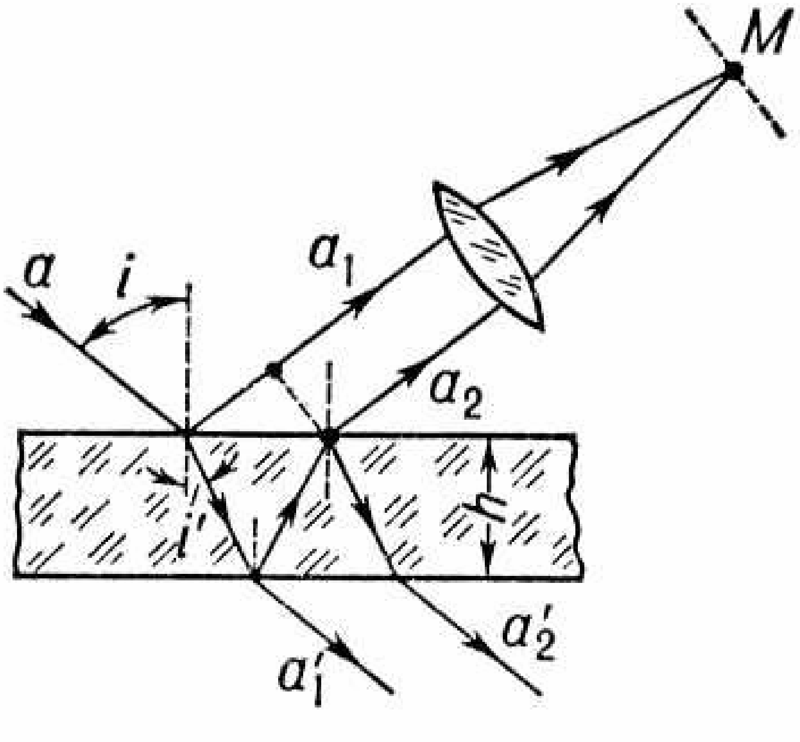
Welcome to the world of optics!



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МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

САНКТ-ПЕТЕРБУРГСКИЙ НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ, МЕХАНИКИ И ОПТИКИ

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Иностранный язык для оптиков

Welcome to the world of optics!

(Добро пожаловать в мир оптики!)

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Учебное пособие “Welcome to the world of optics!” (“Добро пожаловать в мир оптики!”) – предназначено для студентов факультетов оптико-информационных систем и технологий и фотоники и оптоэлектроники. Пособие может быть использовано как на аудиторных занятиях, так и для самостоятельной работы студентов.

Пособие состоит из четырех глав, в которых представлены оригинальные тексты, знакомящие студентов с миром оптики: геометрической и волоконной оптикой, лазерами. Пособие также включает в себя четыре приложения и словарь. Каждый урок снабжен терминологическими и лексико-грамматическими упражнениями по изучаемой тематике.
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Contents

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. In1784 Benjamin Franklin invented bifocals. In his invention the two lens sections were hold 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 seventeenths 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 in1808 by Malus and the polarizing angle was discovered by Brewster in 1811. In 1842, an Austrian physicist Johann Christian Dopler 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 theconstruction of the first laser in 1960 and have led to the rapid development of opticalcommunication systems, imaging systems and holography, optical data storage andretrieval systems, and optical processing.

CHECK YOUR UNDERSTANDING

Exercise 1. ***Answer the following questions*.**

1. Where and when did optical device first appear?
2. What did Roger Bacon make in 1262?
3. What was the telescope made by Galileo Galilei?
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. Spectacles, the first optical device …
2. Galileo Galilei announced …
3. Thomas Young revealed…
4. Sir Isaac Newton discovered…

INCREASE YOUR VOCABULARY

Exercise 1. ***Match the synonyms.***

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

Exercise 2. ***Compare two columns and find Russian equivalents to words or wordcombinations.***

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 свет
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, eyepiece, history, lens, theory, paper, wave, source, vessel, chief, spectrum, radius, device;

b) cavity, frequency, eyeglass, cross-section, parameter, headphone, possibility, paperboard, twin-engine, statesman, refractor.

Exercise 2. ***Insert articles where necessary.***

1. Galileo Galilei announced … telescopic observations of …moon and planets.
2. Spectacles,… first optical device, known also as eyeglasses, appeared first in… Florence about 1280.
3 Sir Isaac Newton, … great scientist and thinker, who discovered some of …fundamental laws of mechanics, is known also by his invention of … reflecting telescope.
4. Some think that eyeglasses were invented by … Chinese.
5. … first great improvement of … microscope was due to Robert Hooke.
6. …shift to the wave explanation of …nature of light began at… beginning of …19th century.

Exercise 3. ***Insert prepositions of time where necessary.***

1. … 1784 Benjamin Franklin invented bifocals.
2. … the 20th century the revolutionary advances in optics began with the construction of the first laser … 1960.
3. My sister often goes … the disco… Saturdays.
4. It sometimes snows … Christmas.
5. I have not seen him … over a week.
6. The movie was to start … nine … the morning.
7 He has three buttons … his coat.

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 – аберрация, 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. By the beginning of the 17th century, however, it was known that rays of light travelled in curve lines.
2. To the ancients, the processes of image formation were full of mystery.
3. There are two main types of image to be considered: real and virtual.
4. Lenses of moderately good quality were being made only for microscopes.
5. Optics had progressed rapidly by the early years of the 19th century.

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 Dopler 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 did it, having created the corpuscular theory of light.
b) Gauss laid, having made the geometrical theory of light, which was later extended
to the calculation of five principal aberrations.
c) Maxwell did, having found the equations for electromagnetic field, that helped to identify optics with electromagnetism.

INCREASE YOUR VOCABULARY

Exercise 1. ***Give the definitions to the following*.**
1. The lens of the eye is…
2. A real image is …
3. A virtual image …

Exercise 2. ***Compare two columns and choose the matching words and wordcombinations.***

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) кардиальные точки
	x) перекрываться
	y) одновременно

LANGUAGE ACTIVITY

Exercise 1. ***Choose the right form of pronouns*.**

1. She always keeps her/hers promises.
2. It is not your/yours problem, it is my/mine.
3. The sun gives ours/us light during the day.
4. These glasses are their/theirs.
5. I gave him/his address to our/ ours friends.

Exercise 2. ***Complete the sentences with*** *myself/yourself,* ***etc. only where necessary.***

1. I made … a sandwich for lunch.
2. They taught … to drive.
3. Help … to tea and cake!
4. “Shall I help you?” “No, I can do it by …”.
5. Tommy bought … a present.

Exercise 3. ***Insert prepositions of place***.

1. The dog is hiding in/under/on the chair.
2. Read the note at/under/in the bottom of the page.
3. The bakery is at/opposite/on the park.
4. There is a playground at/near/above the bank.
5. My house is between/on/among the bank and the post office.
6. There is a very interesting article about UFOs in/on/at the newspaper today.
7. John is in/on/at bed at the moment. He is not feeling very well.
8. The Jacksons live at/in/on the second floor.

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

1…. broke into our house last night.
2. I had … time to go to the post office today.
3. Are you going … nice for your holiday?
4. There was … left at the party by two o’clock.
5. …is allowed to park in front of this building.
6. Have I done … to offend you?
7. If … is looking for me, tell them I have gone home.
8. It will take you … time to get used to such a hot climate.

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

a) 35; 700; 268; 4093l; 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 A 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 ¾ as fast in water and only 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 Å) – 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.

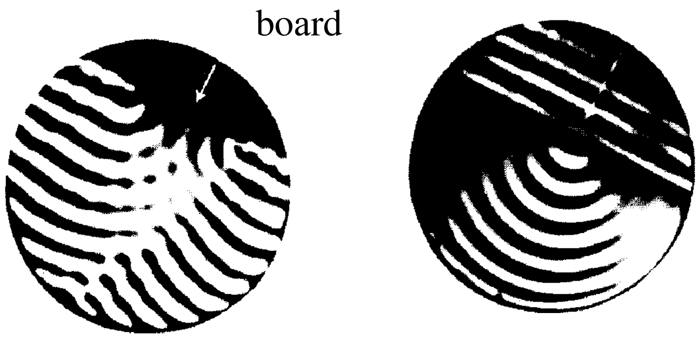


Fig.1.

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, 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.

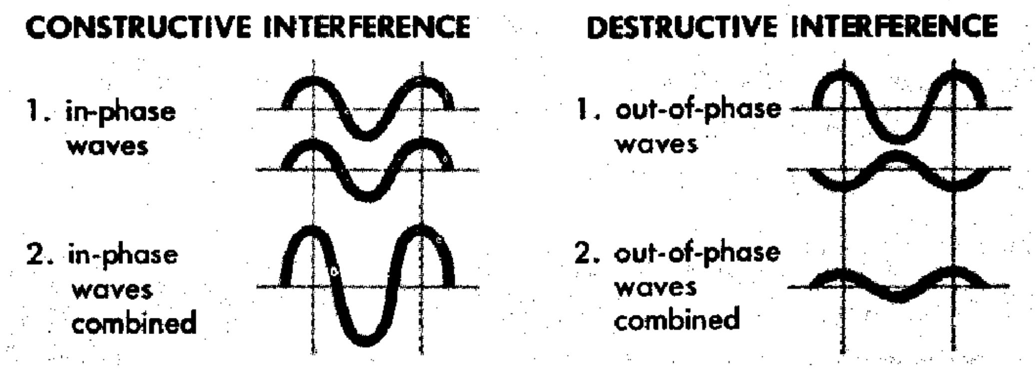


Fig.2.

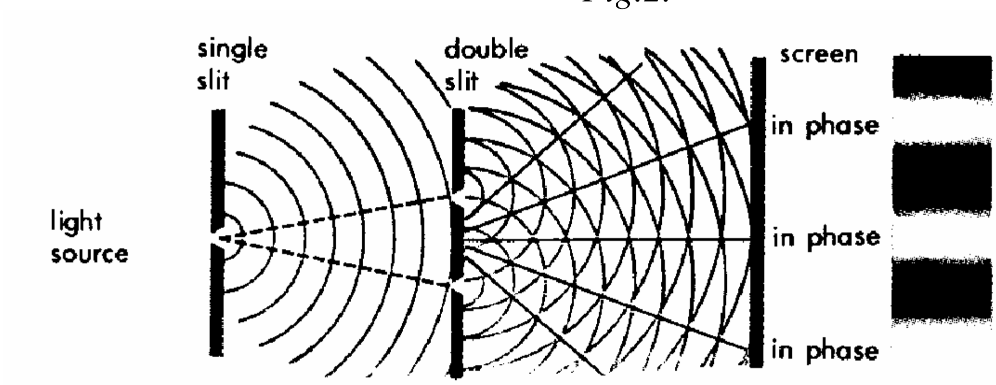


Fig.3.

CHECK YOUR UNDERSTANDING

Exercise 1. ***True or false?***

1. All electromagnetic waves travel in space at the same speed - the speed of light.
2. Light behavior includes only transmission and absorption.
3. 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.
4. When light from a distant street lamp is viewed through a window screen it forms a sphere.
5. Interference is an effect that occurs when two waves of equal frequency are superimposed.

6. Two waves interfere only if their phase relationship changes.

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 doesit 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 which are parallelograms, body of this form made of glass breaks up white light into the colours of the rainbow.
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. Anna swims … you do (fast).
2. My sister drives … us all (carelessly).
3. I left the party … you did (late).
4. Catherine dances … all (beautifully).
5. The leading actress speaks … all (clearly).
6. My uncle gives … to the poor … my father does (generously).
7. Is the Gobi desert … the Sahara desert (large)?
8. Which is … animal in the world (heavy)?
9 Is Mount Everest … Kilimanjaro (high)?
10.Which is … planet in our solar system (cold)?

Exercise 2. ***Insert prepositions*** *in, into, of, on, at* ***where it is necessary.***
1. Nature electromagnetic waves carry energy … all directions through the universe.
2 Its speed … air is almost the same as its speed … space.
3. When light strikes a mirror… an angle, it is reflected … the same angle.
4. Incident and reflected rays are … opposite sides … the normal.
5. When a beam … light enters a plane …glass perpendicular to the surface, it slows down.
6. Such an image is formed … a microscope or a telescope and can be seen by looking … the eyepiece.

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. Very interesting results *have been* obtained by the scientists of this institute.
2. She *will be* working in the laboratory from 5 to 6 o'clock.
3. The task *is* to provide low pressure.
4. The problem *was to* find the materials for the experiment.
5. This occurs when an impurity atom has acceptor properties, *that is,* can attract electrons.
6. The quality of this device *was* much spoken about.
7. It *is* usually warm here in October.

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 and translate these sentences, stating the function of «provided».***
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, optical.
Noun + less = adjective
use, harm, help, shape, color.
Noun + ic = adjective
ion, electron, atom, photon.

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 – фокусное расстояние
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, semi-permanent form, far-off objects, a convex objective lens, incident light rays.

Exercise 2. ***Match the synonyms.***

Verbs

1	**2**
1) operate	a) allow
2) change	b) bend
3) invent	c) influence
4) curve	d) alter
5) reach	e) enlarge
6) permit	f) devise
7) widen	g) work
	h) leave

	i) broaden
	j) achieve
	k) pass
	l) travel

Nouns

1	**2**
1) viewer	a) mechanism
2) aid	b) goggles
3) increase	c) side
4) fall	d) quantity
5) device	e) eyepiece
6) amount	f) source
7) spectacles	g) observer
	h) incidence
	i) ray
	j) help
	k) enlargement
	l) advantage

Exercise 3. ***State the part of speech of the following words and determine their meaning without using a dictionary.***
1) power, powerful, powerless, empower, powerfully.
2) general, generalize, generally, generalization, generality, general-purpose.
3) vary, various, varying, variety, variously, variance, variable .
4) practical, practice, practitioner, practise, practised, practically, practicable, practicability.

Exercise 4. ***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 <u>been</u> improved and refined continuously throughout its history, that <u>is</u> practically since the 17th century.
2. The main characteristics to <u>be</u> refined have always <u>been</u> the resolution and the elimination of aberrations.
3. The projection lens <u>is</u> to <u>be</u> 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. Some stars *that* look white to the naked eye can be seen in their true colour when viewed with a telescope.
2. It is common knowledge *that* looking at the Sun can cause permanent damage to your eyes.
3. Everything in this article refers to a light microscope, *that* is a microscope *that* includes a built-in light source.
4. Total magnification is achieved by multiplying the power of the objective lens by *that* of the eyepiece lens.
5. 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.
6. *That* other promising applications including cascade QD lasers for future light sources will appear soon is without a question.
7. It is an achromatic lens *that* corrects for the fact *that* different colours refract through a curved, glass lens at different angles.
8. At *that* time the researchers did not have the technology to fabricate the necessary multidimensional nanostructures.
9.Most of *those* microscopes were made of inferior quality materials, had minimal optical quality and were likely to break quickly.
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. In 1981 Aracawa *was receiving/received* his Ph.D. in electrical engineering from the University of Tokio.
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. The great mathematician Carl Friedrich Gauss *was pablishing/published* his classical book on optics in 1841.
4. What *did/were* they *research/researching* when they *obtained/ were obtaining* high-speed modulation dynamics?
5. Dr. Stephen A. Benton *was inventing/invented* white-light transmission holography while he *was researching/researched* holographic television at Polaroid Research laboratories.
6. There is a legend that Sir Isaac Newton, the great scientist and thinker, *was discovering/discovered* one of the fundamental laws of mechanics when he *was sitting/sat* under an apple-tree.
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. About 1609 Galileo Galilei *was learning/learned* of the invention of the telescope by Hans Lippershey and one year later he *was announcing/announced* the telescopic observations of the moon and planets.

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 filmes 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 medium 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 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 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 galaxy bends light passing in its vicinity, thereby forming multiple images of a distant celestial object, such as quasars).

No lens is thin, in the strict sense of having thickness that approaches zero. Yet many simple lenses, for all practical purposes, function as a fashion equivalent 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 descriptionperfectly.

CHECK YOUR UNDERSTANDING

Exercise 1. ***Answer the following questions.***
1. What is the most widely used optical device?
2. What definitions of the lens do you know?

3. What natural or artificial objects can be used as a lens?
4. Which lens tends to decrease the radius of curvature of the wavefronts?
5. What does GRIN stand for? How does this lens work?
6. What lens can be considered thin?

Exercise 2. ***True or false?***
1. Optical quality is largely determined by the quality of the objective lenses and to a secondary degree, by the quality of the eyepieces.
2. There are some unconventional lenses, including gravitational and acoustic lenses.
3. Lenses first appeared in the 16^{th} century.
4. Lenses are always made of glass.
5. All spectacle lenses can be considered thin.

INCREASE YOUR VOCABULARY

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

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

Exercise 2. ***Read and translate the collocations below.***
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) fabricate	a) traverse
2) coat	b) look

3) cross	c) consider
4) want	d) produce
5) peer	e) cover
	f) consist
	g) desire

Nouns

1	2
1) interface	a) regulation
2) adjustment	b) velocity
3) purpose	c) surface
4) range	d) change
5) speed	e) interval
	f) goal
	g) approach

LANGUAGE ACTIVITY

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

1. … lot of people enjoy watching sport.
2.After … accident, … injured were quickly taken to … hospital.
3. … hospital on … High Street was destroyed during … war.
4. … Spanish love fish and Madrid has … second largest fish market in … Spain.
5. Before he goes to … sleep ,he likes to watch … TV or listen to … radio.
6. I talked to … manager of my department about … conference we are having on …Saturday.
7. My friend met … famous actor two days ago. … actor gave him … photograph of himself.
8. What will you do if … phone rings late at … night?
9. This candidate is very popular because he promised to help … disabled people and … elderly.
10. Some of …Kate's clothing was dirty.
11. … number of people interested in …job has surprised us.
12. … number of students are learnig … French language as … second language because they have already mastered … English.

Exercise 2. ***Insert prepositions where it is necessary.***

1.We see the world … a pair of lenses.
2. Convex lenses tend to decrease the radius … curvature of the wavefronts.
3. The gravity of galaxy bends light passing … its vicinity.
4. Some of microwave lenses are made of glass or wax … easily recognizable shapes.
5. Generally the nonplanar surfaces are centered … a common axis.
6. Negative lenses, … the other hand, are thinner … the center.

7. In the broadest sense, a lens is a refracting device that is used to reshape wavefronts … a controlled manner.
8. Different portions of the wave propagate … different speeds.

Exercise 3. ***Summarize your knowledge of Present Perfect Tense. Put the verbs in brackets into the correct form.***
1. He already (to finish) to translate the articles.
2. The students (not to discuss) such problems before.
3. They just (to offer) to make a presentation but they don’t know how to do it.
4 Lenses (to use) since the thirteenth century.
5. “How long you (to be married)?” she asked her old friend.
6. This is the best film I ever (to see).
7. The secretary (to write) ten e-mails so far this morning.
8. They (not to complete) the work yet.

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 преподаватель 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 2020 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
single-use– 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 a 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 centurydigital 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 most 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) considerable	a) outdated
2) medium	b) improved
3) conventional	c) wide
4) old-fashioned	d) total
5) advanced	e) determined
6) broad	f) average
	g) large
	h) usual

Exercise 2. ***Find the antonyms.***

1	**2**
1) professional	a) contemporary
2) manual	b) still
3) old-fashioned	c) required
4) common	d) automatic
5) weak	e) experienced
	f) amateur
	g) powerful
	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. Try to concentrate on the topic, or you will do/make a lot of mistakes.
2. People can't do/make without natural resources.
3. To see the doctor, he will have to do/make an appointment.
4. Empty vessels do/make the greatest noise.
5. My English isn't perfect so I will do/make all my best to do/make it better.
6. Smoking can do/make harm to your health.
7. Will you do/make me a favour and do/make the shopping for me?
8. My sister is very smart and always does/makes a good impression on people.
9. They have decided to do/make some research in this field.

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

1. It's not easy to … a discovery nowadays.
2. The role of chance is merely to provide the opportunity and the scientist … to recognize it.
3. Men … houses, women … homes.
4. Most of this work already …. .
5. Technology … great advances in the past two decades.
6. Many people like … yoga .
7. We must … a decision right now.
8. She … this dress herself. She is very proud of it.
9. I wasn't able to go to the theatre yesterday as I … a lot to … .

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. Two waves (to interfere) only if their phase relationship (not to change).
2. When the teacher came in, students (to work) on the project.
3. They (to apply) new methods of research for three years.
4. If a light ray (to strike) the glass at some other angle, it will change its direction.
5. Albert Einstein (to recognize) the existence of stimulated emission in 1917.
6. The teacher (to disappoint) because the students failed to fulfil the task.
7. The applications of fiber optics (to increase) at a rapid rate since 1977.
8. How (to work) a transmitter?

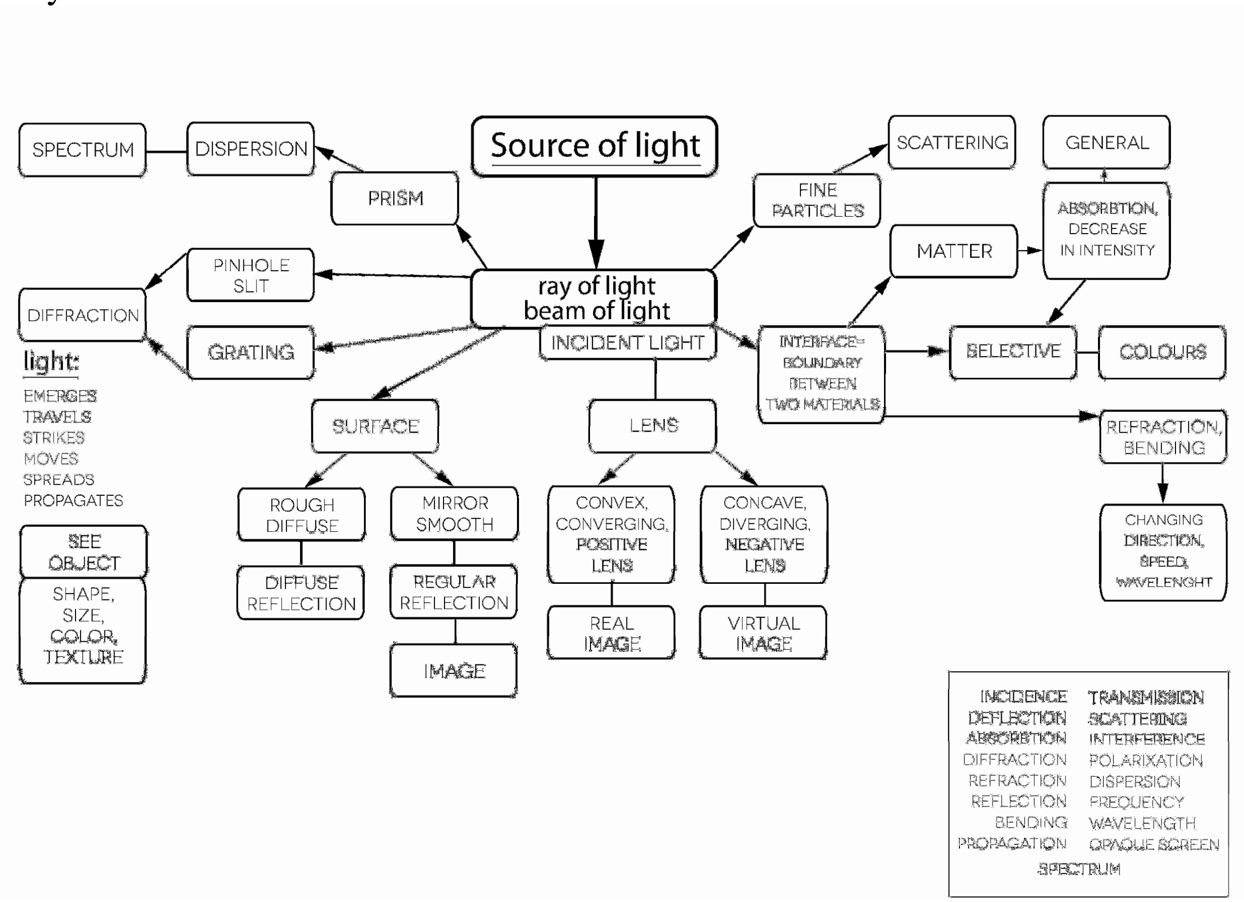
REVIEW OF THE CHAPTER I

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 attentionis 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 the 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.

Keppler 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, which he quickly improved to eight, twenty and then thirty power.
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.
2. Galileo and Keppler much contributed to telescope-making.
3. Why are there different types of telescopes?

Exercise 3. ***Put the verbs in brackets into the correct form.***

1. If I were you, I (to take) the advice of your superviser.
2. If they start this war they (to lose) .
3. Had you told him, he (to come) to the conference.
4. I don’t like living in the city. If I (to have) a choice, I (to move) to the country.
5. Tom will finish the report if he (to work) hard on Sunday.
6. Were they ecologists, they (to try) to prevent an ecological disaster.

TASK 2

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

Holography

<u>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.</u>

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, <u>The 2-nd step, called the reconstruction, consists of placing the</u>

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.

List of Terms:
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.***

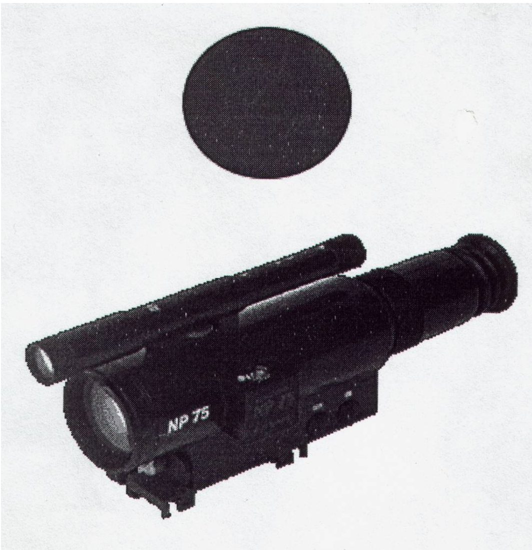
Exercise 2. ***Read and translate two definitions of the word "hologram".***
1. Hologram is a pattern produced by the interference between one part of a split beam of coherent light, e.g. from a laser, and the other part of the same beam reflected off an object.
2. Hologram is a photographic reproduction 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

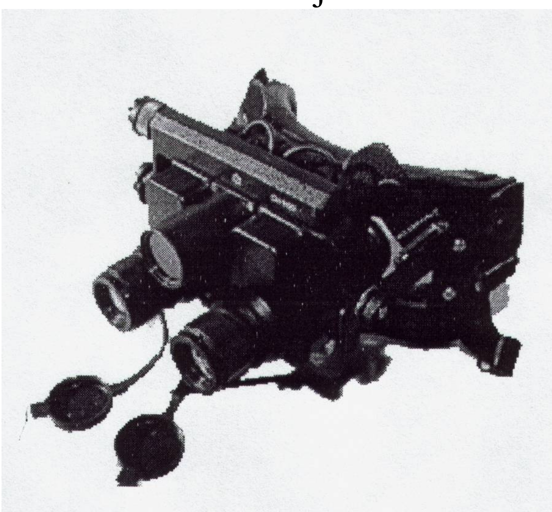
A. The night vision sight NP-75 is designed for aimed hunting gun firing in the twilight and at night. Intensification of luminous flux from the observed scene is taken place by an electrooptical transducer. Luminous laying mark in the field of view of the sight is used for a target aiming. Smooth adjustment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

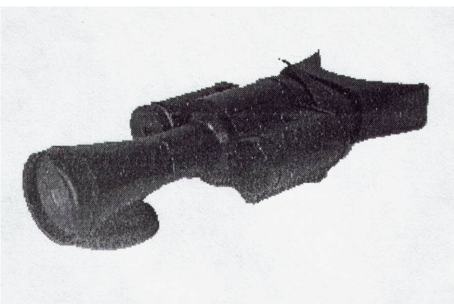
B. ON 1x20 night vision goggles is an optronic device, intended for visual observation of objects in dark time of the day, to orient oneself in a given area, or on water surface in conditions of natural night illumination.

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
Interpuppilary distance, mm:	from 59 to 70
Dimensions, mm:	180x120x170
Mass, kg:	1

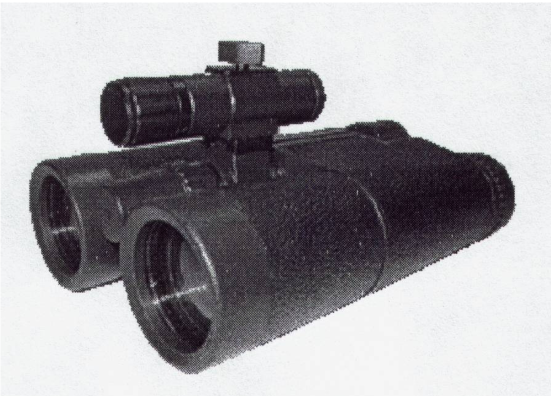
C. BAIGISH-6U is an excellent example of how elaborations of the night vision equipment designed for the military take stable positions now on a consumer market. If you are looking for real 2-nd generation night vision binocular with resolution not less than 30 lines/mm this is BAIGISH-6U. Its perfect 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

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 – радиорефрактор, 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).

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 HEAO-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

inaccessible – неудобный, недоступный

decode – декодировать, расшифровывать

glass-clad fibre – волокно со стеклянным покрытием

in the intervening years – в период (между)

fused silica – кварцевое стекло

lossy – с большими потерями
melting point – точка плавления
one wave-guide mode – передатчик определенных длин волн, одномодовый 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 to be 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 were 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 questions.***

1. When did the study of fiber optics begin?
2. Who invented “optical telegraph”?
3. What was the reason of Bell’s optical telephone system failure?
4. How did the invention of optical fibers affect optical communication?

INCREASE YOUR VOCABULARY

Exercise 1. ***Find Russian equivalents to English word combinations.***

1	2
1. relayed message	a) полное отражение
2. fused silica	b) оптоволоконный кабель
3. theoretical specifications	c) показатель преломления
4. bundle of optical fibers	d) одноволновая мода колебаний
5. total reflection	e) переданное сообщение
6. refrective index	f) усилитель оптических частот
7. melting point	g)теоретические условия
8. optical-frequency amplifier	h)точка плавления
	i)плавленый кварц
	j)полые трубки
	k)критическая температура

Exercise 2. ***Match the synonyms.***

1	2
1. to carry	a) to present
2. to adapt	b) to take
3. to introduce	c) to show
4. to amplify	d) to move along
5. to apply	e) to make suitable
6. to demonstrate	f) to intensify
	g)to reduce
	h)to use

LANGUAGE ACTIVITY

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

1. An optical-fiber core is coated by a lower density glass layer.
2. Light can be transmitted over long distances by being reflected inward thousands of times with no loss.
3. Optical fibers are used in some medical instruments to transmit images of the inside of the human body.
4. Fibers have also been developed to carry high-power laser beams for cutting and drilling.
5. Optical fiber was technologically advanced in 1970 by Corning Glass Works, with attenuation low enough for communication purposes (about 20dB/km), and at the same time GaAs semiconductor lasers were developed that

were compact and therefore suitable for transmitting light through fiber optic cables for long distances.
6. Long-range communication systems are being successfully used worldwide nowadays.
7. Particular attention had been paid to the means of improving the properties of semiconductors.
8. Several general requirements should be met to match transistor stages in an amplifier.

Exercise 2. ***Use the right Passive Construction.***

1. Wavelengths of visible light …………in meters or in nanometers (nm), which are one-billionth of a meter.
a) can measure
b) can be measured
c) be measured
2. The distance light travels in one second ………… since 1983.
a) having known
b) have known
c) has been known
3. Accurate measurements of the speed of light ………… by scientists because they were looking for the medium that light traveled in.
a) were made
b) is made
c) to be made
4. This special theory of relativity predicted many unexpected physical consequences, all of which …………… in nature since.
a) being observed
b) have been observed
c) has observed

Exercise 3. ***Put the verbs in brackets in the right form of the Passive.***

1. Light ……. (to keep) in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes ……………(to call) multi-mode fibers (MMF), while those that only support a single mode ………(to call) single-mode fibers (SMF). Multi-mode fibers generally have a larger core diameter, and …………(to use) for short-distance communication links and for applications where high power must …………(to transmit). Single-mode fibers ………(to use) for most communication links longer than 1,050 meters . 2. Fiber-optic communication systems ….. primarily ……… (to install) in long-distance applications, where they can …..(to use) to their full transmission capacity, offsetting the increased cost. 3. The second generation of fiber-optic communication ……….. (to develop) for commercial use in the early 1980s, operated at 1.3 μm, and used in GaAsP semiconductor lasers. These early systems ….. initially ………(to limit) by multi-

mode fiber dispersion, and in 1981 the single-mode fiber ….. (to reveal) to greatly improve system performance. 4. When a photon, or packet of light energy, ……….. (to absorb) by an atom, the atom gains the energy of the photon, and one of the atom's electrons may jump to a higher energy level. The atom ……(to say) to be excited. When an electron of an excited atom falls to a lower energy level, the electron's excess energy may………(to emit) by the atom in the form of a photon.

Exercise 4. ***Insert the following prepositions in the sentences.***
In, for, of, by, on, with, without

1. …. 1880 Alexander Graham Bell and his assistant Charles Sumner Tainter created a very early precursor to fiber-optic communications, the Photophone, at Bell's newly established Volta Laboratory …… Washington, D.C.
2. Since 2000, the prices ……. fiber-optic communications have dropped considerably.
3. Fiber-optic communication is a method ……. transmitting information from one place to another …… sending pulses of light through an optical fiber.
4. The device allowed for the transmission of sound ………. a beam of light.
5. The Photophone's first practical use came ……… military communication systems many decades later.
6. Fiber Optics is a branch of optics dealing …… the transmission of light through hair-thin, transparent fibers.
7. A basic fiber-optic system consists …….. a transmitting device which generates the light signal, an optical-fiber cable which carries the light, and a receiver which accepts the transmitted light signal and converts it to an electrical signal.
8. Newly developed optical fiber amplifiers, for example, can directly amplify optical signals …….. first converting them to an electrical signal, speeding up transmission and lowering power requirements.

Exercise 5. ***Translate the following sentences paying attention to the meaning of the word "as".***

As: 1. Так как 2. В то время как 3. Поскольку 4. Столько – сколько 5. Как и 6. По мере того как

1. As the time passed, stone tools were substituted by metal ones.
2. There are two kinds of transformations which are known as physical and chemical changes.
3. The synthetic materials of which the construction is made can be relied upon as they are of high quality.
4. At present plastics as well as metals are widely used in various branches of industry.
5. Every second the Sun sends into space as much energy as it was consumed during the whole period of human existence.
6. The outer and inner walls had been made as thick as 40 centimeters.

Exercise 6. ***Choose the required verb and put it in necessary tense and voice (to house, to make, to fill, to pay, to work out, to use).***

1. It should be noted that the first house of glass and plastics … by engineers of several institutes.
2. Its construction … great attention to.
3. Everything in it …. of glass and plastic.
4. The vacuum between inner and outer walls … with excellent thermal and soundproof materials.
5. All the equipment … in the technical chamber.
6. It can be said that soon plastics … in all branches of our industry.

Exercise 7. ***Complete the sentences using Present Perfect Passive.***

1. During the last several years some attempts … (to make) to classify the elementary particles. 2. In recent years much of our interest … (to center) around the problem of the evolution of comets. 3. The contribution of scientists to space research greatly … (to appreciate). 4. In the last few decades much of the data in various areas of physics … (to analyze) quite well in terms of the quantum theory. 5. The studies which … (to describe) in this paper have become classical ones. 6. In recent literature the problems and prospects of this new trend … not… (to discuss) exhaustively. 7. A few improvements lately… (to recommend) to facilitate the experiments of atomic collisions. 8. Various ideas … (to propose) to explain the origin of this planet.

Exercise 8. ***Translate the sentences paying attention to the Modal Verbs and their equivalents.***

1.The designers *can* always improve the operation of these receivers.
2.Any transmitter *could* be used in this system.
3.The scientists *are able to* construct a new device by using semiconductors.
4.We *have to* increase the current strength by decreasing the resistance of the circuit.
5.Electrolysis *may* be defined as a process by which a chemical reaction is carried out.
6.The energy which *has to* be supplied by the generator or battery is transformed into heat within the conductor.
7.To detect very weak radio signals a directional antenna and a highly sensitive radio receiver *are to be* used.
8.A number of scientific problems *were to be* solved in connection with the construction of electrotransmission lines.
9.To improve the operation some tubes *are to be* replaced.
10. The experiment *must* have been done in a wrong way because of the data obtained being in contradiction with Lenz`s law.
11. The voltage *may* have been too high, the insulation being broken down.
12. To get better results another method *ought to* have been applied.
13. These important results *might* have been easily overlooked, as they were published in a popular science magazine.

14. The resulting figures *should* have been corrected for the energy losses to make the picture look more realistic.

Exercise 9. ***Put the following sentences into the Passive Voice and translate them.***

Example: They must have overlooked this possibility. - This possibility must have been overlooked.

1. They must have underestimated the result.
2. They should have extended the conception to include this case as well.
3. They may have disregarded smaller defects.
4. They may have postponed the further work.
5. They must have overestimated the potentialities of this technique.
6. They could have reorganized this department long ago.
7. They might have neglected the errors.

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 Nouns
transmit transmitter, transmission
receive receiver, receivership
inform informer, information
translate translator, translation
reflect reflector, reflection
construct constructor, construction
contribute contributor, contribution
advertise advertiser, advertisement employ 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, кожух
optic core – сердцевина оптического волокна, жила
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 reflection – 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. How does a fiber optic system work? What are the three main components of a fiber optic system?
3. How is a fiber optic cable constructed?
4. What is the purpose of an optical receiver and how does it work?
5. What can serve as a means of signal transmission?
6. What are the advantages of fiber optic systems?
7. Where can fiber optic systems find wide application?

INCREASE YOUR VOCABULARY

Exercise 1. ***Match nouns from the left column with their Russian equivalents from the right one.***

1	2
1. abrasion	a) передатчик
2. interface	b) растворитель
3. transmitter	c) кабель
4. solvent	d) трение
5. strand	e) импульс
6. value	f) падение
7. incidence	g) приемник
	h) стык
	i) величина, значение

Exercise 2. ***Match collocations from the left column with their Russian equivalents from the right one.***

1	**2**
1. copper wire	a) передающая среда
2. basic purpose	b) внешне покрытие
3. reflective surface	c) сердцевина оптического волокна
4. outer jacket	d) основная цель
5. transmission medium	e) медный провод
6. optic core	f) внутреннее отражение
7. internal reflection	g) отражающая поверхность
8. optic cladding	h) оптическое покрытие

Exercise 3. ***Insert the proper collocations: a) optic cladding, b) fiber-optic system, c) copper wires, d) light pulses.***

1. Using a lens the … are introduced into the fiber-optic medium.
2. A … is a system with three main components.
3. Optic core is surrounded with the … .
4. Electronic pulses transmit information through … .

Exercise 4. ***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 …

Exercise 5. ***Choose the proper explanations to the terms:***

1	**2**
1. Optical Fiber	a) The change of direction of light rays or photons after striking small particles. It may also be regarded as the diffusion of a light beam caused by the inhomogeneity of the transmitting material.
2. Core	b) The path of a point on a wavefront.
3. Cladding	c) A single electromagnetic wave traveling in a fiber.
4. Coating	d) The light-conducting central portion of an optical fiber, composed of material with a higher index of refraction than the cladding. The portion of the fiber that transmits

	light.
5. Scattering	e) The material surrounding the cladding of a fiber. Generally a soft plastic material that protects the fiber from damage.
6. Refraction	f) A property of optical materials that relates to the speed of light in the material versus the speed of light in a vacuum.
7. Lightwave	g) A device that imposes a signal on a carrier.
8. Refractive Index	h) The changing of direction of a lightwave in passing through a boundary between two dissimilar media, or in a graded-index medium where refractive index is a continuous function of position.
9. Mode	i) Material that surrounds the core of an optical fiber. Its lower index of refraction, compared to that of the core, causes the transmitted light to travel down the core.
10. Modulator	j) A glass or plastic fiber that has the ability to guide light along its axis.

LANGUAGE ACTIVITY

Exercise 1. ***Insert the following prepositions in the sentences (in, of, by, on, with, into).***

1. Light scattering depends … the wavelength of the light being scattered.
2. The scattering of light … optical quality glass fiber is caused … molecular level irregularities (compositional fluctuations) … the glass structure.
3. In practical fibers, the cladding is usually coated … a tough resin *buffer* layer, which may be further surrounded … a *jacket* layer, usually glass.
4. The main component … an optical receiver is a photo detector, which converts light … electricity using the photoelectric effect.

Exercise 2. ***Translate the following sentences, pay attention to the predicates and define the tense forms.***

1. Nowadays the most commonly-used optical transmitters *are* semiconductor devices such as light-emitting diodes (LEDs) and laser diodes.
2. The difference between LEDs and laser diodes *is* that LEDs *produce* incoherent light while laser diodes *produce* coherent light.
3. Engineers are always looking at current limitations in order to improve fiber-optic communication.
4. Internet protocol data traffic *was increasing* exponentially, at a faster rate than integrated circuit complexity *had increased* under Moore's Law.
5. After a period of research starting from 1975, the first commercial fiber-optic communications system *was developed*.
6. The information transmitted *is* typically digital information generated by computers, telephone systems, and cable television companies.

7. German-born American physicist Albert Einstein’s elegant equation $E=mc^2$ *predicted* that energy *could be converted* to matter.
8. Recent advances in fiber and optical communication technology *have reduced* signal degradation so far that regeneration of the optical signal *is* only *needed* over distances of hundreds of kilometers.

Exercise 3. ***Put the verbs in brackets in the required tense form and translate the sentences into Russian.***
1. Light waves from the Sun … (to produce) a very large number of photons.
2. Scientists … (to learn) through experimentation that light … (to behave) like a particle at times and like a wave at other times.
3. In the late 1990s through 2000 research companies such as KMI and RHK … (to predict) massive increases in demand for communications bandwidth due to increased use of the Internet.
4. Since 1990 optical-amplification systems … (to become) commercially available, the telecommunication industry … (lay) a vast network of intercity and transoceanic fiber communication lines.
5. In 1900 the German physicist Max Planck … (to discover) that light energy … (to carry) by photons.
6. Modern fiber-optic communication systems generally … (to include) several components, each … (to perform) some certain functions. An optical transmitter … (to convert) an electrical signal into an optical signal to send into the optical fiber. A cable containing bundles of multiple optical fibers … (to route) through underground conduits and buildings. Multiple kinds of amplifiers and an optical receiver … (to recover) the signal as an electrical signal.
7. The main component of an optical receiver … (to be) a photodetector, which … (to convert) light into electricity using the photoelectric effect.
8. Human eyes … (to respond) best to green light at 550 nm, which … (to be) also approximately the brightest color in sunlight at Earth’s surface.
9. 5. An optical fiber … (to consist)of a core, cladding, and a buffer, in which the cladding … (to guide)the light along the core by using the method of total internal reflection
10. First developed in the 1970s, fiber-optic communication systems … (to revolutionize) the telecommunications industry and … (to play) a major role in the advent of the Information Age since then.
11. The core and the cladding … usually … (to make) of high-quality silica glass, although they can both … (to make) of plastic as well.
12. Connecting two optical fibers is … (to do) by fusion splicing or mechanical splicing and requires special skills and interconnection technology.
13. For use in optical communications, semiconductor optical transmitters must … (to design) to be compact, efficient and reliable while operating in an optimal wavelength range and directly modulated at high frequencies.

Exercise 4. ***Put the verbs in brackets using the Past Simple (Active or Passive).***

In 1880 Alexander Graham Bell and Sumner Tainter … (to invent) the 'Photophone' at the Volta Laboratory in Washington, D.C., to transmit voice signals over an optical beam. It … (to be) an advanced form of telecommunications, but … (to subject) to atmospheric interferences and impractical until the secure transport of light that would be offered by fiber-optical systems.

In the late 19th and early 20th centuries, light … (to guide) through bent glass rods to illuminate body cavities. Jun-ichi Nishizawa, a Japanese scientist at Tohoku University also … (to propose) the use of optical fibers for communications in 1963. He … (to state) these ideas in his book published in 2004 in India. Nishizawa … (to invent) other technologies that … (to contribute) to the development of optical fiber communications, such as the graded-index optical fiber as a channel for transmitting light from semiconductor lasers.

Charles K. Kao and George A. Hockham of the British company Standard Telephones and Cables (STC) … (to be) the first to promote the idea that the attenuation in optical fibers could be reduced below 20 decibels per kilometer (dB/km), making fibers a practical communication medium. They … (to propose) that the attenuation in fibers available at the time … (to cause) by impurities that could be removed, rather than by fundamental physical effects such as scattering. They correctly and systematically … (to theorize) the light-loss properties for optical fiber, and … (to point out) the right material to use for such fibers — silica glass with high purity. This discovery … (to earn) Kao the Nobel Prize in Physics in 2009.

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 rate – скорость передачи информации
duct – соединительная трубка
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 – управление, слежение
transmission media – среда, средства передачи информации
optical receiver – оптический приемник
optical transmitter –оптический передатчик
light emitting diode – светодиод
point-to-point fiber optic transmission system – поточечная передающая оптоволоконная система
power line – силовой кабель (линии электропередачи)
solid-state laser diode – полупроводниковый лазерный диод
spark – возгорание, искровой разряд
splice – сросток, 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 wave-guides 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. ***Answer the following questions.***

1. What components does the basic point-to-point optic transmission system consist of?
2. What function has an optical transmitter?
3. What kinds of cables are used in fiber optics?
4. What is a fiber optic system?
5. What are the advantages of fiber optic systems?

INCREASE YOUR VOCABULARY

Exercise 1. ***Find the synonyms.***

1	**2**
1. invention	a) development
2. ability	b) receiver
3. evolution	c) provider
4. construction	d) discovery
5. interference	e) diapason
6. bandwidth	f) possibility
7. optical fiber	g) structure
	h) lightguide
	i) interaction
	j) provision

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

Most responsible for its evolution, basic point-to-point fiber optic transmission system, wide range of benefits, virtually all kinds, there is no possibility of a spark, to expand the boundaries, information carrying capacity.

Exercise 3. ***Match collocations from the left column with their Russian equivalents from the right one.***

1	**2**
1. optical splice	a) внешние атмосферные условия
2. ground loops	b) линии электропередачи
3. replica	c) отражение

4. advantage	d) угроза пожара
5. fidelity	e) сплетение (проводов)
6. lightning	f) преимущество
7. spark	g) трубопровод
8. power lines	h) молния
9. duct	i) замыкание
10. fire hazard	j) возгорание
11. outdoor atmospheric conditions	k) точность
	l) скорость
	m) копия

Exercise 4. ***Find the synonyms to the following adjectives.***

1	2
1. immune	a) transistorized
2. explosive	b) initial
3. unlimited	c) important
4. digital	d) bursting
5. solid-state	e) similar
6. original	f) unaffected
7. significant	g) boundless
	h) numerical

Exercise 5. ***Find the synonyms to the following verbs.***

1	2
1. to corrode	a) to transform
2. to handle	b) to include
3. to install	c) to propose
4. to carry	d) to rust
5. to offer	e) to order
6. to monitor	f) to manipulate
7. to contain	g) to transmit
8. to convert	h) to set up
9. to require	i) to strike
	j) to supervise

LANGUAGE ACTIVITY

Exercise 1. ***Choose the right form of the verb.***

1. He said he (is staying, was staying) at the "Ritz" Hotel. 2. They realized that they (lost, had lost) their way in the dark. 3. He asked me where I (study, studied). 4. I thought that I (shall finish, should finish) my work at that time. 5 He says he (works, worked) at laboratory two years ago. 6. The lecturer said he (is, was) very

busy. 8. My friend asked me who (is playing, was playing) the piano over there. 9. He said he (will come, would come) to the station to see me off. 10. I was sure he (posted, had posted) the letter. 11. I think the weather (will be, would be) fine next week. I hope it (will not change, would not change) for the worse. 12. I knew that he (is, was) a very clever man. 13. I want to know what he (has bought, had bought) for her birthday. 14. I asked my sister to tell me what she (has seen, had seen) at the museum.

Exercise 2. ***Open the brackets using the correct form of the verb.***
1. He said he (to leave) tomorrow morning. 2. She says she already (to find) the book. 3. He stopped and listened: the clock (to strike) five. 4. She said she (can) not tell me the right time, her watch (to be) wrong. 5. I asked my neighbour if he ever (to travel) by air before. 6. The policeman asked George where he (to run) so early. 7. The delegates were told that the guide just (to go) out and (to be) back in ten minutes. 8. I knew they (to wait) for me at the metro station and I decided to hurry. 9. I didn't know that you already (to wind) up the clock. 10. I was afraid that the little girl (not to be) able to unlock the front door and (to go) upstairs to help her. 11. He says that he (to know) the laws of the country. 12. It was clear why Lanny (not to come) the previous evening. 13. He understood that the policemen (to arrest) him. 14. He could not understand why people (not to want) to take water from that well.

Exercise 3. ***Change the following sentences into Indirect Speech.***
1. He said, "I like this song." He said __________. 2. "Where is your sister?" she asked me. She asked me __________. 3. "I don't speak Italian," she said. She said __________. 4. "Say hello to Jim," they said. They asked me __________. 5. "The film began at seven o'clock," he said. He said __________. 6. "Don't play on the grass, boys," she said. She told the boys __________. 7. "Where have you spent your money?" she asked him. She asked him _____. 8. "I never make mistakes," he said. He said __________. 9. "Does she know Robert?" he wanted to know. He wanted to know __________. 10. "Don't try this at home," the stuntman told the audience. The stuntman advised the audience __________. 11. "I was very tired," she said. She said __________. 12. "Be careful, Ben," she said. She told Ben __________. 13. "I will get myself a drink," she says. She says __________. 14. "Why haven't you phoned me?" he asked me. He wondered __________. 15. "I cannot drive them home," he said. He said __________. 16. "Peter, do you prefer tea or coffee?" she says. She asks Peter __________. 17. "Where did you spend your holidays last year?" she asked me. She asked me _. 18. He said, "Don't go too far." He advised her __________.

Exercise 4. ***Choose the right form of the verb.***
1. She realized that nobody (will come/would come). 2. We understood that she (sees/saw) nothing. 3. He said he (will arrive/would arrive) in some days. 4. My mother was sure I already (have come/had come). 5. I didn't know they (are/were) in the room. 6. We supposed the rain (will stop/would stop) in some hours. 7. He

said he never (has been/had been) to London. 8. We wanted to know who (is singing/was singing) in the next room. 9. I always thought he (is/was) a brave man. 10. When I saw him, he (is working/was working). 11. We know she always (comes/came) in time. 12. They thought he (will have finished/would have finished) his work by the evening. 13. She said she (has/had) a terrible headache. 14. We supposed they (will send/would send) us the documents. 15. He said he (has not seen/had not seen) us for ages.

Exercise 5. ***Put the verb in brackets into the right form.***
1. Her brother said he never (to see) that film before. 2. He came home and listened: his son (to play) the piano. 3. They didn't worry too much because they (to lock) the door. 4. I asked her when she (to give) me that book to read. 5. We wanted to know if they (to enjoy) the meal. 6. She supposed she (to like) the hotel. 7. I am afraid they (not to come) yet. 8. He wanted to know if the station (to be) far away. 9. Eric doesn't know who (to phone) him at five o'clock. 10. He admitted he (not to be) here for weeks. 11. She was sorry she (to arrive) so late. 12. Jean promised she never (to speak) to me again. 13. Andy said he just (to buy) a new car. 14. My mother decided that she never (to drink) coffee late at night. 15. I hear you already (to find) a new job. 16. We were sure our children (to sleep). 17. I didn't think they still (to discuss) that problem. 18. It is remarkable that you (to come) at last. 19. My doctor thinks I (to be) allergic to pineapples. 20. Sophia knew her aunt (to be) glad to visit her in two days. 21. Copernik proved that the Earth (to revolve) round the Sun. 22. The teacher said the sun (to set) in the west. 23. Who said we (to be) the only intelligent race in the universe?

Exercise 6. ***Put the verb in brackets into the right form.***
1. When I opened the window, I saw the sun (to shine). 2. We are sure Simon (to marry) her some time later. 3. He can't remember where he (to put) his glasses. 4. George thought the restaurant (to be) expensive. 5. She was disappointed that she (not to get) the job. 6. I didn't understand why they (to destroy) their relationship. 7. He is not sure they (to find) their way in the darkness. 8. Jane asked me if I (to invite) Ann to the party. 9. People say that he always (to be) very rich. 10. She said she (to wait) for me since seven o'clock. 11. They thought I (to give) them my telephone number. 12. I am afraid I (not can) answer your question. 13. We wanted to know what (to happen) to John. 14. George thought he (can) repair the car himself. 15. She is very upset: she (to break) her watch. 16. Bill said he (to feel) ill. 17. We thought she still (to be) in hospital. 18. I knew he (to pass) his examination at that time. 19. My cousin promised he (to visit) me in a week. 20. We didn't know they (to be) tired.

Exercise 7. ***Change the following sentences into Indirect Speech.***
1. "We are going to have dinner", my mother said to me. 2. "She has made great progress in her English", her teacher said. 3. "I will be glad to help you, don't mind", Joe said to Polly. 4. "We are playing a boring game", his children said. 5. Robert said: "Nobody has mentioned about it". 6. "I can't stay here", he said. 7. "As

soon as you see him, give him my telephone number", Henry said to me. 8. "I'll just step out the door for a minute", Julia said. 9. "Be a good boy and be careful", his father said. 10. "If I go back my parents will not let me go out", the boy said to his friends. 11. "I think you don't know anything about it", Victor said. 12. "They have been discussing this question for two hours", said the secretary. 13. "I am all right. I feel better now", the patient said. 14. "If it is possible I will return in time", he said. 15. Her sister said to me: "She is still doing her homework".

Exercise 8. ***Change the following sentences into Direct Speech.***
1. She said she had already found her book. 2. My father told me that he was busy. 3. The pupil said he had not learnt the lesson. 4. All said that he was ill and felt unwell. 5. My sister told me that if she got that book she would give it me to read. 6. Mother asked me to stay at home as the weather was bad. 7. The man said he had never been to England. 8. Jane told us she would be working the whole day on Sunday.9. The man said that there was no room for us. 10. His father asked him to put the papers on the table. 11. Barry said that he thought he had left his watch at home. 12. Jane said that she is going to go for a walk. 13. The teacher told the boy to leave the room immediately. 14. Derek told me he had got to entertain his cousins on Sunday evening.

Exercise 9. ***Change the following sentences into Indirect Speech.***
1. They said: "We have forgotten to phone our friend". 2. "I'm going to the cinema straight from work. Will you go with me?" Barry said to Ann. 3. "What will you be doing at ten o'clock on Friday?" asked Ben. "I think I will be having breakfast", said Mike. 4. The man asked us: "Is there a post office near here?" 5. "Where is my magazine, Alice?" asked mother. "I have put it on the table", said Alice. 6. "I won't do it until they give me some money", said the boy. 7. "Don't smoke in the compartment", said the passenger. 8. Rita said to me: "What has mother told you to do today?" 9. "Which of you is free now?" asked the teacher. 10. "I think she works in a bank", said Andrew. 11. Helen said to me: "I know they're your best friends". 12. "I met your sister in the street yesterday", she said to Johnny. 13. Eric said to me: "Come and have a look at my new bike". 14. He said to me: "Where was Chris going when you met him?" 15. The doctor said to his patient: "How are you feeling now?"

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
announce – объявлять
attenuation – ослабление, затухание
application – применение
backbone architecture – основная составляющая структура
coaxial – коаксиальный
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 – энергетические компании
revenue streams – источники дохода
shared program software – общее программное обеспечение
shrinking – уменьшающийся, сокращающийся

information superhighway-информационная магистраль (телекоммуникационная сеть, обеспечивающая мгновенную передачу информации)
supplement – (зд.) в дополнение к
terrestrial – наземный
utilities – предприятия
via – через

COMPREHENSIVE READING

Optical Fiber Applications

The use of fiber optics 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 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 travelling 1 km. Today's optical fiber attenuation ranges from 0.5 dB/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. What requirements to the characteristics of optical fiber were there to make it feasible for telecommunication transmission? When was the crucial attenuation limit achieved?
2. How did telephone companies use optical fiber? How do they use it now?
3. How do different cable television companies and LAN systems use optical fiber communications?
4. Why are power companies so interested in applying 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. ***Find in each of two similar sentences which is true (T) and which is false (F).***

1. Why was the use of fiber optics generally not available until 1970?

a) The use of fiber optics generally was not available until 1970 because the loss in dB/km was too heavy.
b) The use of fiber optics generally was not available because telecommunication companies considered quartz as a not suitable material for them.

2. What have you learnt about the applications of fiber optics by telephone companies?

a) Telephone companies were the last to replace old copper wire systems with optical fiber lines.
b) Telephone companies early began replacing their old copper wire systems with optical fiber lines.

3. How did different television companies and LAN systems use optical fiber communications?

a) Cable television companies and LAN systems integrated fiber optics into their cable systems and computer systems.
b) Cable television companies and LAN systems were ready to experiment with the fiber.

4. Were power companies interested in applying fiber optics?

a) Power companies were interested in applying fiber optics because it could be a new source of revenues.

b) Power companies were not interested in applying fiber optics because they didn`t see it as a new source of revenues.

5. What carriers of information are suitable for Information Superhighway bandwidth?
a) Copper cable as well as optical fiber are able to provide bandwidth needs for Information Superhighway.
b) The Information Superhighway bandwidth requires a medium like optical fiber.

INCREASE YOUR VOCABULARY

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

1	2
1. delivery	a. применение
2. installation	b. доставка, передача
3. attenuation	c. база данных
4. trunk line	d. узел
5. superhighway	e. общее программное обеспечение
6. application	f. ослабление
7. power companies	g. информационная магистраль
8. utilities	h. энергетические компании
9. plant	i. завод
10. database	j. установка
11. node	k. магистральная линия
12. shared program software	l. предприятия
	m. увеличение

Exercise 2. ***Read the English words and find the Russian equivalents to them.***
Verbs:

1	2
1. to convert	a. объявлять
2. to allow (for)	b. заменять
3. to integrate	c. предоставлять
4. to announce	d. переходить
5. to replace	e. предусматривать
	f. объединять, включать

Adjectives:

1	2
1. coaxial	a. наземный
2. terrestrial	b. доступный
3. available	c. главный

4. rapid	d. осуществимый
5. major	e. быстрый
6. feasible	f. коаксиальный

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. ***Open the brackets using Subjunctive Mood after "as if/as though".***

Pattern: - Why do you always treat me as though I /to be/ a backward child of 12?
– Why do you always treat me as though I were a backward child of 12?

1. She kept trying on hat after hat as if she … (not to make up) her mind from the very beginning which she would take.
2. He spoke French as if I … (to be) a Frenchman or (to spend) most of my life over there.
3. She could discuss the latest novel as though she … (to read) it.
4. She spoke as if she … (to know) everyone there.
5. She behaved as if she … (to graduate) from the university long ago.

Exercise 3. ***Rewrite each sentence so that it contains the construction "but for".***
Pattern: It began to rain and we didn't go for a walk. - But for the rain we would have gone for a walk.
1. He could not see the play as he had some work to do.
2. I don't want to tell you this. But I promised to.
3. He didn't die. The operation saved him.
4. We didn't have a very good time after all. The weather was too bad.
5. He has the makings of a good teacher but he has a slight defect of speech.
6. Of course I want to help you. But I've a conference today.
7. He had a good guide so he managed to climb the mountain.
8. It was only because the ice was so good that she could set a new record.
9. I could do it all in so short a time only because of your kindness and understanding.
10. You can't do it only because of a certain lack of concentration.

Exercise 4. ***Make one new sentence from each pair of sentences using Mixed Conditionals.***
Pattern: She didn't study hard. She won't pass the exams.
If she had studied hard she would pass the exams
1. You didn't wake me up. Now I'm late for my appointment.
2. She isn't well-qualified. She didn't get the job.
3 We didn't go to the restaurant. We don't like fast food.
4. She didn't bring her umbrella. Now, she's getting wet.
5. I don't know them very well, so I didn't go to the party.
6. He isn't at the lecture because he wasn't told about it.
7. They didn't take a map with them. They're lost now.
8. I didn't buy tickets. We can't go to the theatre tonight.
9. They missed the flight. They won't arrive until tomorrow.

Exercise 5. ***Choose the right form of the verb in brackets.***
1. If she (comes/came) late again, she'll lose her job.
2. I'll let you know if I (find/found) out what's happening.
3. If we (live/lived) in a town, life would be easier.
4. I'm sure he wouldn't mind if we (arrive/arrived) early.
5. (We'll/We'd) phone you if we have time.
6. If I won the lottery, I (will/would) give you half the money.
7. It (will/would) be a pity if she stopped studying foreign languages.
8. If I'm free on Saturday, I (will/would) go to the mountains.
9. She (will/would) have a nervous breakdown if she goes on like this.
10. I know I'll feel better if I (stop/stopped) smoking.

Exercise 6. ***Rewrite each sentence so that it contains the construction "I wish".***
Pattern**:** I'm sorry I haven't got a washing machine. – I wish I had a washing machine.
1. I'm sorry I don't know Finnish.
2. I'm sorry I didn't book a seat.
3. I'm sorry I haven't got a car.
4. I'm sorry I can't drive.
5. I'd like Tom to drive more slowly (but I haven't any great hopes of this).
6. I'd like you to keep quiet. (You're making so much noise that I can't think.)
7. It's a pity he didn't work harder during the term.
8. It's a pity you are going tonight.
9. I'm sorry I left my last job.
10. I'm sorry I didn't know you were coming.
11. I'm sorry you told Jack.
12. I'm sorry you aren't coming with us.
13. I'm sorry you aren't going to a job where you could use your English.
14. It's a pity you didn't ask him how to get there.

Exercise 7. ***Fill in the correct form of the verb in brackets.***
1. I didn't learn to play any instrument when I was at school. I wish I … (learn) to play the guitar.
2. I'm over six feet. I wish I … (grow) so tall.
3. He is such a bad driver. I wish he … (be) given a driving licence.
4. I can't cook. I wish I … (can) prepare a family dinner for twelve people.
5. We get invited to parties all the time. We wish we … (be) so popular.
6. I decided to study law. I wish I … (become) a solicitor.
7. This car is fantastic. I wish I … (have) a similar one.
8. This walkman was very cheap and it broke down at once. I wish I … (buy) it. 9. If only I … (not/make) that mistake yesterday.

REWIEW 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. A*nswer 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 states – 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 amplification 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 gasdymamic laser was successfully operated at the Avco Everett Research Laboratory.

The 1970s years became the time of discovery of a 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 instruments are called lasers?
2. What marked the beginning of maser period ?
3. What kind of active medium was used in masers for radio astronomy ?
4. When was the first operable laser invented ?
5. Where was the first gas laser developed?
6. What are the main fields of laser application ?

Exercise 2. ***Choose the correct item.***

1.When the wavelength of the emitted radiation is about 1 cm we speak of...

a) lasers
b) masers
c) magnifiers.

2. It was ... who announced the construction and operation of a maser.

a) Townes
b) Schawlow
c) Basov

3. The achievement of ... opened the laser period.

a) the gas laser
b) the ruby laser
c) the dye lasers

4. It was proposed that ... could produce population inversion in molecular systems.
a) slow cooling
b) rapid heating
c) rapid cooling

5. The ... years became the time of discovery of a free electron laser.
a) 1960s
b) 1970s
c) 1980s

INCREASE YOUR VOCABULARY

Exercise 1. ***Match the synonyms.***

Nouns

1	**2**
1. development	a) reversal
2. emission	b) exploration
3. inversion	c) difference
4. mixture	d) transition
5. recognition	e) radiation
6. research	f) compound
7. variety	g) adoption
	h) achievement
	i) importance

Verbs

1. achieve	a) adopt
2. amplify	b) incite
3. convert	c) increase
4. cool	d) attain
5. demonstrate	e) show
6. stimulate	f) discover
	g) freeze
	h) happen
	i) turn into

LANGUAGE ACTIVITY

Exercise 1. ***Define the form and the function of the Participle in the sentences given below. Translate the sentences into Russian.***

1. Russian scientists are successfully developing quantum generators called lasers.
2. Electrons collide with many ions passing through the metal.
3. Functioning as a generator the laser is used as a source of coherent light.
4. Being pumped by another laser the colour – centre laser can successfully operate in the near infra-red region.
5. Having been cooled the mixture was examined.
6. Energy barriers confine injected holes and electrons within the active layer.
7. Having been cooled the mixture was examined.
8. The raising temperature increases the movement of the electrons.

Exercise 2. ***Summarize your knowledge of the Absolute Participial Construction. Translate the sentences into Russian.***

1.Radioactivity having been discovered, we made great progress in atomic physics.
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 3. ***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 Einstein who recognized the existence of stimulated emission.
2. It was only in 1969 that the operation of semiconductor cw laser became possible at room temperature.
3. It was the invention of a floppy disk that resulted in a convenient way to read computer programs.
4. It is because the FELs are so large and expensive that their application is practically limited by the frequency ranges unavailable for conventional lasers.

5. It was the nature of p-n junction that became one of the most difficult things for scientists.
6. It was Keppler who invented the form of the refracting telescope.

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:
active species – активные частицы
arc lamp – дуговая лампа
associative – ассоциативный, объединенный
combustion reaction – реакция сгорания
exothermal chemical reaction – экзотермическая химическая реакция
flash tube – импульсная лампа, лампа-вспышка
in a pulsed manner – в импульсном режиме
junction – стык, соединение, переход
metal-vapour lamp – лампа с разрядом в парах металлов
retinal treatment – лечение сетчатки
transition element – переходный элемент
tunable dye laser – перестраиваемый лазер на красителе
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 term "solid-state laser" is usually reserved for those lasers that have as their active medium either an insulating crystal or a glass. Solid-state lasers often use as their active species impurity irons introduced into an ionic crystal. Usually the ion belongs to one of the series of transition elements in the Periodic Table.

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 heliumneon 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 gasdynamic 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. ***Answer the following questions.***

1. What types of lasers can you name?
2. What crystals are mostly used in solid-state lasers?
3. How should tiny semiconducter lasers be mounted to use energy more efficiently?
4. What are the most common gas laser media ?
5. What kind of radiation can free-electron lasers generate?
6. Where are liquid lasers used?
7. What is the most important area of chemical lasers application?

Exercise 2. ***Complete the sentences.***

1. The most common solid laser media are... .
2. Gas lasers are pumped by... .
3. Free-electron lasers are tunable ... .
4. The active medium of the liquid lasers consists of ... .
5. Chemical lasers are able to provide... .

Exercise 3. ***True or false?***

1. Lasers can be classified according to the laser medium used.
2. The ends of the rod in a solid-state laser are fashioned into two parallel surfaces coated with a highly refracting nonmetallic film.
3. To get better efficiency tiny semiconductor lasers are placed vertically in circuits.
4. Chemical lasers can provide direct conversion of chemical energy into electromagnetic energy.

INCREASE YOUR VOCABULARY

Exercise 1. ***Find the equivalents.***

1	2
1. combuston	a) среда
2. conversion	b) пар
3. dye	c) вспышка
4. liquid	d) стержень
5. medium	e) накачка
6. mixture	f)преобразование
7. pumping	g) растворитель
8. rod	h) жидкость
9. solvent	i) сгорание
10.vapour	j) проводимость
	k) смесь
	l) краситель

Exercise 2. ***Match the synonyms.***

Verbs

1	2
1. coat	a) invent
2. confine	b) set
3. devise	c) link
4. expand	d) bound
5. generate	e) force
6. mount	f) produce
7. pump	g) spread
	h) cover
	i) measure

Nouns

1	2
1. application	a) reflector
2. burning	b) pureness
3. burst	c) use
4. cavity	d) extent
5. junction	e) resonator
6. mirror	f) interface
7. purity	g) current
	h) flash
	i) combuston

LANGUAGE ACTIVITY

Exercise 1. ***Summarize your knowledge of the Gerund. Find Gerunds and state their tense, voice and function. Translate the sentences into Russian.***

1. Good management involves selecting people who know when to listen and when to act.
2. This hologram made with laser light is worth seeing.
3. The kind of molecular gas laser depends on using the type of transition.
4. The process for building up of signal strength is called amplification.
5.The experiments of the physicist resulted in making much more powerful microscopes.
6.In a free-electron laser moving of an electron beam at a speed close to the speed of light is made to pass through the magnetic field generated by a periodic structure.
7. Basov's favourite work was experimenting.

Exercise 2*.* ***In the texts about lasers you have come across such 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. She rewrote the text (fast, yesterday, at the lesson).
2. I'm travelling (every summer, by bicycle, to my native village).
3. They studied (a lot, last year, at the university).
4. He drives (every morning, to work).
5. The play was performed (at the theatre, magnificently, last night).
6.The manager worked (at the office, hard, today).
7. They return (by plane, to London, every weekend).

Exercise 3. ***Read and give Russian equivalents to the adverbs with two forms and differences in meaning.***

deep = a long way down	**full** = exactly, very	**late** = not early	**wide** = fully, off target
deeply = greatly	**fully** = completely	**lately** = recently	**widely** = to a large extent
direct = by the shortest route	**hard** = intently, with effort	**near** = close	**wrong** = incorrectly
directly = immediately	**hardly** = scarcely	**nearly** = almost	**wrongly** = incorrectly; unjustly

easy = gently and slowly	**high** = at/to a high level	**short** = suddenly; off target
easily = without difficulty	**highly** = very much	**shortly** = soon
free = without cost	**last** = after all others	**sure** = certainly
freely = willingly	**lastly** = finally	**surely** = without doubt

Exercise 4. ***Fill in:*** *hard, hardly, hardly ever / anyone / anything*.
All that day, I'd been thinking 1) .... 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 5. ***Underline the correct item, then explain the difference in meaning.***
1. I would like to say that I would *free/freely* give my life for the cause of world peace.
2. Ann told everyone she would pass the exam *easy/easily*, so she was *deep/deeply* embarrassed when she 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. *Sure/Surely* you can't have answered every question *wrong/wrongly*.
5. Although he arrived an hour *late/lately*, he started work *direct/directly* and tried *hard/hardly* to make up for lost time.
6. It is *wide/widely* believed that there is a bus that goes *direct/directly* from here to the airport, but it's not true.
7. 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*.
8. 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.

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, coherent , 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
end face – торцевая поверхность
excitation current – ток возбуждения
fluorescence – флуоресценция
frequency width – полоса частот
facing side – лицевая сторона
feedback **–** обратная связь

induced recombination – индуцированная рекомбинация
injection laser – инжекционный лазер
input energy – входная энергия
optical pumping – оптическая накачка
pulsed condition – импульсный режим
resonator – резонатор
solid-state laser – твердотельный лазер
spontaneous radiation – спонтанное излучение

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 flashlamp 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 a stronger coupling between the radiation and the excited atoms.

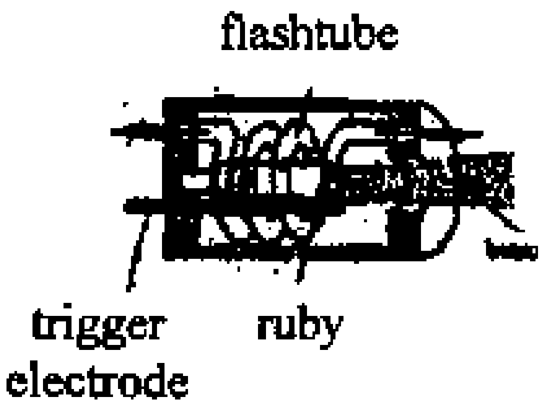


Fig. 1. Construction of ruby laser.

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 the intense coherent radiation emerges.

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. 2).

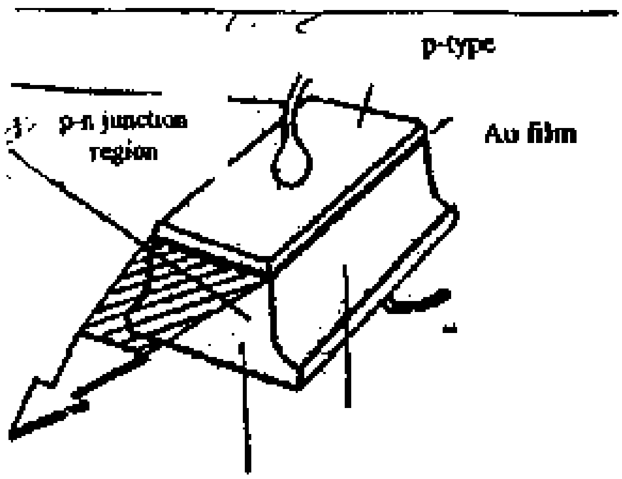


Fig. 2. Construction of typical GaAs semiconductor injection laser.

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 *71* 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 cm2.

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. (AlxGayAs) 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 do we know about the working element of a ruby laser ?
4. What is the resonator used for ?
5. Why do solid-state lasers usually operate in the pulsed condition ?
6. What elements does a solid-state laser consist of?
7. What are the advantages of a semiconductor laser?

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

1. The major properties of laser radiation are low intensity, wide width, directionality and coherence.
2. In practice a laser is generally used as a source or generator of radiation.
3. A resonator provides a weak coupling between the radiation and the excited atoms.
4. It is easy to provide a powerful source of exciting light capable of continuous operation.
5. Semiconductor lasers can’t be excited directly by electric current.

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

1.The laser is a device that ...

a) amplifies
b) light.decreases
c) light.reflects light.

2. Lasers require some type of resonator for ...
a) the light.
b) field.the magnetic
c) field.the radiation field.

3. Ordinary ruby lasers are excited for periods of ...
a) a few milliseconds.
b) many milliseconds.
c) a few seconds.

4. The mirrors on either end of the active region provide the optical feedback ...
a) to sustain laser action.
b) to increase laser action.
c) to slow down laser action.

INCREASE YOUR VOCABULARY

Exercise 1. ***Match Russian and English equivalents.***

1	2
1. end face	a) оптическая накачка
2. excited atom	b) рубиновый стержень
3. flash tube	c) обратная оптическая связь
4. intense current	d) возбужденный атом
5. optical feedback	e) лампа-вспышка
6. ruby rod	f) объемный резонатор
7. semiconductor laser	g) торцевая поверхность
8. spontaneous emission	h) полупроводниковый лазер
9. strong coupling	i) однородный переход
10.uniform junction	j) сильная связь
	к) большой ток
	l) спонтанное излучение

Exercise 2. ***Match the synonyms.***
Adjectives

1	2
1. bulky	a) energetic
2. directional	b) natural
3. exceptional	c) limpid
4. flat	d) special
5. spontaneous	e) large

6. transparent	f) plane
7. uniform	g) straight
	h) coherent
	i) constant

LANGUAGE ACTIVITY

Exercise 1. ***Define the functions of the Infinitive in each sentence. Translate the sentences.***

1. The cooling is effected by methods to be discussed in the next chapter.
2.These data had to be checked twice to avoid any mistake.
3.The best agreement is to be found in the case of carbonic acid.
4.The receiver must use a selective filter to minimize the effects of interference.
5.To show the dependence of solubility on temperature was the aim of our experiment.
6. We may suppose the alpha-particles within nucleus to be in motion.
7.In our discussion the nucleus will be taken to be at rest.
8.The materials to be used in the present-day tubes are described in this article.

Exercise 2. ***Translate from Russian into English.***

1. В статье описывается полупроводниковый лазер.
2. Полупроводниковый лазер на арсениде галлия был изготовлен в 1962 г.
3. Лазер 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°=77К 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 – высокий КПД.
12. Полупроводниковые лазеры возбуждаются электрическим током.

Exercise 3. ***Translate the sentences into Russian paying attention to the structure "is made to do".***

1.These students <u>were made to revise</u> for the exam.
2. In this laser the electron <u>is made to pass</u> through the magnetic field generated by the wiggler.
3. Only two types of color-centres <u>have been made to lase.</u>
4. X-ray lasers <u>are</u> usually <u>made to operate</u> without mirror.
5. Semiconductor lasers <u>were made to operate</u> CW at room temperature after the invention of the heterojunction laser in 1969.
6. Electrons <u>can be made to travel</u> at very high speeds.

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).

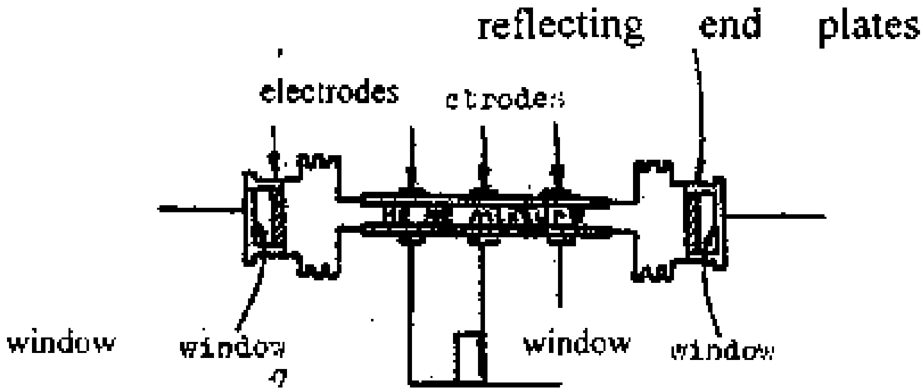


Fig.1. Construction of He-Ne laser

The first such 1aser was built in I960 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 = 1млн герц
d.c. – direct current – постоянный ток
torr – тор - единица измерения давления
1 тор = 1 мм ртутного столба
760 тор = 1 атмосфера

CHECK YOUR UNDERSTANDING

Exercise 1. ***Answer the following questions.***

1. Why do gases offer interesting possibilities as laser materials?
2. How does a helium-neon laser work.
3. Why is the helium-neon type of laser of great value?
4. How do molecular lasers operate?
5. What type of structure is used in molecular lasers ?
6. What are the advantages of molecular lasers ?

Exercise 2. ***Rearrange the sentences in a logical order to make a summary of the text "Gas Lasers".***
1. The radio-frequency generator serves to establish an electric discharge in the gas which excites the helium atoms.
2. Transmitted through the plates it forms a very narrow output beam of coherent infra-red light.
3. The neon lasers were the first to be discovered and studied.
4. Then neon atoms in the mixture collide with the excited helium atoms and the energy is transferred to them through the collision process.
5. The first He-Ne laser was built in I960 at Bell Telephone Laboratories.
6. Helium-neon lasers are remarkable because of their monochromaticity.
8. While being reflected back and forth through the length of gas-filled tube by semi-reflecting end plates the beam is growing in intensity with each trip.
7. Their energy is radiated in a continuous stream.
9.They use a mixture of helium and neon gases through which an electrical discharge flows.

Exercise 3. ***Is it false or true?***
1. The neon atoms themselves can't be stimulated to radiate their energy in a continuous stream.
2. Bell Telephone Laboratory was the place where the first He-Ne laser was built.
3. Molecular lasers are the most high powered but least efficient type of gas laser.
4. The length of the carbon dioxide laser tube must be as short as possible if large amounts of power are to be obtained.

INCREASE YOUR VOCABULARY

Exercise 1. ***Match the synonyms.***

Verbs

1	**2**
1. adjust	a) move
2. collide	b) restore
3. flow	c) mirror
4. reflect	d) crash
5. replace	e) simplify
6. transmit	f) oscillate
7. vibrate	g) transfer
	h) regulate
	i) differ

Nouns

1	2
1. coupling	a) passage
2. discharge	b) cylinder
3. efficiency	c) frequency
4. orbit	d) burst
5. path	e) connection
6. stability	f) level
7. tube	g) constancy
	h) effectiveness
	i) circl

LANGUAGE ACTIVITY

Exercise 1. ***Translate into Russian paying attention to the Complex Object Structure.***

1. We expect the Web to provide distant students with full university level courses.
2. Every student knows semiconductor to be a material having an electrical conductivity intermediate between that of metals and insulators.
3. Scientists believe other types of lasers to be further developed.
4. The researchers suppose an electron beam to move at a speed close to the speed of light.
5. Specialists believe preparation of laser crystals based on different types of color centers to require considerable care and skills.
6. The mass-media report the environment to have been heavily polluted due to the man's irresponsible activity.
7. We know lasers to play a great part in human life.

Exercise 2. ***Transform the following sentences using the Complex Subject Structure. Translate into Russian.***

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

1. Scientists consider that light is some kind of wave motion of electromagnetic origion.
2. We know that ion lasers typically operate in the visible or ultraviolet regions.
3. They believe that excimer lasers are widely used in scientific research.
4. It appeared that fiber optics replaced copper wire as an appropriate means of signal transmission.
5. We are sure that organic dye lasers will play an important role in various fields.

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 chemical lasers provided large output power in CW operation.

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. 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 the scientist got interesting results.

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-pumping
to process, to focus, to lock, to tune, to scatter, to broaden.

Verb + ion
to compress-compression
to oscillate, to investigate, to operate, to indicate, to propagate.

Verb = noun
to increase-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. ***Answer the following questions.***

1. Why are lasers used in so many fields of our life?
2. What makes lasers useful in photography?
3. How do lasers help to study molecular structures?
4. What can we use laser techniques for?
5. How are lasers used in medicine?
6. What type of lasers is more suitable for construction of nuclear weapons and why?

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

1.The focused beams can readily...
2.Highly directional laser beams are used for ...
3. Lasers have been used for precise determination ...
4. Laser light can carry ...
5. Laser light simplifies ...
6. Lasers should be used only by...

a) of the earth-moon distance.
b) the recording of a hologram.
c) alignment in road and building construction.

d) heat, melt or vaporize material in a precise manner.
e) trained personnel wearing protective goggles.
f) 1,000 times as many television channels as are now carried by microwaves.

Exercise3. ***True or false ?***
1. The focused beams can readily heat, melt or vaporize material in a precise manner.
2. The powerful long pulse produced by a laser makes possible high-speed photography.
3. Lasers are not very effective detectors of certain types of air pollution.
4. Very slow laser-activated switches are being developed for use in particle accelerators.
5. Laser light can travel a large distance in outer space with little reduction in signal strength.

INCREASE YOUR VOCABULARY

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

1	2
1. collision process	a) энергия колебания
2. continuous stream	b) внутренний разряд
3. exposure time	c) точное определение
4. frequency shift	d) процесс столкновения
5. internal discharge	e) лазерные технологии
6. laser beam	f) непрерывный поток
7. laser techniques	g) использование лазеров
8. particle accelerator	h) луч лазера
9. precise determination	i) ускоритель частиц
10.vibrational energy	j) время экспонирования
	k) наземная связь
	l) сдвиг по частоте

Exercise 2. ***Translate the following word combinations with Participle II as an attribute as shown below.***
Model: described mechanism – описанный механизм
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.***

Model: I decided to enter this university. It is the best in our city.(because)
I decided to enter this university because it is the best in our city.

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 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 пойдем гулять.

Exercise 3. ***Summarize your knowledge of attribute clauses.***

1. The problem the scientists are working on is connected with a new source of radiation.
2. In actual tubes the secondary electrons may be attracted back to the electrode they come from.
3. The results you are speaking about were obtained in our laboratory.
4. An electron may have enough kinetic energy to knock one or more electrons out of any material it comes in contact with.
5. The scanning device we have just mentioned generates an electric current.
6. A price of p-type semiconductor we use in our experiment depends on its battery.
7. The main subject the scientists studied at that time was the general theory of oscillations.
8. The choice of a variable condenser depends on the range of frequencies it is necessary to cover.

Exercise 4. ***Translate the following sentences paying attention to the function of "that".***

1. The resistivity of silicon at room temperature is about 3.000 ohm-m, and that of germanium about 0,6 ohm-m.
2. A semiconductor laser is a few tenths of a millimeter long, whereas the density of its radiation for volume is hundreds of thousands of times as great as that of the best ruby laser.
3. The laser can increase the size of the TV screen to that of a modern cinema.
4. The intensity of the coherent radiation exceeds that of the spontaneous radiation by several orders of magnitude.
5. The spectral range of the induced radiation is considerably narrower than that of fluorescence.

Exercise 5. ***Translate the sentences paying attention to the phrase-preposition "by means of".***

1. Conventional electron devices function by means of the effect of an electrostatic field on the movement of charged particles, usually electrons.
2. The discharge may be excited by means of an rf osclillator using external electrodes.
3. The resonator used for laser action is made by means of two small mirrors facing each other.
4. A chemical laser is usually defined as one in which the population inversion is "directly" produced by means of a chemical reaction.
5. The laser cavity is confined to the junction region by means of two reflective boundaries.

REWIEW 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 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

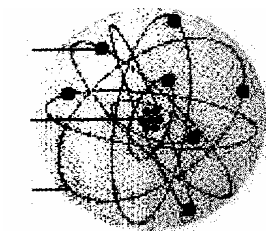


Fig.. Simple Atom Model

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 twomile- 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 folly functioning laser. (Theodore Maiman invented the ruby laser on May 16th 1960 at the Hughes Research Laboratories.)

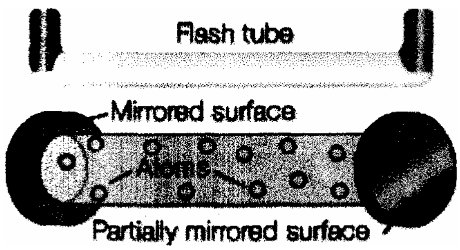


Fig.1. Schematic of Laser in Non-Lasing State.

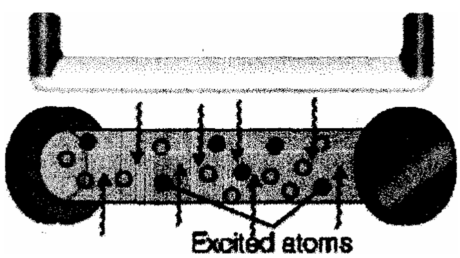


Fig.2. Schematic Illustrating the Excitation of Atoms Using Light Source.

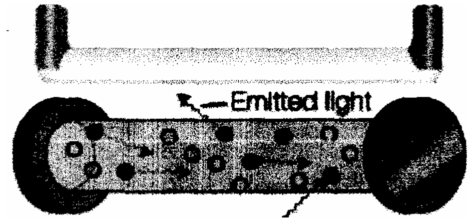


Fig.3. Schematic Showing Photon Emission.

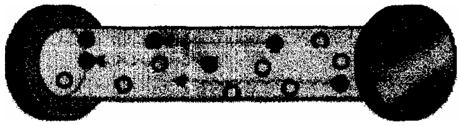


Fig.4. Schematic Showing the Stimulated Emission of Further Photons.

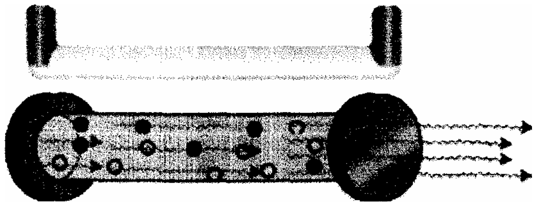


Fig.5. Schematic Showing Column of Laser Light Leaving Optical Osculate.

*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.

Chapter IV

Аннотация (Abstract/Summary) – это краткое изложение содержания статьи (доклада, заметки) с целью дать возможность понять читателю стоит ли знакомиться с текстом более подробно. Аннотация отражает тематику текста и основную мысль автора. Обычный объем аннотации 500-600 п.зн.

Структура аннотации:

1) название работы (статьи, доклада), фамилия и инициалы автора, выходные данные оригинала, (т.е. название журнала или монографии, год издания, том, номер, и т.д.);
2) формулировка темы работы (текста, статьи, доклада);
3) краткое содержание статьи (доклада), составленное из простых предложений, связанных по определенным правилам.

Если аннотация составляется на английском языке, то допускаются только безличные предложения со сказуемым в страдательном залоге, как правило, в форме Present или Past Simple, иногда в Present Perfect Passive Voice.

Чаще всего используются следующие клише:

…is/are discussed (described, mentioned)…	…обсуждаются (описываются, упоминаются)…
…is/are considered (outlined)…	…рассматриваются…
…is/are presented (shown)…	…представлены, показаны
…is/are studied (investigated, examined)…	…исследуются…
…is/are obtained (found, established)…	…получены (обнаружены, установлены)…

A (short) description is given to …	Кратко описаны…
A (thorough) study is made of …	Тщательно исследованы .
Particular (special) attention is given (paid) to …	Особое внимание уделено …

Иногда используются конкретизирующие наречия и сочетания, такие как:

accurately (carefully) - тщательно, внимательно
thoroughly, in detail – подробно, детально
clearly – четко, ясно
fully – во всей полноте и т.д.

Для формулировки темы работы (статьи) можно использовать сказуемое в Present Active Voice. Например: The text deals with (studies) …

Далее придаточные предложения должны быть преобразованы в причастные или инфинитивные конструкции, а примеры и иллюстрации любого вида исключены.

Пример аннотации:

Text 1

List of Terms
Czochralski method - метод Чохральского
lidar (light detection and ranging) - лидар (устройство обнаружения удаленных объектов на оптических частотах)
lithotripsy – камнедробление

ALEXANDRITE LASERS MAKE THEIR MARK IN INDUSTRIAL APPLICATIONS

Named for Russian Czar Alexander II, alexandrite was discovered in the Ural Mountains in the 1830s. This rare, naturally occurring material was first synthesized by the Czochralski method in the early 1970s. Alexandrite laser-based marking and materials processing applications are emerging in the fields of telecommunications, microelectronics and bio-medical technology. Applications in these industries have until now been dominated by excimer, CO_2, and Nd:YAG lasers. In the future, laser technology solutions will broaden as the unique advantages exhibited by alexandrite lasers become better known.

These lasers were initially researched and developed by Allied Signal Corp. (now Honeywell; Morristown, NJ). The company invested more than $100 million in the development of alexandrite laser systems and the growth of high-quality laser material. It developed these lasers for military and government applications, such as laser isotope separation, man-portable laser countermeasures (weighing less than 45 lb), laser lidar applications, and low-light-level long-range (5 miles) illumination systems.

Medical applications such as laser lithotripsy were investigated but not commercially exploited. More recently, several companies have developed commercial alexandrite laser systems for tattoo and hair removal. Alexandrite lasers are now being introduced into scientific, medical and industrial applications where the unique characteristics of these lasers provide a clear process and process integration advantage to its customers.

Abstract (Summary). Text 1.

Alexandrite lasers make their mark in industrial applications.”Laser Focus World”, 2004, v.34, №2, p.42.
The text focuses on the use of alexandrite lasers in industry.
The discovering and synthesising of alexandrite are described.
Particular attention is paid to the company which initially developed these lasers.

A short description is given to medical applications of such lasers.
This information may be of interest to research teams engaged in studying lasers.

Резюме (Resumé) – вид компрессии текста. В резюме допускаются краткая оценка исходного материала и выводы из прочитанного. Обычно требуется изложение текста в виде устного резюме.
Резюме состоит из трех частей, которые соединяются в единое целое с помощью определенных речевых клише.

I.Вступление. Формулировка темы.

The text (clipping, item) deals with The text (clipping, item) concerns … The text (clipping, item) is concerned with … The text (clipping, item) focuses on …	В тексте (отрывке, заметке) говорится о …

II. Основное содержание – краткое описание текста с некоторой оценкой.

According to the text … From the text we know that … It is clear from the text …	Из текста ясно, что…
According to the author …	Как считает автор …
One of the main problems to pay attention to is …	Одной из главных проблем, на которую следует обратить внимание, является…
It should be mentioned (noted, pointed out) …	Следует упомянуть (отметить, указать)…
Particular emphasis is placed on …	Особое внимание обращается на …
In my opinion …	По моему мнению …
Thus …	Таким образом …
Further on …	Далее …

III.Заключение.

In conclusion we can say …	В заключении можно сказать
Summing it up…	Подытоживая …
On the whole one can safely say …	В целом вполне можно сказать…
The author comes to the conclusion that …	Автор приходит к выводу, что
All things considered we can conclude that …	Рассмотрев все, мы можем сделать вывод, что …

Resume

Text 1

The text "Alexandrite lasers make their mark in industrial applications" deals with different applications of these lasers.

It is clear from the text that alexandrite laser-based marking and materials processing applications are emerging in some fields of technology. According to the author the company which initially researched such lasers invested more than $ 100 million in the development of alexandrite laser systems. Particular emphasis is placed on medical applications.

In conclusion we can say that the unique characteristics of alexandrite lasers allow them to be introduced into scientific, medical and industrial applications.

Text 2

Laser microprocessing of diamond surface

Diamond films 300-400 μm thick were grown on polished Si substrates by a CVD technique using a microwave plasma chemical reactor. Upon separation from the substrates, the resulting freestanding diamond plates were cut with a laser, mechanically polished, and then were used for laser patterning experiments.

For selective-area material removal a KrF excimer laser operating at 248 nm, was used as the laser source in a projection optical scheme. The pulse duration is 15 ns, and the laser pulse energy is typically ~200 mJ, although only a small fraction of the output energy is utilized. The image of a mask (sqaure) was projected onto the sample surface by a short-focal length objective with linear demagnification of 1:15. A diamond sample placed on a computer-driven X-Y stage was translated controllably so that a selected region of given coordinates on the diamond surface be irradiated by a certain number of laser shots to achieve the resulting surface profile close to the calculated one. The etching depth was controlled by the laser influence and the number of laser shots. A surface profiler "Zygo" (model New View 5000) based on phase-shifting interferometry was used to examine the topology of original and laser-irradiated surface.

Task 1. ***Build up an abstract (summary) of text in writing.***

Check your summary:

1) make sure each sentence is simple and to the point;
2) make sure there are no examples or illustrations;
3) remove adjectives, adverbs, repetition of words.
4) replace full clauses with participle constructions.

Task 2. ***Build up a resume of text 2 according to the instruction given above.***

Реферат (Precis) - это конспективное описание оригинального произведения (текста, статьи, доклада или монографии), передающее его основной смысл. В реферате кратко и четко излагаются все основные положения оригинала. Как правило, объем реферата составляет 1/3 оригинала.

Реферат не предполагает выводов или комментариев составителя, допускаются только выводы автора оригинала, если таковые есть.

По структуре реферат напоминает развернутую аннотацию, с употреблением вышеприведенных речевых клише.

К списку речевых клише можно добавить следующие:

I. The aim (object, purpose, task) of the study is...
Цель (задача, назначение) работы состоит в …

The paper describes new approaches (methods, techniques) to …
В статье описываются новые подходы (методы, методики) к …

The book is further developing the concept of …
В книге далее разрабатывается концепция о …

II. The study was intended to establish …(for determining) …
Это исследование было предпринято с целью установления (определения) …
New facts (as to how) … have been found …
Были обнаружены новые данные о …

If should be noted that this approach allows (permits, enables) to assume …
Следует отметить, что этот метод позволяет (дает возможность) предположить, …

The details of … are reported.
Описаны подробности о …

The theory supports the author's assumption …
Теория подтверждает предположение автора …

The approach used presents (has, offers) several advantages…
Использованный метод имеет (представляет) несколько преимуществ.

The limitations are shown to be insignificant…
Показано, что ограничения незначительны.

Among other problems the paper raises the problem of …
Среди других проблем в статье поднимается вопрос о …

Another approach was offered (suggested) …
Был предложен другой подход …

What is more … - Более того….
Not only…but also… - не только … но и…

On the one hand/on the other hand – с одной стороны/с другой стороны

Therefore – Следовательно
Nevertheless – тем не менее

III. A general conclusion is made concerning as to …
Делается общий вывод относительно …

Thus, a conclusion is made that …
Таким образом, сделан вывод, что …

Having analyzed the information the author comes to the conclusion that…
Проанализировав всю информацию, автор делает вывод, что …

Text 3.

“Spaser” Shakes Up the Nanoworld

1. Researchers at Georgia State University in Atlanta and Tel Aviv University in Israel have proposed a device based on surface plasmons* to shake things up in very small systems. In a manner analogous to the way a laser operates, the “spaser” (surface plasmon amplification by stimulated emission of radiation) would amplify a specific surface plasmon excitation mode using a metallic particle as a resonant cavity.

2. Surface plasmons are highly localized energy excitations on the surface of materials. Although small in volume, they can cause big effects, making them suitable for probing nanostructures. Today surface plasmons are generated with a laser or by other resonant optical methods.

3. Unlike a laser, the spaser itself would be a nanoscale device. As theorized, it would consist of quantum dots surrounding metallic nanoparticles. When excited optically, electrically or chemically, the quantum dots would interact with their surroundings and generate surface plasmons amplified by and accumulated in the metallic nanoparticle, much like a resonant cavity in a laser.

4. The spaser would offer a number of advantages over current techniques, explained Mark I. Stockman, a professor of physics and astronomy at Georgia State University, who developed the concept with David J. Bergman. Because of its size, the energy would be concentrated in a small area and in a specific and single mode. A laser, in contrast, spreads its energy over the focal volume and over many plasmon modes. This is inefficient and noisy, making precise nanoscale measurements difficult. And again unlike a laser, a spaser would not be limited to creating luminous surface plasmon modes. So-called dark surface plasmon modes exist, and they also could be used to probe nanostructures with no stray radiation.

5. The device exists only in theory, but Stockman and Bergman are working with Victor Klimov's research group at Los Alamos National Laboratory in New Mexico to implement it experimentally.

*plasmon – квант плазменных колебаний

Task 1. ***Find in the text advantages of spaser over laser. Name and explain them.***
Task 2. ***Write out key-words and wordcombinations and give their Russian equivalents.***
Task 3. ***Headline each paragraph.***

Text 4.

A Brief History of Fiber Optic
The Nineteenth Century

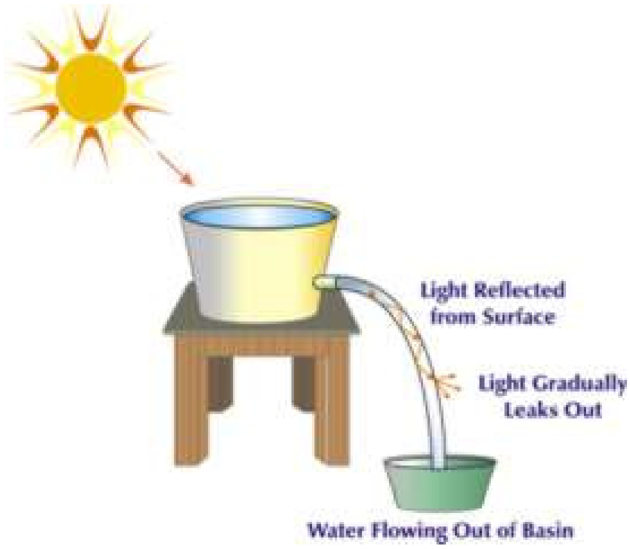


Figure 1 - John Tyndall's Experiment

1. In 1870, John Tyndall, using a jet of water that flowed from one container to another and a beam of light, demonstrated that light used internal reflection to follow a specific path. As water poured out through the spout of the first container, Tyndall directed a beam of sunlight at the path of the water. The light, as seen by the audience, followed a zigzag path inside the curved path of the water. This simple experiment, illustrated in Figure 1, marked the first research into the guided transmission of light.

2. William Wheeling, in 1880, patented a method of light transfer called "piping light." Wheeling believed that by using mirrored pipes branching off from a single source of illumination, i.e. a bright electric arc, he could send the light to many different rooms in the same way that water, through plumbing, is carried throughout buildings today. Due to the ineffectiveness of Wheeling's idea and to the concurrent introduction of Edison's highly successful incandescent light bulb, the concept of piping light never took off.

3. That same year, Alexander Graham Bell developed an optical voice transmission system he called the photophone. The photophone used free-space light to carry the human voice 200 meters. Specially placed mirrors reflected sunlight onto a diaphragm attached within the mouthpiece of the photophone. At the other end, mounted within a parabolic reflector, was a light-sensitive selenium resistor. This resistor was connected to a battery that was, in turn, wired to a telephone receiver. As one spoke into the photophone, the illuminated diaphragm vibrated, casting various intensities of light onto the selenium resistor. The changing intensity of light altered the current that passed through the telephone receiver which then converted the light back into speech. Bell believed this invention was superior to the telephone because it did not need wires to connect the transmitter and receiver. Today, free-space optical links find extensive use in metropolitan applications.

The Twentieth Century

4. Fiber optic technology experienced a phenomenal rate of progress in the second half of the twentieth century. Early success came during the 1950's with the development of the fiberscope. This image-transmitting device, which used the first practical all-glass fiber, was concurrently devised by Brian O'Brien at the American Optical Company and Narinder Kapany (who first coined the term "fiber optics" in 1956) and colleagues at the Imperial College of Science and Technology in London. Early all-glass fibers experienced excessive optical loss, the loss of the light signal as it traveled the fiber, limiting transmission distances.

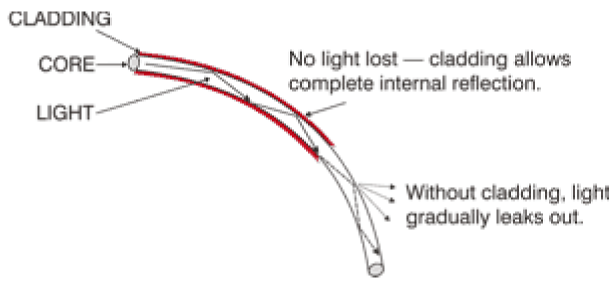


Figure 2 - Optical Fiber with Cladding

5. This motivated scientists to develop glass fibers that included a separate glass coating. The innermost region of the fiber, or core, was used to transmit the light, while the glass coating, or cladding, prevented the light from leaking out of the core by reflecting the light within the boundaries of the core. This concept is explained by Snell's Law which states that the angle at which light is reflected is dependent on the refractive indices of the two materials — in this case, the core and the cladding. The lower refractive index of the cladding (with respect to the core) causes the light to be angled back into the core as illustrated in Figure 2.

The fiberscope quickly found application inspecting welds inside reactor vessels and combustion chambers of jet aircraft engines as well as in the medical field. Fiberscope technology has evolved over the years to make laparoscopic surgery one of the great medical advances of the twentieth century.

6. The development of laser technology was the next important step in the establishment of the industry of fiber optics. Only the laser diode (LD) or its lower-power cousin, the light-emitting diode (LED), had the potential to generate large amounts of light in a spot tiny enough to be useful for fiber optics. In 1957, Gordon Gould popularized the idea of using lasers when, as a graduate student at Columbia University, he described the laser as an intense light source. Shortly after, Charles Townes and Arthur Schawlow at Bell Laboratories supported the laser in scientific circles. Lasers went through several generations including the development of the ruby laser and the helium-neon laser in 1960. Semiconductor lasers were first realized in 1962; these lasers are the type most widely used in fiber optics today.

7. Because of their higher modulation frequency capability, the importance of lasers as a means of carrying information did not go unnoticed by communications

engineers. Light has an information-carrying capacity 10,000 times that of the highest radio frequencies being used. However, the laser is unsuited for open-air transmission because it is adversely affected by environmental conditions such as rain, snow, hail, and smog. Faced with the challenge of finding a transmission medium other than air, Charles Kao and Charles Hockham, working at the Standard Telecommunication Laboratory in England in 1966, published a landmark paper proposing that optical fiber might be a suitable transmission medium if its attenuation could be kept under 20 decibels per kilometer (dB/km). At the time of this proposal, optical fibers exhibited losses of 1,000 dB/ km or more. At a loss of only 20 dB/km, 99% of the light would be lost over only 3,300 feet. In other words, only 1/100th of the optical power that was transmitted reached the receiver. Intuitively, researchers postulated that the current, higher optical losses were the result of impurities in the glass and not the glass itself. An optical loss of 20 dB/km was within the capability of the electronics and opto-electronic components of the day.

8. Intrigued by Kao and Hockham's proposal, glass researchers began to work on the problem of purifying glass. In 1970, Drs. Robert Maurer, Donald Keck, and Peter Schultz of Corning succeeded in developing a glass fiber that exhibited attenuation at less than 20 dB/km, the threshold for making fiber optics a viable technology. It was the purest glass ever made.

9. The early work on fiber optic light source and detector was slow and often had to borrow technology developed for other reasons. For example, the first fiber optic light sources were derived from visible indicator LEDs. As demand grew, light sources were developed for fiber optics that offered higher switching speed, more appropriate wavelengths, and higher output power. For more information on light emitters see Laser Diodes and LEDs.

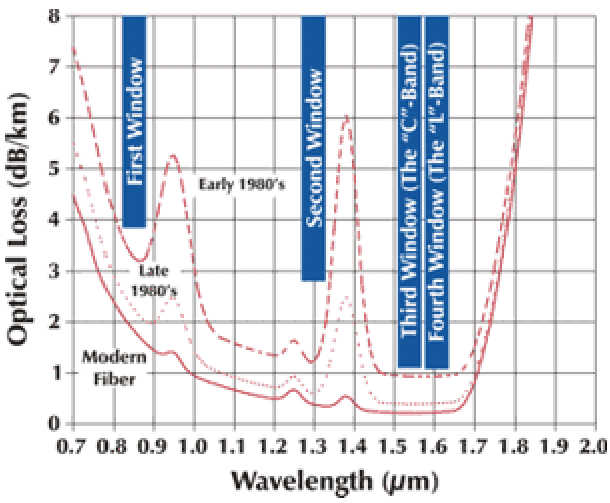


Figure 3 - Four Wavelength Regions of Optical Fiber

10. Fiber optics developed over the years in a series of generations that can be closely tied to wavelength. Figure 3 shows three curves. The top, dashed, curve corresponds to early 1980's fiber, the middle, dotted, curve corresponds to late 1980's fiber, and the bottom, solid, curve corresponds to modern optical fiber. The earliest fiber optic systems were developed at an operating wavelength of about 850 nm. This wavelength corresponds to the so-called "first window" in a silica-based optical fiber. This window refers to a wavelength region that offers low optical loss. It sits between several large absorption peaks caused primarily by moisture in the fiber and Rayleigh scattering.

11. The 850 nm region was initially attractive because the technology for light emitters at this wavelength had already been perfected in visible indicator LEDs. Low-cost silicon detectors could also be used at the 850 nm wavelength. As technology progressed, the first window became less attractive because of its relatively high 3 dB/km loss limit.

12. Most companies jumped to the “second window” at 1310 nm with lower attenuation of about 0.5 dB/km. In late 1977, Nippon Telegraph and Telephone (NTT) developed the “third window” at 1550 nm. It offered the theoretical minimum optical loss for silica-based fibers, about 0.2 dB/km.

13. Today, 850 nm, 1310 nm, and 1550 nm systems are all manufactured and deployed along with very low-end, short distance, systems using visible wavelengths near 660 nm. Each wavelength has its advantage. Longer wavelengths offer higher performance, but always come with higher cost. The shortest link lengths can be handled with wavelengths of 660 nm or 850 nm. The longest link lengths require 1550 nm wavelength systems. A “fourth window,” near 1625 nm, is being developed. While it is not lower loss than the 1550 nm window, the loss is comparable, and it might simplify some of the complexities of long-length, multiple-wavelength communications systems.

Applications in the Real World

14. The U.S. military moved quickly to use fiber optics for improved communications and tactical systems. In the early 1970’s, the U.S. Navy installed a fiber optic telephone link aboard the U.S.S. Little Rock. The Air Force followed suit by developing its Airborne Light Optical Fiber Technology (ALOFT) program in 1976. Encouraged by the success of these applications, military R&D programs were funded to develop stronger fibers, tactical cables, ruggedized, high-performance components, and numerous demonstration systems ranging from aircraft to undersea applications.

15. Commercial applications followed soon after. In 1977, both AT&T and GTE installed fiber optic telephone systems in Chicago and Boston respectively. These successful applications led to the increase of fiber optic telephone networks. By the early 1980’s, single-mode fiber operating in the 1310 nm and later the 1550 nm wavelength windows became the standard fiber installed for these networks. Initially, computers, information networks, and data communications were slower to embrace fiber, but today they too find use for a transmission system that has lighter weight cable, resists lightning strikes, and carries more information faster and over longer distances.

16. The broadcast industry also embraced fiber optic transmission. In 1980, broadcasters of the Winter Olympics, in Lake Placid, New York, requested a fiber optic video transmission system for backup video feeds. The fiber optic feed, because of its quality and reliability, soon became the primary video feed, making the 1980 Winter Olympics the first fiber optic television transmission. Later, at the 1994 Winter Olympics in Lillehammer, Norway, fiber optics transmitted the first ever digital video signal, an application that continues to evolve today.

In the mid-1980’s the United States government deregulated telephone service, allowing small telephone companies to compete with the giant, AT&T. Companies like MCI and Sprint quickly went to work installing regional fiber optic telecommunications networks throughout the world. Taking advantage of railroad lines, gas pipes, and other natural rights of way, these companies laid miles fiber optic cable, allowing the deployment of these networks to continue throughout the 1980's. However, this created the need to expand fiber's transmission capabilities.

17. In 1990, Bell Labs transmitted a 2.5 Gb/s signal over 7,500 km without regeneration. The system used a soliton laser and an erbium-doped fiber amplifier (EDFA) that allowed the light wave to maintain its shape and density. In 1998, they went one better as researchers transmitted 100 simultaneous optical signals, each at a data rate of 10 gigabits (giga means billion) per second for a distance of nearly 250 miles (400 km). In this experiment, dense wavelength-division multiplexing (DWDM technology, which allows multiple wavelengths to be combined into one optical signal, increased the total data rate on one fiber to one terabit per second (10^{12} bits per second).

For more information on fiber optic applications see Fiber Optic Transport Solutions

The Twenty-First Century and Beyond

18. Today, DWDM technology continues to develop. As the demand for data bandwidth increases, driven by the phenomenal growth of the Internet, the move to optical networking is the focus of new technologies. At this writing, nearly half a billion people have Internet access and use it regularly. Some 40 million or more households are "wired." The world wide web already hosts over 2 billion web pages, and according to estimates people upload more than 3.5 million new web pages everyday.

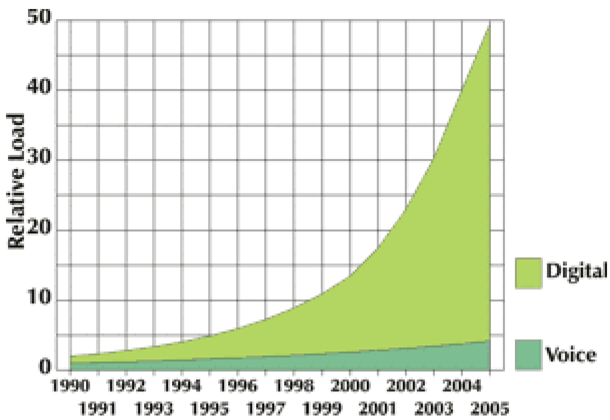


Figure 4 - Projected Internet Traffic Increases

19. The important factor in these developments is the increase in fiber transmission capacity, which has grown by a factor of 200 in the last decade. Figure 5 illustrates this trend. **B**ecause of fiber optic technology's immense potential bandwidth, 50 THz or greater, there are extraordinary possibilities for future fiber optic applications. Already, the push to bring broadband services, including data, audio, and especially video, into the home is well underway.

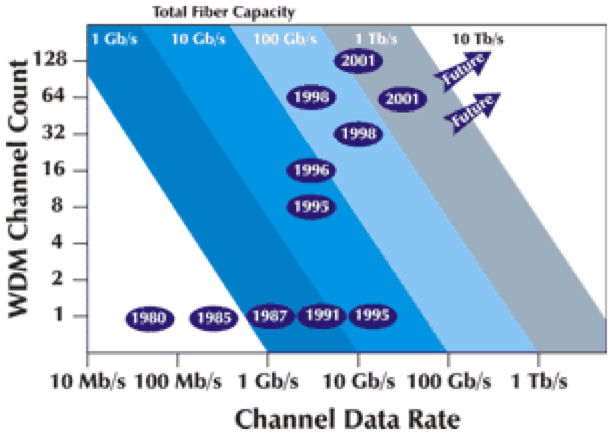


Figure 5 - The Growth of Optical Fiber Transmission Capacity

20. Broadband service available to a mass market opens up a wide variety of interactive communications for both consumers and businesses, bringing to reality interactive video networks, interactive banking and shopping from the home, and interactive distance learning. The "last mile" for optical fiber goes from the curb to the television set top, known as fiber-to-the-home (FTTH) and fiber-to-the-curb (FTTC), allowing video on demand to become a reality.

Tasks to the texts:

1. Write the précis of the text in English.
2. Translate into Russian in writing paragraphs 4-5, 14-16.
3. Add to the text what you now about present usage of optical fiber.

Text 5.

Lasers for Atmospheric Studies

1. Using Lasers to Study Our Atmosphere

The Earth's atmosphere and climate have become big concerns – and not just to scientists. Terms like greenhouse effect, ozone hole and global climate are now household words which conjure up either concern or controversy. What is causing them? How serious are they?

Since the 1930s, when scientists first discovered ozone, a lot of progress has been made in defining and measuring both natural and human influences on our atmosphere. Using advances in technology such as radar and lasers, scientists have gained a greater understanding of Earth's atmosphere and how it might be changing.

Our ability to gather data from ground-based, airborne and now spaceborne remote sensing devices has given us a new global perspective on our atmosphere.

2. Uses of Lasers

One key to understanding the atmosphere is the ability to study its components, including clouds (liquid), aerosols (suspended particles) and ozone and water vapor (gases). Researchers at NASA Langley use laser-based systems called lidars (light detection and ranging) to study the atmosphere with high precision. A lidar can penetrate thin or broken clouds in the lower atmosphere, where humans live, letting researchers “see” the vertical structure of the atmosphere. A space-based lidar can provide global measurements of the vertical structure of clouds and atmospheric gases. Both ozone and water vapor are involved in many important atmospheric processes that can affect life on Earth, climate change, weather, the Earth’s energy budget, and regional and global pollution levels.

Perhaps the greatest value of lasers as remote sensing tools is the unprecedented accuracy with which they can measure clouds. The latest advancements in laser remote sensing can fill the gaps we have in our understanding of how clouds reflect and absorb solar energy, and how heat and moisture are exchanged between the air, ocean and earth.

3. How Does A Lidar Work?

A lidar is similar to a radar, which is commonly used to track everything from airplanes in flight to thunderstorms. Instead of bouncing radio waves off its target, however, a lidar uses short pulses of laser light to detect particles or gases in the atmosphere. Traveling as a tight, unbroken beam, the laser light disperses very little as it moves away from its origin – such as from space down to the Earth’s surface. Some of the laser’s light reflects off of tiny particles – even molecules – in the atmosphere. The reflected light comes back to a telescope and is collected and measured.

4. Why Put Lasers in Space?

Ground-based lidar instruments can profile the atmosphere over a single viewing site, while lidars aboard aircraft can gather data over a larger area. Each of these methods, however, is limited to sampling a comparatively small region of the Earth. Spaceborne lidars, including instruments on satellites, have the potential for collecting data on a global scale, including remote areas like the open ocean, in a very short period of time.

5. Remote Sensing Lasers in Space.

In September 1994, NASA launched the Lidar In-Space Technology Experiment (LITE). LITE was the first use of a lidar system for atmospheric studies from space. LITE orbited the Earth while positioned inside the payload bay of the Space Shuttle Discovery (STS-64). During the ten-day mission, LITE measured the Earth’s clouds and various kinds of aerosols in the atmosphere for 53 hours.

Because this type of lidar had never flown in space before, the LITE mission was primarily a technology test. Scientists and engineers wanted to verify that the entire system worked as planned while on orbit.

An important secondary goal of the LITE mission was to explore the applications of space-based lidars and gain operational experience for a future satellite-based lidar system. Such a satellite could provide continuous global atmospheric data.

NASA Langley researchers are now exploring the feasibility and potential advantages of using lidar instruments on Earth-observing satellites.

6. The Future of Laser Remote Sensing

LITE and LASE collected data on a wide range of phenomena, from aerosols in the upper atmosphere, to cloud droplets, pollutants and ozone in the lower atmosphere. Future lidar instruments will be tailored to more specific purposes. While one instrument studies the vertical structure of clouds, another will track urban smog or desert dust storms; all of which affect Earth's atmosphere, and, in turn, its weather and climate.

Only by gathering more accurate information scientists can improve their understanding of the atmosphere to the point where they can confidently predict its behavior, and determine how it is being affected by human activities. This improved understanding would enable us to prepare for natural telescope, scientists can accurately determine the location, distribution and nature of the particles.

A lidar carries its own source of laser light, which means it can make measurements both in the daytime and at night. The result is a revolutionary new tool for studying what's in our atmosphere from cloud droplets to industrial pollutants – many of which are difficult to detect by other means.

7. Measuring Atmospheric Gases

While lidars like LITE measure the vertical distribution of clouds and small particles in the atmosphere, they cannot measure important atmospheric gases, such as water vapor and ozone. This type of measurement can be made with a Differential Absorption Lidar (DIAL). The DIAL technique was first demonstrated in the mid-1960s, and DIAL systems have been flying on research aircraft for over a decade.

DIAL uses two pulsed beams of light at two slightly different wavelengths. One beam determines the location of the particles or gases- its beam strength remains relatively unchanged regardless of how many particles or how much gas is present. The second beam, which is tuned to a slightly different wavelength, is partially absorbed by the particles or gas. The amount of the second beam that is absorbed is used to determine the amount of gas or particles present.

The LITE project paved the way for using laser technology on satellites.

Tasks to the text.

1. Match the following questions with the blocks of the text, rearrange questions in their logical order and answer them.

1) When did scientists for the first time use a lidar system for atmospheric studies from space?
2) What is the purpose of ground – based and spaceborne lidars?
3) What stands for the abbreviation a DIAL and what measurements can be made with a DIAL?
4) When was it possible for scientists to get better understanding of Earth's atmosphere? Why did it become possible?
5) What new opportunities will lidar instruments give to scientists?
6) Where can a lidar penetrate and what can a space-based lidar provide?
7) What instrument is a lidar similar to?

2. Describe the principle of a lidar's (the 3^{d} blocks) and a DIAL's (the 7$^{\underline{th}}$ blocks) operation.

3. What have you learnt from the 6$^{\underline{th}}$ block of the text about important goals of the LITE mission?

4. Write the abstract of the text (in English).

Text 6.

Read the t ext and choose the most suitable title.

1. Схема формирования голограммы.
2. Формирование простой голограммы.
3. Схема простой голограммы.
4. Схематическое изображение формирования голограммы.

In forming holograms two set of waves are involved, the reference wave (usually a simple plane wave) and the rather complicated set of waves issuing from the screen. The hologram is the photographic record of the interference pattern generated by these two sets of waves. Fig.1. shows how a simple hologram, that of a point source of light, might be made. At the left, a beam of laser light falls on the screen and also passes around it, and the plane reference waves interfere with the spherical waves, issuing from the pinhole. The photographic record of the light-wave pattern formed by interference between plane and spherical waves is almost identical to an optical device known as a zone plate, a set of concentric annular rings which cause wave energy to be diffracted. The open spaces of a zone plate permit passage of that energy which will add constructively at a desired focal point, and the opaque rings prevent passage of energy which would interfere destructively at the point.

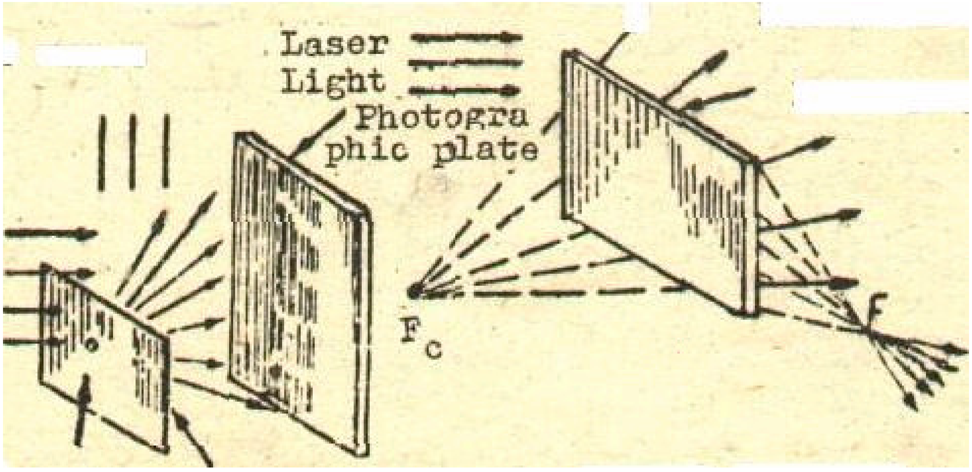


Fig.1.

In Fig.1. only the upper segments of the circular interference zones which exist in the plane of the photographic plate are recorded. This recording of a reference wave and a second set of waves is the hologram. When the plate is developed and illuminated with laser light, as shown at the right, the diffraction process causes converging waves to be produced, creating a real image of the original scene at the focal point F. We shall see shortly that diffraction at the zone plate also generates diverging waves, and these waves create, for a viewer, the illusion of a point source of light located at the conjugate focal point F_c. This diverging light is indistinguishable from that originally issuing from the pinhole, and the viewer imagines he sees this source of light located in space behind the illuminated photographic plate.

Exercise 1. ***Answer the questions.***
1. What source of light is used here?
2. What happens to a light beam emerging from a laser?
3. What waves are necessary for forming a hologram?

Exercise 2.
1.Divide the text into its logical parts.
2.Formulate the topic of each part.
3.Render the text in English (5-6 sentences).

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
$\rightarrow$ - forms, is formed from;
$\leftarrow$ - give, pass over to, lead to.

Например:

$\mathbf{CO_2+H_2O \rightarrow H_2CO_3}$ – c, o, two plus h, two, o give h, two, c, o, three;

$\mathbf{C+2H_2 \rightarrow CH_4}$ – c plus 2 molecules of h two form c, h, four.

APPENDIX II

Ar – argon – аргон
As – arsenic – мышьяк
Cd – cadmium – кадмий
CO_2 – 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 галий
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	$2\text{x}10^4$	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				
CO_2	CW	10.6 μm	$(1\text{-}50)\text{x}10^3$			10-20
N_2	P	337.1 nm	0.1	10^3	10 ns	<0.1
KrF	P	248 nm	500	$5\text{x}10^3$	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. Schavlow, 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 off 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

Nikolay 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 CO_2 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

band –n полоса, зона
banded – *att*. полосатый
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
coarge, adj – необработанный, грубый

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
crest, n –гребень (волны)
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
deflexion – *n* оотклонение
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
elongate, v – удлинять, продлевать
efficiency – *n* коэффициент полезного действия - КПД
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
FEL – free-electron laser – лазер на свободных электронах
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
ground glass, – матовое стекло

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

I
immerse, v – погружать
immune, adj – невосприимчивый
impact, n – влияние
imperious, adj – непроницаемый
imply – *v* подразумевать, означать
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

J
jet, n – струя

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

M
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
obstruction – *n* преграда
optics, n – оптика, оптические приборы
original, adj – исходный, изначальный

P
particle, n – частица
pebble, n – голыш, галька
peer, v – всматриваться, вглядываться
perceive – v понимать
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
shaft – n вал, ось, луч (света)
shift, n – смещение, сдвиг
shrink, v – уменьшать, сокращать
shutter, n – затвор (в фотоаппарате)
sideways – att направленный в строну, по косой
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
translate – v преобразовывать
transmit, v – передавать
transmitter, n – трансмиттер, передатчик
transmission, n – передача
transparancy, n – прозрачность
transparent, adj – прозрачный
travel, v – перемещаться, распространяться (о волнах)
traverse, v – пересекать, проходить сквозь
truncated, – усеченный
trough, n – впадина
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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В 2009 году Университет стал победителем многоэтапного конкурса, в результате которого определены 12 ведущих университетов России, которым присвоена категория «Национальный исследовательский университет». Министерством образования и науки Российской Федерации была утверждена Программа развития государственного образовательного учреждения высшего профессионального образования «Санкт-Петербургский государственный университет информационных технологий, механики и оптики» на 2009–2018 годы.

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 Markushevskaya 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 then 75 manuals were published at the department. The electronic versions of English Grammar, Computer in Use, Studying Optics have been produced. It helps students to improve their knowledge working on computers.
Much attention is given to working out different tests for distance education and special courses.

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