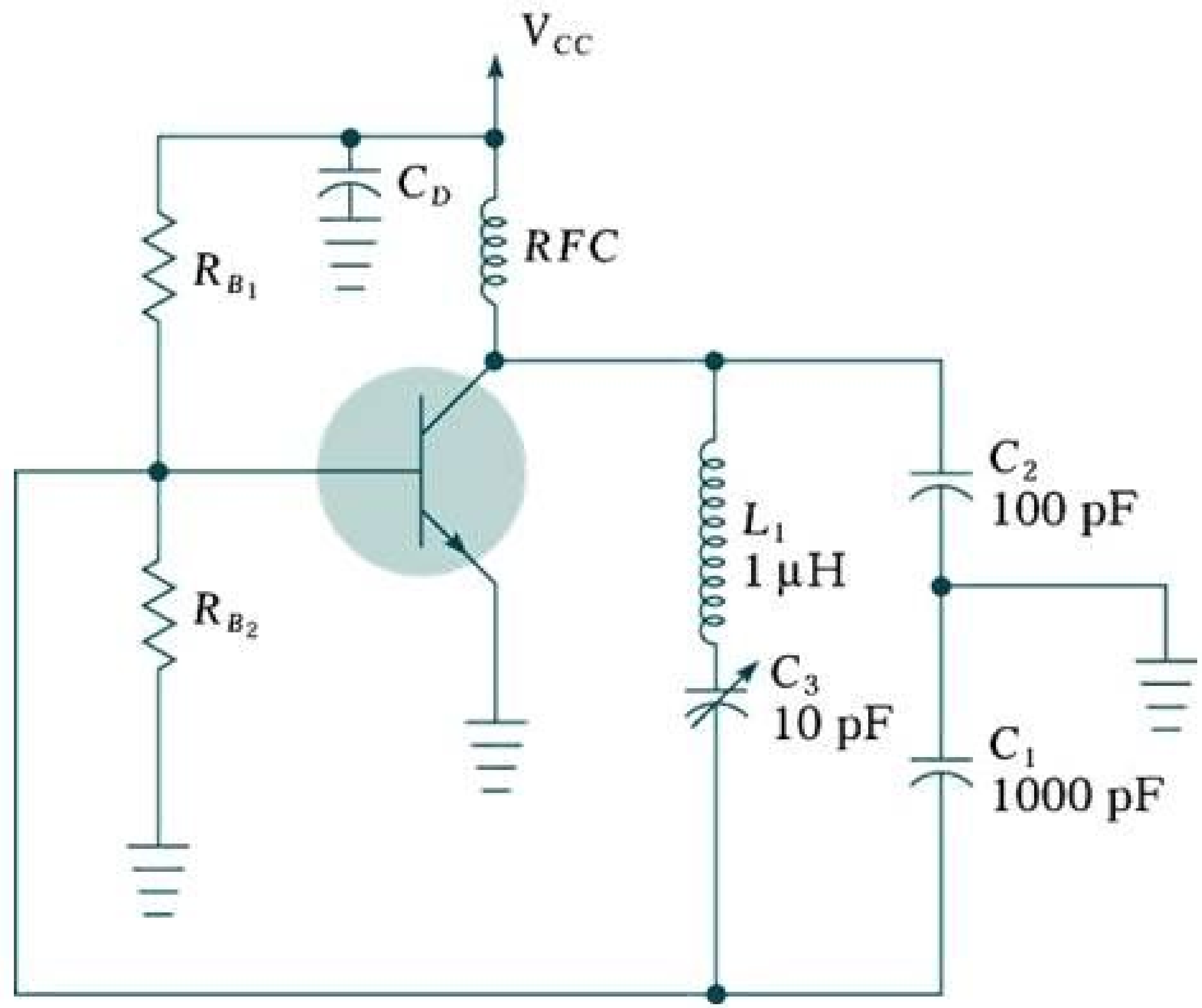
- Common configurations for a Colpitts Oscillator





Clapp Oscillator

- Common configuration for a Clapp Oscillator

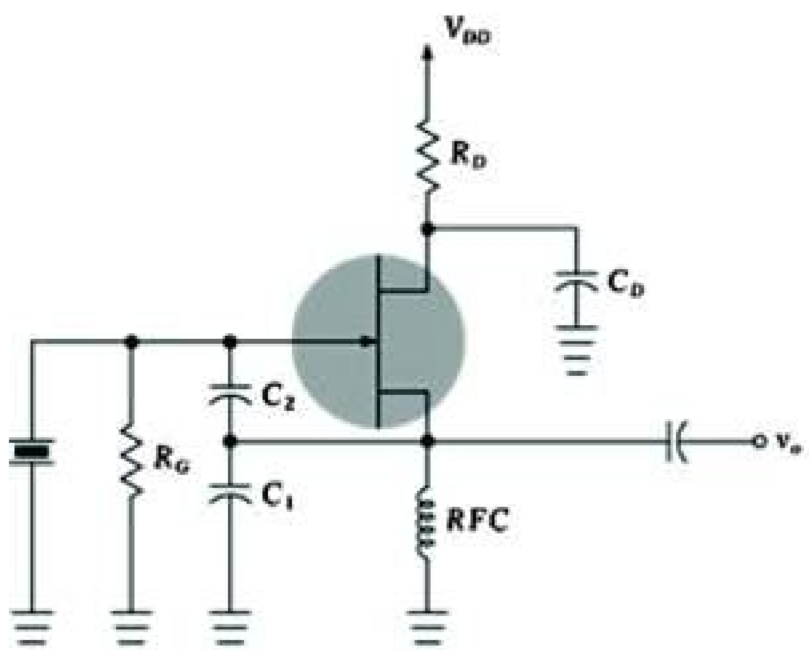


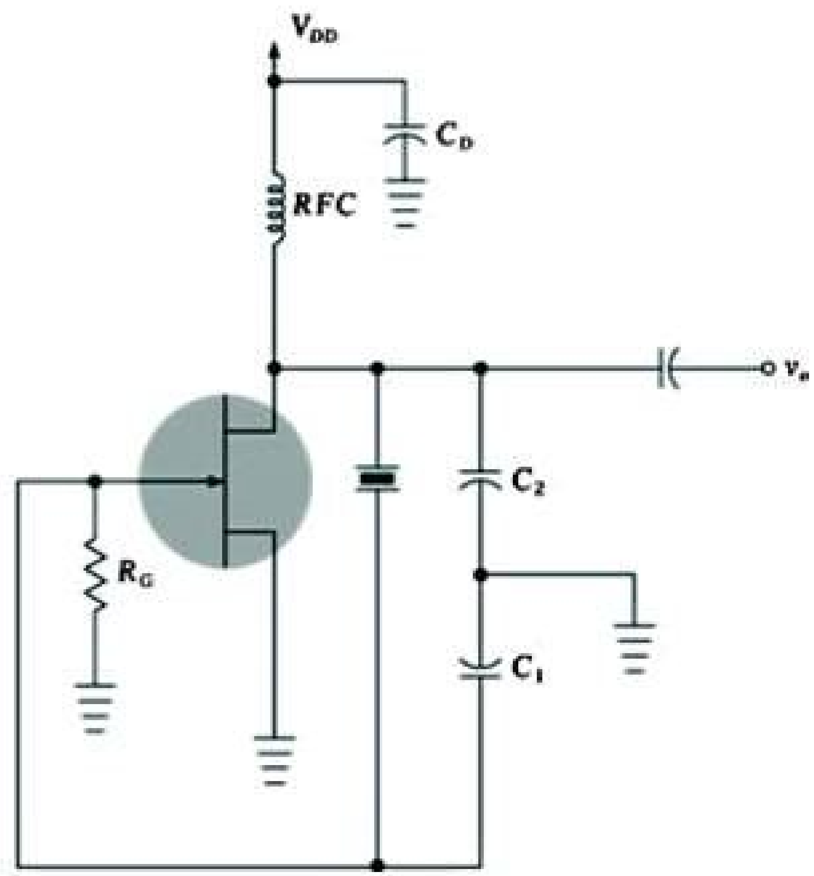
Varactor-Tuned Oscillator

- The frequency of an oscillator may be tuned by varying the inductance or capacitance of the circuit
- **Varactors** are more convenient substitutes than variable capacitors in many circumstances

Crystal-Controlled Oscillators

- Crystal-controlled oscillators are more stable than LC oscillators
- Crystal oscillators utilize the *piezoelectric effect* to generate a frequency-variable signal





Single-Stage Transmitters

A simple, single-tube cw transmitter can be made by coupling the output of an oscillator directly to an antenna (figure 1-28). The primary purpose of the oscillator is to develop an rf voltage which has a constant frequency and is immune to outside factors which may cause its frequency to shift. The output of this simple transmitter is controlled by placing a telegraph key at point **K** in series with the voltage supply. Since the plate supply is interrupted when the key is open, the circuit oscillates only as long as the key is closed. Although the transmitter shown uses a Colpitts oscillator, any of the oscillators

Capacitors C2 and C3 can be GANGED (mechanically linked together) to simplify tuning. Capacito C1 is used to tune (resonate) the antenna to the transmitter frequency. C_A is the effective capacitance existing between the antenna and ground. This antenna-to-ground capacitance is in parallel with the tuning capacitors, C2 and C3. Since the antenna has capacitance, any change in its length or position, such as that caused by swaying of the antenna, changes the value of C_A and causes the oscillator to change frequency. Because these frequency changes are undesirable for reliable communications, the multistage transmitter was developed to increase reliability.

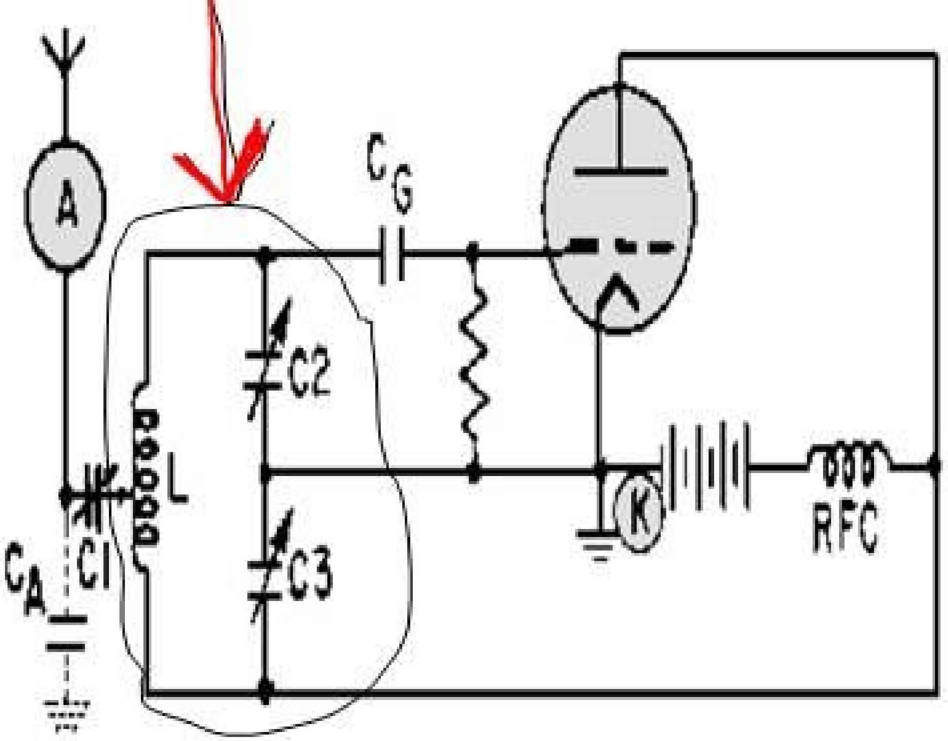


Figure 1-28.—Simple electron-tube transmitter.

Multistage Transmitters

The simple, single-tube transmitter, shown in figure 1-28, is rarely used in practical equipment. Most of the transmitters you will see use a number of tubes or stages. The number used depends on the frequency, power, and application of the equipment. For your study, the following three categories of cw transmitters are discussed: (1) master oscillator power amplifier (mopa) transmitters, (2) multistage, high-power transmitters, (3) high- and very-high frequency transmitters.

The mopa is both an oscillator and a power amplifier. Power-amplifying stages and frequency-multiplying stages must be used to increase power and raise the frequency from those achievable in a mopa. The main difference between many low- and high-power transmitters is in the number of power-amplifying stages that are used. Similarly, the main difference between many high- and very-high frequency transmitters is in the number of frequency-multiplying stages used.

MASTER OSCILLATOR POWER AMPLIFIER.—For a transmitter to be stable, its oscillator must not be LOADED DOWN. This means that its antenna (which can present a varying impedance) must not be connected directly to the oscillator circuit. The rf oscillations must be sent through another circuit before they are fed to the antenna for good frequency stability to be obtained. That additional circuit is an rf power amplifier. Its purpose is to raise the amplitude of rf oscillations to the required output power level and isolate the oscillator from the antenna. Any transmitter consisting of an oscillator and a single-amplifier stage is called a master oscillator power amplifier transmitter (mopa), as shown in figure 1-29.

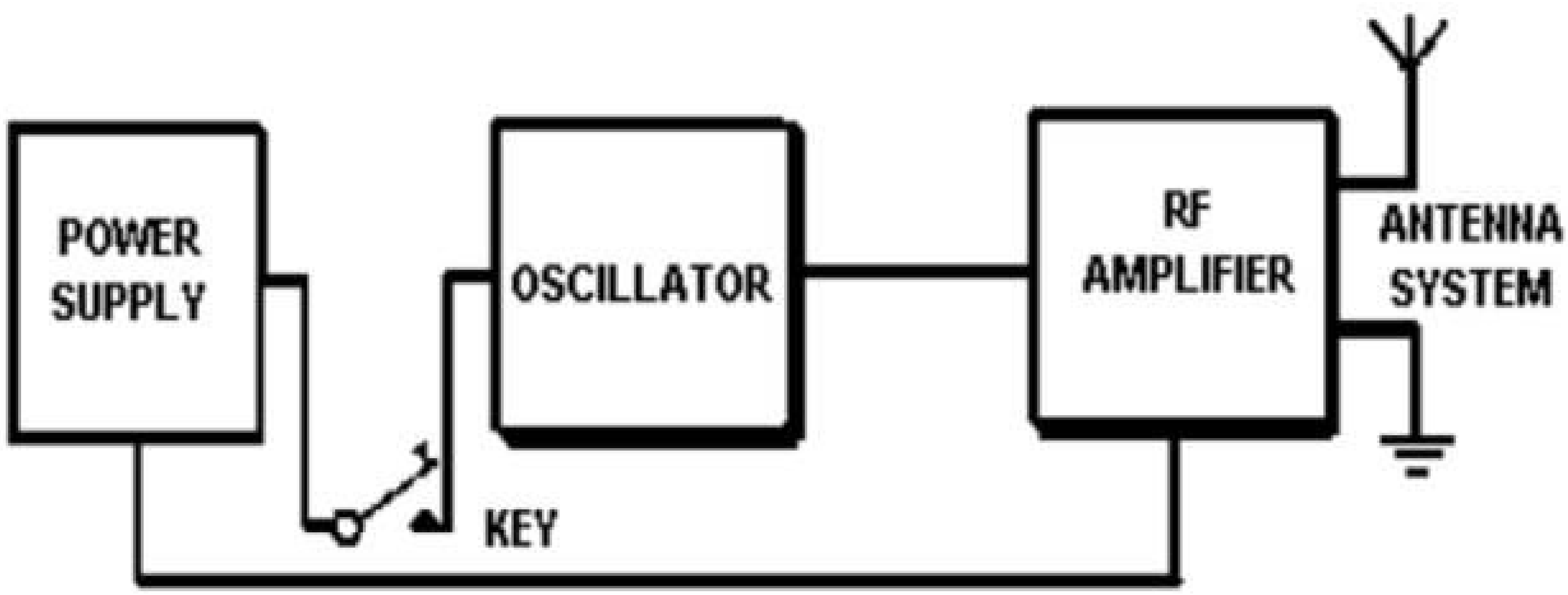


Figure 1-29.—Block diagram of a master oscillator power amplifier transmitter (mopa).

MULTISTAGE HIGH-POWER TRANSMITTERS.—

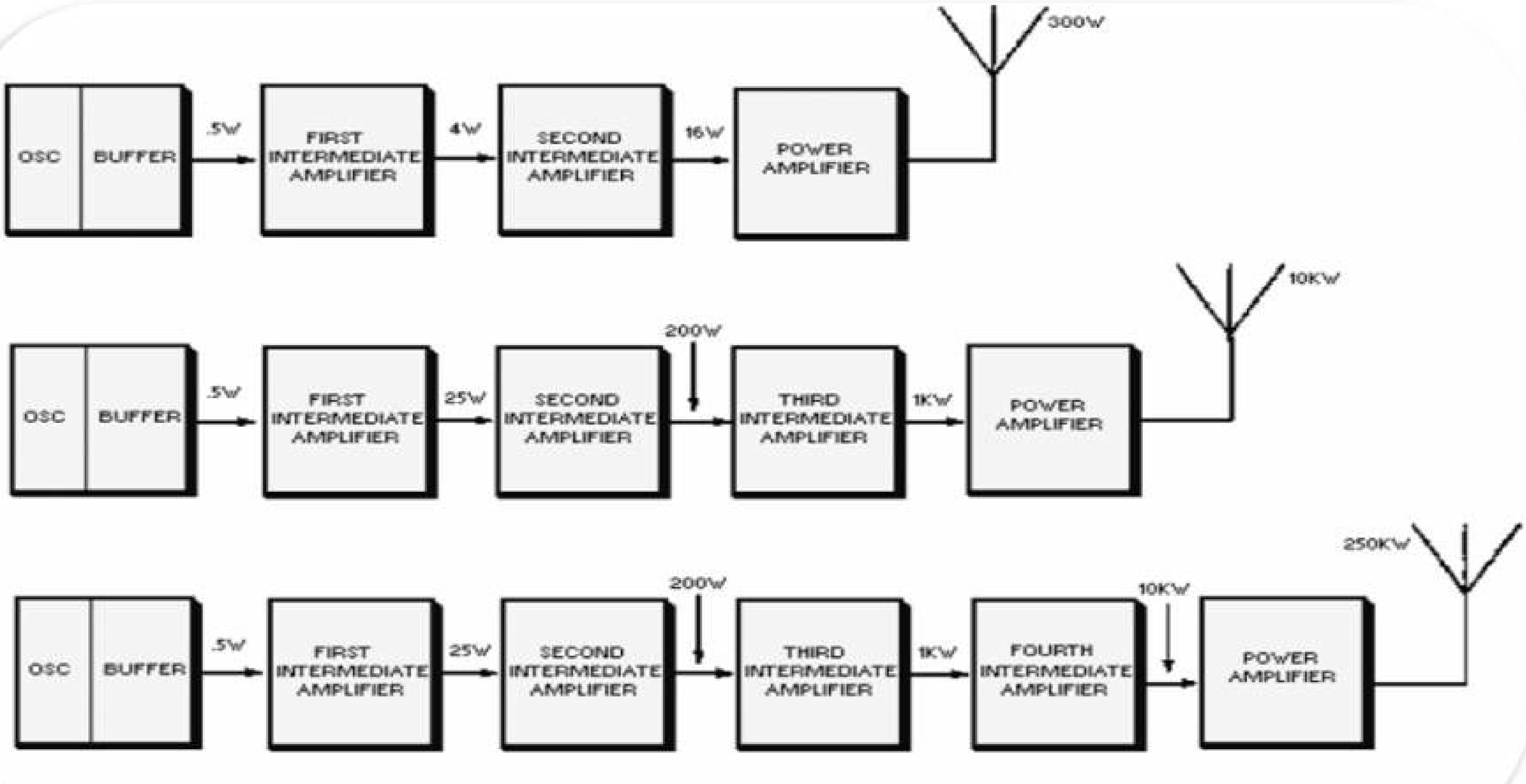


Figure 1-30.—Block diagram of several medium-frequency transmitters.

HF AND VHF TRANSMITTERS.—

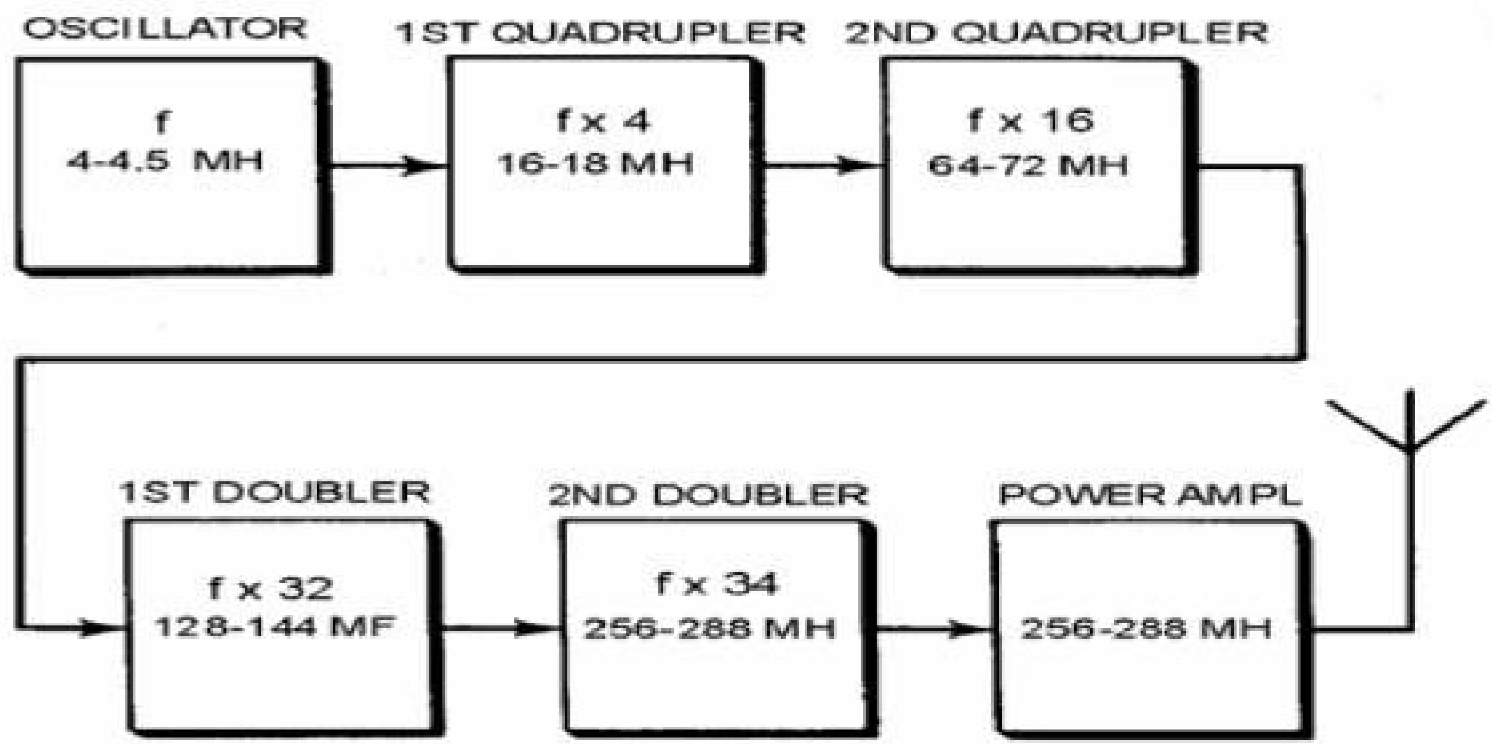


Figure 1-31.—Block diagram of a vhf transmitter.

The stages which multiply the frequency by two are DOUBLERS; those which multiply by four are QUADRUPLERS. The oscillator is tunable from 4 to 4.5 megahertz. The multiplier stages increase the frequency by multiplying successively by 4, 4, 2, and 2, for a total factor of 64. In high-power, high-frequency transmitters, one or more intermediate amplifiers may be used between the last frequency multiplier and the power amplifier.

Harmonic Generators

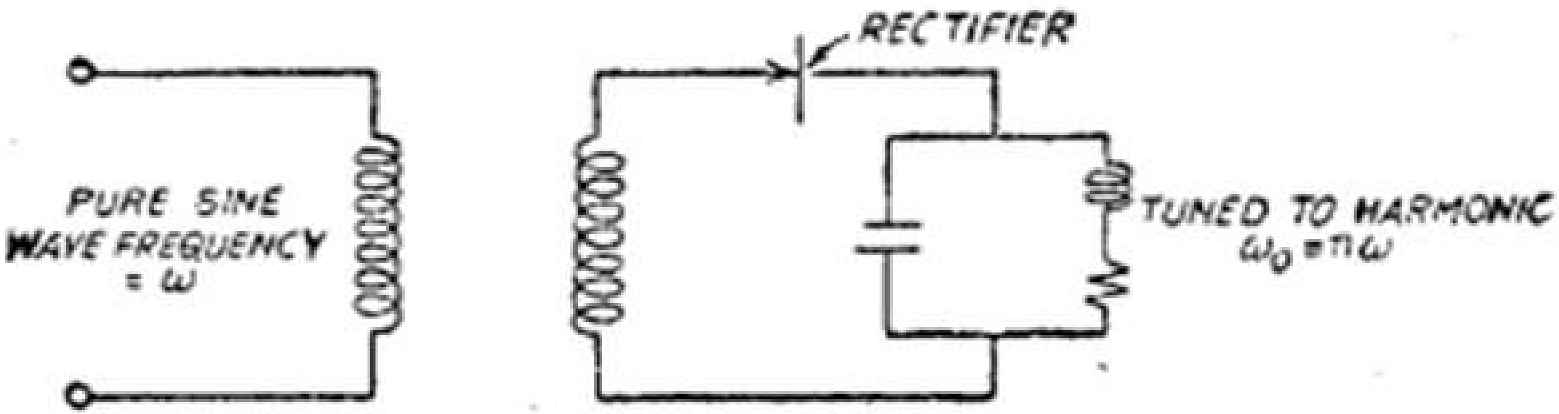


Fig.6.5. A simple harmonic generator using the half-wave rectifier.

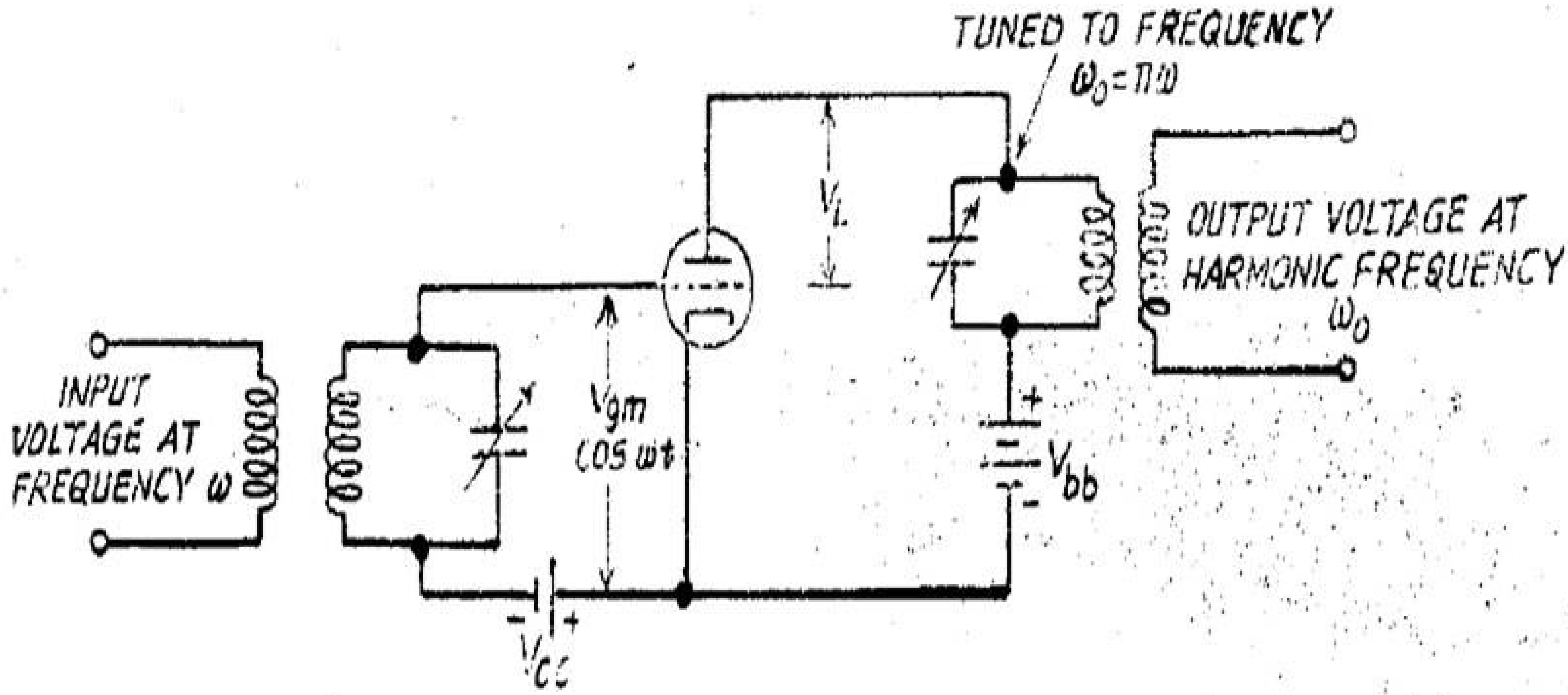


Fig.6.6. Basic circuit of class *C* harmonic generator using triode.

Radio Transmitters

Radio Transmitters have special features such as

1. Volume compressor
2. Peak clippers
3. Pre emphasis
4. Voice operated device anti-singing (VODAS)
5. Privacy devices etc.

Volume compressor

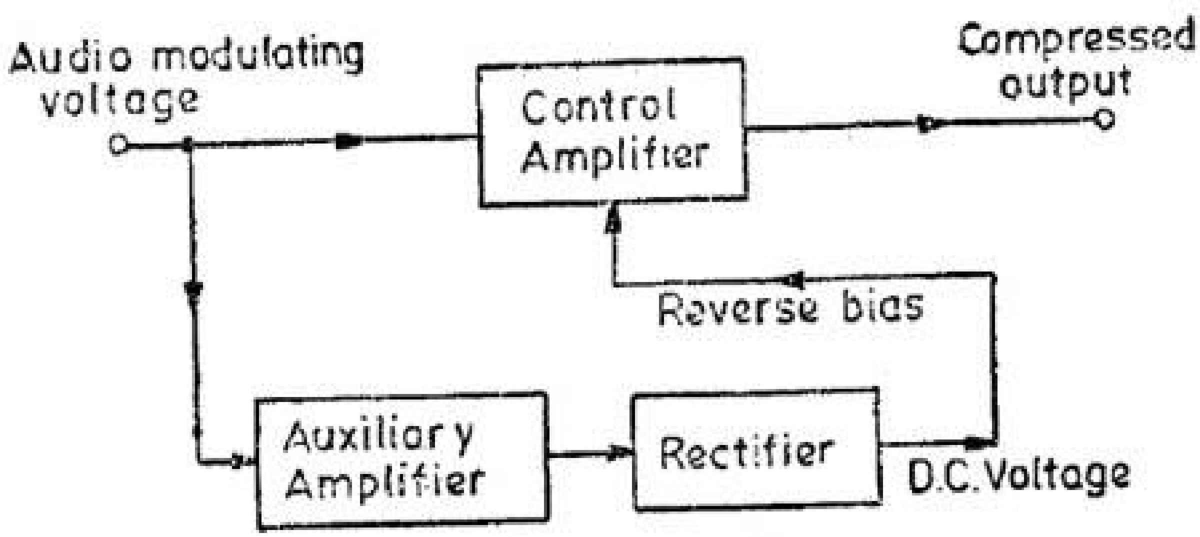


Fig. 6.9. Block diagrams of volume compressor.

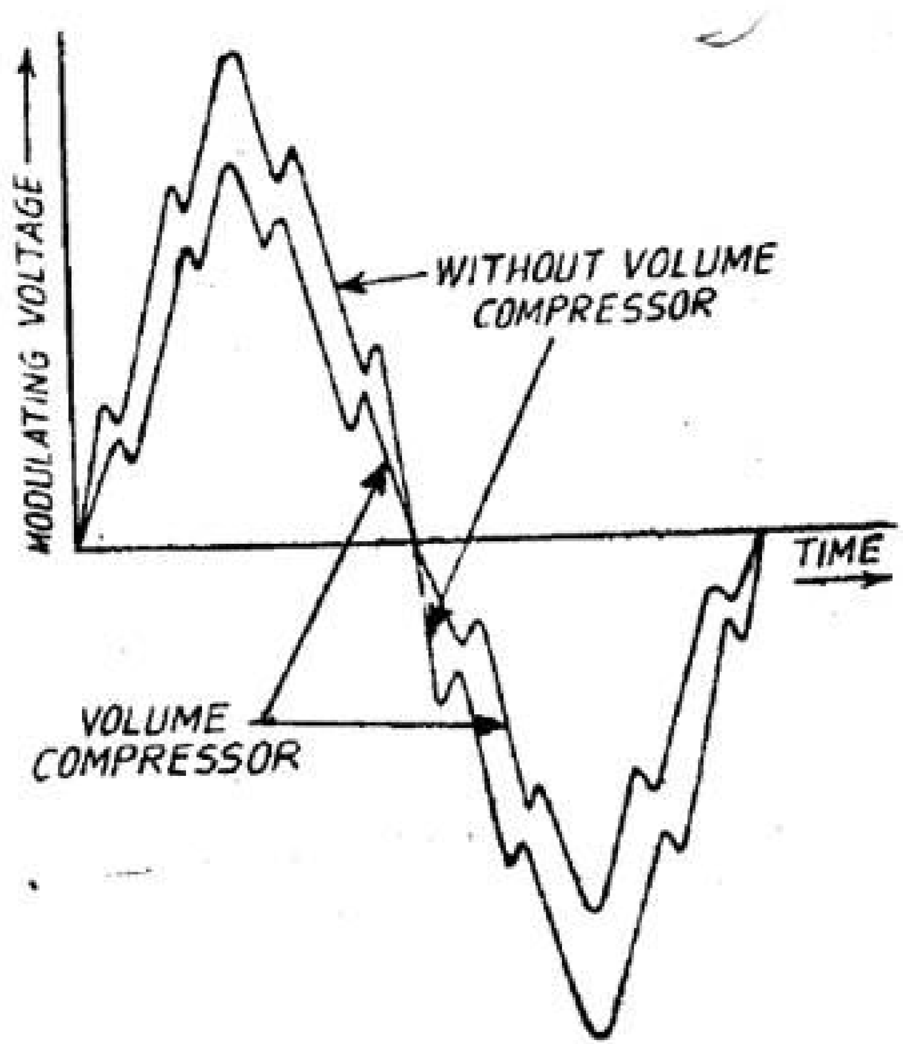


Fig. 6.10. Volume compression action.

Details of Volume compressor

Volume compressor compresses this volume range so as to have the ratio of maximum to minimum volume of say 20dB.

This results in improvement in three ways

(I) average modulation level gets raised

(iI) over modulation at peaks of modulation signal gets eliminated and

(iii) signal to noise ratio at modulating signal minima gets improved.

Of course,

all these benefits are obtained at the cost of reduced volume range. The original volume range is then restored in the radio receiver by using corresponding volume expander.

WORKING: In a volume compressor, a bias proportional to the audio modUlating voltage is applied to an audio amplifier so that low amplitude signals are less attenuated while high amplitude signals are more attenuated. Fig. 6.9 gives the block diagram of a volume compressor. Here a DC voltage proportional to the audio voltage is obtained after rectification in a linear rectifier. This DC voltage is applied as reverse bias to the control audio amplifier which feeds the modulating amplifier. The mutual conductance *gm of the control* amplifier device (transistor or tube) decreases and hence the voltage gain of this control amplifier decreases. Thus effectively the volume gets compressed. Fig. 6.10 shows the volume compression.

Peak clippers

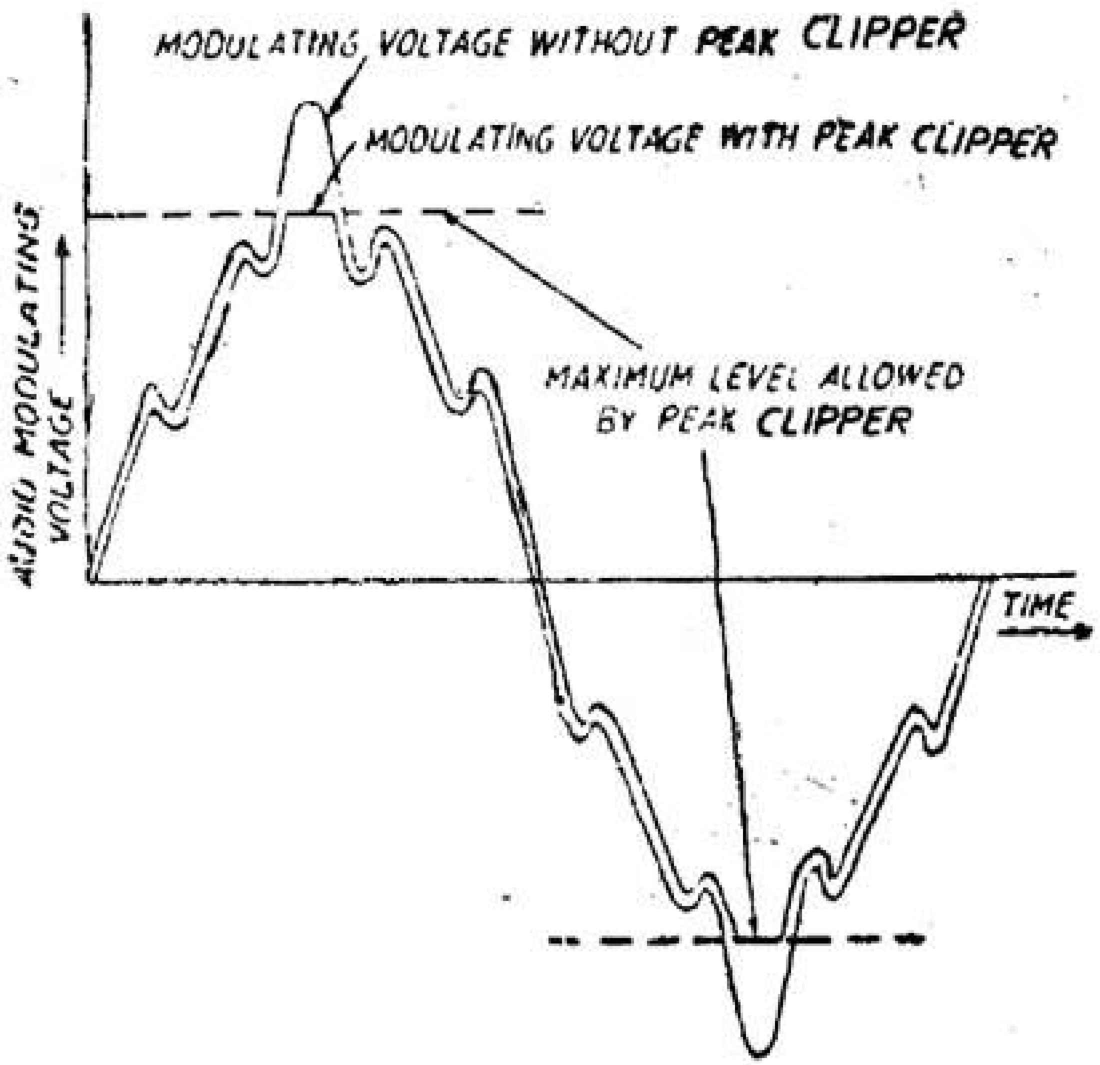


Fig. 6.11. Action peak clipper.

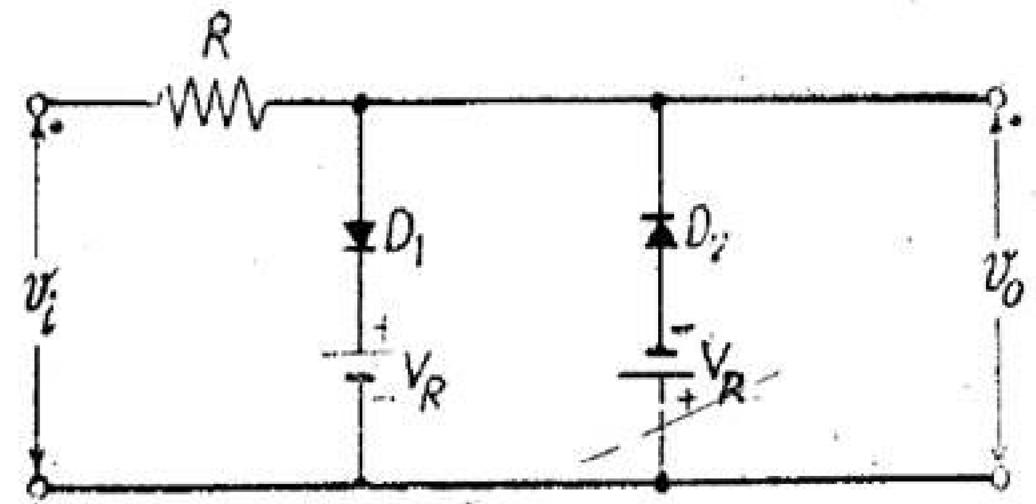


Fig. 6.12. Diode peak clipper

Details of Volume clippers

In similarity with volume compressor, a peak clipper also prevents over-modulation at modulation voltage peaks of very high intensity thus preventing adjacent channel interference due to higher order sidebands.

But whereas volume compressor starts choking the signal right from the beginning, peak clipper starts choking the modulating voltage only when it has reached a certain predetermined value. There is thus a sort of delay " action. Fig.6.11 shows the audio modulating voltage with and without peak clipper. Evidently because of clipping at the fixed level, information contained in the clipped part of modulating voltage is lost and this results in certain distortion of audio signal. Such a distortion is however, not large. Such a peak clipper is however, not commonly used.

Fig. 6.12 shows a simple diode peak clipper. Diode *D1 in conjunction with resistor R and series biasing* battery *VR clips the audio voltage to a maximum positive level equal to YR' Diode D2 in conjunction with*

resistor *R and series baising battery VR clipps the audio voltage to a maximum negative level of YR'*

Such a clipper may be placed in between two audio amplifier stages.

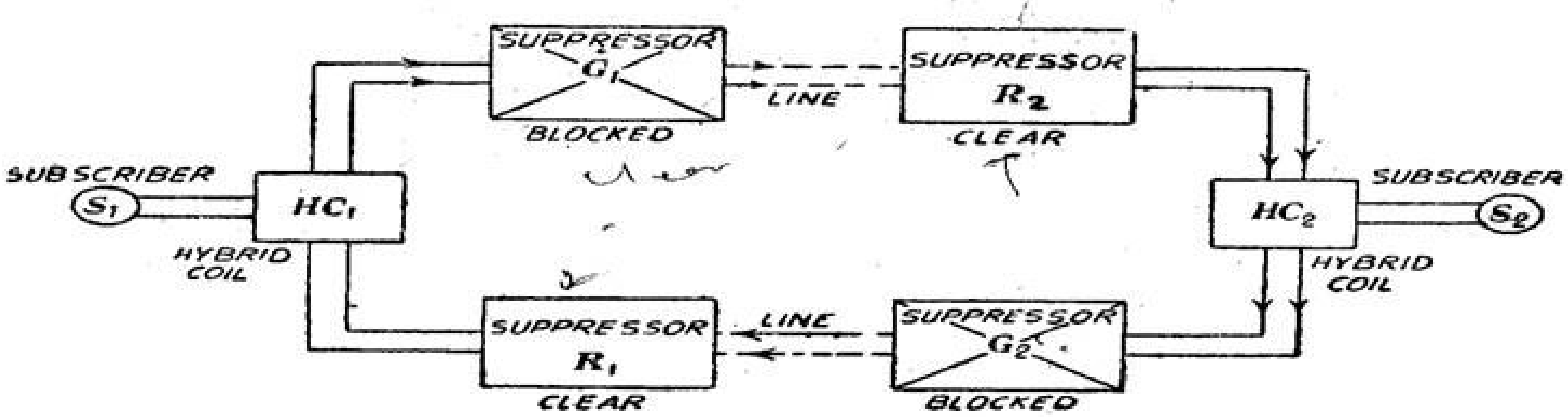
Pre-emphasis (see circuits in slides of FM unit-4)

In transoceanic radio telephone transmitter, frequently **the high frequency terms in the audio modulating voltage are boosted up** before modulating. Of course, in the corresponding receiver these high frequency terms are brought back to their proper proportion after demodulation. This technique of boosting the high frequency terms before modulation is called *pre-emphasis and is also used in F.M. broadcast and communication* and in television.

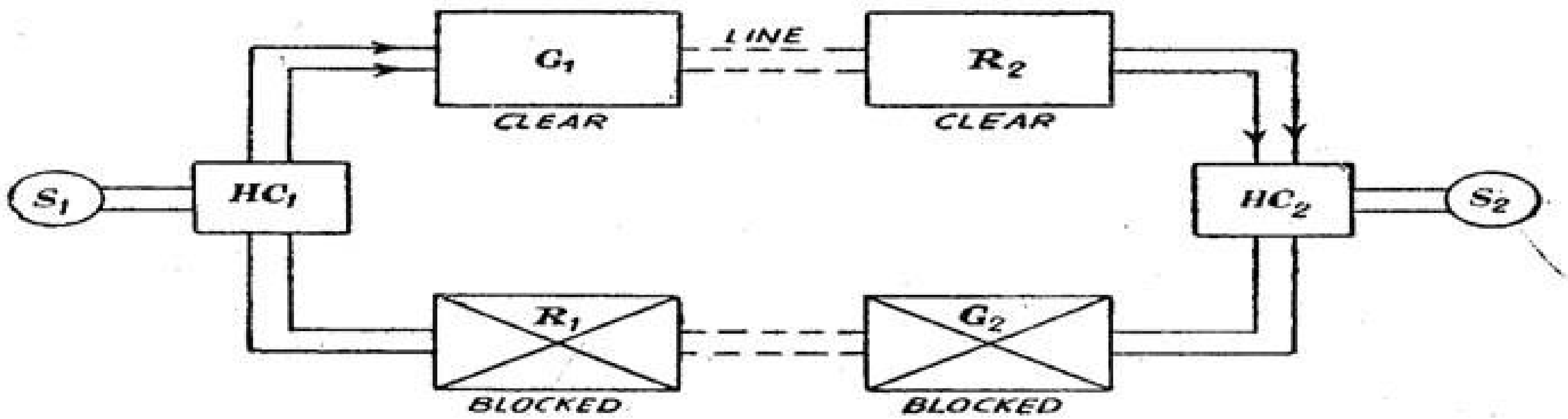
Pre-emphasis is desirable because normally high frequency terms have small amplitudes and have, therefore, powers small relative to those In low frequency terms.

On the other hand, thermal and other internal noises generated in the reciever are uniformily *distributed over the entire frequency spectrum.*

Voice Operated Devices Anti-singing (VODAS):



(a) VODAS under quiescent condition.



(b) VODAS with subscriber S_1 speaking

Fig. 6.13. Operation of VODAS.

Single Sideband Modulation

Advantages:

1. SSB require half the bandwidth.
2. Power is saved due single sideband.
3. Less circuitry, less noise interference due to narrow bandwidth filtering most of the noise.
4. Fading doesn't occur in SSB transmission.

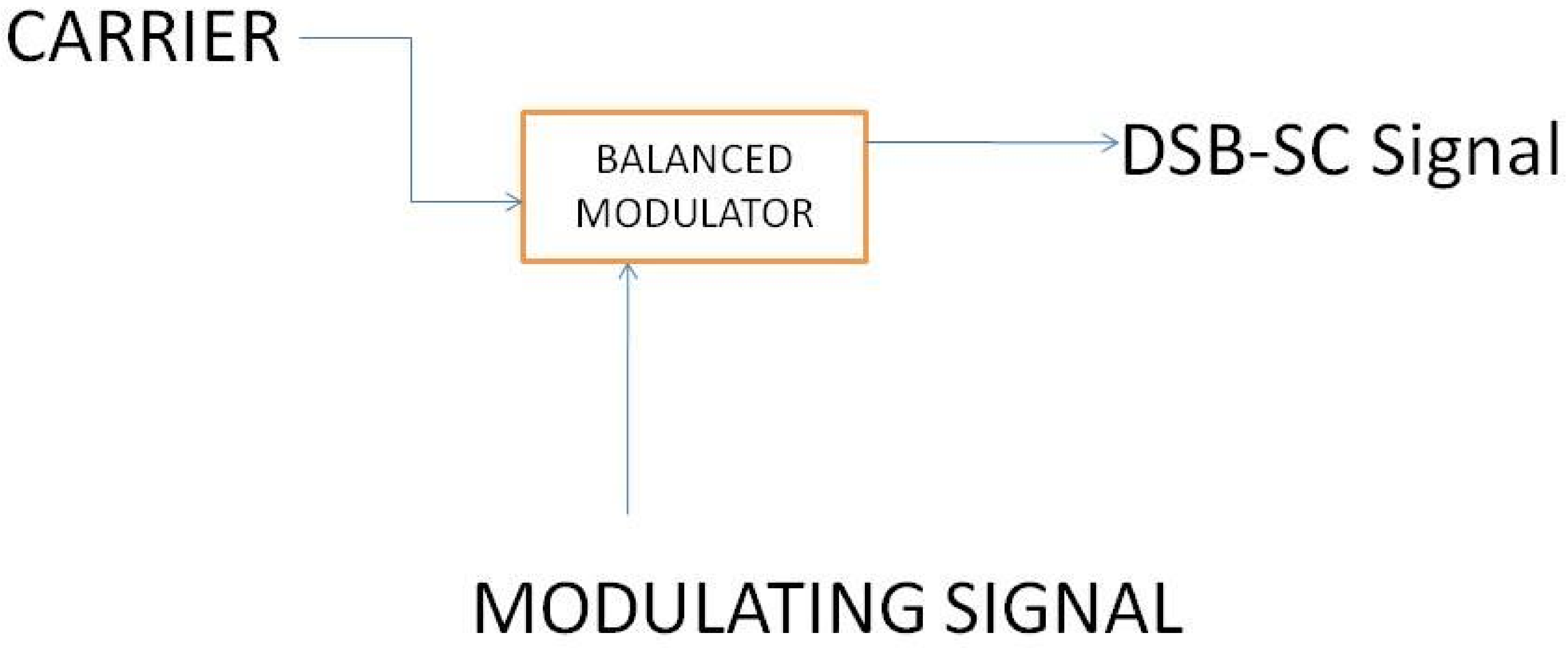
Disadvantages:

1. Generation and reception of SSB signal is complex process. See diagram
2. SSB txr and rxr must have excellent frequency stablity since carrier is absent.
3. THUS SSB is not used to transmit the good quality music signals , only transmits the speech signal

Application of SSB

1. SSB is used to save power in applications where such a power saving is required e.g mobile systems.
2. Also find application where Bandwidth requirement is low.
3. Point to point communications, military communication, amateur radio are greatest user of SSB in one form or other.

Suppression of unwanted sideband:



To get single, sideband signal we have to suppressed one of the sidebands of the double sideband signal available at the output of the balanced modulator .

There are three practical methods used to remove unwanted sideband from the double sideband signal to get the single sideband signal.

These are:

1. *Filter method*
2. *Phase shift method*
3. *The third method or weavers method*

Filter method

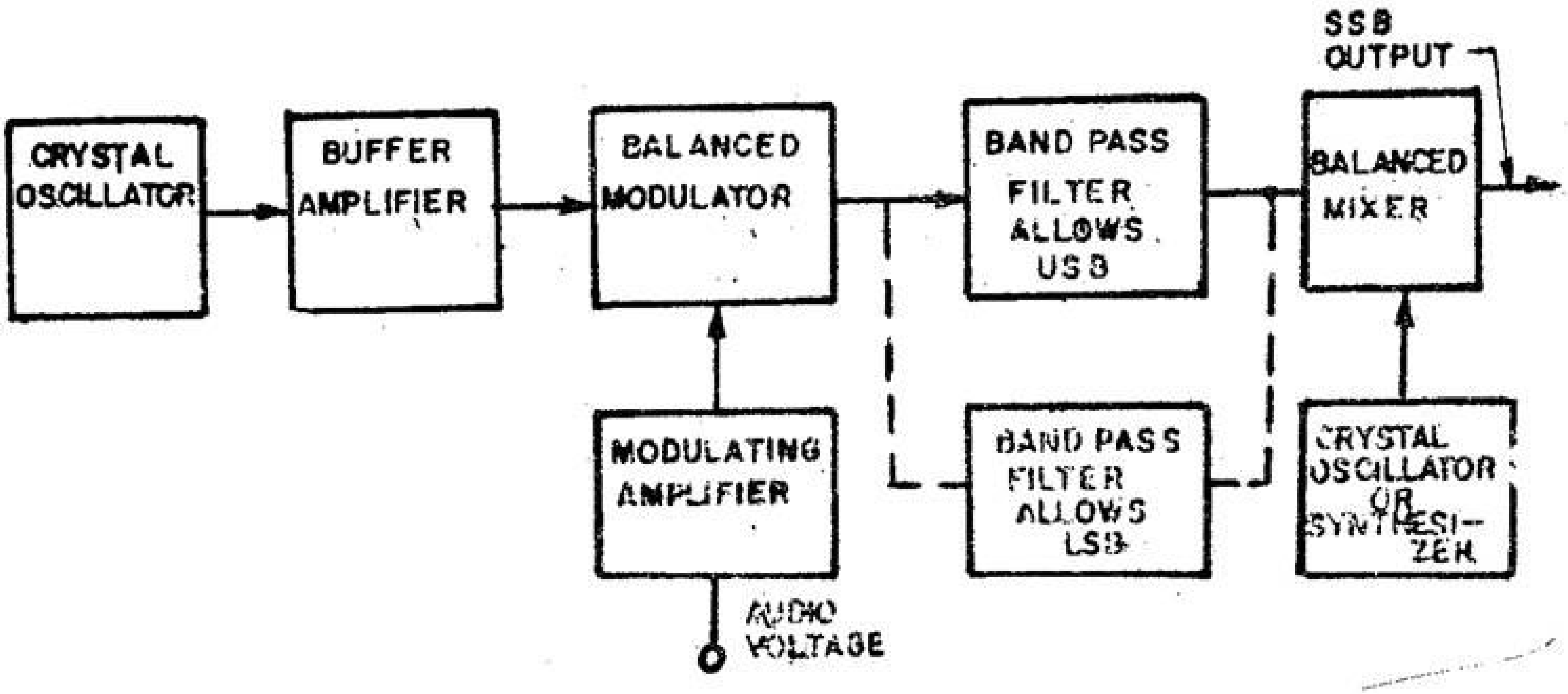


Fig.6.18. Filter method of sideband suppression.

Phase shift method

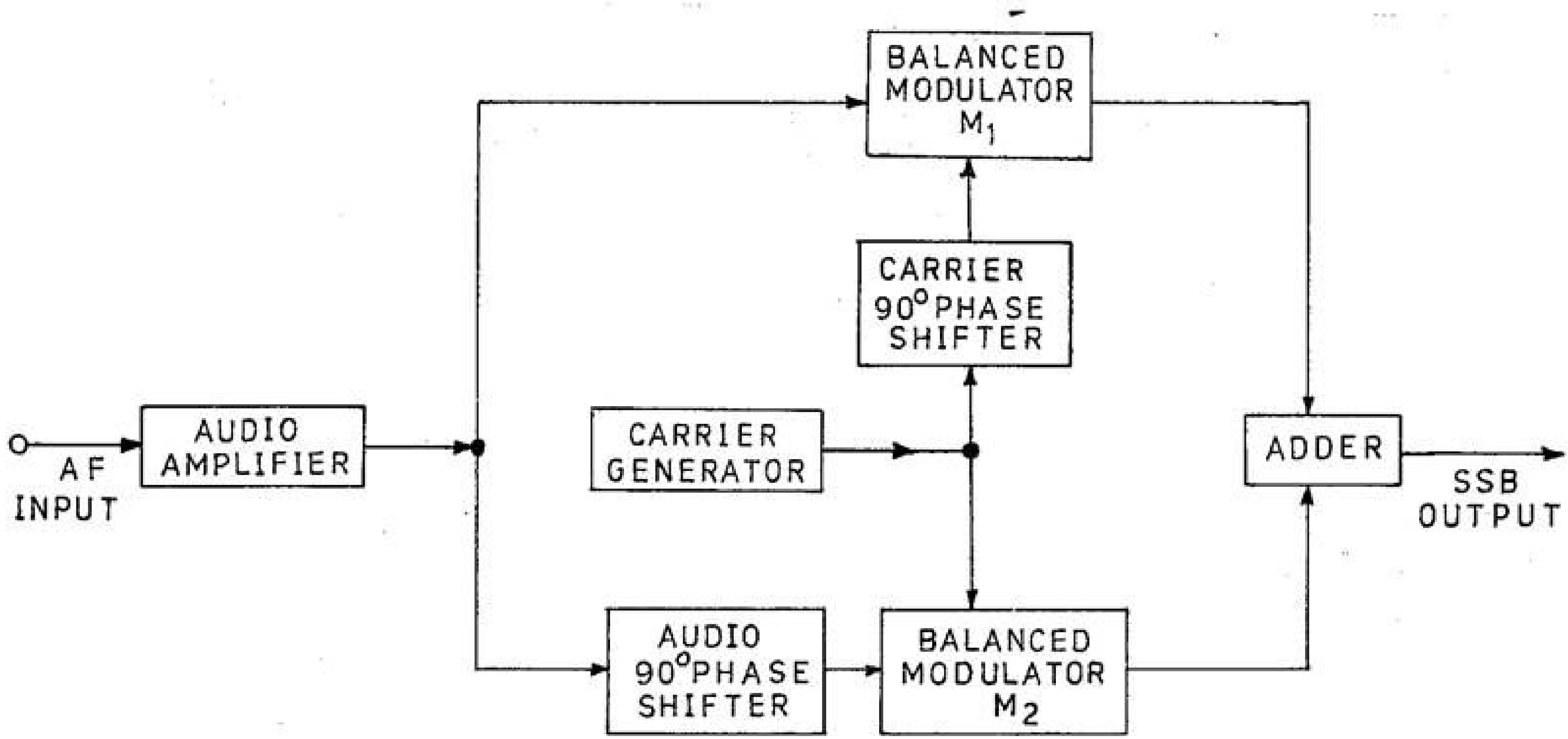


Fig. 6.19. Production of single sideband by phase shift method.

Weaver's Method of Sideband Suppression

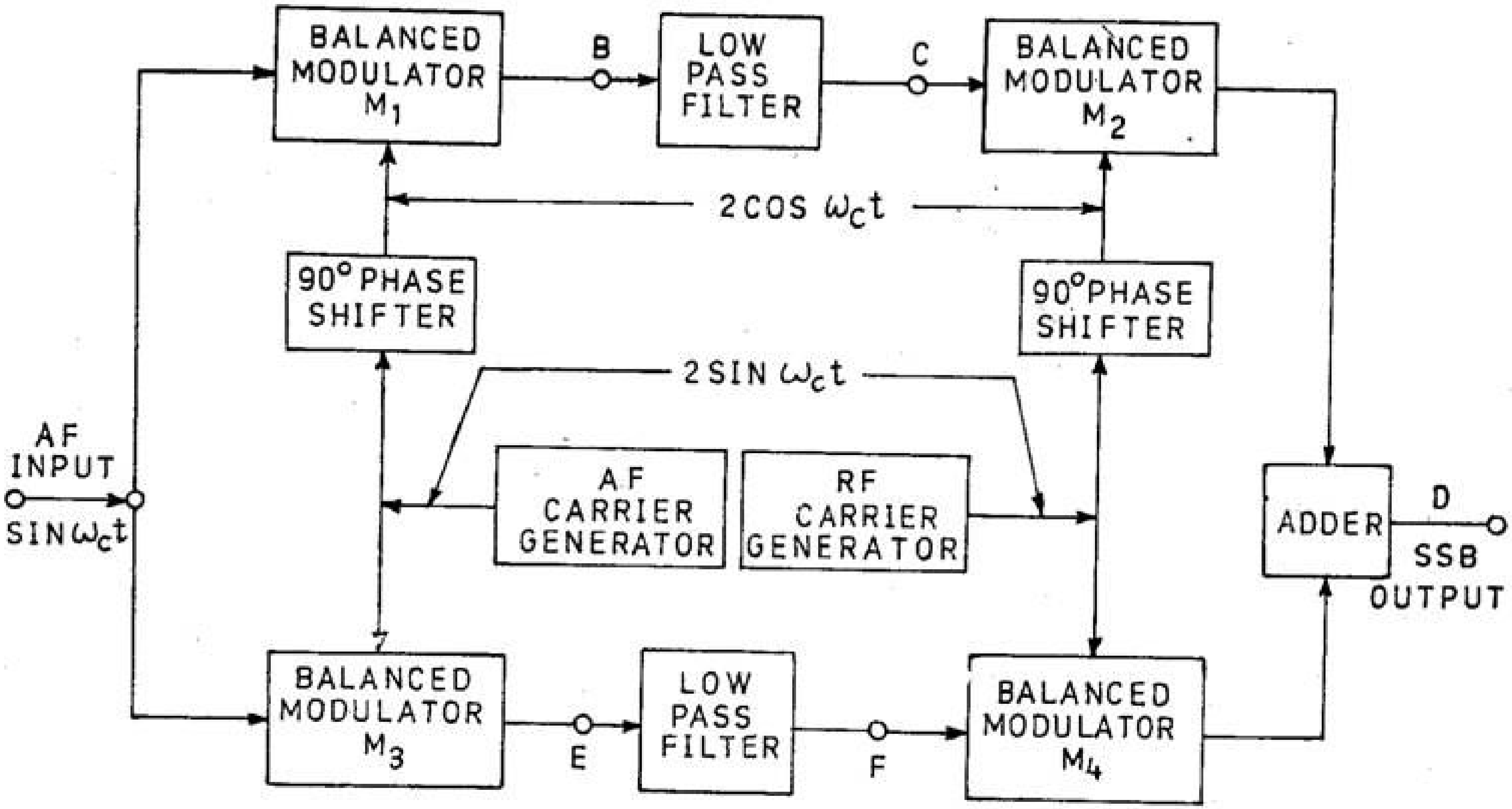


Fig. 6.20. Weaver's method of sideband suppression.

❖COMPARISION BETWEEN SIDE BAND SUPPRESSION METHOD

S.NO.	PARAMETER	FILTER METHOD	PHASE SHIFT METHOD	WEAVERS METHOD
1	METHOD USED	Filter is used	Phase shifting technique is used	Similar to phase shift method but carrier is phase shifted by 90^0
2	90^0 PHASE SHIFT	Not required	Require complex phase shift network	Phase shift network is simple RC network
3	POSSIBLE FREQUENCY RANGE OF SSB	Not possible to generate SSB at any frequency	possible to generate SSB at any frequency	possible to generate SSB at any frequency
4	NEED FOR UPCONVERSION	Required	Not Required	Not Required
5	COMPLEXITY	less	medium	high
6	BULKYNESS	yes	no	No
7	SWITCHING ABILITY	Not possible	Easily possible	Easily possible

Block diagram of SSB transmitter

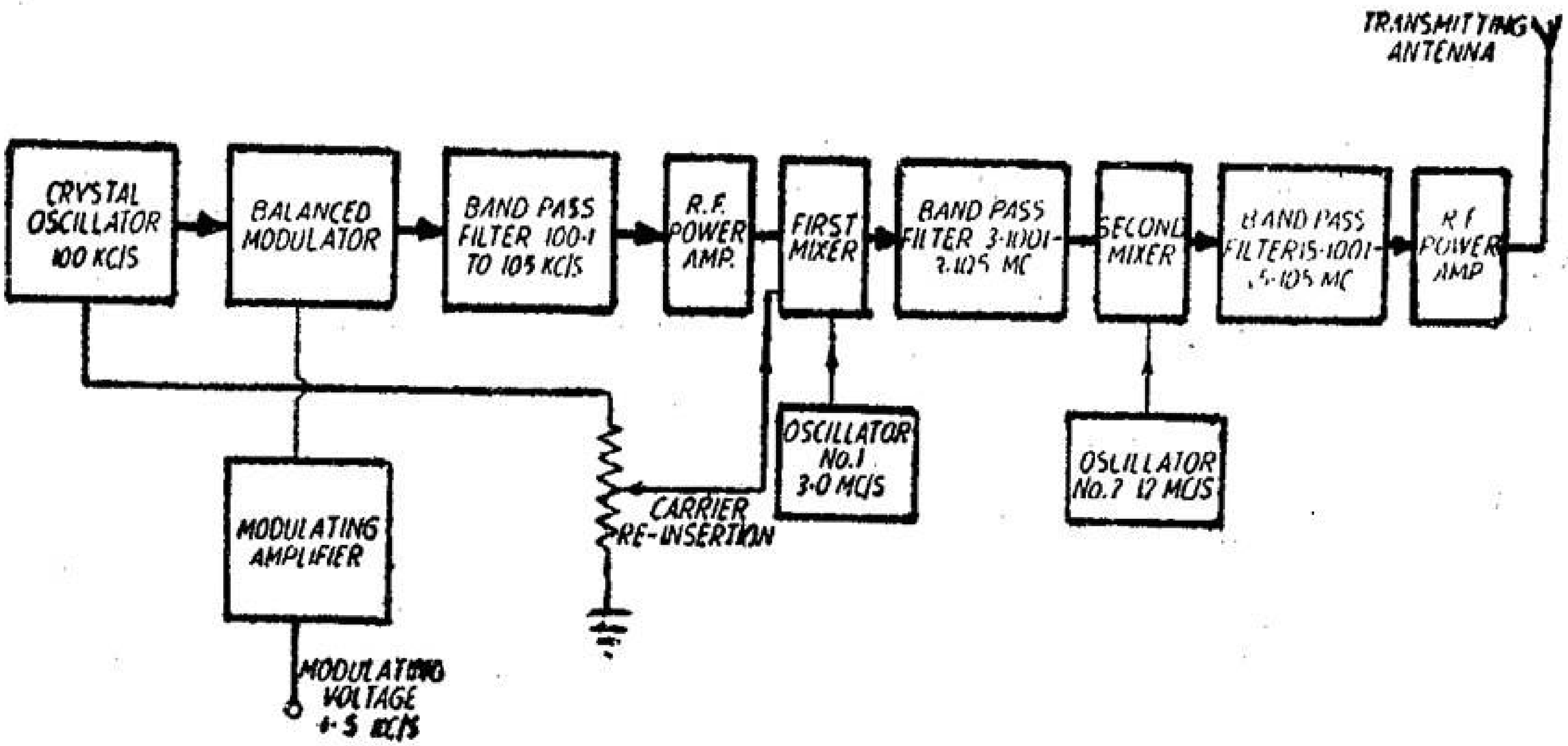


Fig. 6.21. Block diagram of SSB transmitter.

RADIO TELEGRAPH TRANSMITTER

- **Radio telegraph transmitter Using amplitude modulation**
  - ASK Type OR ON-OFF KEYING
  - AMPLITUDE MODULATED CONTINUOUS TYPE
- **Radio telegraph transmitter using frequency modulation**
  - FSK TYPE
  - FREQUENCY MODULATED CONTINUOUS TYPE

Amplitude modulation radio telegraph transmitters may be of two types:

*(a) interrupted carrie*CW) type or ON-OFFkeying type.

(b) Modulated Continuous Wave (MCW) type.

ON-OFF keying type.

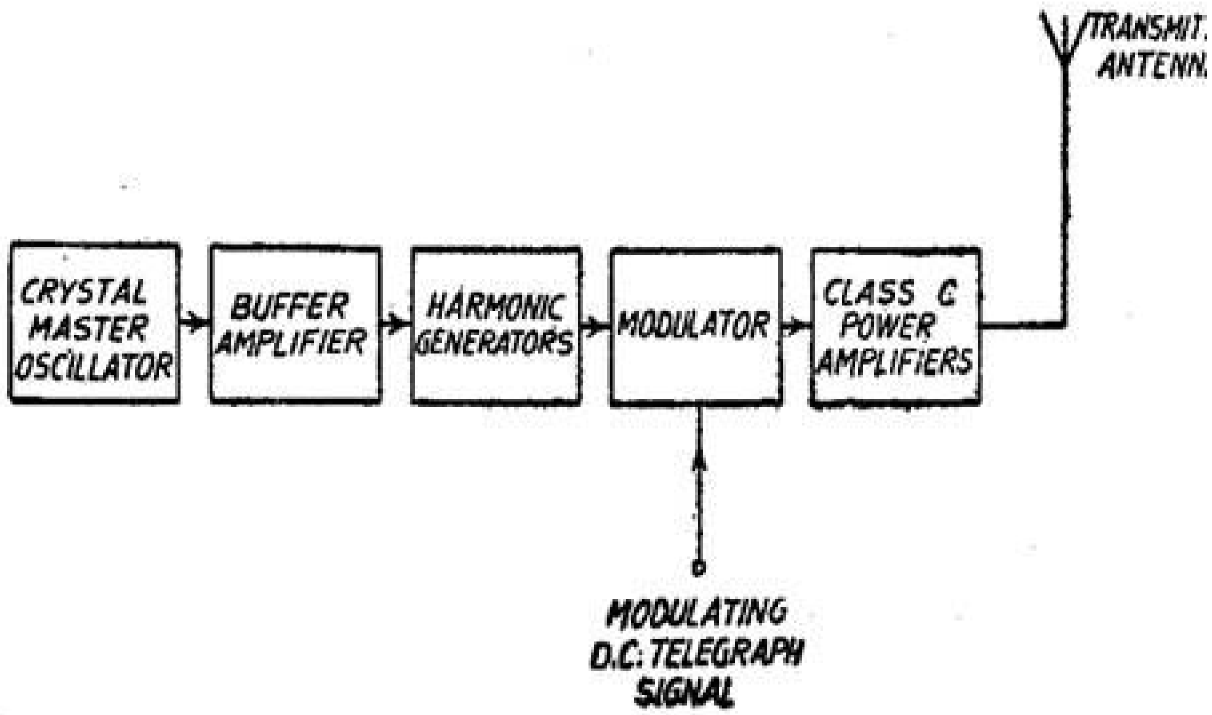


Fig. 6.23. Block diagram of radio telegraph transmitter using off keying.

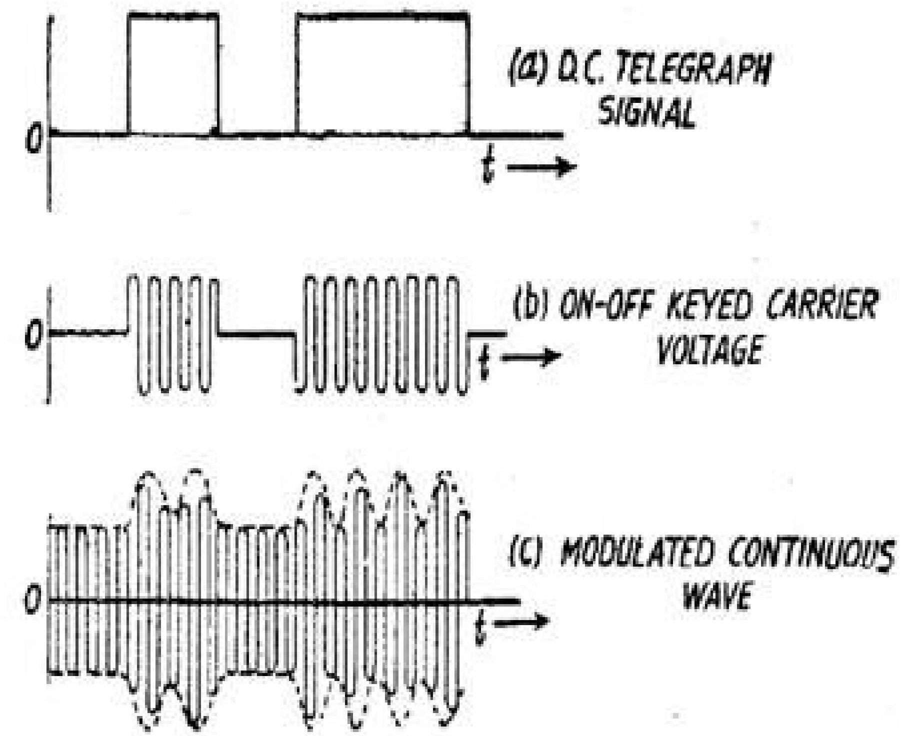
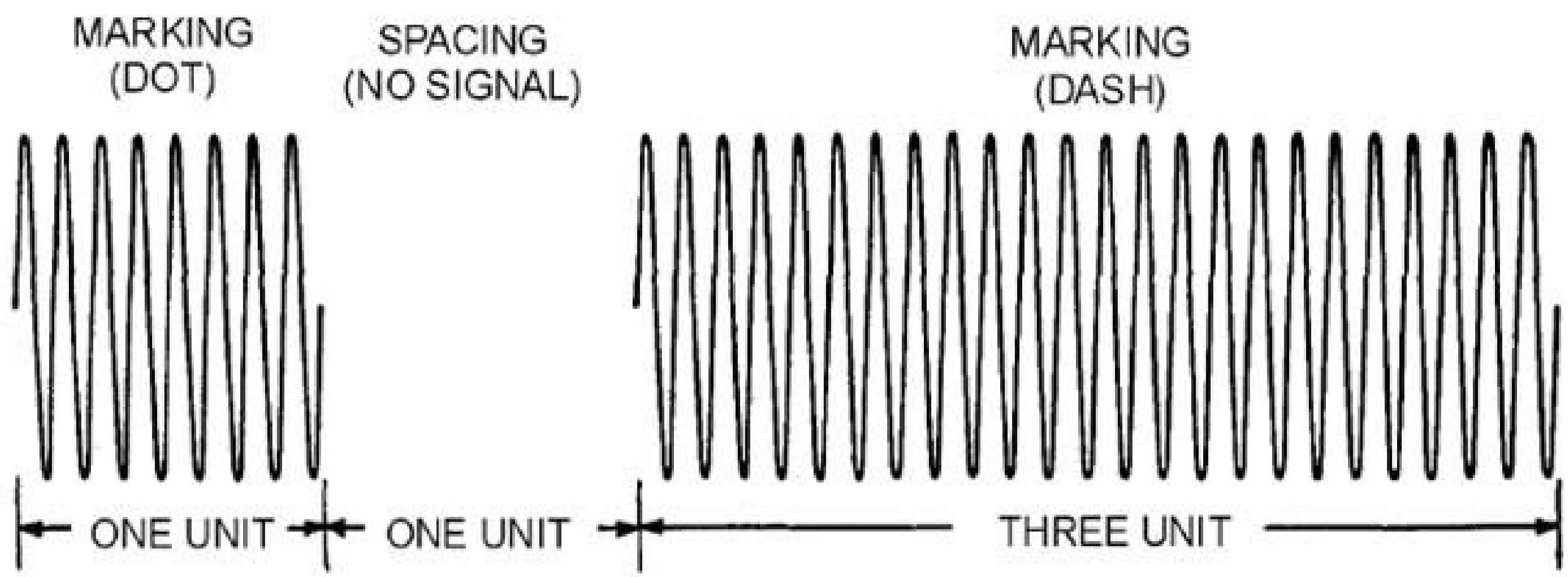


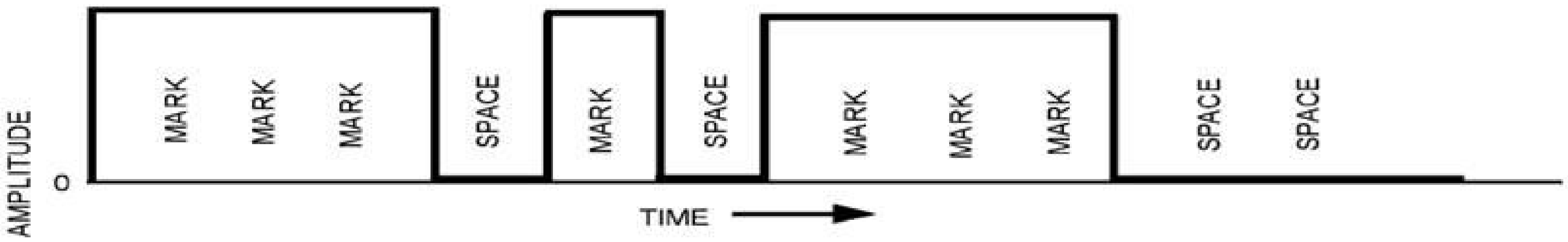
Fig. 6.22. Waveforms of on-off keyed carrier and modulated continuous wave carrier.

International Morse code

Figure 1-20.—International Morse code.



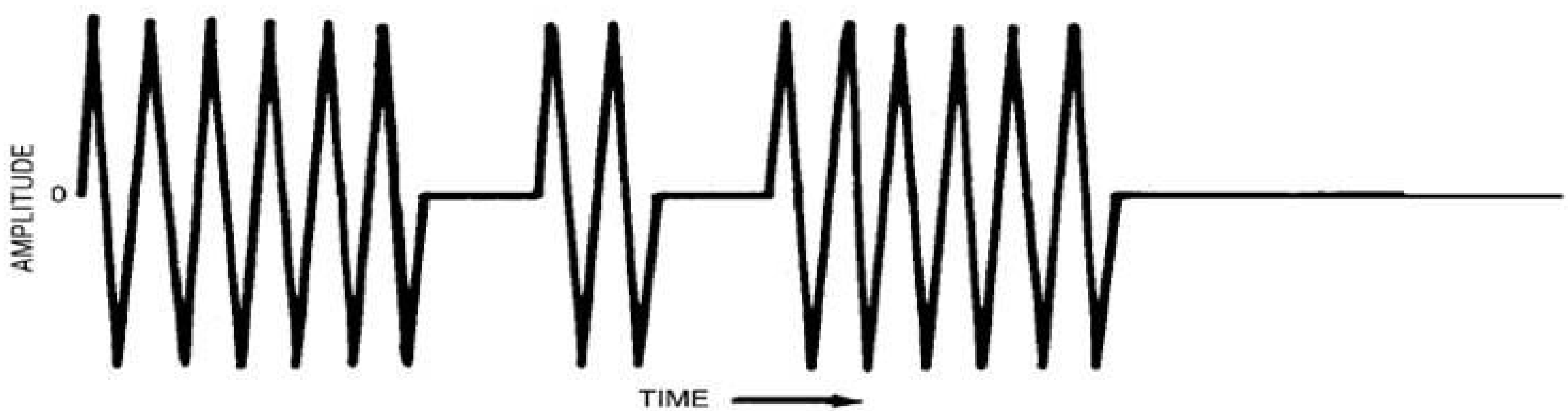
Dot and dash in radiotelegraph code.



ON-OFF KEYED MORSE CODE CHARACTER (LETTER "K")

(B)

Figure 1-22B.—Essential elements of ON-OFF keying.



RESULTANT CARRIER WAVE TRANSMITTED ALONG CONNECTING PATH.

(C)

Figure 1-22C.—Essential elements of ON-OFF keying.

Frequency modulation radio telegraph transmitters

The frequency modulation radio telegraph transmitters may be of two types.

*(a) Frequency Shift Keying (FSK) Transmitter: In an FSK transmitter, the carrier frequency gets shi*lightly different value during marking interval. Thus the carrier voltage is continuous but has different frequencies during marking and spacing intervals.

(b) Frequency Modulated Continuous Wave Type. In this system, an audio tone interrupted according to the: telegraph signal frequency modulates the carrier.Out of these various methods,

NOTE: the on-off keying and frequency shift keying are more commonly used

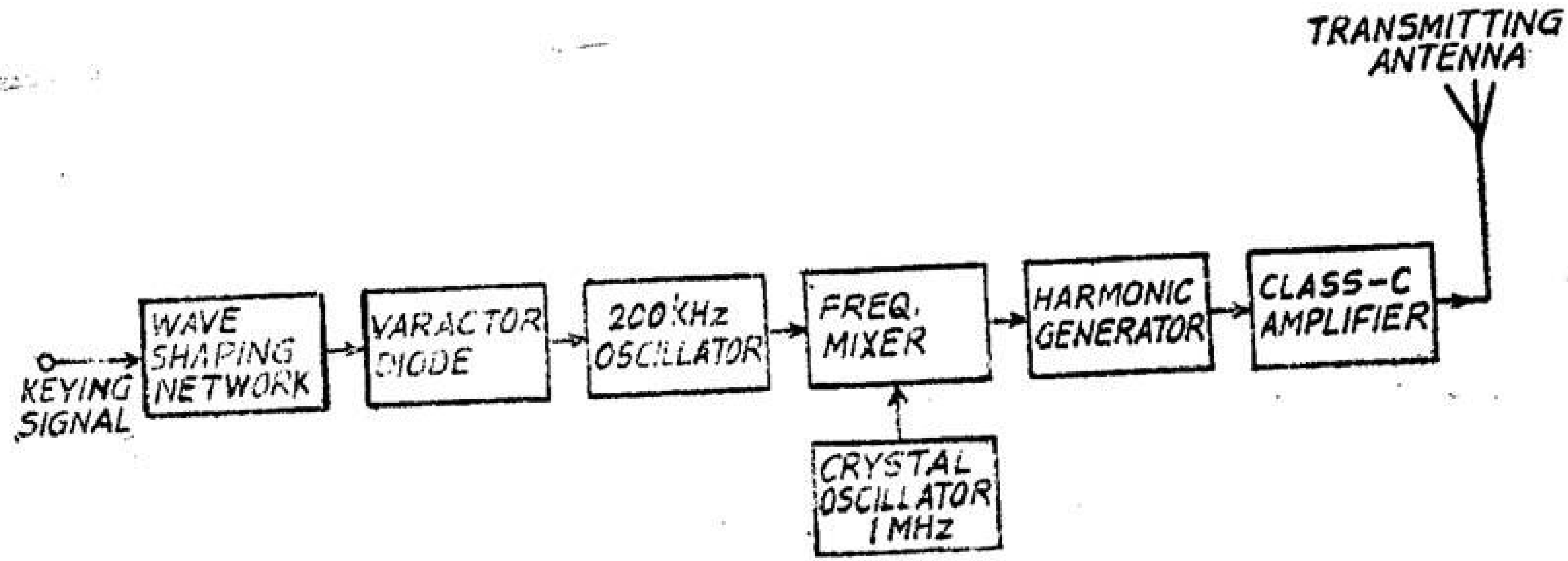


Fig. 6.29. Block diagram of FSK transmitter.

Frequency Shift Keying:

This consists in using one carrier frequency for the mark interval and another carrier frequency for the space interval. Fig. 6.29 gives the block diagram of a typical FSK transmitter. Here the D.C. telegraph signal is applied to a varactor diode changing its effective capacitance.

❖**Neutralization:** Neutralization of feedback from output to input in a Triode amplifier from the Grid to Plate capacitance C(gp) may be done in following means:

1. Hazeltine system.
2. Rice system.
3. Cross neutralisation.
4. Coil Neutralisation.

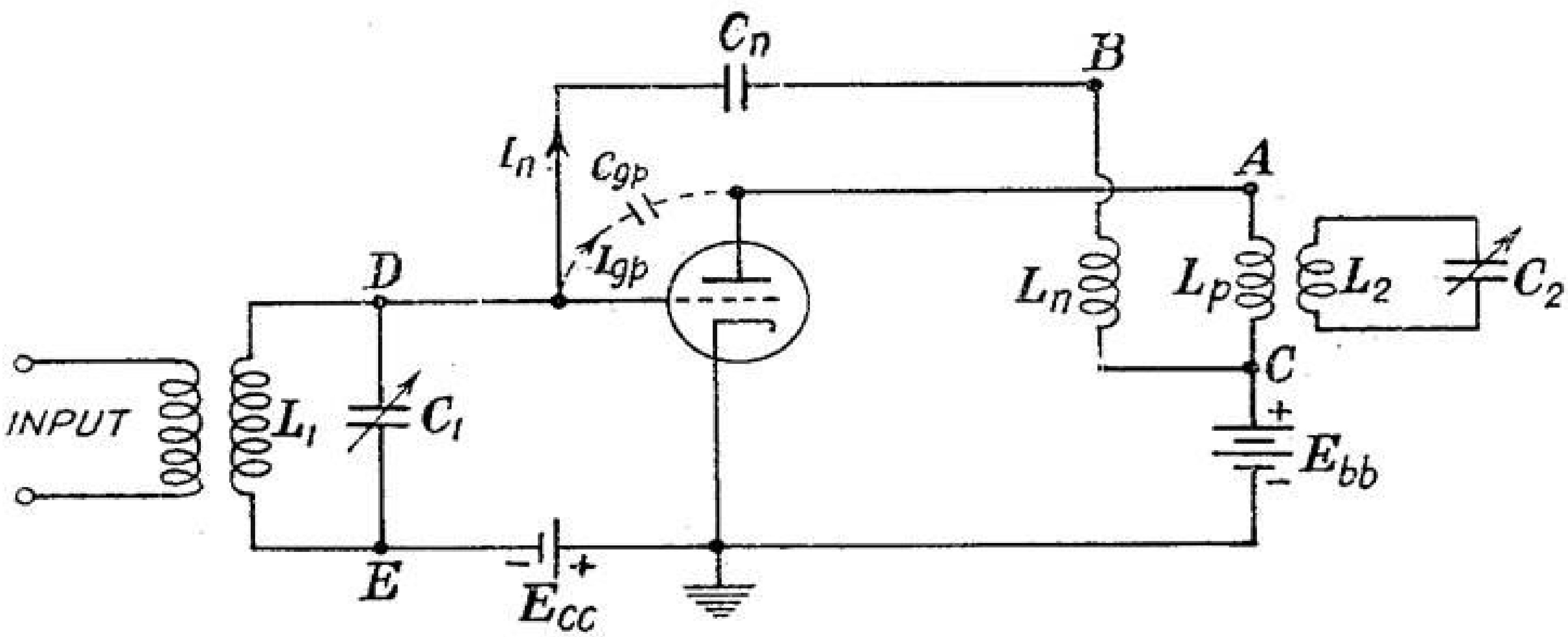


Fig. 6.36. Hazeltine system of neutralisation.

✓Neutralization consists in feeding an equal and opposite amount of energy through the feedback network so as to neutralize the energy feedback taking place through inter electrode capacitance Cgp.

Perfect neutralization results at a frequency at which the reactance of the inductive branch equals the reactance of the plate –grid capacitance.

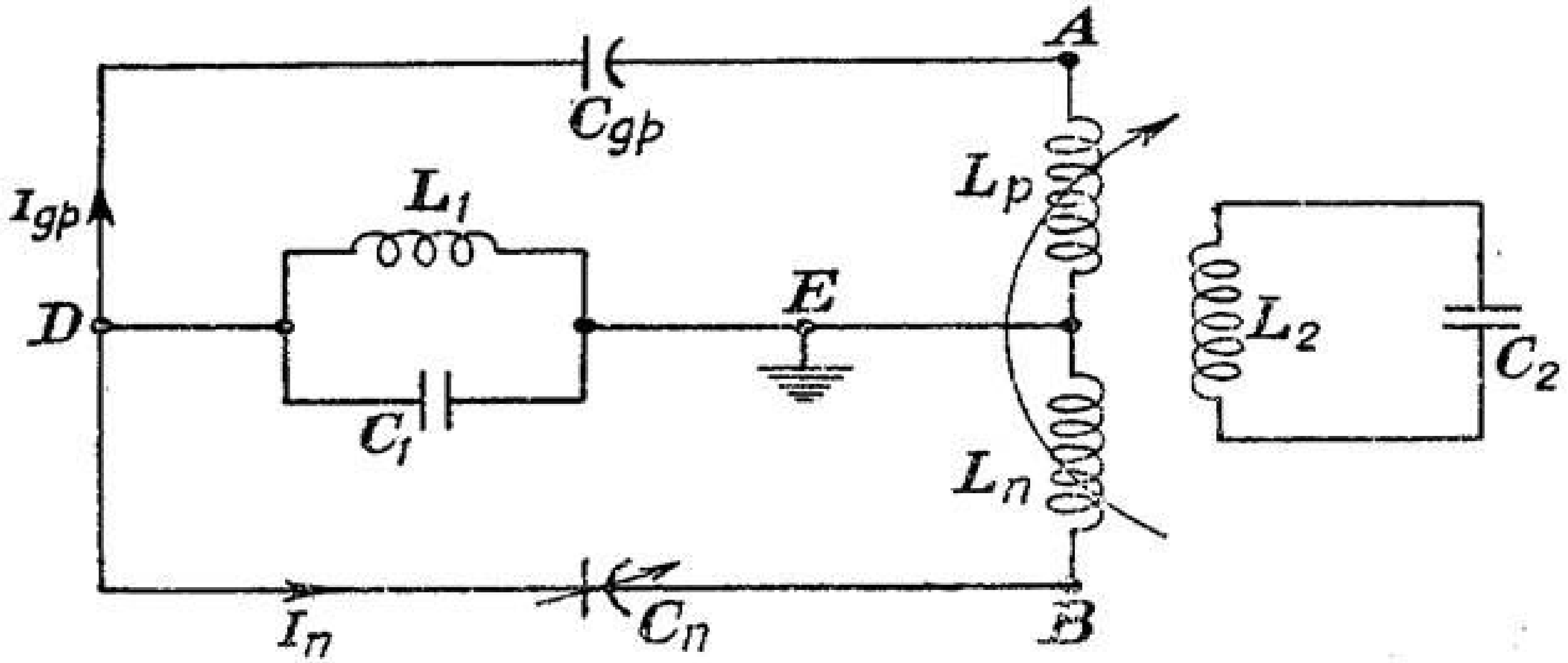


Fig. 6.37. Equivalent bridge circuit of Hazeltine system.

Rice System of Neutralization

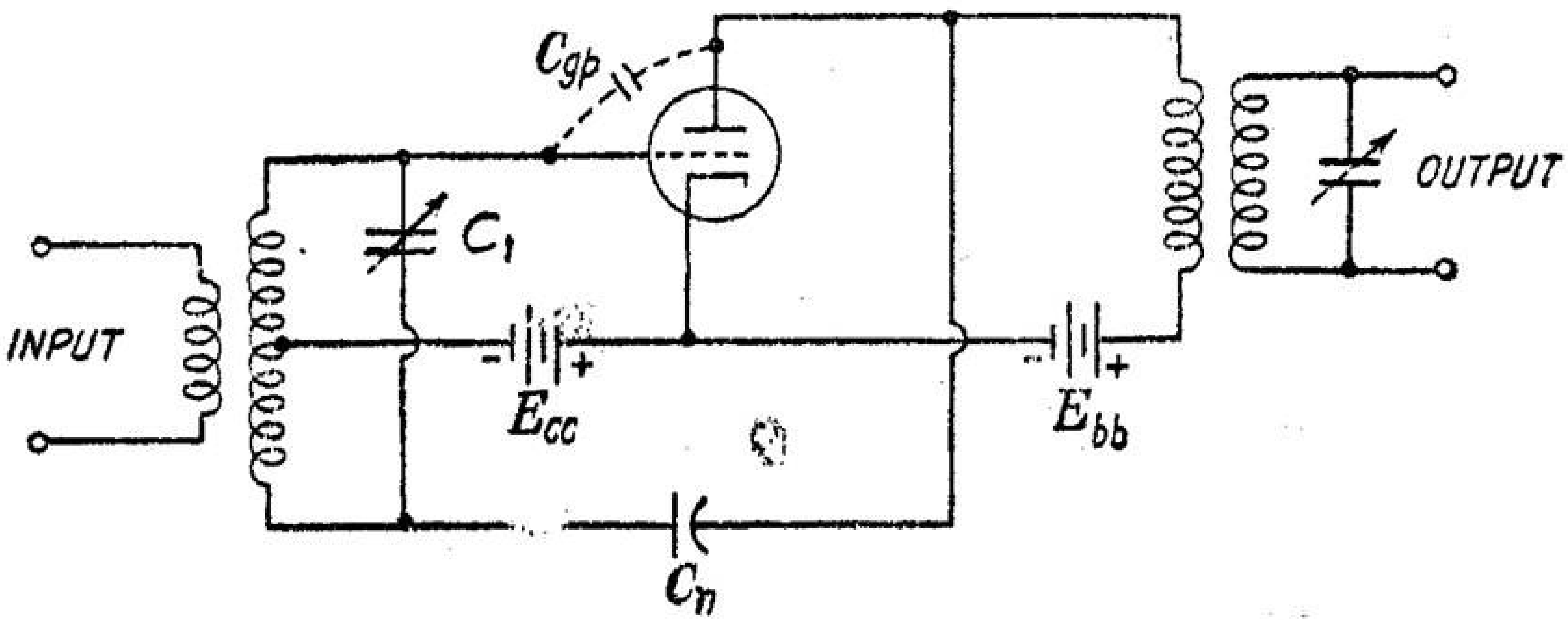


Fig. 6.38. Rice system of neutralization.

Cross Neutralisation

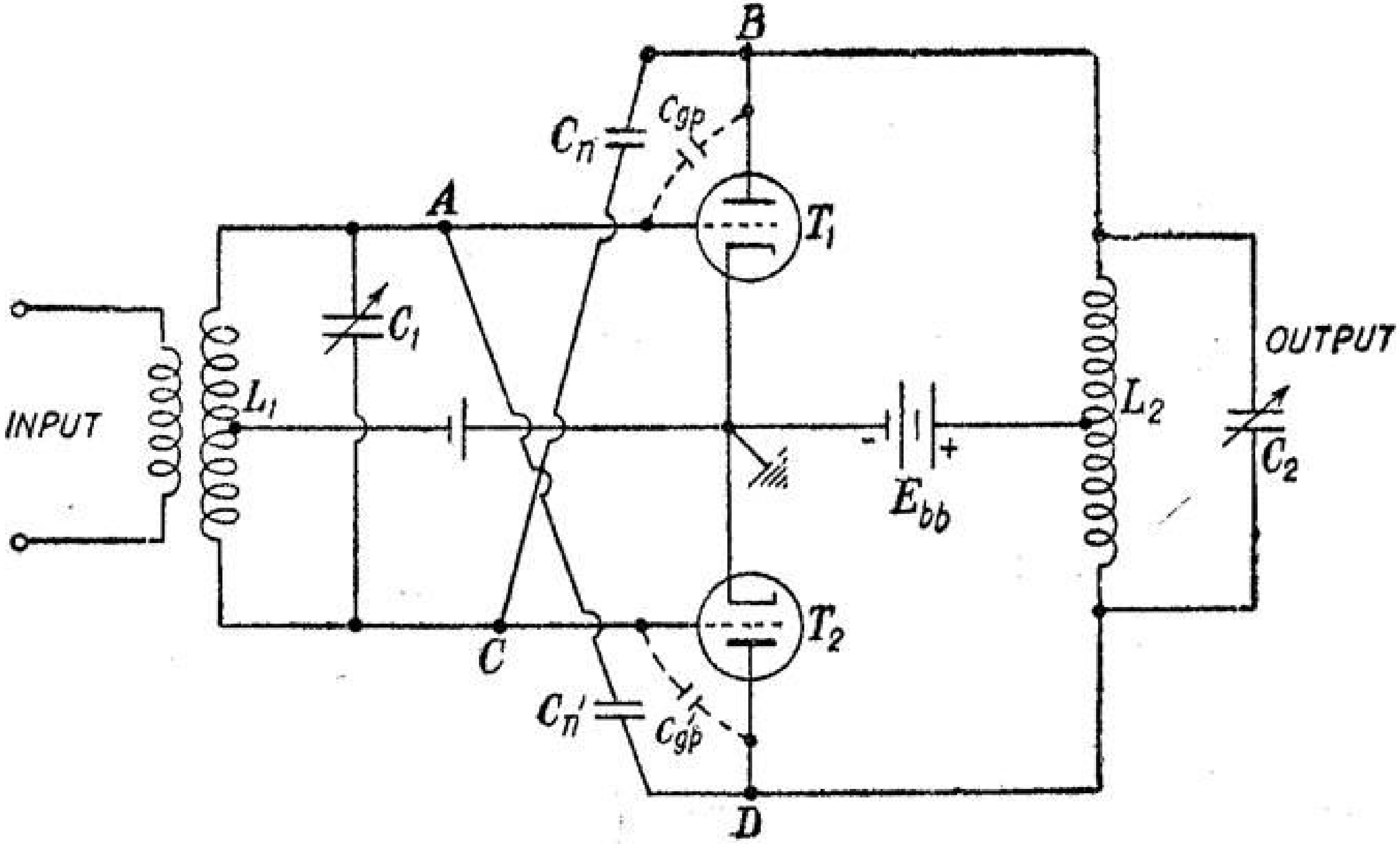


Fig. 6.39. Cross-neutralisation.

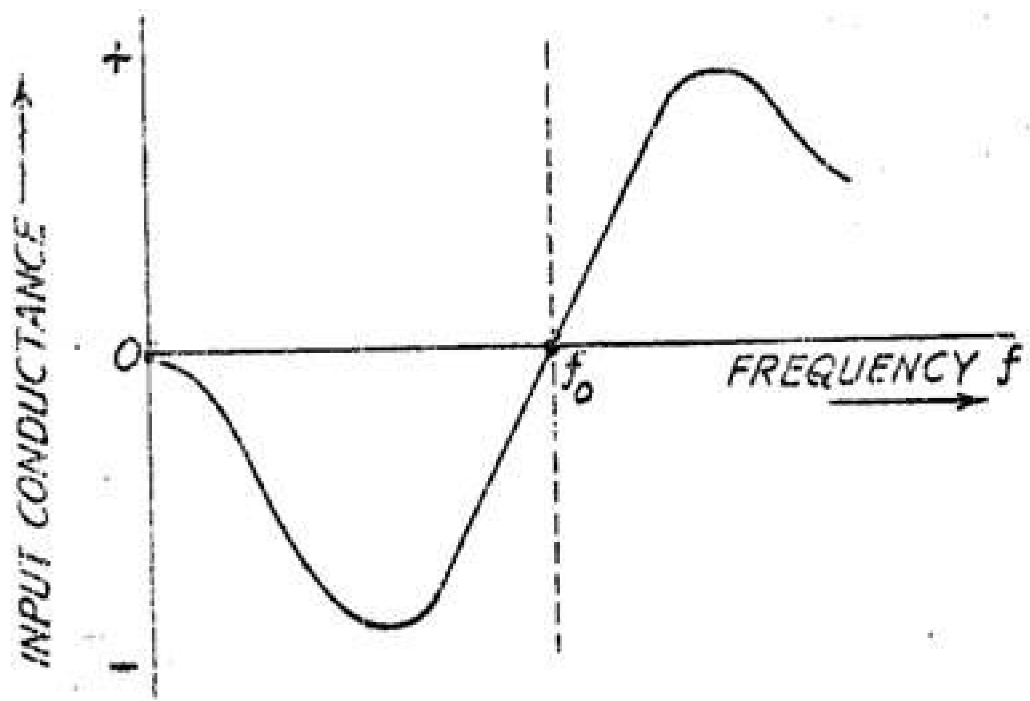


Fig. 6.34. Input conductance curve of a single tuned amplifier.

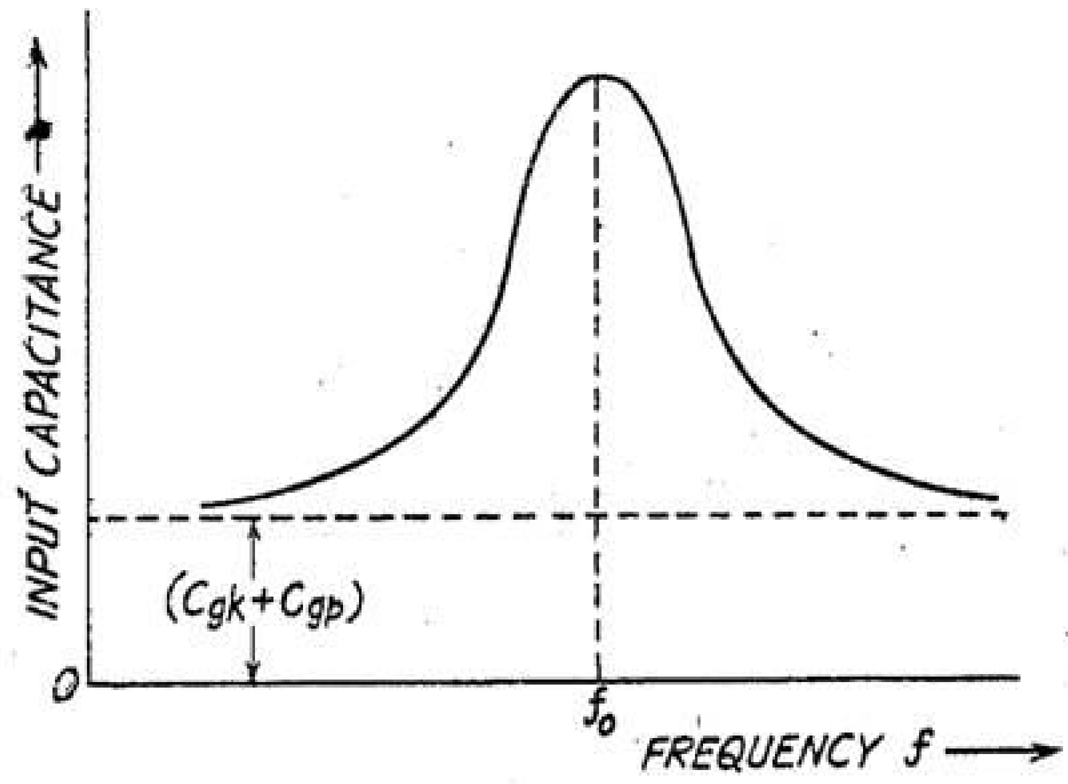


Fig. 6.35. Input capacitance of a single tuned amplifier.

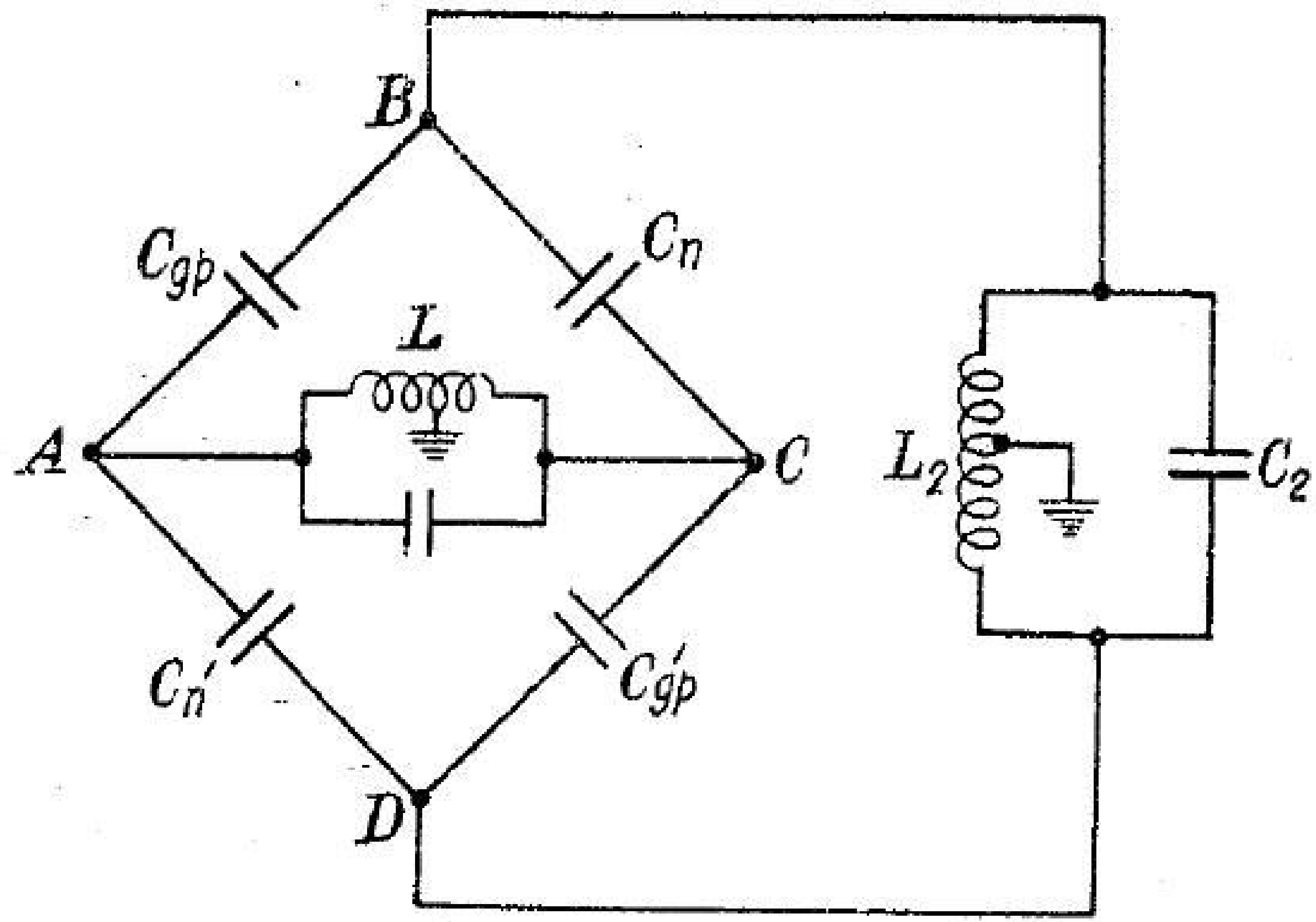


Fig. 6.40. Bridge equivalent circuit of pushpull amplifier with cross-neutralisation.

fier with cross-neutralisation.

Coil Neutralisation

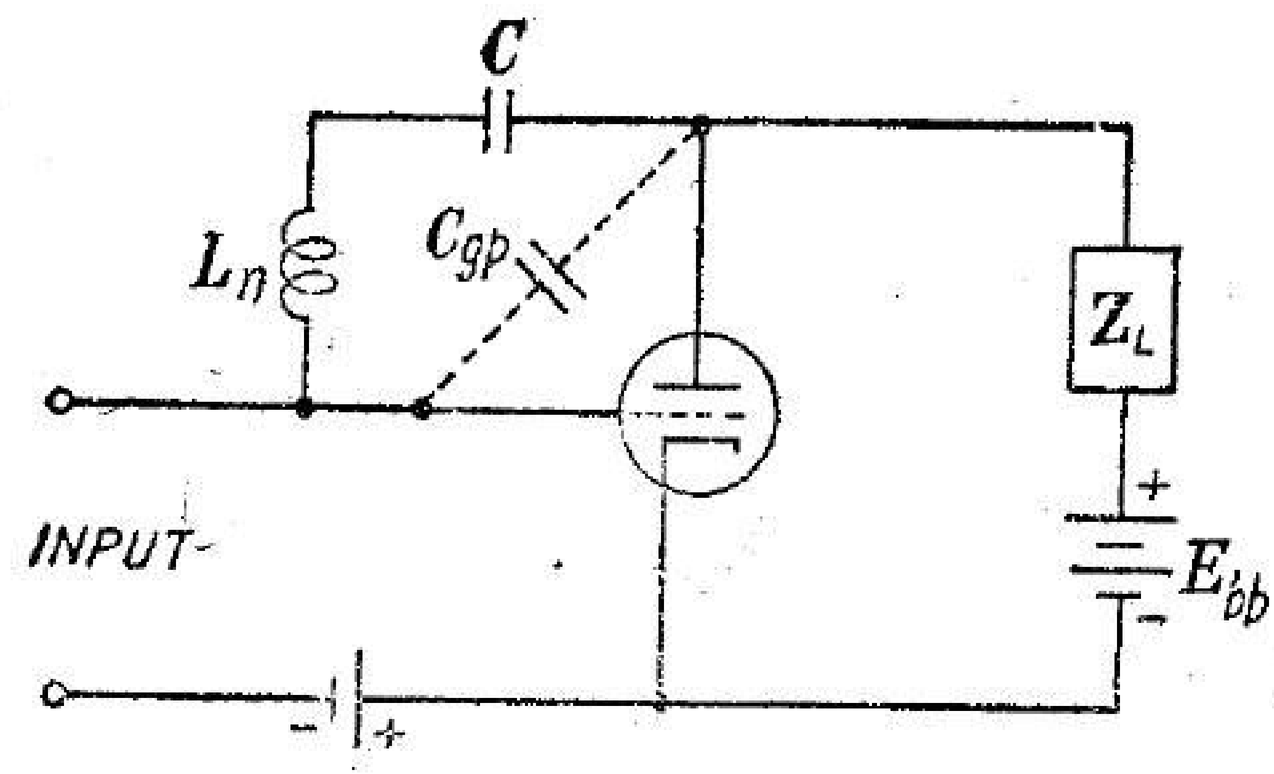
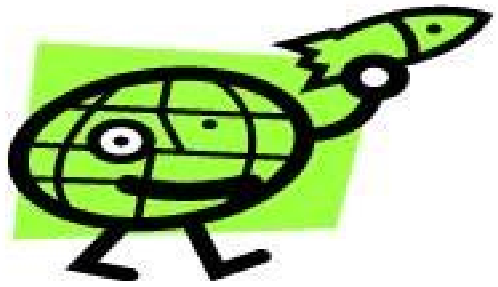


Fig. 6.41. Coil Neutralisation.

Any Questions???



THANK YOU…………!!!!!!!!!!

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