**IV. Answer the following questions embracing the contents of the Text C.**

1. What does the design of an amplifier without coupling capacitors restrict? 2. What is the solution of a problem in the case of d. c. amplifier? 3. What is shown in Fig. 4.5? 4. What does it use? 5. What is $T_2$?

**V. Ask additional questions on the Text C.**

**VI. Combine your answers into a short summary of the text.**

**VII. Prepare a dialogue on a simple two-transistor amplifier.**

**VIII. Speak on d. c. amplifier.**

**IX. Translate the Text C to be sure you understand it well.**

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| in assessing | гарантировать, обеспечивать |
| split v. | синфазный вход (вход общего сигнала) |
| common-mode input | точная копия |
| common-mode gain | разделять |
| ensure v. | оценивая, при оценке |
| exact replica | усиление (коэффициент усиления) синфазной составляющей |

**II. Use the following word-combinations when reading the Text D.**

Now we shall consider сейчас мы рассмотрим; here we can no longer assume здесь мы не можем больше допустить; as we did in Fig. 4.6 как мы допускали, рассматривая рис. 4.6; as this would imply that как это подразумевалось бы (значило бы), что; for the purpose of calculating с целью расчета; it is reasonable to assume that целесообразно предположить, что; thus we see that таким образом, мы видим, что; note that заметьте, что; hence следовательно; we have seen that мы увидели, что.

**III. a) Give the initial forms of the following words and translate them. b) State the function of suffixes.**

Assessing, differential, assuming, corresponding, negligible, calculating, comparison.

### Text D

#### VOLTAGE GAIN IN THE D. C. AMPLIFIER

**I. Read the text and speak on voltage gain.**

In assessing the voltage gain of the differential amplifier we shall consider two input conditions. First of all, in Fig. 4.6, input (1) and



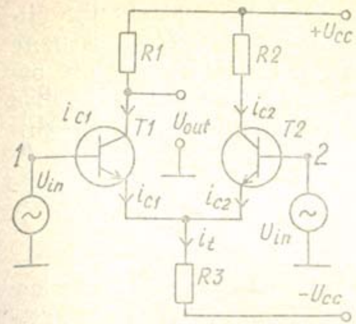


Fig. 4.6. The differential amplifier with common mode inputs.

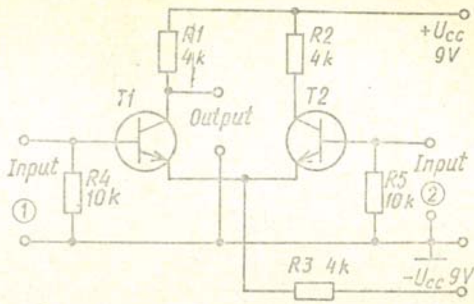


Fig. 4.7. The basic differential amplifier.

input (2) are both connected to the same signal $U_{in}$. Emitter follower action will ensure that an exact replica of the input signal appears across the tail resistor $R_3$. The total signal current in $R_3$ ($i_t$) will be given by

$$i_t = \frac{U_{in}}{R_3}.$$

Again, assuming the transistors to be identical, this current will be split equally between both devices so that signal collector current of $T_1$ = signal collector current of $T_2$, i. e. $i_t = i_{c1} + i_{c2}$ (assuming $i_c \cong i_e$) and since $i_{c1} = i_{c2}$, $i_t = 2i_{c1}$. Now, $U_{out} = -i_{c1}R_1 \cong -\frac{U_{in} \cdot R_1}{2R_3}$ therefore voltage gain $= \frac{U_{out}}{U_{in}} = -\frac{R_1}{2R_3}$.

In the case of Fig. 4.6 $R_1 = R_3$ and, when both inputs are driven together with the same signal, the overall voltage gain is one half. This type of input is called a common-mode input and the corresponding gain the common-mode gain. The higher the value of the tail resistor $R_3$ compared with the collector load $R_1$, the lower the common-mode gain.

Now we shall consider the amplifier with a differential input, i. e. with a different signal on input (1) from that on input (2) Fig. 4.7. Here we can no longer assume that the emitters are connected together with negligible resistance as we did in Fig. 4.6, as this would imply that the output could not be different. For the purpose of calculating the differential voltage gain we shall consider the signal current flowing in $r_e$ for each transistor. It is reasonable to assume that $R_3$ is much larger in value than $r_e$ so that any common mode signal current ($i_t$) flowing in $R_3$ can be neglected in comparison with $i_{c1}$ and $i_{c2}$. Then,

$$U_{out} = \frac{-g_m R_1 (U_{in(1)} - U_{in(2)})}{2}.$$

Thus we see that the differential amplifier responds to the difference in potential between its input. Note that if $U_{in(1)}$ is more positive than $U_{in(2)}$ the output is negative and if $U_{in(2)}$ is more positive than $U_{in(1)}$ the output is positive. Hence, input (1) is called the inverting input and input (2) the non-inverting input. The differential voltage gain $A_{VD}$ is given by

$$A_{VD} = \frac{U_{out}}{U_{in(1)} - U_{in(2)}} \cong -\frac{g_m R_1}{2}, \; g_m \text{ in } mA/V, \; R_1 \text{ in k}\Omega.$$

We have seen that the differential amplifier exhibits a very low gain when both inputs carry the same signal (common-mode) but responds with a high gain to a potential difference between input (differential mode).

*ASSIGNMENTS*

**I. Answer the following questions embracing the contents of the Text D.**

1. Where are input (1) and input (2) connected to in Fig. 4.6? 2. What will emitter follower action ensure? 3. What will the current be, assuming the transistors to be identical? 4. When is the overall voltage gain one half?

**II. Prepare a dialogue on the topic of the lesson.**

**III. Make up a plan of the Text D and speak on the text according to your plan.**

**IV. Examine Figs. 4.6, 4.7 and comment on:**

1. The differential amplifier with common mode inputs.
2. The basic differential amplifier.

**V. Look through the latest magazines and find additional material on the topic. Discuss it with your fellow-students.**

## III. GRAMMAR EXERCISES

**I. Define the function of the Infinitive in the following sentences and translate them.**

1. This limitation may seem to present a problem: we have so far assumed that the output signal should sit at $U_{CC}/2$ in order to allow both positive and negative swings in the signal. 2. If zero input does not result in zero d. c. output, the amplifier is said to exhibit an offset voltage; the purpose of variable resistor $R_5$, the "offset null control" is to adjust to zero output with zero input, rather as a voltmeter zero-set screw is adjusted to bring the pointer to scale zero with no applied signal.

**II. Pay attention to the verbs in Subjunctive Mood while translating the sentences.**

1. It is very desirable that, when there is no signal, both the input and the output should be at earth potential. 2. Here we can no longer assume that the emitters are connected together with negligible resistance as we did in Fig. 4.6, as this would imply that the input could not be different.



**III. Define the function of -ing-forms in the following sentences and translate them.**

1. The design of an amplifier without coupling capacitors restricts the range of permissible circuit voltages. 2. By means of potential divider, consisting of $R_4$ and $R_5$ with $R_3$, the emitter of $T_1$ is held at a potential just a slightly negative of earth. 3. $T_2$ is simply a fully-stabilized amplifier stage working between supplies at +9 V and —9 V.

# Lesson 3. THE OPERATIONAL AMPLIFIER

I. Independent Work.
  In the laboratory.
  1. *Skimming Reading.*
    Pre-text Exercises
    Text A. Building Bricks in Electronic Systems.
  2. *Average Reading.*
    Text B. Simplifying Assumptions.
    Assignments.
II. Classwork.
  3. *Close Reading.*
    Pre-text Exercises.
    Text C. The Non-inverting Amplifier.
    Assignments.
  4. *Searching Reading.*
    Pre-text Exercises.
    Text D. The Inverting Amplifier.
    Assignments.
III. Grammar Exercises.

## I. INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Listen and repeat after the speaker. b) Practise the pronunciation of the following.**

[s] facts, gets, inclusive, famous, numerous, continuous; [ʒ] division, provision, corrosion; measure, explosure, enclosure; but: expension, extension, pressure [ʃ]; [aɪ] design, resign, sign; [i:] field, piece, yield; [ju:] few, dew, new; [u:] grew, screw, blew.

**II. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Construction, electronic system, integrated, revolution, silicon, proportion, construct, analogue, impedance, typically, bipolar, isolated, fact, megohm, configuration, parallel.

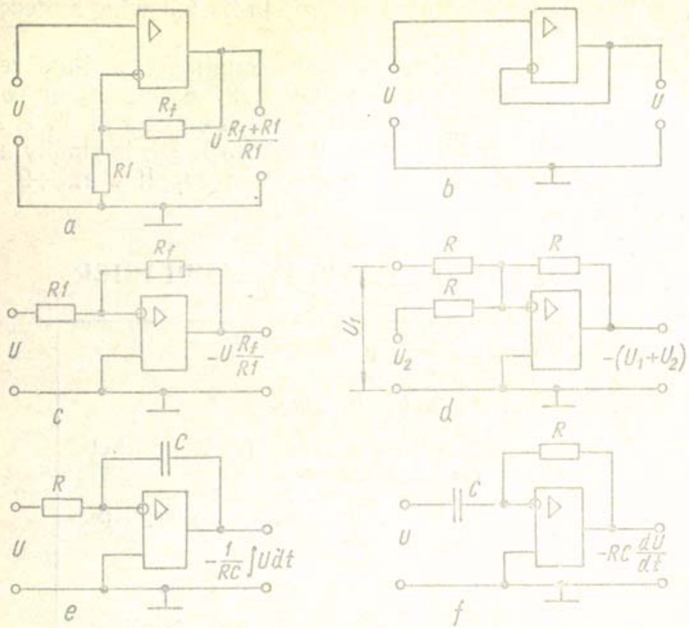


Fig. 4.8. Operational amplifier applications:
*a* the non-inverting amplifier; *b* the voltage follower; *c* the inverting amplifier; *d* the adder; *e* an integrator; *f* a differentiator.

**III. a) Listen, repeat and memorize the following words and word-combinations. b) Check if you know the meaning of these words.**

Operational amplifier операционный усилитель; elaborate тщательно разработанный; offset voltage напряжение сдвига; inherent свойственный, присущий; appropriate interconnection соответствующее взаимосоединение; "building bricks" «строительные кирпичи», основные элементы, simplifying assumptions упрощающие предположения; high-gain voltage amplifier усилитель напряжения с большим усилением; infinite open-loop voltage gain, $A_{vol}$ коэффициент усиления по напряжению при разомкнутой петле $A_{vol}$, design consideration конструктивное соображение.

**IV. a) Make up sentences using the following word-combinations from the Text A and the Text B. b) Learn them.**

A considerable proportion of present-day circuit design значительная часть конструкций современных схем; the latter may be seen as последние можно рассматривать как; which can easily be used которые можно легко использовать для; all the circuits of Fig. 4.8 make use of все схемы рис. 4.8 используют; the term "operational" is generally used nowadays to describe термин «операционный» вообще используется сегодня для описания; the name is derived from the use of such amplifiers название происходит от использования таких усилителей; typically *зд.* обычно; the first design consideration therefore is that первое конструктивное соображение, следовательно,



заключается в том, чтобы; the difference between the two input bias currents is known as разница между двумя токами смещения на входе известна как; yet another factor to be considered is that, irrespective of еще одним фактором, который рассматривается, является то, что несмотря на ... .

## Text A

### BUILDING BRICKS IN ELECTRONIC SYSTEMS

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

In the design and construction of complicated electronic system, integrated circuits (IC) have cause a major revolution. The chip of silicon in an IC is typically only 3 mm square, but twenty transistors, eleven resistors and a capacitor are included in that area.

A considerable proportion of present-day circuit design is achieved by the appropriate interconnection of ICs. The latter may be seen as "building bricks" which can easily be used to construct elaborate electronic system. Fig. 4.8 includes many circuits of this basic building bricks.

## 2. Average Reading

## Text B

### SIMPLIFYING ASSUMPTIONS

**I. a) Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with the characteristics of an op amp. Translate it.**

All the circuits of Fig. 4.8 make use of an operational amplifier (op amp.). The term "operational" is generally used nowadays to describe a high-gain voltage amplifier, particularly one in an IC or modular form. The name is derived from the use of such amplifiers in analogue computing operations. The characteristics of an op amp are such that the following simplifying assumptions can be made in most practical circuits: infinite open-loop voltage gain, $A_{vol}$ (typically $2.10^5$); infinite input impedance (typically 2 MΩ); zero output impedance (typically 75Ω). Most IC amplifiers use bipolar transistors. The input terminals in fact connect to transistor bases which must be able to draw a small bias current if the amplifier is to function (d.c. coupling prevents the input terminals from being isolated with coupling capacitors). Input bias current typically is about 100 μA. The first design consideration therefore is that each input of any IC amplifier must have some sort of d. c. parth to earth.

The internal circuitry may be slightly unbalanced so that the two bias current are not equal (Fig. 4.9*a*).

The difference between the two input bias current is known as the input offset current and typically amounts to 20 μA.

Yet another factor to be considered is that, irrespective of external voltage at the input, the IC itself has a small inherent input offset voltage, about 1 mV.

*ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. a) Skim through the Text B and find the part of it dealing with the most IC amplifiers using bipolar transistors. b) Discuss the information.**

**III. Find the part of the text containing information about input bias current. b) Express your opinion of it.**

**IV. Answer the following questions embracing the contents of the Text A.**

1. Have integrated circuit caused a major revolution in the design and construction of complicated electronic system? 2. What is the chip of silicon in an IC? 3. What is a considerable proportion of present-day circuit design achieved by? 4. What figure includes many circuits of the basic building bricks?

**V. Ask additional questions on both texts.**

**VI. Summarize your answers into a sh a summary of these texts.**

**VII. Prepare a dialogue on simplifying ssumption.**

**VIII. Speak on the operational amplifier.**

**IX. Examine Fig. 4.8 and comment on:**

1. The non-inverting and inverting amplifiers.
2. The voltage follower and the adder.
3. An integrator and a differentiator.

## II. CLASSWORK

### 3. Close Reading

PRE-TEXT EXERCISES

**I. Be sure that you know these word-combinations.**

Significant attenuation значительное ослабление; thanks to благодаря; unit-gain non-inverting amplifier неинвертирующий усилитель с единичным усилением.

**II. Find these word-combinations in the Text C and translate the sentences containing them.**

This latter requirement arises from the fact that это последнее требование возникает вследствие того, что; if the signal source output resistance is comparable with $R_x$, если выходное сопротивление источника сигнала сравнимо с $R_x$; it may be thought at first that вначале можно подумать, что; it will be noted будет отмечено; the answer is that ответ заключается в том, что.

**III. a) State the function of each suffix in the following words. b) Translate these words.**



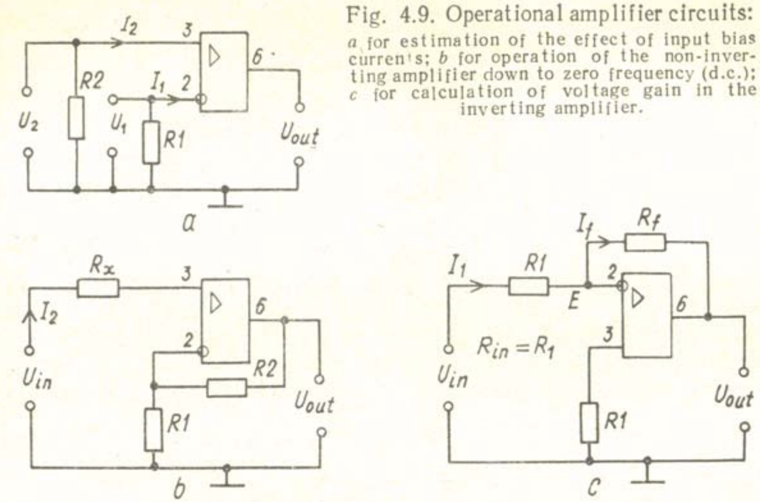


Fig. 4.9. Operational amplifier circuits:
*a* for estimation of the effect of input bias currents; *b* for operation of the non-inverting amplifier down to zero frequency (d.c.); *c* for calculation of voltage gain in the inverting amplifier.

Feeding, inverting, operation, connection, resistance, requirement, comparable, significant, fortunately.

## Text C

### THE NON-INVERTING AMPLIFIER

**I. a) Read the text. b) Find the part of it describing the value of signal source output resistance, comparable with $R_x$. Translate it.**

The feedback signal is affectively subtracted from the input signal by feeding the latter into the non-inverting input of the op amp and the feedback into the inverting input. Fig. 4.9*b* shows a non-inverting amplifier designed for operation down to zero frequency (d. c.) and with the input arranged for connection to a signal source of low output resistance. This latter requirement arises from the fact the amplifier must draw its input bias current from the signal source and must therefore see a d. c. path to earth. Resistor $R_x$ is in circuit simply to ensure that both inputs see the same resistance to earth. If the signal source output resistance is comparable with $R_x$, its value should be subtracted from $R_x$. It may be thought at first that $R_x$, being in series with the signal, will cause significant attenuation; fortunately this is not the case because the amplifier itself thanks to the negative feedback, has an input impedance of at least 50 $M\ \Omega$. There will thus be a negligible signal loss across the 10 $k\ \Omega$ or so of $R_x$.

It will be noted in Fig.4.9*b* that circuit may be used to give unity voltage gain though the practical use of this may be questioned. The answer is that the unity-gain non-inverting amplifier is used to provide an impedance match like the emitter follower. The input impedance may be many hundreds of megohms at low frequencies and the output impedance less than 1 Ω.

**I. a) Divide the text into logical parts. b) Entitle each part.**

**II. Look through the Text C and find the part of it dealing with the amplifier having a voltage gain approaching infinity.**

**III. Examine Fig. 4.9 and comment on:**

1. Op. am. circuit for estimation of the effect of input bias currents.

2. Op. am. circuit for operation of the non-inverting amplifier down to zero frequency (d. c.).

**IV. Answer the questions embracing the contents of the Text C.**

1. What is called a virtual earth in Fig. 4.9c? 2. What makes the inverting amplifier very flexible in use? 3. What is the difference between the inverting amplifier and non-inverting one? 4. What does Fig. 4.9b show? 5. What does the latter requirement arise from? 6. What is resistor $R_x$ in circuit simply to ensure? 7. What will $R_x$ cause?

**V. Ask additional questions on the Text C.**

**VI. Summarize your answers into a short summary of the text.**

**VII. Make up a plan of the Text C and speak on the topic.**

**VIII. State the tense-forms of the verbs in the Text C and translate them.**

Subtract, show, arise, draw, see, think, cause, note, use.

**IX. Translate the Text C to be sure you understand it well.**

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| op amp = operational amplifier | фактически, в сущности |
| instead of | гибкий |
| approaching infinity | операционный усилитель |
| negligible | приближаясь к бесконечности |
| virtually | вместо |
| flexible | незначительный |

**II. Give the initial forms of the following words from the Text D and translate them.**

Perfectly, inverting, configuration, simplifying, approaching, virtually, accepting, immediately, considering.



## Text D

### THE INVERTING AMPLIFIER

**I. Read the text and speak on inverting amplifier.**

It is perfectly feasible to feed the input signal into the inverting input of an op amp along with the negative feedback. This, as might be expected, produces an inverting amplifier, the output signal being 180° out of phase with the input. The circuit configuration, which is shown in Fig. 4.9c is known as shunt feedback because the negative feedback, instead of being in series with the input signal, is in parallel with it and feeds into the same input. To calculate the effect of shunt feedback, we use the three simplifying assumption about an op amp: open-loop gain $A_{vol} = \infty$, input impedance $Z_{in} = \infty$, output impedance $Z_{out} = 0$.

In Fig. 4.9c the point $E$, where $R_f$ and $R_1$ join the inverting input, is called a virtual earth. This is so because, if the amplifier has a voltage gain approaching infinity, there must be a negligible potential difference between the two inputs. Thus, as far as the signal is concerned, the inverting input looks virtually the same as the non-inverting input, which is earthed.

Accepting that point $E$ is a virtual earth means that the full input voltage $U_{in}$ appears across input resistor $R_1$. Thus we see immediately why the input resistance $R_{in}$ is quoted in Fig. 4.9 c as being equal to $R_1$: $R_1$ is the only resistance which stands between the input terminal and the virtual earth. Signal current in $R_1$ is therefore given by $i_1 = \frac{U_{in}}{R_1}$. Now, considering feedback $R_f$, which is connected between the virtual earth and $U_{out}$, and taking signal current $i_f$ in the direction shown:

$$i_f = \frac{-U_{out}}{R_f}.$$

If the op amp input impedance is infinite, no signal current is drawn by the inverting input, so it follows that $i_f = i_1$, i. e. $\frac{-U_{out}}{R_f} = \frac{U_{in}}{R_1}$ therefore $A_{vol} = \frac{U_{out}}{U_{in}} = -\frac{R_f}{R_1}$.

The way that the gain is dependent upon the simple ratio of two resistors makes the inverting amplifier very flexible in use.

### ASSIGNMENTS

**I. Answer the following questions embracing the contents of the Text D.**

1. What is known as shunt feedback? 2. What do we use to calculate the effect of shunt feedback? 3. What is called a virtual earth? 4. When can be a negligible potential difference between the two inputs? 5. What formula is given for signal current in $R_1$?

**II. Prepare a dialogue on your own situation describing a virtual earth.**

**III. Make up a plan of the Text D and retell it according to your plan.**

**IV. Make a short written summary of the Text D.**

**V. a) Look through the latest magazines and find additional information on the topic of the lesson. b) Discuss the problem of amplifier with your fellow-students.**

## III. GRAMMAR EXERCISES

**I. Define the form and function of the verbs in the Passive Voice and translate the sentences with them.**

1. The latter may be seen as "building bricks" which can be used to construct elaborate electronic system. 2. The term "operational" is generally used nowadays to describe a high-gain voltage amplifier. 3. It may be thought at first that $R_x$, being in series with the signal, will cause significant attenuation. 4. It will be noted in Fig. 4.9*b* that circuit may be used to give unity voltage gain though the practical use of this may be questioned.

**II. Define the function of ing-form in these sentences and translate them.**

1. D. c. coupling prevents the input terminals from being isolated with coupling capacitors. 2. It may be thought at first that $R_x$, being in series with the signal, will cause significant attenuation. 3. In Fig. 4.9*c* the point E, where $R_f$ and $R_1$ join the inverting input, is called a virtual earth. 4. The inverting input looks virtually the same as the non-inverting input, which is earthed.

**III. Translate the following sentences paying attention to the Infinitive.**

1. Yet another factor to be considered is that, irrespective of external voltage at the inputs, the IC itself has a small inherent input offset voltage. 2. Resistor $R_x$ is in circuit simply to ensure that both inputs see the same resistance to earth.

**IV. a) Analyse the following sentences paying attention to the tense of the verbs. b) Translate them.**

1. This, as might be expected, produces an inverting amplifier, the output signal being 180° out of phase with the input. 2. The circuit configuration, which is shown in Fig. 4.9*c* is known as shunt feedback because the negative feedback, instead of being in series with the input signal, is in parallel with it and feeds into the same input. 3. If the signal source output resistance is comparable with $R_x$, its value should be subtracted from $R_x$.



# Lesson 4. LOGARITHMIC AMPLIFIER AND OSCILLATOR



## I. INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Logarithmic, instrumentation, meter, decade, parameter, accustical, decibel, phenomenon, physics, result, characteristic, basic, normal, temperature, limitation, potentiometer, factor.

**II. a) Listen, repeat and memorize the following words and word-combinations from the Text A and the Text B. b) Check if you know their meanings.**

Display v. отображать; roughly [rʌflɪ] грубо; prior to до; conveniently удобно; decay разложение, спад, понижение; reverse leakage current обратный ток утечки; swing раскачка (максимальное отклонение); fine control $R_3$ резистор $R_3$ для точной подстройки; offset potentiometer потенциометр сдвига; snag препятствие; logging transistor регистрирующий транзистор; base-emitter p. d. (potential difference) разность потенциалов между базой и эмиттером; single meter scale одна измерительная шкала; sound pressure levels уровни звукового давления; threshold of hearing порог слышимости; basic feature основная особенность.

**III. Find attributes in these word-combinations and say what parts of speech they are expressed by. b) Translate them.**

Logarithmic amplifiers; each major scale division; one decade of the parameter measured; in accustical measurement work; sound pressure level; some sound level meters; a single linear scale; input-output characteristic; low input voltage; the basic log amplifier circuit; the main logging transistor.

## Text A

### LOGARITHMIC AMPLIFIER

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

Logarithmic amplifier have applications in instrumentation where a wide range of signal amplitude must be displayed on a single meter scale; each major scale division can then represent one decade of the parameter measured.

In accustical measurement work, sound pressure levels are usually expressed in decibels relative to a reference level of $2 \cdot 10^{-5}$ N/m$^2$, which corresponds roughly with the threshold of hearing. A logarithmic amplifier connected prior to the read-out device can give readings directly in decibels. Some sound level meters cover the range 70 dB to 120 dB on a single linear scale. There are many such phenomena in physics which have an exponential decay with time. Such results can conveniently be displayed as a straight line decay via a logarithmic amplifier.

2. Average Reading

## Text B

### THE BASIC CIRCUIT

**I. a) Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with an input-output characteristics for a basic log amplifier. Translate it.**

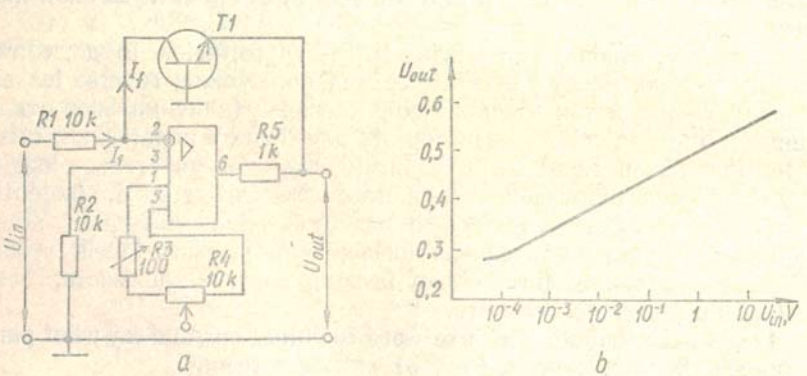


Fig 4.10. Logarithmic amplifier:
*a* the basic circuit; *b* a typical input-output characteristics.



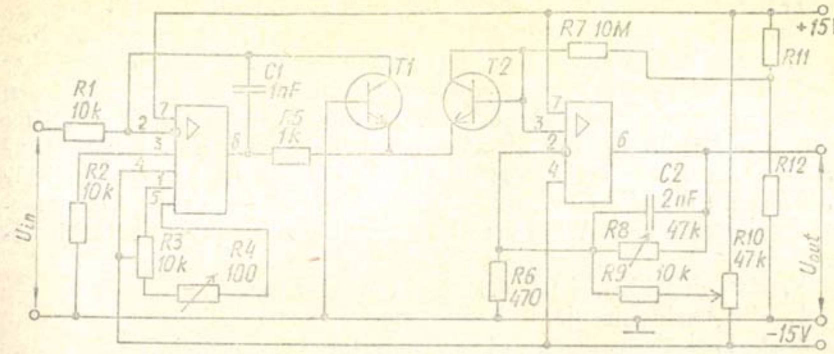


Fig. 4.11. The temperature-compensated logarithmic amplifier circuit.

The basic circuit of a logarithmic amplifier is given in Fig. 4.10*a*. Fig. 4.10*b* shows an input-output characteristic for a basic log amplifier, and it is clear that the output voltage swing is relatively small, changing by only about 0.3 V for four decades of input signal range. At low input voltages, the setting of the offset control $R_3$ become critical. To assist adjustment, the fine control $R_4$ is connected in series with the normal 10 kΩ offset potentiometer. The offset control are adjusted for zero amplifier output with the input shorted to earth.

In addition to the limited output voltage range, there is another snag associated with the basic log amplifier circuit of Fig. 4.10: it is temperature sensitive because of the kT/e factor in the transistor equation. Those two limitations may be overcome by using the more advanced circuit of Fig. 4.11. Here a second stage is added, both to increase gain and to provide temperature compensation. The latter feature is achieved by the inclusion of a second base-emitter junction $T_2$, in opposition to the main logging transistor $T_1$; $T_2$ experiences a negligible change in operating current over the full operating range so that it does not tend to counteract the logging of $T_1$. It does however encounter the same temperature changes as $T_1$ so that the resultant changes in its base-emitter p. d. compensate for the variations in $T_1$.

Potentiometer $R_8$ determines the scale factor (gain) and can be readily adjusted so that a 10 dB change in input gives a convenient 1 V change in output.

The remaining three preset potentiometers are offset controls.

### *ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. a) Skim through the Text B and choose the key sentences. b) Translate the sentences.**

**III. Discuss the main idea of the Text A and the Text B.**

**IV. Answer the following questions on the Text A and the Text B.**

1. What is given in Fig. 4.10*a*? 2. Why is a logarithmic amplifier used in instrumentation? 3. How are sound pressure levels expressed in accustical measurement work? 4. When can a logarithmic amplifier give readings in decibel directly? 5. What does Fig. 4.10*b* show? 6. When does the setting of the offset control $R_3$ become critical? 7. What are the offset controls adjusted for? 8. What does potentiometer $R_8$ determine? 8. What are the remaining three preset potentiometers?

**V. Examine Figs. 4.10, 4.11 and comment on:**

1. The basic circuit.
2. A typical input-output characteristics.
3. The temperature-compensated logarithmic amplifier circuit.

**VI. Prepare a dialogue on typical input-output characteristics of simple logarithmic amplifier.**

**VII. Speak on:**

1. Logarithmic amplifier.
2. The basic circuit.

## II. CLASSWORK

### 3. Close Reading

PRE-TEXT EXERCISES

**I. Find the following word-combinations in the Text C and translate them with the sentences they are involved in.**

One of the most useful test instruments; it is appropriate, therefore; in the case of; it is possible to arrive; this implies that; a sine-wave generator is designed so that.

### Text C

#### POSITIVE FEEDBACK

**I. a) Read the text. b) Describe the basic factor common to signal generator, i. e. positive feedback.**

One of the most useful test instruments in experimental electronics is the signal generator. It is appropriate, therefore, that we should consider the methods used for signal generations.

Positive feedback is the basic factor common to signal generators. We found in the discussions of negative feedback that the gain of any amplifier with feedback is given by

$$A = \frac{A_0}{1 - \beta A_0}, \qquad (4.5)$$

where $A_0$ is the gain without feedback and $\beta$ is the fraction of the output fed back to the input. Now, with negative feedback, either $\beta$ or



$A_0$ is negative, so that the denominator is always greater than one. In the case of positive feedback, however, it is possible to arrive at the condition $1 - \beta A_0 = 0$ (4.6) which gives an infinite value for $A = A_0/(1 - \beta A_0)$. This implies that the amplifier produces an output signal with no input, which is the condition for oscillation. An oscillator forms the heart of every signal generator. A sine-wave generator is designed so that the condition of (4.6) often called the Barkhausen criterion, is satisfied at only one frequency.

*ASSIGNMENTS*

**I. a) Divide the text into logical parts. b) Choose the key sentences, analyse and translate them.**

**II. Entitle each of the paragraphs of the text using the key sentences.**

**III. Look through the text and find the part of it dealing with the case of positive feedback.**

**IV. Answer the following questions embracing the contents of the text.**

1. What is one of the most useful test instruments in experimental electronics? 2. What is positive feedback? 3. When is the denominator greater than one? 4. What is the heart of every signal generator? 5. How is a sine-wave generator designed?

**V. Ask additional questions and discuss the problem of feedback.**

**VI. Skim through the text and find the sentences containing the Participle. Translate them.**

**VII. Review the text in written form.**

**VIII. Translate the Text C to be sure you understand it well.**

### 4. Searching Reading

PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| neglect | гасящий резистор |
| giving near infinite attenuation | нежелательный |
| unwanted | генератор с фазовым сдвигом (RC-генератор) |
| phase-shift oscillator | погашать, подавлять |
| "stopper" resistor | пренебрегать |
| damp out | создавая почти бесконечное ослабление |

**II. Translate the following word-combinations from the Text D.**

A useful starting point; practical oscillator circuits; the phase-shift circuit; the voltage amplifier; a passive network; significant output; the capacitor reactance.

## Text D

### THE PHASE-SHIFT SINUSOIDAL OSCILLATOR

**I. Read the text and speak on the application of positive feedback to a single-stage voltage amplifier.**

A useful starting point in the study of practical oscillator circuits is to apply positive feedback to a single-stage voltage amplifier. This is accomplish in the phase-shift oscillator of Fig. 4.12a.

The phase-shift circuit is necessary in oscillation to be achieved, the amplifier output is 180° out of phase with its input. Hence, for positive feedback, the external circuit ($R_1$, $C_1$, $R_2$, $C_2$, $R_3$, $C_3$) must shift the phase through a further 180°.

The voltage amplifier uses a Darlington pair, so that we can neglect the transistor input impedance, which is very high. It is interesting to notice that, when 180° phase-shift is required, a passive network requires three RC stages if significant output is to be available. One *RC* stage will just manage a 90° phase-shift, but the capacitor reactance must be very high compared with the resistor, giving near infinite attenuation.

The 100 Ω resistor $R_5$ in Fig. 4.12*a*, is a "stopper" resistor to damp out unwanted high-frequency oscillation.

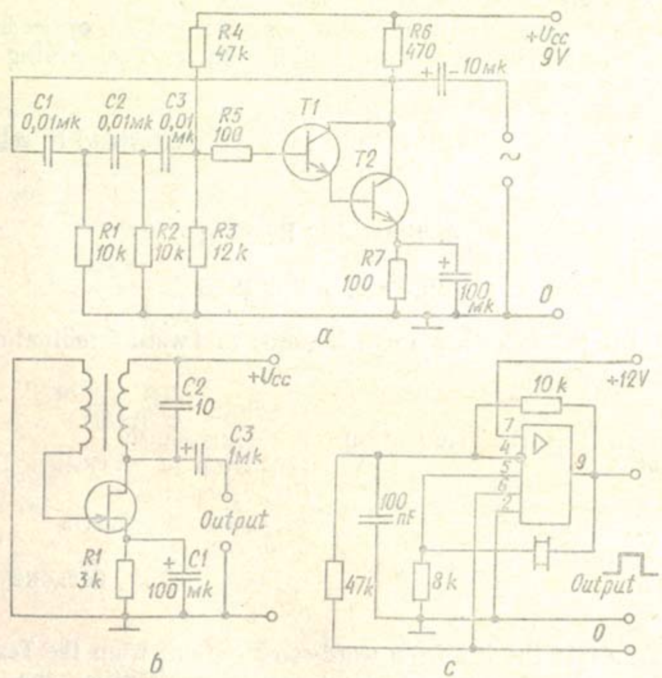


Fig. 4.12. Signal generator circuits:
*a* the phase-shift generator for sine-wave output; *b* simple LC generator, using FET; *c* the crystal-controlled rectangular wave output.





**I. Skim through the Text D and find the part of it dealing with the phase-shift circuit.**

**II. Answer the following questions embracing the contents of the Text D.**

1. What is a useful starting point in the study of practical oscillator circuits? 2. Does the voltage amplifier use a Darlington pair? 3. When can we neglect the transistor input impedance? 4. When does a passive network require three *RC* stages? 5. What shift will one *RC* stage just manage?

**III. Discuss the problem of oscillators.**

**IV. Examine Fig. 4.12 and comment on:**

1. The phase-shift generator for sine-wave output.
2. Simple LC generator, using FET.
3. The crystal-controlled rectangular wave output.

**V. Make up a plan of the Text D and speak on the topic according to your plan.**

**VI. Look through the latest magazines and find the material on the topic.**

**VII. Prepare a short information on the topic and discuss it with your fellow-students.**

## III. GRAMMAR EXERCISES

**I. a) Analyse the following sentences and translate them. b) Pay attention to the words in bold type and define their forms.**

1. It is clear that the output voltage swing is relatively small, **changing** by only about 0.3 V for four decades of input signal range. 2. **To assist adjustment**, the fine control $R_4$ is connected in series with the normal 10 kΩ offset potentiometer. 3. In addition to the limited output voltage range, there is another snag **associated** with the basic log amplifier circuit. 4. Here a second stage is added, both **to increase** gain and **to provide** temperature compensation.

**II. Translate these sentences and pay attention to the modal verbs with the Passive Infinitive.**

1. A wide range of signal amplitude must be displayed on a single meter scale. 2. The results can conveniently be displayed as a straight line decay via a logarithmic amplifier. 3. Those two limitations may be overcome by using the more advanced circuit of Fig. 4.11. 4. Potentiometer $R_8$ can be readily adjusted so that a 10 dB change in input gives a convenient 1 V change in output.

**III. Change the tense-forms of the verbs in these sentences into the Past and the Future.**

1. The fine control $R_4$ is connected in series with the normal 10 kΩ offset potentiometer. 2. The offset controls are adjusted for zero amplifier output with the input shorted to earth. 3. The latter feature is achieved by the inclusion of a second base-emitter junction $T_2$.

# Lesson 5. INTEGRATED CIRCUITS



## I. INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Listen and repeat after the speaker. b) Practise the pronunciation of the following.**

Miniaturize [ˌmɪnjətʃə'raiz], advantage [əd'va:ntɪdʒ], reliability [rɪˌlaɪə'bɪlɪtɪ], microminiaturization ['maɪkrɔˌmɪnjətʃərɪ'zeɪʃ(ə)n], particular [pə'tɪkjulə], evaporation [ɪ'væpə'reɪʃ(ə)n], ceramic [sɪ'ræmɪk], photolithographic [ˌfouto(u)ˌlɪθə'græfɪc], essential [ɪ'senʃ(ə)l].

**II. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Electronics, industry, engineers, components, miniaturize, passive, elements, physical, material, technology, monolithic, integrated, process, individual, typical, naturally, factor, apparatus, temperature, basic, form, ceramic, active, combination, metallized, base, discrete, collector, emitter, start.

**III. a) Listen, repeat and memorize the following words and word-combinations from the Text A and the Text B. b) Check if you know their meanings.**

Integrated circuits интегральные схемы, микросхемы; continued effort непрерывная попытка, продолжающееся усилие; miniaturize



делать миниатюрным; reliable надежный; trend направление, тенденция; build into встраивать, вмонтировать; eventually в итоге, в конце концов; "face of stone" поверхность камня; simultaneous fabrication одновременное изготовление; merely только, просто; chip чип (*кристалл небольшого размера*); on account of за счет чего-л.; impact влияние, воздействие; confine ограничивать; offer предлагать, давать; failure отказ, сбой в работе, провал; space probe космический зонд; soldered connections пайки, паянные соединения; actual overall cost фактическая полная стоимость; consumer потребитель; design cost стоимость разработки; literally буквально; breakdown авария, неисправность; emphasis особое значение, ударение; operating temperature рабочая температура; intimate construction *зд.* близкое размещение; total demand общая потребность; require less power to operate требовать меньше мощности для работы; in order to take full advantage для того, чтобы получить все преимущества; saving in space экономия пространства (объема).

**IV. Find in the Text A and in the Text B English equivalents of the following word-combinations and translate the sentences with them.**

С самого начала; миниатюризация электронного оборудования; значительно меньше; для того, чтобы получить полное преимущество; сделать возможным с помощью того же процесса, который используется; так, чтобы разрешить; электронная промышленность; жизненно важные преимущества; надежность электронного оборудования; все возрастающая сложность; может привести к полной неисправности системы; за счет трех основных факторов; по мере того, как рабочая температура увеличивается; зависит от общего требования; для определенной цепи.

**V. Analyse the following words from the viewpoint of their structure. Learn them.**

Development, microminiaturization, monolithic, measuring, interconnection, vitally, reliability, breakdown, furthermore, construction, manufacturing, ultimately.

### Text A

#### MINIATURIZATION IN ELECTRONIC EQUIPMENT

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

Almost since the beginning of the electronics industry, scientists and engineers have concerned themselves with producing smaller components in a continued effort to miniaturize electronic equipment. In 1948, a major step forward was achieved by the invention of the transistor. Not only is the transistor considerably smaller than the thermionic valve it replaced, but also more reliable, cheaper and requires less power to operate. In order to take full advantage of the transistor, passive elements such as resistors, capacitors and inductors were greatly reduced in physical size by using new materials and improved technology.

The transistor was only a stage in the development of true microminiaturization which was made possible by the development of the monolithic integrated circuit. This is a complete circuit which is built into a single "face of stone", i. e. silicon.

The silicon monolithic integrated circuit is produced by the same processes used to fabricate individual transistors and diodes. The technology is merely extended so as to permit a complete circuit to be made within a single silicon chip, e. g. a typical integrated chip, measuring only 1.25 mm square by 0.25 mm thick, may contain up to fifty electronic components (transistors, diodes, resistors, capacitors) plus their interconnections.

## 2. Average Reading

### Text B

### RELIABILITY OF INTEGRATED CIRCUITS

**I. a) Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with the three main factors of high reliability of integrated circuits. Translate it.**

The impact the integrated circuit has had on the electronics industry is not confined to miniaturization. It offers two other vitally important advantages over the older discrete components circuit, these are: a) greater reliability; b) production of large number of circuits at low cost.

Naturally, reliability of electronic equipment has always been important. However, the ever increasing complexity of present day electrical equipment (in space probes, computers, etc.) where literally hundreds of thousands of circuit elements are utilized and where failure of any may cause complete breakdown of the system, means that greater emphasis is placed on reliability. Integrated circuits offer high reliability on account of three main factors:

a) absence of soldered connections between circuit components;

b) simultaneous fabrication of whole circuits by carefully controlled processes;

c) low power operation. In general, reliability of electronic apparatus decreases as the operating temperature increases. Thus, since integrated circuits are low power operated, the resulting temperature rise is small, giving high reliability. Furthermore, due to its intimate construction the effects of temperature variation are more uniform than in discrete assemblies and this contributes to greater reliability.

The reduction in manufacturing cost is achieved because many similar circuits may be fabricated simultaneously. The actual overall cost per circuit to the consumer, i. e. design cost plus manufacturing cost, does ultimately depend on the total demand for that particular circuit.



*ASSIGNMENTS*

**I.** a) Choose the key sentences from **the Text A and compare them with** the title of the text. b) Say what the text is about.

**II.** Skim through the Text B and find **the part of it dealing with the** reliability of electronic equipment. **Translate it.**

**III. Find the part of the text containing information about the effects of temperature variation. Discuss it.**

**IV. Answer the following questions.**

1. When did scientists invent the transistor? 2. What was the transistor invented for? 3. What are the advantages of the transistor as compared with the thermionic valve? 4. By what means were passive elements reduced in physical size? 5. How is the silicon integrated circuit produced? 6. What advantages does the integrated circuit offer over the older discrete component circuit? 7. Is the silicon monolithic integrated circuit produced by the same processes used to fabricate individual transistors and diodes? 8. Has reliability of electronic equipment always been important? 9. On account of what factors do integrated circuits offer high reliability? 10. When are the effects of temperature variation more uniform? 11. Does it contribute to greater reliability?

**V. Prepare a dialogue on the main factors of high reliability of integrated circuits.**

**VI. Speak on the advantages of transistors and integrated circuits.**

**VII. Make up a plan of the Text B.**

**VIII. Retell the text according to your plan.**

**IX. Translate the question-answer units into English. Work in pairs.**

1. Когда был изобретен транзистор? (Транзистор был изобретен в 1948 г.).

2. Каковы преимущества транзистора по сравнению с электровакуумной лампой? (Транзистор значительно меньше, чем электровакуумная лампа, более надежен, дешевле и требует меньше мощности для работы.)

3. Намного ли уменьшены физические размеры пассивных элементов? (Да. Пассивные элементы, такие как резисторы, конденсаторы и катушки индуктивности, значительно уменьшены в размере путем использования новых материалов и улучшенной технологии).

4. Как изготавливается кремниевая интегральная схема? (Кремниевая интегральная схема изготавливается посредством тех же процессов, которые применяются при изготовлении отдельных транзисторов и диодов.)

5. Какими преимуществами обладает интегральная схема по сравнению со схемой из старых дискретных деталей? (Она обеспечивает большую надежность и изготовление большого количества схем меньшей стоимости.)

## II. CLASSWORK

### 3. Close Reading

PRE-TEXT EXERCISES

**I. Be sure that you know these words.**

Approach подход; true истинный; both ... and как ..., так; simultaneously одновременно; fabricate изготавливать; directly непосредственно; separate отдельный; somewhat similar кое в чем подобна interconnected взаимосвязанный.

**II. Memorize these words and word-combinations used in their specialized meaning.**

Mount устанавливать; bonding связь, соединение, сваривание; common base общая основа, подложка; deposite осаждать; diffuse planar technique диффузионная планарная технология.

**III. Find the following word-combinations and terms in the Text C and translate the sentences containing them.**

A small single wafer небольшая отдельная «вафля», пластинка; film circuit пленочная схема; insulation substrate изолирующая основа, подложка; thin-film circuits тонко-пленочные схемы; thick-film circuits толсто-пленочные схемы; interconnection wiring pattern узор, рисунок из соединительных проводников; evaporation technique техника напыления (с помощью испарения); separate semiconductor wafer отдельная полупроводниковая пластинка (кристалл); silk-screen technique техника шелкографии; multiple-chip circuit многокристальная схема; oxidized surface оксидированная поверхность; wiring patterns проволочный узор.

**IV. a) Arrange the following words of the same root according to the model. b) Do the same with other words from the Text C.**

*Model.* metal — metallize — metallization — metallic

interconnect, deposite, evaporate, combine, approach, use, add.

### Text C

#### CLASSIFICATION OF INTEGRATED CIRCUITS

**I. a) Read the text. b) Find the part of it dealing with the thick-film methods. Translate it.**

There are two basic approaches to microelectronics.

**1. Monolithic Integrated Circuits.** This is the true integrated circuit, in which all components both active and passive are formed simultaneously in a small single wafer of silicon by the diffused planar technique.

**2. Film Circuits.** Film circuits are microminiature electronic circuits fabricated by forming passive electronic components directly on the surface of an insulation substrate. There are two types: thin-film circuits and thick-film circuits.



In the thin-film technique, passive components — resistors and capacitors, and the interconnection wiring pattern — are formed, using evaporation technique, onto glass or ceramic substrates. The active components — transistors and diodes — are fabricated as separate semiconductor wafers and these wafers are then mounted directly onto prepared locations on the pattern and connected into the circuit.

The thick-film method is somewhat similar to the thin-film approach. The passive components and wiring pattern are formed using silkscreen technique on ceramic substrates. The active semiconductor devices are again added as discrete wafers.

In addition to the two basic approaches to microelectronics, there are two other methods using a combination of techniques.

**1. Multiple-chip Circuits.** Here, the passive and active components are formed in separate wafers or "chips" of semiconductor material and these are then mounted onto a common base and interconnected with very small diameter gold wire using thermocompression bonding.

**2. Hybrid Integrated Circuits.** This is a combination of monolithic and film technique, in which the active components are first formed in a single wafer of silicon with an oxidized surface, and the passive components and metallized interconnection pattern are deposited onto the silicon-oxide surface by evaporation technique.

*ASSIGNMENTS*

**I. Divide the text into logical parts. Choose the key sentences and translate them.**

**II. Find the part of the text describing the two basic approaches to microelectronics. Discuss it.**

**III. Read the Text C attentively and answer the questions.**

1. How many approaches are there to microelectronics? 2. What are they? 3. What are film circuits? 4. How are they fabricated? 5. How many types of film circuits are there? 6. What are these types of film-circuits? 7. How are passive elements formed? 8. How are the active components fabricated? 9. Is the thick-film method similar to the thin-film approach? 10. How are the passive components and wiring pattern formed? 11. What are additional basic approaches to microelectronics? 12. What are the passive components and metallized interconnection pattern deposited onto?

**IV. Prepare a dialogue on your own situation.**

**V. Analyse the structure of the following sentences and translate them into Russian.**

1. Using the standard photolithographic technique previously described, silicon oxide is removed so that the only oxide film remaining is that over the region where the transistor is to be formed. 2. Compare the structure of the transistor just considered with the structure of a discrete planar transistor shown in Fig. 4.13*a*. 3. The important steps involved in the manufacture of one widely used type of integrated

circuit transistor are the following. 4. Starting with a suitable prepared silicon wafer, a thin film of silicon oxide is thermally deposited on the working surface.

**VI. Speak on:**

1. Multiple-chip Circuit.
2. Hybrid Integrated Circuit.

**VII. Translate the Text C to be sure you understand it well.**

**VIII. Make up a plan of the text.**

**IX. Retell the text according to your plan.**

**X. Review the text in written form.**

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| through one common working surface | как сверху, так и снизу |
| starting with | ранее описанный |
| suitably prepared | первоначально разработанная |
| previously described | еще одна пленка |
| heavy p-type impurity diffusion | через одну общую рабочую поверхность |
| both the top and bottom | начиная с |
| further film | сильно легированная область эмиттера |
| heavily doped emitter region | подготовленный соответствующим образом |
| originally developed | сильная диффузия примеси p-типа |
| except for | за исключением |

**II. Be sure that you know these words.**

Etch v. вытравливать; subsequently впоследствии; final film завершающая пленка; laterally горизонтально; sandwich v. прослаивать; essential существенный; solution решение; $n^+$ buried layer скрытый $n^+$ слой; prefer v. предпочитать; eventually в конечном счете.

**III. Give the initial forms of the following words and translate them.**

Originally, working, widely, using, remaining, diffusion, immediately, thickness, approximately, readiness, resistivity.

### Text D

### TRANSISTORS FOR INTEGRATED CIRCUITS

**I. Read the following text and tell about the important steps involved in the manufacture of one widely used type of integrated circuit transistor.**



Although there are several different ways in which transistors for integrated circuits can be fabricated, they are all based on the planar process originally developed for discrete transistors. The name planar is used because the collector, base and emitter region are all formed through one common working surface of the wafer and the external connections all come to the same surface (planar means single surface). The planar process utilizes the various processes.

The important steps involved in the manufacture of the widely used type of integrated circuit transistor are:

*Step 1:* Starting with a suitably prepared silicon wafer, a thin film of silicon oxide is thermally deposited on the working surface (top face).

*Step 2:* Using the standard photolithographic technique silicon oxide is removed so that the only oxide film remaining is that over the region, where the transistor is to be formed.

*Step 3:* The wafer is subjected to heavy p-type impurity diffusion from both the top and bottom. The original n-type material is converted to p-type except for the region immediately below the silicon oxide mask. The thickness of this isolated n-type region which will eventually contain the collector, base and emitter region is approximately half the wafer thickness. A new film of silicon oxide is deposited over the entire working surface of the wafer.

*Step 4:* A window in the silicon oxide is created in readiness for a second diffusion process.

*Step 5:* P-type impurities are diffused through the windows in the oxide until the n-type silicon immediately below the window is converted to p-type of the correct resistivity to form the base of the transistor. A further film of silicon oxide is then deposited on the working surface of the wafer.

*Step 6:* Further windows are etched in the silicon oxide in readiness for a third diffusion process.

*Step 7:* N-type impurities are diffused through the windows to form the heavily doped emitter region ($n^+$), plus a heavily doped ($n^+$) region within the collector so as to provide a good contacts. A final film of silicon oxide is laid on the working surface.

*Step 8:* Contact holes are etched in the oxide film and aluminium is then deposited on the wafer. This aluminium film is subsequently etched to form the separate collector, base and emitter terminals.

Compare the structure of the transistor just considered with the structure of a discrete planar transistor shown in Fig. 4.13*a*. It will be seen that the essential difference is that with the discrete transistor the collector contact is made at the bottom of the structure, whereas it is at the top for the integrated circuit transistor. Because of the necessity for this top connection, the collector current must flow laterally along a narrow n-type region of relatively high resistivity. The result is a higher $U_{CE(sat)}$.

Two methods are used to overcome this high collector resistance. One approach is to use two collector contacts as suggested. Although the resistance may be reduced from say 30Ω to 20Ω and $U_{CE(sat)}$

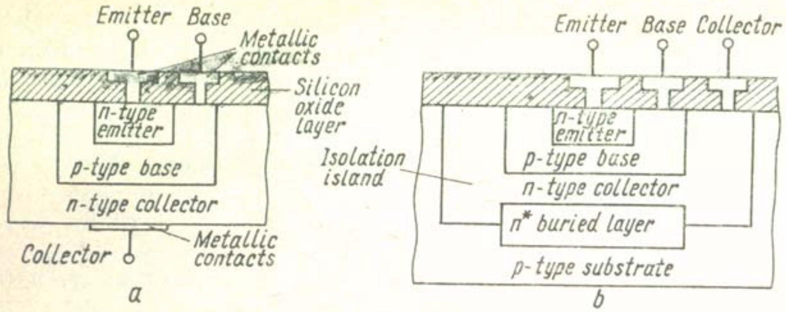


Fig. 4.13. The comparison of the structure of a discrete and integrated transistors:
*a* a discrete transistor; *b* an integrated transistor, utilizing buries $n^+$-layer.

from 0.32 V to 0.20 V by using this method, the improvement is obtained at the expense of increased transistor area. A preferred solution is to diffuse a heavily doped (low resistivity) n-type silicon layer sandwitched between the p-type substrate and the n-type collector. The resulting structure is shown in Fig. 4.13*b*, from which it may be seen that the collector current can now flow laterally through a low resistance region, resulting in considerable decrease in the collector resistance and $U_{CE(sat)}$.

*ASSIGNMENTS*

**I. Give the main idea of the Text D.**

**II. Answer the following questions embracing the contents of the Text D.**

1. What are different ways for transistor fabrication based on? 2. How many important steps are there in the manufacture of integrated circuit transistor? 3. What is shown in Fig. 4.13*a*? 4. What essential difference is in the structure of the discrete transistor, on the one hand, and the integrated circuit transistor, on the other? 5. What methods are used to overcome the high collector resistance? 6. What is the first approach to this problem? 7. What is the second approach to the same problem? 8. What does Fig. 4.13*b* show? 9. Why is the name *planar* used? 10. Does the planar process utilize the various processes? 11. What are the important steps involved in the manufacture of one widely used type of integrated circuit transistor? 12. Where is the comparison of the structure of a discrete and integrated transistors shown?

**III. Prepare a dialogue on your own situation.**

**IV. Speak on:**

1. The planar processes originally developed for discrete transistors.
2. The important steps involved in the manufacture of integrated circuits.
3. Compare the structure of the transistor just considered with the structure of a discrete planar transistor.



**V. Make up a plan of the text.**

**VI. Retell the text according to your plan.**

**VII. Look through the latest magazines and find additional material about integrated circuits. Discuss it with your fellow-students.**

## III. GRAMMAR EXERCISES

**I. Find the verbs in Perfect Tenses in the following sentences and translate them.**

1. Scientists and engineers have concerned themselves with producing smaller components. 2. The impact the integrated circuit has had on the electronics industry is not confined to miniaturization. 3. Reliability of electronic equipment has always been important. 4. Many new devices have been invented by the scientists.

**II. State the tense-forms of the verbs in the Passive Voice in the following sentences. Translate the sentences.**

1. Passive elements were greatly reduced in physical size. 2. The development of true microminiaturization was made possible by the development of the monolithic integrated circuit. 3. This circuit is built into a single "face of stone", i. e. silicon. 4. Many thousands of circuit elements are utilized. 5. The reduction of manufacturing cost is achieved because many similar circuits may be fabricated simultaneously. 6. The active components — transistors and diodes — are fabricated as separate semiconductor wafers and these wafers are then mounted directly onto prepared locations on the pattern and connected into the circuit. 7. The active semiconductor devices are again added as discrete wafer.

**III. Find the sentences with the verbs in the Passive Voice in the Text D.**

**IV. a) State the forms and functions of the Infinitive and-*ing*-forms. b) Translate the sentences.**

1. Almost since the beginning of the electronics industry, scientists and engineers have concerned themselves with producing smaller and smaller components in a continued effort to miniaturize electronic equipment. 2. In order to take full advantage of the transistor, passive elements such as resistors, capacitors and inductors were greatly reduced in physical size by using new materials and improved technology. 3. The technology is merely extended so as to permit a complete circuit to be made within a single silicon chip. 4. However, the ever increasing complexity of present day electrical equipment means that greater emphasis is placed on reliability.