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ENCYCLOPEDIA  
AMERICANA



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VOLUME 23

Pumps to Russell

T H E E N C Y C L O P E D I A  
**AMERICANA**  
I N T E R N A T I O N A L E D I T I O N

COMPLETE IN THIRTY VOLUMES  
FIRST PUBLISHED IN 1829



GROLIER INCORPORATED

International Headquarters: Danbury, Connecticut 06816

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1972, 1971, 1970, 1969, 1968, 1967, 1966, 1965,  
1964, 1963, 1962, 1961, 1960, 1959, 1958, 1957,  
1956, 1955, 1954, 1953, 1952, 1951, 1950, 1949,  
1948, 1947, 1946, 1945, 1944, 1943, 1942, 1941,  
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**Library of Congress Cataloging in Publication Data**

Main entry under title:

The Encyclopedia Americana—International Edition  
p. cm.

“First published in 1829.”

Includes bibliographical references and index.

ISBN 0-7172-0122-8

I. Encyclopedias and dictionaries. I. Grolier Incorporated.  
AE5.E333 1991 90-23041  
031—dc20 CIP

PRINTED AND MANUFACTURED IN THE U.S.A.

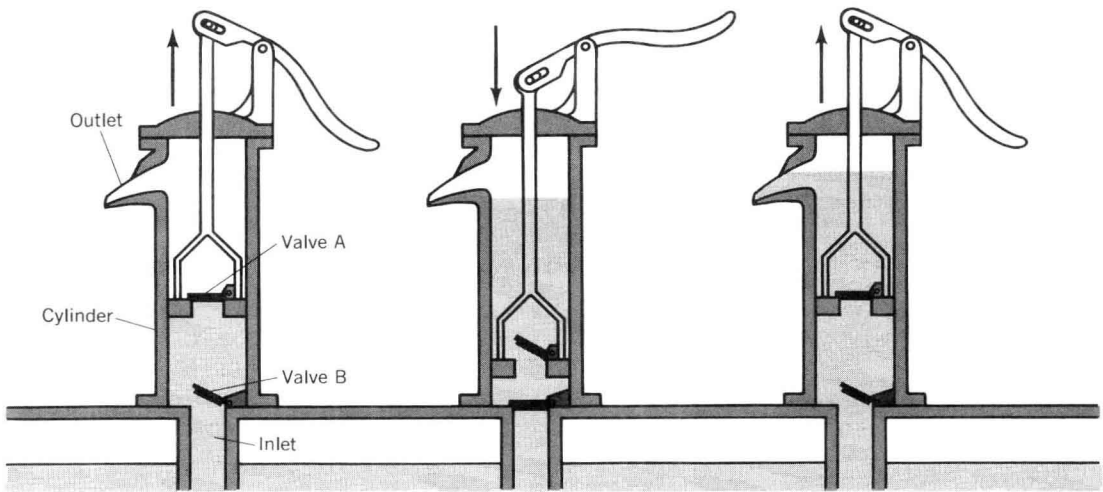


Fig. 1. Lift Pump. As the piston is raised, valve A closes and a partial vacuum is created beneath the piston. Water is drawn into the cylinder through valve B. When the piston is pushed down, valve B closes, valve A opens, and water passes through the piston into the upper part of the cylinder. When the piston is raised again, valve A closes and valve B opens. The water above the piston is lifted by the piston and flows out through the spout. At the same time water is drawn through valve B into the cylinder.

**PUMPS**, devices that move fluid substances from one place to another. The substance may be moved through pipelines, stored at a higher pressure, or raised to a higher elevation. Generally pumps are used to move liquids, but they may also move ore and coal when these are in the form of slurries—that is, fine particles that are suspended in water.

Some pumps move freshly made concrete and plaster, while others have been developed that can move a mixture of live sardines and water from a boat to the cannery. Most industrial plants use a large number and variety of pumps, which rank next to electric motors as the most widely used equipment in industry.

Pumps have a wide range of capacity, pressure, and operating depth. Pumps with capacities of 1 billion gallons (3.8 billion liters) per day are used in irrigating systems such as the Grand Coulee on the Columbia River. They can operate under pressures ranging from a fraction of a pound to more than 10,000 pounds per square inch (psi) (700 kg/sq cm). They may be used to deliver oil from wells 10,000 feet (3,048 meters) or more in depth.

#### TYPES OF PUMPS

Pumps are classified into two main categories—positive displacement pumps and turbomachinery pumps. The major difference between the two is the way in which energy is transferred to the fluid in order to move it.

**Positive Displacement Pumps.** The common principle of all positive displacement pumps is the development of pressure in the fluid being moved by the action of an element that moves a definite volume of fluid in a close-fitting housing.

All types of positive displacement pumps are self-pumping (that is, they do not need to be filled with fluid before pumping). The movement of fluid into this pump is often dependent upon atmospheric pressure. Fluid is caused to flow into the pump by the creation of a partial vacuum in the piston chamber. Atmospheric pressure can support a column of water no more than approximately 32 feet (10 meters). In practice, reciprocating pumps are rarely placed higher than 25 feet (7.5 meters) above water level.

The pumping rate is relatively constant as long as the speed of the driving mechanism is

#### PUMPS FOR HOME WATER SUPPLY

The appropriate pump for a home water supply depends on the depth of the well and the amount of water required. Pumps are manufactured for shallow wells or for deep wells, but there are many types within each category.

The most common shallow-well pump is a cylinder reciprocating pump that lifts water from the pump and forces it into a storage tank under pressure. The pressure is created by compressing air at the top of the storage tank. At sea level a shallow well pump of this kind can lift water only 25 feet. Jet pumps are also available for shallow wells.

Deep-well pumps are available in cylinder, jet, and submersible types. In a deep well the jet mechanism is submerged in the water. Some jet pumps can be used to a depth of several hundred feet. However, at depths over 90 feet, cylinder or submersible pumps are preferable. A submersible pump can be used at practically any depth. Usually the pump is a centrifugal pump, long and narrow in shape, attached to a long narrow motor. Both are located below the

water level within the pipe and can fit into wells as small as four inches in diameter. The submersible pump can handle large quantities of water from a deep well more economically than cylinder or jet pumps. It has a relatively high efficiency over a wide range of discharge pressures and is capable of delivering large quantities of water against high pressure. It has no pumping problems and is quiet in operation. However, the pump can be more easily damaged by sand or abrasives than the other pumps.

Uniform pressure for the home water supply is usually supplied by a pressure storage tank. Water from the well is pumped into the tank for storage so that the pump need not operate each time even small amounts of water are drawn from the supply. Most commonly the home storage tank is either a 42-gallon or 82-gallon tank. With a 42-gallon tank approximately 8 gallons of water can be drawn before the pump automatically starts. With an 80-gallon tank about 16 gallons can be drawn between each start and stop of the pump.

Fig. 2. Single-action Reciprocating Pump. During the suction stroke, as the piston moves to the left a partial vacuum is created and water enters the cylinder through valve A. On the delivery stroke the piston moves to the right, exerting pressure on the water in the cylinder. Valve A closes, and water is forced out of the cylinder, opening valve B. In the single-action pump, water is pumped only during the delivery stroke. No water is pumped during the suction stroke while the cylinder is filling with water.

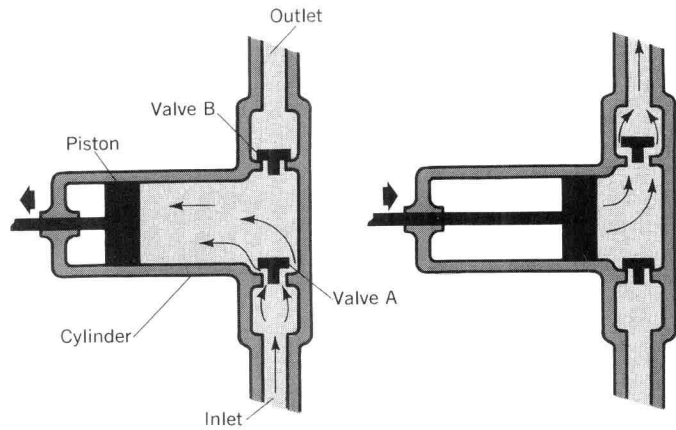
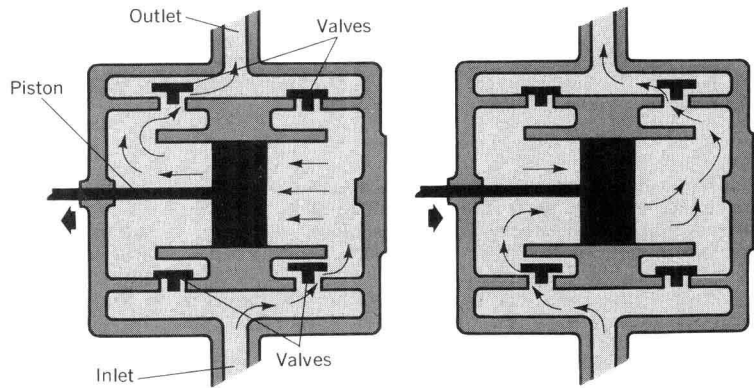


Fig. 3. Double-action Reciprocating Pump. Movement of the piston to the left produces a discharge stroke in the left-hand part of the pump and a suction stroke in the right-hand part of the pump. As the piston moves to the right, it produces a suction stroke in the left-hand portion and a discharge stroke in the right-hand portion. Fluid therefore moves in and out of the pump on each stroke of the piston.



fixed. The maximum pressure that can be developed is limited only by the power of the driving unit and the strength of the pump housing. The moving element may be a piston, a plunger, a vane, or a gear. When the moving element moves back and forth the pump is known as a reciprocating pump. When the moving element moves in a circular motion the pump is known as a rotary pump.

**Reciprocating Pumps.** All reciprocating pumps operate by the movement of a piston or a plunger within a cylinder. The fluid is moved either as a result of atmospheric pressure, pressure exerted by the piston, or a combination of the two. Generally, a reciprocating pump operates at relatively low speed and is used for relatively high pressures and small volume flows per unit of time. Some reciprocating pumps are single-acting, delivering liquid only when the piston moves in one direction. Others are double-acting, delivering liquid during each stroke of the piston.

One of the simplest reciprocating pumps is the hand-operated lift pump, whose operation is shown in Fig. 1. A single-action reciprocating pump operates very similarly to the lift pump, whose action is shown in Fig. 2.

The double-action reciprocating pump, as illustrated in Fig. 3, is in effect two single-action pumps joined together. In a double-action pump water is pumped continuously because the piston is moving in a delivery stroke regardless of its direction.

**Rotary Pumps.** Rotary pumps employ various forms of rotating elements moving within a close-fitting housing, in contrast to the linear displace-

ment of the reciprocating pumps. The discharge from rotary pumps is steady rather than pulsating due to the high speed of operation in comparison with the piston or plunger pump. Rotary pumps are used to handle a wide range of liquids from gasoline and water to heavy petroleum products, paint, and molasses. This type of pump is not used for liquids containing abrasives or for certain corrosives because of the rapid wear on the closely fitted moving parts of the pump.

All pumps of this class depend on close clearances to prevent excessive liquid leakage from the high to low pressure sides. The most widely used rotary pumps can be grouped into four types describing the rotating elements: cam or lobe, screw, gear, and vane. Diagrams illustrating these types are shown in Fig. 4.

In the cam or lobe type (Fig. 4a), two counter-rotating impellers, each having three lobes, trap the fluid between each lobe and the case at the suction entrance and deliver it to the discharge side. Lobe pumps are suitable for the movement of large volumes of fluids at moderate pressures. Perhaps the simplest and most widely used rotary pump is the gear type shown in Fig. 4b. The operation is similar to that of the lobe pump, with the gear teeth replacing the lobes. The spur gear pumps are primarily intended for relatively slow-speed operation up to 600 rpm for pumping oils and other viscous fluids having lubricating qualities. The vane type of pump (Fig. 4c) has a rotating member eccentrically located with regard to the casing and is provided with a number of spring-loaded radial vanes that slide on the casing. Fluid is trapped

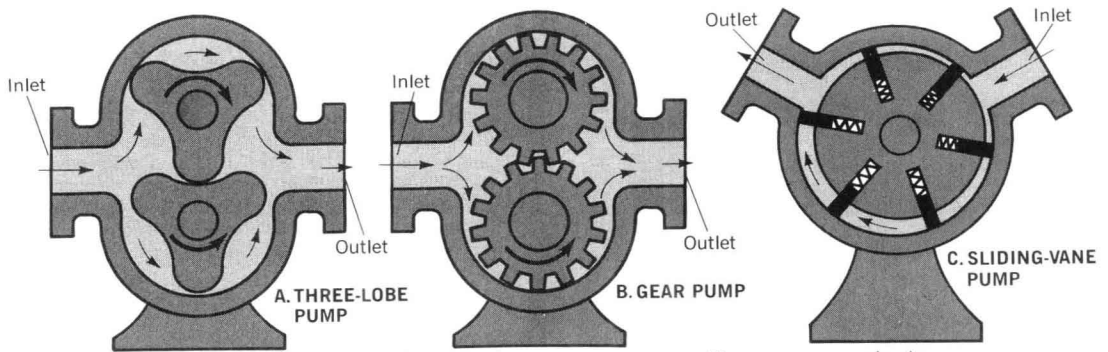


Fig. 4. Rotary Pump. The three most common rotary pumps. These pumps are simply constructed, do not contain valves, and produce a nonpulsating discharge.

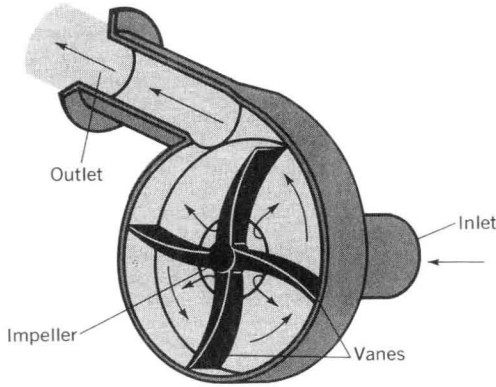


Fig. 5. Centrifugal Pump. The simplest centrifugal pump has a spinning impeller that moves fluid by means of centrifugal force.

between vanes and squeezed out at the discharge side as the eccentricity of the case reduces the space between vanes to zero.

In many applications rotary pumps have replaced reciprocating pumps due to their smaller size, nonpulsating discharge, simpler construction, and absence of suction and discharge valves. Pressures of 2,000 psi are readily obtainable in rotary pumps and discharge rates of 35,000 gallons (130,000 liters) per minute have been reached under low pressures.

Rotary pumps are self-priming and are capable of operating against a suction lift up to 25 feet. They are of particular importance in the food-processing industry due to the ease with which they can be taken apart for cleaning.

**Turbomachinery Pumps.** Pumps in this class move fluid by exerting hydrodynamic forces on the fluid by means of a propeller or similar element. Turbomachinery pumps often are classified in terms of the direction in which fluid is pumped. In axial-flow pumps the fluid moves parallel to the axis. In radial-flow pumps the fluid moves away from the axis of rotation. The primary elements of all turbo pumps are the rotating vanes or blades, called the impeller, and the stationary casing, or pump housing.

**Centrifugal Pumps.** In a centrifugal pump, centrifugal force is applied to the fluid by a propeller. A simple example can illustrate how such force produces a pumping action. If water in a cylinder is stirred vigorously, centrifugal force drives the water away from the center of the cylinder and up its sides. If the stirring is

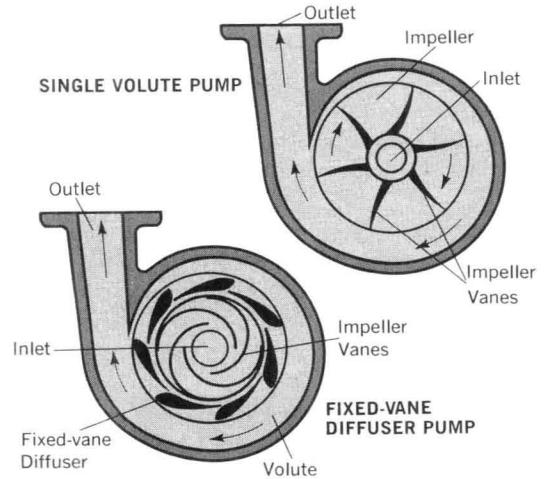


Fig. 6. Single Volute Pump and Fixed-vane Diffuser Pump. In both pumps the fluid leaving the impeller moves through an expanding spiral casing, increasing the pressure of the fluid.

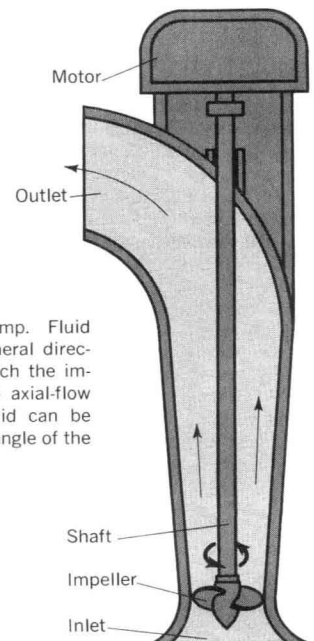


Fig. 7. Axial-flow Pump. Fluid moves in the same general direction as the axis on which the impeller rotates. In some axial-flow pumps the flow of fluid can be varied by changing the angle of the impeller blades.

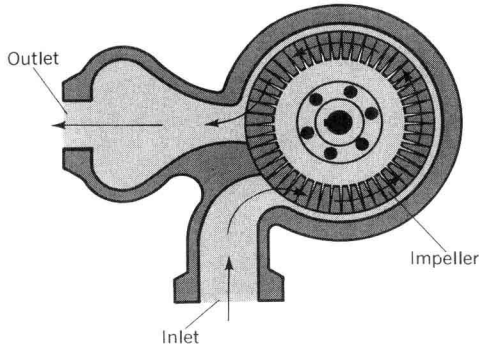


Fig. 8. Peripheral Pump. The peripheral pump develops pressure in the pump by recirculating the fluid through a sequence of vanes.

sufficiently fast, the water will rise up the side of the cylinder and over the edge. Water is thus pumped from the bottom of the cylinder out over the edge. If more water were introduced at the bottom of the cylinder, a flow would be established from the bottom up the walls of the cylinder and over the edge.

If the open cylinder is replaced by a closed one completely filled with a liquid and the liquid is rotated by vanes, pressure from the center to the outer wall of the cylinder will increase. A pump of this description, called the Massachusetts Pump, was developed in Boston in 1818. It consisted of four straight radial vanes rotating in a housing similar to that shown in Fig. 5. Curved vanes were introduced as early as 1839 and increased the pumps' efficiency by almost 300%. Early centrifugal pumps were driven by steam engines and operated at slow speeds. The development of the electric motor made it possible to drive centrifugal pumps at higher speeds for greater efficiency.

Centrifugal pumps are radial-flow machines. Fig. 6 shows the two basic forms of the radial

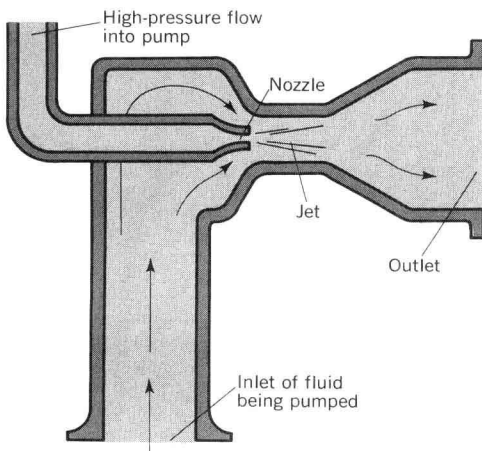


Fig. 9. Jet Pump. High-pressure fluid entering the pump forms a jet as it goes through the nozzle and causes the fluid to be pumped in the direction of the jet.

pump, the volute type and the diffuser type. In both types fluid enters along the axis of rotation, turns at a right angle, and enters the rotating impeller radially. In the volute pump, the fluid leaving the impeller is collected in a progressively expanding spiral casing in which the velocity is gradually reduced with a corresponding increase of pressure. The increase is accomplished more efficiently by installing a series of fixed-guide vanes surrounding the impeller as in the diffuser pump. Despite the slightly greater efficiency, the volute type is more common because of lower cost and simpler construction.

The head developed by a radial-flow pump is dependent upon the size of the impeller and the speed at which it rotates. However, increasing the speed increases the stress on the impeller material. It is usually impractical to produce heads greater than 400 feet (122 meters) with a single-stage pump. Higher heads may be produced by operating two or more pumps in series, with the discharge from the first pump connected to the suction or inlet of the second pump. Pumps of this type are known as multistage pumps. Deep-well centrifugal pumps having 300 or more stages have been used at the bottom of oil wells extending more than 8,000 feet (2,440 meters) into the ground.

**Propeller and Mixed-Flow Pumps.** All types of propeller pumps are axial-flow machines, and the rotating element consists of a few relatively flat blades whose cross section resembles an airfoil. The pumping action depends almost entirely upon the lift developed by the rotating blades. Although the head developed is usually less than 40 feet (12 meters), the amount of liquid that can be handled may be extremely large. The runner usually consists of from two to six blades rotating within a cylindrical casing.

Axial-flow pumps are frequently arranged vertically so that the impeller is submerged in the sump or source from which the liquid is to be pumped. Fig. 7 shows a vertical axial-flow pump of the type frequently employed in irrigation and flood-control service. In applications in which considerable variations in either head or flow capacity are necessary, the range of peak efficiency operation can be extended by constructing the impeller so that the angle of the vanes can be adjusted to meet the changing operating requirements. In this type of pump the blade-adjustment mechanism is in the hub of the runner. Each blade is connected by levers to an operating shaft in the center of the motor shaft. The blade angle may be changed either manually or automatically by means of a device that senses changes in the pump water level.

**Mixed-Flow Pumps.** Mixed-flow impellers are in the transition region between the extremes of the radial and axial types described above. In a mixed-flow pump the head is developed partly by centrifugal force and partly by the lifting action of the vanes. The heads developed are higher than the propeller pump and less than the radial. Mixed-flow pumps may be of multistage design, while those of the axial type are commonly single stage.

**Peripheral Pumps.** A pump with an impeller that develops heads by recirculating the liquid through a sequence of vanes is known as a peripheral pump. Pumps of this type are classified with the centrifugal pumps even though the fundamental principle of operation is quite different from that of the radial- or axial-flow

pump. They are also known by several other names, such as vortex, regenerative, and turbine pumps. The impeller of the peripheral pump is usually a solid, one-piece disc with closely spaced vanes formed on both sides at the periphery. The liquid enters the impeller as shown in Fig. 8, in such a way that it is directed toward the roots of the vanes. Due to the centrifugal forces developed by the rotation, the liquid leaves the vane at the periphery and is directed toward the root of the next vane by the casing. In this manner the fluid is carried toward the discharge side in a helical path. As it circulates through each successive vane, its pressure is increased in much the same way as in a multistage radial pump. Peripheral pumps combine the flexible operating characteristics of radial-flow pumps with some positive-displacement pump features and are used mostly in low-capacity, high-head service.

**Jet Pumps.** Jet pumps are frequently used in wells for small capacities and lifts not exceeding 250 feet (76 meters). The jet pump makes use of the principle that a jet of fluid will entrain surrounding fluid and cause it to flow in the direction of the expanding jet. A widely used arrangement for farm water-supply systems consists of a combination of a centrifugal pump and a jet pump as shown in Fig. 9, the centrifugal pump furnishing the driving head and water to create the jet. Because of the entrainment principle, more water flows up the vertical pipe than is delivered by the jet. Among the advantages of the centrifugal-jet pump combination are the accessible location of the centrifugal pump and motor on the ground surface and the fact that there are no moving parts of the pump submerged in the well.

**Special Pumps.** Some pumps use compressed air as a means of lifting water. An airlift pump generally contains two pipes—a discharge pipe and an air pipe. The end of the discharge pipe is submerged deeply in the water, and the air pipe introduces air at the base of the discharge pipe. The resulting mixture of water and air bubbles in the discharge pipe is less dense than water alone and is raised to the surface by the pressure of the water at the base of the discharge pipe. Pumps of this sort are used in pumping oil, brine, and water from wells as deep as 600 feet (183 meters). Airlift pumps are also frequently used for the purpose of circulating water in a home aquarium.

Another special type of pump is the electro-magnetic pump, which can be used for pumping metals in a liquid state. Liquid sodium and potassium alloys are used as heat-transfer units in atomic-power plants. Since these metals are extremely dangerous, it is too risky to move them by mechanical pumps, which might leak. Electro-magnetic pumps move liquid metals through seamless pipes by means of the "motor" principle—that is, a conductor in a magnetic field, carrying a current that flows at right angles to the direction of the field, has a force exerted on it. The fluid is the conductor, and the force developed in the fluid manifests itself as pressure, thereby causing the fluid to flow.

See also VACUUM PUMPS.

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**Further Reading:** Black, Perry O., *Pumps*, 3d ed. (McMillan 1977); Karassik, Igor, and Krutzsch, William C., *Pump Handbook* (McGraw 1975).

**PUN**, a form of humor depending on wordplay, using a word having two meanings or two words with different spellings that have the same pronunciation. The first instance is illustrated by: I'll start a bakery if I can raise the dough; the second by: I hate school because of the principal of the thing. The similarities between the words need not be exact so long as they are suggestive—for example, Dorothy Parker's pun, "A girl's best friend is her mutter."

Puns are often held in low esteem, as indicated by the American humorist Arthur ("Bugs") Baer's line: "It was so quiet, you could hear a pun drop." Oscar Wilde used a pun in the title of his play *The Importance of Being Earnest*, as did Charles Addams, the cartoonist of the macabre, for his collection *Addams and Evil*. A pun of serious intent is Shakespeare's "Ask for me tomorrow and you shall find me a grave man," from *Romeo and Juliet*.

**PUNCH**, a humorous British magazine, first published in 1841. Its inspiration was the French magazine *Charivari*, and the full title is *Punch, or the London Charivari*. Its first editors, the beginning of a long line of distinguished journalists, were Henry Mayhew, Mark Lemon, and Joseph Stirling Coyne. From the beginning, *Punch* featured humorous and satirical articles, poems, and cartoons. It has generally been on the liberal side of issues (it began as a Radical paper), aiming its most telling barbs at the government, clergy, and other members of the Establishment.

*Punch* has had a distinguished roster of authors and illustrators, including Thackeray, Thomas Hood, John Leech, Sir John Tenniel, and George du Maurier. Its famous cover, used from 1849 to 1956, was drawn by Richard Doyle.

The famous cover of *Punch*, by Richard Doyle, showing Punch and his dog Toby, appeared from 1849 to 1956.

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EWING GALLOWAY

Punch and Judy perform in their traditional show with a plot that has hardly changed since the 17th century.

**PUNCH AND JUDY**, the principal characters in the English puppet show named for them. The shows in their present form date from about 1800, but similar puppet plays were given in England by Italian companies in the 17th century. When Charles II returned from the Continent in 1660, puppeteers in his retinue introduced the French *Polichinelle* to the English public.

Punch (*Polichinelle* became "Punchinello" and finally "Punch") is a grotesque hunchback with a hooked nose and chin and a protruding belly. His wife, Judy (originally "Joan" or "Joanie"), is ugly and shrewish. In the traditional story, which in spite of Punch's ancestry is probably English in origin, Punch is left to mind the baby while Judy is shopping. The baby begins to cry, Punch is unable to soothe it, and when Punch beats the baby it screams more loudly. In desperation Punch finally throws the baby out the window. When Judy returns and discovers what has happened, she furiously attacks Punch with a stick. Punch seizes the stick and beats Judy senseless, finally killing her.

From this point on the story varies. Punch may encounter such characters as the Doctor, the Negro, and the Beadle, most of whom he beats and kills. He may be captured and taken to be hanged, but tricks the hangman, Jack Ketch, into putting his own head in the noose.

Punch sometimes has a friendly companion, Joey the Clown. A live dog, Toby, may be introduced. Occasionally a crocodile or alligator is one of Punch's enemies. Punch sometimes does battle with the Devil and wins. Thus Punch triumphs over all his adversaries.

Punch and Judy probably began as marionettes. But marionette theaters are difficult to transport, and by the end of the 18th century the couple had become hand puppets, whose theater could be carried on the puppeteer's back.

See also PUPPET.

**PUNCHED-CARD SYSTEM**, an operation in which punched cards are used to feed data into a computer or to process such data rapidly. The system employs a standard-size punched card that has 80 vertical columns with 12 punching positions in each column. Information is carried in coded form on the card by means of small rectangular holes punched at fixed positions in each column. One, two, or three punches are used to represent a number or a single character. The cards are automatically fed from a hopper to a card-reading machine. This machine senses the pattern of holes in each card and translates them into electrical signals for the computer.

One type of reading station has rows of metallic brushes, one for each column of the card. The brushes pass through the holes and complete an electric circuit for each hole. In a photoelectric-type reader, a light shines through the holes and activates photocells that convert the data into electrical signals.

**PUNCTUATION**, the use of certain conventional marks to lessen the confusion and ambiguity that would result if words, phrases, and sentences were written as an unbroken series. Punctuation also includes the use of marks in writing abbreviations, dates, geographical names, footnotes, and other brief formal notations. The marks themselves, and their ensemble in any given text, can also be called "punctuation."

In view of their purposes, the spaces between words, capitalization, quotation marks and italics, and such arrangements as paragraphing can also be considered punctuation, although in the last instance punctuation clearly merges with logic.

From either the linguistic, the historical, or the commonsense point of view, punctuation has two chief functions: (1) to give a partial representation of the structural signals conveyed in speech by pause, stress, and pitch; and (2) to indicate grammatical structure. The question mark, the exclamation point, and the comma, for instance, stand for the patterns of rising, falling, or sustained pitch, of heightened or lessened stress, and of pause by which we signal questions, ejaculations, and the limits of separate constructions in speech. This use of punctuation is called "elocutionary," "intonational," or "oral."

Punctuation that indicates grammatical structure may be illustrated by functions of the semicolon and period. When written text is read aloud, the ear cannot distinguish between independent clauses that are connected by the semicolon to form a compound sentence or are separated by the period-plus-capital-letter to make two sentences. This use of punctuation, called "grammatical" or "syntactical," has more to do with writing style than with speaking.

**English Punctuation.** English, like other European languages, has certain punctuation symbols with generally standardized functions. The following marks are those most frequently used.

**The Period**, called the "full stop" in British usage, indicates the end of a declarative or imperative sentence (She sings well. Go upstairs.). It is also used after or within many abbreviations (Dr. Jones; W. Broadway; N. J.).

**The Question Mark**, or interrogation point, is used after a question, either one that solicits an answer (Where am I?) or one that expresses the speaker's attitude (Will wonders never cease?). When a question is quoted, the question mark is used after a direct quotation (I asked, "Are you

serious?") but not after an indirect quotation (I asked if he were serious.). Certain routine or courteous requests need not end with the question mark (Will you please send me a catalogue.).

**The Exclamation Point** follows an emphatic, loud, or highly charged statement (Help! He's alive! Hurry!). It may also be used in running text as a comment on the truth or correctness of an assertion: Savonarola was praised for the kindness (!) of his judgments.

**The Colon** is now used chiefly to indicate that an illustration, amplification, or analysis immediately follows a main clause (I have three aims: to be brief, to be clear, and to be helpful.). It is also used as a purely graphic device to set off the speaker from his speech in dialogue (Brutus: Follow me then.) and in certain special constructions, such as a biblical citation (Luke 8:16), elements of time (6:45 P. M.), and the salutation of a business letter (Dear Mr. Smith:).

**The Comma** in a sense is the least prominent punctuation mark but the most difficult to use. Authorities typically list 30 to 50 or more rules, each with exceptions, that govern its application. It is by far the mark that is most amenable to the elocutionary or oral method of punctuating—for example, if one speaks a sentence to oneself, with the normal intonational signals to render its meaning, a nonterminal pause preceded by a distinct rise in pitch usually marks where to place a comma.

Customary uses of the comma are: (1) between the clauses of a compound sentence joined by a conjunction (I could not go, although I had the money.); (2) to set off a modifying construction when it is not part of the identifying criteria of the thing modified—that is, when it is non-restrictive (Susan, who has red hair, is here.); (3) with most appositives (Mr. Smith, the president, spoke.); (4) between items and usually before the "and" of the last item in a series (apples, oranges, and bananas); and (5) to point thousands and larger numerals (1,000), to set off the year from other figures in dates (July 4, 1976), to separate geographical entities from larger units of which they are a part (Butte, Montana; the Rhineland, Germany), and to end the salutation of an informal letter (Dear Helen,).

**The Semicolon** connects independent clauses to make compound sentences (He was not able to go; the meeting took place without him.). It is also used to separate the items of a series when commas are used within the items (We visited Kalamazoo, Mich.; Kansas City, Mo.; and Boulder, Colo.).

**The Apostrophe** is used to indicate where letters or numbers have been omitted (it's; 'twas; '43), to mark the possessive forms of nouns (the dog's tail; Paris' streets; the teachers' salaries), and to set off the -s of the plural of figures and of special and artificial nouns (during the 1500's; 50 RPM's).

**The Hyphen** joins words to form compounds (all-weather; self-reliant; men-at-arms) and shows that a word at the end of a printed or written line continues on the next (The capital is Wash-).

**The Dash** is used to set off material that seems to come after a break in the thought of the running text, either as an interpolation, a kind of second thought, or a final, more or less summary statement (He was—let it be said emphatically—a genius. There was no way to help them—no

way that made sense. Thinking clearly, organizing, and writing succinctly—these make a good report.). In addition, the dash is used to show a span (8–10 pounds; 1900–1905).

**Quotation Marks** enclose material that is quoted directly and word for word ("Life is real! Life is earnest!" Longfellow wrote.). They are also used in running text to set off material that is a brief allusive quotation (We were well into "the cruelest month.") or is a special kind of vocabulary, such as slang, that the writer does not wish to be taken as his normal phraseology (I saw "the fuzz" approaching). Quotation marks also are sometimes used to set off certain titles and names ("The Wild Swans at Coole"; the "Sultan of Swat"). A quotation within a quotation is enclosed by single quotation marks (He said, "General Sherman declared 'War is hell.'").

**Parentheses** set off interpolated material that is regarded as dispensable but still useful or does not fit with close logic into the flow of text but is relevant nevertheless. The parentheses in this article illustrate such uses.

**History of European Punctuation.** The separation of texts into words was an early and not uncommon practice in ancient Greek writing. In the early 3d century B. C. the grammarian Alexander of Byzantium elaborated a system of points that did the work of the period, semicolon, and comma. However, marks to indicate grammatical constructions and paragraphs were not regularly and consistently used in Greek and Latin texts until the early Middle Ages, about the same time that they were being adopted for the newly written European vernaculars.

After the invention of printing in the mid-15th century, European punctuation rapidly became standardized, developing very nearly the marks used today. The Gutenberg Bible of 1455, for instance, uses periods, colons, and commas (represented by a point printed above the line). The words are separated by spaces, and each sentence begins with a capital letter.

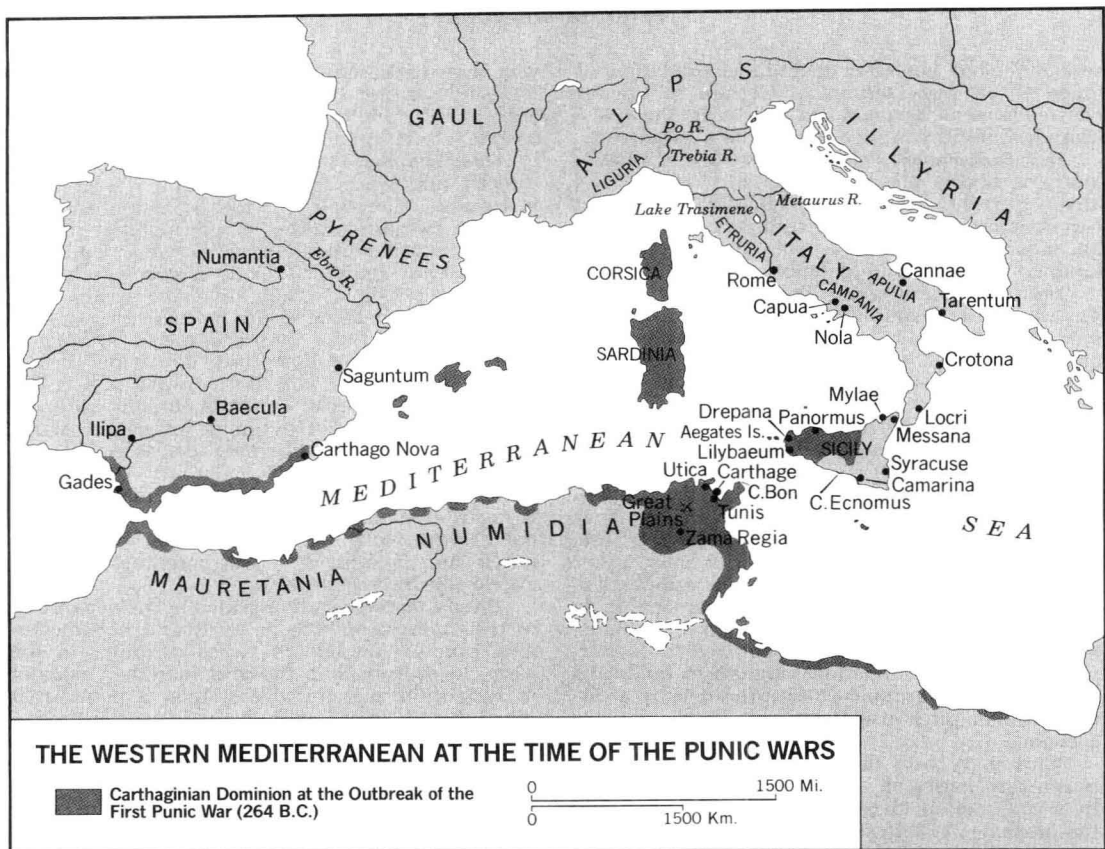
At the end of the 15th century, Aldus Manutius of Venice, the great printer of humanistic texts, used the modern forms of the comma, semicolon, colon, period, and question mark. The exclamation point, apostrophe, quotation mark, and dash were added to the general European system in the 17th and 18th centuries to complete the modern set of marks. Each of the major European languages uses a slightly individual set of marks, but the basic system is that developed by Manutius.

In English punctuation, printers' preference for the elocutionary style was gradually replaced in the early 18th century by a determined advocacy of the grammatical style. This dictated, for example, a comma to set off from the subject and verb a clause used as an object (He said, that he wished to go.). This strikes the modern reader as overpunctuation, and indeed the tendency is toward the less doctrinaire view that punctuation is inescapably and legitimately both elocutionary and grammatical.

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**Further Reading:** *Chicago Manual of Style*, 13th rev. ed. (Univ. of Chicago Press 1982); Paxton, William C., *Mentor Guide to Punctuation* (New Am. Lib. 1986); Roberts, William, *The Writer's Companion: A Short Handbook* (Little 1984).

PUNE. See POONA.



**PUNIC WARS**, pū'nik, three conflicts between ancient Rome and Carthage. The wars determined the control of the entire Mediterranean and ultimately of the entire Mediterranean area.

**The First Punic War (264–242 B. C.).** Before the first war, Carthage, an early Phoenician settlement on the coast of modern Tunisia, had controlled a maritime empire in the western Mediterranean for about three centuries. Carthage dominated the coasts of North Africa, Spain, Sardinia, and western Sicily, its wealth and power deriving in large part from seaborne trade. Rome, on the other hand, had slowly advanced as a land-based power to a dominating position in the Italian peninsula. Treaty relationships existed early between Rome and Carthage, but there was little contact and no evident antagonism because Rome had few trading interests and Carthage had ceased to be expansive.

The cause of the First Punic War was an adventurist move by Rome—led by a landed aristocracy of an increasingly militarist outlook—into affairs in Sicily, which had been divided between Carthaginians and Greeks. When a faction in the strategic city of Messana appealed to Rome rather than Carthage for help, the Romans accepted, calculating wrongly that Carthage would not react. The mercantile oligarchy in Carthage apparently regarded the move as the first step toward Roman expansion outside Italy and hence a serious threat.

The ensuing war was marked by greater casualties than any earlier known war, largely because of losses at sea. From 264 to 261 the Romans tried to drive the Carthaginians from Sicily, relying on their traditional strength in infantry, but failed to take many fortified towns.

In 261 they turned to the sea and enlarged their fleet to challenge Carthage in spite of their lack of naval experience. They had, however, the assistance of Italian states that were better equipped. Roman naval tactics were to try to neutralize superior Carthaginian seamanship by boarding the enemy ships wherever possible, so that the fighting qualities of the Roman marines could be effective.

In 260 in a battle off Mylae, near Messana, a Roman fleet of 143 ships, under the consul Gaius Duilius, defeated a Carthaginian force of 130 ships, for Rome's first naval victory. The Romans captured 31 ships and inflicted losses of 10,000 men. This battle, however, was not decisive, and after further inconclusive engagements at sea and in Sicily, Rome further enlarged its fleet and launched an invasion of North Africa. A Carthaginian force sent to intercept was defeated off Cape Ecnomus, Sicily, losing 94 ships, and the expedition under the consul Marcus Atilius Regulus landed at Cape Hermaeum (Cap Bon). It advanced as far as Tunis, near the city of Carthage, causing great devastation. The arrival in Carthage of a force of mercenary soldiers under the Spartan Xanthippus restored Carthaginian confidence, and in 255 the invading force was defeated and destroyed. A Roman fleet sent to rescue the survivors captured 114 Carthaginian ships off Cape Hermaeum, but on the return voyage it was annihilated in a storm off Camarina, Sicily, with the loss of 25,000 soldiers and 70,000 rowers. Yet another fleet was built. This time the Carthaginians were unable to prevent the fall of a number of their Sicilian towns, including Panormus (Palermo). By 250, Carthage had no more than a foothold at Lilybaeum and

Drepana. In 249 the consul Publius Claudius Pulcher attacked Drepana but lost 93 ships, and in 248 a Roman fleet was wrecked in a storm, again off Camarina.

The number of Roman citizens had apparently decreased by some 17% over the previous 20 years, and many of Rome's dependent Italian states no doubt had suffered as much. Carthage had sustained smaller population losses, because of its heavy reliance on mercenaries, but its financial exhaustion was complete. Thus for some years military operations were on a reduced scale, and while Hamilcar Barca successfully defended Lilybaeum and Drepana, Carthage allowed most of its fleet to go out of commission. In 242 a new Roman fleet under the consul Gaius Lutatius Catulus defeated the remaining Carthaginian ships off the Aegates Islands. Hamilcar Barca could no longer be kept supplied, and he negotiated peace terms. Carthage had to surrender Sicily and pay an indemnity. The terms were far less severe than the Romans usually imposed and testify to their own war-weariness.

**The Second Punic War (218–202 B.C.).** The Roman seizure of Sardinia in 237 prevented any chance of a reconciliation with Carthage. The loss of Sardinia after Sicily forced Carthage to give attention to Spain. Previously, only the Spanish coastal areas had been dominated, but after 237, Hamilcar Barca, followed by his son-in-law Hasdrubal and his son Hannibal, achieved direct control over more than half the Iberian peninsula. Not only did this produce a vast revenue from the Spanish silver mines, but an army said to have numbered 50,000 men was raised from the warlike tribesmen. Leadership of the venture went to Hannibal, then aged 25, in 221. Roman tradition held that he had been brought up to fight a war of revenge and was responsible for the Second Punic War. More probably the Romans tried to warn Carthage against further expansion in Spain and were ignored.

In 219, Hannibal laid siege to Saguntum, a Roman ally, and when a Roman ultimatum was rejected he made his famous crossing of the Alps in 218 and descended into Italy. His strategy was based on the correct conviction that Rome could only be defeated on land and in Italy, and he believed his new army could do this. At the Trebia River (218), Lake Trasimene (217), and above all at Cannae (216), massive defeats were inflicted on the Roman legions in the field.

Hannibal's psychological domination was complete, and the Romans were forced to adopt the "Fabian tactic," advocated by Quintus Fabius Maximus, of avoiding pitched battle, however provoked. Hannibal also won the allegiance of a number of Rome's subjects in Italy, especially in Campania and Samnium, although the majority remained loyal to Rome. This was crucial to the final result of the war since the bulk of Italy's manpower resources remained at Rome's disposal. Furthermore, after its lack of naval success in the First Punic War, Carthage had placed less emphasis on its fleet. Consequently, apart from the difficulties of keeping Hannibal supplied, it could not prevent Rome from sending a force to Spain to block reinforcements from reaching him. In 215, Hannibal made an alliance with Philip V of Macedonia, but the effect was limited because of Roman naval supremacy.

In 214 an anti-Roman coup took place at Syracuse, an ally of Rome, but the city was besieged and taken by storm in 211. In the latter

year Rome took and destroyed Capua, the most important defector among its Italian subjects. Hannibal had insufficient men either to prevent this sort of major operation or, increasingly, to take Italian cities by storm. In 210, Publius Cornelius Scipio (Scipio Africanus Major) was sent to Spain as proconsul although only 26 years old. His brilliant and dynamic generalship came to rival Hannibal's. Scipio seized the main Carthaginian base at Carthago Nova (Cartagena) and in a series of campaigns defeated the Carthaginians at Baecula in 208 and Ilipa (near Seville) in 206, clearing them from Spain.

In Italy, Hannibal's position was gradually confined to the far south of the peninsula as difficulties of supply and reinforcement increased, above all when his brother Hasdrubal Barca, who had led an army from Spain in a march as epic as Hannibal's, was defeated and killed in 206 at the Metaurus River in northern Italy. At Rome, Scipio won a policy victory for an invasion of Africa rather than a campaign in Italy to drive Hannibal out. The army landed in 204, and after victories at Utica and the "Great Plains" in 203, Scipio forced Carthage to sue for terms. Hannibal was recalled from Italy, and the truce was broken by revived Carthaginian confidence. But Hannibal was finally defeated by Scipio at the Battle of Zama Regia in 202.

The peace terms now imposed on Carthage included the surrender of all possessions outside the northeastern portion of Tunisia, the surrender of its fleet and a prohibition against building a new one, a vast indemnity, and an agreement not to make war without Rome's consent. Thus Carthage became in effect a client state of Rome. A wider result was to make Rome supreme in the western Mediterranean and potentially so in the eastern part as well.

**The Third Punic War (149–146 B.C.).** Rome asserted supremacy over the major remaining powers of the Mediterranean between 202 and 167 B.C. In North Africa, Rome tended to support its major ally, the Numidian chieftain Masinissa, whenever Masinissa made claims on Carthaginian territory. Carthage inevitably gave way whenever Roman pressure was exerted, and it regained a measure of prosperity. But Roman policy became increasingly domineering. The advice of Cato the Elder, who called constantly for the destruction of Carthage, was increasingly supported, though the claim that Carthage's prosperity threatened Roman security was irrational.

On a flimsy pretext, the Carthaginians were ordered to leave their city and settle at least 10 miles (16 km) from the coast, which would have led to their economic ruin. The ultimatum was rejected, and though Carthage sustained a three-year siege by the Romans under Scipio Aemilianus, the final result was inevitable. The city of Carthage was totally destroyed in 146 B.C. and the site ritually cursed, a gesture testifying to the fact that Carthage had been Rome's most formidable enemy.

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**Further Reading:** Astin, Alan A., *Scipio Aemilianus* (Oxford 1967); Caven, Brian, *The Punic Wars* (St. Martin's Press 1980); Pedley, John, ed., *New Light on Ancient Carthage* (Univ. of Mich. Press 1980); Warmington, Brian H., *Carthage* (Praeger 1960).

**PUNISHMENT.** See CAPITAL PUNISHMENT; CORPORAL PUNISHMENT; CRUEL AND UNUSUAL PUNISHMENT; and the Index entry *Punishment*.

**PUNJAB**, pən-jäb', a region in northeastern Pakistan and northwestern India. The region extends between the Indus River on the west, in Pakistan, and the Yamuna (Jumna) River on the east, in India. The Himalaya and associated mountains rise to its north, and the Thar and other deserts of Sind and Rajasthan lie to its south.

**The Land.** The Punjab is a large alluvial plain formed by the Indus River and its main tributaries—the Jhelum, Chenab, Ravi, Beas, and Sutlej. These five tributaries give the region its name (*panj*, "five"; *ab*, "waters"). They flow southwestward in almost parallel but converging courses and join to form the Panjnad, which flows into the Indus in the southwestern Punjab. The lands between the rivers, known as *doabs*, are mostly low lying and monotonously flat.

Most of the Punjab has a semiarid or arid climate, with cool winters and hot summers. Winter frosts are common in the northern sections. The average annual precipitation declines from 25 inches (635 mm) in the east to 5 inches (125 mm) in the west, the heaviest occurring in the foothills of the north. Most rainfall comes during the summer monsoon season (about July 1 to September 15), but the northern and central Punjab also receive some cyclonic rain in the winter. Precipitation is unreliable, with drought common and severe flooding in some years.

The Punjab's outstanding natural resources are its relatively fertile alluvial soils and its large rivers, the latter bringing waters from the northern mountains to irrigate the plains. Small supplies of petroleum and coal and reserves of limestone, gypsum, rock salt, bauxite, and China clay are present.

**History.** The Punjab was a prominent part of the Indus Valley Civilization, or Harappa Culture, which flourished between 2500 and 1800 B. C. This civilization, the earliest in India, had more than 100 cities and towns and an advanced system of irrigation agriculture.

Indo-European peoples entered the region from the northwest about 1200 B. C. The Persian Empire of Darius (reigned 521–486 B. C.) included the Punjab, and Alexander the Great campaigned there in 326 B. C. The Punjab was part of the Mauryan Empire (about 324 to 184 B. C.), but afterward it was generally under foreign rule until much of it came within the Gupta Empire (320 to the mid-6th century).

The long period of Muslim control began in the early 11th century after Turko-Afghans under Mahmud of Ghazni defeated the Hindu king Jaipal in 1001. Ghaznavid rulers held the region until 1186, when the Afghan conqueror Muhammad Ghuri wrested it from them. His lieutenant Qutb-ud-Din Aibak founded the Delhi Sultanate (1206–1526), which included the Punjab. Babur, a Central Asian Muslim, defeated the Delhi Sultanate and founded the Mughul (Mogul) Empire, which eventually ruled most of India. With the decline of the Mughuls after 1707, the Sikhs became the dominant Punjab power and established a kingdom under Ranjit Singh (reigned 1801–1839). After his death the British annexed the Punjab in 1849.

In 1947 the British Indian province of Punjab was partitioned between newly independent India and Pakistan. India received the Hindu and Sikh majority areas in the east, and Pakistan the Muslim majority areas in the west. Most of the region's 34 princely states joined India. The partition left a 35% Muslim minority in Indian

Punjab and a 25% Hindu and Sikh minority in Pakistan Punjab. Chaos, riots, and fear uprooted people from their ancestral homes. Hundreds of thousands were killed, and 9 million migrated.

After partition, the eastern part of the former Punjab province became a state of India. Twenty-one small Punjab princely states in the northern foothills were joined to form a separate Indian state, Himachal Pradesh, which later added Bilaspur, another Punjab princely state. Eight larger princely states formed into the Patiala and East Punjab States Union (PEPSU), which was merged into Punjab state in 1956.

The majority language of the eastern part of the state was not Panjabi but Hindi. In 1966, in response to Sikh demands for a separate Panjabi-speaking state, the Hindi-speaking sections were organized as the new state of Haryana.

The western part of the former British Indian Punjab became a province of Pakistan. The province was abolished in 1955 but recreated in 1970, this time including the former princely state of Bahawalpur.

**Punjab State (India).** The state has an area of 19,422 square miles (50,303 sq km) and in 1975 had an estimated population of 14,676,000. The capital city is Chandigarh, shared with Haryana state. The largest city, Amritsar, is the center of Sikh culture and religion.

About three fourths of the population is rural. Agriculture is the main economic activity. Fairly rich soils and irrigation water supplied by canals and wells help bring some of the most productive farming in India. Three fourths of the net sown area is under irrigation, compared with less than one fourth for all India. Since independence, considerable new irrigated land has been added through the Bhakra-Nangal and other government canal irrigation projects.

The major crops are wheat, rice, cotton, and maize, the first three grown mainly on irrigated land. Yields per acre for most crops exceed the all-India average. Manufactures include wool and synthetics, food products, cotton textiles, machinery, and other metal products.

**Punjab Province (Pakistan).** The province has an area of 80,085 square miles (207,420 sq km) and in 1972 had a population of 37,507,855. Punjab is the major province in Pakistan, with 58% of the national population. While the majority of the people live in agricultural villages, there are several large cities. The capital and major urban area is Lahore, with a population of more than 2 million. Other large cities are Lyallpur, Rawalpindi, and Multan.

Irrigation is even more important in the Pakistan Punjab than in the Indian Punjab. Partition disrupted the canal irrigation system because some of the canal headworks and all of the river headwaters that supplied Pakistan were left in India. The Indus Waters Treaty of 1960 granted Pakistan exclusive rights to all the waters of the Indus, the Jhelum, and the Chenab. Since then an ambitious and vast new irrigation system has been under construction.

The two major food crops are wheat and rice. Grain sorghums, oilseeds, cotton, sugarcane, and barley are other important crops. Manufactures include cement, fertilizers and other chemicals, cotton and wool textiles, metal products, and foods.

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**PUNJABI LANGUAGE.** See PANJABI.

**PUNT**, pōnt, in ancient Egyptian records, probably the Somali coast of eastern Africa and perhaps both sides of the lower Red Sea. The Egyptians obtained myrrh, gold, ivory, skins, and rare woods from Punt in exchange for tools, weapons, and beads. Their trading expeditions, which began as early as the 25th century B. C., went by ship from ports on the upper Red Sea.

In the 15th century B. C., Queen Hatshepsut resumed Egyptian trade with Punt after an interruption of 400 years. Her expedition of five large vessels was recorded in detail on the walls of her mortuary temple near Thebes.

**PUNTA ARENAS**, pōn'tā ä-rā'nās, a city in Chile, midway along the Strait of Magellan and on the east side of the Brunswick Peninsula, the southernmost extension of the South American mainland. The city lies farther south than any in the world except Ushuaia, Argentina, which is much smaller. Strong winds from Antarctica make the climate uncomfortable.

Punta Arenas is the capital of Magallanes province and contains 60% of its population. It is a port of call for most ships passing the strait, which connects the Atlantic and Pacific oceans, and it has a free port. The city is the service and supply center for southern Chile's sheep ranches, lumber camps, and oil fields. It exports large quantities of wool and mutton.

A penal colony was established on the site of Punta Arenas in 1843. The city was founded in 1849. Population: (1970) 64,456.

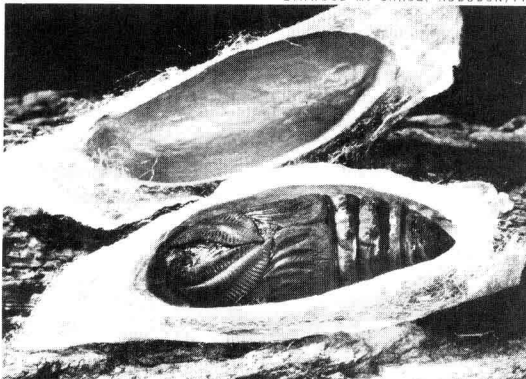
**PUNTA DEL ESTE**, pōn'tā hæl es'tā, a resort city in Uruguay, on a peninsula between the Atlantic Ocean and the Río de la Plata, 70 miles (110 km) east of Montevideo. Punta del Este has fine beaches, luxury hotels, and casinos.

In 1939, within sight of the city, British warships engaged the German battleship *Graf Spee*, which was later scuttled. Important inter-American meetings have been held in Punta del Este. One in 1961 launched the Alliance for Progress; another in 1962 suspended Cuba from the Organization of American States. Population: (1963) 5,272.

**PUPA**, pū'pə, a transitional stage in the development of many winged insects, in which a larva such as a caterpillar is transformed into a radically different adult such as a butterfly. Pupae

A cecropia moth pupa is protected from enemies by a silky cocoon, opened here to show the pupa.

LYNWOOD M. CHACE, AUDUBON/PR



occur in the development of beetles, flies, butterflies and moths, and other winged insects that undergo complete metamorphosis. Such insects develop in four stages: egg, larva, pupa, and adult. The larva is a wingless stage in which the insect feeds and grows. As it grows, the larva molts several times. At its last molt, the larva becomes a pupa; the wings, legs, and antennae appear but are still not in their adult form. The insect stops feeding and becomes inactive, and the final transformation into adult form begins.

Before its last molt the larva typically makes some provision for protecting the helpless, inactive pupa. Most butterfly and moth larvae spin camouflaging cocoons. The larvae of many other insects hide in the ground or under tree bark before pupating, while flies pupate within the hardened skin of the last larval stage.

During pupation most larval structures disappear or are transformed into very different adult structures. Typically, when the transformation is complete, the new adult splits the pupal skin by swallowing air to expand its body. Those insects that have spun cocoons cut or break their way out of the covering. The adult then expands its wings by pumping blood through them and flies away. See also INSECT.

**PUPFISH**, any of several tiny egg-laying topminnows that live in pools and desert springs in Death Valley and nearby areas of Nevada. Pupfishes (*Cyprinodon* and *Empetrichthys*), sometimes called desert sardines, are about 2.5 inches (6.5 cm) long. They can survive in mud puddles, water as warm as 112° F (45° C), and briny pools six times saltier than seawater. They can flip themselves from one small pool to another, and some are able to hibernate in mud during the winter. Five of 13 known species of pupfishes have become extinct as a result of man-made environmental changes.

**PUPIL**, the dark-appearing opening in the center of the iris through which light rays enter the eye. The pupil is widened in dim light and narrowed in bright light by the circular muscles of the iris. See EYE—*Structure of the Human Eye*.

**PUPIN**, pū-pēn', **Michael Idvorsky** (1858–1935), American physicist and inventor, who is best known for his invention of numerous electrical devices used in telegraphy and telephony. Pupin was born in Idvor, Hungary (now Yugoslavia), on Oct. 4, 1858. He went to the United States in 1874 and received a B. A. from Columbia University in 1883. He studied under Hermann von Helmholtz at the University of Berlin, obtaining his Ph. D. in 1889. Pupin began teaching at Columbia in 1889 and was a professor of electromechanics there from 1901 to 1931. He died in New York City on March 12, 1935.

About 1894, Pupin improved the quality of long-distance telephone and telegraphy transmission by using inductance coils inserted in the long lines at proper intervals to reduce attenuation and distortion of the signals. In 1896 he discovered that matter struck by X rays is stimulated to radiate other X rays (secondary radiation). Earlier, about 1890, Pupin studied vacuum-tube discharges at low pressures and invented an electrical resonator. He received a total of 34 patents for his inventions. Pupin won the 1924 Pulitzer Prize in biography for his autobiographical work *From Immigrant to Inventor* (1923).



RETNA

Kermit the frog, a rod-hand puppet, frequently acted as master of ceremonies on the Muppet television show.

**PUPPET**, any object that is animated for a dramatic purpose or in a dramatic manner by a human operator. Purists do not regard automata, gas-filled parade balloons, carnival figures, masks, and the like as puppets, but more liberal interpretations of the term are becoming accepted. The most effective puppets usually are boldly modeled and are more caricatures than faithful copies of what they represent. Simplification and slight exaggeration in design, movement, and presentation require the audience to interpret what they see, mentally adding extra dimensions to the performance. This audience involvement, together with the fascination of the inanimate object animated, perhaps account for the tremendous power of puppetry to command attention and to have survived for more than 4,000 years.

#### TYPES

**The Glove or Hand Puppet.** This type of puppet is used like a glove on the operator's hand. Usually it is simple in structure and limited in gesture to the movement of the fingers, although expressive movement can be achieved with practice. The hand inside the puppet limits the possible basic body shapes, but it also lends flexibility and permits quick, robust action.

Once presented almost exclusively in a small, Punch and Judy style booth, glove puppets now generally have an "open" stage or booth, wider than the original booth and with no top. This provides a wider viewing angle and allows much greater scope for movement, scenery, additional acting levels, and the combining of glove puppets with rod puppets. The glove-puppet show's size, portability, and speed of setting up and striking (dismantling) make it particularly popular.

**The Marionette.** A puppet on strings, the marionette is suspended from a control held by the puppeteer. It can be simply made, with just a few strings, but more often it is the most com-

plex type of puppet. Though not as suitable as the more directly operated puppets for fast, aggressive action because of the risk of tangling, it lends itself to most other uses.

Materials, construction, and control techniques vary considerably, but the basic principle is to construct a figure so balanced as to move naturally with a minimum of imposed control. It should be strung in such a way that simply tilting or turning the control effects many of the movements, reducing the need to pull individual strings.

Marionettes long have been popular in variety and cabaret shows, where trick puppets are common—the come-apart skeleton, the Grand Turk that turns into six different puppets, the juggler and acrobat. Transformations and other effects are achieved by means of extra stringing and special constructions.

Variety-show marionettes most frequently are presented either with no staging or with some form of open stage with no proscenium front, so that the puppeteer is in view, operating over a backdrop. But plays generally are given on a full proscenium-fronted stage, with hidden puppeteers working from a bridge above the acting area.

Marionette developments in the West include plays with the operators in view, controlling large figures by a traditional method, from southern India, in which head and body strings are attached to a cloth-covered ring that fits onto the puppeteer's head. The puppet's hands and arms are controlled by short rods, and its feet are attached by other short rods to the puppeteer's shoes. Thus through his own body movements the puppeteer effects all movements of the puppet.

**The Rod Puppet.** This puppet, held and moved by a rod or rods, usually from below, has been taken up throughout the world during the 20th century, especially in eastern Europe. It offers scope for creativity in design and presentation and makes possible swift, subtle, graceful movements. Generally a central rod held in one hand controls head and body movements, and two rods held in the other hand control the puppet's hands.

Rod puppets are presented most frequently in some form of open booth, with the operators hidden, but flexible staging that can be rearranged during the performance has been introduced, as have techniques in which the operators move freely about the stage in view of the audience. Sometimes actors and puppets are combined. These last two trends have made popular a style of puppet akin to the Japanese Bunraku puppets or the ventriloquist's dummy, with the head and any movable facial features controlled from a short rod inside the puppet's body and the limbs moved by the operator's free hand or by extra operators.

**The Rod-Hand Puppet.** An increasingly common type, the rod-hand puppet is operated either by a hand inside a puppet's head and rods to the puppet's hands or by a rod to the puppet's head and the operator's own gloved hand used as the puppet's hand. Sometimes one operator controls the puppet and another the puppet's hands.

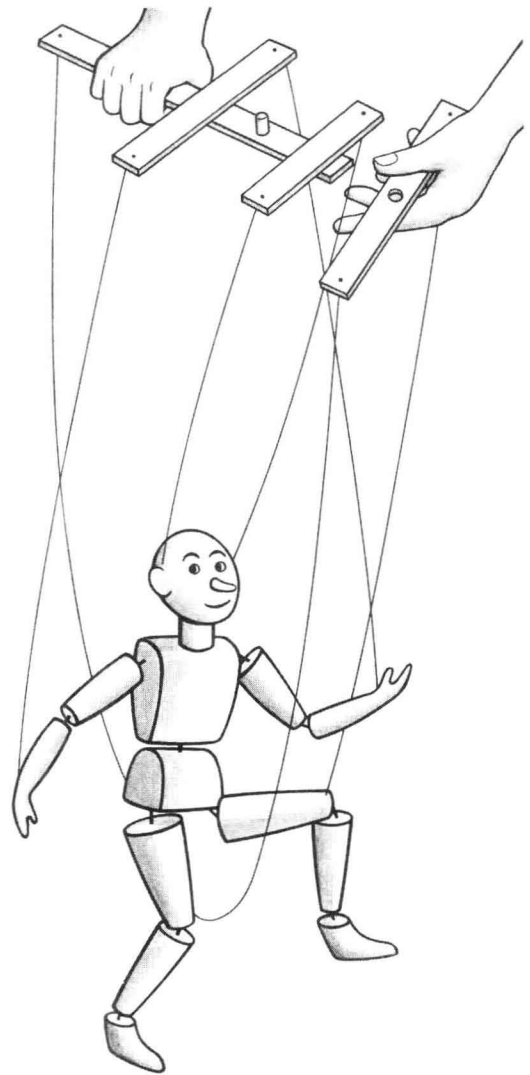
The Muppets of television are examples of such mixed-style puppets. Some of them are rod-hand figures, but the large Muppets have operators inside them.

**The Shadow Puppet.** This usually is a flat, cutout figure held by a control rod or wire against a translucent screen while some form of light is shone on it. As the puppet moves, the



AUTHENTICATED NEWS

Marionettes are operated by means of control sticks held by the operator (puppeteer) and strings of black linen thread or fishline attached to the head, arms, and legs of the puppet. The leg controls should be detachable so that the marionette can be made to "walk."



audience on the other side of the screen watches its shadow. With appropriate lighting, three-dimensional puppets can be used to create shadows, and it is possible to create three-dimensional images, but these styles of performance are rare.

Traditionally made of parchment or hide, treated to make it stiff and translucent and colored with dyes, shadow puppets now more often are made of cardboard or acetate. Shapes cut from the cardboard show through on the screen. The shapes may be covered with patterned materials such as lace or net or with colored cellophane or acetate to create decoration and color in the image projected. One technique involves coloring thin cardboard (ivory board) with water-based felt pens and then rubbing the cardboard with cooking oil. The cardboard becomes translucent, and an effect akin to that of the Oriental shadow puppets is achieved.

Control rods (or wires) may be held vertically or horizontally to the puppet. Whatever method is used, it is usual practice to have one main supporting rod to the head or body and additional rods for particular movements, usually to a hand or hands.

Shadow puppets are particularly effective for illustrating a narrated story but can be used, as in the traditional Greek and Turkish shadow shows, for very fast and robust action.

**Television and Film Puppets.** Apart from the straightforward recording of puppet performances or sketches, television and films employ three special techniques: silhouette films, phase-puppet films, and supermarionation.

*Silhouette films* involve laying articulated two-dimensional figures on a translucent glass surface, illuminated from below, and taking a picture of

them with an overhead camera. The figures then are moved slightly, and another picture is taken. A series of frames is built up that, when projected, results in animation.

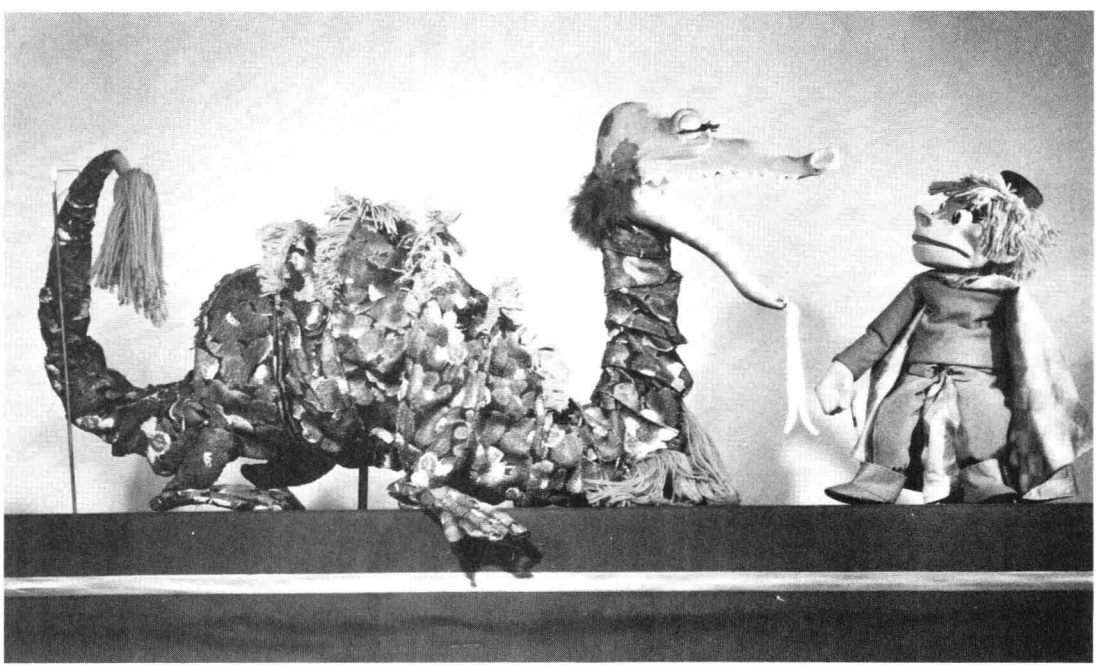
*Phase-puppet films* (or stop-action puppetry) employ a similar technique, using three-dimensional, friction-jointed figures. These are positioned, photographed, repositioned, and so on. Twenty-four frames are required for every second of film time.

*Supermarionation* uses string-operated figures with interchangeable eyes for blinking and swiveling movements, electric solenoids in the necks to trigger mouth movements in synchronization with prerecorded speech, and a host of other effects for both puppets and stage sets. The term was coined for the highly elaborate international puppet television series *Fireball XL5*, *Thunderbirds*, and *Joe 90*.

**The Toy Theater.** This is the small, tabletop theater in which cutout figures are moved on runners projecting from the sides of the stage. The toy theater originated as a 19th century drawing-room entertainment in which young men enacted their favorite melodramas.

Originally homemade and later printed for "a penny plain, twopence coloured," the sheets of





These Bil Baird Marionettes in reality are rod puppets. (Above) The student encounters a not very frightening dragon. (Below) Cora Baird manipulates the rods that control the actions of a character called the Princess in an outdoor puppet show.



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figures, sets, and theaters with the texts still are published by Pollocks Toy Museum in London. A modern version of the technique is found in children's cutout books.

#### HISTORY

Because of the ephemeral nature of puppetry, its history is largely a matter of conjecture, and its origins are confused.

**Asia and the Orient.** Cult figures with moving parts survive from antiquity, but it is not known

whether they were used for dramatic purposes. It is known, however, that puppetry in Asia was highly sophisticated at an early date—perhaps 4,000 years ago in India—and it is believed that puppets were in use before human actors because religious taboos forbade impersonation. Thus the leading player in Sanskrit plays is the *sutradhara*, the “holder of strings.”

Throughout Asia the puppet theater has had close connections with human dance and drama and frequently has made use of classical literature or religious themes. In India the puppets drew on the *Mahābhārata* and the *Rāmāyana*, Hindu epics written some 2,000 years ago. These works are fine puppet fare, containing gods and other supernatural beings, magical monkeys, and the like.

Burmese puppets, traditionally marionettes with up to 50 or 60 strings, are similar sorts of characters, and their plays are based on the *jatakas*, stories of the Buddha's previous incarnations. These puppet plays were created and developed in the 18th century and had considerable influence on the human dance-drama. Thus the dancer's skill is measured by his ability to recreate the movements of the puppet.

Of Java's many styles of puppetry, the major ones are the *wayang golek*, wooden rod puppets that probably originated in Bengal, and the *wayang kulit*, shadow puppets cut from buffalo hide and treated, painted, and gilded. The puppeteer, or *dalang*, performs a semipriestly function, as the puppets are considered to represent gods and ancestral spirits. Even the making of the figures has religious significance.

The Japanese puppet theater originated many centuries ago, probably in Korea, and its presentations at first were mainly religious. By the mid-16th century, however, it was drawing audiences with No plays and Kyogen comic interludes. By the mid-18th century the Bunraku, a unique