

Studying

Optics...

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Учебное пособие
для студентов факультета оптико-информационных систем
и технологий

Studying Optics ...

(Изучая оптику ...)



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Учебное пособие “Studying Optics...” (“Изучая оптику...”) предназначено для студентов факультета оптико-информационных систем и технологий и может быть использовано как на аудиторных занятиях, так и для самостоятельной работы студентов.

Пособие состоит из трех глав, в которых представлены оригинальные тексты, знакомящие студентов с историей развития и применения геометрической и волоконной оптики, лазеров в различных сферах человеческой деятельности. Пособие также включает в себя три приложения и словарь. Каждый урок снабжен терминологическими и лексико-грамматическими упражнениями по изучаемой тематике.

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The History of Optics

WORD-STUDY

Exercise 1. Check the transcription in the dictionary and read the words listed below.

Nouns

bifocals, gravitation, cornea, retina, basis, interference, holography.

Verbs

imply, refract, process, ascribe.

Adjectives

heliocentric, reflecting, corpuscular, adjacent, retrieval.

Exercise 2. Make nouns from the following verbs according to the model and translate them.

a) *to work-a work[er]*

to write, to make, to lead, to teach, to build, to think, to drive, to use, to publish, to photograph, to found;

b) *to reflect-a reflect[or]*

to refract, resist, adapt, resonate, process, regulate, numerate, invent;

c) *to combine-combin[ation]*

to polymerize, demonstrate, unify, translate, invent.

UNDERSTANDING A PRINTED TEXT

List of Terms:

adjacent pinholes – точечные источники света, расположенные друг против друга

bifocals – бифокальные очки

cornea – роговая оболочка

corpuscular nature of light – корпускулярная природа света

data storage – хранение данных, запоминающее устройство

emerald lens – линза из изумруда

eyepiece – окуляр

immutable – постоянный, неизменный

heliocentric – гелиоцентрический

optical processing – оптические технологии

pupil – зрачок

refractor – рефрактор

relative velocity – относительная скорость

retrieval systems – системы коррекции

retina – сетчатка

spectacles, eyeglasses – очки

three power instrument – инструмент с 3-х кратным увеличением

transparent – прозрачный, просвечивающий

twin-lens – двухлинзовый

vessel – сосуд

COMPREHENSIVE READING

The History of Optics

The history of optics and optical devices begins in ancient Greece. The story of Archimedes, focusing the sun's rays to win a battle for Syracuse in 213 BC is only a legend, reported centuries later. But in the Roman Empire, the philosopher, statesman and tragedian, Seneca noted the magnification of objects seen through water-filled transparent vessels, and his friend, the Emperor Nero, may have been the first to use a monocle, employing an emerald lens to view events in the Coliseum.

Spectacles, the first optical device, known also as eyeglasses, appeared first in Florence about 1280. The dispute exists over whether eyeglasses originated in the Far East or in the West: it appears that the eyeglasses used by the Chinese were for adornment or supposed magical powers and contained colored glass, not correcting lenses. And only in 1262 Roger Bacon, the medieval champion of experimental science, made the first recorded reference to the magnifying properties of lenses. In 1784 Benjamin Franklin invented bifocals. In his invention the two lens sections were held by the frame. Johannes Kepler (1571 – 1630) was among the few to accept the Copernican heliocentric astronomy and he discovered the laws of planetary motion, which set the path for Newton's theory of gravitation. In the course of his astronomical investigations he provided a correct explanation of vision and the functions of the pupil, cornea and retina and gave the first correct explanation of how eyeglasses work.

By 1610, Galileo Galilei announced the telescopic observations of the moon and planets. One year earlier Galileo learned of the invention of the telescope by Hans Lippershey, who built a three-power instrument. His telescope was a simple refractor, employing two lenses in a tube. Galileo quickly improved his telescope to eight, twenty and then thirty power. These were the most powerful instruments of his time.

But a man not only wanted to admire distant stars through telescopes, but to make closer some minor things. The invention of the compound (twin lens) microscope at the end of the sixteenth century or the beginning of the seventeenth has been ascribed to the Dutch spectacle maker, Hans Jansen. The first great improvement was due to Robert Hooke, who in 1665 replaced the eyepiece with the twin-lens telescope eyepiece designed by Christaan Huygens. Hooke's three-lens microscope is the basis for modern instruments.

Sir Isaac Newton, a great scientist and thinker, who discovered some of the fundamental laws of mechanics, is known also by his invention of the reflecting telescope. Newton defended the idea of corpuscular nature of light, which implied that light consists of distinct particles with immutable properties.

The shift to the wave explanation of the nature of light began at the beginning of the 19th century. In 1801 Thomas Young discovered the interference of light from adjacent pinholes and established the wave theory of light. The polarization of light was discovered in 1808 by Malus and the polarizing angle was discovered by Brewster in 1811. In 1842, an Austrian physicist Johann Christian Doppler published a paper "Concerning the Colored Light of Double Stars" which first described how the frequency of light and sound is changed by the relative velocity of the source and observer.

The union of electromagnetic theory with optics began when Maxwell found that his equations for the electromagnetic field (1873) described waves travelling at the velocity of light and with the demonstrations that electromagnetic waves were refracted and reflected like light waves. The final mathematical identification of optics with electromagnetism was achieved in 1944.

In the 20th century revolutionary advances in optics began with the construction of the first laser in 1960 and have led to the rapid development of optical communication systems, imaging systems and holography, optical data storage and retrieval systems, and optical processing.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. What do you know about the history of spectacles?
2. How did Galileo Galilei contribute to the development of the telescope?
3. What instrument helps us to examine minor things and who was its maker?
4. How were views of the nature of light changing through the history?
5. What revolutionary advances were made in optics in the 20th century?

Exercise 2. Complete the sentences:

1. According to a legend Archimedes...
2. Johannes Kepler provided...
3. Thomas Young revealed...
4. Maxwell came to the conclusion that...

INCREASE YOUR VOCABULARY

Exercise 1. Match the synonyms.

1	2
1) spectacles	a) processing
2) sight	b) eyeglasses
3) speed	c) view
4) technology	d) velocity
5) to start	e) to discover
6) to enlarge	f) to improve
7) to find	g) to begin
8) to update	h) to magnify
	i) to invent
	j) to polarize
	k) to replace
	l) to design
	m) to store

Exercise 2. Compare two columns and find Russian equivalents to words or word-combinations.

1	2
1) adjacent pinholes	a) роговая оболочка
2) particle	b) линза из изумруда
3) cornea	c) окуляр
4) corpuscular nature of light	d) постоянный
5) bifocal	e) оптические технологии
6) emerald lens	f) корпускулярная природа света
7) eyepiece	g) система коррекции
8) immutable	h) сетчатка
9) optical processing	i) зрачок
10) pupil	j) сосуд
11) refractor	k) увеличение
12) retrieval systems	l) очки
13) retina	m) частота
14) spectacles	n) зрительное восприятие
15) vessel	o) рефрактор
16) magnification	p) частица
17) frequency	q) бифокальные очки
18) vision	r) точечные источники света, расположенные друг против друга
	s) свойство
	t) фотоаппарат
	u) микроскоп

LANGUAGE ACTIVITY

Exercise 1. Form plurals of the following nouns and translate them into Russian.

a) ray, device, history, lens, star, paper, sound, source, datum, chief, glass, spectrum, radius, formula;

b) freshman, man-servant, text-book, eyeglass, cross-section, pinhole, headphone, keyboard, paperboard, twin-engine, statesman, eyepiece.

Exercise 2. Insert articles where necessary.

1. ... Sir Isaac Newton, a great scientist and thinker, is known by... invention of ... reflecting telescope.
2. ... people not only wanted to admire distant stars through telescopes, but to make closer some minor things.
3. ... story about Archimedes is ... legend written centuries later.
4. Some think that eyeglasses were invented by ... Chinese.
5. ... first great improvement of ... microscope was due to Robert Hooke.
6. The construction of ... first laser in ... 1960 led to ... revolutionary advances in optics in ... 20th century.

Exercise 3. Insert prepositions of time where necessary.

1. ... 1801 Thomas Young discovered the interference of light from adjacent pinholes.
2. ... the 20th century the revolutionary advances in optics began with the construction of the first laser ... 1960.
3. I'm busy ... the moment (now).
4. It sometimes snows ... Christmas.
5. I often work ... night.
6. The movie was to start ... nine ... the morning.
7. I was there ... last night.
8. It happened ... Sunday.

Chapter I

Classical (Geometrical) Optics

Unit 1

WORD-STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Nouns

reproduction, transmission, appearance, intermittence, unsharpness, aberration, defocusing, nonuniformity, distribution, resurgence, procedure, frequency, multitude, vision.

Adjectives

apparent, entire, virtual, recognizable, innumerable, convenient.

Verbs

converge, expound, computerize, disappear.

Exercise 2. *Make adverbs from the following adjectives according to the model and translate them.*

Adjective + -ly

general, simultaneous, sequential, rapid, real, virtual, actual, moderate, entire, great, classical, hard, near, recent.

UNDERSTANDING A PRINTED TEXT

List of Terms:

aberration – абберрация, отклонение
bend – отклоняться
cardinal points – кардинальные точки
carrier – носитель
converge – сходиться
diverging rays – расходящиеся лучи
emerging rays – исходящие лучи
expound – излагать
extended object – протяженный объект
external object – внешний объект
focal length – фокусное расстояние
finite field of view – ограниченное поле зрения
flicker – мелькание
intermittence – задержка

nonuniformity – неравномерность
overlap – перекрываться
principal aberrations – основные аберрации
point-by-point scanning – сканирование по точкам
real – действительный
sensation – ощущение
sequentially – последовательно
spatial – пространственный
virtual – мнимый

COMPREHENSIVE READING

From the History of Geometrical Optics

An optical image may be regarded as the apparent reproduction of an object by a lens or mirror system, employing light as a carrier. An entire image is generally produced simultaneously, as by the lens in a camera, but images may also be generated sequentially by point-by-point scanning, as in a television system or in the radio transmission of pictures across long distances in space. Nevertheless, the final detector of all images is the human eye, and, whatever means is used to transmit and control the light, the final image must either be produced simultaneously or scanned so rapidly that the observer's vision will give him the mental impression of a complete image, covering a finite field of view. For this to be effective the image must be repeated (as in motion pictures) or scanned (as in television) at least 40 times a second to eliminate flicker or any appearance of intermittence.

To the ancients, the processes of image formation were full of mystery. Indeed, for a long time there was a great discussion as to whether, in vision, something moved from the object to the eye or whether something reached out from the eye to the object. By the beginning of the 17th century, however, it was known that rays of light travelled in straight lines, and in 1604 Johannes Kepler, a German astronomer, published a book on optics in which he postulated that an extended object could be regarded as a multitude of separate points, each point emitting rays of light in all directions. Some of these rays would enter a lens, by which they would be bent around and made to converge to a point, the "image" of the object point whence the rays originated. The lens of the eye was not different from other lenses, and it formed an image of external objects on the retina, producing the sensation of vision.

There are two main types of image to be considered: real and virtual. A real image is formed outside the system, where the emerging rays actually cross; such an image can be caught on a screen or a piece of film and is the kind of image formed by a slide projector or in a camera. A virtual image, on the other hand, is formed inside an instrument at the point where diverging rays would cross if they were extended backward into the instrument. Such an image is formed in a microscope or a telescope and can be seen by looking into the eyepiece.

Kepler's concept of an image as being formed by the crossing of rays was limited in that it took no account of possible unsharpness caused by aberrations, diffraction, or even defocusing. In 1957 the Italian physicist Vasco Ronchi went the other way and defined an image as any recognizable nonuniformity in the light distribution over a surface such as a screen or film; the sharper the image, the greater the degree of nonuniformity. Today, the concept of an image often departs from Kepler's idea that an extended object can be regarded as innumerable separate points of light, and it is sometimes more convenient to regard an image as being composed of overlapping patterns of varying frequencies and contrasts; hence, the quality of a lens can be expressed by a graph connecting the spatial frequency of a parallel line object with the contrast in the image. This concept is investigated fully under optics and information theory.

Optics had progressed rapidly by the early years of the 19th century. Lenses of moderately good quality were being made for telescopes and microscopes, and in 1841 the great mathematician Carl Friedrich Gauss published his classical book on geometrical optics. In it he expounded the concept of the focal length and cardinal points of a lens system and developed formulas for calculating the position and size of the image formed by a lens of given focal length. Between 1852 and 1856 Gauss's theory was extended to the calculation of the five principal aberrations of a lens, thus laying the foundation for the formal procedures of lens design that were used for the next 100 years. Since about 1960, however, lens design has been almost entirely computerized, and the old methods of designing lenses by hand on a desk calculator are rapidly disappearing.

By the end of the 19th century numerous other workers had entered the field of geometrical optics, notably an English physicist, Lord Rayleigh (John William Strutt), and a German physicist, Ernst Karl Abbe. It is impossible to list all their accomplishments here. Since 1940 there has been a great resurgence in optics on the basis of information and communication theory.

CHECK YOUR UNDERSTANDING

Exercise 1. *True or false?*

1. Images can't be generated sequentially by point-by-point scanning, they can be produced only simultaneously.
2. To the ancients, the processes of image formation were full of mystery.
3. In the 19th century scientists discovered that rays of light traveled in straight lines.
4. Today's concept of an image is more convenient to regard an image as being composed of overlapping patterns of varying frequencies and contrasts.
5. Gauss published his classical book on geometrical optics, in which he expounded the concept of the theory of relativity.

Exercise 2. Choose the correct answer.

1. Who published a book on optics in which some important principles of geometrical optics were postulated? When did it happen?
 - a) Johannes Kepler did it in 1604.
 - b) James Gregory did it in 1663.
 - c) Christian Doppler did it in 1842.
 - d) Roger Bacon did it in 1262.

2. What is the today's concept of an image?
 - a) An image is considered as innumerable separate points of light.
 - b) An image is formed when something reaches from the eye to the object and vice versa.
 - c) An image is considered as a combination of real and virtual images.
 - d) An image is being composed of overlapping patterns of different frequencies.

3. Who and how laid the foundation for the formal procedures of lens design?
 - a) Isaac Newton having created the corpuscular theory of light.
 - b) Gauss having made the geometrical theory of light, which was later extended to the calculation of five principal aberrations.
 - c) Maxwell having found the equations for electromagnetic field, that helped to identify optics with electromagnetism.
 - d) Gabor having developed the theory of holography.

INCREASE YOUR VOCABULARY

Exercise 1. Give the definitions to the following.

1. An optical image is ...
2. A real image is ...
3. A virtual image ...

Exercise 2. Compare two columns and choose the matching words and word-combinations.

1	2
1) bend	a) луч
2) cardinal points	b) излагать
3) converge	c) задержка
4) expound	d) действительный
5) extended object	e) отклоняться
6) external object	f) вычислять
7) focal length	g) поле зрения
8) field of view	h) изотропность
9) flicker	i) ощущение
10) intermittence	j) движение
11) nonuniformity	k) внешний объект
12) overlap	l) сходиться
13) principal aberrations	m) распространяться
14) real	n) мнимый
15) scan	o) отображение
16) sensation	p) фокусное расстояние
17) simultaneously	q) неравномерность
18) travel	r) протяжённый объект
19) virtual	s) просматривать
20) ray	t) мелькание
21) motion	u) основные аберрации
22) transmit	v) передавать
	w) кардильные точки
	x) перекрываться
	y) одновременно

LANGUAGE ACTIVITY

Exercise 1. Choose the right form of pronouns.

1. Is this your/yours lens?
2. The improved telescope was my/mine.
3. I know their /theirs invention. But this one is our/ours.
4. They are her/hers glasses.
5. I gave him/his address to our/ ours friends.
6. I locked my/mine bike. And they locked their/theirs.

Exercise 2. Complete the sentences with the following verbs: burn, do, dry, concentrate, meet, blame, feel. Use myself/yourself, etc. only where necessary.

1. I really ... well today, much better than yesterday.
2. Be careful. The pan is hot. Don't
3. It isn't her fault. She really shouldn't
4. He climbed out of the pool and
1. 5.I tried to study but I just couldn't
5. Mary and Jack first ... at a party five years ago.
6. "Do you want me to post this letter for you?" "No, I'll"

Exercise 3. Insert prepositions of place: in, at, on.

1. That man standing...the window is a well-known professor.
2. I couldn't hear the teacher very well. She was talking quietly and I was sitting ...the back.
3. The water ...the tank should be heated up to 50⁰C.
4. St. Petersburg is situated ...the Neva river.
5. Look at this beautiful clock ...the wall over there.
6. We shall see a picture ...the screen 0.1 sec after it actually has disappeared.
7. The device is ...the corner of the room.
8. Our laboratory is located ...the 3-rd floor of the main building of the University.
9. Kate isn't ...home, she must be ...work.

Exercise 4. Put some, any, something, somebody, anything, anybody, somewhere, anywhere in the blanks.

1. I was looking for ... a little cheaper.
2. A blind man cannot see
3. If you have no money, you can buy
4. May I offer you ... tea?
5. ... has parked his car right in front of mine.
6. I don't like ... in his family.
7. There isn't ... time for discussion.
8. I don't see my glasses
9. He's ... in the garden.
10. There's ... on the phone for you.
11. I never eat ... with sugar in it.
12. We'll get ... to eat at that snack bar.

Exercise 5. Read the following figures, dates, numerals, etc.

- a) 35; 700; 268; 40931; 1175;
- b) 1954; 1961; from 1954 up to 1960; 1812; 2005;
- c) 1/4; 3/7; 2,58; 0,005; 3⁷; 5⁻¹⁰;
- d) 90%; 1 cm; 140 km/h; 25°C.

Unit 2

WORD-STUDY

Exercise 1. *Check the transcription in the dictionary and read words listed below.*

Nouns

stimulus, vision, behavior, frequency, spectrum, roughness, incidence, ratio, surface.

Verbs

perceive, exhibit, emerge, occur, vibrate.

Adjectives

fascinating, perpendicular, diffuse, mirror-like.

Exercise 2. *Make nouns from the following verbs using suffixes -ation, -tion, -ion, and translate them.*

Adsorb, demonstrate, diffract, direct, illuminate, oppose, propagate, polarize, reflect, refract.

UNDERSTANDING A PRINTED TEXT

List of Terms:

diffraction – дифракция
enlargement – увеличение
interference – интерференция
inverted image – перевернутое изображение
opaque – светонепроницаемый
pinhole – точечное отверстие
polarization – поляризация
propagation – распространение
refraction – преломление
scattering – рассеивание
thermal rays – тепловые лучи
virtual image – мнимое изображение

READING FOR PRECISE INFORMATION

Nature of Light and Color

We know the world through our senses: sight, hearing, touch, taste, and smell. Each sense responds to particular stimulus, and the sensations we experience give us information about our surroundings. Sight is the most important of the senses. Through sight we perceive the shape, size, and color of objects, also their distance,

motions, and relationships to each other. Light is the stimulus for the sense of sight - the raw material of vision.

To understand the fascinating story of light, let us explore its nature, its behavior in lenses and prisms, and then its uses in science and art.

Nature electromagnetic waves carry energy in all directions through the universe. All objects receive, absorb, and radiate these waves which can be pictured as electric and magnetic fields vibrating at right angles to each other and also to the direction in which the wave is travelling. Light is one form of electromagnetic wave. All electromagnetic waves travel in space at the same speed - the speed of light.

Electromagnetic waves show a continuous range of frequencies and wavelengths. Frequency is the number of wave crests passing a point in one second. Electromagnetic wave frequencies run from about one per second to over a trillion per second. For light, the frequencies are four to eight hundred trillion waves per second. The higher the frequency, the shorter the wavelength.

Visible light is that portion of the electromagnetic spectrum that normally stimulates the sense of sight. Electromagnetic waves exhibit a continuous range of frequencies and wavelengths. In the visible part of the spectrum these frequencies and wavelengths are what we see as colors. The wavelengths of light range from 3,500 Å to 7,500 Å. The wavelengths of infrared rays (7,500 Å - 10,000,000 Å), longer than light rays, are not detected by the eye, and do not appreciably affect ordinary photographic film. They are also called heat or thermal rays and give us the sensation of warmth.

Light behavior includes transmission, absorption, reflection, refraction, scattering, diffraction, interference and polarization. Transmission, absorption and reflection account for all the light energy when light strikes an object. In the course of transmission, light may be scattered, refracted or polarized. It can also be polarized by reflection. The light that is not transmitted or reflected is absorbed and its energy contributes to the heat energy of the molecules of the absorbing material. The modification of light through these processes is responsible for all that we see.

Reflection is of two kinds - diffuse and regular. Diffuse reflection is the kind by which we ordinarily see objects. It gives us information about their shape, size, color and texture. Regular reflection is mirror-like. We don't see the surface of the mirror; instead, we see objects that are reflected in it. When light strikes a mirror at an angle, it is reflected at the same angle. In diffuse reflection, light leaves at many different angles. The degree of surface roughness determines the proportion of diffuse and regular reflection that occurs. Reflection from a smooth, polished surface like a mirror is mostly regular, while diffuse reflection takes place at surfaces that are rough compared with the wavelength of light. Since the wavelength of light is very small (about 5,000 Å), most reflection is diffuse.

Laws of reflection:

1. Angle of reflection equals angle of incidence.
2. Incident and reflected rays lie in the same plane.
3. Incident and reflected rays are on opposite sides of the normal - a line perpendicular to the reflecting surface and passing through the point of incidence.

Refraction is the bending of a light ray when it crosses the boundary between two different materials, as from air into water. This change in direction is due to a change in speed. Light travels faster in empty space and slows down upon entering matter. Its speed in air is almost the same as its speed in space, but it travels only $\frac{3}{4}$ as fast in water and only $\frac{2}{3}$ as fast in glass. The refractive index of a substance is the ratio of the speed of light in space (or in air) to its speed in the substance. This ratio is always greater than one.

When a beam of light enters a plane of glass perpendicular to the surface, it slows down, and its wavelength in the glass becomes shorter in the same proportion. The frequency remains the same. Coming out of the glass, the light speeds up again, the wavelength returning to its former size.

When a light ray strikes the glass at some other angle, it changes direction as well as speed. Inside the glass, the ray bends toward the perpendicular or normal. If the two sides of the glass are parallel, the light will return to its original direction when it leaves the glass, even though it has been displaced in its passage. If the two sides of the glass are not parallel, as in the case of a prism or a lens, the ray emerges in a new direction.

Laws of refraction:

1. Incident and refracted rays lie in the same plane.
2. When a ray of light passes at an angle into a denser medium, it is bent towards the normal, hence the angle of refraction is smaller than the angle of incidence.

Scattering is the random deflection of light rays by fine particles. When sunlight enters through a crack, scattering by dust particles in the air makes the shaft of light visible. Haze is a result of light scattering by fog and smoke particles.

Absorption of light as it passes through matter results in the decrease in intensity. Absorption, like scattering, may be general or selective. Selective absorption gives the world most of the colors we see. Glass filters which absorb part of the visible spectrum are used in research and photography.

Diffraction is the bending of waves around an obstacle. It is easy to see this effect for water waves. They bend around the corner of a sea wall, or spread as they move out of a channel. Diffraction of light waves, however, is harder to observe. In fact, diffraction of light waves is so slight that it escaped notice for a long time. The amount of bending is proportional to the size of light waves – about one fifty-thousandth of an inch ($5,000 \text{ \AA}$) – so the bending is always very small indeed.

When light from a distant street lamp is viewed through a window screen it forms a cross. The four sides of each tiny screen hole act as the sides of a slit and bend light in four directions, producing a cross made of four prongs of light. Another way to see the diffraction of light waves is to look at a distant light bulb through a very narrow vertical slit. Light from the bulb bends at both edges of the slit and appears to spread out sideways, forming an elongated diffraction pattern in a direction perpendicular to the slit.

Light can be imagined as waves whose fronts spread out in expanding concentric spheres around a source. Each point on a wave front can be thought of as the source of a new disturbance. Each point can act as a new light source with a new

series of concentric wave fronts expanding outward from it. Points are infinitely numerous on the surface of a wave front as it crosses an opening.

As new wave fronts fan out from each point of a small opening, such as a pinhole or a narrow slit, they reinforce each other when they are in phase and cancel each other when they are completely out of phase. Thus lighter and darker areas form the banded diffraction patterns.

A **pattern of waves** will move outward, forming concentric circles, if small pebbles are dropped regularly from a fixed point into a quiet pond. If a board is placed in the path of these waves, they will be seen to bend around the edges of the board, causing an interesting pattern where the waves from the two edges of the board meet and cross each other. When an obstruction with a vertical slit is placed in the pond in the path of the waves, the waves spread out in circles beyond the slit.

Diffraction patterns are formed when light from a point source passes through pinholes and slits. A pinhole gives a circular pattern and a slit gives an elongated pattern. A sharp image is not formed by light passing through because of diffraction. As the pinhole or slit gets smaller, the diffraction pattern gets larger but dimmer. In the diffraction patterns shown below the alternate light and dark spaces are due to interference between waves arriving from different parts of the pinhole or slit.

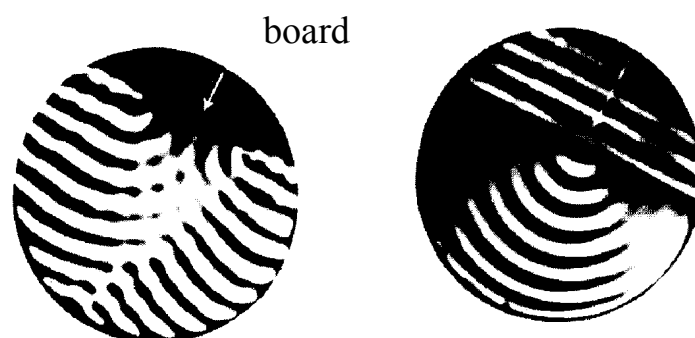


Fig.1.

Interference is an effect that occurs when two waves of equal frequency are superimposed. This often happens when light rays from a single source travel by different paths to the same point. If, at the point of meeting, the two waves are in phase (vibrating in unison, and the crest of one coinciding with the crest of the other), they will combine to form a new wave of the same frequency. The amplitude of the new wave is the sum of the amplitudes of the original waves. The process of forming this new wave is called constructive interference.

If the two waves meet out of phase (crest of one coinciding with a trough of the other), the result is a wave whose amplitude is the difference of the original amplitudes. If the original waves have equal amplitudes, they may completely destroy each other, leaving no wave at all. Constructive interference results in a bright spot; destructive interference producing a dark spot.

Partial constructive or destructive interference results whenever the waves have an intermediate phase relationship. Interference of waves does not create or destroy light energy, but merely redistributes it.

Two waves interfere only if their phase relationship does not change. They are then said to be coherent. Light waves from two different sources do not interfere because radiations from different atoms are constantly changing their phase relationships. They are non-coherent.

Interference occurs when light waves from a point source (a single slit) travel by two different paths (through the double slit). Their interference is shown by a pattern of alternate light and dark bands when a screen is placed across their path.

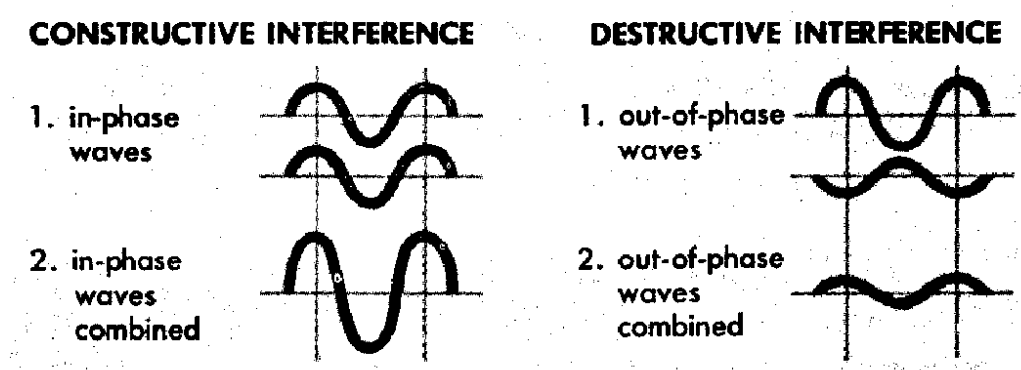


Fig.2.

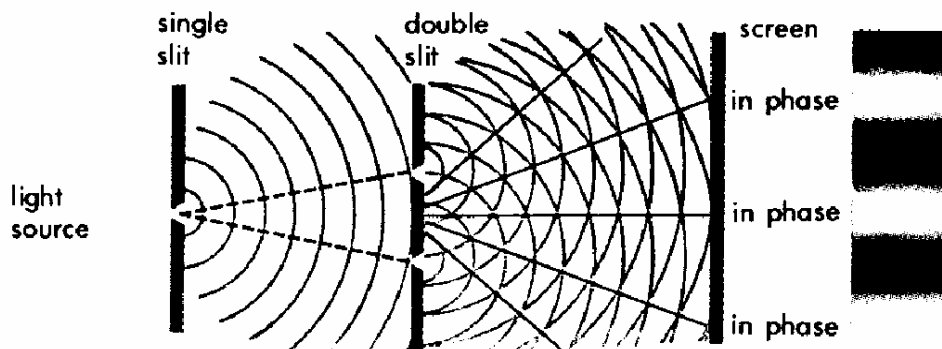


Fig.3.

CHECK YOUR UNDERSTANDING

Exercise 1. True or false?

1. Frequency is the number of wave crests passing a point in one second.
2. When light strikes a mirror at an angle, it is reflected at some other angle.
3. The ratio of the speed of light in space (or in air) to its speed in the substance is always less than one.
4. Diffuse reflection takes place at surfaces that are rough compared with the wave length of light.
5. When the two sides of the glass are parallel, the light emerges in a new direction when it leaves the glass.
6. Light travels faster in empty space and slows down upon entering some matter.

Exercise 2. Choose the correct answer.

1. What is the nature of light?
 - a) Light is the form of electromagnetic wave.
 - b) Light is a magnetic field.
 - c) Light is an electric field.
 - d) Light is a stream of molecules.

2. What happens with the light that is not transmitted or reflected?
 - a) It is polarized.
 - b) It is refracted.
 - c) It is scattered.
 - d) It is absorbed.

3. At what angles does the light leave an object in diffuse reflection?
 - a) The light leaves an object in diffuse reflection at the same angle as it strikes an object.
 - b) The light leaves an object in diffuse reflection so, that incident and reflected rays are on opposite sides of the normal.
 - c) The light leaves an object in diffuse reflection at many different angles.
 - d) When the light leaves an object in diffuse reflection angle of reflection equals to angle of the incidence.

4. When a light ray crosses the boundary between two different materials what does it change?
 - a) It changes its speed.
 - b) It changes its direction.
 - c) It changes its wavelength and frequency.
 - d) It changes its wavelength, speed and direction.

5. How many laws of reflection do you know?
 - a) 3 laws
 - b) 2 laws
 - c) 1 law
 - d) 4 laws

INCREASE YOUR VOCABULARY

Exercise 1. Arrange the following words in pairs of antonyms.

Negative, light, top, shade, positive, small, diverge, base, more, thin, less, converge, thick, large.

Exercise 2. Translate the following words and word combinations into Russian.

a) recognize, diffuse, finite, converge, join, diverge, curvature, enlargement, truncated, incident;

b) image quality, image formation, light intensity, light diffraction, light propagation, pinhole size, image enlargement, surface curvature, object point, lens axis, light beam;

c) luminous point, straight line, truncated prism, bright image, practical value, coarse pinhole, certain limit, diffuse image, finite size, further enlargement, ground glass, dotted lines, infinite number, opaque screen, fine pinhole.

Exercise 3. Remember the meaning of the terms that you have found in the text.

Focus is a meeting point of rays of light; point, distance at which the sharpest outline is given (to the eye, through a telescope, through a lens, etc.).

Lens is a piece of glass or glass-like substance with one or both sides curved for use in spectacles, cameras, telescopes and other optical instruments.

Prism is a solid figure with similar equal and parallel ends and which are parallelograms body of this form made of glass which breaks up white light into the colours of the rain bow.

Diffraction is scattering of waves in back of a solid object after they strike it.

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the Degrees of Comparison. Use comparative or superlative forms of adjectives or adverbs in brackets.

1. Sight is (important) of the senses.
2. Schmidt-Cassegrain telescope is (popular) among amateur astronomers.
3. As the conversation went on, he became (talkative).
4. Travelling is becoming (expensive).
5. You look (beautiful) than usual.
6. Your accent is the (bad) in the class.
7. If you're very hungry, you can have the (big) steak.
8. My mother's driving is getting (dangerous) as the years go by.
9. It's getting (hard) to find time for everything you want to do.
10. Reflecting telescopes can be (powerful) than retractors.

Exercise 2. Insert the prepositions in, into, of, on, at where it is necessary.

1. When light strikes ...a mirror ... an angle, it is reflected ... the same angle.
2. Light travels faster ... empty space than ... matter.
3. Diffuse reflection is the kind of reflection ... which we usually see objects.
4. Light rays bend when they go from air ... water.
5. Many optical devices are similar ... principle though their design and purpose may differ.
6. Absorption ... light results in the decrease in intensity.
7. Refracting telescopes consist ... a mirror as it permits the observer to be ... the opposite side from the incoming light.

Exercise 3. State the function and translate the verb "to be" according to the list given below.

- a) СМЫСЛОВОЙ ГЛАГОЛ
- b) ВСПОМОГАТЕЛЬНЫЙ ГЛАГОЛ, ОБРАЗУЮЩИЙ СТРАДАТЕЛЬНЫЙ ЗАЛОГ
- c) ВХОДИТ В СОСТАВ ОБЩЕПРИНЯТЫХ ВЫРАЖЕНИЙ И НЕ ПЕРЕВОДИТСЯ
- d) ГЛАГОЛ-СВЯЗКА
- e) that is = то есть
- f) ВСПОМОГАТЕЛЬНЫЙ ГЛАГОЛ, ОБРАЗУЮЩИЙ ГРУППУ ПРОДОЛЖЕННЫХ ВРЕМЁН
- g) to be to = must

1. The working element of the ruby laser is a cylinder of pink ruby containing 0.05 per cent chromium.
2. In the commonly used laser configuration a ruby rod is surrounded by the coils of a helical flashlamp operated usually for a few milliseconds with an input energy of 1000 to 2000 joules.
3. The narrowing of the linewidth is due to effect of the resonant cavity formed by the mirror.
4. Why is it difficult for scientists to compare performance of different kinds of lasers?
5. One of the most characteristic features of the He-Ne laser is that the output power does not increase monotonically with discharge current but reaches a maximum and thereafter decreases.
6. This occurs when an impurity atom has acceptor properties, that is, can attract electrons.
7. Powder metallurgy is finding new applications in various industries – in electronics, aviation, machine-building, etc.
8. If we are to achieve the aim we must confine our attention to one point only.

Exercise 4. Pay attention to the different usage of the verb "to have".

- a) СМЫСЛОВОЙ ГЛАГОЛ
- b) ВСПОМОГАТЕЛЬНЫЙ ГЛАГОЛ, ОБРАЗУЮЩИЙ ПЕРФЕКТНУЮ ГРУППУ ВРЕМЁН
- c) have to = must

1. Commercial applications for gas-dynamic laser have not yet been found.
2. Our brief mention made here has been to estimate the conceptual interest of creating a population inversion by a gas-dynamic expansion.
3. Excimer laser has two peculiar but important properties.
4. The ordinary F-centers have a very low fluorescence quantum efficiency.
5. Let us indicate the difficulties that have to be overcome to obtain X-ray laser operation.

Exercise 5. Read the sentences, state the function of provided and translate these sentences.

- a) при условии, если (что);
- b) давать, обеспечивать.

1. If this condition is not satisfied, however, laser action can still occur under pulsed operation provided condition mentioned above is fulfilled.
2. Copper vapor lasers provide the most efficient (~ 1%) green laser source so far available.
3. Polymethine dyes provide laser oscillation in the red or near infrared region.
4. Chemical lasers provide an interesting example of direct conversion of chemical energy into electromagnetic energy.
5. They are potentially able to provide either large output power or large output energy.
6. A resonator provides for a stronger coupling between the radiation and the excited atoms.
7. The elliptic cylinder is made of highly reflective material and is provided with reflective end plates.
8. The discharge is provided by radio-frequency generator which is usually operated in the 25-to-30 nm region.
9. Provided the temperature is changed, the force attracting electrons to atoms is also changed.

Unit 3

WORD-STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Nouns

horizon, grating, microscope, screen, binoculars, importance, magnification, advantage, enlarger, spectrum.

Adjectives

intellectual, predictable, virtual, transparent, fundamental, terrestrial, objective, photographic.

Exercise 2. *Make different parts of speech from the following words according to the models.*

Noun + ive = adjective

effect, act, excess, success.

Adjective + ly = adverb

sufficient, special, notable, rotational, vibrational, intermediate, spontaneous, optic.

Noun + less = adjective

use, increase, help, shape, color.

Noun + ic = adjective

ion, electron, atom, scientific.

Exercise 3. *Read and translate the words paying attention to the meaning of the prefix “semi”.*

Semiconductor, semi-conductive, semi-conductivity, semiautomatic, semicircle, semifinal, semi-period, semi-terminating, semi-reflecting.

UNDERSTANDING A PRINTED TEXT

List of Terms:

angle of incidence – угол падения

concave mirror – вогнутое зеркало

converging – схождение

convex eyepiece lens – выпуклая линза окуляра

far-off objects – отдаленные объекты

focal length – фокусные расстояния

grating – решетка

magnifier – увеличитель

refractive index – показатель (индекс) преломления
refractor – рефрактор (телескоп)
screen – экран

SCAN-READING

Optical Instruments

An optical instrument uses mirrors, lenses, prisms or gratings, singly or in combination, to reflect, refract or otherwise modify light rays. Optical instruments, especially microscopes and telescopes, have probably broadened man's intellectual horizons more than any other devices he has made.

Perhaps the best way to understand the operation of optical instruments is by geometrical optics- a method that deals with light as rays instead of waves or particles. These rays follow the laws of reflection and refraction as well as the laws of geometry.

Images formed by mirrors and lenses may be either real or virtual and of a predictable size and location. A real image, as formed by a camera or projector, is an actual converging of light rays and can be caught on a screen; virtual images cannot. The rays from object points do not pass through corresponding points of a virtual image. Images seen in binoculars are virtual.

Optical prisms are transparent solids of glass or other material whose opposite faces are plane but not necessarily parallel. They are used to bend light rays by refraction or internal reflection. The amount of bending depends on the refractive index of the prism, the angle between its faces, and the angle of incidence of the light. Since the refractive index depends also on the wavelength, prisms are often used to disperse a light beam into its spectrum.

Lenses form an image by refracting the light rays from an object. Curved glass lenses were first used as simple magnifiers in the 13th century, but it was not till nearly 1600 that the microscope was devised, followed by the telescope a decade or so later. Mirrors, which form an image by reflecting light rays, had already been known for several centuries and were easier to understand. A lens, however, has an advantage over a mirror in that it permits the observer to be on the opposite side from the incoming light.

Microscopes, projectors and enlargers are similar in principle, but they differ in purpose and design. In each, a positive lens forms a real image of a brightly illuminated object. With projectors, the image is caught on a screen; with microscopes, it is viewed through an eyepiece; and with photographic enlargers, the image is projected on light sensitive paper, where it is recorded in semi-permanent form.

But description of light as traveling along rays is only approximately true; it gave us the simplest way of explaining making an image.

Light and color are so much a part of our lives that we often overlook their fundamental importance to many businesses such as astronomy, optics photography, television and many others.

Telescopes enlarge the image of far-off objects. Two types of telescopes in common use are refracting telescopes and reflecting telescopes. Refracting telescopes are often used as terrestrial (land-use) viewers. They consist of an objective lens, a long tube, and an eyepiece lens. Light rays from an object are refracted through a convex objective lens and form a real image in the tube of the telescope. However, the real image is less than one focal length of the convex eyepiece lens. As a result, the eye of the viewer sees the image of the object as a virtual image, inverted and enlarged. The magnification of a refracting telescope is found by dividing the focal length of the objective lens by the focal length of the eyepiece lens.

A reflecting telescope works in much the same way, but it uses mirrors instead of objective lenses to collect the light rays from an object. The incident light rays enter the telescope's tube and strike a concave mirror at the base of the tube. As the rays are reflected off the base mirror, they strike a mirror in the tube. The newly reflected light rays then converge at a focus in front of the eyepiece and the viewer sees an enlarged image.

Reflecting telescopes can be more powerful than refractors because large mirrors can collect more light than lenses can.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the questions.

1. What do optical instruments use to modify light rays?
2. What kinds of images can be formed by mirrors and lenses?
3. What has influence upon the amount of bending?
4. What is an advantage of a lens over a mirror?
5. What is similar in microscopes, projectors and enlargers?
6. What telescopes are used most often in everyday life?
7. Why can reflecting telescopes be more powerful than refracting ones?

Exercise 2. Topics for discussion.

1. What do you know about optical prisms?
2. What can you tell about the use of telescopes?

INCREASE YOUR VOCABULARY

Exercise 1. Read the collocations and translate them.

Intellectual horizons, transparent solids of glass, a predictable size and location, refractive index, curved glass lenses, in semi-permanent form, far-off objects, a convex objective lens, incident light rays.

Exercise 2. Match the synonyms.

Verbs

1	2
1) broaden	a) watch
2) bend	b) alter
3) devise	c) widen
4) modify	d) achieve
5) observe	e) curve
6) reach	f) reflect
7) pass	g) invent
	h) go
	i) enlarge
	j) enter
	k) leave
	l) travel

Nouns

1	2
1) aid	a) observer
2) device	b) beam
3) glasses	c) help
4) enlargement	d) fall
5) ray	e) eyepiece
6) viewer	f) spectacles
7) incidence	g) increase
	h) mechanism
	i) pupil
	j) goggles
	k) side
	l) speed

Exercise 3. State the part of speech of the following words and determine their meaning without using a dictionary.

- 1) approximate, to approximate, approximation, approximative, approximately;
- 2) most deficient, deficiency;
- 3) to emit, emitter, emission, emissive, emissivity;
- 4) the use, to use, user, using, usage, useless, useful, usefulness.

Exercise 4.

a) *Make up singular-plural pairs.*

Phenomenon, spectra, index, spectrum, radius, indices, phenomena, radii.

LANGUAGE ACTIVITY

Exercise 1. *Summarize your knowledge of the functions of the verb “to be”. Translate the following.*

1. The microscope has been improved and refined continuously throughout its history, that is practically since the 17th century.
2. The main characteristics to be refined have always been the resolution and the elimination of aberrations.
3. The projection lens is to be especially corrected for curvature of field and distortion.
4. The purpose of the condenser is to concentrate the light coming from the mirror to a point approximately 1.25mm above the surface of its top lens.
5. The magnifying power of microscopes is being increased from year to year.

Exercise 2. State different meanings of “that (those)”.

- a) тот, этот
- b) что
- c) который
- d) заменитель существительного (that of)
- e) то есть [that is = i.e. (id est - лат.)]
- f) именно, только лишь (it is ...that – усилительный оборот)
- g) то, что

1. It is also worth pointing out that ruby lasers were extensively used in the past for military rangefinders.
2. Gas lasers are usually excited by electrical means, *i.e.*, pumping is achieved by passing a sufficiently large current through the gas.
3. One of the most characteristic features of the He-Ne laser is that the output power does not increase monotonically with discharged current but reaches a maximum and thereafter decreases.
4. Since these pure rotational lasers are relatively less important than the other categories, we shall not discuss them further in the sections that follow.
5. That metals are good conductors of electricity is known to everybody.
6. It was the nature of p-n junction that happened to be one of the most difficult things for scientists.
7. At that time the engineers were testing a new semiconductor for the application in industry.
8. Semiconductor is a material having an electrical conductivity intermediate between that of metals and insulators.

9. Output energy and peak power in Q-switched operation are comparable to *those* obtainable with a Nd:YAG rod of comparable dimensions.
10. This was the laser scheme *that* was proposed in the original paper of Schawlow and Townes.

Exercise 3. Summarize your knowledge of Present Simple or Present Continuous. Put the verbs in brackets into the correct tense.

1. A lens (to be) a piece of glass, plastic or other transparent material curved on one or both sides.
2. Lenses (to refract) the light rays from an object forming an image.
3. I (to use, never) my mobile phone if I (to drive).
4. The walls of the house (to absorb) heat day after day.
5. The news bulletin (to begin) at 6 p.m.
6. In spring the days (to grow) longer and the nights (to become) warmer.
7. Jack often (to go) to the theatre. On Saturday he (to go) to see a new play.
8. Electromagnetic waves (to travel) in all directions through the Universe.
9. Some people still think the sun (to go) round the earth.

Exercise 4. Summarize your knowledge of Past Simple or Past Continuous. Choose the correct tense.

1. Kepller *was inventing/invented* the form of the refracting telescope.
2. British-Hungarian scientist Dennis Gabor *was developing/developed* the theory of holography while he *was working/worked* to improve the resolution of an electron microscope.
3. Alexander Graham Bell *was patenting/patented* an optical telephone system, which he called the Photophone, in 1880.
4. When *did/was* it *become/becoming* possible to produce holograms of high-speed events?
5. Dr. Stephen A. Benton *was inventing/invented* white-light transmission holography while he *was researching/researched* holographic television at Polaroid Research laboratories.
6. Sir Isaac Newton, the great scientist and thinker *was discovering/discovered* some of the fundamental laws of mechanics.
7. The union of electromagnetic theory with optics *was beginning/began* when Maxwell *was finding/found* that his equations for the electromagnetic field (1873) described waves travelling at the velocity of light.
8. From 1609 till 1610 Galileo Galilei *was learning/learned* of the invention of the telescope by Hans Lippershey.
9. Bernhard Schmidt *was inventing/invented* a third type of telescope.

Exercise 5.

a) Choose the correct modal verb.

Можно передать / (must, may, can) be transferred

Нельзя собрать / (must not, cannot, may not) be collected

Нужно придать параллельность / (must, may, can) be collimated

Нельзя обеспечить / (must, can, cannot) be provided

Можно возобновить / (must, can, cannot;) be resumed

Нужно получить / (must, can, cannot) be obtained

b) Translate from English into Russian, paying attention to modal verbs.

1. The diode radiation can be collected by a simple lens. 2. Illumination of a semiconductor may be followed by various consequences; electron conductivity, “intrinsic” photoconductivity, impurity or defect photoconduction. 3. A conductor and an insulator must be distinguished by their extreme values of electrical conductivity.

Unit 4

WORD STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Diverging, notwithstanding, antiquity, microwave, negligible, axis, curvature, exposure, dye - sensitizing, average, subtle, latent, diaphragm.

Exercise 2. *Make adverbs from the following adjectives according to the model and translate them.*

Adjective + ly

traditional, general, rotational, effective, automatic, usual, wide, frequent, easy.

UNDERSTANDING A PRINTED TEXT

List of Terms:

arrays – наборы

burning glasses – зажигательные стекла

compact copiers – малогабаритные копировальные устройства

compound lens – сложная линза (объектив, окуляр)

concave, diverging, negative lens – вогнутая, рассеивающая, отрицательная линза

convex, converging, positive lens – выпуклая, собирающая, положительная линза

curvature – кривизна

effectively negligible – фактически ничтожный

facsimile machines – фототелеграфные аппараты

interface – поверхность раздела

rotationally symmetric – аксиально-симметричный (осесимметричный)

subtle in appearance – едва различимы по внешнему виду

traverse – проходить (пересекать)

READING AND TRANSLATING THE TEXT

Lenses

No doubt the most widely used optical device is the lens, and that notwithstanding the fact that we see the world through a pair of them. Lenses date back to the burning glasses of antiquity, and indeed who can say when people first peered through the liquid lens formed by a droplet of water.

Lenses are made in wide range of forms; for example, there are acoustic and microwave lenses; some of the latter are made of glass or wax in easily recognizable shapes, whereas others are far more subtle in appearance. In the traditional sense, a

lens is an optical system consisting of two or more refracting interfaces, at least one of which is curved. Generally the nonplanar surfaces are centered on a common axis. These surfaces are most frequently spherical segments and are coated with thin dielectric films to control their transmission properties. A lens that consists of one element is a simple lens. The presence of more than one element makes it a compound lens. A lens is also classified as to whether it is thin or thick, that is, whether its thickness is effectively negligible or not. We will limit ourselves, for the most part, to centered systems (for which all surfaces are rotationally symmetric about a common axis) of spherical surfaces. Under these restrictions, the simple lens can take the diverse forms. Lenses that are variously known as convex, converging, or positive are thicker at the center and so tend to decrease the radius of curvature of the wavefronts. In other words, the wave converges more as it traverses the lens, assuming, of course, that the index of the lens is greater than that of the media in which it is immersed. Concave, diverging, or negative lenses, on the other hand, are thinner at the center and tend to advance that portion of wavefront, causing it to diverge more than it did upon entry.

In the broadest sense, a lens is a refracting device that is used to reshape wavefronts in a controlled manner. Although this is usually done by passing the wave through at least one specially shaped interface separating two different homogeneous media. It is not the only approach available. For example, it is also possible to reconfigure a wavefront by passing it through an inhomogeneous medium. A gradient-index, or GRIN, lens is one where the desired effect is accomplished by using a medium in which the index of refraction varies in a prescribed fashion. Different portions of the wave propagate at different speeds, and the front changes shape as it progresses. In the commercial GRIN material the index varies radially, decreasing parabolically out from the central axis.

Today GRIN lenses are still fabricated in quantity only in the form of small-diameter, parallel, flat-faced rods. Usually grouped together in large arrays, they have been used extensively in such equipment as facsimile machines and compact copiers. There are other unconventional lenses, including the holographic lens and even the gravitational lens (where, for example, the gravity of a galaxy bends light passing in its vicinity, thereby forming multiple images of a distant celestial object, such as quasars).

No lens is a thin, in the strict sense of having a thickness that approaches zero. Yet many simple lenses, for all practical purposes, function in a fashion equivalent to that of a thin lens. Almost all spectacle lenses, which, by the way, have been used at least since the thirteenth century, are in this category. When the radii of curvature are large and the lens diameter is small, the thickness will usually be small as well. A lens of this sort would generally have a large focal length, compared with which the thickness would be quite small; many early telescope objectives fit that description perfectly.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. What is the most widely used optical device?
 - a) The most widely used optical device is a telescope.
 - b) The most widely used optical device is a prism.
 - c) The most widely used optical device is a microscope.
 - d) The most widely used optical device is a lens.
2. Which definition of the lens is correct?
 - a) An optical system consisting of two or more refracting interfaces, at least one of which is curved.
 - b) Nonplanar surface centered on a common axis.
 - c) Two spherical segments coated with thin dielectric films.
 - d) Optical system used for converging or diverging of light waves.
3. Which of these natural objects can we use as a lens?
 - a) Our eyes
 - b) A droplet of water
 - c) Lake surface
 - d) A pearl

Exercise 2. True or false?

1. A latent image in the emulsion is produced by light rays.
2. A positive latent image is produced by fixing.
3. A lens can substitute a pinhole making much more light to pass through.
4. A pinhole requires less time to make a picture than a lens.
5. The shutter prevents tape from being damaged.

INCREASE YOUR VOCABULARY

Exercise 1. Find the Russian equivalents of the words listed below.

1	2
1) compound lens	a) сложная линза (объектив)
2) burning glasses	b) поверхность
3) concave lens	c) ничтожный
4) diverging	d) кривизна
5) curvature	e) вогнутая линза
6) negligible	f) форма
7) interface	g) рассеивающая
8) nonplanar	h) экран
9) surface	i) неплоский
10) wavelength	j) волновой фронт
11) shape	k) поверхность раздела
	l) зажигательные стёкла
	m) длина волны
	n) выпуклая линза

Exercise 2. Read and translate the collocations below.

That notwithstanding the fact, lenses date back, for the most part, tend to decrease, in other words, on the other hand, a millionth of a second.

Exercise 3. Match the synonyms.

Verbs

1	2
1) achieve	a) make
2) allow	b) wish
3) produce	c) consist
4) desire	d) let
5) coat	e) get
	f) require
	g) cover

Nouns

1	2
1) interface	a) photo
2) adjustment	b) pinhole
3) picture	c) surface
4) aperture	d) change
5) speed	e) device
	f) velocity
	g) image

LANGUAGE ACTIVITY

Exercise 1. Complete the following sentences with a, an, the or no article.

1. ... audience clapped and cheered.
2. People say ... British are not very friendly but I disagree.
3. If we do not protect ... nature, our environment will get worse and worse.
4. I pick up ... kids from school and take them ... home when Mary is at ... work.
5. Take these letters to ... post office, will you?
6. Are we going round to ... Wilsons for supper on Saturday?
7. Where do you work during ... day?
8. What will you do if they cut ... electricity off?
9. She kissed him on ... cheek.
10. The Government should tax ... rich more and ... poor less.
11. ... power doesn't interest him but ... money does.
12. We arrived at Heathrow and got ... taxi which took us to ... Oxford Street.

Exercise 2. Insert prepositions where it is necessary.

1. The first lens was a liquid lens, formed ... a droplet of water.
2. Convex lenses are thicker ... the center.
3. A lens that consists ... one element is a simple lens.
4. Nonplanar surfaces of a lens are often spherical segments and are coated ... thin dielectric films.
5. Lenses are made ... a wide range of forms.
6. Photography depends ... a photochemical reaction in an emulsion of silver halide crystals.
7. An optical image is the reproduction ... an object ... a lens or mirror system, employing light as a carrier.
8. It is impossible to get any kind of image ... light.

Exercise 3. Summarize your knowledge of Present Perfect Tense. Put the verbs in brackets into the correct form.

1. The students (to read) the articles today.
2. He never (to conduct) such experiments.
3. The manufacturing technology (to improve) to the point that more complicated computers can be produced.
4. The production of lenses already (to become) an important branch of optical industry.
5. “Ever (to be) to such a conference?” professor asked the post – graduate student.
6. He not (to come) home yet.
7. The astronomer just (to write) down all the observations of the planets.
8. Two foremost opticians (to complete) a great scientific work this year.

Exercise 4. Summarize your knowledge of Past Perfect and Future Perfect Tenses. Translate the sentences from Russian into English.

1. Они прочитали, перевели и записали текст к тому моменту (до того), как он пришёл.
2. Инженеры закончат испытывать самолёт к 3 часам.
3. Конференция закончится к полудню.
4. Студентка уже сдала экзамен к 5 часам.
5. Учёные закончат работу к концу месяца.
6. Уже к 1610 году Галилей сообщил о проведении первых телескопических наблюдений.
7. К 2005 году будут созданы ещё более мощные телескопы.

Unit 5

WORD STUDY

Exercise 1. Check the transcription in the dictionary and read the words listed below. Translate them.

Nouns

trait, photography, aperture, tripod, clarity, width, balance, variety.

Verbs

imply, discourage, introduce, define, rival.

Adjectives

manual, ancient, amateur, old-fashioned, widespread, compact.

Exercise 2.

a) make adjectives from the following verbs according to the model.

Model: verb + -able: compare - comparable

operate, change, solve, reason, vary, convert, note, use, extend, control, recognize.

b) and now make negative forms of these adjectives and translate them.

Model: un- + adjective: comparable - uncomparable.

UNDERSTANDING A PRINTED TEXT

List of Terms:

camera obscura – камера-обскура

bellows – мехи (фотоаппарата)

imaging media – средство получения (оптических) изображений

body – корпус

zoom – объектив

disposable – одноразового использования

spool – наматывать (на катушку, шпульки и т. п.)

affordability – доступность

conventional – обычный, традиционный

contemporary – современный

subminiature – микроминиатюрный

large format view camera – широкоформатный панорамный фотоаппарат

large format camera – широкоформатный фотоаппарат

still camera – фотоаппарат

READ THE TEXT AND ENTITLE IT

Cameras are the defining tools of photography. Descended from the ancient camera obscura, all cameras share three basic traits: an *aperture* to focus light, an *imaging media* (usually film) to record the focused image, and a *body* to keep unfocused light away from the media. Cameras exist in an variety of forms, ranging from "single-use" disposable cameras to professional large format view cameras, while supporting media formats ranging from 19th-century glass plates to 21st-century digital media.

The most common type of camera today, *35mm cameras* were invented in 1914 by Oskar Barnack. As implied by the name, these cameras use 35mm-wide film, spooled into light-tight cartridges. The 35mm format provides a balance between image clarity, camera size, and affordability that has made the format popular with professional and amateur photographers.

The *Advanced Photo System (APS)* is a 24mm film format developed in the 1990s by a group of five camera manufacturers responding to consumers' difficulties with conventional 35mm cameras. APS' smaller film and redesigned film cartridge allow for more compact, easier-to-load cameras with more powerful zooms, but produce a considerably smaller image than the 35mm format. While APS is experiencing considerable growth in the amateur market, its smaller negatives and limited selection of film types have discouraged many experienced photographers.

Large format cameras are manual-focus view cameras that use sheet film to produce images significantly larger than other formats. Similarly, large format cameras are the largest contemporary cameras, requiring tripods to hold them steady, and bellows to adjust focal lengths. Large format cameras are widely considered the most "old-fashioned" types of cameras, having changed relatively little over the past century.

One of the oldest formats still in widespread use, *medium format* cameras and film were introduced by Eastman Kodak in 1898. Medium format film is 2-3/8 inches wide. Medium format images are 56mm high, with image widths depending on the camera used.

Subminiature cameras are usually defined as any still camera that exclusively uses a single film format smaller than 16.7mm x 30.2mm, which is the size of the Advanced Photo System's (APS) IX240 film. The size of the camera is not the determining factor, though in most cases these cameras are some of the smallest ever produced. The majority of these cameras are not toys. In fact, many of them have some of the more advanced optics of their time, as well as being mechanical marvels. Many older models rival the better lenses produced today. Cameras produced fifty years ago are carried daily in the pockets of many professional photographers.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. What types of camera do you know?
2. What basic traits do all cameras have?
3. Could you name the most common type of camera today? What advantages does it have?
4. How do large format cameras work?
5. Explain why subminiature cameras cannot be called toy cameras.

INCREASE YOUR VOCABULARY

Exercise 1. Find the synonyms.

1	2
1) common	a) huge
2) medium	b) improved
3) conventional	c) colorful
4) old-fashioned	d) average
5) advanced	e) outdated
6) widespread	f) usual
	g) extensive
	h) expansive

Exercise 2. Find the antonyms.

1	2
1) professional	a) manual
2) old-fashioned	b) still
3) large	c) present
4) common	d) big
5) past	e) contemporary
	f) amateur
	g) small
	h) unusual

LANGUAGE ACITIVITY

Exercise 1.

a) Study using “make” and “do”.

“Make” or “do”? In some contexts these two words have a similar meaning. However, there is a rule which says that “make” usually carries the idea of creation, construction.

- Example:*
- Marry made this dress herself.
 - This device was made by two students in one of the laboratories of the University.
 - Second-year students will make experiments next year.

As for “do”, it is usually associated with work, particular activity.

- Example:*
- Have you done your homework?
 - We don’t do aerobics this year.
 - He plans to do business.

However, there are many exceptions to these rules and specific uses of these verbs:

- to make a decision
- to make a mistake
- to make entry
- to make a device

but:

- to do a service
- to do subjects
- to do a favour
- to do without
- to do one’s best

b) Now cross out incorrect variant.

1. My mother doesn’t do/make housework.
2. Did he do/make many mistakes?
3. Every child must do/make his room.
4. Will you do/make a cup of coffee?
5. I will do/make all my best to help you.
6. I’d like to do/make you an offer.
7. Will you do/make me a favour and pass the bread.
8. My mother is going to do/make a cake for your birthday.
9. Now I can’t do/make without my computer.

Exercise 2. Insert do, make, have into the gaps, in the their correct form.

1. We must ... a decision at last - they are going to break the door!
2. I ... lots of messages every day and most of them is just junk mail.
3. Dr. Smith, we should ... an agreement at last. We accept your offer.
4. It's terrible how many mistakes she ... in her dictations. I don't think she will pass an exam.
5. I ... so much homework in math to I simply don't know with what to start!
6. My brother ... swimming professionally. He is excellent in it.
7. Though being quite young, about 5 years old, she always ... her bed herself.
8. This film was ... by a famous French producer, the author of many well-known films.
9. I wouldn't be able to work as a babysitter. Children ... so much noise!

Exercise 3. Translate the following sentences paying special attention to different meanings of "that" and "those".

1. The distinguishing feature of a converging lens is that it is thicker at the center than at the edge.
2. We know that the telescope is an instrument that presents to the eye an enlarged image of distant objects.
3. A field of view afforded by a plane mirror is very similar to that of a simple window.
4. There are close analogies between the effects produced by a thin lens and those produced by a single spherical refracting surface.
5. That spherical aberration can be completely eliminated for a single lens by aspherising is a very important fact in optical design.
6. The diaphragm restricts the rays to those which pass through the central portion of the lens.

Exercise 4. Put the verbs in brackets into the correct form.

1. Light (to travel) faster in empty space and (to slow) down upon entering matter.
2. Optics (to progress) rapidly by the early years of the 19th century.
3. Since 1940 there (to be) a great resurgence in optics on the basis of information and communication theory.
4. If space (to be) empty, light (to travel) faster.
5. In 1841 Gauss (to publish) his classical book on geometrical optics, in which he (to expound) the concept of the focal length.
6. Before More Hall (to find) the correct combination of flint and crown lenses he (to experiment) with different types of glass.
7. The scientist (to invent) the form of the refracting telescope, which (to be) the basis for modern refractors.
8. How (to work) a transmitter?

REVIEW OF THE CHAPTER I

Exercise 1. *Give a brief summary of the texts.*

Define the main problems dealt with in the texts. Try to use the following words and expressions in your summary: the article covers the period (periods), special attention is given to, thus, hence, that's why.

Exercise 2. *Topics for discussion on the material of Chapter I.*

1. Who contributed much to the development of geometrical optics?
2. In your opinion, what types of camera will be the most popular in future and why?

SUPPLEMENTARY TASKS

IMPROVE YOUR TRANSLATION PRACTICE

TASK 1

Translate the text and discuss the topics given below.

The History of the Telescope

At least two other Dutch spectacle makers made telescopes about the same time, and there were rumours of some such sort of magical device during the 16th century. Nevertheless, a Dutch eyeglass maker, Hans Lippershey, has been given credit for the invention of the telescope in 1608; when he offered it to the government for military use, they required that it be converted to binocular form. Lippershey was the first to describe the telescope in writing.

By 1610, Galileo announced the telescopic observations of the moon and planets, which signaled the end of the Ptolemaic theory of the heliocentric solar system. Galileo's telescope was a simple refractor, employing two lenses in a tube. In 1609 Galileo learned of the invention of the telescope, a three-power instrument, which he quickly improved to eight, twenty and then thirty power. These were the most powerful instruments of his time and with them he made the discoveries that established Copernican system.

Kepler invented the form of the refracting telescope, which is the basis for modern refractors; it has a convex lens placed in back of the focus. The reflecting telescope invented by Isaac Newton used an on-axis planar mirror to move the focus of the parabolic reflector to a point outside the light collecting cylinder; reflector telescopes avoid the problem of lens chromatic aberration, which affect refractors. Variations of the Newtonian reflector, in which the light was reflected back through a hole in the primary mirror, were invented by James Gregory in 1663 and by Cassegrain in 1672.

One hundred years later, Jesse Ramsden, an English instrument maker who rose from poverty to membership in the Royal Society, discovered that the Cassegrain design may be used to reduce spherical aberration using a paraboloidal reflector and a hyperboloid for the secondary reflector. Microwave reflector antennas often employ the Cassegrain design, with the feed-horn between the primary and secondary reflectors. A lens design, which resolved the problem of chromatic aberration for refractor telescope was discovered in 1733 by Hall but kept secret until it was uncovered and used commercially in 1759 by John Dolland and his son.

A third type of telescope, which uses a spherical mirror and a correcting lens was invented in 1930 by Bernhard Schmidt. It employs a correcting plate at the telescope aperture to compensate for spherical aberration, thus it is a combination reflector-refractor system. The Schmidt telescope serves astronomy as a wide-angle

camera. The Schmidt-Cassegrain telescope is the most popular among amateur astronomers because of its compact design and large aperture and because the optics are completely enclosed.

Exercise 1. *Rearrange the sentences in the chronological order.*

1. Keppler invented the form of the refracting telescope, which has a convex lens placed in back of the focus.
2. Hans Lippershey has been given credit for the invention of the telescope in 1608.
3. In 1930 Bernhard Schmidt invented a third type of telescope, which uses a spherical mirror and a correcting lens.
4. In 1609 Galileo learned of the invention of the telescope, built a three-power instrument.
5. Jesse Ramsden, an English instrument maker, reduced spherical aberration in the Cassegrain design, having used a paraboloidal reflector and a hyperboloid for the secondary reflector.

Exercise 2. *Topics for discussion.*

1. The invention of the telescope was a great step in science.
1. Galileo and Keppler much contributed to telescope-making.
2. Why are there different types of telescopes?

TASK 2

Translate the text without a dictionary using terms given below. Pay special attention to the underlined sentences.

Holography

The use of a lens to image an object is one of the oldest principles in optics and photography. However, in 1948 Gabor introduced a two-step imaging process in which an intermediate record, containing the information necessary to create an image, is formed.

The 2-step imaging process consists of first photographing the interference pattern which exists when a diffracted or object field is allowed to interfere with a reference field or background wave (usually a plane or spherical wave) on or off axis with respect to the diffracted field. The 1-st step is called the formation or recording. The 2-nd step, called the reconstruction, consists of placing the photographic transparency (film) into a coherent beam of light and producing an image of the original object.

The resulting record of the interference pattern obtained in the 1-st step is called a hologram after the Greek word "holos", which means "the whole", because the photographic record contains information concerning both the amplitude and phase of the original object.

The hologram bears little resemblance to the object, and upon visual observation contains a seemingly meaningless combination of fringes or diffraction patterns. The image of the object which is obtained from a hologram is referred to as the reconstructed image, and there are two types. A real image is one that appears on the opposite side of the hologram from the source and has the property that no auxiliary focusing devices are needed to record a focused image. A virtual image is one that appears on the same side of the hologram as the source and has the property that an additional focusing device is needed to detect a focused image.

The entire process is known as the hologram process and the wave-front reconstruction process, and also the science of holography.

background wave – опорная волна

coherent beam of light – когерентный пучок света

diffracted or object field – дифрагированное поле или поле предметной волны

fringes or diffracted pattern – полосы или дифракционная картина

interference pattern – интерферограмма, интерференционная картина

intermediate record – промежуточная запись

photographic transparency – фотографическая пленка

plane or spherical wave – плоская или сферическая волна

reference field – опорное поле

two step imaging process – двухшаговый процесс формирования изображения

wave-front reconstruction process – процесс восстановления волнового фронта

Exercise 1. Retell the text, find out three main ideas.

Exercise 2. Read and translate two definitions of the word “hologram”.

1. Hologram is a pattern produced by the interference between one part of a split beam of coherent light, e.g. from a laser, and the other part of the same beam reflected off an object.

2. Hologram is a photographic reproduction of a pattern that when suitably illuminated produces a three-dimensional picture.

TASK 3

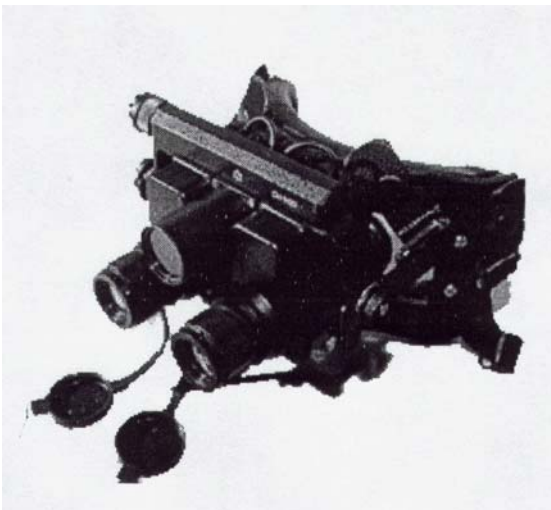
Read the text paying attention to the specifications of the optical instruments and the ways they are used.

Optical Instrument



A. The night vision sight NP-75 is designed for aimed hunting gun firing in the twilight and at night. Intensification of luminous flux from the observed scene is taken place by an electrooptical transducer. Luminous laying mark in the field of view of the sight is use for a target aiming. Smooth adjustment of the mark's brightness allows aiming on targets with different illumination.

Generation:	I
Magnification, times:	2
Field of view, degrees:	12
Range of target detection, m:	400
Dimensions, mm:	256x72x76
Mass, kg:	0.95

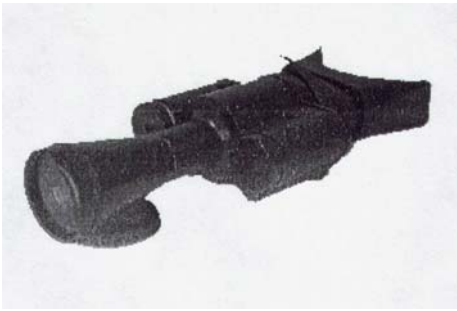


B. ON 1x20 night vision goggles is an optronic device, intended for visual observation of objects in dark time of the day, to orient oneself in a given area, or on water surface in conditions of natural night illumination.

The device is provided with refocusing of the objectives to observe both remote and nearby objects.

Generation:	I
Magnification, times:	1
Field of view, degrees:	40
Interpupillary distance, mm:	from 59 to 70
Dimensions, mm:	180x120x170
Mass, kg:	1

Caution: While test-operating the goggles in the day time or under condition of artificial illumination, NEVER remove protective cover from the objective lens!



Caution: While test-operating the binocular in the day time or under condition of artificial illumination, NEVER remove protective cover from the objective lens!

C. BAIGISH-6U is an excellent example of how elaborations of the night vision equipment designed for the military take stable positions now on a consumer market. If you are looking for real 2-nd generation night vision binocular with resolution not less than 30 lines/mm this is BAIGISH-6U. Its perfect binocular eyepiece lets easily keep observation at any distance. It's very important that BAIGISH-6U has a weather proof metal body. Unlike other night vision devices, especially equipped with a plastic body, BAIGISH-6U does not look like a toy at all. Really, this device is for a serious user.

Generation:	II
Magnification, times:	2.4
Field of view, degrees:	8
Dimensions, mm:	405x168x85
Mass, kg;	1.8



Caution: While test-operating the goggles in the day time or under condition of artificial illumination, NEVER remove protective cover from the objective lens!

D. The night glasses "Baigish- 9M2" are designed for observation of animate nature and terrain at an ambient skylight or faint artificial intensity. The visibility range depends on the ambient light intensity, nature of objects being observed, contrast between the object and background and transparency of atmosphere.

Generation:	I
Magnification, times:	2.2
Field of view, degrees:	14
Dimensions, mm:	165x125x80
Mass, kg:	0.87

Exercise 1. Answer the following questions.

1. Where can these optical instruments be used?
2. Are these devices cheap or expensive?
3. What information, you think, is the most important?
4. Would you like to buy one of them and for what purpose?

TASK 4

Translate the article into English using words given below.

Астрономические наблюдения объектов в широком диапазоне длин волн

Атмосфера Земли прозрачна не только к видимому свету, но также и к радиоволнам, простирающимся в диапазоне от 1 мм до, приблизительно, 10 м. Однако только в 1931 году это радио "окно" было открыто для астрономических наблюдений. Сегодня, астрономы систематически изучают радиоизлучения многих видов астрономических объектов, включая звезды, галактики, и квазары. Наиболее знакомый тип радиотелескопа – радиорефлектор, состоящий из большой параболической антенны, которая общеизвестна как "тарелка". Самый большой и единственный инструмент этого вида – 305-ти метровая тарелка установленная в Обсерватории Аресибо в Пуэрто-Рико.

С начала 1960-ых годов, были сделаны большие усилия, чтобы изучить астрономическую сферу в других диапазонах длин волн электромагнитного спектра. Приборы, подобные оптическим телескопам, но более чувствительные к излучению длин волн которые несколько длиннее, чем видимый свет были установлены на высоких пиках гор (таких как Мауна Кеа на острове Гавайи). Инфракрасные телескопы также находятся выше земной атмосферы и называются спутниками.

Наблюдения ультрафиолетовых, рентгеновских и гамма излучений могут быть сделаны только из космического корабля, потому что атмосфера непрозрачна к электромагнитному излучению длины волны меньше чем приблизительно 3,000 ангстремов. Ультрафиолетовые телескопы похожи на отражатели, но их оптические поверхности требуют специальных покрытий, которые обеспечивают высокую отражаемость. Хороший пример такого прибора – Космический телескоп Хаббла. Рентгеновские телескопы, с другой стороны, радикально отличаются от обычных оптических систем. Из-за их чрезвычайно высокой энергии, рентгеновские лучи не могут быть сосредоточены линзами, но могут проникать через зеркала, если они устроены как в обычных отражателях. Поэтому, рентгеновские телескопы, такие как на спутнике НЕАО-2, оборудованы полированными зеркалами для того, чтобы отразить поступающие лучи под малым углом на фокальную плоскость; сформированное изображение регистрируется электронным датчиком. Подобные методы используются и в гамма-лучевых телескопах. Такие приборы находятся на борту орбитальных спутников, чтобы наблюдать за остатками новых звезд, группами галактик, и другими космическими системами с высокой энергией.

observation – наблюдение
image – изображение
space ship – космический корабль
transparent – прозрачный
effort – усилие
reflector – отражатель
high energy – высокая энергия
 γ radiation – гамма излучение
X-ray radiation – рентгеновское излучение
visible light – видимый свет

Exercise 1. Answer the questions.

1. Is the atmosphere of the Earth transparent for the visible light?
2. What did astronomers investigate systematically?
3. Where can the γ and X-ray radiation be investigated from?
4. Why can't the X-rays be focused in a common way?

Chapter II

Fiber Optics

Unit 1

WORD STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Nouns

atmosphere, facsimile, fountain, frequency, phenomenon, semaphore, spectrum, turbulence.

Verbs

confine, illustrate, install, languish, mount.

Adjectives

analogous, dielectric, inaccessible, transparent.

Exercise 2. *Make adverbs from the following adjectives according to the model and translate them.*

Adjective + -ly = adverb

a) careful – carefully

experimental, essential, practical, total, virtual;

b) simple – simply

gentle, probable, suitable, terrible;

c) easy – easily

lazy, noisy;

d) complete – completely

efficient, brilliant, effective, ultimate.

Adjective + -ally = adverb

e) heroic – heroically

atomic, automatic, tragic, analytic, symbolic.

UNDERSTANDING A PRINTED TEXT

List of Terms:

bandwidth – диапазон

bundle of optical fibres – оптоволоконный кабель

core – сечение

critical specification – технические условия

decode – декодировать, расшифровывать
glass-clad fibre – волокно со стеклянным покрытием
in the intervening years – в период (между)
fused silica – плавленое стекло
lossy – проигрышный
melting point – точка плавления
one wave-guide mode – передатчик определенных длин волн,
одноименный тип колебаний
optical-frequency amplifier – усилитель оптических частот
phenomenon of total internal reflection – эффект полного внутреннего отражения
refractive index – показатель преломления
theoretical specification – теоретические условия (спецификации)
transparent – прозрачный
wave-guide – волновод
world's long-distance traffic – международное сообщение

COMPREHENSIVE READING

The History of Fiber Optics

Optical communication systems date back two centuries to the "optical telegraph" that French engineer Claude Chappe invented in the 1790s. His system was a series of semaphores mounted on towers, where human operators relayed messages from one tower to the next. It reduced the need in hand-carried messages, but by the mid-19th century it was replaced by the electric telegraph.

Alexander Graham Bell patented an optical telephone system, which he called the Photophone, in 1880, but his earlier invention, the telephone, proved far more practical. He dreamed of sending signals through the air, but the atmosphere didn't transmit light as reliably as wires carried electricity. In the decades that followed, light was used for a few special applications, such as signalling between ships, but otherwise optical communications, like the experimental photophone Bell donated to the Smithsonian Institution, languished on the shelf.

In the intervening years, a new technology slowly took root that would ultimately solve the problem of optical transmission, although it was a long time before it was adapted for communications. It depended on the phenomenon of total internal reflection, which can confine light in a material surrounded by other materials with lower refractive index, such as glass in air. In the 1840s, Swiss physicist Daniel Collodon and French physicist Jacques Babinet showed that light could be guided along jets of water for fountain displays.

Optical fibers went a step further. They were essentially transparent rods of glass or plastic stretched so they long and flexible. During the 1920s, John Logie Baird in England and Clarence W. Hansell in the United States patented the idea of using arrays of hollow pipes or transparent rods to transmit images for television or facsimile systems. However, the first person known to have demonstrated image transmission through a bundle of optical fibers was Heinrich Lamm, then a medical

student in Munich. His goal was to look inside inaccessible parts of the body. During his experiments, he reported transmitting the image of a light bulb.

By 1960, glass-clad fibers fine for medical imaging were made, but they didn't match communication purposes.

Meanwhile, telecommunications engineers were seeking more transmission bandwidth. Radio and microwave frequencies were in heavy use, so they looked to higher frequencies to carry loads they expected to continue increasing with the growth of television and telephone traffic.

The next step towards optical communications was the invention of laser. The July 22, 1960 issue of Electronics magazine introduced its report on Theodore Maiman's demonstration of the first laser by saying "Usable communications channels in the electromagnetic spectrum may be extended by development of an experimental optical-frequency amplifier." But rain, haze, clouds, and atmospheric turbulence limited the reliability of long-distance atmospheric laser links. Optical wave-guides were proving to be a problem.

Optical fibers had attracted some attention because they were analogous in theory to plastic dielectric wave-guides used in certain microwave applications. In 1961, Elias Snitzer demonstrated the similarity by drawing fibers with cores so small that they carried light in only one wave-guide mode. However virtually everyone considered fibers too lossy for communications.

1964, a critical (and theoretical) specification was identified by Dr. C.K. Kao for long-range communication devices, the 10 or 20 decibels of light loss per kilometer standard. Kao also illustrated the need for a purer form of glass to help reduce light loss.

In 1970, one team of researchers began experimenting with fused silica, a material capable of extreme purity with a high melting point and a low refractive index. Corning Glass researchers Robert Maurer, Donald Keck and Peter Schultz invented fiber optic wire or "Optical Waveguide Fibers" capable of carrying 65,000 times more information than copper wire, through which information carried by a pattern of light waves could be decoded at a destination even a thousand miles away. The team had solved the problems presented by Dr. Kao.

The first optical telephone communication system was installed about 1.5 miles under downtown Chicago in 1977, and each optical fiber carried the equivalent of 672 voice channels. Today more than 80 percent of the world's long-distance traffic is carried over optical fiber cables. About 25 million kilometers of the cable Maurer, Keck and Schultz designed has been installed worldwide.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. What is known about the invention of the optical telegraph?
2. Why didn't Bell's optical telephone system find wide application?
3. How did the invention of laser affect optical communications?

4. What goal did Heinrich Lamm set working on image transmission through optical fibers?
5. What were the results of the experiments with fused silica?

Exercise 2. Topics for discussion.

1. Why do you think the development of fiber optics took such a long time?
2. Why is it possible to call the development of fiber optics a key for world's communications?

INCREASE YOUR VOCABULARY

Exercise 1. Compare the two columns and find Russian equivalents.

1	2
1) bandwidth	a) показатель преломления
2) bundle of optical fibers	b) прозрачный
3) critical specification	c) опорная волна
4) decode	d) диапазон
5) glass-clad fiber	e) выбирать
6) fused silica	f) технические условия
7) melting point	g) передача
8) optical-frequency amplifier	h) оптический телеграф
9) phenomenon of total internal reflection	i) медный провод
10) refractive index	j) теоретические условия (спецификация)
11) theoretical specification	k) плавленное стекло
12) transparent	l) волокно со стеклянным покрытием
13) wave-guide	m) усилитель оптических частот
14) transmission	n) эффект полного внутреннего отражения
15) message	o) оптоволоконный кабель
16) copper wire	p) критическая температура
	q) волновод
	r) точка плавления
	s) декодировать, расшифровать
	t) сообщение
	u) коэффициент упругости

Exercise 2. Match the antonyms.

1	2
1) short	a) incident
2) unpractical	b) real
3) opaque	c) low
4) inflexible	d) practical
5) high	e) plane
6) partial	f) fused
7) virtual	g) intermediate
8) concave	h) long
	i) lossy
	j) convex
	k) total
	l) flexible
	m) transparent

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of Passive Constructions and translate the following sentences.

1. The reflecting telescope was invented by Isaac Newton.
2. A Dutch eyeglass maker, Hans Lippershey, has been given credit for the invention of the telescope in 1608.
3. In the 17th century it was known that rays of light travelled in straight lines.
4. Lenses of moderately good quality were being made for telescopes and microscopes during the first half of the 19th century.
5. It is said that New York was discovered by an Italian navigator.
6. Before 1932 two fundamental particles had been discovered as a result of great experimental work.
7. Nearly all properties of matter are affected by temperature changes.
8. Optics is being made very important in various branches of industry.
9. Why is this book talked about?
10. London is visited by thousands of tourists every year, isn't it?

Exercise 2. Choose the suitable Passive construction.

1. Mendeleev's ... a periodic law of nature has entered his name into the history book of science.
 - a) being established
 - b) having established
 - c) having been established

2. If the distance to the star ... , its lights power would be judged from its brightness.
 - a) is known,
 - b) was known
 - c) were known

3. Newton suggested that the light ... as a stream of particles.
 - a) is interpreted
 - b) be interpreted
 - c) was interpreted

4. Molecular biology ... to dominate other science.
 - a) expects
 - b) is expected
 - c) is expecting

5. Such phenomena should ... as early as in the 18th century.
 - a) know
 - b) have known
 - c) have been known

6. They considered all water on the surface of this planet ... by volcanic action.
 - a) having liberated
 - b) to be liberated
 - c) to have been liberated.

Exercise 3. Fill in the blanks with the verbs given below: can use, to use, to overcome, to award, can duplicate, to produce, can view, to print, to achieve. Use them in the Passive Voice.

1. Further development in the field ... during the next decade.
2. This barrier ... in 1960 with the invention of the laser.
3. In 1962 two scientists recognized from their work in side-reading radar that holography ... as a 3-D visual medium.
4. "Train and Bird" ... in 1964 at the University of Michigan.
5. Denisyuk's approach produced a white-light reflection hologram which ... in light from an ordinary incandescent light bulb.
6. The first hologram of a person ... in 1967.
7. Benton's holograms ... by stamping the interference pattern onto plastic.
8. The resulting hologram ... millions of times for a few cents apiece.
9. Embossed holograms ... now by the publishing, advertising and banking industries.
10. In 1971 Dr. Dennis Gabor ... the Nobel Prize in Physics.

Exercise 4. Insert prepositions: on, in, of, for, to, with, by, from.

1. Operators of optical telegraph relayed messages ... one tower ... the next.
2. Bell dreamed ... delivering messages through the air.
3. They have already started experiments ... germanium.
4. This fiber optic wire was capable ... carrying much more information.
5. Fibers with small cores can carry light ... only one wave-guide mode.
6. The National Geographic issued the report ... some new achievements in holography.
7. It took quite a long time before a new technology was adapted ... communications.
8. Those fibers were especially fine ... medical imaging.
9. The problems presented ... Dr. Kao had been successfully solved.

Exercise 5. Translate the following sentences paying attention to “due to” and “is due to”.

Compare: due to – благодаря, вследствие, из-за
is (are, was, were) due to – обусловлен

1. The first space flight became possible due to the efforts of many scientists.
2. Due to the phenomenon of stimulated emission and to the feedback mechanism laser radiation has special characteristics.
3. There is a theory that magnetism is due to electric currents that flow around the Earth.
5. Due to external energy affecting enough atoms, their internal energy can be triggered.
6. Due to the failure with the new device further development of the project was stopped.

Unit 2

WORD STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Nouns

diode, contaminant, cladding, silica, interface, abrasion, germanium, medium, utility.

Verbs

to bounce, to shield, to channel, to convert, to tunnel, to replace, to transmit.

Exercise 2. *Read and translate the following collocations.*

Outer jacket, strength material, coded electronic pulse information, total internal reflexion, injection-laser diode.

Exercise 3. *The following groups of words are all related in meaning because they have the same roots. Point out suffixes indicating nouns.*

Verbs

transmit
receive
inform
translate
reflect
construct
contribute
advertise
employ

Nouns

transmitter, transmission
receiver, receivership
informer, information
translator, translation
reflector, reflection
constructor, construction
contributor, contribution
advertiser, advertisement
employer, employment

UNDERSTANDING A PRINTED TEXT

List of Terms:

abrasion – механические повреждения поверхности, трение
angle of incidence – угол падения
buffer material – буферный материал
copper wire system – связь, осуществляемая по медным проводам
critical value – предельное значение
electric utility company – электрическая бытовая компания
extremely reflective surface – поверхность с высоким отражением
head end – входящий конец
injection-laser diode (ILD) – инжекционный лазерный диод

light-emitting diode (LED) – световой диод
optic cladding – оптическое покрытие
optic core – сердцевина оптического волокна
outer jacket – внешнее покрытие, внешний слой
solvent – разъедание, коррозия, растворитель
strand – пучок волокон, кабель
tunnel into – проходить, направляться в
terrestrial hardwired systems – наземные электронные системы
total internal reflexion – полное внутреннее отражение
transmission medium – средство передачи

READING FOR PRECISE INFORMATION

Fiber Optic Systems

In recent years it has become apparent that fiber optics are steadily replacing copper wire as an appropriate means of communication signal transmission. Fiber optic systems are currently used most extensively as the transmission link between terrestrial hardwired systems. They span the long distances between local phone systems as well as other system users which include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

Fiber Optic Technology

A fiber-optic system can generally be seen as a system with three main components: a transmitter, a transmission medium and a receiver. As a model it is similar to the copper wire system that fiber optics is replacing. The difference is that fiber optics use light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the three main components in the fiber optic chain will give a better understanding of how the system works in conjunction with wire based systems.

At the head end of the chain is a transmitter. This is a place of origin for information coming on to fiber optic lines. The transmitter accepts coded electronic pulse information coming from copper wire. It then processes and translates that information into equivalently coded light pulses. A light-emitting diode (LED) or an injection-laser diode (ILD) can be used for generating the light pulses. Using a lens, the light pulses are tunneled into the fiber-optic medium where they transmit themselves down the line.

Light pulses move easily down the fiber-optic line because of a principle known as total internal reflection. This principle of total internal reflection states that when the angle of incidence exceeds a critical value, light cannot get out of the glass; instead, the light bounces back in. When this principle is applied to the construction of the fiber-optic strand, it is possible to transmit information down fiber lines in the form of light pulses.

There are generally five elements that make up the construction of a fiber-optic strand, or cable: the optic core, optic cladding, a buffer material, a strength material and the outer jacket. The *optic core* is the light carrying element at the center of the optical fiber. It is commonly made from a combination of silica and germanium. Surrounding the core is the *optic cladding* made of pure silica. It is this combination that makes the principle of total internal reflection possible. The difference in materials used in the making of the core and the cladding creates an extremely reflective surface at the point in which they interface. Light pulses entering the fiber core reflect off the core/cladding interface and thus remain within the core as they move down the line.

Surrounding the cladding is a buffer material used to help shield the core and cladding from damage. A strength material surrounds the buffer, preventing stretch problems when the fiber cable is being pulled. The outer jacket is added to protect against abrasion, solvents, and other contaminants.

Once the light pulses reach their destination they are channeled into the optical receiver. The basic purpose of an optical receiver is to detect the received light incident on it and to convert it to an electrical signal containing the information impressed on the light at the transmitting end. In other words the coded light pulse information is translated back into its original state as coded electronic information. The electronic information is then ready for input into electronic based communication devices such as a computer, telephone or TV.

CHECK YOUR UNDERSTANDING

Exercise 1. *Answer the following questions.*

1. What is the purpose of fiber optic systems?
2. What are three main components of a fiber optic system?
3. How does a transmitter work?
4. How is a fiber optic cable constructed?
5. What is the purpose of an optical receiver and how does it work?

Exercise 2. *Complete the sentences with words from the text.*

1. At the head end of the chain is the
2. Light pulses move easily down the fiber-optic line because of a principle known as
3. ... is the light carrying element at the center of the optical fiber.
4. Surrounding the core is ... made of pure silica.
5. The outer jacket is added to protect against
6. The transmitter accepts ... coming from copper wire.
7. A light-emitting diode or an injection laser diode can be used for

INCREASE YOUR VOCABULARY

Exercise 1. *Match words and collocations from the left column with words and collocations from the right column.*

1	2
1) abrasion	a) механическое повреждение поверхности
2) angle of incidence	b) поверхность с высоким отражением
3) buffer material	c) стык, поверхность раздела
4) copper wire system	d) сердцевина оптического волокна
5) contaminant	e) импульс
6) critical value	f) угол падения
7) extremely reflective surface	g) связь, осуществляемая по медным проводам
8) injection-laser diode	h) приемник
9) interface	i) наземные электронные системы
10) light-emitting diode	j) буферный материал
11) optic cladding	k) средство передачи
12) optic core	l) входить
13) outer jacket	m) вредный фактор
14) pulse	n) превосходить
15) receiver	o) выходить
16) terrestrial	p) световой диод
17) transmitter	q) внутреннее покрытие
18) transmission medium	r) предельное значение
19) to enter	s) инжекционный лазерный диод
20) to exceed	t) внешнее покрытие, кожух
	u) оптическое покрытие
	v) передатчик
	w) пластинка

Exercise 2. *Insert the proper words or collocations: a) optical receiver, b) fiber optics, c) optic core, d) fiber optic strand, e) principle, f) transmitter.*

1. A ... usually consists of five main elements.
2. The received light is detected and converted into an electrical signal by
3. Instead of using electronic pulses to transmit information down copper lines ... use light pulses to transmit information down fiber lines.
4. ... accepts coded electronic pulse information coming from copper wire.
5. In a fiber optic line a ... known as total internal reflection is used.
6. This is the light carrying element at the center of the optical fiber. It's called ...

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the Sequence of Tenses. Translate the sentences into Russian.

1. It is clear that the newest devices of today will become obsolete tomorrow.
2. The engineers asked if the work could be compressed into 6 days.
3. We finally realized that we had chosen the worst possible moment to visit the company.
4. We were told that the Earth revolves round the Sun.
5. He considered that this problem would be solved in the nearest future.
6. I was not sure whether this theory could account for these phenomena.
7. It is known that magnifying power of microscopes is being increased from year to year.

Exercise 2. Put the verbs in brackets into the correct tense form according to the Sequence of Tenses rule.

1. It is apparent that fiber optics steadily (to replace) copper wire as an appropriate means of communication signal transmission.
2. He said that fiber optics (to use) light pulses to transmit information.
3. The students were told that today more than 80 percent of the world's long-distance traffic (to be carried) over optical fiber cables.
4. They read that lenses (to date back) to the burning glasses of antiquity.
5. She has learnt that revolutionary advances in optics of the 20th century (to begin) with the construction of the first laser.
6. The Danish astronomer Olaf Roemer calculated that the light (travel) a distance equal to the diameter of the Earth's orbit around the Sun for about 22 minutes.
7. In the 19th century none could predict that it (to be possible) to produce images of high-speed events.

Exercise 3. Confirm the expression using Tag Question.

1. We use electricity to produce heat, ... ?
2. This student made a report at the conference, ... ?
3. The scientists were astonished to discover masers in the galaxy space, ... ?
4. You were not ready to continue this work, ... ?
5. Many laser physicists have been awarded Nobel Prize, ... ?
6. The experimentalists couldn't obtain wholly coherent beams of light, ... ?

Exercise 4. Change modal verbs of the predicates into their equivalents.

1. Under the action of light this phenomenon must produce conduction electrons.
2. In a number of cases, the junction between a metal and a semiconductor or between two semiconductors may have a rectifying action.
3. Both kinds of conductivity could occur in semiconductors.
5. This energy must be in the form of a photon.
6. A layer of metal might be made so thin that light easily passes through it.
7. An electric current can flow when the circuit is closed.
8. In some cases, the energy may be transferred to another electron.

Unit 3

WORD-STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Boundary, extraneous, coaxial, unique, bandwidth, fidelity, corrode, hazard.

Exercise 2. *Choose the proper English equivalents to the Russian words.*

Излучение – radiate, radiation, radiative, radiated;

проводить – conductive, conduct, conductance;

приемник – receive, receiver, receiving;

обеспечивать – provide, provider, providing;

первоначальный – original, origin, originally;

передача – transmitter, transmit, transmitting, transmission.

UNDERSTANDING A PRINTED TEXT

List of Terms:

coaxial – коаксиальный кабель

corrode – подвергаться действию коррозии

data rates – скорость передачи информации

duct – труба для кабеля, оболочка

extraneous signal pickup – прием постороннего сигнала

fidelity – точность, достоверность

fire hazard – угроза пожара

ground loops – замыкание

lash – подсоединять

low-loss glass fiber optic cable – стеклянный оптоволоконный кабель
с низкими потерями

monitor – передавать (информацию)

transmission media – средства передачи информации

optical receiver – оптический приемник

optical transmitter – оптический передатчик

light emitting diode – светодиод

point-to-point fiber optic transmission system – точечная передающая
оптоволоконная система

power lines – силовой кабель (линии электропередачи)

solid-state laser diode – полупроводниковый лазерный диод

spark – возгорание, искровой разряд

splice – сплетение (проводов)

tap – подключаться

READING AND TRANSLATING THE TEXT

Our current "age of technology" is the result of many brilliant inventions and discoveries, but it is our ability to transmit information, and the media we use to do it, that is perhaps most responsible for its evolution. Progressing from the copper wire of a century ago to today's fiber optic cable, our increasing ability to transmit more information, more quickly and over longer distances has expanded the boundaries of our technological development in all areas.

Today's low-loss glass fiber optic cable offers almost unlimited bandwidth and unique advantages over all previously developed transmission media. The basic point-to-point fiber optic transmission system consists of three basic elements: the optical transmitter, the fiber optic cable and the optical receiver.

The optical transmitter converts an electrical analog or digital signal into a corresponding optical signal. The source of the optical signal can be either a light emitting diode, or a solid-state laser diode. The most popular wavelengths of operation for optical transmitters are 850, 1300, or 1550 nanometers.

The fiber optic cable consists of one or more glass fibers, which act as waveguides for the optical signal. Fiber optic cable is similar to electrical cable in its construction, but provides special protection for the optical fiber within. For systems requiring transmission over distances of many kilometers, or where two or more fiber optic cables must be joined together, an optical splice is commonly used.

The optical receiver converts the optical signal back into a replica of the original electrical signal.

Fiber optic transmission systems – a fiber optic transmitter and receiver, connected by fiber optic cable – offer a wide range of benefits not offered by traditional copper wire or coaxial cable. These include:

1. The ability to carry much more information and deliver it with greater fidelity than either copper wire or coaxial cable.

2. Fiber optic cable can support much higher data rates, and at greater distances, than coaxial cable, making it ideal for transmission of serial digital data.

3. The fiber is totally immune to virtually all kinds of interference, including lightning, and will not conduct electricity. It can therefore come in direct contact with high voltage electrical equipment and power lines. It will not also create ground loops of any kind.

4. As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil or exposed to most corrosive atmospheres in chemical plants without significant concern.

5. Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber. Even in the most explosive of atmospheres, there is no fire hazard, and no danger of electrical shock to personnel repairing broken fibers.

6. Fiber optic cables are virtually unaffected by outdoor atmospheric conditions, allowing them to be lashed directly to telephone poles or existing electrical cables without concern for extraneous signal pickup.

7. A fiber optic cable, even one that contains many fibers, is usually much smaller and lighter in weight than a wire or coaxial cable with similar information

carrying capacity. It is easier to handle and install, and uses less duct space. (It can frequently be installed without ducts.)

8. Fiber optic cable is ideal for secure communications systems because it is very difficult to tap but very easy to monitor. In addition, there is absolutely no electrical radiation from a fiber.

CHECK YOUR UNDERSTANDING

Exercise 1. Which title better suits the text?

1. From the History of Fiber Optics.
2. Advantages of Fiber Optics.
3. Fiber Optic Systems.
4. Future of Fiber Optics.

Exercise 2. Answer the following questions.

1. What are the main parts of the basic point-to-point optic transmission system?
2. What is the purpose of optical transmitter?
3. What kinds of cable are used in fiber optics?
4. What is fiber optic system?

INCREASE YOUR VOCABULARY

Exercise 1. Read the English nouns and collocations and find the Russian equivalents to them.

1	2
1) fiber optic cable	a) возгорание
2) light emitting diode	b) оптический передатчик
3) coaxial cable	с) внешние атмосферные условия
4) optical signal	d) угроза пожара
5) optical transmitter	e) светодиод
6) fire hazard	f) оптический сигнал
7) transmission	g) длина волны
8) spark	h) оптоволоконный кабель
9) outdoor atmospheric conditions	i) коаксиальный кабель
10) weight	j) отражение
11) copper wire	k) сердцевина оптического волокна
12) advantage	l) вес
13) optical receiver	m) носитель
14) wavelength wave-guide	n) волновод
15) rate	o) передача
16) carrier	p) оптический приемник
17) radiation	q) излучение
	r) скорость
	s) преимущество
	t) медный провод

Read the English adjectives and find the Russian equivalents to them.

1	2
1) immune	a) первоначальный
2) explosive	b) огнеупорный
3) unlimited	c) цифровой
4) digital	d) твердотельный
5) solid-state	e) взрывчатый
6) original	f) защищенный
	g) стеклянный
	h) узкий
	i) неограниченный

Read the English verbs and find the Russian equivalents to them.

1	2
1) tap	a) обеспечивать
2) monitor	b) скреплять
3) contain	c) раскрывать
4) convert	d) подключаться
5) conduct	e) проводить
6) provide	f) превращать
7) lash	g) подсоединять
	h) отражать
	i) передавать
	j) содержать

Exercise 2. Read and translate the collocations given below.

Most responsible for its evolution, basic point-to-point fiber optic transmission system, replica of the original signal, wide range of benefits, virtually all kinds, ground loops, there is no possibility of a spark, outdoor atmospheric conditions, information carrying capacity.

LANGUAGE ACTIVITY

Exercise 1. Insert prepositions used in text.

A fiber optic transmitter and receiver are connected ... fiber optic cable. The fiber is totally immune ... virtually all kinds of interference. The basic fiber is made ... glass. Fiber optic cable is ideal ... secure communications systems. Fiber can carry much more information and deliver it ... great fidelity. The optical transmitter converts an electrical analog or digital signal ... a corresponding optical signal. Progressing ... the copper wire to fiber optic cable has promoted technological development in all areas.

Exercise 2. Which of the italicized words in each sentence is the predicate?

1. Last month our laboratory *developed* a new technique *required* for thermodynamic studies of a two-phase system.
2. The technique *allowed* us to obtain results *predicted* by theory.
3. The results *obtained* *disagreed* with earlier data *reported* by Dr. Brown.
4. After a *heated* discussion the laboratory *applied* the method *improved* by Dr. Brown.
5. The model *suggested* *described* adequately the thermodynamic peculiarities *studied* by Dr. Brown.
6. The method *applied* *increased* the accuracy of the results.
7. The scientist theoretically *predicted* *complicated* interaction between the components *involved* in the process.
8. The crystal *produced* *revealed* *cracked* faces.

Exercise 3. Summarize your knowledge of the Sequence of Tenses and the Reported Speech, and put the verbs in brackets into correct form.

1. The librarian says that she (to work) at a primary school in Seattle.
2. The teacher said that her pupil (to be) a very smart boy.
3. We know that experts (to elaborate) new data transmitting technologies.
4. Alexander Graham Bell declared that he (to work out) an optical telephone system.
5. The Corporation sells its transmitters and receivers on the terms it previously (to insist on).
6. It is known that Robert Maurer, Donald Keck and Peter Schultz (to invent) fiber optic wire.

Exercise 4. Convert the sentences into the Reported Speech.

1. – Are you ill? – mother asked.
– No, I'm just tired, - I answered.
2. The teacher said: "The pupil will come tomorrow".
3. My friend said: "I'm working at the state Library now".
4. The boy said: "I did this work yesterday".
5. The freshman asked: "Can I help in the laboratory?"
6. The young scientist said: "I've worked in this laboratory for two years".

Unit 4

WORD STUDY

Exercise 1. Read and translate the collocations below.

Revenue streams, telecommunication transmission, copper wire system, light impulse, shared program software, optical fiber application, optical bandwidth, fiber/coaxial hybrid, optical receiver, optical convert, commercial installation, trunk line, backbone architecture.

Exercise 2. Form nouns from the verbs listed below.

Transmit, receive, convert, connect, communicate, promote, modernize, develop, determine, applicate.

Exercise 3. Fix your attention on the prefix “re” – meaning “again”. Translate these verbs.

Read – reread;
write – rewrite;
make – remake;
combine – recombine;
design – redesign.

UNDERSTANDING A PRINTED TEXT

List of Terms:

allow (for) – предусматривать
attenuation – ослабление, затухание
backbone architecture – основная структура
convert – переходить
curb – ограничение
database – база данных
delivery – доставка, передача
feasible – годный, подходящий
installation – установка
integrate – объединять, включать
node – узел
trunk line – магистральная линия
power companies – энергетическая компания
revenue streams – источники дохода
shared program software – общее программное обеспечение
shrinking – уменьшающийся, сокращающийся
superhighway – супермагистраль
to supplement – в дополнение к
terrestrial – наземный
utilities – предприятия

COMPREHENSIVE READING

Optical Fiber Applications

The use of fiber was generally not available until 1970, when Robert Maurer of Corning Glass Works was able to produce a fiber with a loss of 20 dB/km. It was recognized that optical fiber would be feasible for telecommunication transmission only if glass could be developed so pure that attenuation would be 20dB/km or less. That is 1% of the light would remain after traveling 1 km. Today's optical fiber attenuation ranges from 0.5dB/km to 1000 dB/km depending on the optical fiber used.

The applications of optical fiber communications have increased at a rapid rate since the first commercial installation of a fiber-optic system in 1977. Telephone companies began early on, replacing their old copper wire systems with optical fiber lines. Today's telephone companies use optical fiber throughout their system as the backbone architecture and as the long-distance connection between city phone systems.

Cable television companies have also begun integrating fiber optics into their cable systems. The trunk lines that connect central offices have generally been replaced with optical fiber. Some providers have begun experimenting with fiber to the curb using a fiber/coaxial hybrid. Such a hybrid allows for the integration of fiber and coaxial at a neighborhood location. This location, called a node, would provide the optical receiver that converts the light impulses back to electronic signals. The signals could then be fed to individual homes via coaxial cable.

Local Area Networks (LAN) have also integrated or constructed their systems using optical fiber. A LAN is a collective group of computers, or computer systems, connected to each other allowing for shared program software or databases. Colleges, universities, office buildings, and industrial plants, just to name a few, all make use of optical fiber within their LAN systems.

Power companies are an emerging group that may begin to apply fiber optics as new revenue streams. With declining revenues in the power industry, some utilities are considering entering the telecommunications business as a way to supplement these shrinking revenues.

Based on industry activity, it is evident that fiber optics has become the industry standard for terrestrial transmission of telecommunication information. The choice is not whether to convert to optical fiber, but rather when to convert to optical fiber. The bandwidth needs of the Information Superhighway require a medium, like optical fiber, that can deliver large amounts of information at a fast speed. It will be difficult for copper cable to provide for future bandwidth needs. Satellite and other broadcast media will undoubtedly play a role alongside fiber optics in the new-world telecommunications order. Considering all the services that the telecommunications industries are announcing to be just around the corner, and a modern society that seems to be expecting them, it is evident that fiber optics will continue to be a major player in the delivery of these services.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. Why was the use of fiber optics generally not available until 1970?
2. What could you tell about the applications of fiber optics by telephone companies?
3. How do different cable television companies and LAN systems use optical fiber communications?
4. Why are some power companies so interested in application of fiber optics?
5. Why is it possible to say that fiber optics has become the industry standard for terrestrial transmission of telecommunication information?

Exercise 2. Complete the sentences given below.

1. Until 1970 the use of the fiber optics was ...
2. The choice is not whether to convert to optical fiber, but ...
3. The optical receiver converts the light impulses ...
4. Colleges, universities, office buildings, etc make use of ...

INCREASE YOUR VOCABULARY

Exercise 1. Match the synonyms.

1	2
1) backbone	a) old
2) able	b) remarkable
3) beneficial	c) useful
4) similar	d) personal
5) wonderful	e) analog
6) ancient	f) safe
7) private	g) capable
	h) late
	i) main

Exercise 2. Read and translate explanations of the terms given below.

1. Telecommunications – communications by cable, telegraph, telephone, radio or TV.
2. Telescope – instrument with lenses for making distant objects appear nearer and larger.
3. Convert – change from one form into another.
4. Fiber optics – the use of very thin bundles of glass or plastic fibers that transmit light throughout their length by internal reflection and are used e.g. for transmitting optical signals.
5. Strand – any of the threads or wires twisted or laid parallel to make a cord or cable.

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the Conditional Sentences. Translate the sentences into Russian.

1. Should it be desirable to divide the powder of two substances, several ways are possible.
2. It would be worthwhile investigating the substance mentioned, provided we could get it in sufficient quantity.
3. Should your work meet these conditions, it will be of great service to our industry.
4. Unless the cathode C is water cooled, it will overheat and emit gases.
5. Had it not been for a large size of this body, we should have already weighed it on our pan.
6. If a compass needle were sensitive enough, it would swing back and forth as the waves went on.
7. But for space meteorological stations we would not be able to observe the formation of hurricanes.
8. Provided one knows the rate of the emission, one can determine the range of the particles.
9. If the results of their molecular weight determination had been accredited, the concept of giant molecular structures might have been established long before the 1930s.
10. On Venus were it not for the horrid humid climate, we should probably feel quite at home.
11. If atomic nuclei contain electrons, their charges should be always whole multiples of the electronic charge.
12. Had this material been heated, the reaction might have taken quite a different turn.
13. Providing that a profound change were to occur, slip ought to take place along the direction of maximum stress.

Exercise 2. Put the verbs in brackets into the correct form of Subjunctive Mood I.

1. If he (to understand) the situation, he (to act) differently.
2. If I (to be) you, I (to consider) the matter settled.
3. If these words (to be) synonymous, you (can use) either of them.
4. They (to buy) those implements if they (to need) them.
5. (To be) the temperature higher, the results of the test (to be) better.
6. If you (to classify) the data, fewer tests (to be needed).
7. If the sensitivity measurement of a detector (to be done) with no indication of the time of response, it (to be) of little significance.

Exercise 3. Put the verbs in brackets into the correct form of Subjunctive Mood II.

1. If you (to give) me more time, I (to make) a better experiment.
2. The results (to be) remarkable if all the figures (to be checked).
3. Unless there (to be) an important drawback in the design of the detector, the latter (to be used) in the experiment.
4. If the experiment (to be over), everyone (to leave) the lab.
6. I (not to mention) it if my friends (to warn) me.
7. If you (to use) another technique, the data obtained (to be) more reliable.
8. If he (to have) enough time, he (to test) the equipment.

Exercise 4. Open the brackets paying attention to the Conditional Sentences. Translate the Sentences into Russian.

1. If you studied more hard, you (can learn) English quickly.
2. Would you have learnt more rapidly if you (to have) more lessons in England?
3. Unless the atoms (to be held) together by an externally applied pressure they cannot be brought close enough to be bonded as a solid.
4. If no external force (to act) on a system the total momentum of the system remains unchanged.
5. It would seem that a nucleus would be more stable if it (be made up) exclusively of neutrons.
6. Unless all the necessary mechanical and optical devices had been provided, the position and intensity of spectral lines (no to be recorded).
7. If you (to check) the data, you will find everything in order.
9. If they had mentioned this yesterday, everything (to be done).
10. Had he had enough time, he (to test) the equipment.
11. If the electrons emerged with a wide spectrum of energies, they (be bent) by varying amounts in passing through the magnetic lens and the image (be blurred).

Revise your knowledge of modal verbs.

Exercise 5. Translate these sentences into Russian having in mind the meaning of the modal verb.

Can-ability, may –permission and probability, must necessity, will-inevitability, would-insistence.

1. The sea can be rough in the harbour.
2. A scientist may freely choose his line of research.
3. Most people can question the uncertain, only few can question the obvious.
4. Good ideas should be written down before they are forgotten.
5. A true scientist will enjoy his work more than anything else.
6. Occasionally a machine will go wrong and it is impossible to find out what the matter is.
7. Two basic types of semiconductor laser diode can be distinguished.
8. Free electrons lasers require large facilities since they must make use of sufficiently large e-beam accelerators.

9. After a very short time the electrons in the conduction band will have dropped to the lowest level in that band.
10. It should be noted that preparation of laser crystals requires considerable care and skill.
11. The foil could be irradiated from one or both sides.

REVIEW OF THE CHAPTER II

Exercise 1. *Write a brief summary of the texts. Define the main problems dealt with in the texts. Try to use the following words and expressions in your summary.*

1. As the title implies the text describes
2. It is specially noted that
3. It is spoken in detail
4. The text gives valuable information on .. .
5. ... (e.g. some important facts or principles) are considered (mentioned, discussed, stressed).
6. The text may be of interest (great help) to

Exercise 2. *Topics for discussion on the material of Chapter II.*

1. Do you consider fiber optics to be really usable communication of nowadays and why?
2. How do you view the future of fiber optics?
3. What could you say about the advantages and disadvantages of fiber optic systems?

SUPPLEMENTARY TASKS

IMPROVE YOUR TRANSLATION PRACTICE

TASK 1

Translate the text into Russian. Write down key words from the text.

Fiber Optic Economics

One of the initial economic factors to consider when converting to fiber optics is the cost of replacing wire systems with fiber. Increased demand for optical fiber has brought the prices down within competitive range of copper. However, since transmitters, converters, optical repeaters and a variety of connecting hardware will be needed, the initial cost of changing over to fiber can be expensive. Increased demand, advances in the technology and competition have brought the prices down somewhat. Short term and long term gains should be considered when updating a communication system. In the short term it is often less expensive to continue using copper cabling for covering expanded communication needs. By simply adding more wire to an existing system, expanded needs can be covered. This avoids the expense of adding the transmitters and receivers needed for integrating optical fiber. Long-term needs, however, may require more expansion in the future.

In the long term it may be more cost effective to invest in conversion to fiber optics. This cost effectiveness is due to the relative ease of upgrading fiber optics to higher speeds and performance. It has already been seen in the industry as communication providers are wiring customers with optical fiber bandwidth that exceeds consumer bandwidth needs. This is in anticipation of future bandwidth needs. It is generally accepted that customers will need increased bandwidth as the information highway grows. Replacing copper with fiber today would avoid continuing investment in a soon to be outdated copper system.

Television and telephone companies hurry to build systems that will convert television and telephone technology and thus provide a one-server system for their customers. Fiber optics will play a pivotal role in this race since the bandwidth needed for providing an all-in-one service with television, telephone, interactive multimedia and Internet access is not available in much of the wiring of America. Competition for customers is a strong factor motivating communication networks to convert their systems over to fiber optics.

Competition is not only between providers of fiber optics networks. Recent developments and proposed plans in the satellite industry may have an effect on the use of fiber optics as a transmission medium. The satellite industry is proposing and building several systems that they say will provide the telecommunication services needed without the need for laying more fiber-lines. Like terrestrial cellular systems, satellites also have an advantage over fiber in that they can provide mobile access to telecommunications services. They can provide a level of global ubiquity that is not

possible with fiber optics or with terrestrial cellular. Satellite services could potentially serve rural and undeveloped communities that may never see a fiber optic line come through the part of the world.

None of these satellite systems, however, can provide the bandwidth potential of fiber optics. Fiber optics has the proven ability to deliver more information per second. So, it is no wonder that satellite providers have not announced plans that could effectively provide television, telephone, interactive multimedia and Internet services into an all-in-one service. Evidently, tomorrow is with fiber optics.

Exercise 1. Answer the questions.

1. What economic factors should we consider to decide if to convert to fiber optics?
2. Why may it be more effective in the long term to invest in conversion to fiber optics?
3. Why do television and telephone companies hurry to apply the achievements in fiber optics?
4. What could you tell about the competition between the satellite industry and fiber optics?
5. Does fiber have any advantages over satellite systems?

Exercise 2. Translate the following parentheses into Russian.

Therefore, thus, though, although, probably, basically, however.

Exercise 3. Retell the text, using the aforementioned parentheses.

TASK 2

Read the text and point out the main ideas.

How Optical Fibers Work

Fiber optics is one of the newer words these days. Optical fiber has a number of advantages over the copper wire used to make connections electrically. For example, optical fiber, being made of glass (or sometimes plastic), is immune to electromagnetic interference, such as is caused by thunderstorms. Also, because light has a much higher frequency than any radio signal we can generate, fiber has a wider bandwidth and can therefore carry more information at one time.

But just how does it work? We're talking about a thin, flexible "string" of glass. Looking sideways at it, we can see right through it. How can we keep light that's inside the fiber from getting out all along the length of the fiber?

Consider an ordinary glass of water. We know that if we look through the water at an angle, images will appear distorted. This happens because light actually slows down a little bit when it enters the water, and speeds up again when it moves back into the air again.

Since the light has a slight but measurable width if it hits the water at an angle, the part of the light that hits the water first will slow down first. The result is that the direction the light is traveling changes, and the path of the light actually bends at the surface of the water.

No matter what angle the light is traveling as it approaches the water, it will take a steeper angle once it actually enters the water. You can see this at any time by looking at a picture or newspaper through a glass of water, and by looking at different angles. Even a straw in a glass of water *looks* bent, although it really isn't. This phenomenon is called *refraction*.

Any substance that light can travel through will exhibit this phenomenon to some extent. Glass happens to be a very practical choice for optical fiber because it is reasonably strong, flexible, and has good light transmission characteristics.

Now, consider looking into a glass of water from below the surface of the water. If you look up through the bottom of the glass, you will see a somewhat distorted view of the ceiling or whatever is above the glass. However, if you look in from the side of the glass and observe the underside of the top surface, you will begin to note an interesting and useful effect: the light you see is reflected from the surface, rather than being refracted through it. This effect persists for all angles shallower than the *critical angle* at which the phenomenon first appears. As you might expect, glass or any other material through which light might pass exhibits the same phenomenon.

Consider a single glass fiber. The actual fiber is so thin that light entering one end will experience the "mirror effect" every time it touches the wall of the fiber. As a result, the light will travel from one end of the fiber to the other, bouncing back and forth between the walls of the fiber.

This is the basic concept of optical fibers, and it correctly describes the fundamental operation of all such fibers. Unfortunately, it is not possible to use fibers of this basic construction for any practical application. The reason for this has to do with the physical realities of the phenomenon of reflection within the fiber, and how the parameters involved will change under different conditions.

The basic fact governing the reflection of light within the fiber has to do with the speed of light inside the fiber and the speed of light in the medium just outside the fiber. Every possible material through which light can pass has a characteristic called the *refractive index*, which is a measure of the speed of light through that material as compared to the speed of light in open space.

One of the requirements of an optical fiber is that its diameter remains constant throughout its length. Any change in the thickness of the fiber will affect the way light reflects from the inner walls of the fiber. In some cases, this could even mean that the reflected light could exceed the critical angle required for total reflection, and so be lost through the walls of the fiber.

Unfortunately, the same effect will be noticed if the characteristics of the medium outside the fiber should change. For example, if the fiber gets wet (as it would in rain, fog, or some underground situations), the characteristics of the boundary between the inside and the outside of the fiber will change, and hence the effective shape of the fiber will change and will keep changing as drops of water move along the surface of the fiber.

The easiest way to ensure that the boundary between the inside of the fiber and the outside of the fiber remains constant and unchanging no matter what is to create a permanent boundary of known characteristics. The practical approach is to surround the glass fiber with another layer of glass while making sure that the speed of light in the outer layer remains faster than the speed of light in the inner fiber.

The original fiber is now the *core* of a two-layer construction. The diameter of the core is kept constant at approximately 50 to 60 μm (micrometers, at one time designated "microns") and its surface is kept as perfectly smooth as possible. The outer layer, known as *cladding*, is bonded at all points to the surface of the core.

To the outside world, this construction is effectively one solid piece of glass, even though it is constructed of two different types of glass. Thus, it is impervious to water, dirt and other materials. If the outer surface gets wet, that makes no difference because it still doesn't affect the boundary between the core and the cladding. The whole composite fiber may be covered with rubber or plastic for easier handling and visibility.

Exercise 1. *Make a summary of the text giving answers to the following questions.*

1. What are the advantages of optical fibers?
2. Describe the phenomenon of refraction.
3. What substances exhibit the phenomenon of refraction?
4. What role does the critical angle play?
5. What are the requirements for optical fibers?
6. How is an optical fiber constructed?

Chapter III

Lasers

Unit 1

WORD STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Nouns

acronym, amplifier, characteristic, existence, emission, frequency, microwave, mixture, recognition, technique, technology, width.

Verbs

award, extend, patent, pertain, recognize, require.

Adjective

dynamic, molecular, monochromatic, notable, quantitative, relevant, simultaneous.

Exercise 2. *Read and translate the following international words.*

Fundamental, emission, experimentation, intensity, monochromatic, radiation, recombination, technology.

UNDERSTANDING A PRINTED TEXT

List of Terms:

amplifier – усилитель

cavity dimensions – размеры резонатора

continuous wave (CW) – незатухающая волна

energy level – энергетический уровень

free electron laser – лазер на свободных электронах

forbidden transition – запрещенный переход

high-resolution microwave spectrometer – спектрометр с высокой разрешающей способностью

line width – ширина линии

long-lived energy state – устойчивые энергетические состояния

molecular beam – молекулярный пучок

neodymium-doped glass laser – лазер на стекле с примесью неодима(ND)

optical frequency range – диапазон оптических частот

oscillator – осциллятор, генератор

pink ruby medium – лазерная активная среда на розовом рубине

population inversion – инверсия заселенности энергетических уровней

semiconductor junction laser – диодный полупроводниковый лазер
spontaneous emission – спонтанное излучение
stimulated emission – вынужденное излучение
time delay – временная задержка
wavelength – длина волны

READING FOR DISCUSSION

Maser-Laser History

The devices known as masers and lasers serve as amplifiers and generators of radiation. Their common characteristic is that they make use of the conversion of atomic or molecular energy to electromagnetic radiation by means of the process known as stimulated emission of radiation. When the wavelength of the emitted radiation is in the vicinity of 1 cm we speak of microwave amplifiers or masers. Instruments which generate or amplify visible or nearly visible radiation are called optical masers or lasers.

Albert Einstein recognized the existence of stimulated emission in 1917, but it was not until the 1950s when the first device was demonstrated.

The maser period begins with the publication of an article by the Russian scientists Basov and Prokhorov and the construction of the first operating maser by Townes, Gordon and Zeiger (from the USA). Basov and Prokhorov gave a detailed theoretical exploration of the use of molecular beams in microwave spectroscopy. The article of Basov and Prokhorov contained detailed calculations pertaining to the role of the relevant physical parameters, the effects of line-width, cavity dimensions, and the like. Thus the quantitative conditions for the operation of a microwave amplifier and generator were found.

In 1954 at Columbia University Charles Townes and two of his students announced the construction and operation of a device that may be used as a high-resolution microwave spectrometer, a microwave amplifier, or a very stable oscillator. They named the device a “maser” – an acronym for microwave application by stimulated emission of radiation.

From 1958 on, many masers were constructed for applications in radio astronomy and as components of radar receivers. These masers were mostly of the ruby type. Their design became a part of the engineering art and research interest turned toward the extension of stimulated emission techniques in the visible and infrared regions.

Arthur Schawlow of Bell Laboratories and Charles Townes proposed extending the maser concept to the optical frequency range in 1958.

The maser period extends from 1954 to 1960.

The laser period opens with the achievement of the ruby laser. The acronym l.a.s.e.r. stands for light amplification by stimulated emission of radiation.

Physicist Theodore Harold Maiman invented the first operable laser in 1960. He developed, demonstrated, and patented a laser using a pink ruby medium, for

which he gained worldwide recognition. In 1962 Maiman founded his own company, Korad Corporation, devoted to the research, development, and manufacture of lasers.

Early in 1961 the first continuously operating laser was announced by Ali Javan and his coworkers at Bell Laboratories. This laser was the first to use a gas, a mixture of helium and neon, for the light emitting material. At the same years scientists from American Optical Company made the first neodymium-doped glass laser. In 1962 scientists at General Electric and International Business Machines (IBM) almost simultaneously demonstrated the first semiconductor junction laser.

In 1962 Basov and Oraevskii proposed that rapid cooling could produce population inversions in molecular systems. And in 1966, the first gasdynamic laser was successfully operated at the Avco Everett Research Laboratory.

The 1970s years became the time of discovery of free electron laser.

The 1964 Nobel Prize in physics was awarded to Charles Townes and to the Russian scientists Nikolai Basov and Alexander Prokhorov “for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based in the maser-laser principle”.

Laser applications have also increased in variety. Experiments requiring really high intensities in narrow spectral regions can only be done with lasers. Outside the field of scientific experimentation many applications were found in medicine, communications, geophysical and space exploration, military and metals technology. The potential importance of these applications continues to stimulate new developments in the laser field.

Now lasers are everywhere. In your computer CD-ROM, your CD player, at supermarket and in laser light shows. As far as technologies go, they have been one of the inventions most quickly absorbed into society.

The future of lasers is a promising one. Judging from the quick development of lasers in the past and continuing laser research, there does not appear to be a slowing of laser research in the near future. As time progresses, there will doubtless be new scientists with new ideas and new inventions.

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. What is the common characteristic of masers and lasers?
2. What did Basov and Prokhorov work out?
3. Who was the first to announce the construction and operation of a “maser”?
4. Where were masers mainly applied?
5. What does the acronym l.a.s.e.r stand for?
6. What are the main fields of laser application?

Exercise 2. Join the suitable parts.

1. It was ... who recognized the existence of stimulated emission.
 - a) Townes
 - b) Schawlow
 - c) Einstein

2. Masers and lasers serve as
 - a) amplifiers and generators
 - b) magnifiers
 - c) calculators

3. It was ... who invented the first operable laser.
 - a) Basov
 - b) Townes
 - c) Maiman

4. A laser invented by Ali Javan used ... for the light emitting material.
 - a) ruby medium
 - b) a mixture of helium and neon
 - c) a mixture of helium and nitrogen

5. The 1964 Nobel Prize was awarded to Ch. Townes, N. Basov and A. Prokhorov for fundamental achievements in the field of
 - a) radioactivity
 - b) quantum electronics
 - c) wave optics

INCREASE YOUR VOCABULARY

Exercise 1. Match the synonyms.

Nouns

1	2
1) application	a) development
2) recognition	b) progress
3) invention	c) science
4) evolution	d) use
5) co-worker	e) research
6) importance	f) friend
7) achievement	g) project
	h) colleague
	i) adoption
	j) discovery
	k) significance
	l) mixture

Verbs

1	2
1) generate	a) turn into
2) lead	b) need
3) pertain	c) start
4) convert	d) show
5) gain	e) produce
6) announce	f) connect
7) require	g) receive
	h) declare
	i) conduct
	j) propose
	k) operate
	l) start

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the non-finite forms of the verb and translate the following sentences.

1. Light generated by a laser is known as coherent light.
2. The thin beams of coherent light are used to build laser radar systems.
3. A power supply pumps energy into the active medium exciting the active atoms and making amplification possible.
4. Breaking the circuit causes sparking.
5. The problem to be discussed is connected with the laws of quantum mechanics.
6. She informed us of his having checked and improved the theory.
7. Having made many tests scientist got interesting results.

Exercise 2. Translate the sentences paying attention to the participles.

1. Russian scientists are successfully developing quantum generators called lasers.
2. The mechanism described played an important role in this process.
3. The data presented have been obtained from two series of experiments.
4. An injected excited electron can be stimulated for emitting a proton.
5. Placing a magnetic material in the field of another magnet we can magnetize it to a certain degree.
6. Functioning as a generator the laser is used as a source of coherent light.
7. Having such properties as high intensity, coherence and directionality the laser is a unique source of radiation.

Exercise 3. Summarize your knowledge of the Absolute Participle Construction. Translate the sentences into Russian.

1. The solid being heated, its photons become more and more energetic.
2. The Curies discovered radioactive elements radium and polonium, the latter being named after M. Curie's native country Poland.
3. An electron leaving the surface, the metal becomes positively charged.
4. The cell being charged, a certain quantity of electricity is passed through it.
5. The scanning electron microscope employs either two, three or four electron-optical lenses, all performing the same function.
6. Atoms being held together by electromagnetic forces, their electromagnetic properties can be accurately predicted.

Exercise 4. Summarize your knowledge of emphatic structure "It is (was) ... that" and translate the sentences into Russian according to the model.

Example: It was a ruby crystal that was used in the first lasers.

Именно рубиновый кристалл использовался в первых лазерах.

It was after my first accident that I started driving more carefully.

Только после своей первой аварии я стал ездить более осторожно.

1. It was after the invention of the heterojunction laser that it became possible to operate semiconductor CW laser at the room temperature.
2. It is the X-holography of cells that resulted in obtaining three dimensional pictures with a resolution of a few angströms.
3. It is due to the irradiation of the foil by the pump beam of high intensity that a highly ionized Se plasma could be formed.
4. It was invention of a floppy disk that resulted in a convenient way to read computer programs.
5. It is because the FELs are so large and expensive, that their application is practically limited by the frequency ranges unavailable for conventional lasers.
6. It is due to the Fabry-Perot etalon that the fine tuning can be achieved in color-centers lasers.
7. It was academician Denisyuk's fundamental discovery that paved the way to three-dimensional television.

Unit 2

WORD STUDY

Exercise 1. *Check the transcription in the dictionary, read and translate the words listed below.*

Nouns

vapour, xenon, burst, quartz, chemistry, junction, dye, circuit, efficiency.

Adjectives

ultraviolet, cylindrical, efficient, chemical, infrared, inside, outside, nonmetallic, biometrical.

Exercise 2. *Adjective suffix -able/-ible combined with verbs often means “can be done”, e.g. washable-can be washed or flexible-can be bent. Translate the following adjectives.*

Breakable, readable, tunable, achievable, adjustable, variable, convertible, repeatable, affordable, useable.

UNDERSTANDING A PRINTED TEXT

List of Terms:

arc lamp – дуговая лампа

associative – ассоциативный, объединенный

combustion reaction – реакция сгорания

continuous wave (CW) – незатухающая волна

exothermal chemical reaction – экзотермическая химическая реакция

flash tubes – импульсная лампа, лампа-вспышка

in a pulsed manner – в импульсном режиме

junction – стык, соединение

metal-vapor lamp – лампа с разрядом в парах металлов

retinal treatment – лечение сетчатки

tunable dye laser – перестраиваемый лазер на красителе

xenon flash tube – ксеноновая лампа-вспышка

X-rays – рентгеновские лучи

READING FOR PRECISE INFORMATION

Types of Lasers

According to the laser medium used, lasers are generally classified as solid state, gas, semiconductor, free-electron, liquid, chemical lasers and others.

Solid-State Lasers

The most common solid laser media are rods of ruby crystals and neodymium-doped glasses and crystals. The ends of the rod are fashioned into two parallel surfaces coated with a highly reflecting nonmetallic film. Solid-state lasers offer the highest power output. They are usually operated in a pulsed manner to generate a burst of light over a short time. Certain bursts have been achieved, which are useful in studying physical phenomena of very brief duration. Pumping is achieved with light from xenon flash tubes, arc lamps or metal-vapour lamps. The frequency range has been expanded from infrared (IR) to ultraviolet (UV).

Gas Lasers

The laser medium of a gas laser can be a pure gas, a mixture of gases, or even metal vapour usually contained in a cylindrical glass or quartz tube. Two mirrors are located outside the ends of the tube to form the laser cavity. Gas lasers are pumped by ultraviolet light, electron beams, electric current, or chemical reactions. The helium-neon laser is known for its high frequency stability, color purity, and minimal beam spread. Carbon dioxide lasers are very efficient, and consequently, they are the most powerful continuous wave (CW) lasers.

Semiconductor Lasers

The most compact of lasers, the semiconductor laser usually consists of a junction between layers of semiconductors with different electrical conducting properties. The laser cavity is confined to the junction region by means of two reflective boundaries. Gallium arsenide is the semiconductor most commonly used. Semiconductor lasers are pumped by the direct application of electrical current across the junction, and they can be operated in the CW mode with better than 50 per cent efficiency. A method that permits even more efficient use of energy has been devised. It involves mounting tiny lasers vertically in such circuits, to a density of more than a million per square centimetre. Common uses for semiconductor lasers include CD players and laser printers.

Free-Electron Lasers

Lasers using beams of electrons unattached to atoms and spiralling around magnetic field lines to produce laser radiation were first developed in 1977 and are now becoming important research instruments. They are tunable, as are dye lasers, and in theory a small number could cover the entire spectrum from infrared to X-rays. Free-electron lasers should also become capable of generating very high-power radiation, which is currently too expensive to produce.

Liquid Lasers (Dye Lasers)

The liquid lasers are those in which the active medium consists of solutions of certain organic dye compounds in liquid solvents such as ethyl alcohol, methyl alcohol, or water.

Due to their wavelength tunability, wide spectral coverage, and the possibility of generating very short pulses, organic dye lasers have found an important role in various fields. In particular, these lasers are widely used in scientific applications. Other applications include the biometrical field (e.g., retinal treatment or photodynamic therapy) and applications in the field of laser photochemistry.

Chemical Lasers

A chemical laser is usually defined as one in which the population inversion is “directly” produced by a chemical reaction. According to this definition, the gas-dynamic CO₂ laser should not be regarded as a chemical laser even though the upper state population arises ultimately from a combustion reaction (e.g., combustion of CO with O₂). Chemical lasers usually involve a chemical reaction between gaseous elements, and often involve either an associative or a dissociative exothermal chemical reaction.

Chemical lasers are interesting for two main reasons: (1) They provide an interesting example of direct conversion of chemical energy into electromagnetic energy. (2) They are potentially able to provide either large output power (in CW operation) or large output energy (in pulsed operation). This is because the amount of energy available in an exothermal chemical reaction is usually quite large.

Chemical lasers of the HF type can give large output powers (or energies) with good chemical efficiency. The most important area of these lasers seems to be for high-power military applications.

CHECK YOUR UNDERSTANDING

Exercise 1. Read the text and answer the questions.

1. What types of lasers can you name?
2. What are the most common solid laser media?
3. What are common uses for semiconductor lasers?
4. Where are liquid lasers used?
5. What is the most important area of chemical lasers applications?
6. What are the advantages of free-electron lasers?

Exercise 2. Complete the sentences.

1. Solid-state lasers offer They are usually operated in a pulsed manner...
2. The laser medium of a gas laser can be ...
3. The helium neon laser is known for its high frequency stability, ...
4. Gallium arsenide is ...
5. ... were first developed in 1977 and are now becoming important research instruments.
6. The active medium of the liquid lasers consists of ...
7. A chemical laser is usually defined as one ...

Exercise 3. True or false?

1. The laser medium of a gas laser can be a pure gas, a mixture of gases or even metal vapour.
2. Solid state lasers offer the lowest power output.
3. Liquid lasers have the active medium consisting of solutions of organic dyes compounds in liquid solvents.
4. Chemical lasers don't involve a chemical reaction between gaseous elements.

INCREASE YOUR VOCABULARY**Exercise 1. Find the equivalents.**

1	2
1) amount	a) определение
2) combustion	b) в импульсном режиме
3) definition	c) проводимость
4) conduction	d) фотохимия
5) semiconductor	e) выходная мощность
6) laser beam	f) чистота
7) in a pulsed manner	g) преобразование
8) purity	h) стержень
9) conversion	i) терапия
10) rod	j) краситель
11) output power	k) лазерный луч
12) therapy	l) сгорание
	m) количество
	n) полупроводник

Exercise 2. Match the synonyms.

Verbs

1	2
1) change	a) grind
2) emit	b) alter
3) adjust	c) couple
4) lap	d) agree
5) link	e) radiate
6) coincide	f) align
	g) supply
	h) excite

Nouns

1	2
1) boundary	a) knob
2) handle	b) jacket
3) cover	c) interface
4) core	d) radiation
5) measure	e) current
6) emission	f) nucleus
	g) standard

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the Absolute Participial Construction. Find the constructions in the sentences. Translate the sentences into Russian.

1. Rare elements possessing wonderful properties, it makes them indispensable in science and technology.
2. With the experiments having been carried out, we started our calculations.
3. There being no time left, we had to hurry.
4. Multiple statements expose several viewpoints, each leading to different solutions.
5. The energy sources of the world decreasing, the scientists must find new sources of energy.
6. With revenues declining in power industry, some utilities began to apply fiber optics as new revenue streams.
7. This country has good ports, each possessing good rail connection with the interior.
8. Normally only three operators are required, their duties being concerned with loading of the raw material.
9. The conference being over, the delegates made a tour of the country.

Exercise 2. Summarize your knowledge of the Gerund. Find Gerunds and state their tense, voice and function. Translate the sentences into Russian.

1. Electronic control has become so available that more and more equipment buyers insist on having it.
2. Good management involves selecting people who know when to listen and when to act.
3. Finding enough workers is not a concern for employers nowadays. But finding the right ones may be.
4. This hologram made with laser light is worth seeing.
5. After making a few more experiments professor Benton drew some new conclusions.
6. In doing the work we meet with lots of problems.
7. A specialist wants 96 per cent of the facts before making a decision, whereas a manager can cope with 30 per cent of the available facts and still make a decision that will work.
8. Buying capital equipment such as electron microscopes, up-to-date computers, advanced technologies can be a strain on a company's resources.

Exercise 3. In the texts about lasers you have come across adverbs as considerably, frequently, continuously etc. Let's remember what an adverb is.

At first, these are words which inform us about:

- 1) how something is done (quickly, slowly, carefully, on foot, by bus, etc.). These are adverbs and adverbial phrases of manner;
- 2) where something is done (there, at home, in England, on Web, at work, etc.). These are adverbs and adverbial phrases of place;
- 3) when something is done (yesterday, today, next week, at 5 o'clock, etc.). These are adverbs and adverbial phrases of time.

Now, you should remember the order of these words in a sentence: it is "manner-place-time".

Example: Our students made this experiment successfully last week.

However this order changes as soon as we meet "movement verbs". Then the order is: "place-manner-time".

Example: We went to the Computing laboratory quickly after classes.

Try this exercise.

1. I worked (at the office, hard, today).
2. I'm travelling (every summer, by bicycle, to my native village).
3. He studied (last year, a lot, at university).
4. I drive (every morning, to work).
5. The friend walked (through the park, home, this afternoon).
6. The orchestra performed (at the concert, magnificently, last night).
7. She translated the text (quickly, yesterday, at the lesson).
8. The engineers return (by plane, to France, every weekend).

Exercise 4. Read and give Russian equivalents to the adverbs with two forms and differences in meaning.

deep = a long way down
deeply = greatly
direct = by the shortest route
directly = immediately
easy = gently and slowly
easily = without difficulty
free = without cost
freely = willingly

full = exactly, very
fully = completely
hard = intently: with effort
hardly = scarcely
high = at/to a high level
highly = very much
last = after all others
lastly = finally

late = not early
lately = recently
near = close
nearly = almost
short = suddenly; off target
shortly = soon
sure = certainly
surely = without doubt

wide = fully; off target
widely = to a large extent
wrong = incorrectly
wrongly = incorrectly; unjustly

Exercise 5. Fill in: hard, hardly, hardly ever / anyone / anything.

All that day, I'd been thinking 1) ...*hard*... to myself about whether or not to go to Jane's party. I 2) go to parties, but this time I thought I'd make an effort. I worked 3) all day so that I could leave early and get ready. When I got home, I looked for something nice to wear, and eventually decided on a red dress that I had 4) worn and 5) had seen me in before. Unfortunately, I got caught in the rain and when I eventually arrived there was 6) left, just a couple of Jane's friends. I had 7) talked to them before so making conversation was very 8) As I had eaten 9) all day, I spent the rest of the party in the kitchen alone!

Exercise 6. Underline the correct item, then explain the difference in meaning.

1. The soldier *near/nearly* died as a result of being hit *full/fully* in the chest by a bullet, which penetrated *deep/deeply* inside him.
2. Simon told everyone he would pass the exam *easy/easily*, so he was *deep/deeply* embarrassed when he came *last/lastly* in the class, with 20%.
3. "I *sure/surely* am happy to meet you," said the reporter to the *high/highly* respected singer. "You're *pretty/prettily* famous around here, you know."
4. When he was almost *full/fully* recovered from his illness the doctor told him to take it *easy/easily* and said that he would be able to return to work *short/shortly*.
5. As he was found *near/nearly* the scene of the murder with a knife in his hand, it is *hard/hardly* surprising that he was *wrong/wrongly* accused.
6. *Sure/Surely* you can't have answered every question *wrong/wrongly*.
7. Rob was a very poor archer. His first arrow fell *short/shortly* of the target, his second flew about 10 metres *wide/widely* and the third flew *high/highly* into the air and landed behind him.
8. Although he arrived an hour *late/lately*, he started work *direct/directly* and tried *hard/hardly* to make up for lost time.
9. *Lately/Late* she has been getting all her clothes *freely/free* from the fashion company, so I can't understand why she doesn't dress more *prettily/pretty*.
10. It is *wide/widely* believed that there is a bus that goes *direct/directly* from here to the airport, but it's not true.
11. *Last/Lastly*, I would like to say that I would *free/freely* give my life for the cause of world peace.

Unit 3

WORD-STUDY

Exercise 1. Check up the transcription in the dictionary and read the words listed below.

Nouns

junction, cavity, feedback, crystal, flash, radiation

Verbs

Apply, process, excite, stimulate, induce, inject, pump

Adjectives

Transparent, spontaneous, ruby, entire, uniform

Exercise 2. Translate noun – adjective pairs of words.

Atom – atomic

Molecule – molecular

Electron – electronic

Energy – energetic

System – systematic

Bulk – bulky

Period – periodic

Loss – lossy.

Exercise 3. Fix your attention on the prefix “re” – meaning “again”. Translate these verbs.

Read – reread

Write – rewrite

Make – remake

Combine – recombine

Design – redesign.

UNDERSTANDING A PRINTED TEXT

List of Terms:

coherence – когерентность

coherent radiation – когерентное излучение

continuous operation – непрерывное действие

directionality – направленность

flash-lamp – лампа-вспышка

fluorescence – флуоресценция

frequency width – полоса частот

input energy – входная энергия

pulsed condition – импульсный режим

resonator – резонатор
solid-state laser – твердотельный лазер
spontaneous radiation – спонтанное излучение
end face – торцевая поверхность
excitation current – ток возбуждения
facing side – лицевая сторона
feedback – обратная связь
induced recombination – индуцированная рекомбинация
injection laser – инжекционный лазер
optical pumping – оптическая накачка

COMPREHENSIVE READING

Solid - State Lasers

The laser, by definition, is a device that amplifies light by means of stimulated emission of radiation. The major properties of laser radiation are high intensity, narrow width, directionality and coherence.

In practice a laser is generally used as a source or generator of radiation.

The working element of the ruby laser is a cylinder of pink ruby containing 0.05 per cent chromium. The cylinder is usually between 0.1 to 2 cm in diameter and 2 to 23 cm long; the end faces are plane and parallel to a high degree of accuracy (Fig.1).

In the commonly used laser configuration a ruby rod is surrounded by the coils of a helical flashtube operated usually for a few milliseconds with an input energy of 1000 to 2000 joules.

Lasers require some type of resonator for the radiation field. A resonator provides for a stronger coupling between the radiation and the excited atoms.

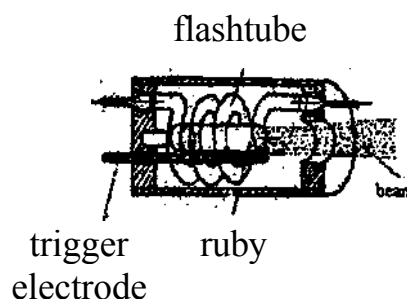


Fig. 1. Construction of ruby laser.

The resonator most commonly used for laser action is composed of two small mirrors facing each other. When the ruby crystal is illuminated by short, intense bursts of white light from a flash tube, a red light beam of enormous power starts to bounce back and forth between the mirrors increasing in strength each time it passes through the ruby. One of the mirrors is partially transparent and from this mirror emerges the intense coherent radiation.

The intensity of this radiation exceeds that of the spontaneous radiation by several orders of magnitude, and spectral range of the induced radiation is considerably narrower than that of fluorescence. The narrowing of the line-width is due to effect of the resonant cavity formed by the mirrors.

Solid-state lasers generally operate in the pulsed condition. The reasons for this are mostly technical. First it is difficult to provide a powerful source of exciting light capable of continuous operation; second, a great deal of heat evolves within the laser which must be dissipated. Ordinary ruby lasers are excited for periods of a few milliseconds, the length of the period being determined by the duration of the exciting flash.

Semiconductor Lasers

Several fundamental modifications of the basic p-n junction electroluminescent diode exist, and chief among these is the semiconductor injection laser. The gallium arsenide semiconductor laser was invented in 1962. (Fig.1).

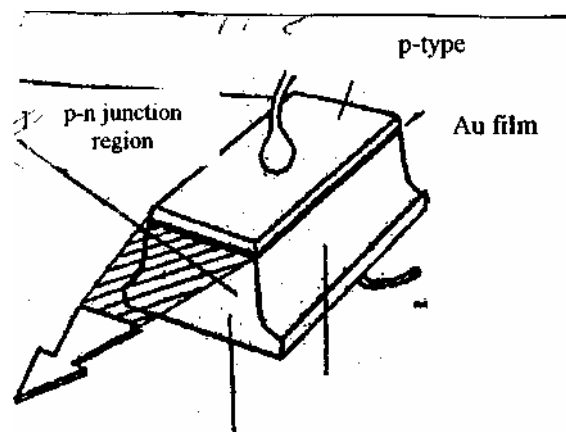


Fig. 1. Construction of typical GaAs semiconductor injection laser.

The gallium arsenide diode consists of a layer of the p-type gallium arsenide and a layer of n-type gallium arsenide. In its simplest form, the injection laser is a direct band-gap LED having an exceptionally flat and uniform junction (the active region) bounded on facing sides by two parallel mirrors perpendicular to the plane of the junction~Which provide a Fabry-Perot resonant cavity to produce quasi-coherent laser radiation.

The lasers usually operate at 77 K, or lower. The p-n junction is usually made by diffusing Zn (acceptor) in one side of a Te (donor)-doped GaAs crystal. The entire area of the junctions is of the order of 10^{-4} cm^2 .

When an intense electric current, about 20,000 amperes per square centimeter, is applied to the device, it emits coherent or incoherent light, depending on the diode type, from the junction between the two layers of gallium arsenide.

Induced recombination of holes and electrons produces photons, which stimulate in-phase recombination and photon emission by other holes and electrons.

The mirrors on either end of the active region provide the optical feedback necessary to sustain laser action, and a small fraction of the wave propagating

between the mirrors emerges from each on each pass. One end face on many commercial lasers is overcoated with a reflective Au film to cause all the radiation to emerge from only one end of the device and thus enhance radiation efficiency.

The most common and best-developed injection laser utilizes GaAs (905 nm), though many other semiconductors have been used to produce wavelengths ranging from 630-nm. ($\text{Al}_x\text{Ga}_y\text{As}$) to 34 μm (PbSnSe).

The development of a semiconductor laser is one of the most important developments in the rapidly changing field of technology. The advantages of this type of laser - a gallium arsenide (GaAs) diode - are great compared to crystal and gas lasers. Semiconductor lasers approach efficiencies of 100% as compared to a few percent of other types; they are excited directly by electric current while other lasers require bulky optical pumping apparatus; because they are excited by an electric current they can be easily modulated by simply varying the excitation current.

CHECK YOUR UNDERSTANDING

Exercise 1. *Answer the following questions.*

1. What are the major properties of laser radiation?
2. In what way is a laser used in practice?
3. What is the working element of a ruby laser?
4. When was the first semiconductor laser invented?
5. What elements does it consist of?
6. What do two parallel mirrors provide?
7. At what temperatures do these lasers operate?
8. In what way is the p-n junction made?
9. Under what conditions does the laser emit light?
10. What semiconductors are used in the injection lasers?
11. What are the advantages of a semiconductor laser?

Exercise 2. *Define what is true and what is false.*

1. Laser light can travel a large distance in outer space with little reduction in signal strength.
2. The gallium arsenide semiconductor laser was invented in 1962.
3. The lasers usually operate at 77⁰C or lower.
4. When the intense electric current about 10000 amperes per square centimeter is applied to the device, it emits coherent or incoherent light.
5. The mirrors on either end of the active region provide the optical feedback.

Exercise 3. *Finish the sentences with the suitable parts.*

1. In practice a laser is used as...
 1. ... an amplifier of current.
 2. ... a source of radiation.
 3. ... a frequency converter.

2. This intensity of the laser radiation...
 - a) ... is equal to that of the spontaneous radiation.
 - b) ... is smaller than that of the spontaneous radiation.
 - c) ... exceeds that of the spontaneous radiation.

3. A resonant cavity is necessary ...
 - a) ... to produce photon emission.
 - b) ... to produce coherent radiation.
 - c) ... to produce diffusion electron.

4. In semiconductor laser light is emitted ...
 - a) ... from the layer of p-type.
 - b) ... from the layer of n-type.
 - c) ... from the junction between the two layers.

5. Two parallel mirrors in the laser provide ...
 - a) ... a resonant cavity.
 - b) ... a p-n junction.
 - c) ... optical pumping.

INCREASE YOUR VOCABULARY

Exercise 1. Match Russian and English equivalents.

1	2
1) uniform junction	a) однородный переход
2) parallel mirrors	b) параллельные зеркала
3) resonant cavity	c) объемный резонатор
4) coherent light	d) когерентный свет
5) entire area	e) общая площадь
6) photon emission	f) фотонная эмиссия
7) active region	g) активная зона
8) optical feedback	h) оптическая обратная связь
9) reflective film	i) отражающая пленка
10) radiation efficiency	j) эффективность излучения
	k) оптическая накачка
	l) когерентное излучение
	m) инжекционный лазер

Exercise 2. Match the synonyms.

Adjectives

1	2
1) single	a) usual
2) convenient	b) energetic
3) typical	c) various
4) synchronous	d) suitable
5) different	e) individual
6) active	f) actual
7) near	g) similar
8) same	h) simultaneous
	i) close
	j) auxiliary
	k) some
	l) passive

LANGUAGE ACTIVITY

Exercise 1. Define the functions of Infinitive Constructions in each sentence.

1. The idea of the experiment is to transform gas into metal.
2. Astronomers use radar to explore the Universe.
3. The experiment is to be carried out at low pressure.
4. To transmit the human voice around the Earth became possible by means of radio
5. I'm glad to have come in time to see her off.
6. The instrument to be tested will help us to compare the sources of illumination.
7. To understand this rule we have to read it several times.
8. I don't want to burden you with my own troubles.
9. To carry more current a larger conductor must be used.
10. The telephone is out of order, you'll have to make your call from a public phone.
11. To prove this law experimentally is very difficult.
12. Higher education is a major issue to be discussed.

Exercise 2. Translate the sentences paying special attention to Infinitive Constructions.

1. The radius of our orbit is believed to be increasing very slowly.
2. The copper to be refined is cast into large plates.
3. This property allows the alpha particles to be detected.
4. There appeared to be two distinct effects in this case.
5. Electrons can be made to travel at very high speeds.
6. The idea of nuclear charge and atomic number is now realized to be most important.

7. The cooling is effected by methods to be discussed in the next chapter.
8. A certain period of time must be allowed for the oil drops to be removed by the electric field or by precipitation.
9. There appears to be direct evidence of the existence of negative electrons in matter.
10. The distance “d” was calculated from equation 1-25 and found to be 2.814 angströms.
11. The best agreement is to be found in the case of carbonic acid.
12. In our discussion the nucleus will be taken to be at rest.
13. We may suppose the alpha-particles within nucleus to be in motion.
14. Ordinary objects are not likely to move with a velocity approaching the velocity of light.

Exercise 3. Translate from Russian into English.

1. В статье описывается полупроводниковый лазер.
2. Полупроводниковый лазер на арсениде галлия был изготовлен в 1962 г.
3. Он состоит из двух слоев арсенида галлия.
4. Один слой – это слой n-типа, а другой – p-типа.
5. Инжекционный лазер имеет очень ровный (плоский) переход.
6. Два параллельных зеркала образуют объемный резонатор.
7. Лазеры работают при $t^0=77\text{K}$ и ниже.
8. Когерентный свет выходит из перехода между двумя слоями арсенида галлия.
9. Зеркала обеспечивают обратную связь.
10. Излучение выходит только с одной стороны прибора.
11. Главное преимущество полупроводникового лазера – самый высокий КПД.
12. Полупроводниковые лазеры возбуждаются электрическим током.

Exercise 4. Translate the sentences into Russian paying attention to the structure “is made to do”.

1. In this laser the electron is made to pass through the magnetic field generated by the wiggler.
2. The first FEL was made to operate at $\lambda=3.4$ mm using the Standford University linear accelerator.
3. Only two types of color-centres have been made to lase.
4. Mode-locked color-center lasers emitted at $\lambda=1.5$ mm have been made to generate very short pulses in single-mode fibers.
5. X-ray lasers are usually made to operate without mirror.
6. Semiconductor lasers were made to operate CW at room temperature after the invention of the heterojunction laser in 1969.

Unit 4

WORD-STUDY

Exercise 1. Check up the transcription in the dictionary and read the words and expressions listed below. Translate them.

Suitable, operate, conventional, frequency generator, internal discharge, beam of coherent infra-red light, mixture, remarkable monochromaticity, stability.

Exercise 2. Find the equivalents.

Electrical discharge, conventional tube, energy level, internal discharge, collision process, continuous stream, infrared light, inside diameter, simplified diagram, experimental conditions, end mirror, chemically stable, flowing nitrogen, large amounts of power.

Процесс столкновений, поток азота, инфракрасный свет, экспериментальные условия, электрический разряд, большая мощность, упрощенная диаграмма, обычная трубка, торцовое зеркало, внутренний разряд, энергетический уровень, непрерывный поток, внутренний диаметр, химически стабильный.

UNDERSTANDING A PRINTED TEXT

List of Terms:

continuously operating source – источник непрерывного действия

energy level – энергетический уровень

excitation – возбуждение

monochromaticity – монохроматичность

output beam – выходящий луч

output power – выходная мощность

carbon dioxide laser – лазер на двуокиси углерода (углекислом газе)

electric discharge – электрический разряд

fold – сгибать

ground state – основное состояние

isolated atom – изолированный атом

molecular laser – молекулярный лазер

neutral atom laser – лазер на нейтральных атомах

vibrational energy – энергия колебания

COMPREHENSIVE READING

Gas and Molecular Lasers

Gas Lasers

Gases offer interesting possibilities as laser materials because their atoms are more suitable for excitation. The neon lasers were the first to be discovered and studied and are the easiest to construct and to operate. They use a mixture of helium and neon gases through which an electrical discharge flows, in the same way as in a conventional neon tube.

The discharge is provided by the radio-frequency generator which is usually operated in the 25-to-30 mc region. It serves to establish an electric discharge in the gas, although a d-c discharge may serve the purpose as well.

The energy from the internal discharge excites the helium atoms to a very light energy level, from which they normally would not radiate energy. However, the neon atoms in the mixture collide with the excited helium atoms, and the energy is transferred to them through the collision process. The neon atoms themselves can then be stimulated to radiate their energy in a continuous stream.

The beam is reflected back and forth through the length of gas-filled tube by semi-reflecting end plates, growing in intensity with each trip. Some part of the beam is transmitted through the plates, and forms a very narrow output beam of coherent infra-red light (Fig.1).

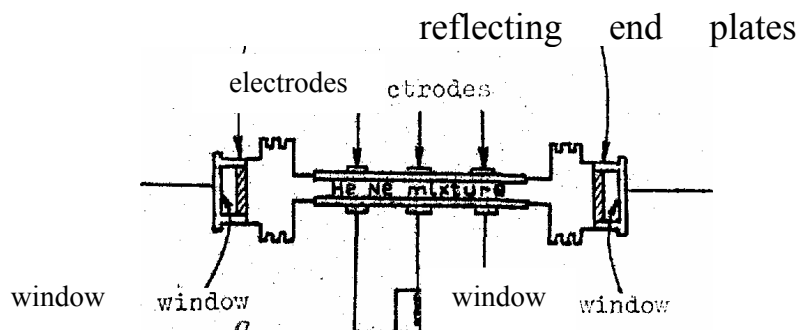


Fig.1. Construction of He-Ne laser

The first such laser was built in 1960 at Bell Telephone Laboratories. It consists of a discharge tube 100 cm long with an inside diameter of 1.5 cm filled with helium at 1 torr pressure and with neon at 0.1 torr. Flat reflector plates, which must be adjusted parallel within a few seconds of arc, are included in the gas filled section of the tube.

A simplified diagram of this laser is given in Fig.1.

The power required to excite the laser action is in the tens-of-watts range. The output power is in the 1/100-th watt range. At this level of operation, the tube is so cool that it can be held in the hand without discomfort.

The great value of helium-neon lasers is their remarkable monochromaticity and stability under carefully controlled experimental conditions.

To communication engineers such a continuously operating source is an important device.

Molecular Lasers

Molecular lasers are the most high powered and most efficient type of gas laser. They work by the transfer of vibrational energy from one type of molecule to another. The atoms making up the molecule, when it is excited, vibrate relative to one another, and the molecule has energy levels similar in form, although of different value, to the energy levels of isolated atoms. But the process does not involve the movement of orbiting electrons to more distant orbits.

The type of structure used in molecular lasers is very different from that used in neutral atom lasers. In one type of molecular laser, flowing nitrogen is excited by electrical discharge and then flows into the tube between the end mirrors which contains the active gas. This is usually carbon dioxide. The vibrational energy of the nitrogen molecules is transferred to the carbon dioxide molecules by collision, and the carbon dioxide atoms later return to the ground state giving up the energy to the laser beam.

An efficiency of about 15 per cent was obtained with the carbon dioxide type, which is far greater than the 0.1 per cent achieved with the neutral atom lasers. Apart from the fact that it is more efficient than the other molecular gases, carbon dioxide also has the advantage that it is chemically stable and can, if necessary, be excited directly by an electric discharge.

The path between the end mirrors, that is, the length of the carbon dioxide laser tube, must be as long as possible if large amounts of power are to be obtained. Tubes 20 m long have been used and if such lasers are to be conveniently mobile they must be folded in some way. Two, three and four tubes placed parallel to each other and optically coupled have been used in some carbon dioxide lasers.

Abbreviations

mc – megacycle – единица измерения частоты = 1 млн герц

d.c. – direct current – постоянный ток

torr – тор - единица измерения давления

1 torr = 1 мм ртутного столба

760 torr = 1 атмосфера

CHECK YOUR UNDERSTANDING

Exercise 1. Answer the following questions.

1. Why do gases offer interesting possibilities as laser materials?
2. What is the most high powered type of gas laser?
3. Describe how helium-neon laser works. Why is the helium-neon type of laser of great value?
4. How do molecular lasers operate?
5. What are the advantages of carbon dioxide laser over neutral atom laser?

Exercise 2. Rearrange the sentences in a logical order to make a summary of the text.

1. If we want to obtain large amounts of power, the length of the carbon dioxide laser must be as long as possible.
2. The neon lasers were the first to be discovered and studied.
3. The vibrational energy of the nitrogen molecules transferred to the carbon dioxide molecules by collision.
4. Molecular lasers work by the transfer of vibrational energy from one type of molecules to another.
5. The energy from the internal discharge excites the helium atoms to a very high level. From which they normally would radiate energy.
6. The beam in the neon laser is reflected back and forth through the length of gas-filled tube by semi-reflecting end plates.
7. Later carbon dioxide atoms return to the ground state.

Exercise 3. Is it false or true?

1. Gas lasers, namely helium-neon lasers, have a very low level of monochromaticity.
2. The efficiency of the carbon dioxide laser is greater than that of the neutral atom lasers.
3. The first gas laser was built in 1960 at Bell Telephone Laboratories.
4. The vibrational energy of the nitrogen molecules is transferred to the carbon dioxide molecules by radiation.

INCREASE YOUR VOCABULARY

Exercise 1. Match the synonyms.

Verbs

1	2
1) place	a) transfer
2) couple	b) put
3) operate	c) regulate
4) transmit	d) work
5) obtain	e) achieve
6) adjust	f) bound
	g) establish
	h) manipulate
	i) excite

Nouns

1	2
1) action	a) combination
2) mixture	b) opportunity
3) possibility	c) operation
4) state	d) position
	e) energy
	f) contamination

LANGUAGE ACTIVITY

Exercise 1. Transform the following sentences into one with the Complex Subject Structure as shown below.

Model: We assume that Equation 4 is used for simplicity.

Equation 4 is assumed to be used for simplicity.

1. We suppose that electrons are raised from the valence band to the conduction band.
2. We consider that semiconductors deal with a wave function relating to the crystal as a whole.
3. We know that laser action was first observed in 1962 using Ga As.
4. They say that semiconductor-laser pumping has been achieved in a number of ways.
5. We believe that atomic and molecular systems energy levels belong to single atoms or molecules.

6. We see that population inversion is achieved in a narrow stripe between the p and n sides of the junction.
7. We found that some color-center lasers have been mode-locked.
8. It is reported that mode-locked color-center lasers generate very short pulses in single-mode fibers.

Exercise 2. Translate into Russian paying attention to the Complex Object Structure.

1. Computer people know the number of viruses to be rapidly growing.
2. The researchers expected the combined effect of a few factors to reduce the threshold current density.
3. She doesn't want her washing-machine to have been broken down again.
4. Such a diode structure of the Ga As laser allows the current density to be reduced.
5. To make a computer collect data is much better than to pay a person to do the same work.
6. Going from the green to the soft X-ray region we see the wavelength decrease by a factor of 50.
7. They assumed the energy barriers to have confined injected holes and electrons within the active region.
8. We believe other types of double-heterojunction lasers to be vigorously developed.
9. We expect the web to provide distant students with full university level courses.
10. The mass-media report the environment to have been heavily polluted due to the man's irresponsible activity.
11. By means of a special program the experimenter made the robot obey his commands.

Exercise 3. Summarize your knowledge on non-Finite forms. Define the form of the underlined words (Infinitive, Participle - I, Participle - II, Gerund). Translate the sentences.

1. While carrying out his experiment Heinrich Lamm reported transmitting the image of a light bulb.
2. His goal was to look inside inaccessible parts of the object.
3. The team had solved the problems presented by Dr. Kao.
4. Having been tested, the new apparatus was recommended for work in all the laboratories.
5. The experiments of the physicists resulted in making much more powerful microscopes.
6. The described results of the test depended on the accuracy of the used instrument.
7. Diagrams illustrate two methods of connecting a series of cells.
8. Some of the produced effects are discussed in the following chapter.

Exercise 4. While translating the sentences pay attention to the chains of attributes.

1. The transmitter processes and translates the information into *equivalently coded light pulses*.
2. The optic core is *the light carrying element* at the center of the optical fiber.
3. In other words *the coded light pulse information* is translated back into its original state as *the coded electronic information*.
4. The electronic information is then ready for input into *electronic based communication device*, such as a computer, telephone or TV.
5. When a photon is absorbed by an electron and becomes excited there is a rapid transition into *another long-lived energy state*.
6. The development of a semiconductor laser is one of the most important developments in *the rapidly changing field* of technology.

Unit 5

WORD STUDY

Exercise 1. *Check the transcription in the dictionary and read the words listed below.*

Alignment, geodetic, cauterize, lesions, missile, satellite, isotope, fusion, reduction.

Exercise 2. *Read and translate the collocations given below.*

To trim microelectronic components, to heat-treat semiconductor chips, to cut fashion patterns, trace substances, tunable dye laser, to vaporize lesions, a small fraction of a second

Exercise 3. *Make nouns from the following verbs according the model and translate them.*

Verb + ing

to pump, to process, to focus, to lock, to tune, to scatter, to broaden.

Verb + ion

to compress, to oscillate, to investigate, to operate, to indicate, to emit, to propagate.

Verb – noun

to increase, to decrease, to trap, to center, to focus, to pump, to power, to slope.

UNDERSTANDING A PRINTED TEXT

List of Terms:

cauterize – прижигать

crustal – корковая руда

dye laser – лазер на красителе

earthbound communication – наземная связь

exposure time – время экспонирования

fashion patterns – формы образцов

frequency shift – сдвиг по частоте

fusion – плавление

heat-treat – подвергать термообработке

high-density information recording – высокая плотность записи информации

laser-activated switches – лазерные переключатели

lesions – повреждения

low-loss optical fibers – оптические волокна с низкими потерями

protective goggles – защитные очки

trim – подрезать, формировать

trace substances – следы вещества

SCAN-READING

Laser Applications

The use of lasers is restricted only by imagination. Lasers have become valuable tools in industry, scientific research, communication, medicine, military technology, and the arts.

Industry

Powerful laser beams can be focused on a small spot with enormous power density. Consequently, the focused beams can readily heat, melt or vaporize material in a precise manner. Lasers have been used, for example, to drill holes in diamonds, to shape machine tools, to trim microelectronic components, to heat-treat semiconductor chips, to cut fashion patterns, to synthesize new material, and to attempt to induce controlled nuclear fusion. The powerful short pulse produced by a laser also makes possible high-speed photography with an exposure time of several trillionths of a second. Highly directional laser beams are used for alignment in road and building construction.

Lasers are used for monitoring crustal movements and for geodetic surveys. They are also the most effective detectors of certain types of air pollution. In addition, lasers have been used for precise determination of the earth-moon distance and in tests of relativity. Very fast laser-activated switches are being developed for use in particle accelerators, and techniques have been found for using laser beams to trap small numbers of atoms in a vacuum for extremely precise studies of their spectra.

Scientific Research

Because laser light is highly directional and monochromatic, extremely small amounts of light scattering or small frequency shifts caused by matter can easily be detected. By measuring such changes, scientists have successfully studied molecular structures. With lasers, the speed of light has been determined to an unprecedented accuracy, chemical reactions can be selectively induced, and the existence of trace substances in samples can be detected.

Communication

Laser light can travel a large distance in outer space with little reduction in signal strength. Because of its high frequency, laser light can carry, for example, 1,000 times as many television channels as are now carried by microwaves. Lasers are therefore ideal for space communications. Low-loss optical fibres have been developed to transmit laser light for earthbound communication in telephone and computer systems. Laser techniques have also been used for high-density information recording. For instance, laser light simplifies the recording of a hologram, from which a three-dimensional image can be reconstructed with a laser beam.

Medicine

Intense, narrow beams of laser light can cut and cauterize certain tissues in a small fraction of a second without damaging the surrounding healthy tissues. They have been used to "weld" the retina, bore holes in the skull, vaporize lesions, and cauterize blood vessels. Laser techniques have also been developed for lab tests of small biological samples.

Military Technology

Laser guidance systems for missiles, aircraft, and satellites are commonplace. The use of laser beams against hostile ballistic missiles has been proposed, as in the defence system urged by US President Ronald Reagan in 1983. The ability of tunable dye lasers to excite selectively an atom or molecule may open up more efficient ways to separate isotopes for construction of nuclear weapons.

Laser Safety

Because the eye focuses laser light as it does other light, the chief danger in working with lasers is eye damage. Therefore, laser light should not be viewed, whether it is direct or reflected. Lasers should be used only by trained personnel wearing protective goggles.

CHECK YOUR UNDERSTANDING

Exercise 1. *Read the text and answer the questions.*

1. Why are lasers ideal for space communication?
2. What is the use of lasers restricted by?
3. Why are lasers used in so many fields of our life?
4. Why should lasers be used only by trained personnel wearing protective goggles?
5. In what sphere to your mind have lasers found the widest application and why?

Exercise 2. *Find the suitable endings of the following sentences.*

1. Lasers have become valuable tools in...
 2. Powerful laser beam can be focused on...
 3. Lasers are also the most effective detectors of...
 4. Laser techniques have also been used for...
 5. Lasers have been used to...
 6. Laser techniques have also been developed for...
- a) industry, scientific research, communication, medicine, military technologies and arts.
 - b) a small spot with enormous power density.
 - c) certain types of air pollution.
 - d) high-density information recording.
 - e) "weld" the retina, bore holes in the skull, vaporize lesions and cauterize blood vessels.
 - f) lab tests of small biological samples.

Exercise 3. Translate the passage “Military Technology” and discuss the topic “What do you think about missile defense systems situation in Russia and the USA?”

INCREASE YOUR VOCABULARY

Exercise 1. Read English words and collocations and find Russian equivalents to them.

1	2
1) exposure time	a) импульс
2) frequency shift	b) система защиты
3) speed of light	c) ядерное плавление
4) laser light	d) свет лазера
5) intensity	e) вред
6) tunable dye laser	f) структура молекулы
7) damage	g) лазерный луч
8) defense system	h) защита
9) nuclear weapon	i) скорость света
10) pulse	j) интенсивность
11) molecular structure	k) перестраиваемый лазер на красителе
	l) сдвиг по частоте
	m) время экспонирования

Exercise 2. Translate the following word combinations with Participle II as an attribute.

Focused beams, powerful short pulse produced by, very fast laser-activated switches, small frequency shifts caused by, in the defense system urged by, trained personnel.

LANGUAGE ACTIVITY

Exercise 1. Summarize your knowledge of the types of Subordinate Clauses. Form one sentence out of two using conjunctions given in brackets and translate it.

1. I don't remember the day. They left for London. (when)
2. We went across the fields. There stood Anne's cottage. (where)
3. I asked him. He wanted of me. (what)
4. I thought. He was a good actor. (that)
5. He managed to get such books. He did not tell me about it. (how)
6. I couldn't come to see you. I was unwell. (because)
7. Wait for me a little. You are not in a hurry. (if)
8. I met them. They arrived from London. (as soon as)
9. I leave Stratford. I'll let you know. (before)
10. The reason is not clear. Many students were absent at the lecture. (why)

Exercise 2. Translate the sentences into English using conjunctions “which”, “when”, “if”, “as”, “where”, “that”, “till”.

1. Школа, в которой (где) я учился, находится в центре города.
2. Вот книга, которую вы хотели прочитать.
3. Преподаватель сказал, что я должен много работать над английским произношением.
4. Когда мы вернулись, было уже темно.
5. Я буду ждать до тех пор, пока вы не позвоните.
6. Мы не могли вас навестить, так как только вчера прибыли из Лондона.
7. Если дождь не прекратится, мы не пойдём гулять.

Exercise 3. Cross out “that”, “who”, “which”, “when” if one can manage without them. Underline the subject in the second sentence.

1. This is the house that Jack built.
2. This is the house that stands next to mine.
3. He only likes people who like him.
4. He only talks to people who/whom he likes.
5. He told me an anecdote which I remember for a long time.
6. The newspaper gives the facts that speak for themselves.
7. I think Mary is a person who forgets nothing.
8. Jim is the person that everyone is talking about.
9. He said he was sorry and the question which he had asked meant nothing bad and that was true.
10. What's the time when the bus comes?

REVIEW OF THE CHAPTER III

Exercise 1. Give a brief summary of Texts 2, 3 and 4 using the following words and expressions.

This text deals with ...

The four main types of lasers ...

It's known ...

Nevertheless ...

Therefore ...

Just for that ...

It's not by chance ...

They are widely used ...

Exercise 2. Topics for discussion on the material of Chapter III.

1. How many stages in maser-laser history can you find?
2. Who contributed much to the development of masers and lasers?
3. What other (not mentioned in the texts) uses of lasers do you know?

SUPPLEMENTARY TASKS

IMPROVE YOUR TRANSLATION PRACTICE

TASK 1

Translate the text using the words given below.

Появление лазеров было результатом работ по созданию генераторов СВЧ-диапазона (1) (мазеров). Обычно лазер определяют как генератор электромагнитного излучения оптического диапазона, основанный на использовании вынужденного излучения (2). С другой стороны (3) квантовый генератор (лазер) может рассматриваться (4) как техническое устройство для преобразования энергии в электромагнитную энергию высокой частоты (5) (как правило (6), видимой или инфракрасной). Изобретение лазеров является одним из наиболее выдающихся достижений науки и техники XX века. Первый лазер появился в 1960-ом году. С тех пор происходит интенсивное развитие лазерной техники. В короткое время (7) были созданы разнообразные типы лазеров и лазерных устройств для решения конкретных научных и технических задач. Лазерная техника сравнительно молода, однако, лазеры уже широко применяются во многих отраслях (8) народного хозяйства и в промышленности.

- 1) super high frequency range;
- 2) stimulated emission;
- 3) on the other hand;
- 4) may be considered;
- 5) high frequency electromagnetic energy;
- 6) as a rule;
- 7) for a short period of time;
- 8) branch.

TASK 2

Translate the text into English using the words given below. Where is laser, welding used nowadays?

Лазерная сварка

Одним из первых применений лазеров в ювелирной отрасли были операции ремонта различных изделий с помощью лазерной сварки. Примером применения в массовом производстве лазерной сварки может быть лазерная сварка цепей при их производстве. Особенностью этого процесса является его двухэтапность: сначала формируется цепочка, потом производится ее пайка

традиционными методами. Лазерная технология позволяет производить сварку звена цепи при его формировании на одной технической операции и одном и том же оборудовании. Впервые такая технология была разработана для сварки золотых цепочек итальянской фирмой Laservall. Преимущество лазерной сварки – локальность ввода тепла, низкие потери материала при сварке, возможность соединения деталей практически без нагрева всего изделия целиком.

- 1) to make a hole;
- 2) to drill;
- 3) labour-consuming;
- 4) jewels (используемые в часах драгоценные камни);
- 5) chain;
- 6) manufacture;
- 7) soldering;
- 8) two-step;
- 9) welding;
- 10) chain section;
- 11) advantages;
- 12) low losses;
- 13) heating.

TASK 3

Translate the text into English. In what branches of medicine are lasers used?

Лазеры в медицине

Одним из крупнейших открытий прошлого века являются лазеры.

Лазеры - это квантовые генераторы оптического диапазона или просто генераторы света. Лазеры представляют собой источники света, работающие на базе процесса вынужденного испускания фотонов возбужденными атомами или молекулами под воздействием фотонов излучения, имеющих ту же частоту.

В сравнительно короткое время появились различные типы лазеров и лазерных устройств, предназначенных для решения конкретных научных и технических задач. Принято различать два типа лазеров: усилители и генераторы. Второй подход к классификации лазеров связан с физическим состоянием активного вещества. С этой точки зрения лазеры бывают твёрдотельными, газовыми, жидкостными, полупроводниковыми.

В настоящее время в большинстве стран мира наблюдается интенсивное внедрение лазерного излучения в биологических исследованиях и в практической медицине. Клинические наблюдения показали эффективность лазера ультрафиолетового, видимого и инфракрасного спектров для местного применения на патологический очаг и для воздействия на весь организм.

Исключительные свойства лазеров привлекли внимание хирургов. Оказывается, что луч лазера с успехом используется в качестве скальпеля. По сравнению с обычным такой скальпель обладает рядом достоинств: надёжность в работе, абсолютная стерильность, производит почти бескровный разрез и т.д.

Лазерный луч найдёт применение в качестве прижигающего инструмента для обработки кожных новообразований и повреждений.

Исследования, демонстрирующие потенциальные возможности применения лазеров в медицине, пока находятся на начальной стадии, и развитие этих областей требует длительных поисков во многих направлениях.

TASK 4

Translate into Russian the following texts in writing. Write down key-words from the texts.

How a Laser Works

The Basics of an Atom

Everything we see within the universe is made up of an infinitely large number of combinations of the 100 different kinds of atoms. The arrangement and bonding of these atoms determines what material/object they constitute.

Atoms are constantly in motion. They continuously vibrate and move. Although all atoms are vibrating to a degree, atoms can be in a different state of excitation (i.e. they can have different levels of energy). If a large degree of energy is applied to an atom then it can leave what is referred to as ground-state energy level and go to an excited level. The level of excitation is proportional to the amount of energy applied.

A simple atom as shown in Figure 1 consists of a nucleus, which consists of protons and neutrons and what is often referred to as an electron cloud. For a simplistic interpretation of the atom model it is easy to think of the electrons within the electron cloud following discrete paths or orbits within the cloud. This analogy suits our purpose as we can then consider these orbits to be the different energy levels that make up the atom. If we add some form of energy to the atom we can assume that electrons from the lower-energy orbitals will transfer to the higher-energy orbitals at a greater distance from the nucleus, resulting in a higher level of excitation.

Electron Nucleus orbit

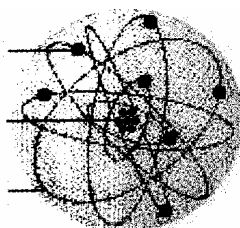


Fig.1. Simple Atom Model

When atoms reach a higher-energy orbital they eventually seek to return to the ground-state energy level. Upon returning to ground-state energy level the excess energy is released in the form of a photon - a particle of light.

The Connection Between Atoms and Lasers

A laser is a device that controls the way in which energised atoms release photons. There are many different types of laser available; all the different types of laser rely on the same basic elements. In all types of laser there is a lasing medium, which is pumped to get the electrons within the atoms to a higher-energy orbital i.e. to get the atoms excited. Typically, very intense flashes of light or an electrical discharge pump the lasing medium and create a large number of excited-state atoms. This creates a high degree of population inversion (the number of excited state atoms versus the number of atoms at ground-state energy level). At any stage the excited state atoms can release some of the energy and return to a lower-energy orbital. The energy released, which comes in the form of photons, has a very specific wavelength that is dependant on the level of energy or excitation of the electron when the photon is released. Two identical atoms with electrons in identical states will release photons with identical wavelengths. This forms the basis for laser light.

Laser light has the following properties:

- Laser light is monochromatic. It contains one specific wavelength of light, which as described earlier is determined by the amount of energy released when the electron drops to a lower-energy orbital.
- Laser light is coherent Each photon moves in step with the other (i.e. all photons have wave fronts that move in unison).
- Laser light is highly directional (i.e. a laser beam is very tight and concentrated).

Any photon that has been released by an atom, (which therefore has a wavelength, phase and energy level dependant on the difference between the excited atom state and the ground-state energy level) should encounter another atom that has another electron in the same excited state, stimulated emission can occur. The first photon can stimulate or induce atomic emission so that the emitted photon vibrates with the same frequency and direction.

UNDERSTANDING A PRINTED TEXT

TASK 6

Translate the text and answer the questions.

Lasers in Communication

Fiber optic cables are a major mode of communication partly because multiple signals can be sent with high quality and low loss by light propagating along the fibers. The light signals can be modulated with the information to be sent by either

light emitting diodes or lasers. The lasers have significant advantages because they are more nearly monochromatic and this allows the pulse shape to be maintained better over long distances. If a better pulse shape can be maintained, then the communication can be sent at higher rates without overlap of the pulses. Telephone fiber drivers may be solid state lasers consuming power of only half a milliwatt. Yet they can sent 50 million pulses per second into an attached telephone fiber and encode over 600 telephone conversations.

1. What is the text about?
2. Why are fiber optic cables becoming a major mode of communication?
3. What lasers may be telephone fiber drives?
4. How many telephone conversations can be encoded per second?

TASK 7

Translate the text and entitle it.

Laser cutters are credited with keeping the U.S. garment industry competitive in the world market. The programmed cutter can cut dozens to hundreds of thicknesses of cloth, and can cut every piece of the garment in a single run. The usefulness of the laser for such operations comes from the fact that the beam is highly collimated and can be further focused to a microscopic dot of extremely high energy density for cutting.

TASK 8

Read the text given below and answer in what abstract your can you find the information about:

- a) holography;
- b) using of laser beams in building construction;
- c) computing the distance to the Moon;
- d) medical uses of lasers.

Laser Uses

1. Eye surgeons can use laser beams to "weld" detached retinas back onto the eyeball without cutting into the eye. The laser beam is directed onto the retina through the pupil of the eye. Scar tissue forms at the impact site of the laser beam and at that point fastens the retina to the inner surface of the eye.

2. Laser beams have been used for industrial purposes. The diamond dies through which extremely thin wire filaments are drawn can be drilled with a laser beam. The already narrow beam of light can be further reduced to a diameter of less than 0.001 inch. The energy concentrated in this tiny beam is known to be sufficient to cut through diamond.

3. Laser beams are sometimes used as reference points* in building construction. They accurately mark straight lines along the course of large buildings. A laser beam is used by scientists to detect whether portions of a two-mile-long particle accelerator in Stanford, California, move out of alignment.

4. Three-dimensional images can be produced by laser beams. Holography, or laser photography, relies on the coherent beam of laser light to produce a *hologram*, a three-dimensional information record of an object on photographic film. A portion of a laser beam is reflected off the object and into the path of a reference beam of unreflected laser light. The interaction of the two beams produces a unique interference pattern in the film. When another laser beam is aimed through the hologram's interference "picture," a three-dimensional image of the original object is reconstructed. The image looks like a picture or a slide.

5. The distance between the Earth and the Moon has been measured accurately by means of a laser beam. Scientists recorded the time taken for a laser beam to bounce off a reflector placed by astronauts on the moon. Knowing the speed of light in a given period of time, scientists were able to compute the distance with accuracy.

Exercise 1. Answer the questions.

1. What are main applications of lasers?
2. What can you tell about measuring distances by means of a laser beam?
3. What do you know about medical uses of lasers?

TASK 9

Read and entitle the text.

To produce laser light it is necessary to have a pair of mirrors at either end of the lasing medium. These mirrors are often known as an optical oscillator due to the process of oscillating photons between the two mirrored surfaces. The mirror positioned at one end of the optical oscillator is half-silvered, therefore it reflects some light and lets some light through. The light that is allowed to pass through is the light that is emitted from the laser. During this process photons are constantly stimulating other electrons to make the downward energy jump, hence causing the emission of more and more photons and an avalanche effect*, leading to a large number of photons being emitted of the same wavelength and phase.

Below is a graphical illustration of what has been detailed above. The graphics illustrate how laser light is created using a ruby laser, the first fully functioning laser. (Theodore Maiman invented the ruby laser on May 16th 1960 at the Hughes Research Laboratories.)

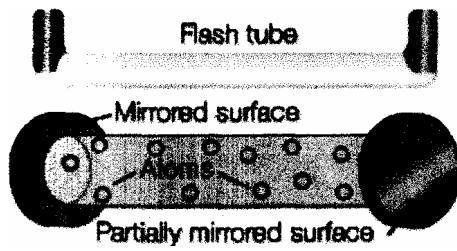


Fig.1. Schematic of Laser in Non-Lasing State.

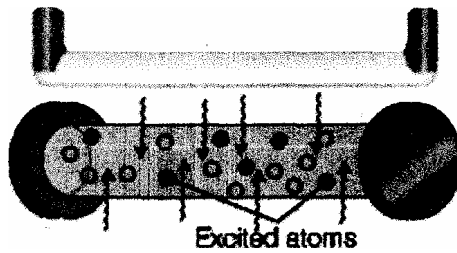


Fig.2. Schematic Illustrating the Excitation of Atoms Using Light Source.

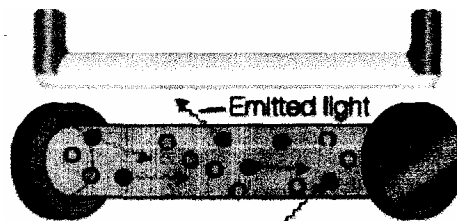


Fig.3. Schematic Showing Photon Emission.

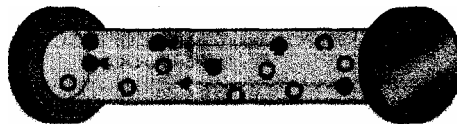


Fig.4. Schematic Showing the Stimulated Emission of Further Photons.

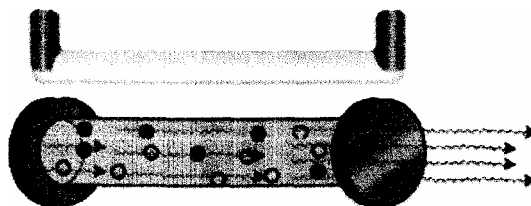


Fig.5. Schematic Showing Column of Laser Light Leaving Optical Osculate.

*avalanche effect – лавинообразный эффект

Exercise 1. Say what you have learnt about:

- a) a ground-state energy level and an excited level.
- b) the properties of laser light.
- c) the stimulated emission.

APPENDIX I

Химические формулы

При чтении химических элементов и формул необходимо помнить следующее:

- каждая буква и цифра читается отдельно, например, **NaCl** читается как: **n, a, c, l**;
- знаки, используемые в такого рода формулах, читаются следующим образом:
 - + - plus, together with, added to, combined with;
 - = - give, form, are equal to
 - - forms, is formed from;
 - ← - give, pass over to, lead to.

Например:

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ – c, o, two plus h, two, o give h, two, c, o, three;

$\text{C} + 2\text{H}_2 \rightarrow \text{CH}_4$ – c plus 2 molecules of h two form c, h, four.

APPENDIX II

Ar – argon – аргон

As – arsenic – мышьяк

Cd – cadmium – кадмий

CO₂ – carbon dioxide – двуокись углерода

Cu – 1) copper; 2) cuprum - медь

F – fluorine – фтор

He – helium – гелий

H – hydrogen – водород

Kr – krypton – криптон

Ne – neon – неон

Nd – neodymium – неодим

N – nitrogen – азот

Pb – plumbum – свинец

Se – selenium – селен

GaAs – gallium arsenide – мышьяковистый галлий

YAG – yttrium aluminium garnet – алюмоиттриевый гранат

APPENDIX III

Performance Data of Some of the Lasers. Using Appendixes I and II read laser technical characteristics.

Working media	Mode of operation*	Wave length, λ	Average power (W)	Peak power (kW)	Pulse duration	Slope efficiency (%)
Ruby	P	694.3 nm	1	$10\text{-}10^4$	1ms-10ns	<0.1
Nd: YAG	CW	1064 nm	200			1-3
Nd: YAG	P	1064 nm	1000	10	1-5 ms	1-3
Nd: YAG	P	1064 nm	10	2×10^4	10-20 ns	1-3
He-Ne	CW	632.8 nm	$10^{-3}\text{-}10^{-2}$			<0.1
Cu	P	510.5nm	40	100	20-40 ns	1-2
Ar⁺	CW	514.5 nm	10-150			<0.1
He-Cd	CW	325 nm	0.1			
		441.6 nm				
CO₂	CW	10.6 μm	$(1\text{-}50) \times 10^3$			10-20
N₂	P	337.1 nm	0.1	10^3	10 ns	<0.1
KrF	P	248 nm	500	5×10^3	10 ns	1
HF	CW	2.6-3.3 μm	$10^4\text{-}10^6$			
HF	P	2.6-3.3 μm		10^3		
GaAs	CW	850 nm	1			40

*P – pulsed or repetitively pulsed; CW – continuous wave.

SUPPLEMENTARY READING

APPENDIX IV

Albert Einstein

Albert Einstein was born in Germany, on March 14, 1879. Later his family moved to Italy and then to Switzerland. In 1896 he entered the Swiss Federal Polytechnic School in Zurich to be trained as a teacher in physics and mathematics. In 1901, the year he gained his diploma, he accepted a position as a technical assistant in the Swiss Patent Office. In 1905 he obtained his doctor's degree.

During his stay at the Patent Office, and in his spare time, he produced much of his remarkable work. For his researches in Relativity he was awarded the Nobel Prize in 1921. In 1933 he renounced his citizenship for political reasons and emigrated to America to take the position of Professor of Theoretical Physics at Princeton. He became a United States citizen in 1940 and retired from his post in 1945.

At the start of his scientific work, Einstein realized the inadequacies of Newtonian mechanics and his special theory of relativity stemmed from an attempt to reconcile the laws of mechanics with the laws of the electromagnetic field. He dealt with classical problems of statistical mechanics and problems in which they were merged with quantum theory: this led to an explanation of the Brownian movement of molecules. He investigated the thermal properties of light with a low radiation density and his observations laid the foundation of the photon theory of light.

In his early days, Einstein postulated that the correct interpretation of the special theory of relativity must also furnish a theory of gravitation and in 1916 he published his paper on the general theory of relativity. During this time he also contributed to the problems of the theory of radiation and statistical mechanics.

In the 1920's, Einstein embarked on the construction of unified field theories, although he continued to work on the probabilistic interpretation of quantum theory, and he persevered with this work in America. He contributed to statistical mechanics by his development of the quantum theory of a monatomic gas and he has also accomplished valuable work in connection with atomic transition probabilities and relativistic cosmology.

After his retirement he continued to work towards the unification of the basic concepts of physics, taking the opposite approach, geometrisation, to the majority of physicists.

Einstein's researches are, of course, well chronicled and his more important works include *Special Theory of Relativity* (1905), *Relativity* (English translations, 1920 and 1950), *General Theory of Relativity* (1916), *Investigations on Theory of Brownian Movement* (1926), and *The Evolution of Physics* (1938).

Albert Einstein received honorary doctorate degrees in science, medicine and philosophy from many European and American universities. During the 1920's he lectured in Europe, America and the Far East and he was awarded Fellowships or Memberships of all the leading scientific academies throughout the world. He gained numerous awards in recognition of his work, including the Copley Medal of the Royal Society of London in 1925, and the Franklin Medal of the Franklin Institute in 1935.

Arthur L. Schawlow

Arthur L. Schawlow was born in New York, U.S.A. on May 5, 1921. His father had come from Europe a decade earlier from Riga. His mother was a Canadian and the family moved to Toronto in 1924. Schawlow attended public schools there, and Vaughan Road Collegiate Institute (high school).

As a boy, Schawlow was always interested in scientific things, electrical, mechanical or astronomical, and read nearly everything that the library could provide on these subjects. He intended to try to go to the University of Toronto to study radio engineering. Unfortunately his high school years, 1932 to 1937, were in the deepest part of the great economic depression. His father's salary as one of the many agents for a large insurance company could not cover the cost of a college education for Schawlow.

There were, at that time, no scholarships in engineering, but Schawlow and his sister were both fortunate enough to win scholarships in the faculty of Arts of the University of Toronto. Schawlow's sister was for English literature, and his was for mathematics and physics. Physics seemed pretty close to radio engineering, and so that was what Schawlow pursued. Physics has given him a chance to concentrate on concepts and methods, and he has enjoyed it greatly.

A scientific career was something that few of them even dreamed possible, and nearly all of the entering class expected to teach high school mathematics or physics. In 1945 Schawlow returned to the University. It was by then badly depleted in staff and equipment by the effects of the depression and the war, but it did have a long tradition in optical spectroscopy. There were two highly creative physics professors working on spectroscopy, Malcolm F. Crawford and Harry L. Welsh. Schawlow took courses from both of them, and did his thesis research with Crawford. It was a very rewarding experience, for he gave the students good problems and the freedom to learn by making their own mistakes. Moreover, he was always willing to discuss physics, and even to speculate about where future advances might be found.

A Carbide and Carbon Chemicals postdoctoral fellowship took Schawlow to Columbia University to work with Charles H. Townes. There were no less than eight future Nobel laureates in the physics department during his two years there. Working with Charles Townes was particularly stimulating. Not only was he the leader in research on microwave spectroscopy, but he was extraordinarily effective in getting the best from his students and colleagues.

From 1951 to 1961, Schawlow was a physicist at Bell Telephone Laboratories. There his research was mostly on superconductivity, with some studies of nuclear quadruple resonance. On weekends he worked with Charles Townes on their book *Microwave Spectroscopy*, which had been started while he was at Columbia and was published in 1955. In 1957 and 1958, while mainly still continuing experiments on superconductivity, Schawlow worked with Charles Townes to see what would be needed to extend the principles of the maser to much shorter wavelengths, to make an optical maser or, as it is now known, a laser. Thereupon, Schawlow began work on optical properties and spectra of solids which might be relevant to laser materials, and then on lasers.

Since 1961, Schawlow has been a professor of physics at Stanford University and was chairman of the department of physics from 1966 to 1970.

Charles H. Townes

Charles Hard Townes was born in Greenville, South Carolina, on July 28, 1915. He attended the Greenville public schools and then Furman University in Greenville, where he completed the requirements for the Bachelor of Science degree in physics and the Bachelor of Arts degree in Modern Languages, graduating in 1935, at the age of 19. He was also interested in natural history while at Furman, serving as curator of the museum, and working during the summers as collector for Furman's biology camp. In addition he was busy with other activities, including the swimming team, the college newspaper and the football band.

Townes completed work for the Master of Arts degree in Physics at Duke University in 1936, and then entered graduate school at the California Institute of Technology, where he received the Ph.D. degree in 1939 with a thesis on isotope separation and nuclear spins.

A member of the technical staff of Bell Telephone Laboratories from 1933 to 1947, Dr. Townes worked extensively during World War II in designing radar bombing systems and has a number of patents in related technology. From this he turned his attention to applying the microwave technique of wartime radar research to spectroscopy, which he foresaw as providing a powerful new tool for the study of the structure of atoms and molecules and as a potential new basis for controlling electromagnetic waves.

At Columbia University, where he was appointed to the faculty in 1948, he continued research in microwave physics, particularly studying the interactions between microwaves and molecules, and using microwave spectra for the study of the structure of molecules, atoms, and nuclei. In 1951, Dr. Townes conceived the idea of the maser, and a few months later he and his associates began working on a device using ammonia gas as the active medium. In early 1954, the first amplification and generation of electromagnetic waves by stimulated emission were obtained. Dr. Townes and his students coined the word "maser" for this device, which is an acronym for microwave amplification by stimulated emission of radiation. In 1958, Dr. Townes and his brother-in-law Dr. A.L. Schawlow, showed theoretically that masers could be made to operate in the optical and infrared region and proposed how this could be accomplished in particular systems. This work resulted in their joint paper on optical and infrared masers, or lasers (light amplification by stimulated emission of radiation). Other research has been in the fields of radio astronomy and nonlinear optics.

Having joined the faculty at Columbia University as Associate Professor of Physics in 1948, Townes was appointed Professor in 1950. He served as Executive Director of the Columbia Radiation Laboratory from 1950 to 1952 and was Chairman of the Physics Department from 1952 to 1955.

In 1966, he became Institute Professor at M.I.T., and made intensive research, particularly in the fields of quantum electronics and astronomy. He was appointed University Professor at the University of California in 1967. In this position Dr. Townes was participating in teaching, research, and other activities on several campuses of the University.

Dr. Townes has served on a number of scientific committees advising governmental agencies and has been active in professional societies.

Aleksandr M. Prokhorov

Aleksandr Mikhailovich Prokhorov was born on July 11th, 1916, in Australia. After the October Revolution he went in 1923 with his parents to the Soviet Union.

In 1934 Alexander Prochorov entered the Physics Department of the Leningrad State University. He attended lectures on quantum mechanics, theory of relativity, on general physics, spectroscopy and on molecular physics. After graduating in 1939 he became a postgraduate student of the P.N. Lebedev Physical Institute in Moscow, in the laboratory of oscillations. There he started to study the problems of propagation of radio waves.

In 1946 he defended his thesis on the theme Theory of Stabilization of Frequency of a Tube Oscillator in the Theory of a Small Parameter.

Starting in 1947, Prochorov carried out a study of the coherent radiation of electrons in the synchrotron in the region of centimetre waves. As a result of these investigations he wrote and defended in 1951 his Ph.D. thesis a "Coherent Radiation of Electrons in the Synchrotron Accelerator".

Starting from 1950 being assistant chief of the laboratory, Prochorov began to investigate on a wide scale the question of radiospectroscopy and, somewhat later, of quantum electronics. He organized a group of young scientists interested in the subjects.

In 1959 when Prochorov has already been the head of the lab, the laboratory of radio astronomy was organized from one of the departments of the laboratory of oscillations, and in 1962 another department was separated as the laboratory of quantum radiophysics (headed by Prof. N.G. Basov).

The investigations carried out by Basov and Prochorov in the field of microwave spectroscopy resulted in the idea of a molecular oscillator. They developed theoretical grounds for creation of a molecular oscillator and also constructed a molecular oscillator operating on ammonia. In 1955, Basov and Prochorov proposed a method for the production of a negative absorption which was called the pumping method.

From 1950 to 1955, Prochorov and his collaborators carried out research on molecular structures by the methods of microwave spectroscopy.

In 1955 Professor Prochorov began to develop the research on electronic paramagnetic resonance (EPR). A cycle of investigations of EPR spectra and relaxation times in various crystals was carried out.

In 1955, Prochorov studied with A.A. Manenkov the EPR spectra of ruby that made it possible to suggest it as a material for lasers in 1957. They designed and constructed masers using various materials and studied characteristics of the masers as well. This research was done in cooperation with the laboratory of radio spectroscopy of the Institute of Nuclear Physics of the Moscow University; this laboratory was organized by Prochorov in 1957. One of the masers constructed for a wavelength of 21 cm is used in the investigations of the radioastronomical station of the Physical Institute in Pushino.

In 1958 Prochorov suggested a laser for generation of infrared waves. As a resonator it was proposed to use a new type of cavity which was later called "the cavity of an open type". Practically speaking, it is Fabry-Perot's interferometer. Similar cavities are widely used in lasers.

At present Prochorov's principal scientific interests lie in the field of solid lasers and their utilization for physical purposes, in particular for studies of multiquantum processes. In 1963, he suggested together with A.S. Selivanenko, a laser using two-quantum transitions.

Nicolay G. Basov

Nicolay Gennadiyevich Basov was born on December, 14, 1922 in a small town near Voronezh. His father was a professor of the Voronezh Forest Institute.

After finishing secondary school in 1941 in Voronezh Basov was called up for military service. In December 1945, he entered the Moscow Institute of Physical Engineers where he studied theoretical and experimental physics.

In 1950 Basov joined the P.N. Lebedev Physical Institute, where he was vice-director and head of the laboratory of quantum radiophysics. He is also a professor of the department of solid-state physics at the Moscow Institute of Physical Engineers.

In 1956 he defended his doctoral thesis on the theme "A Molecular Oscillator", which summed up the theoretical and experimental works on creation of a molecular oscillator utilizing an ammonia beam.

In 1955 Basov organized a group for the investigation of the frequency stability of molecular oscillators. Together with his pupils and collaborators Dr. Basov studied the dependence of the oscillator frequency on different parameters. In the result of these investigations the oscillators with a frequency stability of 10^{-11} have been realized in 1962.

In 1957 Basov started to work on the design and construction of quantum oscillators in the optical range. A group of theorists and research workers began to study the possibilities for realization of quantum oscillators by means of semiconductors, and the possibility of their realization in the gas media was also investigated.

In 1964 semiconductor lasers with electronic excitation have been made and somewhat later, lasers with optical excitation were constructed. For these achievements a group of scientists of Lebedev Physical Institute was awarded the Lenin Prize for 1964.

Beginning from 1961 Dr. Basov carried out theoretical and experimental research in the field of powerful lasers.

In 1962 N.G. Basov and O.N. Krokhin investigated the possibility of laser radiation usage for the obtaining of thermonuclear plasmas. In 1968 Basov and his associates have succeeded in observing for the first time neutron emission in the laser-produced deuterium plasmas. In the same year N.G. Basov and his associate A.N. Oraevsky proposed a method of the thermal laser excitation. Further theoretical considerations of this method by N.G. Basov, A.N. Oraevsky and V.A. Sheglov encouraged the development of the so-called gasdynamic lasers.

In 1963 Dr. Basov and his colleagues began to work in the field of optoelectronics. They developed in 1967 a number of fast-operating logic elements on the basis of diode lasers.

A large contribution has been made by Dr. Basov to the field of chemical lasers. In 1970 under his guidance an original chemical laser was achieved which operates on a mixture of deuterium, F and CO₂ at the atmospheric pressure.

In the end of 1970 N.G. Basov (together with E.P. Markin, A.N. Oraevsky, A.V. Pankratov) presented experimental evidence for the stimulation of chemical reactions by the infrared laser radiation.

Ted Maiman and the world's first laser

Ted Maiman was born in Los Angeles, California, in 1927. His father was an electronics engineer and inventor, who worked for several years at Bell Labs during the war. The elder Maiman inspired his son with a love of electronics, and by the time the younger Maiman was 12 he had a job repairing valve devices. By the time he was 14, he was running the company's shop.

Maiman attended the University of Colorado, receiving a B.S. in engineering physics in 1949. He then set his sights on the Stanford University physics department for graduate work, but was initially rejected. He eventually got into Stanford, he was accepted by the electronics engineering department.

At Stanford, Maiman did graduate work under Nobel Laureate Willis Lamb. While conducting the experiment he learned a great deal about optical instrumentation, which was very appropriate to his later work on the laser.

Maiman graduated with a Ph D in physics from Stanford in 1955.

In 1958, Bell Labs' Schawlow and Townes had predicted the operation of an optical laser. In their paper, they suggested that one way to do it was using alkali vapors. They applied for, and were granted, a patent. But a working laser had yet to be built.

Meanwhile Maiman was now working at Hughes Research, which was one of the many labs involved in the race to implement the laser.

At Hughes, Maiman found himself encountering a number of obstacles. He was under-funded, working with a budget of \$50,000, which included his salary, his assistants' salaries, and equipment. Worst of all, the most important scientists of the day were scoffing at him for continuing to investigate ruby, which had been ruled out as a lasing material. It was measured that the fluorescence quantum efficiency of ruby was about 1 percent.

Maiman began investigating other materials, but having found no alternative prospects, he returned to ruby to try to understand why it was so inefficient. He felt that if he could understand what was causing the inefficiency, he could then work with crystal experts to identify an appropriate material. He measured the quantum efficiency again, and came up with a figure of about 75 percent! Ruby was again a laser candidate.

At this time, nearly all the scientists in the major labs were trying to make a continuous laser. Few were considering the possibility that a pulsed laser might be easier to build. Maiman did not accept this idea.

At about that time he came across an article on photographic strobe lamps, and discovered that their brightness temperature was about 8000 or 9000 K. The continuous dc arc lamp he had looked at had a brightness temperature of about 4000 K. He checked his calculations carefully (calculators and desktop computers were still science fiction in 1960). An innovative optical pump and probe and simultaneous GHz resonant cavity experiment convinced him the strobe lamp could make optical gain a reality.

By surrounding the ruby rod with the lamp and using an external collector, Maiman was able to achieve a reasonable amount of pumping efficiency. He obtained a ruby rod from Union Carbide. It was a unique request, and took the company five or six months to prepare.

In 1960, there were no coating surfaces for laser mirrors, and multilayer coatings were only at the disposal of the largest labs that could afford the technology. But Maiman knew about silvering ruby from his maser days, and he used the same technique to silver the ends of this rod.

Maiman's rigorous investigation was paid off when, on 16 May 1960, the laser made the historic leap from theory to reality.

Dictionary

A

absorb, v – поглощать
accelerator, n – ускоритель
accept, v – принимать, признавать
accomplish, v – выполнять
accuracy, n – точность
acoustic, adj – акустический
adornment, n – украшение
advantage, n, – преимущество
alignment, n – выравнивание
allow (for), v – предусматривать
amount, n – количество
amplifier, n – усилитель
announce, v – объявлять
antiquity, n – древность
apparent, adj – видный, очевидный
approach, n – подход
arc, n – дуга
 ~ lamp – дуговая лампа
assume, v – предполагать, допускать
attenuation, n – ослабление
available, adj – имеющийся в распоряжении, доступный
auxiliary, adj – вспомогательный

B

bend, v – отклоняться
bending, n – изгиб
benefit, n – польза, выгода
blood, n – кровь
 ~ vessel – кровяной сосуд
bond, n – связь
bounce, v – отскакивать, отражаться
boundary, n – граница

C

cancel, v – уничтожать
cavity, n – резонатор
cause, v – вызывать, причинять
celestial, adj – небесный
circuit, n – контур, схема, цепь
coil, n – спираль
collide, v – сталкиваться
collision, n – столкновение

commonplace, adj – общепринятый
competitive, adj – конкурентно-способный
compound, n – соединение
confine, v – ограничивать
consist (of), v – состоять (из)
constitute, v – образовывать
contain, v – содержать
contaminant, n – вредный фактор, загрязнение
conventional, adj – обычный, стандартный
converge, v – сходиться
cooling, n – охлаждение
core, n – сердечник
couple, v – соединять
crack, n – трещина, треск
curb, n – ограничение
curvature, n – кривизна
curve, v – изгибать

D

damage, n – вред, повреждение
date back, v – брать начало
data, n – данные
 ~ base – база данных
decibel, n – децибел
degree, n – степень
deliver, v – доставлять
delivery, n – доставка, передача
dense, adj – густой, плотный
density, n – плотность
depend, v – зависеть
destination, n – расстояние, место назначения, цель
destroy, v – разрушать
detector, n – детектор, определитель
determine, v – определять
determination, n – намерение
devise, v – разрабатывать, изобретать
diamond, n – алмаз
dim, adj – смутный, тусклый
directionality, n – направленность
displace, v – смещать, перемещать
dissipate, v – рассеивать, разгонять
distinct, adj – резко очерченный, различный, отчетливый
distort, v – искажать, искривлять
distorted, adj – искривленный, искаженный
donate, v – дарить

doubtless, adj – несомненный
downward, adj – спускающийся
droplet, n – капля
drill, v – сверлить
duct, n – труба для кабеля

E

easier-to-load, adj – более удобный в обращении
emerge, v – распространяться, появляться
emission, n – излучение
encounter, v – столкнуться
enormous, adj – огромный
equal, adj – равный
equation, n - уравнение
equipment, n – оборудование
establish, v – создавать
event, n – событие, зрелище
evolve, v – развертывать, развивать
exceed, v – превышать
excitation, n – возбуждение
exhibit, v – выставлять, проявлять, показывать
exploration, n – исследование
experience, n – опыт
exposure, n – экспонирование
extend, v – тянуться
extension, n – расширение
eyeball, n – глазное яблоко

F

fabricate, v – изготавливать
fashion, v – обрабатывать, моделировать
fasten, v – пристегивать, прикреплять
feasible, adj – годный, подходящий
filament, n – волокно, нить
fine, adj – высококачественный
fringe, n – край, конец
fusion, n – слияние, синтез (яд. физика), плавление

G

galaxy, n – млечный путь, плеяда
garment, n – одежда
generator, n – генератор

Н

haze, n – туман, дымка
hologram, n – голограмма
 embossed ~ – рельефная голограмма

И

immerse, v – погружать
immune, adj – невосприимчивый
impact, n – влияние
imperious, adj – непроницаемый
inaccessible, adj – недоступный
incidence, n – падение
incident, adj – падающий
inch, n – дюйм
infinitely, adv – бесконечно, безгранично
infinitesimal, adj – бесконечно малый, мельчайший
inner, adj – внутренний
interface, n – поверхность раздела, интерфейс, стык
interference, n – 1) интерференция, 2) вмешательство, помеха,
 3) взаимное влияние
 ~ pattern – интерференционная картина
internal, adj – внутренний
intervene, v – происходить (за такой-то период времени)
involve, v – включать в себя, содержать

Ж

jet, n – струя

Л

languish, v – пылиться
lash, v – подсоединять
layer, n – слой
lesion, n – повреждение
liquid, n – жидкость
lossy, a – проигрышный, убыточный

М

magnitude, n – величина
manual-focus, adj – с ручной фокусировкой
marvel, v – удивляться
matter, n – вещество, материя
meaningless, adj – бессмысленный
measure, v – измерять
measurable, adj – измеряемый
medieval, adj – средневековый

melt, v – плавить
message, n – сообщение
mount, v – устанавливать
multiple, adj – составной, многократный

N

nonplanar, adj – неплоский
notwithstanding, prep – несмотря на
nucleus, n – ядро

O

observe, v – наблюдать
obstacle, n – помеха, препятствие
optics, n – оптика, оптические приборы
original, adj – исходный, изначальный

P

particle, n – частица
pebble, n – голыш, галька
peer, v – всматриваться, вглядываться
permanent, adj – постоянный, неизменный
persist, v – настаивать
pertain, v – иметь отношение
phenomenon, n – явление, эффект
pond, n – труд
precise, adj – точный
predict, v – предсказывать
previously, a – ранее
processing, n – обработка
prong, n – зубец
propagate, v – размножаться, распространяться
protection, n – защита
prove, v – оказаться, доказывать
pump, v – накачивать

Q

quantitative, adj – количественный
quasar, n – квазар

R

radiation, n – излучение
radically, adv – радикально, коренным образом
random, adj – случайный, выбранный наугад
ratio, n – отношение
raw, n – сырье

receive, v – получать
recognizable, adj – узнаваемый
reconfigure, v – изменить
reduce, v – уменьшать
reference, adj – исходный, эталонный
relativity, n – относительность
relay, v – передавать, транслировать
release, v – испускать
relevant, adj – соответственный
replace, v – заменять
require, v – требовать
requirement, n – требование
resemblance, n – сходство
reshape, v – преобразовать
restrict, v – ограничивать
restriction, n – ограничение
resurgence, n – возрождение
rough, adj – шероховатый
roughness, n – шероховатость

S

sample, n – образец
scan, v – сканировать, просматривать
separate, v – отделять, разъединять
shallow, adj – мелкий, малый
sharpness, n – резкость, четкость
shift, n – смещение, сдвиг
shrink, v – уменьшать, сокращать
shutter, n – затвор (в фотоаппарате)
significant, adj – значительный
simplify, v – упрощать
similarity, n – сходство
simultaneously, adv – одновременно
singly, adv – в единственном числе
slit, n – щель, продольный разрез
smooth, adj – гладкий
solvent, n – растворитель
source, n – источник
speed, n – скорость
spot, n – пятно
steep, adj – крутой
stretch, v – вытягивать
straight, adj – прямой
sufficient, adj – достаточный
supplement, v – дополнить

superimpose, v – налагать, совмещать
surface, n – поверхность
sustain, v – поддерживать, выдерживать

T

terrestrial, adj – наземный
tiny, adj – крошечный
tissue, n – ткань
tool, n – инструмент
touch, v – касаться
tower, n – башня
tragedian, n – трагик
trap, v – ловить, заключать
trait, n – характерная черта, особенность, свойство
transfer, v – переносить, передавать
transmit, v – передавать
transmitter, n – трансмиттер, передатчик
transmission, n – передача
transparency, n – прозрачность
transparent, adj – прозрачный
travel, v – перемещаться, распространяться (о волнах)
traverse, v – пересекать, проходить сквозь
tunable, adj – настраиваемый
tunability, n – настраиваемость
turbulence, n – турбулентность
atmospheric ~ – атмосферная турбулентность

U

ultimately, adv – в конечном счете
universe, n – вселенная, мир
unsharpness, n – нерезкость

V

valuable, adj – провод, ценный
vaporize, v – выпаривать, испаряться
versus, adv – против
via – посредством, через
vice versa – наоборот
vicinity, n – близость
visible, adj – видимый
visibility, n – видимость

W

whereas, conj – тогда как
wholly, adv – полностью
wire, n – провод

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The Department of Foreign Languages

The department of foreign languages was established on 20 September 1931. At that time the first new structural subdivision was singled out and the first head of the department, the associate –professor Falk K.I. (1931-1941) was assigned.

13 teachers worked at the department, namely, 7 teachers of English and 6 teachers of German.

The department of foreign languages was headed by:

1941-1951 senior teacher Mitskevich Z.P.

1953-1973 senior teacher Lisikhina B.L.

1973-1993 senior teacher Dygina M.S.

Professor Markushevskaja L.P. has headed the department since 1993.

At present the department consists of four sections: English, French, Russian and German, 30 teachers working in the staff.

More than 60 manuals were published at the department. The electronic versions of English Grammar, Computer in Use, Optics have been designed. It helps students to improve their knowledge working on computers.

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