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TRANCE, trăns, a sleeplike condition, usually accompanied by a state of indifference to the objective environment and amnesia for whatever occurs while the subject is in this condition. The term is more a popular than a precise scientific designation. It may be applied to a daze caused by drugs, illness, prolonged contemplation, or other agencies. The sincere mystic, through fasting, certain strained physical postures, and profound concentration, may induce a trance in which he becomes oblivious to physical discomfort and experiences deep emotional revelations or intellectual adventures of great significance to him. While in this state, he may appear almost entirely detached from objects, events, and persons. Some Eastern philosophies have interpreted the trance as a condition in which the individual is able at times to transcend his physical body and exist as a spiritual entity on a more exalted plane of being. In the Western world, Swedish philosopher and scientist Emanuel Swedenborg and many others have claimed to have undergone similar experiences. At a more mundane level, a sort of cataleptic "trance" has often been induced by such methods as controlled breathing, rotation of the eyeballs, or the use of certain drugs, often for questionable reasons and on at least some occasions, with harmful results.

The term "trance" has also been much used to describe the receptive "otherworldly" state striven for by mediums in efforts to achieve clairvoyance. (See SPIRITUALISM.) It is less correctly used when applied to the condition of a subject under hypnosis; the hypnotic state is believed to resemble trances of the kind discussed above only superficially.

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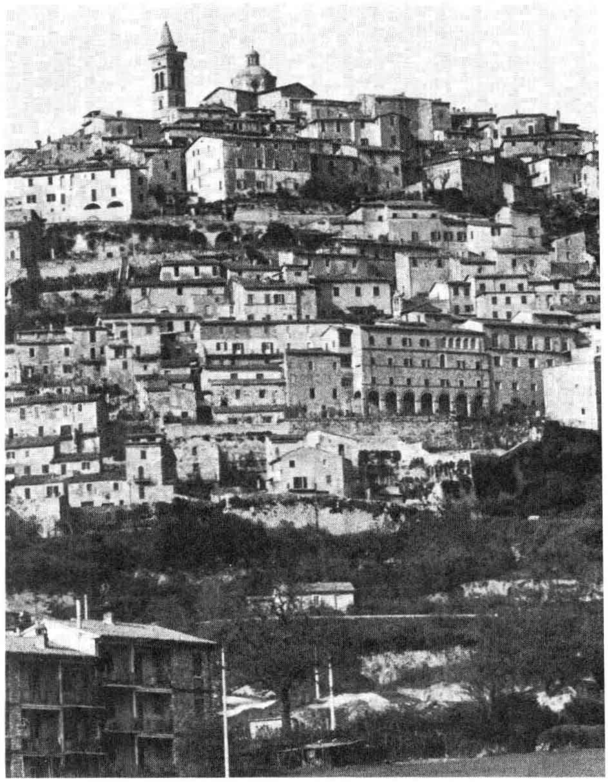
TRANI, trä′nē, city, Italy, in the Province of Bari, in Apulia, a port on the Adriatic Sea, 26 miles northwest of the city of Bari. It is the center of a wine industry, noted for its excellent muscatel. A type of limestone, known as stone of Trani, is quarried in the vicinity. The old town, with its narrow, winding streets, extends around an excellent natural harbor. The Romanesque cathedral, with a fine facade and late 12th century sculptured bronze doors, and a medieval castle started in 1230 are the chief landmarks. According to legend, Trani was founded by Tirrenus, son of Diomedes, but its actual origin probably dates from the 3d or 4th century A.D., when it was known as Turerum. It was a flourishing port under the Byzantines (9th–10th centuries) and, during the Crusades, served as an embarkation point for the Middle East. Its maritime code, *Ordinamenta maris*, was, if the accepted date of its promulgation (1063) is authentic, the first medieval code of its kind. Trani achieved peaks of prosperity in the 13th century (under Emperor Frederick II) and again in the 15th century, but later it declined and never recovered its former importance. Pop. (1961) 37,313.

NELDA G. CASSUTO



© PETER MENZEL/STOCK, BOSTON
The city of Trani, crowned by a Romanesque cathedral, climbs steeply above the Adriatic in southern Italy.

TRANQUILIZING DRUGS, trăng′kwəl-ī-zīng drŭgz. These agents are of two types: major tranquilizers that often help in the treatment of agitated psychotic subjects, and minor tranquilizers that are used in less profound behavioral disturbances such as neuroses. Characteristically, administration of a tranquilizing drug quiets agitated subjects; drugs such as alcohol or phenobarbital may exert this effect in certain circumstances, but these agents are more conveniently classified as general anesthetic-type central nervous system depressants. Conversely, a tranquilizing drug may cause a subject to become much more disturbed and difficult to handle than before. This apparent anomaly does not mean that the effects of the drug are capricious; it is, rather, an illustration of the very general rule that the behavioral changes that result from administration of a drug depend to a large extent on the behavior under study and the circumstances, past and present, under which it occurs. Tranquilization, therefore, is only the characteristic result and not an invariable or unique effect.

History. The main types of tranquilizing drugs were discovered more or less independently of one another, but all within the space of a very few years in the early 1950's. One group was developed from the antihistaminic agents. Many people taking such agents for relief from allergic conditions complained that the drugs made them sleepy or peculiarly lethargic. Substances related to the potent antihistamines were then produced and evaluated for their central nervous system effects. In this way, chlorpromazine, the first of the phenothiazine major tranquilizers, was discovered. The drug was found to have a variety of effects on behavior, most of them now regarded as characteristic of tranquilizing drugs; it quickly found its way into psychiatric practice and soon was in widespread use.

Simultaneously, active substances were isolated from a plant from India, *Rauwolfia serpen-*

tina, that had been used as a folk remedy for a variety of ills for hundreds of years. One of these substances, reserpine, was introduced into Western medicine for the treatment of high blood pressure, but was soon observed to have tranquilizing actions and received trial in the treatment of psychiatric disorders. Although reserpine and chlorpromazine are entirely different types of chemical substances, they are more alike in their behavioral effects than either is to the drugs of any other major class.

Shortly after World War II, the introduction of curare to relax patients during surgical operations led pharmacologists to search for substances that relax skeletal muscle. Mephenesin, a compound discovered in the course of this investigation, was found to act on the central nervous system, by contrast with curare, which exerts its effect on the peripheral system. It was also observed that mephenesin produced tranquilizing effects in animals, and there was some suggestion that it exercised a similar effect in humans. A search was then undertaken for longer-acting and more active compounds that could be given by mouth, and after a number of years meprobamate (known by the trade names Miltown and Equanil) was introduced. Meprobamate is unrelated chemically to either chlorpromazine or reserpine. Although the specific muscle-relaxing action of meprobamate in clinical doses is perhaps not too important, the compound has attained enormous popularity and widespread use as a minor tranquilizer.

Effects.—Suitable doses of chlorpromazine by mouth in normal subjects generally induce lethargy and sleepiness, which usually decrease after a few days of continued dosage. There is much less incoordination than after large doses of alcohol. If all the patients in a ward full of hyperactive subjects are given a major tranquilizer, the total effect is dramatic, the ward being converted from the traditional bedlam to a state of relative decorum. Although the drug often quiets animals and tames the wilder ones, it sometimes induces the opposite effect. The circumstances under which the different types of effect become manifest are being slowly illuminated by studies in animals.

Chlorpromazine cannot produce anesthesia, no matter how much is given, although it may help such other drugs as barbiturates to produce this condition. Similarly, chlorpromazine lacks morphine's ability to alleviate pain but can fortify the latter drug in its effects. Chlorpromazine can also alleviate nausea and vomiting from a variety of causes, but does not help motion sickness.

Patients receiving chlorpromazine regularly over a period of time may come to have a general, sustained increase in muscle tone, called rigidity, that impairs movement and may be accompanied by tremor. Especially in the past, a proportion of patients receiving chlorpromazine suffered impairment of liver function, one result of which was jaundice. In the vast majority of cases, both the rigidity and the liver disability cleared up very quickly when the drug was discontinued. A more dangerous but much rarer complication has been interruption of the process whereby new blood cells are introduced into the circulation.

After chlorpromazine was described, several hundred phenothiazines were synthesized and tested; a dozen or so have found extensive clinical use. They differ from chlorpromazine in the dosage required, in their persistence, and to some extent, in their tendency to induce sleepiness, to affect the liver, and to cause rigidity. Reserpine requires a much longer period, sometimes several hours, to cause its greatest effect, and the effect then persists for days. Several other substances quite closely related to reserpine have received widespread trial, but are seldom used as major tranquilizers.

It is very difficult precisely to state the effects of meprobamate. It is generally prescribed to allay anxiety, and it is certain that many patients feel that it helps in this respect, but this has not yet been subjected to scientific analysis, the difficulties of which remain formidable. Many patients feel that the drug helps them to sleep. Some clear effects of meprobamate on the behavior of experimental animals have been proved, but it is not yet possible to offer a general statement as to its characteristic effects. These remarks apply also to the large numbers of other drugs that have been introduced as minor tranquilizers; they are of a variety of different classes of chemical compounds, and it is far from certain that they should be classed together pharmacologically. They are generally ineffective in psychotic patients. Concern has been expressed that minor tranquilizers may have a subtle deleterious effect on the efficiency of people, so that their widespread use for relatively trivial conditions would have undesirable social consequences. The evidence for such action is at present equivocal.

The introduction of the major tranquilizers has been of both practical and scientific importance. The drugs have altered the atmosphere of mental hospitals, quieting disturbed and violent people without grossly incapacitating them, and reducing the need for physical restraint. Perhaps as important as the direct effects of the drugs has been the change in attitude they have engendered. Even a small improvement in a previously intractable subject gives new hope and leads to increased interest in and study of his case, a fact which in itself benefits the patient. Since the introduction of the major tranquilizers, a long-term trend which saw an almost continual increase in the number of patients under treatment in mental hospitals has been halted and actually reversed (due to reduction in the average length of stay per patient). The sudden hope of dramatic progress in this field is one of the factors that has led to the great increase in scientific research activity on behavior, behavioral disorders, and the behavioral effects of drugs, research that promises rich dividends in the years to come.

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TRANSCENDENTAL MEDITATION, tran-sen-den′təl, is a mental technique for increasing awareness. Derived from ancient Indian tradition, it was introduced to the West in 1959 by Maharishi Mahesh Yogi simply as a means of realizing human potential and relieving the stress of competitive, urbanized, 20th century life.

Goals. Transcendental Meditation (TM) like meditation techniques in world religions, is based on the theory that man can transcend the chattering thoughts and jostling impressions that crowd the surface of his mind to reach a deeper, silent level of pure consciousness that is the most fundamental aspect of the self. This experience of transcendence, in other traditions variously called enlightenment, Nirvana, the One, or the Infinite, is, according to TM, the source of unlimited energy and "creative intelligence." By improving this experience man can improve all aspects of his life.

In meditation he achieves a state of rest deeper than sleep, indicated by slower breathing and heartbeat, conditions confirmed by scientific measurement. Such rest relieves stress and releases energy. As a result, his health improves, often accompanied by reduced consumption of alcohol and drugs. His work improves as he uses more than the 15% of the mind that psychologists say we normally employ. Finally, his relations with others become more harmonious. Not stopping with these personal benefits, Maharishi further promised that harmony between individuals would eventually lead to world peace.

Technique. Other meditation traditions, of limited application, may call for special diets, postures, and ways of life. Most require long years of effortful technique such as contemplating (thinking about) an idea or concentrating (focusing attention) on an object, or on breathing or on emptying the mind. Some call for the silent repetition of a sound or prayer. TM claims to be a unique, effortless technique that anyone, regardless of age or belief, can learn in a few hours from a professional teacher. It requires nothing but two 20-minute meditation periods a day. In them the meditator simply repeats in his mind a mantra (sacred verse), defined by TM as a meaningless sound whose vibrations soothe the brain. It is assigned to him by a teacher according to a formula and may not be revealed lest it be misused. Reciting the mantra permits his wandering, pleasure-seeking attention to flow naturally down to the more pleasurable, deeper levels of awareness.

History. The TM technique is rooted in the Vedas, sacred writings dating from about 1000 B.C. It was transmitted over the centuries by such men as the 8th century Hindu philosopher Shankara and the 20th century sage Guru Dev, the teacher of Maharishi Mahesh Yogi. Maharishi, a 1942 graduate in physics from Allahabad University, spent two years in a Himalayan retreat and then began about 1955 to teach TM in India. Subsequently he traveled in the East and West to implement his "World Plan" for training teachers to spread TM and the Science of Creative Intelligence, which seeks to integrate all knowledge. He lectured, wrote books, made videotapes, and founded the International Meditation Society and Maharishi International University, based in Iowa and Switzerland. Especially active in the United States, Canada, and West Germany, by the mid-1970's TM claimed nearly a million practitioners.

TRANSCENDENTAL PHILOSOPHY, trăn-sĕn-dĕn'-təl, that philosophy which holds understanding to be the creative activity in the real world. Its chief architect was Immanuel Kant (1724–1804), who drew a sharp distinction between the terms "transcendent" and "transcendental." He applied the term "transcendent" to such ideas as he believed were beyond the range of any possible experience. On the other hand, he designated as transcendental those elements which were necessary constituents of experience, but which could not come from sense perception. Chiefly through the writings of Samuel Taylor Coleridge and Thomas Carlyle (qq.v.), the ideas of Kant and his successors became known in England. Subsequently, they spread to the United States, where they inspired a definite movement called transcendentalism (q.v.), led by the "Concord group" of New England intellectuals. See also KANT, IMMANUEL.

TRANSCENDENTALISM, trăn-sĕn-dĕn'təl-ĭz-əm. As applied to 19th century American thought, the term implies essentially, a belief in the superiority of intuitive to sensory knowledge. Transcendentalism flourished in New England in the quarter century preceding the Civil War.

Transcendentalism is more correctly thought of as an intellectual, aesthetic, and spiritual ferment than as a strictly reasoned body of doctrine. James Freeman Clarke said facetiously, but not without reason, "We are called the like-minded because no two of us think alike." Thus it is impossible to assign a specific set of doctrinal beliefs as common to the whole group. But the anonymous pamphlet (probably written by Charles Mayo Ellis, 1818–1878), *An Essay on Transcendentalism* (1842), states the most commonly held principles of the group: "Transcendentalism . . . maintains that man has ideas, that come not through the five senses, or the powers of reasoning; but are either the result of direct revelation from God, his immediate inspiration, or his immanent presence in the spiritual world," and "it asserts that man has something besides the body of flesh, a spiritual body, with senses to perceive what is true, and right and beautiful, and a natural love for these, as the body for its food." This spiritual body within man's physical body the transcendentalists termed variously the oversoul, the conscience, or—borrowing the Quaker term—the inner light. Their emphasis on the innate worth of the individual was thought of as a logical spiritual extension of the political principles set forth in the Declaration of Independence.

Sources. The Unitarianism widespread among intellectual New Englanders in the early years of the 19th century, which was based on the sensationalism of John Locke (q.v.) and insisted that only that knowledge which could be demonstrated to the senses was valid, had produced, in Emerson's words, "a cold intellectualism" that seemed to destroy the validity of man's conscience. Emerson and his friends—it is significant that most of the early transcendentalists were young Unitarian ministers—were ripe for a philosophy that had a broader moral and aesthetic appeal. They found it in the philosophy of Immanuel Kant (q.v.) and the German transcendentalists of the late 18th century, which was brought to America through the writings and translations of Thomas Carlyle and Samuel Taylor Coleridge. The latter's *Aids to Reflection*, in an American edition of 1829 by James Marsh, was particularly influential.

It would be wrong, however, to attribute American transcendentalism solely to the influence of the German transcendentalists. The Americans were basically eclectic in their philosophy and borrowed ideas from their amazingly widespread reading in such esoteric sources as the religious books of the Orient (particularly the *Bhagavad Gītā* of Hinduism and the *Sayings of Confucius*), the writings of the French authors Madame de Staël, Victor Cousin, and François M. C. Fourier; those of Emanuel Swedenborg; and those of the Cambridge Platonists and the 17th century metaphysical writers of England.

Activities. In the fall of 1836, Emerson, Ripley, Hedge, and some of their friends, attending the bicentennial celebration of their alma mater, Harvard College, found their own discussions of the new philosophy more interesting than the official ceremonies, so they adjourned to the parlors of the Willard Hotel in Boston for further talk. This session proved so stimulating that they agreed to hold more such conversations. Since these meetings, held for the most part in private homes, were usually arranged to coincide with Hedge's visits to Boston from his pastorate in Bangor, Me., they called their group informally "the Hedge Club." Their contemporaries, however, noting the frequency with which they used such Kantian terms as "transcendent knowledge," named them, derisively, the "transcendentalists."

The Hedge Club was always completely informal. It never elected officers or drew up a constitution. Its membership varied from meeting to meeting and from year to year, but at one time or another it included all of the leading transcendentalists in its ranks.

Finding that most of the periodicals of the day were closed to their opinions, the transcendentalists in 1840 established the *Dial*. Under the editorship of Margaret Fuller and later of Emerson (aided by Thoreau), it published 16 issues over a period of four years. Although its circulation never exceeded 1,000, its influence was widespread. It is the best single source of the writings of the minor members of the group. Later, individuals in the group sponsored the publication of two short-lived periodicals, the *Massachusetts Quarterly Review* and the *Aesthetic Papers*.

Although transcendentalism places its greatest emphasis on individual reform rather than social action, some of the group became interested in communitarian experimentation. The most outstanding example was George Ripley, who in 1841 founded Brook Farm (q.v.) in West Roxbury, a suburb of Boston. His hope was that, by banding together, artists in every field—writing, painting, music, sculpture—could create an intellectual atmosphere and a financial security more conducive to creative endeavor than the workaday world. Their community unfortunately never received sufficient financial or personal backing and, after tottering along for several years, first turned to Fourierism and then collapsed completely in 1847. A similar but much more impractical and short-lived community was established at Fruitlands in Harvard, Mass., by Bronson Alcott and his followers in 1843.

Although the transcendentalists are often associated with the town of Concord, Mass., about 20 miles northwest of Boston, Thoreau was the only member of the group who was a native of that town. Emerson settled there in 1834, partly because it was the home of his ancestors; then others—such as Alcott, Ellery Channing, and Sanborn—moved there to be near Emerson.

Achievements.—The major literary works of the movement are Emerson's *Nature* (1836), *Self-Reliance* (1841), *The American Scholar* (1837), *Compensation* (1841), *The Poet* (1844), his "Divinity School Address" (1839), and his *Poems* (1846); Thoreau's *Walden* (1854), *A Week on the Concord and Merrimack Rivers* (1849), *Civil Disobedience* (1849), and *Life without Principle* (1863); Jones Very's *Essays and Poems* (1839), particularly his sonnets; William Ellery Channing's *Poems of Sixty-five Years* (1902); Margaret Fuller's *Woman in the Nineteenth Century* (1845); Bronson Alcott's *Record of a School* (1835, edited by Elizabeth Peabody); and the anonymous *Essay on Transcendentalism*, discussed above. Virtually the only work of fiction is *Margaret* (1845), a lengthy local-color novel by Sylvester Judd (1813–1853). Many of the transcendentalists kept voluminous daily journals of their thoughts and observations. Those of Emerson and Thoreau have been published virtually in their entirety and offer an unsurpassed opportunity to study the intellectual development of these men and of their time. Selections have also been published from the journals of Alcott, Higginson, and Margaret Fuller.

Many of the transcendentalists were active in the lyceum movement (see LYCEUM), finding that it not only offered a source of income, but, more important, a means of offering their views to the general public. Emerson delivered 100 lectures in Concord and many more in towns and cities across the country from Maine to California, as well as in England. Virtually all his major writings were tried out on the lecture platform before they were committed to print. Thoreau, too, made frequent use of the lecture platform, though he never attained Emerson's popularity. Margaret Fuller and Bronson Alcott preferred to conduct "Conversations," which were directed discussions of transcendentalist doctrines.

Despite their belief that all true reform must come from within the individual, most of the transcendentalists participated in the many social reform movements of the day, such as temperance, peace, universal suffrage, and antisabbatarianism. They were particularly active in the antislavery movement; Thoreau's *Civil Disobedience*, *Slavery in Massachusetts* (1854), and *A Plea for Captain John Brown* (1860) are classics in the literature of that movement. Many, including Thoreau, participated actively in the Underground Railroad.

The transcendentalist movement flourished, at times reaching almost the proportions of a grass roots movement, until the Civil War. Then, with the death of Thoreau, the intellectual retirement of Emerson, and the increasing materialism of what Mark Twain has called "the Gilded Age," the impetus of the movement was dissipated. There was a brief revival in the Middle West in the 1870's, led by the St. Louis Hegelians under William Torrey Harris (1835–1909), and another in Concord itself with the establishment of the Concord School of Philosophy in 1879. But both of these revivals proved abortive.

Influence.—Transcendentalism has had an influence far out of proportion to its size as a movement. Walt Whitman testified that it was transcendentalism that led him to the writing of *Leaves of Grass*, and Emily Dickinson could well have said the same for her own poetry. Nathaniel Hawthorne never accepted fully the principles of the movement, but deeply felt its influence. Charles William Eliot traced the inspiration for his elective system in collegiate education to Emerson, as did John Dewey for progressive education. Mary Baker Eddy, the founder of Christian Science, was strongly influenced by Bronson Alcott. The early leaders of the British Labour Party were well acquainted with the philosophy of Thoreau; and Mohandas K. Gandhi, the leaders of the anti-Nazi resistance movement in continental Europe during World War II, and Martin Luther King in the United States in the 1960's have all acknowledged the debt that their civil disobedience campaigns owed to Thoreau's essay on that subject.

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TRANSCONA, trans-kō′nə, is a city in Manitoba, Canada, 7 miles (11 km) east of Winnipeg. The community developed after 1912, when the Grand Trunk Pacific Railway transferred its shops here from Rivers, Manitoba. Employment by the railroad, however, dropped substantially after World War II. The years after the war saw the development of tar and chemical, malt-processing, and sulfuric-acid industries, and a trend to suburban living.

The city's name derives from the word "transcontinental" and the name of Baron Strathcona (Donald Alexander Smith), pioneer Canadian railroad builder and statesman. Transcona was incorporated as a town in 1912 and as a city in 1961. It became part of Winnipeg in 1972.

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TRANSDUCER, trans-dōō′sər, a device that receives a signal in one form and delivers it in a different form. The received signal is called the *input* to the transducer, and the delivered signal is called the *output* of the transducer. There are many kinds of transducers, but all of them are classified according to the forms of their input and output.

Electroacoustic transducers are devices that convert sound energy to electric energy, or vice versa. They include microphones, loudspeakers, and telephone transmitters and receivers. For instance, a microphone converts sound energy to electric energy, and a loudspeaker converts electric energy to sound energy. Some electroacoustic transducers are reversible. For example, a sonar transducer on a ship or submarine converts electric signals to high-frequency sound waves that are projected into the ocean, and the same transducer receives the sound waves reflected from underwater targets and converts them to electric signals that are displayed on a cathode-ray tube. See also ELECTROACOUSTICS; LOUDSPEAKER; MICROPHONE; SONAR.

Pressure transducers are devices that respond to a change of pressure by producing an electric signal. They include strain gauges and crystal transducers. A strain gauge, which is commonly used as a measuring device, converts a mechanical pressure on a wire to a voltage that is measured on a suitable indicating instrument. When the strain-gauge wire is stretched, its length increases and its diameter decreases, and therefore its resistance increases. This change of resistance causes a change in the output voltage of the circuit of which the wire is a part. A crystal transducer generates a voltage when subjected to mechanical stress. Crystals of this kind are sometimes used in a microphone or the pickup of a record player. See also SOUND RECORDING AND REPRODUCTION.

Photoelectric transducers are devices that receive light and convert it to an electrical effect. For instance, a photovoltaic cell produces a voltage when light falls on the cell. See also PHOTOELECTRIC CELL.

TRANSFIGURATION, Feast of the, trans-fig-yə-rā′shən, a Christian festival liturgically commemorating Christ's transfiguration, as recorded in the first three Gospels. It probably originated in the Armenian Church in the 4th or 5th century and was gradually accepted throughout the Eastern Church, though the day of celebration and the rites varied.

The feast was not observed in the West until the 9th century or later. In 1457, Pope Callistus III declared it a universal feast and fixed the day as August 6, in commemoration of the victorious defense of Belgrade against the Turks on Aug. 6, 1456. In 1911, Pope Saint Pius X added to its prestige in the ecclesiastical calendar by changes in its liturgy. The feast is also observed by Anglicans and some Protestants.

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TRANSFIGURATION, The, trans-fig-yə-rā′shən, the manifestation of the glory of Christ to three of his disciples recorded in Matthew 17:1–13, Mark 9:2–13, and Luke 9:28–36, and referred to in II Peter 1:16–18.

According to the Gospel accounts, six days after Peter's confession of his belief that Jesus was the Messiah ("about eight days," according to Luke), Jesus took the three disciples who were closest to him—Peter, James, and John—up into a high mountain apart. There, as he prayed, his face shone with a strange light, his raiment glistened, and Moses and Elijah appeared, talking with him. Then Peter, heavy with sleep and afraid, not knowing what he said, blurted out: "Master, it is good for us to be here: and let us make three tabernacles; one for thee, and one for Moses, and one for Elias [Elijah]." Then a cloud overshadowed them, and a voice out of the cloud said, "This is my beloved Son: hear him."

And suddenly when they looked about, they saw only Jesus with them. And as they came down from the mountain Jesus charged them to tell no one what they had seen until after his resurrection. So they kept this saying to themselves, questioning with each other what this rising from the dead could mean. And when they asked Jesus why the scribes said Elijah would first come before the Messiah appeared, he told them that Elijah had come already, and that the people had not known him. Then the disciples understood that he meant John the Baptist.

The details vary somewhat in the three accounts, but the essentials are much the same in all. Where the mountain was is not known. Some, including Saint Jerome, have thought that it was Mt. Tabor, near Nazareth. Others thought it was the Mount of Olives, at Jerusalem. Many modern scholars think it was a spur of Mt. Hermon, in the north, with which both Moses and Elijah had been associated.

Wherever the place, and whatever the details of the experience, it was a vision that clarified and strengthened the faith of the three disciples. The transfiguration presented Jesus as the fulfillment of Jewish law and prophecy and provided a foreshadowing of the glory of Christ in the Resurrection.

TRANSFORMER, a stationary electrical device used to couple two or more electric circuits by electromagnetic induction. It is used to transfer energy from one circuit to another by means of a magnetic field. In its simplest form, a transformer consists of two coils of wire placed close to each other and having no actual wire connections between them. When the two coils are wound on a core of thin iron sheets, the device is called an iron-core transformer. When they are wound on an insulator, such as a large pressboard (compressed wood pulp and rag) or a plastic tube, with no iron present, the device is called an air-core transformer.

The coil (winding) across which the input (source) voltage is applied is referred to as the primary winding, the secondary being that coil (winding) from which the output is taken. When voltage is applied across the input winding, the resulting current flow produces a magnetic field within and around that winding. If an output winding is placed near the input winding, some of the magnetic field produced by the input winding passes through (or "links") the output winding (see Fig. 1). This magnetic field induces a voltage in the output coil. The magnetic field, however, must be continually changing or varying to maintain the induced voltage on the output winding. A transformer will not work with directly applied dc voltage because the field is not varying. However, if the dc voltage is intermittently switched off and on, the magnetic field will vary from zero to the full dc voltage value. This is the principle on which the vacuum-tube automobile radio receiver works, the vibrator being the mechanism that makes and breaks the dc voltage from the battery source.

In an air-core transformer, the magnetic field exists in the air in all directions around the coil. To be most efficient, the magnetic field must encompass as much as possible of both windings. In the air-core transformer, a relatively large amount of magnetic field is ineffective in producing an induced voltage in the output coil.

If both windings are placed on a single iron core and a voltage is applied to the input winding, the iron core becomes magnetized. Iron is used because of its desirable magnetic properties. This causes practically all of the magnetic field to be concentrated and channeled through the core. The magnetic field that is created in the core by the input winding is thus passed through the output winding on the same core, producing voltage in the output winding by induction (see Fig. 2). Very little of the magnetic field in an iron-core transformer is wasted; in fact, the device typically has an efficiency of between 97% and 99.9%. Therefore, for most practical purposes, the input can be considered equal to the output. This can be stated as follows:

(1) Input volts × input amperes = output volts × output amperes.
(2) Input turns × input amperes = output turns × output amperes.

In other words, if both input and output windings have the same number of turns, the amount of voltage transmitted by induction is 100%, and input volts equal output volts.

If the output winding has more turns than the input, the output voltage will be increased in the same ratio as the ratio between the numbers of turns in the two windings. The relationship between the number of turns in the two windings is called the turns ratio. Voltage is always transformed in exact accordance to this ratio. The amperes, or amount of current, changes in inverse ratio to the turns ratio. When voltage increases, current decreases in the same proportion, and vice versa.

A transformer can either step up voltage or step it down, with the turns ratio principle applying equally in both cases. A step-up transformer is one in which the output voltage is greater than the input voltage. In a step-down transformer, the opposite is true. To step down voltage, there need only be a smaller number of turns in the output than in the input winding.

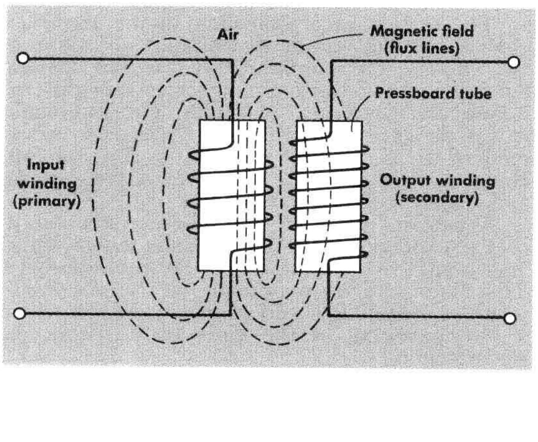
Transformers are rated in volt-amperes (the product of volts and amperes in the input winding). The capacities of very large transformers are rated in thousands of volt-amperes (kilovolt-amperes, abbreviated kva) and in millions of volt-amperes (megavolt-amperes, abbreviated Mva).

More than two windings can be present on the same core. When there are multiple windings, however, the input-output relationship still holds true. The sum of the capacities of all the output windings must be equal to the capacity of the input winding. Since transformer operation depends on varying magnetic fields, and since such fields cause iron to overheat, iron-core transformers are limited to very low frequencies, usually 60 hertz. Solid iron will heat more than thin sheets of iron; therefore, the iron cores are constructed of laminated thin sheets. Because of this heat problem, transformers that are used at radio frequencies are of the air-core type and contain no iron. In electronic circuitry, the air-core transformer is referred to as a radio-frequency transformer.

The autotransformer is one in which windings are shared; that is, one terminal of the primary winding is connected to a terminal of the secondary winding in order to reduce the physical size of the transformer. Often the position of the common terminal is variable. The disadvantage of the autotransformer is that the two windings are not isolated.

Saturable reactors make use of certain magnetic properties of iron (specifically, the nonlinear properties of saturated cores) to operate under conditions that are abnormal for ordinary transformers.

Fig. 1. Air-Core Transformer. In an air-core transformer the only part of the magnetic field that is useful is the part that cuts through both coils.



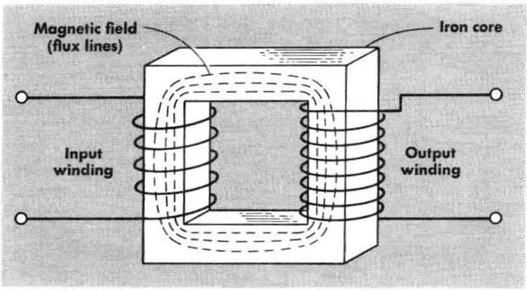


Fig. 2. Iron-Core Transformer. In an iron-core transformer the magnetic field is concentrated in the iron, and thus virtually all of the field is useful.

Uses. Ordinarily, a transformer is used to change the voltage or current in an electric circuit to either a higher or a lower value. Sometimes it is used to insulate or isolate two electric circuits while still permitting an exchange of energy between them (isolation transformer). In electronics, transformers are used chiefly to match impedances, to couple different stages of amplifiers, to transform direct-current pulses to an alternating voltage of a much higher value, and to transmit only certain frequencies. In some of these applications, transformers are used in conjunction with capacitors and resistors (tuned circuits). In electric power transmission, transformers are used chiefly to step up and step down voltage. For metering purposes, special transformers measure current (current transformer) and voltage (voltage transformer).

All transformers, however, perform one basic function, that of transferring energy from one circuit to another by electromagnetic induction, and their chief application—whether it be a 230,000-volt, 600-Mva device for electric power transmission or a 6-volt, 15-volt-amp transformer connected to the filaments of a TV receiver—is to transfer power at convenient voltage levels. The necessity for altering voltage levels may be illustrated by examining the problem of transmitting electric power from a generating station to substations many miles away. Since power is equal to the product of voltage and current, the transmission of a given amount of power at low voltages would require correspondingly heavy wires to carry the higher current. By increasing the voltage to a high value (for instance, to 230,000 volts or more), the current is greatly reduced, as is the weight of the wire required to carry it. Thus the size of cable or transmission lines, towers, and other installations may be reduced to practical proportions. See also POWER, ELECTRIC—*AC Power Transmission Systems*.

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TRANSFUSION, Blood. See BLOOD—*Transfusions and Blood Substitutes.*

TRANSISTOR, tran-zis'tər, a small electronic amplifying device made from a wafer of semiconductor material, usually germanium or silicon. Although the transistor is basically an amplifier, it can perform other major tasks such as oscillation, electronic switching, controlled rectification, and automatic control.

Since its first commercial appearance in the late 1940's, the transistor has almost entirely supplanted the vacuum tube in electronic equipment, including radios, television receivers, home high-fidelity systems, and digital computers. Several thousand transistors may be used in a single computer, saving space and power and reducing heat output.

Because of its small size, the transistor is essential in such miniature devices as hearing aids, heart pacemakers, shirt-pocket radios, and hand-held calculators. Besides small size, noteworthy features of the transistor include simplicity, mechanical ruggedness, long life, freedom from microphonics and other vibratory disturbances, low heat generation in most cases, low operating voltage, low noise generation, and high overall efficiency.

Frequency and Power Capabilities. Transistors now are used for amplification, switching, and control of audio-frequency and radio-frequency alternating-current (ac) signals, direct-current (dc) signals, and pulse signals. Previously, the limited frequency response of the transistor was a serious drawback. For a time it seemed that this revolutionary device would be limited to audio-frequency applications such as hearing aids. However, improved design and better manufacturing techniques extended the upper operating frequency limit, and transistors now can handle frequencies greater than 100 billion hertz (100 GHz). Associated with the high-frequency capability of a transistor is high-speed switching capability, which enables a transistor-type calculator or computer to perform thousands of operations per second.

The power-handling capabilities of transistors were limited to a few milliwatts at first, but some power transistors can now deliver kilowatts of output. Although most transistors are small, the high-power types are comparatively large. However, none is so large as the equivalent electron tube.

HISTORICAL BACKGROUND

The point-contact transistor was invented in 1948 by two scientists at Bell Telephone Laboratories, John Bardeen and Walter H. Brattain. Although it was the first solid-state amplifier, it soon became obsolete. In 1951 the junction transistor was invented by their colleague William Shockley, and it became the basis of all later types of transistors. As a result of their work, the three men shared the 1956 Nobel Prize for physics.

The transistor soon proved to be one of the great inventions in the history of electronics. By the early 1970's it had largely superseded the vacuum tube and had become a fundamental product of the electronics industry, which makes billions of transistors annually. The transistor not only supplanted the vacuum tube in radio and television, but it also broadened the scope of electronics to include such areas as computer memory, logic and switching circuits, minicomputers, minicalculators, medical electronic devices, and automatic control systems for industry.

In the early 1950's all types of transistors were individually wired into their circuits, and such discrete transistors still are manufactured in hundreds of different types. However, since the invention of the semiconductor integrated circuit in 1957, an increasing number of transistors have been manufactured along with other circuit parts on semiconductor chips. A single integrated circuit chip now can include hundreds of transistors, diodes, resistors, and capacitors, as well as their interconnecting wiring, all contained in or on a unit less than 0.1 inch (2.5 mm) square. See also ELECTRONICS—*Microelectronics*.

FORMATION OF *N*-TYPE AND *P*-TYPE SEMICONDUCTOR MATERIAL

Transistors are made from a crystalline solid semiconductor material such as silicon. The term "semiconductor" implies that the electrical properties of the material are intermediate between those of conductors such as copper and those of insulators such as rubber.

The degree of conductivity and the type of current flow in a semiconductor material depend on certain impurities that are added in making a transistor. During its fabrication, extremely small amounts of impurities are added to highly refined semiconductor material in a process called *doping*.

When the semiconductor is doped with one type of impurity called a *donor*, it adds extra electrons to the atomic structure of the semiconductor crystal. A current can then flow through the material by means of the movement of these electrons. This altered semiconductor material is called *n*-type, where the *n* stands for negative, the electrical polarity of the electron. Antimony, arsenic, and phosphorus are typical donor impurities used in making *n*-type material.

When the semiconductor is doped with another type of impurity called an *acceptor*, it introduces empty spaces, or *holes*, in the atomic structure of the semiconductor crystal. A current can then flow through the material by means of the movement of these holes. This altered semiconductor material is called *p*-type, where the *p* stands for positive, the equivalent electrical polarity of the hole. Aluminum, boron, gallium, and indium are typical acceptor impurities used in making *p*-type material.

TYPES OF TRANSISTORS

There are two principal types of transistors—the *bipolar* transistor and the *field-effect* transistor—but each type has many variations in design and manufacture. In the bipolar transistor, a small input-signal *current* causes a larger output-signal current to flow, and thus amplification of the input-signal current takes place. Accordingly, the bipolar transistor is a current amplifier and power amplifier. In the field-effect transistor, a small input-signal *voltage* causes a large output-signal current to flow, and this current develops an output-signal voltage. Thus the field-effect transistor is a voltage amplifier and power amplifier, and its performance more closely resembles that of the vacuum tube.

Bipolar Transistors. A bipolar transistor basically consists of a wafer of *n*-type or *p*-type semiconductor material in which two layers of the opposite type are created by doping to yield an *npn* bipolar transistor or a *pnp* bipolar transistor. Each of these transistors can be made in any of several ways. One comparatively simple way is to start with a *p*-type bar and to dope each end with an *n*-type impurity, yielding an *npn* transistor as shown in Fig. 1. Another way is to start with an *n*-type bar and to dope each end with a *p*-type impurity, yielding a *pnp* transistor. The doping is usually accomplished by alloying or diffusion.

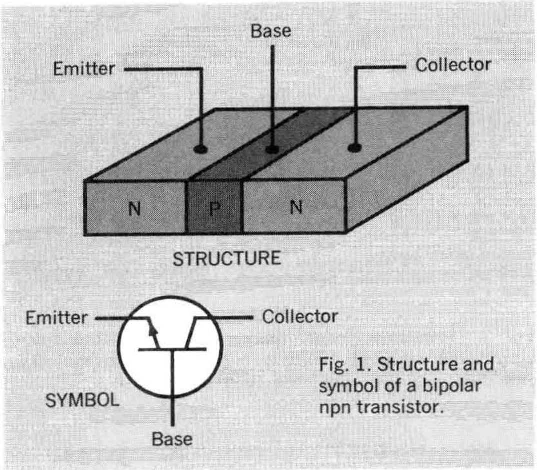


Fig. 1. Structure and symbol of a bipolar npn transistor.

Each of the three layers is an electrode of the transistor. One end layer is called the *emitter*, and the other end layer is called the *collector*. The narrow center layer is called the *base*. Wire leads are attached to these layers for connection to the pigtails or base pins of the transistor package.

This type of bipolar transistor is also called a *junction transistor* because it has two junctions between opposite kinds of semiconductor material. One junction is the interface between the emitter and base layers, and the other junction is the interface between the collector and base layers. Each *n-p* or *p-n* junction is equivalent to a semiconductor diode in some particulars of its behavior.

Bipolar Transistor Operation. When an external voltage is applied across one of the junctions of the transistor in such a way that the *n* layer is positive and the *p* layer is negative, the junction resistance is high and almost no current flows. But when the *n* layer is negative and the *p* layer is positive, the junction resistance is low and a relatively high current flows. The first condition is called a *reverse-biased junction*, and the second condition is called a *forward-biased junction*.

One possible way of operating a bipolar transistor is to connect it in a circuit as shown in Fig. 2, where the base is the common (grounded) electrode. A low external input voltage E_1 forward biases the low-resistance emitter-base (input) junction, and a high external voltage E_2 reverse biases the high-resistance collector-base (output) junction. Initially, a tiny collector current I_c flows through this high resistance. Voltage E_1 causes electrons to be injected into the *p*-type base layer, giving rise to emitter current I_e. Most of the injected electrons diffuse across the thin base layer, being attracted by the high positive voltage E_2 on the collector layer. These electrons raise the value of I_c to

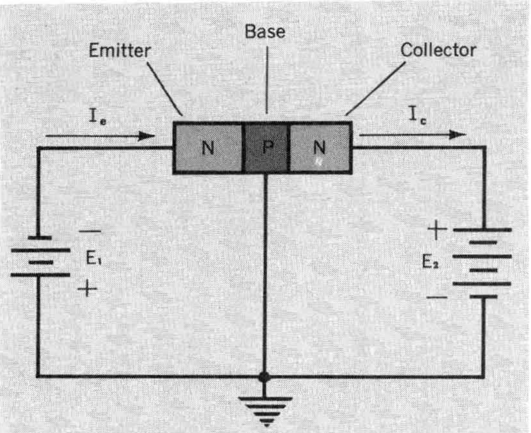


Fig. 2. A bipolar npn transistor connected in the common-base configuration.

90% of I_e, or higher. Although I_c is always lower than I_e, the former flows in a higher (collector) resistance than does the latter, indicating that power amplification has occurred.

Another way of operating a bipolar transistor is to connect it in a circuit in such a way that the emitter is the common (grounded) electrode. In this case, a low external input voltage E_1 forward biases the low-resistance base-emitter (input) junction, and a high external voltage E_2 reverse biases the high-resistance collector-to-emitter path inside the transistor. A tiny collector current I_c initially flows through this high resistance. Voltage E_1 causes electrons to be injected into the *p*-type base layer, giving rise to base current I_b. Most of the electrons diffuse across the thin base layer under the attraction of the high positive voltage E_2 on the collector layer, and these electrons raise the collector current I_c to a value much higher than I_b. Because I_c is higher than I_b, current amplification has occurred. Also, the collector-emitter (output) resistance is higher than the base-emitter (input) resistance, indicating that power amplification has occurred. If collector current I_c were allowed to flow through an external resistor placed in either of the two circuits described here, the voltage drop across this resistor (the output voltage) would be higher than the input voltage E_1, showing that voltage amplification also is obtained.

An *npn* transistor is shown in Fig. 2. However, a *pnp* transistor also is usable. For the *pnp* unit, simply reverse the polarity of both E_1 and E_2.

Field-Effect Transistors. There are two principal types of field-effect transistor (FET): the *junction field-effect transistor* (JFET) and the *insulated-gate field-effect transistor* (IGFET). As with bipolar transistors, there are many variations in the design, structure, and manufacture of field-effect transistors.

Junction-Field-Effect Transistors. A JFET essentially consists of a bar of *n*-type or *p*-type silicon in which two facing layers of the opposite type are created by suitable doping to the proper depth. Fig. 3 shows an *n*-type bar and two *p*-type layers. These layers form *p-n* junctions with the bar. The bar is called the *channel*, and the two doped layers collectively form the *gate* (control electrode). In Fig. 3 the channel is *n*-type, and the gate layers are *p*-type. One end-connection to the bar is called the *source*, and the other end-connection is called the *drain*.

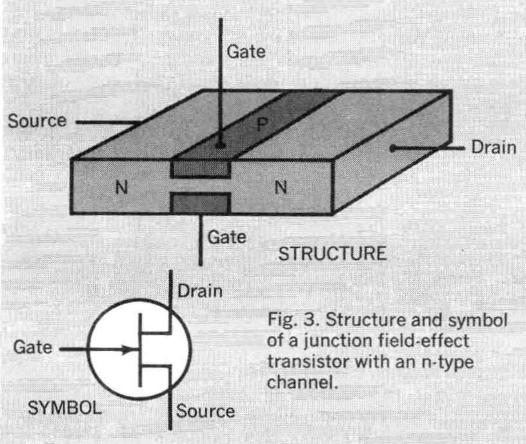
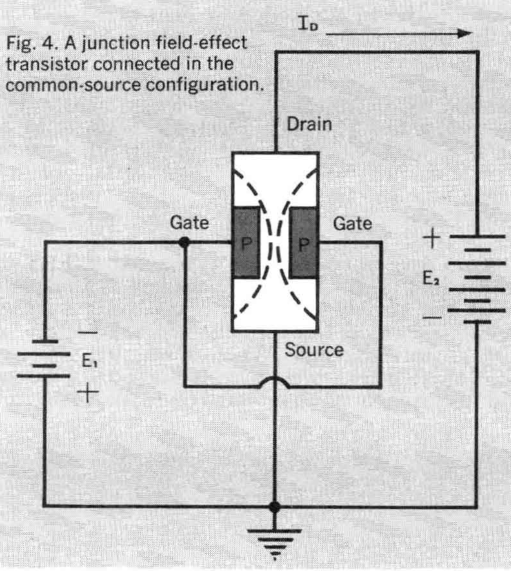


Fig. 3. Structure and symbol of a junction field-effect transistor with an n-type channel.

Fig. 4. A junction field-effect transistor connected in the common-source configuration.



One way of operating a JFET is shown in Fig. 4. In this circuit the source electrode is the common (grounded) terminal. A high external voltage E_2 causes an output current I_D (the drain current) to flow through the channel between the *p*-type gate electrodes. A second external voltage E_1 (the gate or input voltage) is applied between the gate and source terminal, with the gate negative. Because the two *p-n* junctions formed by the gate and channel are reverse biased by E_1, the junction resistance is extremely high and virtually no current flows in the gate-source circuit. Accordingly, the JFET exhibits very high input resistance and therefore is essentially a voltage-actuated device, as is the vacuum tube.

Voltage E_1 creates two regions that extend into the channel from each gate electrode as shown by the dashed lines in Fig. 4. No current carriers (electrons or holes) can exist in these regions, and thus they are called *depletion* regions. When voltage E_1 is zero, these regions disappear, and current I_D flows through the channel easily. However, as the input-signal voltage E_1 is increased, the depletion regions penetrate more deeply into the channel, narrowing the passageway and thereby reducing the output-signal current I_D. When voltage E_1 is high enough, the two depletion regions meet in the center of the channel, blocking the passageway and completely cutting off the flow of current I_D. In this way, the junction field-effect transistor permits the use of an input-signal voltage E_1 to control an output-signal current I_D.

An *n*-channel JFET is shown in Fig. 4. However, a *p*-channel unit operates in the same general manner. For the *p*-channel unit, simply reverse the polarity of both E_1 and E_2.

Insulated-Gate Field-Effect Transistors. Whereas the gate electrode in a JFET consists of two *p-n* junctions, the gate of an IGFET is a metal electrode that is electrically insulated from the rest of the transistor. This arrangement results in an even higher input resistance than that stemming from the reversed-biased gate of the JFET. An IGFET is shown in Fig. 5, where for clarity the metal layer and the insulating layer are shown much thicker than they are.

In the *n*-channel IGFET shown in Fig. 5, the source electrode consists of a *p-n* junction, and the drain electrode consists of another *p-n* junction. The silicon bar or wafer constitutes the *substrate*. The gate electrode consists of a metallic area electroformed on top of a thin oxide layer that was grown on the surface of the substrate. In the structure of a *p*-channel IGFET the *n* and *p* regions are the exact opposite of those of the *n*-channel unit.

One way of operating a *p*-channel IGFET is shown in Fig. 6. Here, the channel is the path under the gate between the two *n* regions. The electron drain current I_D flows from battery 2 through this channel. When a negative voltage E_1 is applied to the gate, with the gate negative and the source positive relative to the gate, an

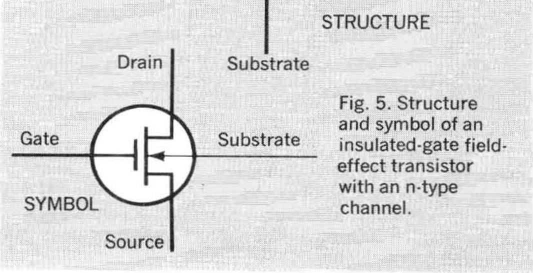


Fig. 5. Structure and symbol of an insulated-gate field-effect transistor with an n-type channel.

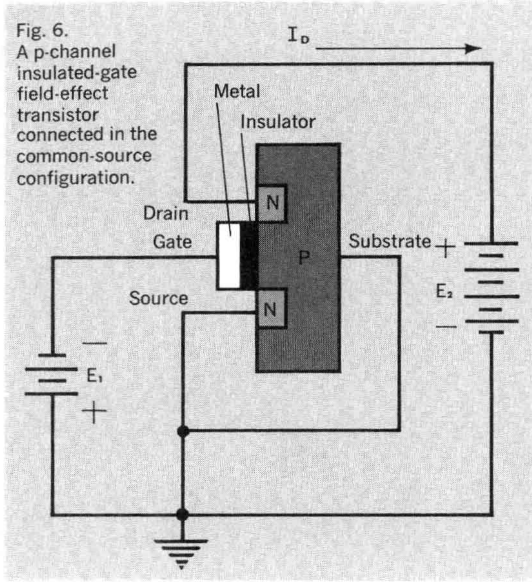


Fig. 6. A p-channel insulated-gate field-effect transistor connected in the common-source configuration.

electric field extends from the gate electrode into the substrate. As voltage E_1 is increased, this field penetrates deeper, narrowing the channel and reducing the drain (output) current I_D. When voltage E_1 reaches a certain critical high value, it closes the channel completely, and the drain current I_D is reduced to zero. In this way the IGFET, like the JFET, permits the use of an input-signal voltage E_1 to control an output-signal current I_D.

Although a *p*-channel IGFET is shown in Fig. 6, an *n*-channel transistor also is usable. For the *n*-channel unit, simply reverse the polarity of both E_1 and E_2.

The insulated-gate field-effect transistor is also known as a *metal-oxide-semiconductor field-effect transistor* (MOSFET). This terminology is appropriate on the basis of reading the order of the materials from the gate to the substrate.

AC Circuits. The performance of the circuits shown in Figs. 2, 4, and 6 was explained in terms of dc input and output signals, but these circuits also can be used for amplification of audio-frequency and radio-frequency ac signals. One way to handle ac signals is to insert an input transformer in series with dc voltage E_1 and an output transformer in series with dc voltage E_2 in each circuit shown in Figs. 2, 4, and 6. In these modified configurations the input transformer couples a small input signal into the circuit, and the output transformer couples the amplified output signal out of the circuit.

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TRANSIT, tran'sit, in astronomy, has three meanings: (1) the apparent passage of a celestial body across the visible disk of a more distant and larger body; (2) the passage of a celestial body across the meridian of the observer; or (3) a type of astronomical telescope.

In the first sense of the word, a transit occurs when two celestial bodies come so nearly in line with the earth that the closer body appears to cross the visible face of the more distant body. This event is similar to an eclipse or an occultation, but the circumstances—specifically, the relative sizes of the respective bodies and the appearance of the phenomenon—are different. Transits of Venus and Mercury across the sun and transits of the four largest satellites of Jupiter across the face of that planet can be observed telescopically. Other transits occur, such as occasional transits of comets across the sun and of other satellites across their respective planets, but these phenomena are not observable from the earth.

Venus and Mercury, because their orbits are closer to the sun than the orbit of the earth, pass approximately between the sun and the earth during each revolution. This position for the planets is called inferior conjunction, and it occurs every 584 days for Venus and every 116 days for Mercury. Because their orbits are inclined slightly to that of the earth—Venus by 3.4 degrees and Mercury by 7 degrees—the planets are usually a little above or below the sun's position at inferior conjunction. Periodically, however, the planets cross the plane of the earth's orbit when inferior conjunction occurs. Viewed from the earth at such a time, the motion of the planet takes it directly across the sun's face, and it appears as a small dark object crossing the disk of the brighter, larger, and more distant sun. The planet first appears on the left (or east) edge of the sun, moves westward across the sun, and disappears on the right (or west) edge of the sun. The event lasts from a few seconds, when the transit is a grazing one, to several hours, when the planet transits across the solar diameter.

During a transit of Venus or Mercury, the earth, planet, and sun are nearly in direct line, and the planet and earth lie on or close to the line of the planet's nodes (the line of intersection between the plane of the planet's orbit and the plane of the earth's orbit). Since, for each planet, the line of nodes remains in nearly a fixed direction in space, the transit occurs only when the earth is at or close to certain positions in its orbit and hence at or close to certain times.

Observations of Mercury during transits have confirmed that the planet has no significant atmosphere; those of Venus have been used to calculate the astronomical unit, the standard for measuring distance in the solar system. Transit observations have also provided data for precise calculation of the orbits of the planets and for correcting their orbital elements.

In its second sense, as used to describe the passage of a celestial body across the celestial meridian of an observer, the transit is a phenomenon caused by the earth's rotation, which produces the apparent westward motion of all celestial bodies above the meridians of the earth. Every celestial body thus transits every meridian of the earth twice daily, once on the upper branch of the celestial meridian (upper transit) and once on the lower branch (lower transit). Transit observations across the meridian are used in determining coordinates of celestial bodies and in computing time and terrestrial coordinates for positions on earth.

Finally, a special type of astronomical telescope, suitably equipped and mounted so as to observe the passage of a celestial body across the meridian, is known as a transit instrument, or simply as a transit. This instrument is used for precise observations of time and position of celestial bodies in transit.

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TRANSIT, tran'sit, in surveying, a telescopic instrument for measuring horizontal and vertical angles, establishing a level line of sight, or measuring distances. See also SURVEYING.

TRANSITION ELEMENTS, a homogeneous group of comparatively dense metals with relatively high melting and high boiling points that lie in the atomic number ranges 21 (scandium) through 30 (zinc), 39 (yttrium) through 48 (cadmium), 57 (lanthanum) through 80 (mercury), and 89 (actinium) through 103 (lawrencium). In the periodic table (see PERIODIC LAW), they are placed between the alkaline earth family (group II_a) and the boron family (group III_a). The exact position for the dividing line between the transition and nontransition elements, such as between groups $VIII_b$ and I_b or between I_b and II_b, is largely a matter of choice and depends on whether greater stress is laid on the electronic constitution of atoms as observed spectroscopically or on their chemical behavior.

The atoms of the transition elements are characterized by electronic configurations in which inner energy levels are being occupied. Two types of elements can be so distinguished: (1) *d*-type transition elements, in which the inner energy level involves *d* electrons and for which the overall "outermost" electronic configuration is $(n{-}1)d^{1-10}ns^{0-2}$; and (2) *f*-type transition elements, in which both an inner level involving *d* electrons and one involving *f* electrons are present and for which the overall "outermost" electronic configuration is $(n{-}2)f^{1-14}(n{-}1)d^{0-1}n\,s^2$. For the first transition series (scandium through zinc), *n*, the principal quantum number, is 4; for the second (yttrium through cadmium), it is 5; for the third, 6; and for the fourth, 7. Because they constitute a series within a transition series, the *f*-type elements are called inner transition elements. Limitations in the number of possible *d* and *f* electrons (10 and 14, respectively) determine the number of elements of each type and for each series.

The *d*-type transition elements include many of the commercially important metals as well as many rare and currently unimportant species. The metals vary widely in chemical reactivity—from the very reactive (scandium, yttrium, manganese, zinc) to the noble (gold, platinum metals). All form a variety of alloys, and many are important catalysts. The metals occur in a wide variety of minerals. They are obtained by electrolytic, hydrogen, metallothermic, or thermal reduction, depending upon their specific properties. The presence of both *s* and *d* electrons permits an abundance of valences (from +2 through +7 for manganese, for instance) and a corresponding variety of compounds. Nearly all compounds are of the complex type. The *d* levels are such that interaction with the electrons of complexing groups (such as NH_3, H_2O, CN^-, NO_2^-, and others) is at a maximum. Many of the complex species have remarkable stabilities, and some exist in isomeric forms. Many are important as pigments, as catalysts, or as analytical reagents.

The *f*-type transition elements are of two types: (1) the lanthanides or rare earths (cerium through lutetium), where 4*f* electrons are involved, and (2) the actinides (thorium through lawrencium), where 5*f* electrons are involved. Few of these elements are abundant or common, but several are useful (for example, cerium and thorium in alloys, uranium and plutonium in nuclear reactors). The metals are all very reactive. The lanthanides are commonly found as phosphates or silicates. Of the actinides, only the lightest (thorium through uranium) occur in nature in appreciable quantities. The others are obtained by bombardment reactions. Electrolytic or metallothermic procedures are required to prepare the metals.

In general, only the *s* and *d* electrons are of importance in determining valences. Common valences characterize both series, +3 for the lanthanides and +3 and +4 for the actinides. Marked chemical similarities in a given valence state require fractional crystallization, ion exchange, or solvent extraction for separations. The compounds are commonly salts, and complex species are less common and important. A few compounds are important as pigments and glass colorants, as components of light filters, as ceramic bodies, as glass polishing agents, and as neutron absorbers.

See also RARE-EARTH; TRANSURANIUM ELEMENTS.

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TRANSITS OF MERCURY, VENUS, AND JUPITER. See TRANSIT, in astronomy.

TRANSJORDAN. See JORDAN, HASHEMITE KINGDOM OF.

TRANSKEI, Republic of, trans-kī', formerly an African reserve territory within South Africa, the Transkei was declared an independent republic by South Africa on Oct. 26, 1976.

The republic comprises 15,831 square miles (41,002 sq km) of hilly and occasionally mountainous land extending northeastward from the Great Kei River of eastern Cape Province to Natal, bounded by Basutoland on the north and by the Indian Ocean on the south and southeast. The capital and largest city is Umtata (1970 population, 24,805).

Though nearly 2,200,000 persons, mostly Xhosa-speaking, are considered to have their homeland in the territory, much of the Transkeian population works in the so-called European areas of South Africa, many as migratory laborers in the gold and diamond mines, in iron and steel works, and in domestic service. An increasing number of families are domiciled in the native townships on the outskirts of major cities such as Johannesburg, in which the wage earners hold jobs. Because the Transkei is overgrazed and overpopulated for its agricultural potential, much of the resident population consists of women and children who depend largely for their subsistence on the money that is remitted by those who work outside the territory. It may be said that labor is Transkei's main export.

As early as 1894, the Transkei (or United Transkeian Territories) was given a framework of representative institutions; these developed into the Transkeian Territories General Council, which was elective but only advisory to white magistrates. Under the Bantu Authorities Act of 1951, the General Council was superseded in 1955 by the Transkeian Territorial Authority, which had original taxing powers and an all-African membership of appointed chiefs.

A new constitution, effective in 1963, granted further local autonomy. An election held Nov. 20, 1963, established a Legislative Assembly of 109 members, of whom 45 were elected by African citizens of the Transkei and 64 were chiefs and paramount chiefs whose offices were dependent on approval of the national government. (Subsequently the assembly was enlarged to 150 members, of whom 75 were elected.) Chief Kaiser Mantanzima was elected prime minister, to work for independence. Control over finances, education, and local government (other than in white towns) was vested in the Legislative Assembly, but the national parliament retained control over internal security and external affairs and many phases of economic life.

On Oct. 26, 1976, South Africa declared the territory independent as the Republic of Transkei. Chief Botha Sigcau of the ruling Transkei National Independence party became the first president. However, recognition by other countries was not quickly forthcoming. As an expression of disapproval of South Africa's apartheid policy, the United Nations voted to request members to prohibit all contacts with the Transkei.

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TRANSLATION, trăns-lā'shən, the art of rendering a work of one language into another. This art is as old as written literature. Fragmentary versions of the Sumerian *Gilgamesh Epic* (q.v.) have been found in four or five Asiatic languages of the 2d millennium B.C. Indeed, it may have been read in their own tongues by early Biblical authors and by the poet of the *Iliad*. The Greeks did not translate, for they viewed their neighbors as barbarians and were too busy exploiting their own genius; and the Romans translated little from the Greek, since they were so impressed by the literature of Greece that every cultivated Roman learned to read the language.

The first important translation in the classical world was that of the Septuagint (q.v.), for the dispersed Jews had forgotten their ancestral language and required Greek versions of their Scriptures. They had, however, little sense of literature; therefore they accepted a poor and archaic Greek, full of Semitic constructions. The "olde-worlde" flavor of the first Bible translation has, in fact, continued through the years to bedevil all of the rest, not excluding the Authorized (or King James) Version. For the religious, unlike the literary, have never given priority to standards of verbal excellence, preferring the bare meaning; and the religious were the translator's first patrons.

The Romans followed Greek models, but did not translate; soon they imposed their language on the whole learned world. Until the Renaissance, no man was called educated unless he could read and write Latin, and no learned work could hope to be widely read unless it were written in Latin. King Alfred's Anglo-Saxon versions of Bede's *Ecclesiastical History* and Boethius' *Consolation of Philosophy* show a premature development of national self-consciousness. No other king supposed that the vernacular of his subjects was a fit vehicle for serious writing; and the church frowned on even partial adaptations of the standard Latin Bible, St. Jerome's Vulgate (dating from about 384).

The first serious task of translation was undertaken by the Arabs, who, having conquered the Greek world, made Arabic versions of its great scientific and philosophical works. Since manuscripts of these scarcely existed in the West, some translations were made from Arabic into Latin during the Middle Ages, chiefly at Córdoba, one of the few gaps in the iron curtain that had fallen between the Christian and Muslim worlds.

Chaucer and Early English Prose.—Medieval translation into the vernacular begins with the emergence of a middle class rich enough to buy manuscripts and sufficiently self-confident to do without an education in Latin grammar. The first English purveyor of fine translations was the first great English poet, Geoffrey Chaucer. By his time, both Italian and French had acquired status as languages fit for a literature of entertainment, if not for learned works. The 14th century Englishman, whose language was still regarded as barbarous in western Europe, therefore required three foreign tongues, not one, if he were to read the fashionable writers of his day: Boethius in Latin, Giovanni Boccaccio in Italian, and the *Roman de la rose* in French. Chaucer freely adapted Boccaccio in his *Knight's Tale* and *Troilus and Criseyde*, began a translation of the *Roman*, and did the whole of Boethius. Called "grant translateur" by the French poet Eustache Deschamps, he founded an English poetic tradition on adaptations and translations. Most medieval literature was based on free adaptation, and since originality was not rated highly before the 19th century, the classical sources were habitually preferred to the vernacular. Indeed, the vulgar tongues contributed little but folk songs and ballads until the Arthurian and cognate legends became widely popular and some plot infiltrations from *The Arabian Nights* had enriched the thematic material inherited from Ovid, Aesop, the Bible and its Apocrypha, and the tales of the saints.

The first great English translation was the Wyclif (Wycliffe) Bible (c. 1382), which, however, displayed all the weaknesses of English prose, for a poetic style is generally formed before a prose one. It was not until the end of the next century that the great age of English prose translation began with Thomas Malory's *Le Morte Darthur*, a free adaptation of Arthurian romances. Malory's style is rich, and his prose rhythms vary. He uses his sources too boldly, however, to be a true translator. The first great monuments of Tudor translation, therefore, are the Tyndale New Testament (1525; rev. 1534), which profoundly influenced the more famous Authorized Version of 1611, and Lord Berners' magnificent rendering of Jean Froissart's *Chronicles* (2 vols., 1523–25), with prose as picturesque and delicately modulated as Malory's.

Renaissance and Elizabethan Translations.—Meanwhile, in Italy, particularly at Florence, a work of translation was proceeding that was to enrich the whole of Western culture. A beginning had been made with the revival of Greek in Sicily. Petrarch and others had collected Greek manuscripts. But with the arrival of the Byzantine scholar Georgius Gemistus Pletho at the court of Cosimo de' Medici shortly before the fall of Constantinople to the Turks (1453), a Latin translation of Plato's works was undertaken by Marsilio Ficino. This and Erasmus' Latin edition of the New Testament, which he compared with the original Greek, were two great achievements of Renaissance scholarship and led to an entirely new attitude toward translation. Now, for the first time, readers demanded exactness of rendering, for religious and philosophical beliefs depended on the exact words that Jesus or Plato or Aristotle had used.

The literature of entertainment, however, continued to be satisfied with adaptations. The Pléiade (q.v.) in France and the first Tudor poets in England wrote variations on themes by Horace, Ovid, Petrarch, and modern Latin writers, founding a new poetic style on their borrowings. The great Elizabethan translators also made free use of these originals. Their purpose was to supply to the new public, created by the growth of a middle class and the development of printing, the type of work the original author would have written had he been a man of their day, writing in their tongue. The Plutarch *Lives* (1579) of Sir Thomas North, famous because Shakespeare used it as a source book and because it has a pleasingly rambling English, was translated not from the Greek but from a French version by Jacques Amyot. The Montaigne *Essays* (1603) of the Italian refugee John Florio, which still has a high reputation, is in fact loosely discursive where Montaigne is both subtle and taut. Philemon Holland, who translated the million and more words of Pliny's *Natural History* (1601) in a year, had a far greater respect for his text than either North or Florio. "Our Holland had the true knack of translating," wrote Thomas Fuller, who named him "the translator-general in his age," a title that he earned by translating not only Pliny, but Livy, Xenophon, Suetonius, and Plutarch's *Moralia* (1603). Holland, like all Elizabethans, wrote a slow-moving prose which required more than twice the number of words of the original. Thomas Shelton's version of *Don Quixote*, the first part of which appeared in 1612, before Cervantes had published his second, has a similar exuberance. Shelton's Spanish was imperfect, but where he failed to understand his author he generally invented a phrase which, if not exact, was just as good. The last of these great Elizabethans was Sir Thomas Urquhart, who actually wrote during the Commonwealth. His version of the first three books of Rabelais (1653, 1693) vastly expanded his French original without departing from its spirit. Shelton and Urquhart, in fact, were alive to the problem of their authors' styles, as North, Florio, and Holland were not.

Truth to the original style was admittedly an easier achievement with a modern language than with an ancient one. It was almost ignored by George Chapman, whose *Iliad* (1611) and *Odyssey* (1616) are written in different meters, and by his predecessor Arthur Golding, whose Ovid (*Metamorphoses*, 1565–67) was one of Shakespeare's source books; but it is clearly important to Sir John Harrington, who fails to capture it in his *Orlando Furioso* (1591). Though he uses Lodovico Ariosto's meter, he fails to appreciate his elegance and is often raw and provincial. Nevertheless it is possible to read his Ariosto for the story, an impossibility with Chapman. Edward Fairfax's Torquato Tasso (*Godfrey of Bulloigne*, 1600, a translation of *Gerusalemme liberata*) and Sir Richard Fanshawe's Camoëns (the *Lusiads*,

1655) not only convey the matter in the original meter, but are pretty faithful to the manner. Thus, the Elizabethan period of translation, which in fact overran the queen's lifetime by about 50 years, witnessed a considerable progress away from mere paraphrase toward an ideal of stylistic equivalence, but even to the last there was no feeling of a need for verbal accuracy.

Augustans and Victorians.—The Restoration and the 18th century, conscious of a kinship with the age of classical Rome, took for granted their power of writing in a classical manner. Certainly John Dryden's Plutarch (*Lives*, 5 vols., 1683–86) is truer to the original than North's, and, in the modern field, Charles Cotton's Montaigne (*Essays*, 1685) is preferable to Florio's. But when Dryden set out to make Virgil speak "in words such as he would probably have written if he were living and an Englishman"—a restatement of the Elizabethan ideal—he entirely forgot that the great Augustan was both subtle and concise. His translation frequently attains nobility, but in the most leisurely and obvious rhymed couplets. Homer, too, suffers at the hands of Alexander Pope, who at best produces a well-polished reflection of the "wild paradise" which he thought it his business to reduce to order. Dryden's *Aeneid* (1697) and Pope's *Iliad* (1715–20) and *Odyssey* (1725–26) are elegant poems for the library; they have not the force of the national epics they imitate.

Though these translations were signed by Dryden and Pope, they were in fact works of collaboration. The English Augustan style was so uniform that one hand could not be distinguished from another. Moreover, translation was now becoming an industry which, though badly paid, never lacked recruits. Peter Motteux, a Huguenot refugee who completed Urquhart's Rabelais and retranslated *Don Quixote* (1700–03), was the first of the new Grub Street practitioners, whose watchword was ease of reading. Whereas Shelton's *Quixote* is longer than Cervantes', that of Motteux is shorter. Anything that he did not understand, or that he thought might bore his reader, he unscrupulously omitted. This was the rule throughout the 18th century, which assumed that its own workaday style was the best and that writers of a less polite age should be pruned and lopped to their level. For scholarship they cared no more than their predecessors. Tobias Smollett took his *Quixote* (2 vols., 1755) from the French; the poet Thomas Gray published poems from the Welsh and the Norse, which he could have known only imperfectly; and when James Macpherson produced his *Fingal* (1762), and *Temora* (1763), half the world believed that he had translated the legendary poet Ossian. In fact his poems owed something to Gaelic fragments, but were mainly of his own composition.

The 19th century set new standards of style and accuracy in translation. In the matter of accuracy, "the text, the whole text, and nothing but the text," with the exception of any bawdy passages and the addition of many explanatory footnotes, became accepted policy. The Victorians' stylistic practices, however, render most of their translations unreadable today. Their aim was to remind the reader on every page that he was reading "a classic" written in a foreign tongue and generally in another age. Thomas Carlyle's Goethe is English written as German; the vocabulary is Teutonic and the constructions Germanically cumbrous. Sir Richard Francis Burton's *Arabian Nights* (16 vols., 1885–88) is full of pseudo-Arabic convolutions. Even Robert Browning, who claimed to be "literal at every cost," indulged in peculiar archaisms in his version of *The Agamemnon of Aeschylus* (1877), and William Morris, in *Beowulf* (1895), which he translated with the aid of A. J. Wyatt, wrote English as it might have been if it had developed straight from the Saxon and there had been no Norman Conquest. By contrast, the outstanding Victorian translation, Edward FitzGerald's *Rubaíyát* of Omar Khayyám (1859), attains its Oriental flavor chiefly by the use of Persian names and by discreet Biblical echoes, and it succeeds as a poem in its own right with very little basis in the Persian.

The 20th Century.—The cult of archaism was broken in 1871 by the Oxford scholar Benjamin Jowett, who translated Plato into simple decent language, thus setting an example that was not generally followed until well into the 20th century, when the whole question of style was put aside and plain accuracy became the criterion. As in the age of Elizabeth I, translators were now providing for a new educated public, though its training was generally scientific rather than literary. Such works as E. V. Rieu's *Odyssey* (1946) set out to translate plainly and word for word into prose that could be read without resort to footnotes. The new paperback translators prefer prose to verse, and approximate meters to close imitations, even when rendering the great poems of the past. They do not view their authors with the reverence of the Victorians and let them kick up their heels when they will. Bayard Taylor's otherwise reputable 19th century *Faust* (2 vols., 1870–71) fails where Goethe writes lightheartedly in doggerel; his American translator calls him gently to order, where more modern writers point or even underline the contrast. Lightheartedness indeed sometimes tempts the translator too far, as when Robert Graves makes Lucan faintly absurd in the duller passages of the *Pharsalia* (1957). Criticism by parody is, however, as much a fault as the 18th century's criticism by omission. Our present age demands the whole of the meaning, even when, as in the case of Jackson Knight's *Aeneid* (1956), this involves a considerably expanded text to account for the multiple layers of meaning in every line of the Latin.

Scientific translation is the aim of an age that would reduce all activities to techniques. It is impossible however to imagine a literary-translation machine less complex than the human brain itself, with all its knowledge, reading, and discrimination. Literary translation is never a matter of word-for-word equivalences. The meaning of a paragraph, with all the associations that it had for its author, must be rendered and, if this is done, the sentences will probably bear only a loose resemblance to those of the original. French or Spanish constructions can often be exactly matched in English. German generally needs recasting. Latin, Sanskrit, and Russian require varying degrees of expansion, which are all presently beyond the capacity of anything but a trained human mind.

The plain prose method has not entirely prevailed in the last half century. Outstanding verse translations such as, in the United States, Leonard Bacon's *Lusiads* (1950) and Dudley Fitts' and Robert Fitzgerald's Aristophanes and Sophocles and, in England, Arthur Waley's Chinese poems