COMMERCIAL BUILDINGS

CHAPTER FIVE

Commercial and industrial buildings, commonly classified as "heavy construction," are built mainly of steel, concrete, and masonry. They represent a more permanent type of construction than residences and other types of small buildings, which, for the most part, are built of wood.

Because of the necessity to protect concentrations of people within these larger buildings, fire and zoning codes are understandably more restrictive and thus require the use of fire-resistive materials.

When reading working drawings of commercial buildings, we must remember that there is a distinct difference between the purpose of the architectural drawings and the purpose of the structural drawings in the set. The architectural drawings show materials, dimensions, and general esthetic design—much of the structural information is omitted in them. The structural drawings, prepared by the structural engineer, chiefly show the structural features—size and placement of steel or concrete members, steel connectors, placement and bending of reinforcing bars, and related notes and information. The intent is to avoid the duplication of information. Consequently, the structural drawings represent a careful analysis of the structural requirements only and indicate an accurately calculated solution. The two types of drawings are compatible, however, and the reader must be able to relate each to the other.

Although commercial buildings vary in appearance on the exterior because of design and choice of materials, their structures are usually variations or combinations of several basic types of structural systems—namely, *bearing-wall*, *reinforced-concrete*, or *steel-frame* construction. Because of advanced techniques in chemical treatment, lamination, and the structural grading of lumber, some buildings are still built of massive wood members and are classified as *heavy timber* construction.

A. BEARING-WALL CONSTRUCTION

As the name implies, bearing-wall construction utilizes the strength of the walls to carry the weight imposed on the floors and roof of the building. In this type of construction, the walls are usually limited to one or two stories in height; higher buildings employ other types of structural systems. In general, bearing walls are economical and feasible only when spans are limited to 30 or 40 ft., otherwise it becomes necessary to use thicker walls or intermediate columns and beams.

If we examine the wall sections in a set of drawings carefully, we can detect if bearing walls are employed. If the floor and roof supports bear on the wall materials and no structural beams or columns are shown along the wall on the plan, we can be reasonably sure that the walls support the weight. Thickened wall piers or buttresses may be shown for the purpose of carrying beam loads or for strengthening the walls to resist lateral loads, yet they are still load bearing. Usually materials like brick, concrete block, stone, and structural tile, which have good compressive characteristics, are used for bearing walls.

B. REINFORCED-CONCRETE CONSTRUCTION

Concrete is one of our most adaptable building materials. In addition to its wide use as a masonry material, concrete cast with steel reinforcing provides architects with a versatile material known as *reinforced concrete*, which finds universal application. Almost unlimited design and architectural expression have been made possible by this combination of materials in today's engineered buildings.

The size and spacing of steel reinforcement in concrete members are based on the spans and the anticipated loads they will be subjected to. Details normally conform to standard practice as shown in the *American Concrete Institute Detailing Manual.* Bar reinforcing is usually designated with a note giving bar size and the number of bars or the distance between centers of adjacent bars. For example, the note #3@ 12″ indicates $\frac{3}{8}$″ diameter bars spaced 12″ on center. The rod number is based on the approximate number of eighths of an inch in its diameter. A No. 5 bar would measure $\frac{5}{8}$″ in diameter; a No. 8 bar would measure 1″ in diameter, etc. However, a No. 11 bar measures $1\frac{7}{16}$″ in diameter, which is a slight variation.

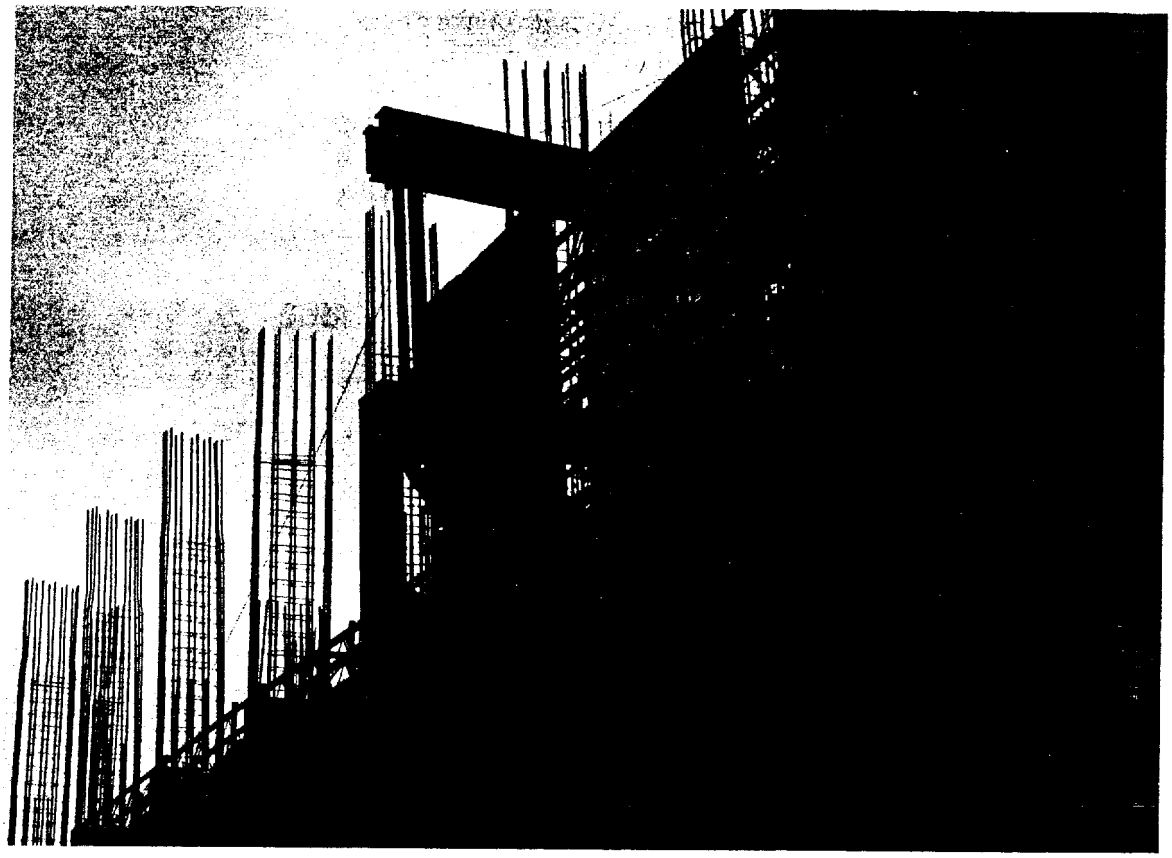


Fig. 5-1 Reinforced concrete construction is now used in a wide variety of commercial structures.

In order to protect the reinforcing from corrosion (rusting) and to provide insulation against heat due to a possible fire, the bars are spaced a definite distance from the outside surface of the concrete. A note, $\frac{3}{4}''$ Cl., indicates that the surface of the bar is to be covered with a minimum of $\frac{3}{4}''$ of concrete.

Expansion joints are also commonly located on drawings, and details of their construction are often shown. These vertical joints in long buildings allow freedom to expand and contract without rupturing the concrete. Usually the joints appear at junctions of L, T, or U shapes, where perpendicular intersections occur. Complete separation of both concrete and steel must be made, and premolded joints and metal coverings are used to conceal the joint. Flexible caulking is also used for this purpose. Frequently expansion joints continue completely through the building. Slabs require expansion joints where large openings occur, around columns, and along the periphery of a slab when it abuts a wall.

Although sometimes not shown on a drawing, *construction joints* appear during extensive pouring of concrete. Theoretically it is preferable to cast concrete in one continuous pour, making it a monolithic structure, but this practice is often impractical. Neat, either vertical or horizontal, joints are made where they will produce the least amount

of weakness to the structure when the pour is terminated at the end of the day. When construction joints can be anticipated by the engineer, they are shown on the drawings. Intersections of column footings or beam columns frequently carry this notation. Where shown on a drawing, this notation indicates a permissible location for the joint. Any other location would have to be approved by the enginner.

You will be able to recognize reinforced-concrete construction on drawings by the use of concrete structural members and the designations of rod reinforcing throughout. The structural drawings typically show a plan view of each floor level with its relating details, notes, and schedules. Much of the technical information is placed in schedules to eliminate cumbersome and numerous unnecessary drawings.

C. STEEL-FRAME CONSTRUCTION

Steel-frame construction, utilizing a skeleton frame throughout the entire height of the structure (see Fig. 5-2), is commonly used for high-rise buildings. Typical structural steel shapes like the I beam and wide-flange (WF) sections (Fig. 5-3) are

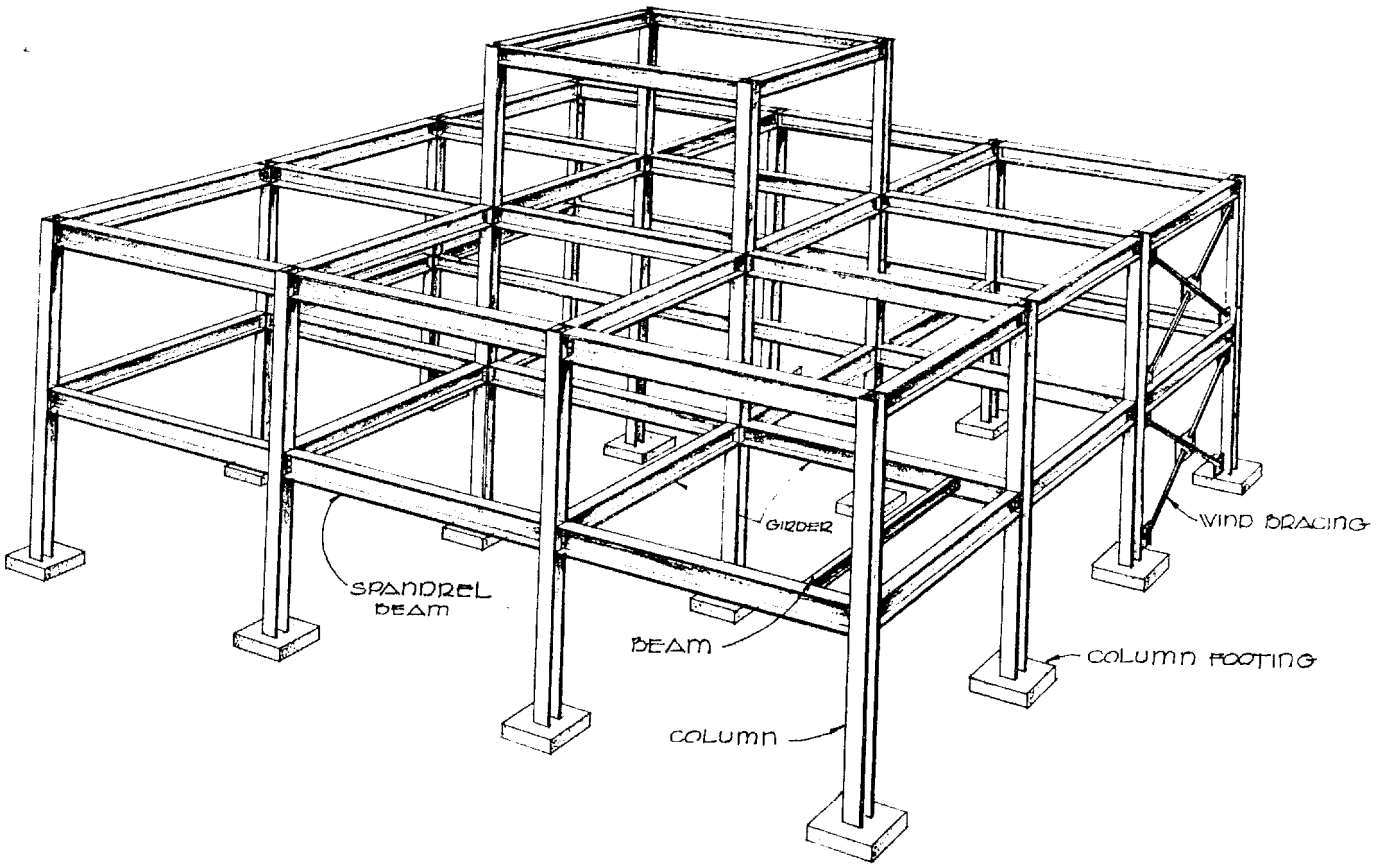


Fig. 5-2 The appearance of the steel structure or skeleton in a steel-frame building.

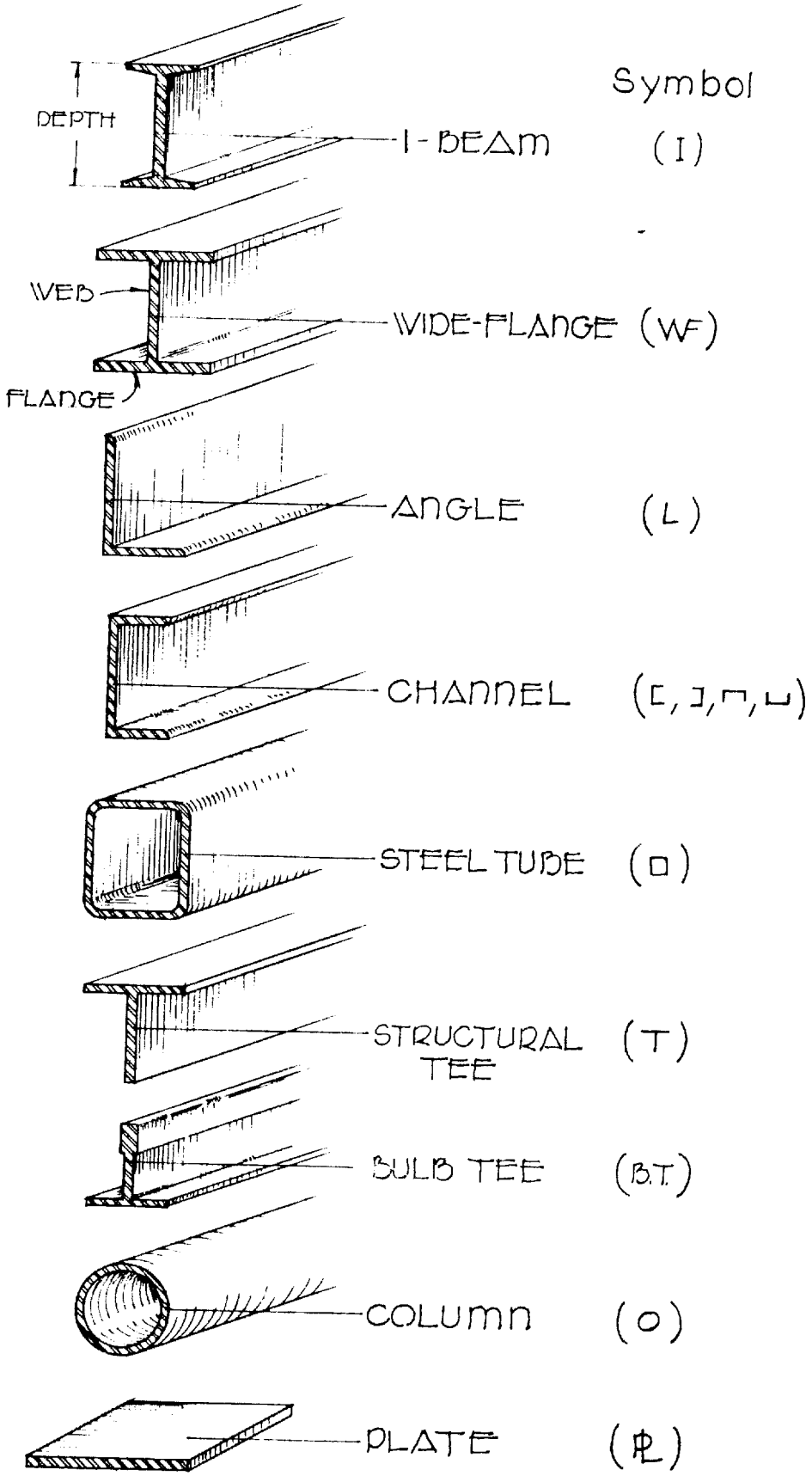


Fig. 5-3 Typical structural-steel sections and their symbols used on drawings.

used to construct the main skeleton, which resembles a rigid steel cage when completed. The connections between each member may be riveted, bolted, or welded; some buildings employ several types. Availability of labor and the job location are important factors in determining the type of connectors to be used. Various other steel shapes may also be necessary around openings in floors, for resistance to lateral wind loads, and so on. Each building requires some special variation from standard framing procedure to accommodate individual requirements. Thus the steel members and their connections are sized to carry the dead and live loads of the building by transferring these loads from floors and roof to the beams and girders, down through the columns to the footings below. Weights of the exterior walls and partitions of each floor level are thereby carried by the columns only, on which tremendous compressive loads can be supported without the need for massive load-bearing walls on the lower floors.

To protect the steel framework from failure due to a possible fire, each member is encased in concrete or other fireproofing material; yet the steel supports the loads. Like a reinforced-concrete building, this is an engineered structure in that sizes for each member and their connectors must be carefully calculated according to accepted standards and codes, and allowances must be made for safety factors as well as local conditions.

Steel columns are usually placed in uniform bays or grids on the plan, and compatible floor systems are designed to be accommodated within the spans of the bays. Structural drawings reveal plan layouts, sizes of each steel member, and accurate information about each con-

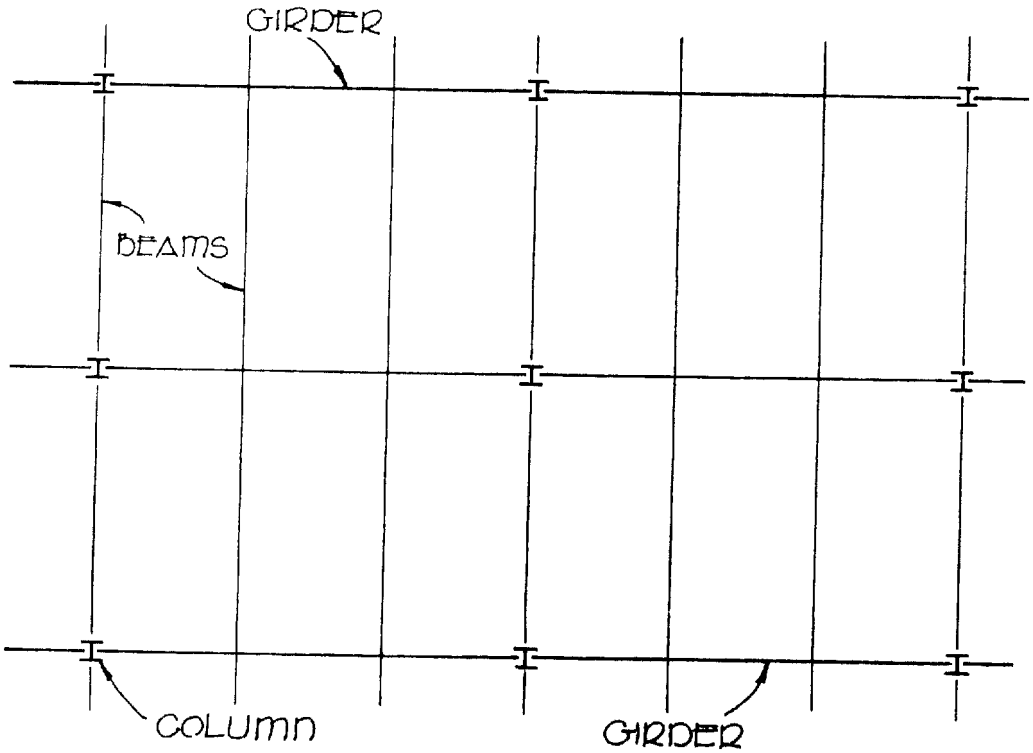


Fig. 5-4 The appearance of steel frame on a floor plan.

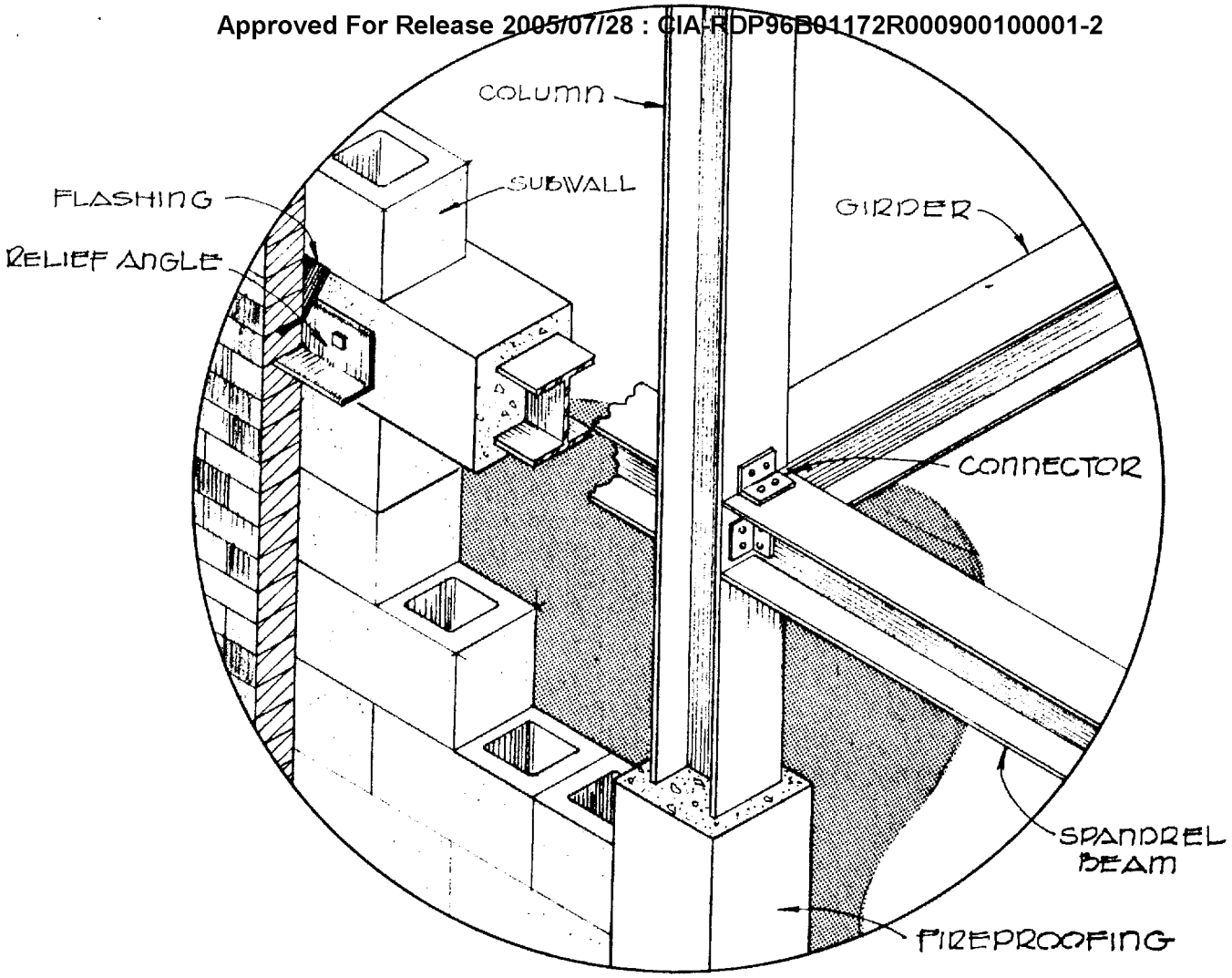


Fig. 5-5 The steel frame is encased in a fireproof material for protection.

nection. The plan layout is ordinarily a schematic diagram showing beams and girders as heavy, solid lines (see Fig. 5-4). Sometimes they may be broken lines. Sections, schedules, and notes used on drawings are similar to those mentioned under reinforced-concrete construction.

The use of steel-frame construction is soon evident when reading a set of working drawings. Wide-flange or I beam members used for column and girder layouts in plan, similar steel shapes shown in the details, and drawings of steel connectors give evidence of this type of construction. Notice that steel members are specified with a note giving the depth of the web, type of profile, and the weight per foot. Thus a note, 12 I 24.6, indicates an I beam 12″ deep that weights 24.6 lb. per foot. Other standard notations are also used for other steel shapes.

D. HEAVY TIMBER CONSTRUCTION

Construction with heavy timbers, which was commonplace in mills during colonial days, still finds acceptance in many types of buildings even today. Southern Yellow

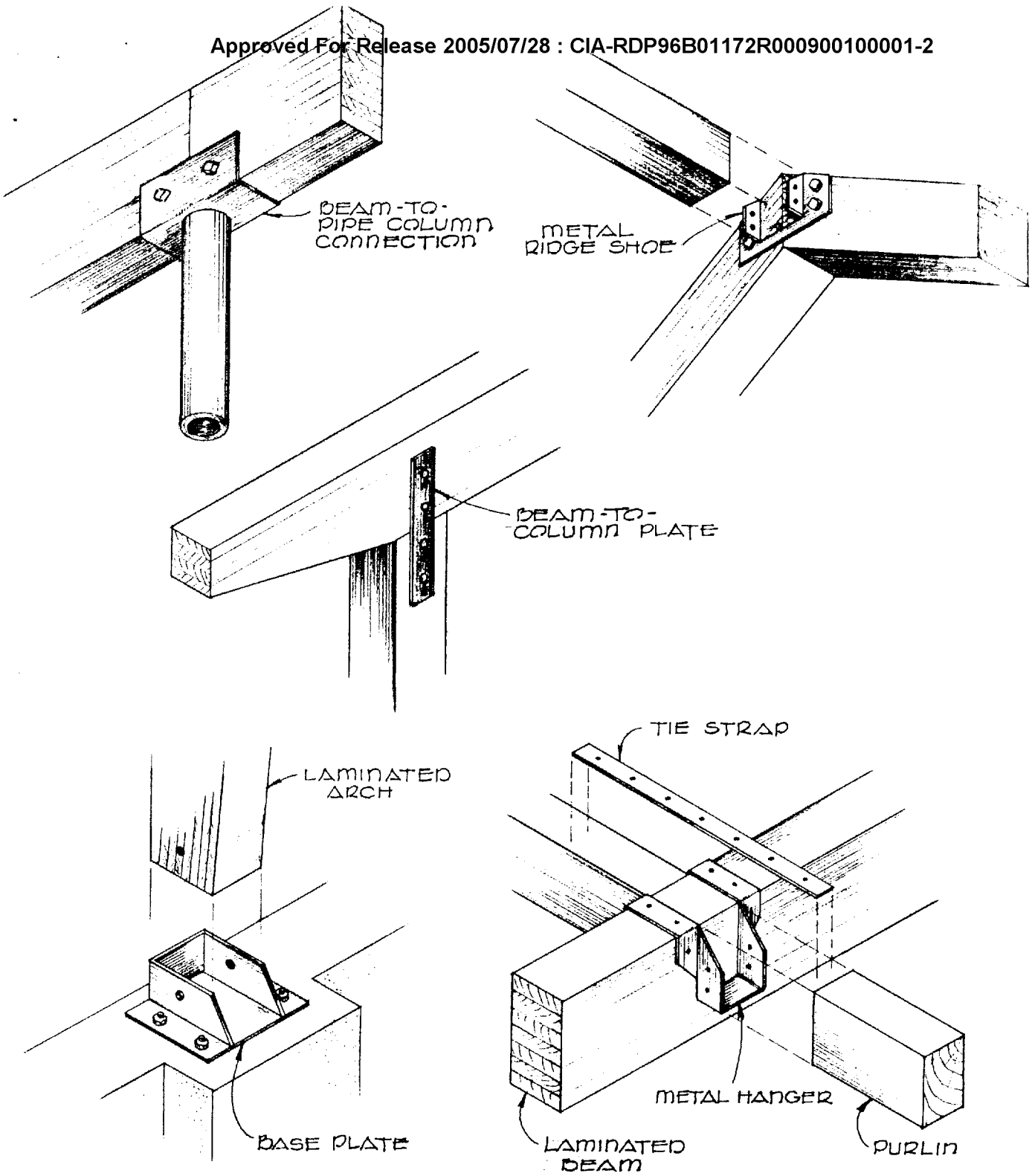


Fig. 5-6 Metal connectors for heavy timber construction. Many heavy timbers are glue-laminated.

Pine and Douglas Fir, both in abundant supply, are the two main species of structural lumber. Lumber carefully graded according to strength and resistance to fiber stress is required. In general, buildings only one or two stories high (in areas where codes are nonrestrictive) are built with this method.

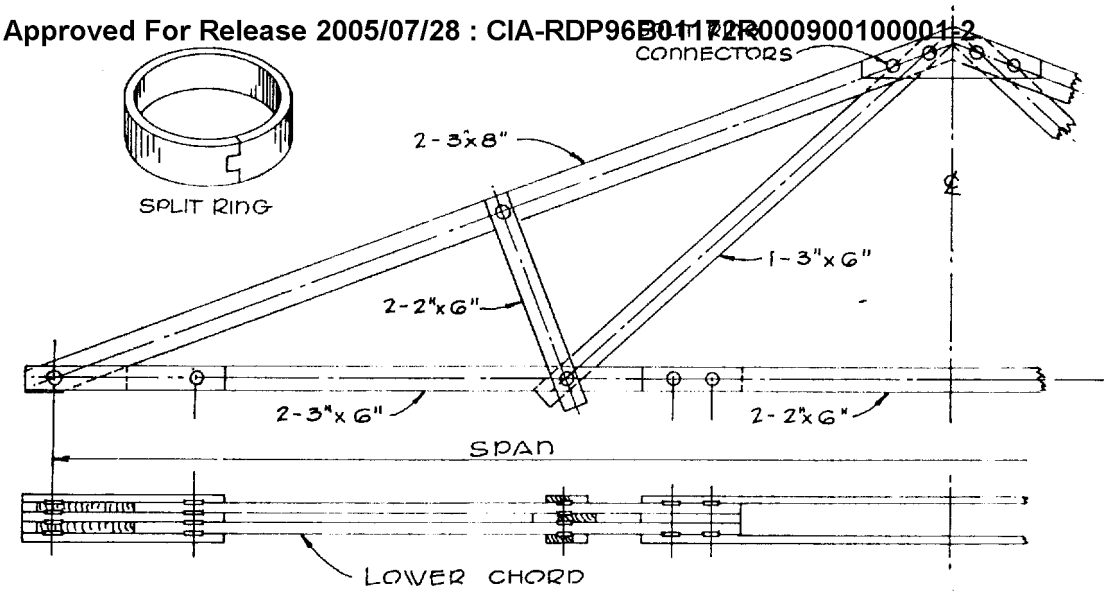


Fig. 5-7 A wood truss used in timber construction.

Although wood burns readily, it can be classified as "fire resistant" if heavy, massive members are used. Extremely severe fires are necessary before timbers burn through and fail under loads. Actually, heavy timber has a better fire rating than exposed steel.

An increasing number of wood structural members are glue-laminated to specified sizes in fabricating plants and transported to the site ready to be erected. Many churches, for example, are constructed with laminated arches or beams and masonry bearing walls. Wide spans are possible. The laminated beams with plank roofs result in interesting interiors for many applications.

Wood trusses (Fig. 5-7) made with heavy members also find use in wide-span roofs. Various truss designs and shapes found on drawings are evidence of continued acceptance of timber roof structures for commercial buildings.

Remember that actual cross-sectional sizes of timbers are slightly smaller than the nominal sizes given on drawings (see Fig. 2-61). All engineering design computations, of course, are based on actual sizes.

In present-day timber construction, various metal pieces are necessary at critical points in the structure—where compression concentrations may cause fiber crushing, where complex connections must be made, where joints must be held in shear, and for bearing seats. Typical of these metal pieces are strap hangers, brackets, rods, metal bases for columns, pintles, split rings, and gusset plates. Bolts and lag screws are needed as fasteners at critical connections. Details for the metal pieces or manufacturers' designations are indicated on the drawings.

Drawings of timber buildings utilize systems for giving information that are similar to systems used in drawings of steel and concrete buildings. Plans are necessary to show the horizontal layout of the columns and horizontal members of each level. Wood columns are often darkened on the plan, with their footings shown in broken lines, and detail sections and schedules are used to give specific information

about individual members. Similar marking systems are used for members commonly represented on the plans with a single heavy line. As in other structural drawings, wood members are often identified by the first letter of the name of the member. For example, B for beam, G for girder, C for column, J for joist, T for truss, etc.

Details of symmetrical wooden trusses usually show only half of the actual truss, to eliminate repetition. The bottom chord of a truss detail is commonly drawn as a section through the truss looking downward. Therefore, although it is placed below the elevation view, it is nevertheless the *top view* of the bottom chord. As we mentioned, details are scaled from actual size dimensions.

E. STRUCTURAL DRAWINGS—GENERAL

Structural drawings are usually laid out with the large plan in the upper left of the sheet and the accompanying sections and details directly below (see Fig. 5-8). Schedules are then placed in the upper right and their relating notes are located in the lower right-hand corner. Plans are often drawn with the north direction toward the top of the sheet. However, a north-point arrow

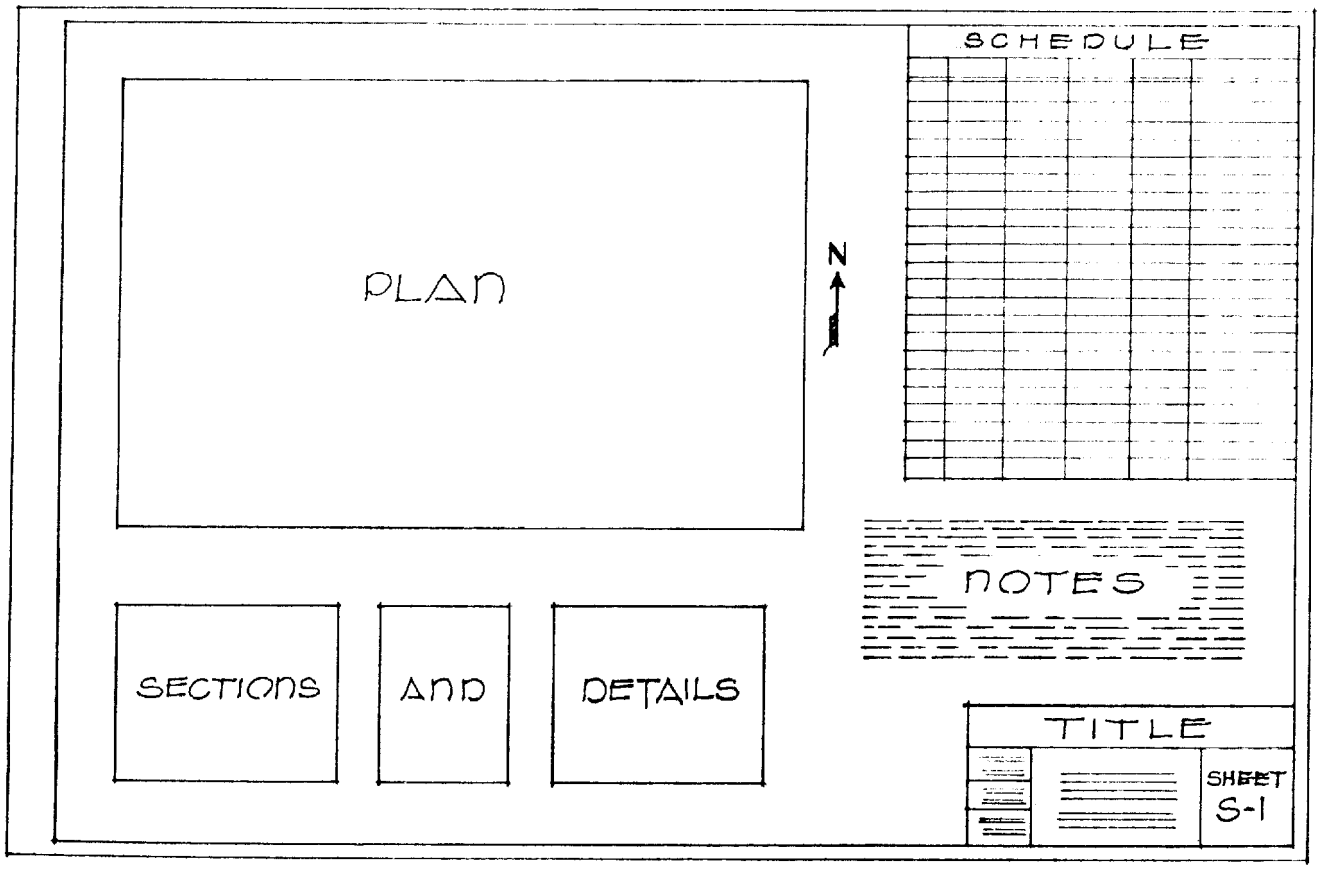


Fig. 5-8 The general layout of a structural drawing.

is commonly used for orientation, for directional reference is often made in details for erecting individual members. Framing plans for larger buildings are frequently drawn at the $\frac{1}{8}'' = 1'0''$ scale. The relating sections usually are drawn at $\frac{1}{2}''$ or $\frac{3}{4}'' = 1'0''$ scales.

Two general systems for identifying columns are in use. When the structure is small, a *sequential* numbering system may be used (see Fig. 5-9). The system most often used for larger buildings, however, is the *grid* system, as shown in Fig. 5-9(2). Both systems identify each column within the structure. Column B-2 in the grid system corresponds to Column 7 in the sequential system. It should be remembered that grid lines are not always equally spaced, nor do they necessarily pass through the column center. This fact must be closely observed in the layout. Sometimes a grid line will be offset to include one or more columns not aligned with the others.

Most drawings utilize a letter, as mentioned before, combined with numbers to identify beams, girders, joists, and slabs. A notation 2B4 would indicate the fourth different beam on the second floor. Or a note 3G6 would indicate the sixth different girder on the third floor. Slight variations in identification systems used by draftsmen can be clarified by relating views to verify them.

Footings are usually identified in the same way as the columns. Footing B-2 would support Column B-2. Many times, however, footings are given an additional identifying notation. When footings vary as to size or reinforcement, they are given a "mark" number to identify all the identical footings. For example, footings B-1 and B-2 could both be referenced as Mark (2). This would indicate that a schedule listing of Mark (2) would apply to both.

As we have already seen, schedules are commonly employed on both architectural and structural drawings for the purpose of compiling

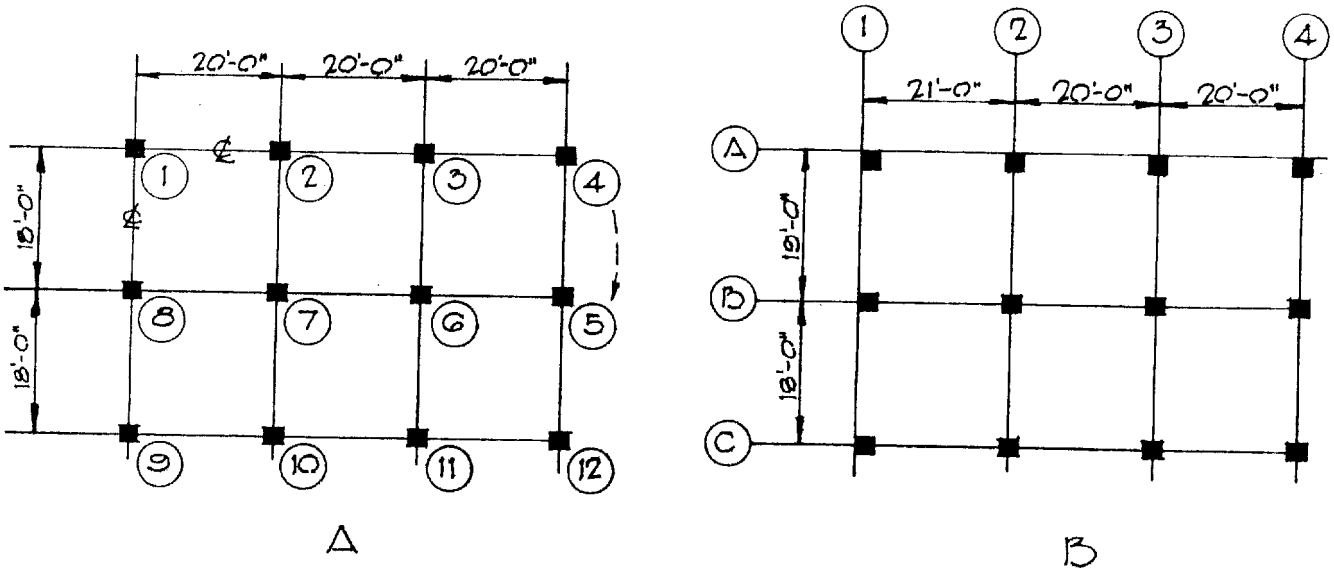
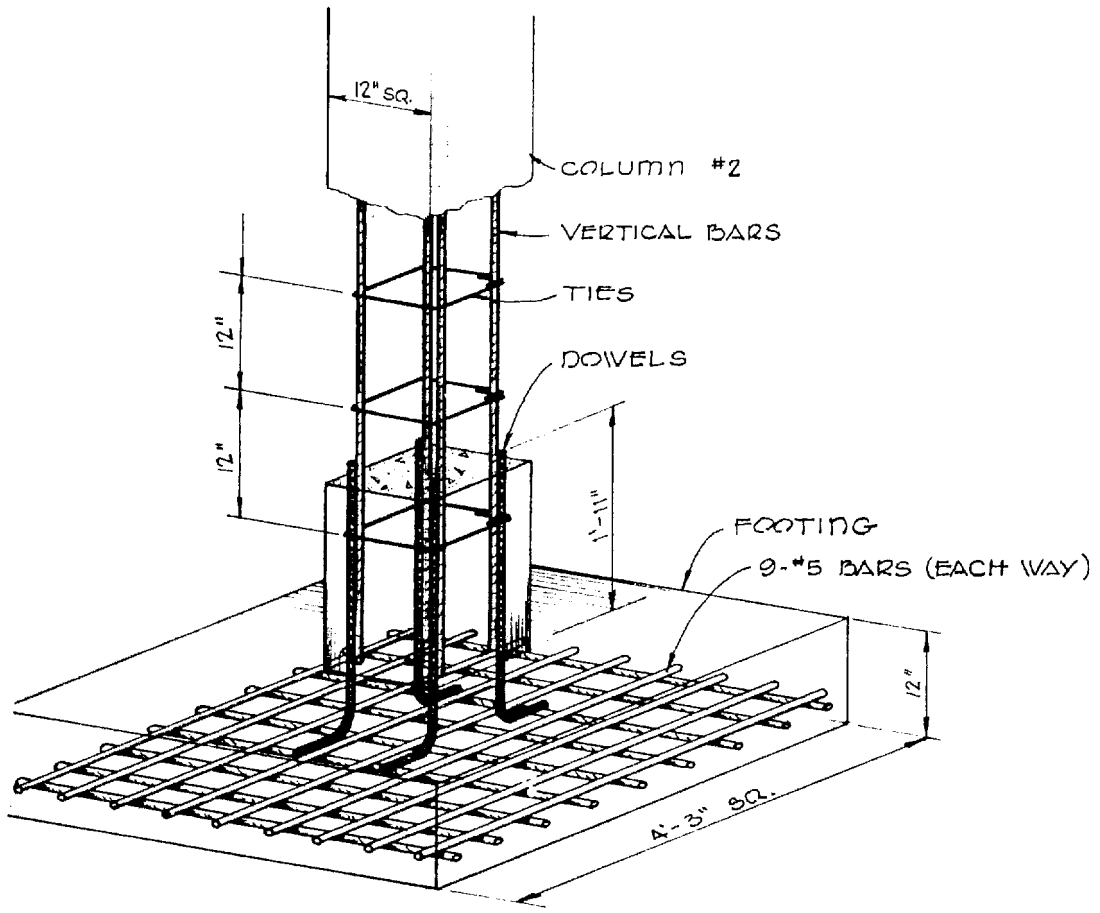


Fig. 5-9 Systems used for identifying columns on plan views. (A) Sequential. (B) Grid.

complex information into a small, convenient space. It is much simpler for a draftsman to place the information in a schedule than to place it in note form throughout the drawing. However, interpreting information in complex schedules requires, in many cases, an intimate knowledge of the proposed construction and all the procedures involved. It is not unusual for members listed as identical in the schedule actually to have slightly different characteristics. Even contractors sometimes have difficulty in reading involved schedules; so the novice should not be discouraged if he sometimes finds a schedule on a drawing difficult to understand. In practice, explanations by the architect or engineer are occasionally necessary before schedule information is entirely clear.



COLUMN & FOOTING SCHEDULE

MARK	COL. SECT. FTG TO 1ST FL	REINF. CONC. COL.	COL. SECT. 1ST FL. TO ROOF	FOOTING SIZE	FOOTING DEPTH	REINF. EA. WAY	STEEL COL. BASE PL	ANCHOR BOLTS	CAP PL	REMARKS
1	12"x12"	4-#6 VERT. #2 TIES@12"	4"x4"x5/16" STEEL TUBE	5'-2" □	12"	6-#4	8"x10"x1/2"	2-1"ø	4"x10"x3/8"	USE 4-#6 DOWELS EXTEND 1'-11" ABOVE FTG.
2	12"x12"	4-#6 VERT. #2 TIES@12"	4"x4"x5/16" STEEL TUBE	4'-3" □	12"	9-#5	DO	DO	DO	USE 4-#6 DOWELS EXTEND 1'-11" ABOVE FTG.
3	DO	DO	DO	7'-4" □	10"	6-#5	DO	DO	DO	

Fig. 5-10 Reading a column and footing schedule. The column and footing are similar to those in the Medical Arts Building.

SCHEDULE OF FIRST FLOOR BEAMS

MARK	SIZE	REINFORCING ST. BARS	REINFORCING BT. BARS	*3 STIRRUPS SPACING EACH END	REMARKS
B-1	13⅜ x 18"	2-#5			NOTCH FOR BRICK
B-2	13⅜ x 18"	2-#5			D.O.
B-3	13⅜ x 18"	2-#5			D.O.
B-4	12" x 24"	4-#9	3-#10	1@3", 2@6", 3@9", 3@12"	D.O.
B-5	12" x 24"	4-#8	4-#10	D.O.	D.O.

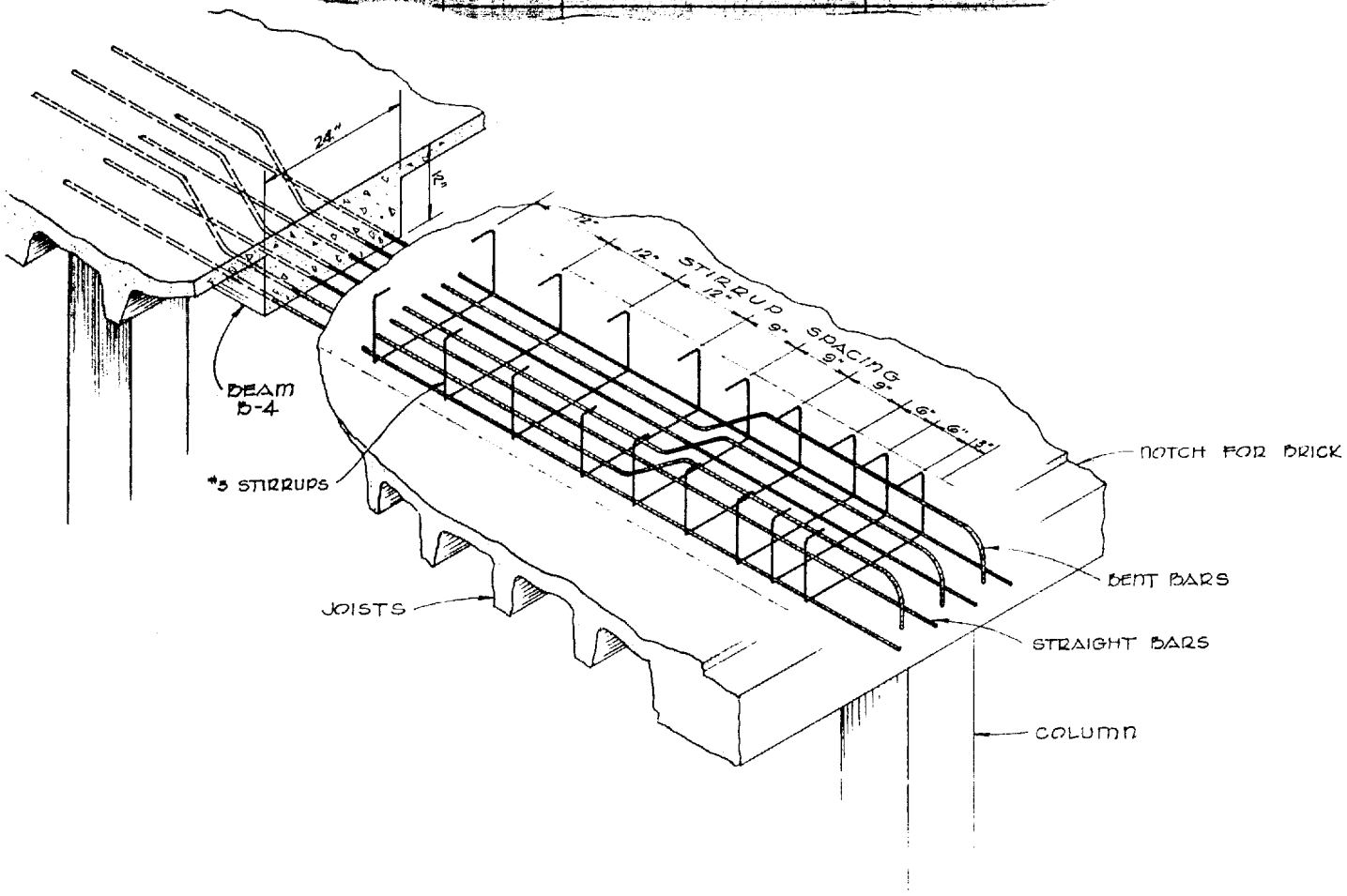


Fig. 5-11 Reading a beam schedule. The beam shown is similar to those in the Medical Arts Building.

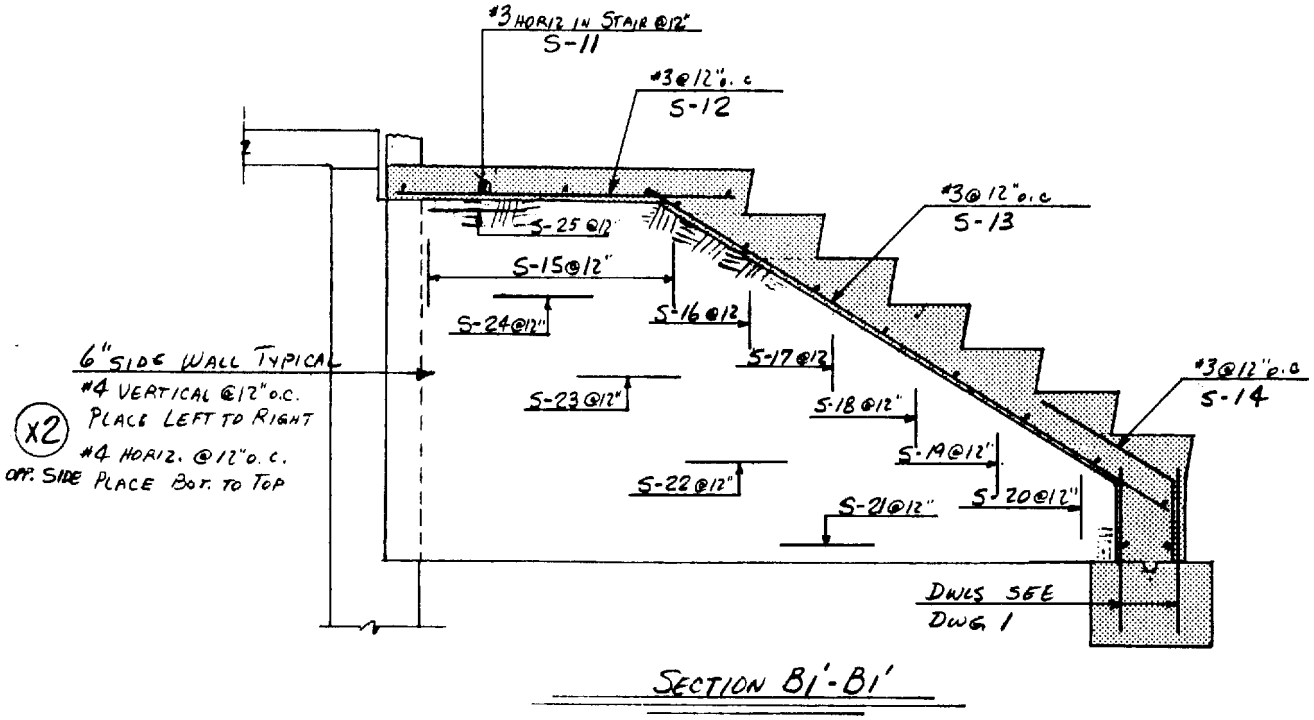
F. COMPUTER APPLICATIONS TO DRAWINGS

Like our other major industries, architecture and construction have been affected by the use of the computer. Numerous architectural and engineering offices now use the digital computer to more efficiently conduct various aspects of their services.

Basically, the computer is an electronic calculating machine that adds and subtracts, yet with the capacity for internal memory storage. It even has the ability to correct itself. The advantage of the machine is its accuracy as well as its tremendous speed in solving complex problems.

Carefully conceived instructions, known as programs, must state the problem in the computer language before it is fed into the machine. These instructions may be in the form of punched cards, paper tape, or magnetic tape. Some computers have automatic typewriter components for typing the results of imput instruction on a paper output sheet.

One type of work in which computers have found application is in the preparation of schedules for reinforced concrete structural drawings.



SECTION B1'-B1'

REINF. AT SECTION B1' - B1'.	S # STAIR BARS
S -11	1X 15 * 3 5 -6 AT 12 IN
S -12	1X 6 * 3 4 -2 AT 12 IN
S -13	1X 6 * 3 7 -4 AT 12 IN
S -14	1X 6 C 3014 AT 12 IN
S -15	2X 4 * 4 4 -6 AT 12 IN
S -16	2X 1 * 4 4 -0 AT 12 IN
S -17	2X 1 * 4 3 -6 AT 12 IN
S -18	2X 1 * 4 2-11 AT 12 IN
S -19	2X 1 * 4 2 -5 AT 12 IN
S -20	2X 1 * 4 1-10 AT 12 IN
S -21	2X 1 * 4 9 -6 AT 12 IN
S -22	2X 1 * 4 9 -6 AT 12 IN
S -23	2X 1 * 4 7 -6 AT 12 IN
S -24	2X 1 * 4 5 -6 AT 12 IN
S -25	2X 1 * 4 4 -0 AT 12 IN

Figure 5-12 Example of a computer printout on structural drawings.

Their use has resulted in greater speed in drawing preparation, simpler drawings, and fewer errors on the project. Conventional detail drawings for steel placement are prepared by the detailer, and the quantities and descriptions information are put on the output sheet by the computer. This saves considerable time, yet the reader of the drawings must have some familiarity with the computer language.

Often a "label system" is used to relate the bars shown on the drawing to the machine printout sheet. Using this system, detailers merely assign a label number to each bar-placing operation—either each individual reinforcing bar or a group of bars. The label number relates the detail drawings to the printout sheet, which shows bar sizes, spacing, etc. Other programs are used to produce entirely machine-printed column schedules, beam schedules, and slab schedules.

Similar applications are made in steel-frame construction. The computer may be used in calculating results of the frame moment distribution or the steel column design. The printout sheets are used mainly as engineering aids in this case.

Some contour maps and sub-division layouts are now also made with the use of the computer. A graphical-output device, known as an XY plotter, in connection with the computer is able to make actual contour maps from input data programs.

Probably the most universal application the computer has provided architectural offices is in the preparation of specifications. In large offices where complex projects require extensive sets of specs, a library of master architectural and engineering specs, which have been punched into cards or loaded on disks or magnetic tape, are used repeatedly. These comprehensive master specs form the base from which individual job specs are printed out by the computer. Before the master spec cards or tape are fed into the machine, the spec writer delets or adds any special paragraphs to customize the material to each individual set. Job deck cards or tape are made of these changes and then inserted into the master cards or tape before they are fed into the machine for final printout. The final tailormade specs are automatically typed out on stencils or offset masters by the high-speed computer so reproductions can be easily made.

G. HEAVY-CONSTRUCTION TERMS

AXIAL LOAD: A load applied on the axial center of a structural member; usually refers to the load centered on a column.

BAR JOISTS: Structural units made from various bar and rod-shaped steel for supporting floors and roofs; also known as steel joists (see Fig. 5-22).

BAY: Square or rectangular areas, usually in a uniform grouping, surrounded by columns (see Fig. 5-9).

BEAM HANGER: A metal strap formed into a stirrup shape, which lies over a supporting member and supports the end of a horizontal beam (see Fig. 5-6).

BELLED PILE: A pile with a flared bottom for better bearing support (see Fig. 5-14).

BULB TEE: An inverted T-shaped steel member with its vertical stem enlarged into a bulb shape; usually used for the support of poured roof deck forming panels (see Fig. 5-22).

CANTILEVER BEAM: An overhanging beam with a rigidly fixed support at only one end.

CAST-IN-PLACE PILE: A pile made by sinking a hollow tube into the ground and pouring concrete into it.

CHAIRS: Metal supports made of heavy wire to hold the steel bars in place during the pouring of concrete in a form.

COLUMN CAPITAL: The upper part of a column, usually enlarged or decorated (see Fig. 5-19).

COMPRESSION: A squeezing force applied to a material, creating a tendancy for it to become compressed.

CONTROL JOINT: A loose joint in a long masonry wall or concrete slab to prevent cracking during expansion and contraction—similar to an expansion joint.

CURTAIN WALL: A nonload bearing wall placed above a spandrel beam or girder in skeleton-frame construction (see Fig. 5-5).

CAISSON: A watertight compartment sunk below ground water level to facilate the removal of earth and the pouring of piers or piles.

DEFLECTION: The amount of sag at the center of a horizontal structural member when subjected to a load.

DOWELS: Short lengths of steel rod cast into footings or columns for fastening adjoining structural members.

DROP PANEL: A thickened area of a flat slab directly above the column capital (see Fig. 5-19).

DRIFT PIN: A metal pin used in lining up holes and temporarily joining members in steel-frame erection.

ECCENTRIC LOAD: A load applied off of the axial center of a structural member; usually refers to an unbalanced load on a column.

ERECTION MARK: An identification mark or number placed on the end of each steel-frame member to aid in the erection of the structure.

EXPANSION JOINT: See control joint.

FIELD RIVERTS & BOLTS: Rivets or bolts to be assembled at the site.

FILLET WELD: The weld along the interior corner of two steel plates that are at right angles (see Fig. 5-25).

FIRE RATING: The comparative resistance of a material to failure, as stated in hours, when subjected to fire. Ratings are standardized by fire underwriters.

FLANGE: The bottom and top portion of an I beam, wideflange (WF), or channel member (see Fig. 5-3).

FLAT SLAB: A type of reinforced-concrete floor or roof construction having no beams or girders below the underside (see Fig. 5-19).

GAGE (Rivets): The distance in inches between rows of rivets.

GLUE-LAMINATED MEMBERS: Structural timber units constructed from smaller pieces fitted and glued under pressure in the shop.

HEADER COURSE: A course of brick with the ends exposed, to bond brick veneer to the subwall. It is usually placed every sixth course.

HIGH-STRENGTH BOLTS: Fastening bolts made of superior strength steel used to connect members together in steel-frame construction.

INVERT ELEVATION: The height at which a drainage line must join a manhole or main for proper drainage.

KICK PLATE: A metal plate fastened to the lower part of a door to prevent damage to the door (see Fig. 5-40).

KIP: A unit of 1000-lb. load.

LATERAL BRACING: Usually diagonal bracing in the structure to counteract wind pressures (see Fig. 5-2).

LOAD FACTOR: The number that results by dividing the failure load by the working load. Often substituted for the safety factor in codes and specifications.

LIGHT-STEEL FRAMING: Construction utilizing light steel members for the structure in smaller buildings.

LUG SILL: A stone or concrete sill under windows. The sill is wider than the window opening and is set into the adjoining masonry.

METAL SHOE: A boxed steel plate used to receive a wooden beam, arch, or column (see Fig. 5-6).

MOMENT: The result of a load on a member, creating a tendancy of the member to rotate about a given point or axis that is within its cross section. Moments are measured in foot-kips, foot-pounds, or inch-pounds.

MOMENT DIAGRAM: A graphic description of the moments along a structural member.

PANS (Forming): Steel forms in the shape of pans, used in forming ribbed and waffle-type concrete floors and roofs.

PEDASTAL: A column base or support that is placed between the column and its footing.

PILE: A long shaft of wood, concrete, or steel driven or cast into the ground to give added support to a foundation supporting heavy loads. It may also be used when stable soil or rock is far below unstable surface soils (see Fig. 5-13).

PITCH (Rivets): The distance between centers of each rivet.

PLATE GIRDER: A steel girder built up with a plate web and angle sections as flanges.

POSTENSIONING: A type of prestressed concrete that is given compression *after* the concrete has set.

PRETENSIONING: A type of prestressed concrete in which the steel is given tension stresses *before* the concrete has set.

PRECAST CONCRETE: Concrete units cast and finished before being erected into place.

PRESTRESSED CONCRETE: Concrete members that have been placed in a state of compression prior to being loaded. The compression is generally induced by tensioning steel tendons. The technique allows longer spans with less materials.

RELIEF ANGLE: A steel angle attached horizontally to the structural frame of a building for the support of masonry veneer that is beyond the support of the main framework (see Fig. 5-5).

RIBBED SLAB: A type of concrete floor construction having ribs (sometimes called joists) formed on the underside of the slab.

RIGID FRAME: A structural system utilizing rigid structural connections between the beam and column elements. Frequently the beam elements are placed on a slope.

ROLLED SECTION: A structural steel member, such as an I beam or wide-flange (WF) section, that is formed into its shape by hot rolling at the mill.

SAFETY FACTOR: The number that results from dividing the ultimate strength by the allowable working stress. Codes regulate the minimum safety factor required in many areas.

SCARFED JOINT: A joint (usually in wood beams) made by notching or grooving adjoining pieces so that the ends lap over and are firmly joined into one continuous piece.

SCUPPER: An opening in a wall for the release of water from a floor or roof.

SEATED CONNECTION: A connection in steel-frame construction having a horizontal seat, formed by an angle connector, for a beam or girder to rest upon (see Fig. 5-31).

SHEAR: A condition in a member resulting from forces or load placement that causes a sliding tendancy within the cross section of the member.

SHEAR DIAGRAM: A graphic description of the shear forces in a loaded structural member.

SHOP RIVETS: Rivets that are fastened in the shop before the steel members have been delivered to the site (see Fig. 5-24).

SHORING: Wooden posts or shores used to support walls or other parts of a building during construction.

SKEW BACK: A sloping surface or a diagonal unit against which the end of a curved arch rests or abuts.

SLIP SILL: A beveled cast concrete or stone piece placed below a window to shed water. It is the same length as the width of the window opening.

SOIL BORING: Boring of subsurface soil for the purpose of investigating the load-bearing and stability characteristics of the site.

SOIL-CEMENT: A mixture of soil and cement for the purpose of obtaining an economical, stable material. Mainly used as a paving underlayment.

SPANDREL BEAM: A horizontal beam supported by columns on each end in skeleton-frame construction.

SPLIT-RING CONNECTOR: A split, circular metal ring inserted into grooves between two wood members of a joint. A bolt in the center passes through both members and creates extreme resistance to shear.

SPREAD FOOTING: A concrete footing that is wider than the structural member it supports and is for the purpose of spreading the load to the soil or foundation (see Fig. 5-10).

STEEL JOIST: A light steel beam made from bars, [illegible] or angles welded into rigid units (see Fig. [illegible]). They are also made from light rolled sections.

STRIPPING: The process of removing the forms from poured concrete after it has hardened.

STIRRUPS: Wood construction—vertical steel [illegible] to support the ends of a beam or joist.

Concrete construction—steel rods [illegible]

formed to surround the horizontal reinforcing near the ends of a concrete beam for the purpose of increasing the resistance to shear (see Fig. 5-15).

SUSPENDED CEILING: A ceiling hung below the underside of a concrete slab or other structure. Wire and channel sections are commonly used to support the ceiling material (see Fig. 5-34).

TEMPERATURE RODS: Steel rods placed perpendicular to the main reinforcing in slabs to counteract the tendancy to cracking during the concrete hardening process and later from expansion and contraction during temperature changes.

TENSION: The stress or force in a material caused by a pulling action, which tends to create a lengthening of the material.

TIMBER CONNECTORS: Metal pieces and devices used in timber construction to contribute greater rigidity and strength to bolted connections of the members (see Fig. 5-6).

TRANSOM: A small window above a door or other window.

TWO-WAY SLAB: A concrete slab floor or roof in which the reinforcing steel in placed in two perpendicular directions (see Fig. 5-18).

ULTIMATE STRENGTH: Generally used in reference to the testing of structural materials. The strength of a material varies during the application of stresses; the point at which the greatest strength is obtained is called the ultimate strength.

VESTIBULE: A small entrance hall next to the entrance of a building (see Fig. 5-38).

VERTICAL STIFFENER: Metal angles or plates fastened to steel members where concentrations of stress occur.

WEB: The center portion of an I beam, wide-flange (WF), or channel member (see Fig. 5-3).

WEEP HOLES: Small holes near the bottom of masonry walls to allow release of moisture accumulating in the walls.

WEEP WICK: A short length of small rope placed in weep holes to allow seepage of moisture from masonry walls to the exterior, yet not having an actual opening.

WELDED WIRE FABRIC: Steel wires welded together to form a mesh for concrete slab reinforcing.

WIND BRACING: Diagonal struts placed within the structure of a building to resist lateral wind pressures (see Fig. 5-2).

WIND LOADS: Lateral forces acting against a building that must be considered in the design of high-rise buildings especially.

WORKING LOADS: Those definite forces, used in design calculations, that act upon the structural members.

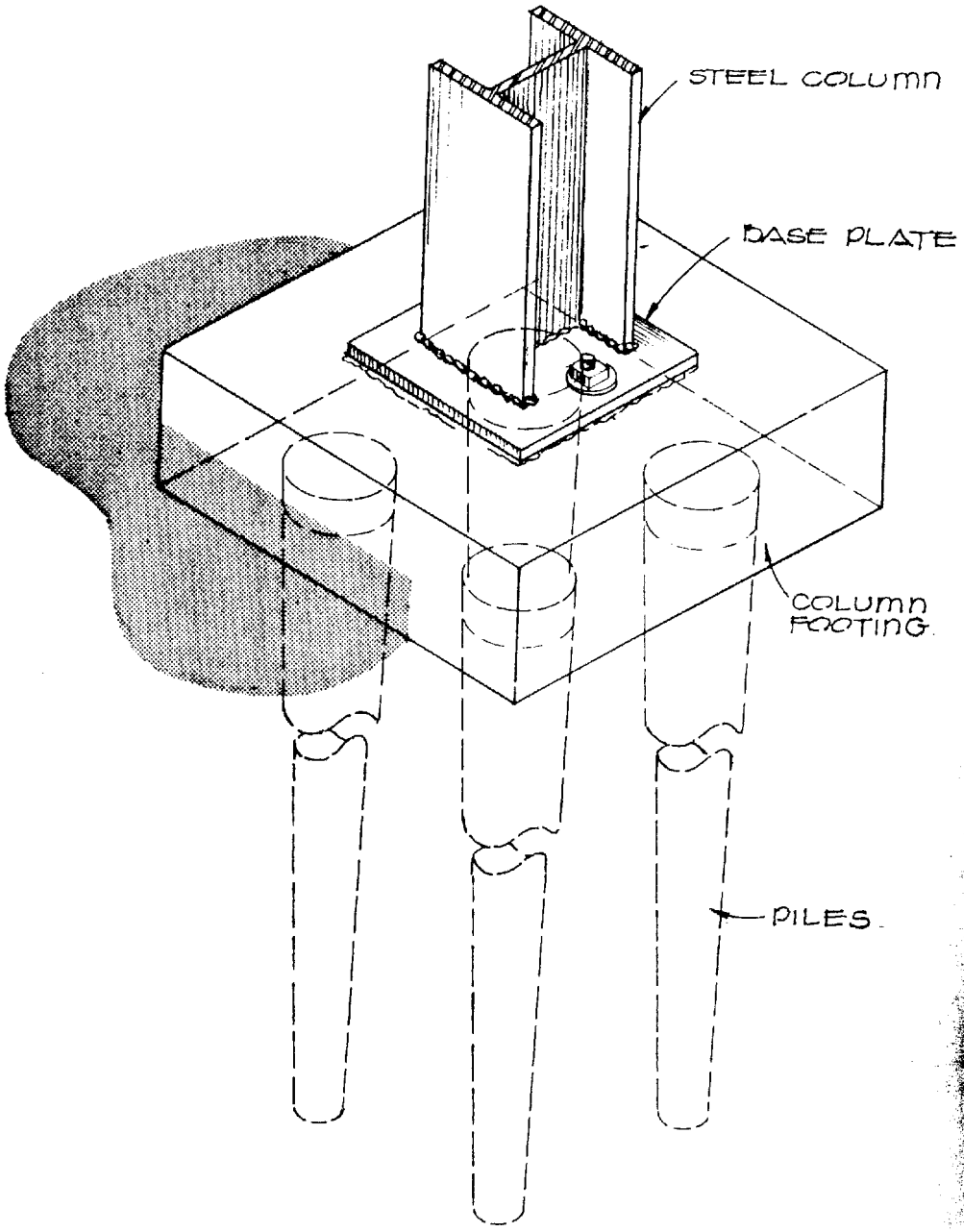


Fig. 5-13 Piling used to support a steel column footing.

H. FOUNDATIONS

1. Boring Logs

Investigation of the soil load-bearing qualities at the site is an important prerequisite before the footings of heavy buildings can be designed. The characteristics of soils vary widely throughout the country and even in local areas. It is general practice to have soil-testing firms make representative borings in the building area so that realistic assumptions can be made. Normally the locations of the borings are indicated on the Site Plan, and sometimes the test results are shown on the drawings in the form of *boring logs*. These graphic logs show the soil, rock, and ground water encountered and their depths.

2. Piling

Depending on the nature of the subsoil and the contemplated weight of the building, *piling* may be necessary for stable support of the foundation. Piles are long lengths of wood, concrete, or steel forced down through soft or unstable strata until they will support the estimated load. Many factors about the structural concept are considered in the selection and use of piling.

On drawings in which piles are used, a pile layout in plan is necessary. Detail drawings of the piles showing sizes, reinforcement, and information about the pile caps are also included in the drawings. Elevation heights are given for the top surface of each pile. Sometimes a pile layout is shown with each pile darkened and the pile footing shown in broken lines. Other layouts may show the piles in broken lines and the footings above in solid lines. Schedules may also be employed to give extensive pile information.

3. Drilled Piers

Some foundation situations may be solved better with the use of *drilled piers* or caissons. These are holes drilled to stable soil or rock and filled with concrete. Some may have belled bottoms to disperse the load over larger areas. Generally, they are not reinforced except for anchor bolts or dowels at their tops. Here again, a plan layout must be shown for the piers, and detail drawings giving sizes, shapes, and elevation heights are needed. Schedules may also be used if extensive piers are shown on the drawings.

4. Grade Beams

Another system for supporting moderately heavy, as well as light, buildings is with the use of *grade beams*. These are continuous reinforced-concrete beams below grade under the exterior walls of the building. They are designed to carry the weight monolithically, with strategically placed piers below the grade beams where concentrations of load occur (see Fig. 5-14). Actually, the piers or caissons act as columns below the grade beams to carry the weight to stable soil levels below. The grade beams are usually reinforced at top and bottom with straight bars rather than bent reinforcing, as is found in typical concrete beams. Stirrups are not required, as a rule. The bars may be indicated with a note on the plan or they may be given on a schedule. Sizes and elevations are also shown by notes on the plan or on typical section views.

5. Wall Footings

Walls (whether load bearing or not) that rest on the ground must have continuous spread-type footings below. The size of the footings is determined by the loads they will carry and the load-bearing capacity of the soil. Frost depths, of course, also determine the depths the footings must be placed below grade. For various reasons, footings are

often placed at different depths below a building; this will be evidenced by the elevation heights shown at different points. Notice in Fig. 5-37 that the top surface of the footings is shown throughout on the elevation views, where the different levels can be easily seen.

Poured concrete, because it can be reinforced to counteract failure from shear and bending, is the most universal material used for footings. Some wall footings may be integral with column footings, requiring only enlargement below the columns where concentrations of load develop; others may show isolated footings for both.

To conserve concrete mass in footings, some are formed in stepped cross-sectional shapes and are termed *stepped* footings. Ideally the footings are designed to provide uniform settlement throughout the building. Uniform settlement of the entire building is not objectional; eccentric settlement, on the other hand, can lead to extensive structural damage.

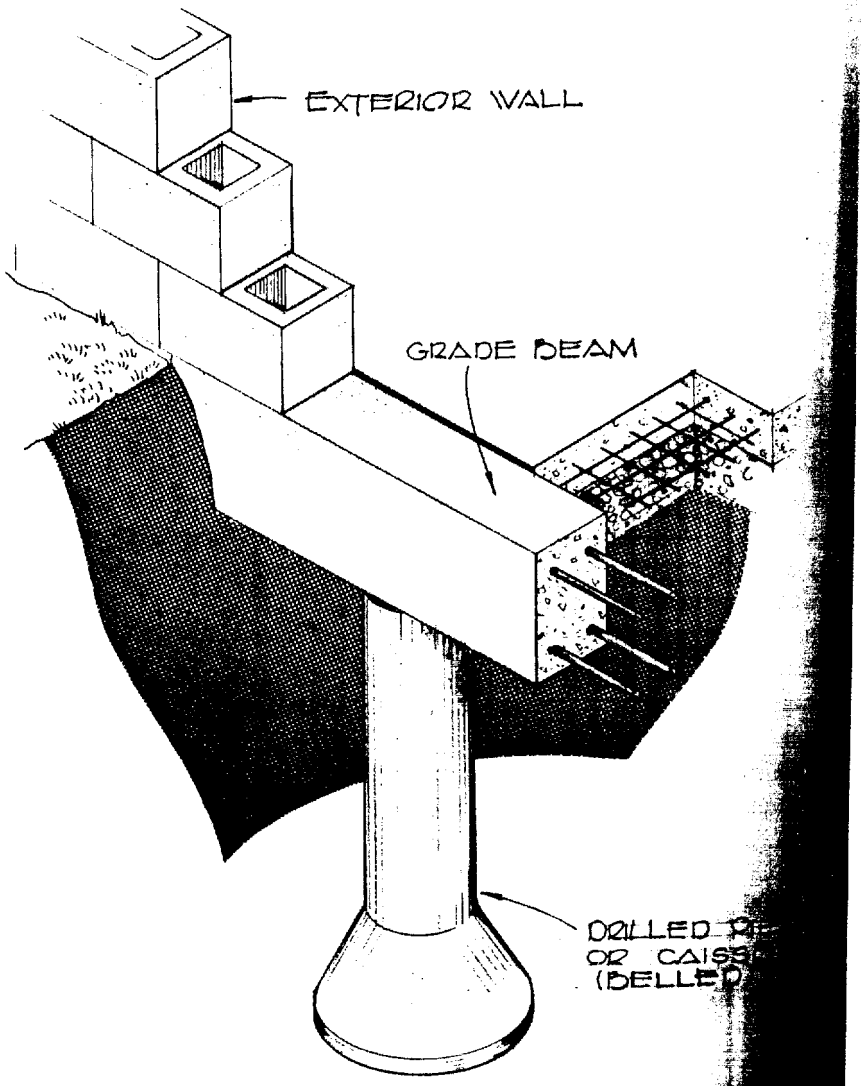


Fig. 5-14 The appearance of a grade-beam foundation.

Continuous footings are ordinarily shown with broken lines on the plan and are detailed in section views to reveal sizes and steel placement. Footing schedules may also supplement the sections in giving size and reinforcement information.

6. Column Footings

Isolated footings are often used to support the concentrated loads at the columns in heavy buildings. The footings are square or rectangular in shape and are reinforced with rods in both directions near the bottom (see Fig. 5-11). Sometimes a *combined footing* is designed to carry the loads of several adjacent columns. Reinforcing steel *dowels* are cast into the footings to anchor concrete columns, whereas *anchor bolts* are used to attach steel-frame column bases. When necessary, piles or drilled piers may be indicated below isolated footings.

Each footing is identified on the drawings with a mark—often the mark identifies both the footing and the column it supports. Some drawings give each footing a different mark in uniform sequence. Others give the same mark to all footings having the same size and steel reinforcement to avoid repetition in the schedules and notes. Each type of column footing is also drawn in section to show the shape and steel reinforcing. Schedules commonly identify size, top elevation, steel reinforcing, and dowels or anchor bolts (see Fig. 5-11). Location dimensions are seldom needed for footings, for their centers coincide with column centerlines.

I. STRUCTURAL SYSTEMS

1. Masonry Bearing Walls

As we mentioned earlier, masonry bearing-wall construction utilizes the strength of the walls to support the weight from the floors and roof of the building. Many small commercial buildings employ this structural system, and it is frequently used in parts of larger buildings having other types of structures.

In reading a drawing, you should be able to recognize the principle by the absence of columns throughout the walls and by the nature of the section details. Structural members for support of floors or roof with the bearing walls may be wood, trusses, steel bar joists, steel beams, or precast concrete joists. Many variations are possible; some may have intermediate columns or posts throughout the interior if long spans are necessary, yet the walls are made load bearing.

For economy and appearance, most walls are veneered and may be either cavity or solid. Codes regulate the thicknesses according to heights and loads imposed upon them. Frequently, metal ties are shown to bond the veneer to the subwall, and horizontal and vertical reinforcement may be required within the walls. Metal bearing plates are often used below steel bar joists and beams to spread the load to the wall. All openings in the walls should have lintels (usually steel angles) to

support the weight above the openings. You will notice that metal flashing is shown within the walls at critical points to protect the structure from moisture seepage.

Bond beams are widely employed in concrete block walls to provide bearing for beams or joists. They also may serve as lintels or as a continuous tie around the entire upper part of the wall. Usually the beams are made with hollow units filled with concrete and steel reinforcing bars.

Various types of metal anchors embedded into the mortar joints of masonry walls are used to prevent lateral movement of beam or joist members.

a. curtain walls

Curtain walls may be placed within the vertical framed planes of a skeleton-frame building, or they may be placed outside the framework to form the complete outer skin of the building. They carry no loads other than their own weight; therefore their function is somewhat different from bearing walls. This difference should be kept in mind when reading the working drawings. In high-rise buildings, the curtain walls are generally the same thickness throughout. As a rule, 8″ subwalls are supported on the spandrel beams with a 4″ thick veneer bonded to the subwall or supported with metal anchors and relief angles attached to the framework.

Masonry curtain walls are made from concrete block, brick, tile, stone, precast concrete panels, etc. In some buildings, the walls are formed mainly of glass set in aluminum frames throughout the major walls of the building. Also, many paneled materials (sandwich panels) having good weather resistance and insulating qualities are used for curtain walls.

Details of the curtain walls must be carefully studied to understand their relationship to the frame and their method of support. Sometimes the curtain walls are keyed to the frame, and the frame is left exposed. Other details may show the frame enclosed within a cavity type wall. Many architectural treatments are possible with the selection and treatment of the curtain wall materials.

b. partition walls

Partitions within a building may be load bearing or nonload bearing. In small buildings with exterior bearing walls, the major partitions very often are also load bearing. This results in economy of floor and roof framing because of the shorter spans. In larger, skeleton-frame buildings, the partitions are commonly nonload bearing and are made with light-weight masonry materials. Major considerations are rigidity, fire resistance, and good sound isolation qualities.

On ground floors, light partitions may rest on slabs that have been thickened to carry their weight, or small footings may be shown below the walls. In upper levels of multistory buildings, the partitions usually are placed directly over beams, or additional support is provided in the floor framing for them. Generally 4- or 6″- thick concrete block or

tile with plaster finishes is used for single-story heights. Lighter partitions may use metal studs and gypsum board or plaster coverings. Some codes allow the use of wood studs for interior partitions.

The interpretation of partition walls is not complex on drawings. Plan views indicate both their placement and the materials required; a typical section may also show further information.

2. Concrete

Until lately *reinforced-concrete* structural systems have mainly been used for large, complex buildings; but in recent years, with advanced techniques in design, quality control, forming, etc., many smaller buildings are being built with the system. As we mentioned, this material seems to have the brightest future in the construction industry.

Basically a reinforced-concrete structure employs the material for all its structural members, including footings, columns, girders, beams, floors, and roof. Elaborate schedules are often necessary to reduce the number of drawings. Yet many sections are still required, and a careful organization of the various drawings is an important task of the architect and the engineer.

The steel reinforcing bars are shown on the structural drawings with bold, heavy lines, whereas the outlines of the concrete are made with somewhat lighter lines. No concrete symbol is ordinarily shown on the sections other than, perhaps, a light pencil shading within the concrete area. Sometimes it is even left blank to save drafting time. Openings in a concrete slab floor for stairs, elevators, chases, etc. are often indicated on the plan with light diagonal lines drawn from the corners of the openings, with the word OPEN placed within. Diagonal lines through areas of a slab may also indicate variations in the slab level.

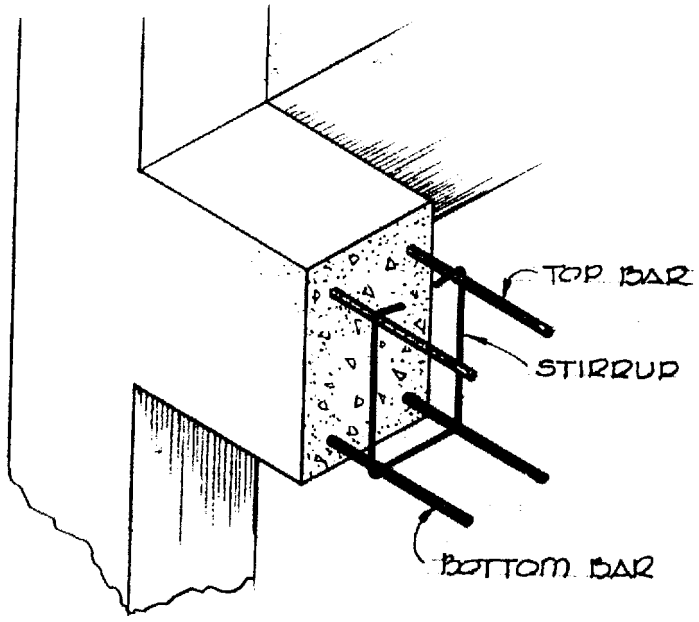


Fig. 5-15 Stirrups used in concrete beam reinforcement.

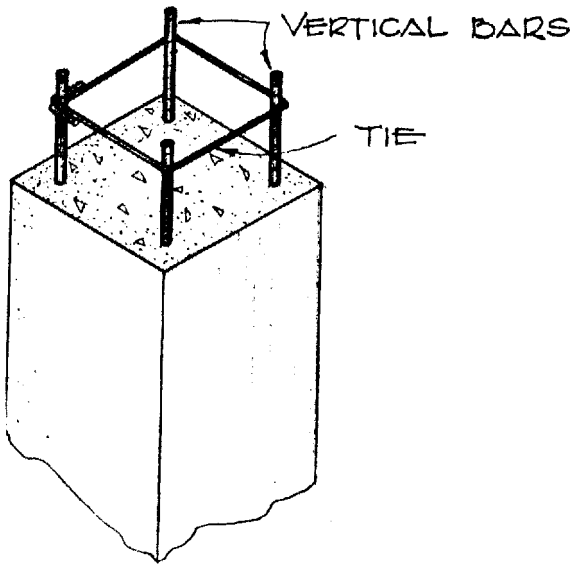


Fig. 5-16 (A) Horizontal ties used in column reinforcement.

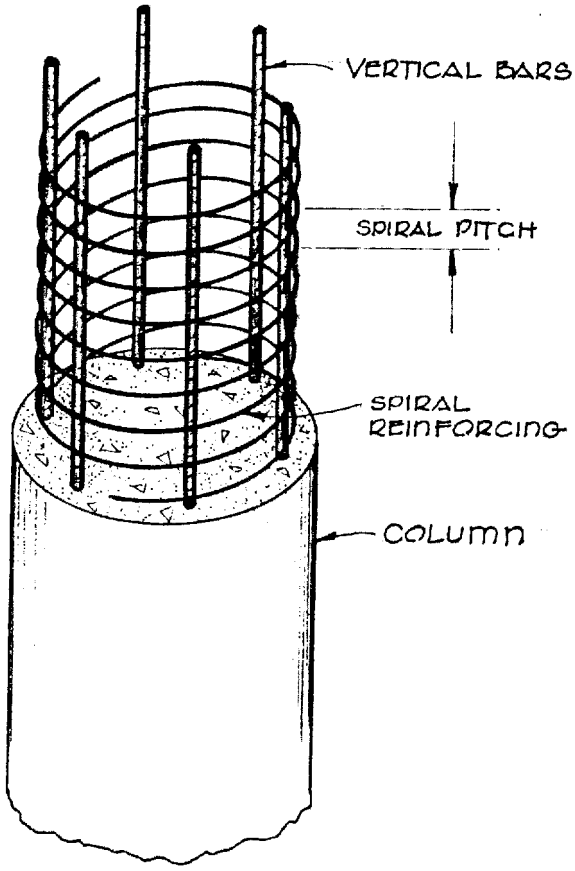


Fig. 5-16 (B) Spiral reinforcement in columns.

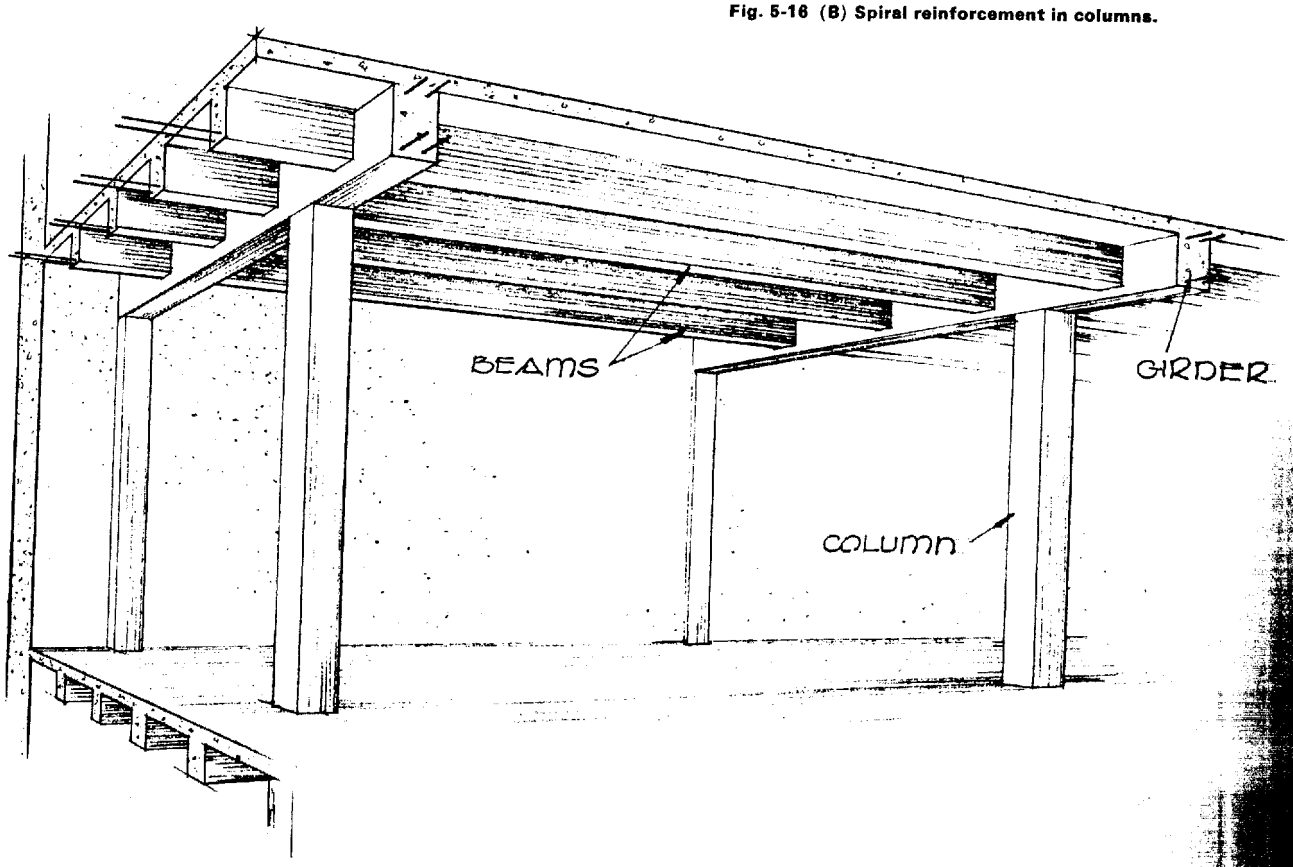


Fig. 5-17 Beam-and-girder construction is commonly used to support one-way slabs.

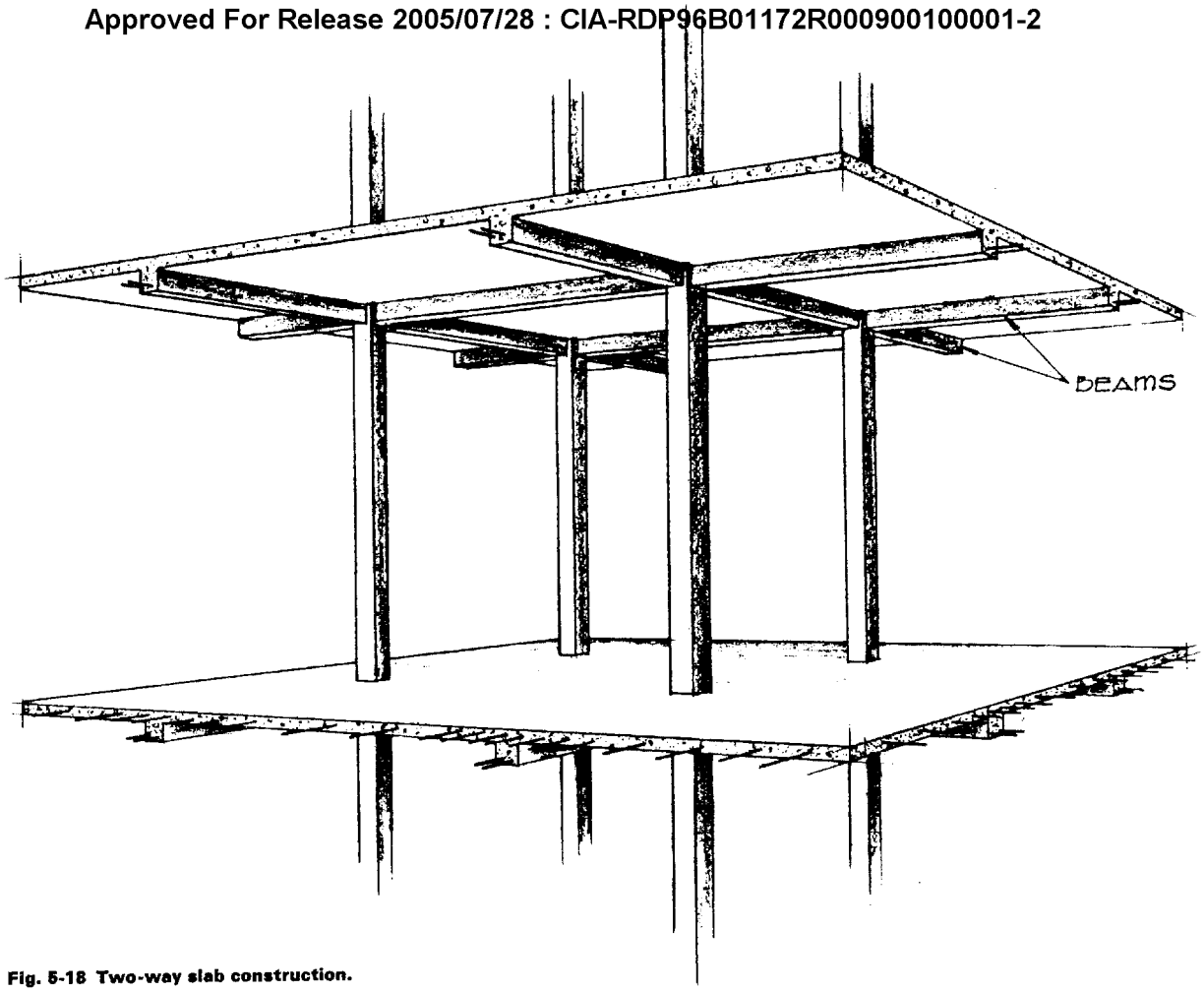


Fig. 5-18 Two-way slab construction.

Important structural heights, such as the top or bottom surface of footings, the tops of beams or girders, or floor levels, may be indicated with an elevation on the plans. These elevations may be shown in feet and inches (Elev. 99′6″) or as feet and decimal parts of a foot (Elev. 99.5′). Sometimes these heights are placed on typical sections.

One of the numbering systems is commonly employed to identify the column footings (often the same as the columns) on the plan, and the sizes and reinforcement needed are placed in the *footing schedule.*

Because of the load variations often imposed upon various columns in a building, *column schedules* are the simplest method of handling all the size and reinforcing information (see Fig. 5-11). Columns may have their vertical bars enclosed either with ties or with a continuous spiral. Details of column splices at the different floor levels should be shown with a vertical section. Sometimes one will notice that column loads (in kips) are placed near each column. This may prove helpful if upper floors are to be added later or if future remodeling becomes necessary.

a. slab floors and roofs

Other than slabs-on-ground, which are discussed in Chapter 3, a number of systems are used to construct the floors and roof of reinforced-concrete buildings.

A *one-way slab,* with the main reinforcing rods placed in one direction (the shorter dimension in rectangular bays), is the simplest

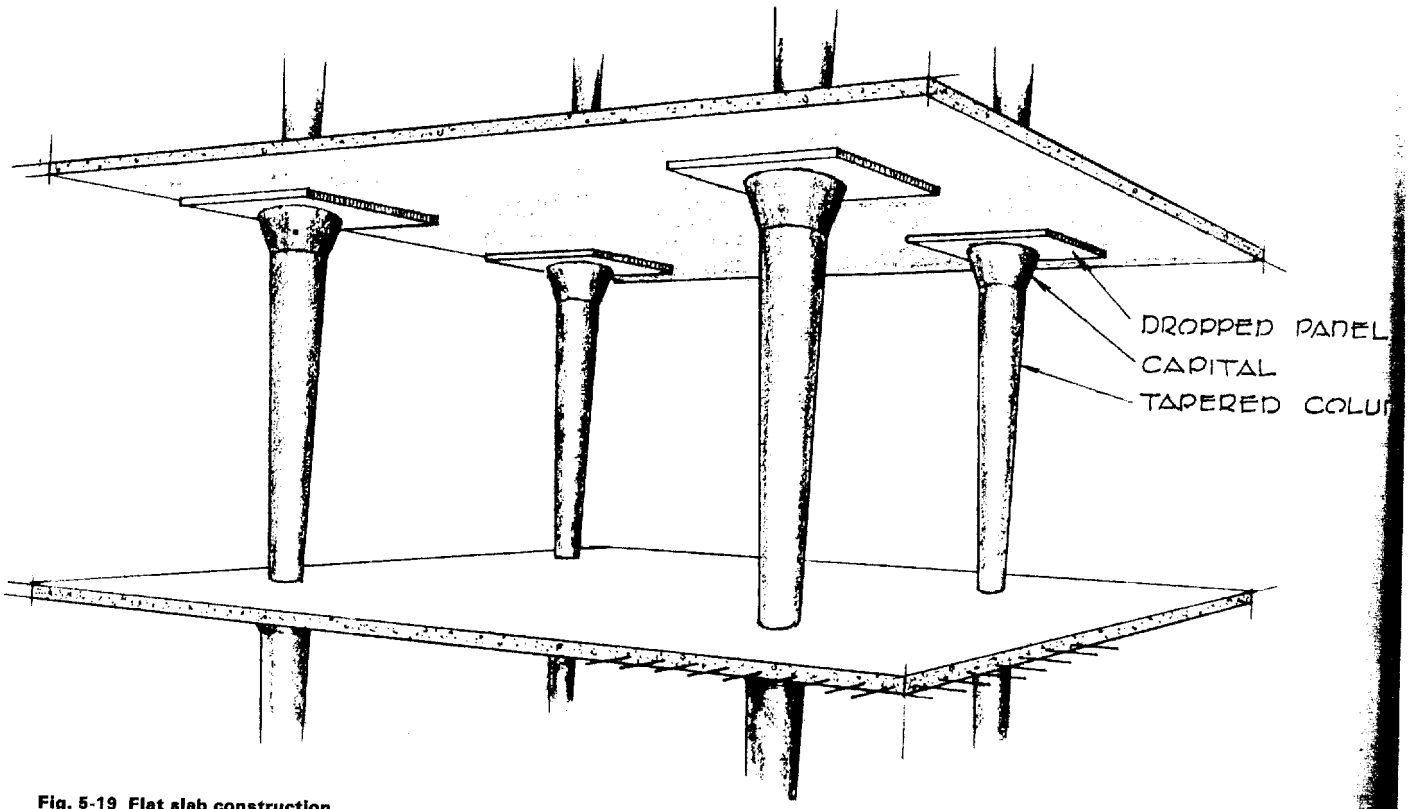


Fig. 5-19 Flat slab construction.

type of concrete floor. The slab must be supported by a concrete or steel beam. For a single span, details will show the bars spaced at regular intervals in the bottom of the slab. If the slab is supported over several beams or parallel walls, the bars are usually bent to the top of the slab over the support. One-way slabs are typically supported by beam-and-girder type construction (see Fig. 5-17).

In concrete slab roofs and floors, "temperature" bars are often noted. These bars are placed perpendicular to the main or load-carrying reinforcing and resist shrinkage cracking during the "setting-up" period of the concrete. They also help resist cracking due to temperature changes during the life of the slab. A note such as #4 @ 12″ TEMP. indicates reinforcement for this purpose.

Beams or girders are the horizontal structural members supported by the columns. Girders support beams and are in turn supported by either other girders or by columns; beams may be supported by girders or columns. Details shown on the drawings should reveal a logical system of showing spans, cross-sectional sizes, both horizontal and vertical steel arrangements, as well as bar sizes and spacing. Beams often vary in size and amount of steel required to sustain the various loads. Therefore each beam or girder in a complex building is listed in a *beam schedule* (see Fig. 5-10).

Another system, called a *flat slab*, is constructed without beams and with the main reinforcing placed in two or more directions. Only columns, usually having enlarged capitals, are used throughout the interior for the slab support. Thickened areas of the slab directly over the columns are called "drop panels" (see Fig. 5-19). Generally the steel is placed in "bands" and is specified as either a "column strip" over the

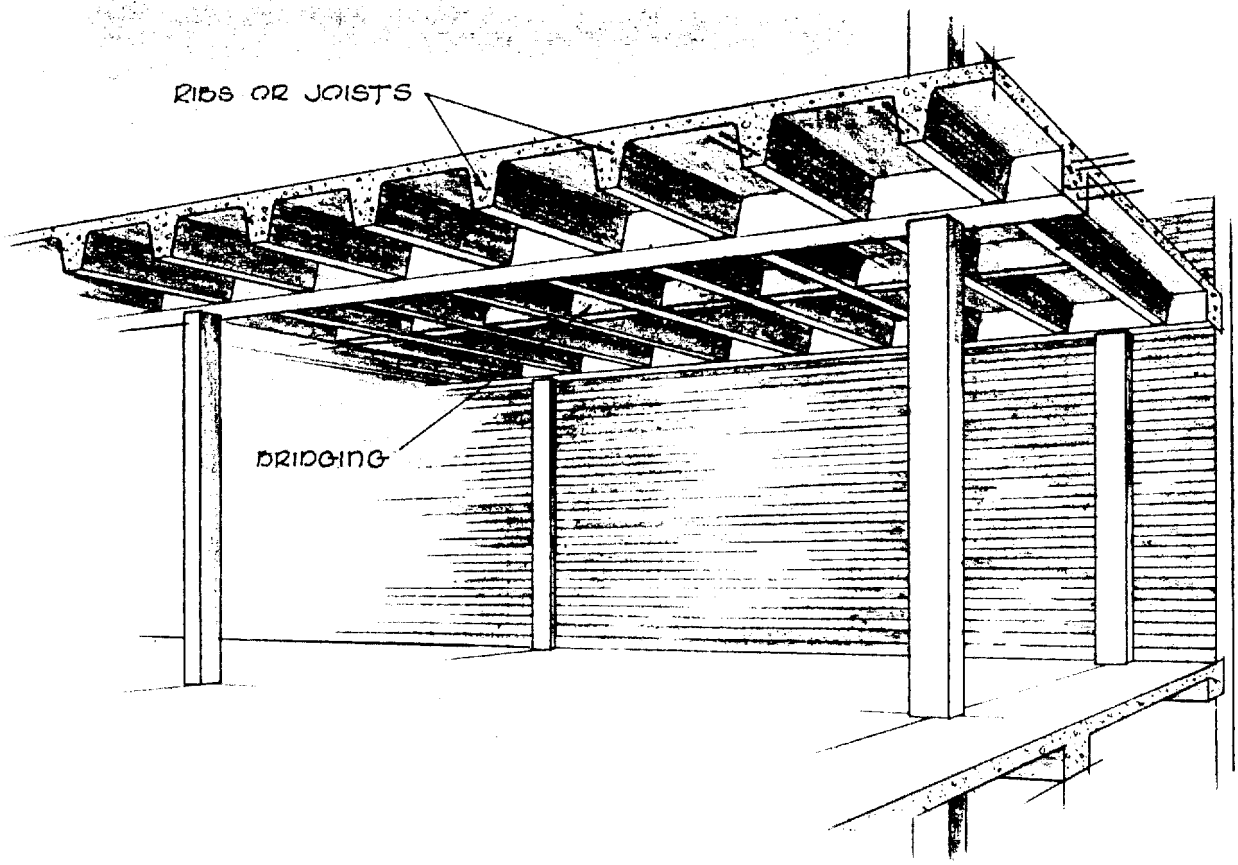


Fig. 5-20 Ribbed slab construction.

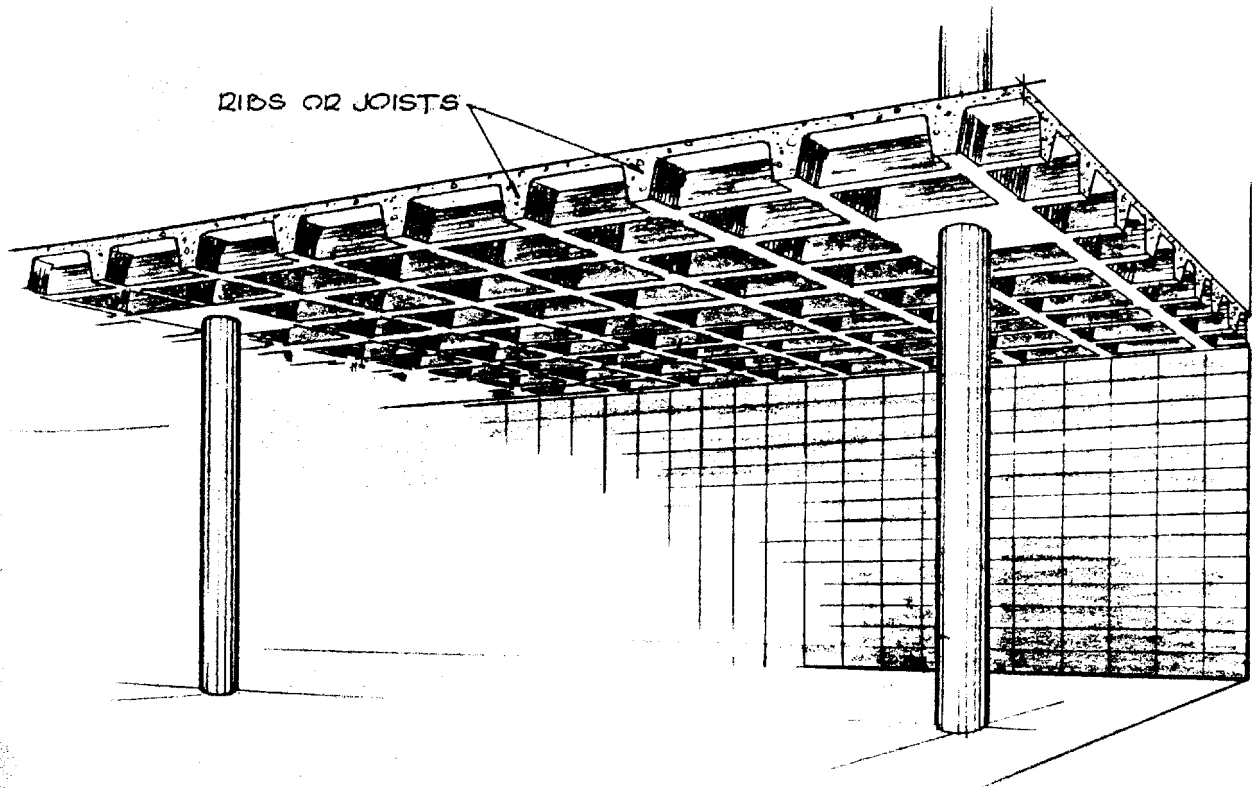


Fig. 5-21 "Waffle" floor construction.

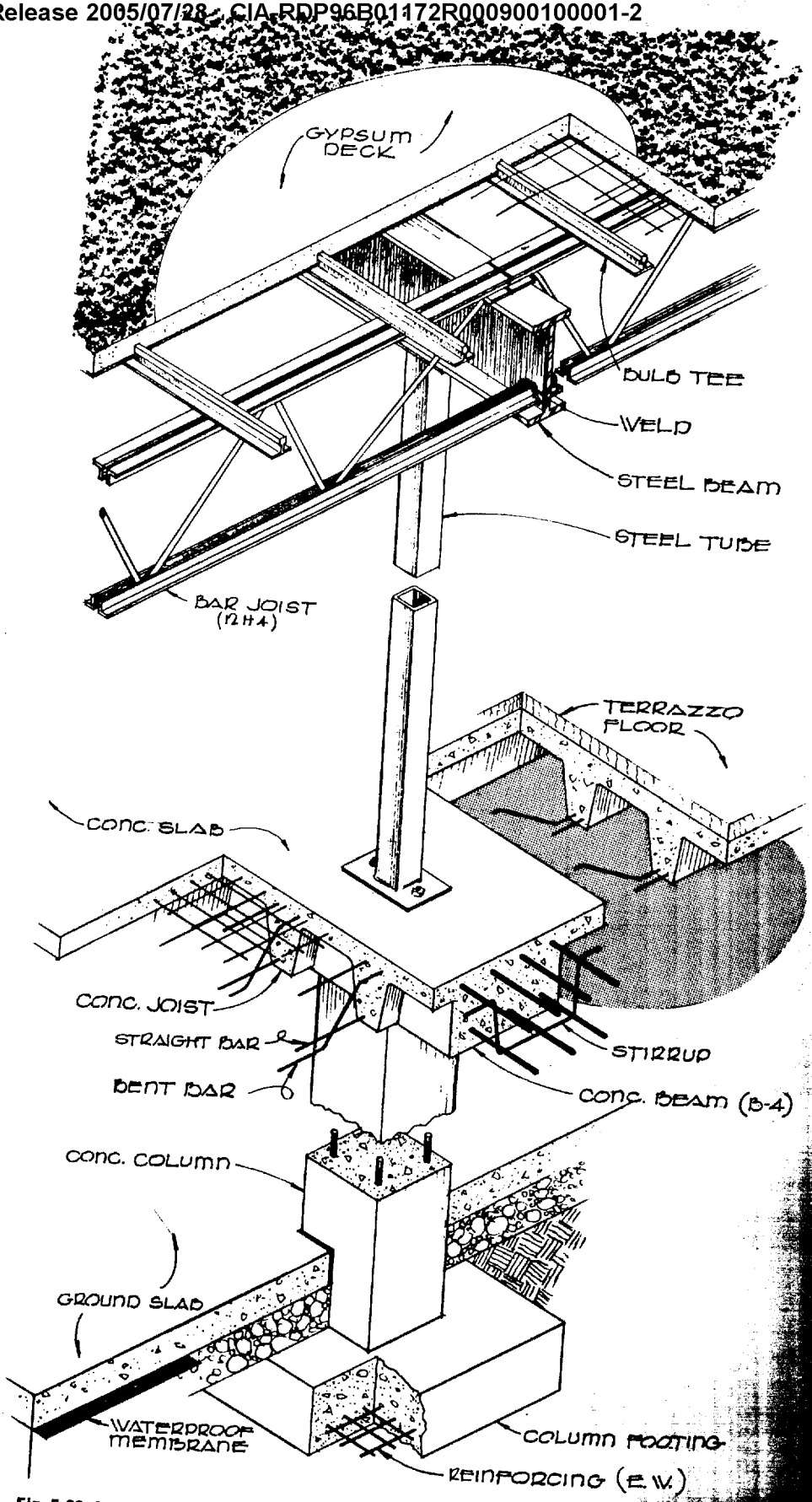


Fig. 5-22 A pictorial section of the Medical Arts Building structure at a center column.

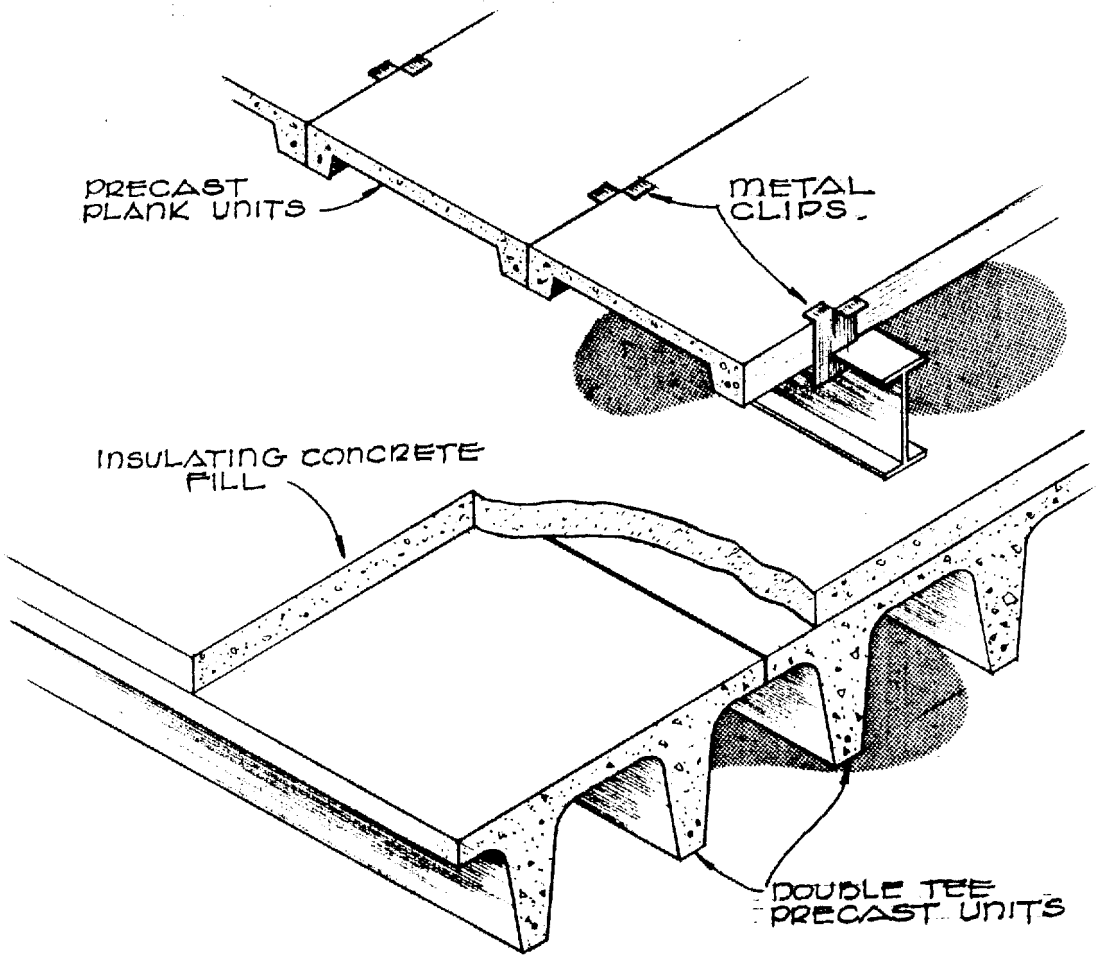


Fig. 5-23 Precast concrete units used for roof and floor decks.

columns or as a "middle strip." The middle strip consists of that half of the span midway between the columns. Careful details of these important points must be shown on the drawings. A floor framing plan with this type of slab ordinarily shows the steel band locations with shaded areas, the drop panels with broken lines, and the columns with darkest tones.

Another popular concrete floor system, called a *ribbed slab* or joist construction, consists of a thin slab (2″ or 2½″ thick) supported on concrete joists spanning between beams (see Fig. 5-20). When the joists run in two directions, it is called a *waffle slab* (see Fig. 5-21). The ribs are cast between metal pans placed in the forms, or sometimes filler blocks may be used. The system therefore decreases the amount and weight of the concrete needed; yet long spans are possible. Two reinforcing rods are usually placed in the lower part of the ribs, and wire fabric or small bars span between joists. Sometimes stirrups are required. Because of their appearance, waffle slabs are often exposed from below to produce interesting ceilings. Otherwise, the ceilings are ordinarily covered with suspended ceiling materials. As a rule, the shape of the supporting bays is influential in determining whether one-way or two-way slabs are best employed.

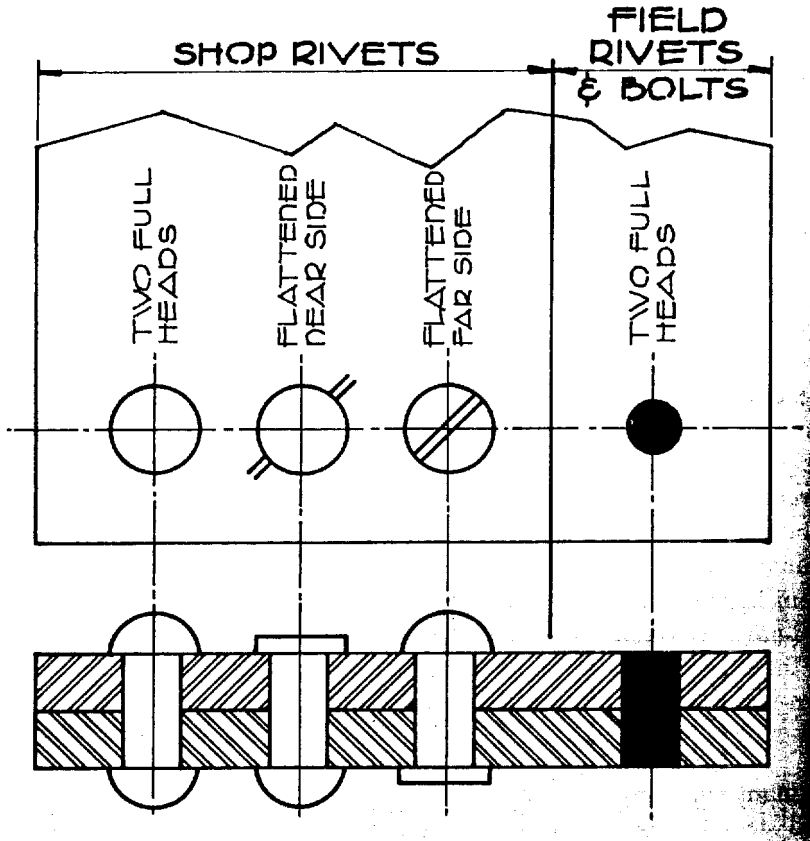
b. precast units

In many cases precast concrete joists, made with light-weight aggregate and steel reinforcing bars, are used as the floor structure, with either

concrete or steel-frame construction. Some are placed on bearing walls. The precast units are manufactured to specifications supplied in the drawings and delivered to the job, ready to be lifted into place. Slabs placed over the units may be poured in place or they may be precast units also.

For longer spans, *prestressed* units may be employed. Numerous plants now manufacture custom-designed prestressed beams and joists, as well as other standardized units, for various applications (see Fig. 5-23). Prestressed units are cast with the steel reinforcing under tension (pretensioning), producing longitudinal compressive stress in the concrete and resulting in less deflection when the unit is subjected to load. Economy in both the material and weight is effected and longer spans are possible. In some units, the steel is given tension after the concrete is cast (postensioning). Some units are made in the form of a wide "T" section and placed against each other in the floor, thereby eliminating the need for slab forming or for placing cast units over them. Various other shapes and units are available for prestressed concrete floors and roofs.

Precast joists or other units in the structure require a placement layout or diagram and an identification method, either by note or with the use of a schedule, as to sizes and placement. After engineering



construction drawings.

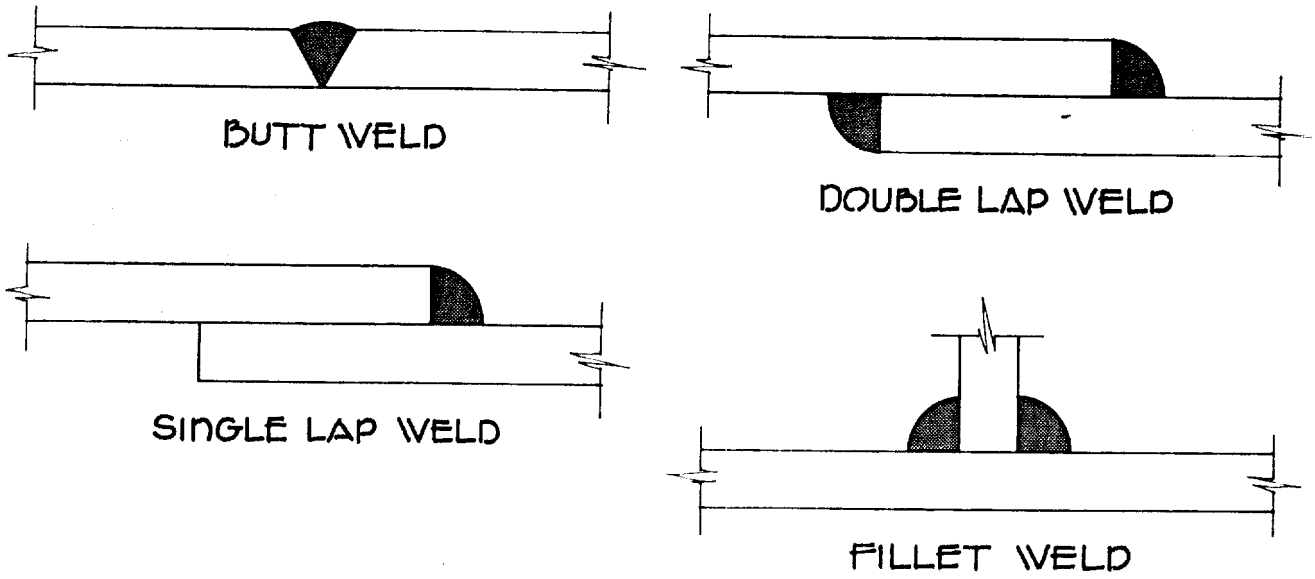


Fig. 5-25 Typical construction welds.

calculations have been furnished in the structural drawings, shop drawings are made by the supplier for the different units before they can be fabricated.

Further information on the technical characteristics of the various types of reinforced concrete roof and floor slabs can be obtained from the Portland Cement Association, Old Orchard Road, Skokie, Ill. 60076.

3. Steel

Steel-frame buildings may have one or several structural systems employed throughout. High-rise steel-frame buildings, generally use the *beam and girder* system. Here the columns resting upon isolated footings continue up to the top of the structure. At each floor level, girders are attached to the columns and beams are attached to the girders, which, in turn, create rectangular or square bays for the purpose of supporting the floor slabs. Variations, of course, exist for almost every building, but in simple terms this is the framework of the major steel members. Beams framing directly into columns are referred to as spandrel beams, as the discussion on concrete buildings mentioned.

Various masonry materials may be used for the walls; even glass may be used for considerable expanses of the walls. The masonry is usually veneered on the exterior with thinner weather-resistant materials having attractive textures and colors. Angle shelves anchored to the steel frame, called relief angles, or various other metal anchors are utilized to support or attach the veneer to the subwalls.

Each column and its bearing plate must be anchored to its footing with anchor bolts. Although the column lengths are generally several stories high, each tier is erected one at a time, with careful consideration given to the column splices. Wide-flange sections are the most common ones used for the columns, and the splices are placed 2 or 3

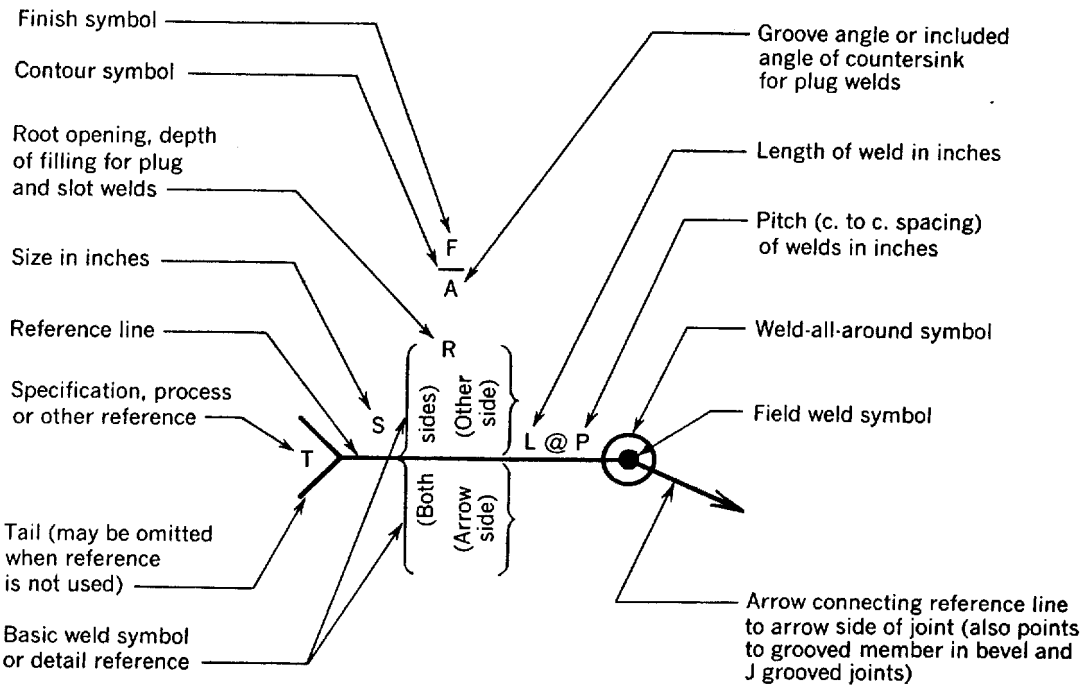
BASIC WELD SYMBOLS

BACK	FILLET	PLUG OR SLOT	GROOVE OR BUTT						
			SQUARE	V	BEVEL	U	J	FLARE V	FLARE BEVEL
									

SUPPLEMENTARY WELD SYMBOLS

	WELD ALL AROUND	FIELD WELD	CONTOUR	
			FLUSH	CONVEX
				

STANDARD LOCATION OF ELEMENTS OF A WELDING SYMBOL



Note:

Size, weld symbol, length of weld and spacing must read in that order from left to right along the reference line. Neither orientation of reference line nor location of the arrow alter this rule.

The perpendicular leg of  ,  ,  ,  weld symbols must be at left.

Arrow and Other Side welds are of the same size unless otherwise shown.

Symbols apply between abrupt changes in direction of welding unless governed by the "all around" symbol or otherwise dimensioned.

These symbols do not explicitly provide for the case that frequently occurs in structural work, where duplicate material (such as stiffeners) occurs on the far side of a web or gusset plate. The fabricating industry has adopted this convention; that when the billing of the detail material discloses the identity of far side with near side, the welding shown for the near side shall also be duplicated on the far side.

Fig. 5-26 Welding symbols used on drawings. (Courtesy of the American Institute of Steel Construction.)

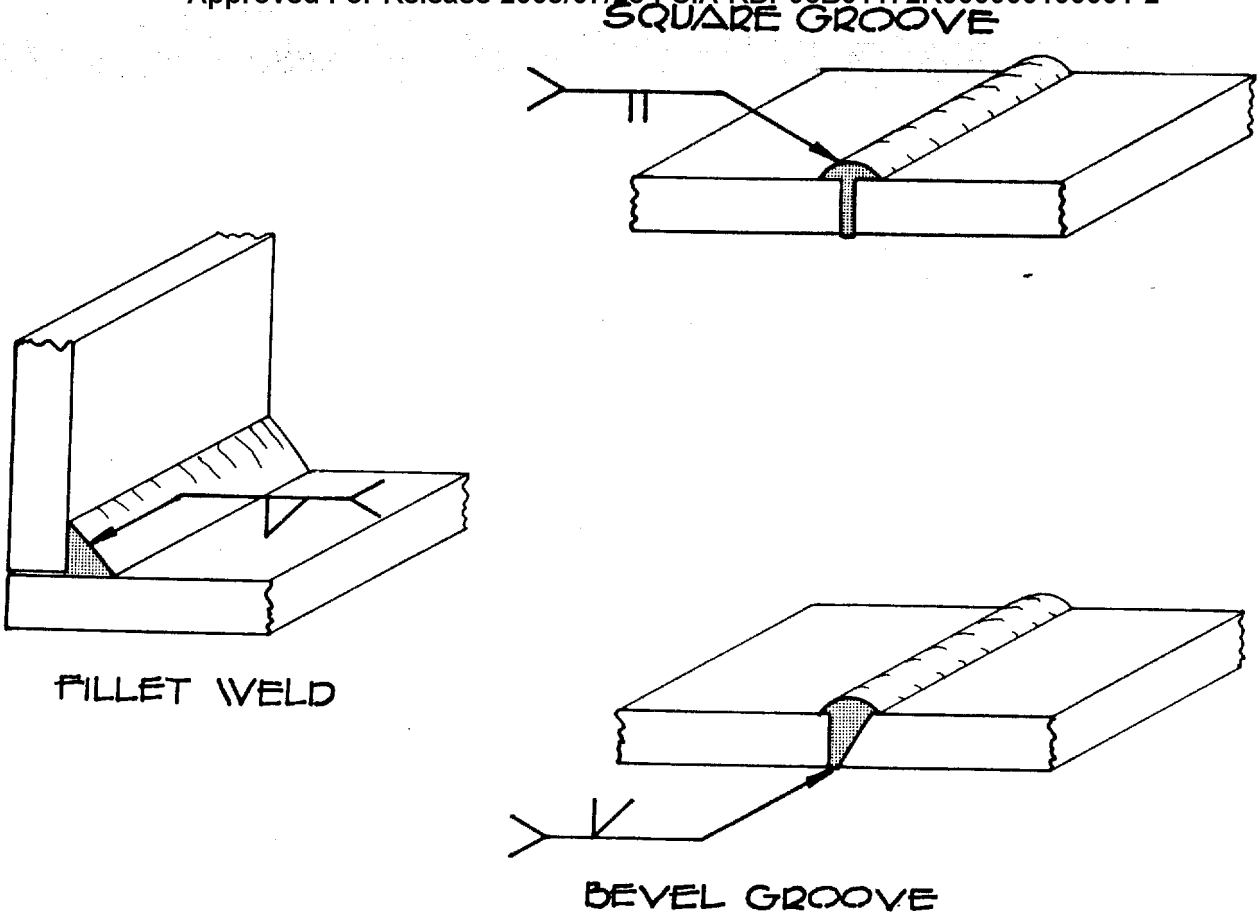


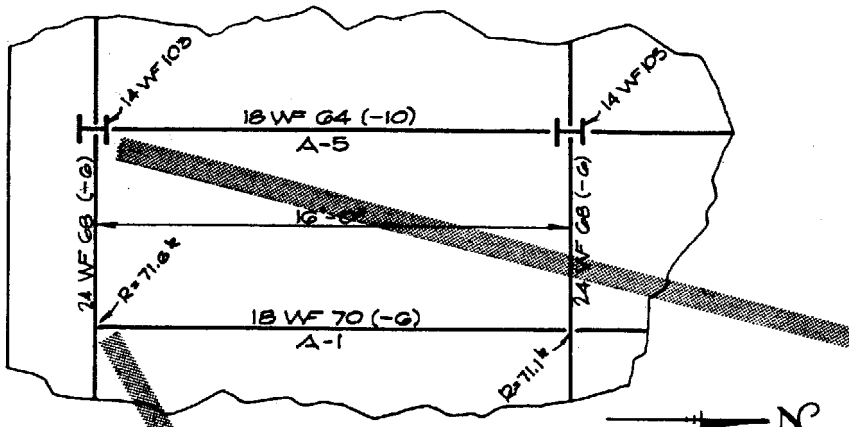
Fig. 5-27 Weld-joint symbols commonly encountered on construction drawings.

ft. above floor levels for structural reasons as well as to prevent interference with girder-to-column connections. Although steel manuals provide the allowable loads for the standard types and their various sizes, connection details must be shown on the structural drawings (see Fig. 5-28).

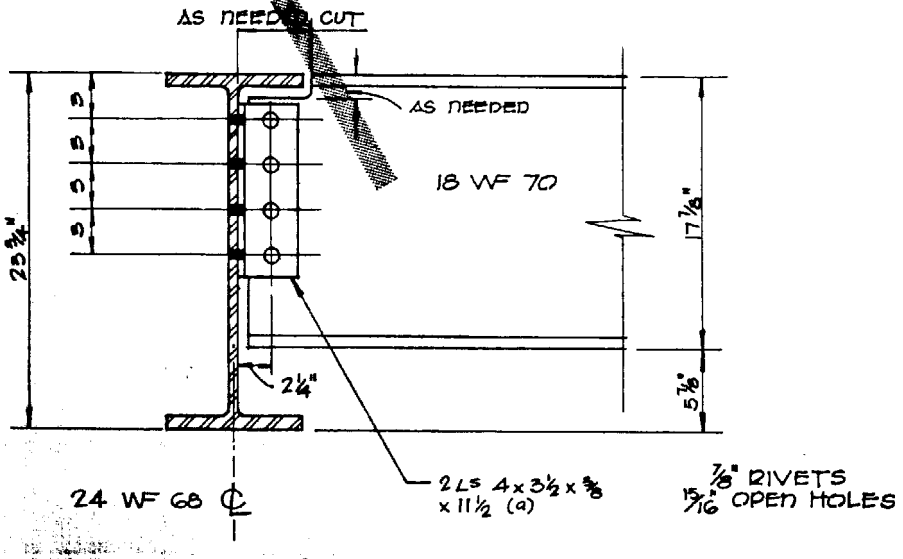
Column schedules for steel buildings give the steel section for each floor, location of splices, elevations of floor levels, and lengths of the columns. Typically, a space between two vertical lines is used to represent each column, and the schedule is arranged to appear similar to the height of the building (see Fig. 5-32). Associated details often accompany the schedule.

Structural drawings must be complete and understandable so that the fabricator can produce and erect the members accurately and economically. Shop drawings by the steel fabricator show how each piece is cut and fabricated, plus how it is erected. Each steel member is given an erection mark, usually on one end, to aid in the erection.

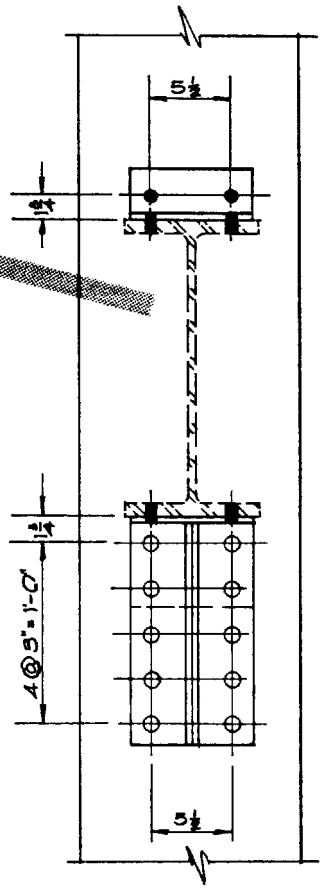
Concrete floor slabs of one type or another are universally utilized in steel-frame buildings. Many are similar to those used with reinforced-concrete construction; in fact, steel buildings are often combinations of both steel and concrete construction. In addition to one-way or two-way floor slabs, steel decking floors, tile or concrete block filler floors, concrete pan floors, precast concrete floors, or slabs on open-web steel joists may be shown on the drawings.

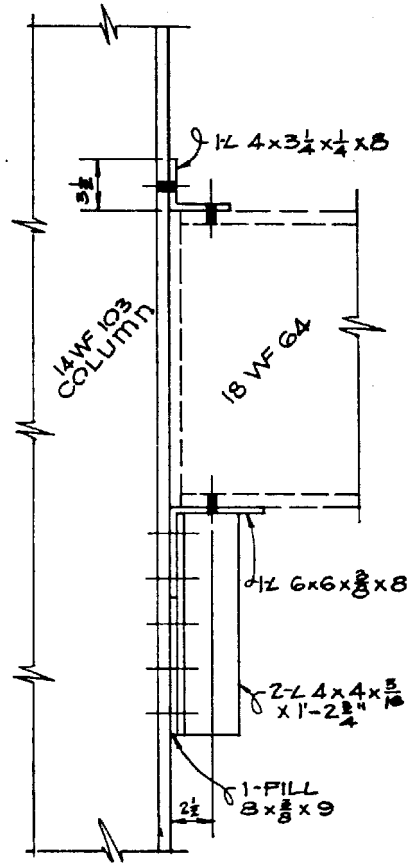


PARTIAL FRAMING PLAN
FIN. FLOOR 106'-2"
USE ASTM A-141 RIVETS
ASTM A-242 STEEL



STRUCTURAL DETAIL





3/4" RIVETS — 13/16" OPEN HOLES

CONNECTION : STRUCTURAL DETAIL

e framing plan to the structural details of a steel-frame building.

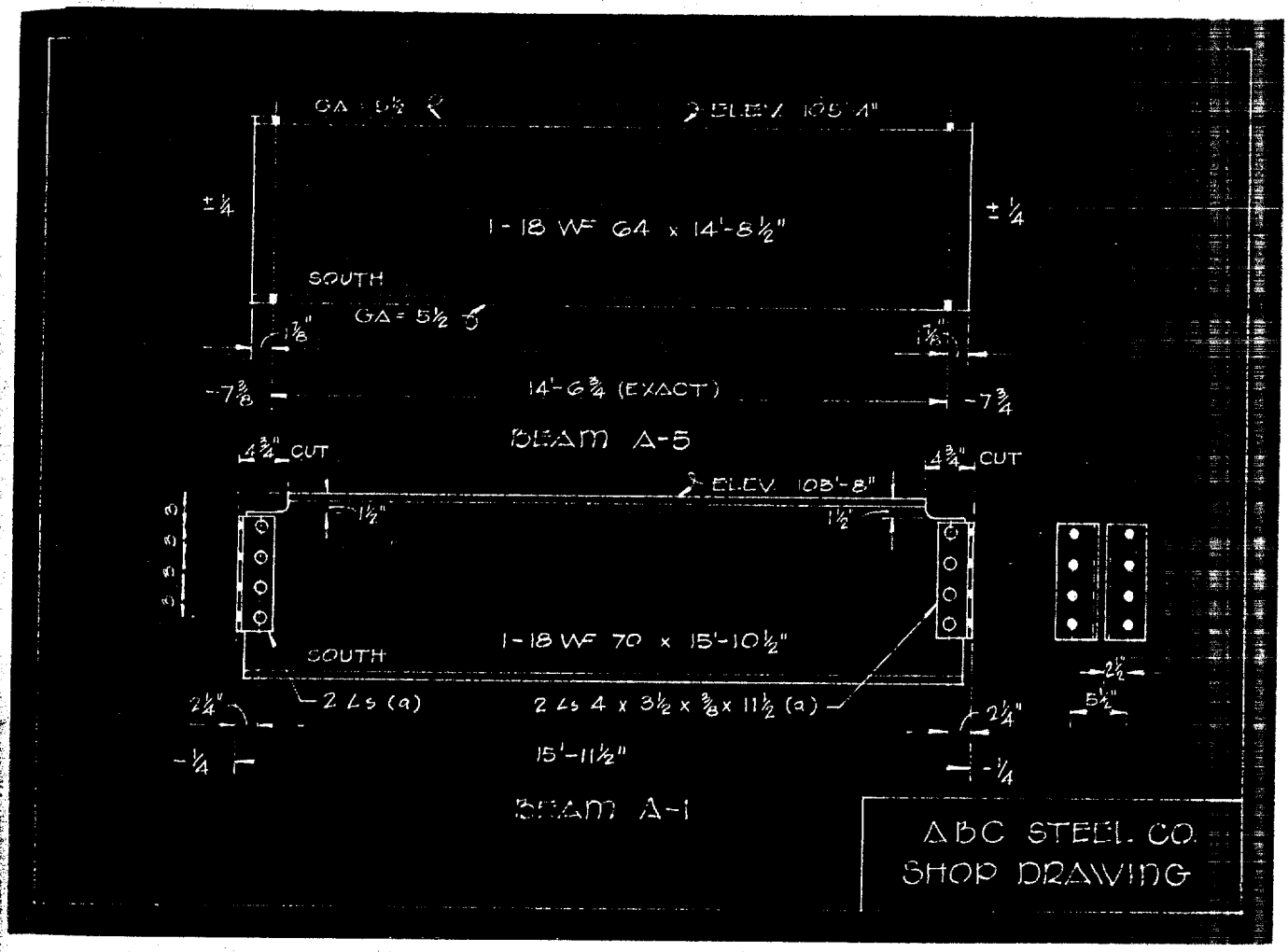


Fig. 5-29 A typical shop drawing of the steel beams shown in Fig. 5-28 plan.

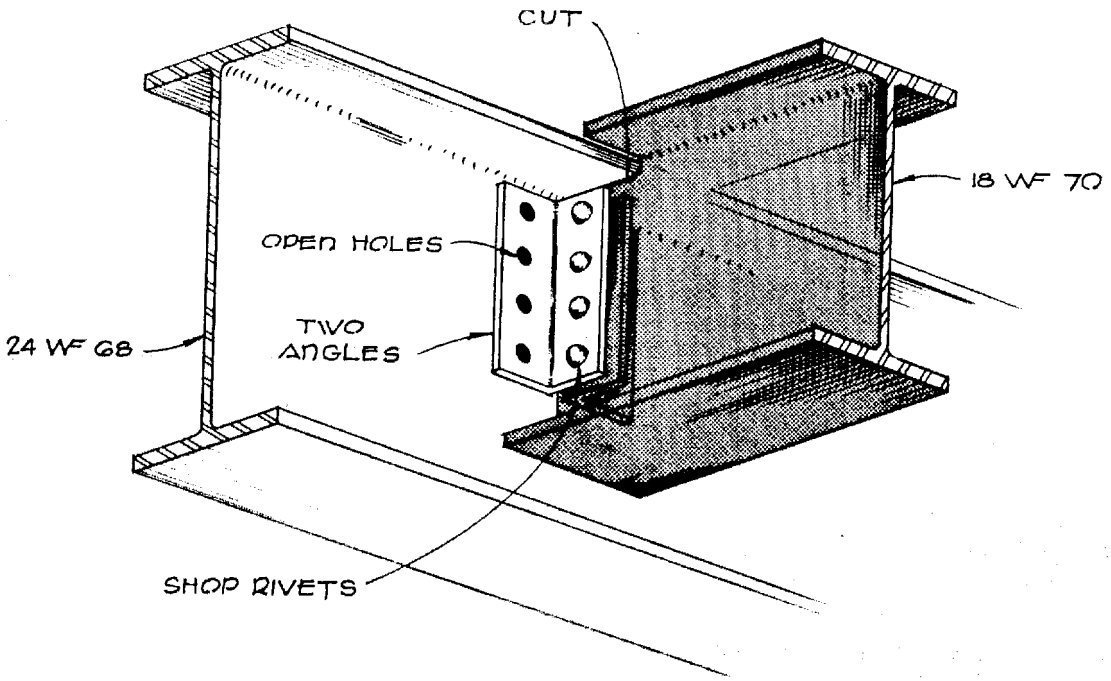


Fig. 5-30 Pictorial view of the framed beam connection shown in Fig. 5-28.

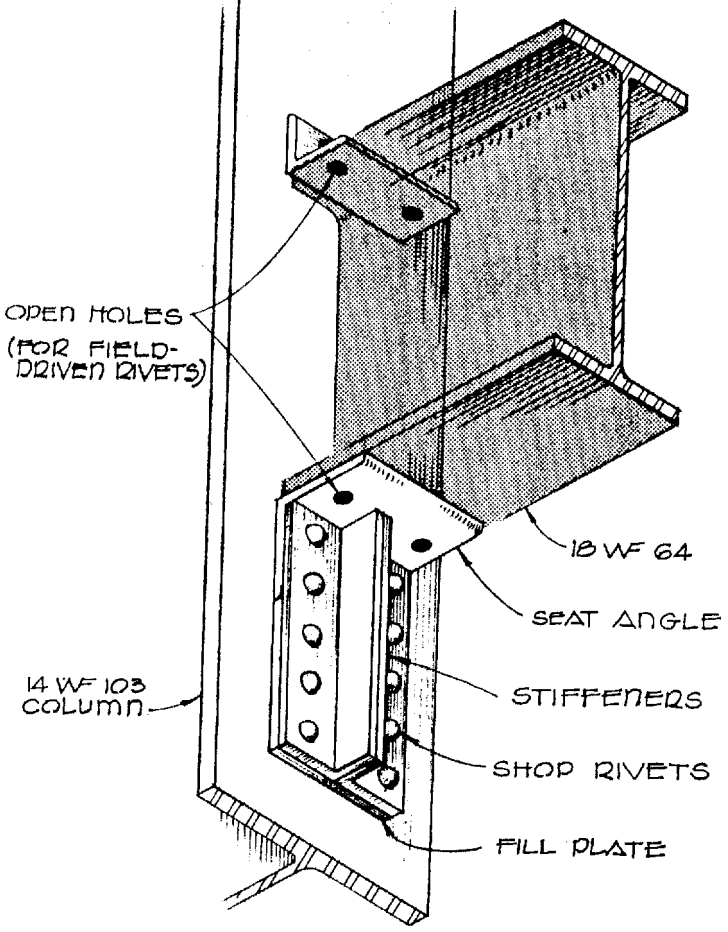


Fig. 5-31 Pictorial view of the stiffened-seated beam connection shown in Fig. 5-28.

COLUMN SCHEDULE

COL.	A5, A6	B5, B6	C5, C6
HIGH ROOF EL. 142-0	6"		
3RD. FLOOR EL. 132-0	12 WF 45	12 WF 65	12 WF 40
2ND. FLOOR EL. 120-0	2'-0" VARIES 12 WF 65	12 WF 106	12 WF 53
1ST. FLOOR EL. 106-0			
BASE PLATE	24x22x2	31x28x2 3/4	22x19x1 5/8

Fig. 5-32. A typical steel column schedule.

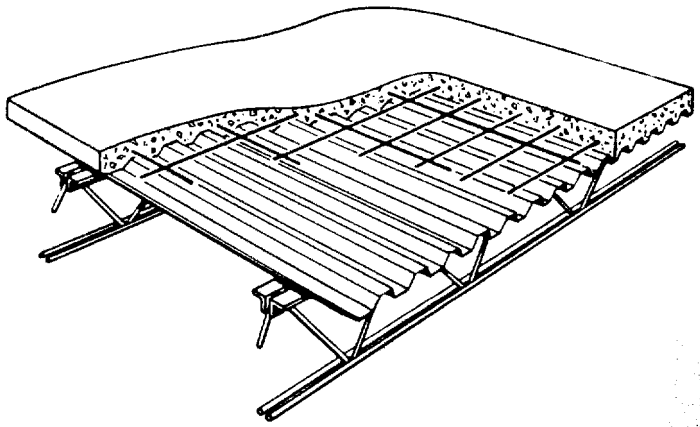


Fig. 5-33 A concrete slab poured over metal forming and steel joists.

a. steel joists

Light steel joists, often called bar joists (Fig. 5-41), are widely used in many commercial buildings for spanning floors and roofs where moderate loads are anticipated. Many standard types and sizes are available from manufacturers in nearly all areas of the country. Normally they form the structure for flat or low-pitch roofs of one or two-story buildings. Often steel lath and plaster or channels and acoustical board ceilings are hung from their lower bars. They are easy to handle and are quickly erected. Ducts, wiring, or piping can be easily run through

their open spaces. Forming panels can be laid over the joists and either concrete or gypsum can be poured over the forms, requiring only wire mesh as reinforcing, to produce adequate floors and lightweight roofs. Precast concrete panels, formed steel decking, fiber panels, or other manufactured products can be used for the decking. Rigid insulation is often included in the roof deck if insulating concrete or gypsum is not shown. Insulating properties are important considerations in the selection of roof decking material.

Because of their widespread use, steel joists are standardized according to their span and depth. Properties of steel joists may be found in the *Manual of Steel Construction*, published by the American Institute of Steel Construction, or in literature from the Steel Joist Institute, 1346 Conneticut Ave., Washington, D.C. 20036.

Joists are seldom completely detailed on drawings; they, of course, must be partially shown in details revealing their arrangement at bearing ends or at points where they influence the construction of other components (see Fig. 5-42). A framing plan is needed to show their layout; sizes or manufacturers' identification numbers are given in a note. Cross bridging between the joists, if needed, is also indicated in the layout. The details may show the joists welded to a steel beam (Fig. 5-22) or to a bearing plate anchored to a reinforced concrete beam, or they may show the joists bolted to plates supported by masonry walls. Many applications are found for these versatile building units.

For long spans in field houses, auditoriums, and similiar buildings, large, steel trusses are often used for the roof structure. Details of the trusses and a layout diagram are shown on the structural drawings.

b. prefabricated steel buildings

Recently the use of small prefabricated steel buildings has increased substantially. For small industrial-commercial type buildings, prefabricated units possess a number of advantages. They are very economical, can be erected quickly, and can be dismantled and re-erected if necessary; they are rigid and can be made resistive to most of the destructive elements. Basic prefabricated designs can also be varied in exterior appearance by variations of exterior coverings, by various arrangements of window and door treatments, and with additional architectural wall effects.

Besides the original shop drawings, only simple architectural drawings are needed to show modifications, floor and footing dimensions, and erection directions. Partitions, which are not usually furnished by the fabricator, must also be indicated on the drawings if required. Manufacturers' specifications, supplied with the prefabricated components, eliminate much of the expense of professional architectural service.

J. DETAILS

Depending on the purpose of a building, many details other than the structure must be defined on the set of drawings. Some details are typical of nearly all buildings; others

may be highly specialized features found only in those buildings intended for nongeneral use. Consideration for these details is important in reading working drawings; often their inclusion results in various modifications of the structure itself during the design stage. A few typical details are mentioned here; other specialized details may require further reference to manufacturers' catalogs for full understanding of their representation on drawings.

1. Stairs

One of the typical details necessary in most buildings of more than one story is a detail of some type of stair connecting the floor levels. Terminology and information about wooden stairs are discussed in Chapter 3. Many of the terms and the drawings involved apply to stairs in commercial buildings as well, although stairs in commercial buildings are usually constructed of steel or reinforced concrete.

Stairwells are commonly constructed with fireproof masonry materials, and adequate railings must be provided for safety. Usually platforms are employed throughout flights of commercial-building stairs to eliminate fatigue and discomfort during ascent and decent.

Steel stairs are often prefabricated, requiring shop drawings for their construction. The units are installed after the floor levels are completed. Details on the architectural drawings reveal their support at both the base and the head of the units, total rise and run, riser and tread sizes, and size and location of platforms, if required. Often full sections through the entire stair flight are shown, along with isolated details of a stair tread, bearing support, and railing profile and anchoring.

Reinforced-concrete stairs are, of course, cast in place, often monolithically with a concrete structural system. Sections show the bar reinforcement running both ways and the anchoring at walls and floors. Substantial support must be provided at the base of a concrete stair; in general, it is provided by a bearing wall or a beam. Essentially, the stairs are similar to an inclined beam with the steel placed accordingly.

Treads are often covered with a nonslipping, wear-resistant material on both reinforced-concrete and steel stairs. Interior stairs are commonly provided with elaborately designed railings having the hand rail of wood or other material that is comfortable to hold. Steel pipe or square tube railings are often used with concrete exterior stairs.

Plan views of stair layouts show not only their widths but also the riser height and the total number of risers in the flight.

2. Windows and Doors

Metal window units vary widely in type and size. As a rule, only high-grade metal units are used in commercial buildings. On the architectural drawings, units are identified on the plan view and a window schedule gives the necessary information, which is similar to the method used in residential drawings. Also, sections through a head, jamb, and sill show exactly how the window units are mounted and

attached to the walls. Many metal windows are glazed after installation.

Doors in commercial buildings are identified in a similar manner. Door schedules give the types and sizes; as with windows, better quality doors are specified in commercial buildings. Many are fire resistant, having at least a one-hour fire rating. The door details are commonly limited to details of the jamb arrangements in the various walls throughout the building. Ordinarily, sections showing the head and side jamb are all that is necessary in the details. Steel jambs set into the masonry openings and attached with metal anchors are universally used. Spaces within the hollow metal jambs are commonly filled with cement grout.

Many window walls as well as windows combined with door units are made of extruded aluminum frames for use in commercial buildings, especially buildings used for retail sales. Careful drawings of these alluminum and glass units are needed in order for the supplier to prefabricate and install them in their openings. For the most part, they are custom built. Usually an elevation of each unit is shown, with the glass or panel materials indicated and with a series of sections showing the aluminum profiles at heads, jambs, mullions, transoms, etc. Stock profile moldings are normally indicated with manufacturers' numbers. Complete dimensions must be given for the aluminum surround so that accurate bids can be made from the drawings. Neoprene plastic gaskets or caulking are the most common types of setting beds for the glass in the aluminum frames.

3. Interior Finishes

Finish materials are the final surfaces applied to the interior of the building as the construction nears completion. Both the drawings and the specifications will furnish detail information about this final stage. Of particular concern is the final surface applied to walls, ceilings, and floors, plus the application of all moldings and trim. Careful workmanship is required in this phase, and complete details on the drawings help to provide it. Aside from the finish materials shown on specific details, interior elevations are often needed for walls of rooms requiring special consideration. Care must be taken when reading drawings to orient these elevation views to their proper locations. Also, finish schedules frequently compile the room-by-room interior materials and the painting that has to be done on the different surfaces.

Portland cement plaster is a popular wall covering in fireproof buildings and is applied over expanded metal lath or bonded directly to masonry. Gypsum plaster is also popular; many ceilings are covered with gypsum acoustical plaster. Other acoustical ceilings are constructed with fiberboard panels hung on metal channels with wires, called "suspended ceilings." Various walls may have ceramic tile, wood paneling, gypsum board, brick or stone, or even plastic laminate. Many buildings are now economically finished by merely painting the exposed concrete block. Base trim materials are compatible with the material used for the finish floor. That is, ceramic tile base is usually used with ceramic tile floors, rubber base with resilient tile, wood base with wood floors, etc.

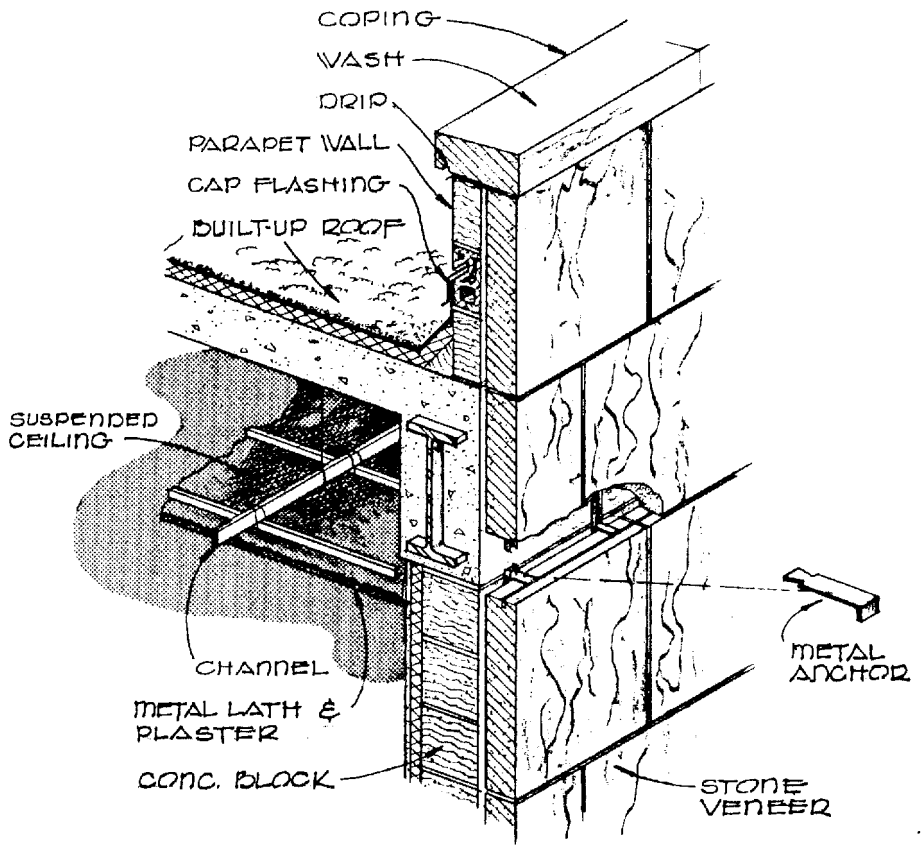


Fig. 5-34 A parapet wall and stone veneer detail, showing a suspended ceiling.

Finish flooring materials are also indicated on the architectural drawings as well as the specifications. Typical flooring materials used in commercial buildings are.

1. Wood (attached with mastic or over sleepers)
2. Troweled concrete
3. Terrazzo
4. Terra cotta
5. Ceramic tile
6. Mastic materials—magnesite, asphalt, epoxy resin
7. Resilient flooring—asphalt, linoleum, vinyl, rubber or cork tile.

K. READING THE MEDICAL ARTS BUILDING WORKING DRAWINGS

Included with this material is a complete set of working drawings for a small medical arts building. Several doctors and their staff would find it appropriate for conducting their general medical practice. Although not large compared to many commercial buildings, it represents a variety of construction elements—both concrete and steel. Hence the drawings will be appropriate for providing various construction examples and their representations on drawings. For a manual of this type, the actual drawings naturally had to be reduced in size to fit the format. The originals were 24" × 36",

which is typical of many used in practice. Further reduction would have made them difficult to read; yet the reduction allows you to refer back and forth through the set with less effort than with the originals.

In general, follow the points listed below in orienting yourself to this set of drawings; the procedure is equally as effective in reading other sets that are totally unfamiliar to you. Keep in mind that drawings must be interpreted together and that they should not be taken as isolated sheets of information.

1. First, Get a Good General Impression of the Building

Look over the elevations and floor plans quickly to create a preliminary mental image of the shape and size of the building and, possibly, the general structural systems employed. Relate the elevations to the plan, and keep in mind the front of the building, where the main traffic will enter. Concern yourself with the exterior features first. Study the materials and where they appear. Look for irregular features on the elevations so that you can identify them on the plan and be positive of the orientation. All the information you can assimilate in your first inspection will naturally save time later on when you are hunting for specific items. Of course, remember the purpose of the building: in this case it will be used by several doctors and nurses, as mentioned, for general medical practice and minor surgery. The ground floor will accommodate a small drugstore. Notice that a stairway in one corner of the building allows interior communications between the two floor levels.

The building is square in plan, with a built-up roof that is nearly flat. Its overhanging fascia is covered with copper having uniformly spaced battens. A ramp leads up to the front door of the waiting room. Major partitions in the first-floor level are constructed with steel studs covered with gypsum board. The wall sections indicate that the first-floor exterior walls are offset from the ground-floor walls, which makes the upper level slightly larger than the lower level.

These are features that should give you a quick, general impression of the building. There will undoubtedly be other features that contribute to this first impression.

2. Orient the Building to the Site

Next, refer to the Site Plan in order to learn how the building is positioned on the site in reference to the north-point arrow. Be sure you understand which sides are east and west, for these can be sometimes confusing when you are looking down on the layout. It is common practice to find the drawing placed on the sheet so that north is toward the top, but this practice is not always feasible because of the shape of the property, as you will see on this plan (Fig. 5-36). The medical building required a definite relationship with the adjoining health building, shown lightly on the right. The medical building, however, has been given more emphasis. Notice that the layout of the parking area is shown and that all improvements, such as recontouring and paving, are included on the Site Plan. Finish elevation heights are shown

throughout the area. Important information about utilities locations is also a part of the plan. This drawing provides the builder with dimensions for excavation work and the preliminary layout of the building, inasmuch as no excavation plan is included.

3. Locate and Identify the "Bones" of the Structure

Study both the architectural and structural drawings to see where columns, girders, beams, etc. are located. See if you can understand the structural system being used; perhaps it is a combination of several systems, as previously mentioned. But you should be able to visualize the skeleton before you try to visualize the details that are attached to it. Look for grid and reference lines in both plans and on elevations. Usually the floor levels are the horizontal reference lines. In most cases, the skeleton members are closely associated with the reference lines. Look for offsets or variations of typical spacing of lines so as to be familiar with the purpose of their being offset. Be sure you understand where horizontal members shown in sections are supported and how their loads are transferred to columns or bearing walls. Sizes of all structural members are given by notes or listed in schedules.

In the medical building, the columns, beams, and joists are reinforced concrete up to and including the first-floor level. However, steel tubes within the cavity walls are used as columns in the tier above. In reading the Foundation Plan (Fig. 5-37), note that footings for the concrete columns are shown in broken lines and are sized according to the loads they will carry. Sizes, together with the amount and placement of steel for both footings and columns, are shown in the accompanying schedule. Elevation heights of footings are shown on the elevation views. Other reinforcement (labeled dowels) is noted in the floor slab below masonry partitions and below the stairwell. Notice that part of the lower ground level is unexcavated. Information about the wall footings is shown in the section details.

The First-Floor Framing Plan, one of the structural drawings (Fig. 5-46), gives us information about the layout of the ribbed slab at the first-floor level. Each rib (joist) is shown with broken lines. The longer joists throughout the center span are flared at their ends to allow easier removal of the pan forms. Because the beams between columns vary in size and amount of steel, individual marks (B-1, B-2, etc.) are used to label them. Complete information about beam size and steel reinforcing is given in the schedule and in the details. Not all beams will require stirrups. Bending points of the steel bars are based on the span of the members. Notice that A bars are straight and B bars are to be bent. These structural drawings provide the steel fabricator with enough information to cut and bend the steel. Information about the concrete joists is presented in a method similar to the one shown for the beams.

In looking at the Roof-Framing Plan (Fig. 5-47), we see that the roof structure consists of bar joists welded to steel beams. Support of the beams is provided by the steel-tube columns placed within the cavity walls and the partitions. Shear splices of the horizontal beams are called for where the least amount of bending stress occurs. Several standard

sizes of bar joists are noted in the layout, and some must be modified by cutting and welding to provide positive slope to the roof drains. Observe that two heavier joists are inserted near the center to support air conditioning equipment that is to be placed on the roof. Both the structural drawings and the architectural drawings show details of the roof overhang arrangements. Bulb tees are clipped over the bar joists, and gypsum formboard is laid between to support the poured gypsum deck. This creates a roof deck that is light and rigid and yet still has good insulating qualities. The soft-copper covering on the fascia provides a durable yet pleasing exterior material on the overhang. Figure 5-39 shows the uniform layout of the copper battens.

4. Look for Consistent Methods Used by the Draftsman to Depict Information

You will find that working drawings by different offices often vary somewhat in the way in which drawings, notes, and schedules are executed and presented, even though, to a large extent, standardization exists in the industry. Observing how these minor variations appear is a part of interpreting the drawings. Notice that throughout the medical-building drawings diagonal marks instead of arrowheads are used at the ends of dimension lines, and fractions have no cross bars. On the plans, numbers within small circles identify doors, letters within triangles identify interior elevation views, and interior metal stud partitions are located to their centerlines. The symbols for ceramic tile, concrete block, or wood may be slightly different than those found on other sets of drawings. Some pictorial drawings have been used to describe the size and construction of the copper fascia battens. Notice how leaders relate notes to features, how titles are arranged, and how cutting-plane lines are drawn to show locations of sections. Variations of these seemingly minor points exist on drawings; yet you must understand their purpose. Structural, mechanical, and electrical drawings, usually prepared in separate offices, are especially noted for the way minor points are handled in comparison to the architectural drawings. Abbreviations, too, vary with draftsmen and sometimes are troublesome for the novice.

5. Relate Details and Schedules to the Larger Views

After you understand the labeling system employed throughout the drawings, relate the details to their position on the plans or elevations. Reference to various drawings may be necessary before this is accomplished. Some sections, of course, are typical and have no definite positioning planes, but you should learn from observation to what extent on the plan the typical construction applies. Some walls or parts of walls, for example, usually vary from the typical condition, and other specific details are included to explain the variation. The wall section in Fig. 5-43, for instance, is a variation of the typical wall in that the entrance ramp and the canopy above needed to be shown; otherwise the wall materials are similar.

Be sure you understand the Stair Details (Fig. 5-43) and how they are related to the floor levels. Section A-A relates to both the enlarged

Ground and First-Floor Plans shown. The first-floor view shows all the treads; yet the ground-floor view shows how the upper part of the stairs is supported. Observe that rubber tread-and-nosing surfacing is required and that the aluminum handrail will need special anchors. On the Exterior-Stair Detail, a steel pipe railing is shown.

Other details show how to construct the lead shields in the X-ray room walls, the vertical brick joint in the exterior brick walls, the roof overhang, etc. To help you understand much of the interior of the building, both a longitudinal and a transverse full-section are shown in Fig. 5-41. You may need to examine the plans and elevations again to orient these sections correctly, since the square nature of the plan will make it questionable as to which plane is transverse and which is longitudinal.

The Room Finish Schedule (Fig. 5-44) lists the interior finish materials to be used in each room of the building—both ground floor and first floor. Even finish ceiling heights are indicated. Information is also self-evident in the Reinforced-Concrete Schedules (Figs. 5-45, 5-46), if you can relate each entry to the plan views. Each structural member has an identification mark. Notice that the abbreviation "DO." (ditto) throughout the schedules indicates that the information in the space above also applies; diagonal lines in a space indicate that no information is needed in the space.

6. Determine How the Mechanical and Electrical Equipment Is Accommodated into the Structure

As mentioned previously, the mechanical (plumbing, heating, and air conditioning) and electrical drawings are made by consulting engineers who specialize in the respective fields and who work closely with the architect during the design stage. Their design work is tailor-made for each building project.

The first mechnical sheet (Fig. 5-48) describes the exterior layout of the utilities connections. The sewage drain had to be run through the adjoining property, requiring a 10′ easement, to the existing sanitary sewer. Six-inch vitrified clay pipe is specified for this line with a cleanout indicated about midway in the line. Elevations of the sewer line at the connection (invert elevation) must be shown on layout drawings or on a section view. On the profile drawing below the plan, the 5 per cent slope required indicates that the line will slope 5 ft. for every 100 ft. of run. Notice that a storm drain is shown leading from the low point of the rear exterior stairs to an outfall away from the building.

The Plumbing Plan (Fig. 5-47) shows the layout of the drainage lines and the hot-and cold-water feeder lines in the ground floor. Much of the piping will have to be placed below the ground floor slab. Notice that risers to the upper floor are indicated with symbols, pipe diameters are given with notes, and standard plumbing symbols are used throughout. To the right of the plan is shown a pictorial layout of the drainage lines only. Three-dimensional isometric drawings are commonly used for these single-line plumbing layouts so that both vertical risers and horizontal runs can be sized. On the first floor, the [illegible] Plumbing

lines for the upper-floor fixtures are given. The pictorial layout for only the hot- and cold-water feeders is included on this sheet. Observe that many of the pipes are run through the ceiling bar joists where possible. Cold-water lines are shown with a dot and long dash; hot-water lines with two dots and a long dash. An 80-gallon hot-water electric heater is to be installed in the mechanical room.

In reading the Air-Conditioning and Heating Plans (Figs. 5-51, 5-52), we see that a major cooling unit is to be installed in the mechanical room, and that also an auxiliary unit is to be located on the roof near the center of the building. Automatic resistance-type heater units are to be placed in the ductwork to furnish heat to the building when temperatures drop. A large chase in the concrete floor provides space for both riser ducts and a large return-air duct to the unit. Individual ducts from the unit provide conditioned air to five zones in the building. Notice that two ducts are circular as they pass through the unexcavated area of the ground floor; otherwise they are mainly rectangular in shape. The duct at one end of the sales area had to be concealed by furring, as shown in the architectural drawings. All horizontal and riser ducts are shown and their cross-sectional sizes indicated with a note. All ducts will be insulated. Much of the ductwork in the upper level passes through the dropped ceiling of the hallway; minor leads go up and through the bar joists where feasible.

Register outlets in the rooms are shown by symbol, size, and capacity in cubic feet of air per minute. Most of the return air from rooms, you will notice, is planned through door grills of various sizes; it then recirculates back through a large return-air register, located in the back hallway, to the central unit below. Some ceiling and floor registers, in addition to the wall registers, are shown. Fresh-air intake provision is made through louvers in the mechanical room and a vent in the roof. Fully automatic controls will be installed to balance the system and to maintain desirable temperature levels in the building throughout the year.

The Electrical Drawings (Figs. 5-53, 5-54), which are plan views of each floor level, show only the electrical work to be done. The power service is brought into the building, with overhead leads located in the rear, and is run to the main distribution panel located in the mechanical room. A separate meter and by-pass is furnished to panel B nearby, which is the distribution panel for circuits to the lower sales area. Notice in the panel schedule that panel B will have 18 circuits, each having a capacity of 20 amperes, and that only 15 of the circuits will actually be used. The main panel provides for circuits to the air conditioning unit, unit heaters, lighting and receptacles, and a major circuit to panel A, located in the first-floor back hall. This is a subpanel furnishing lighting and receptacle circuits to the top floor. Circuits are numbered at the arrowheads pointing toward the panel, but they are not completely drawn in. All wiring is to be run through metal conduit. Symbols for all the fixtures, outlets, switches, etc. are given on the drawing. Dimensions shown near a symbol on the plan indicate the height the outlet is to be placed above the finish floor.

Complete information about the lighting fixtures is included in the fixture schedule. Special electrical equipment will be needed in the X-ray room. Telephone outlets and installation of telephone equipment, as well as outdoor lighting, are also shown on the electrical drawings.

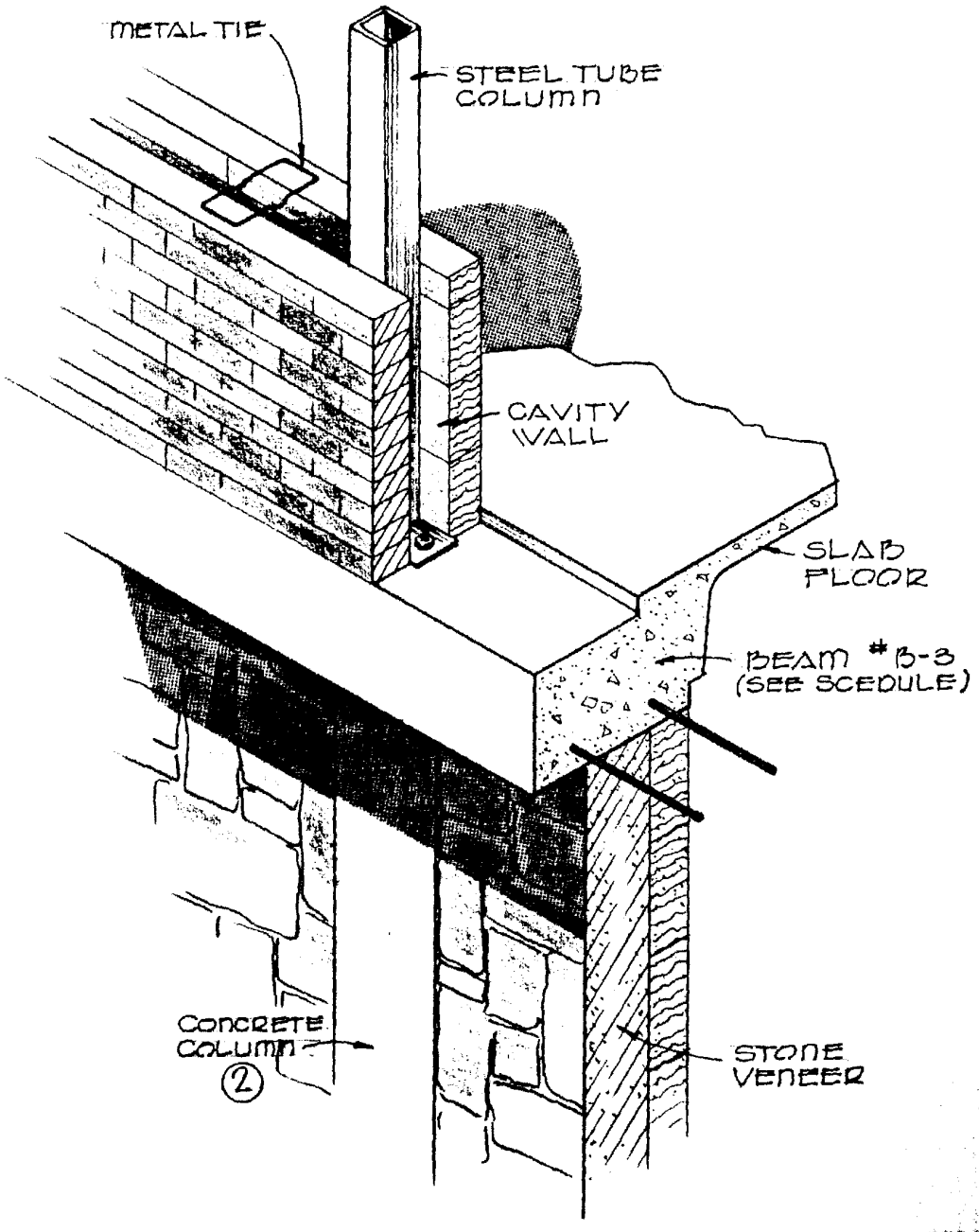


Fig. 5-35. The appearance of the exterior wall construction and slab near the columns in the Medical Arts Building.

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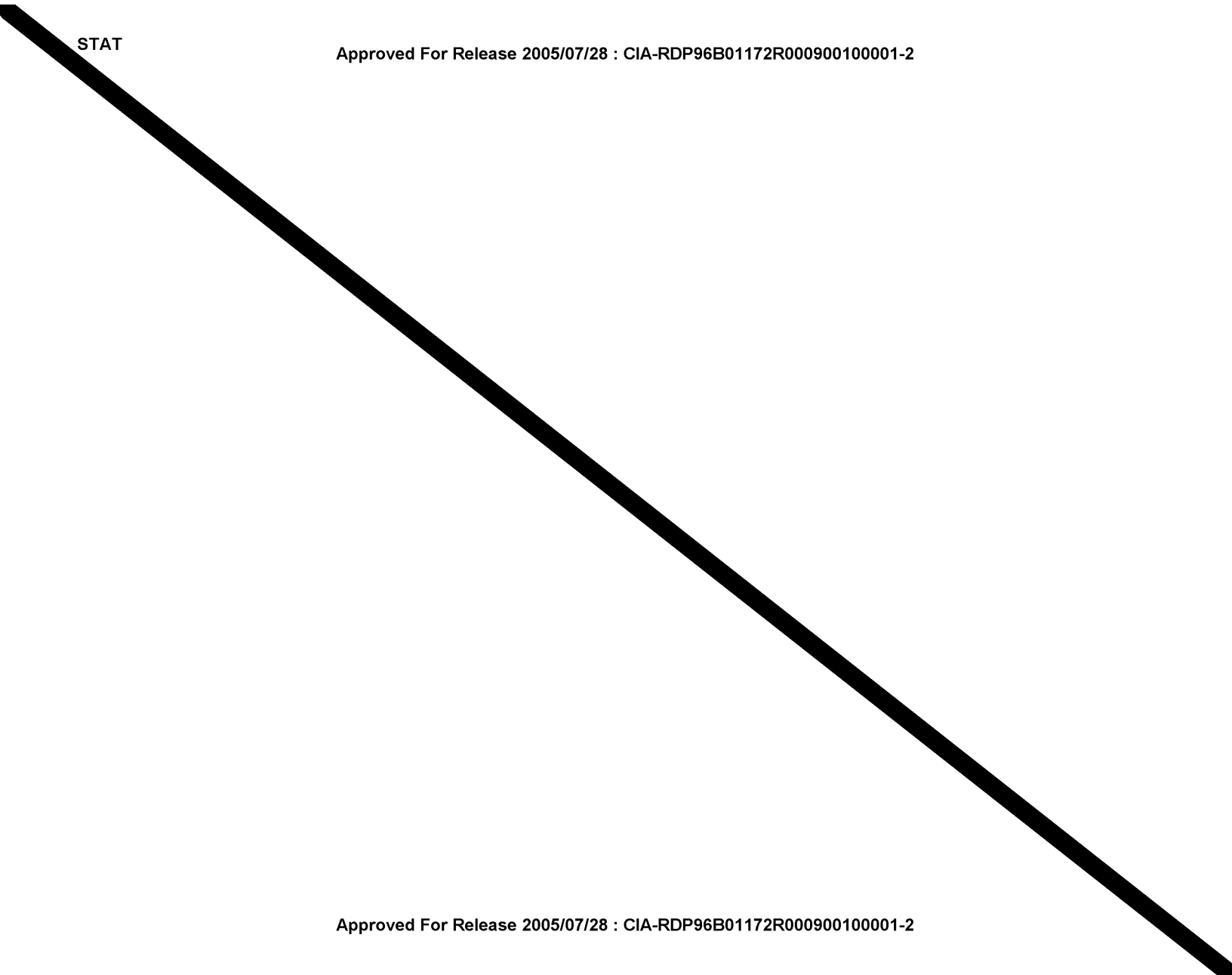

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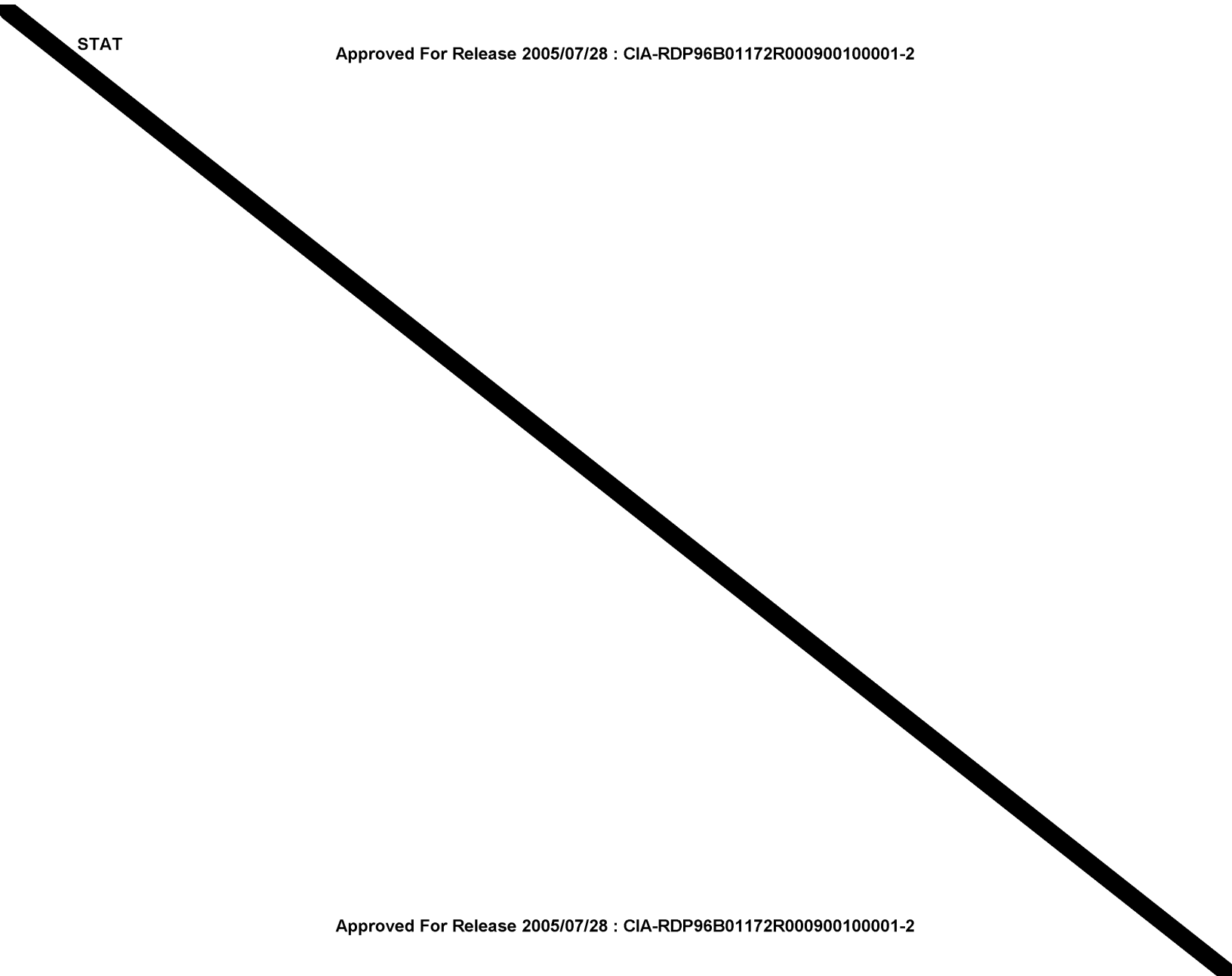

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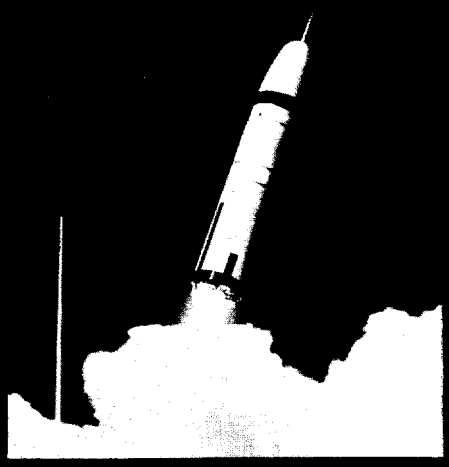
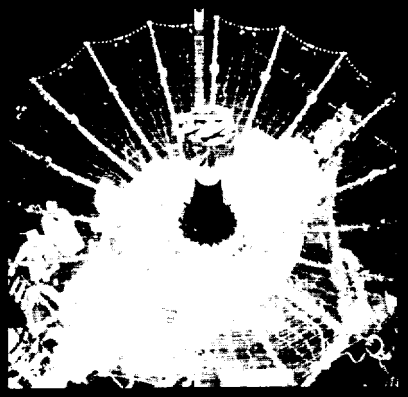
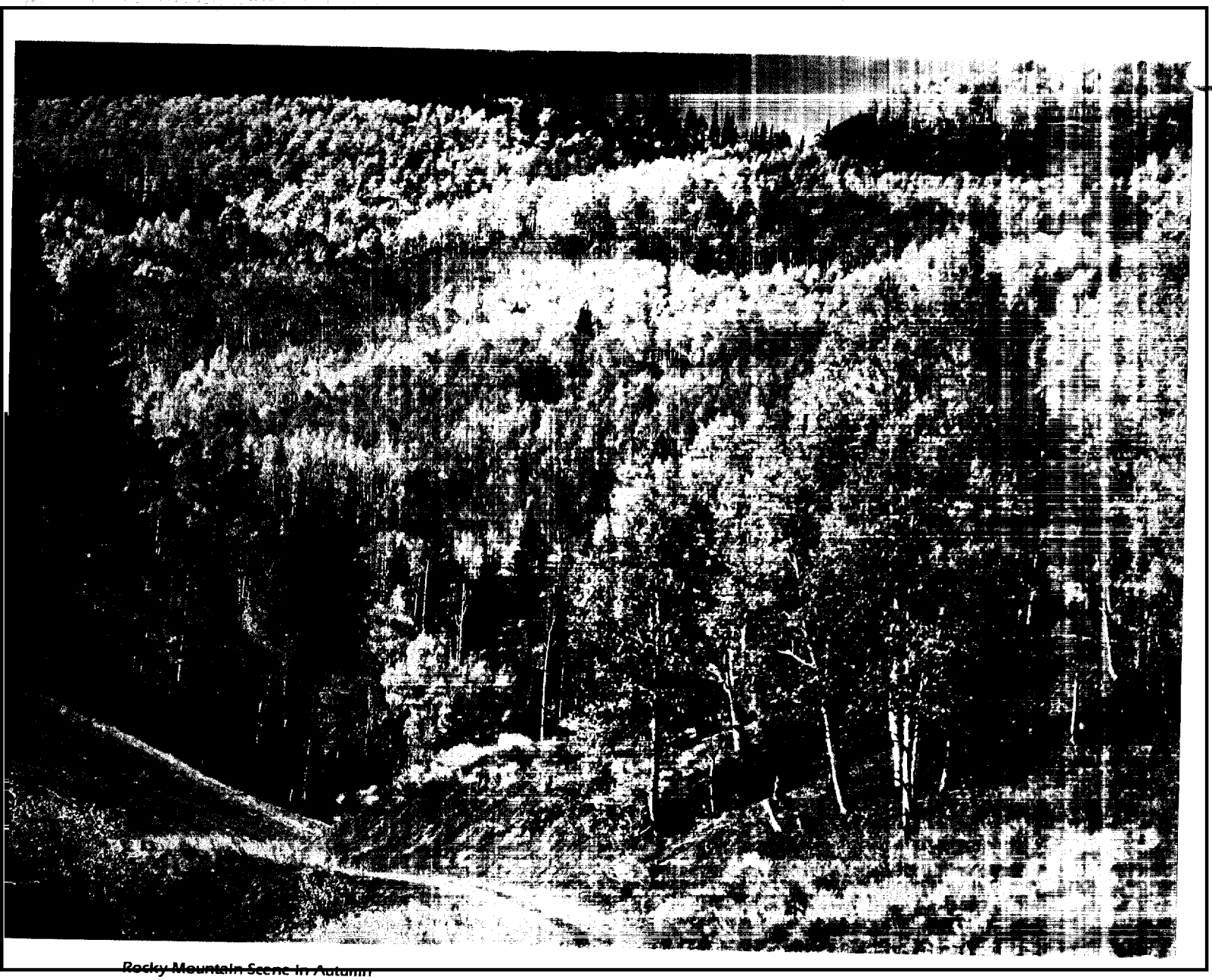


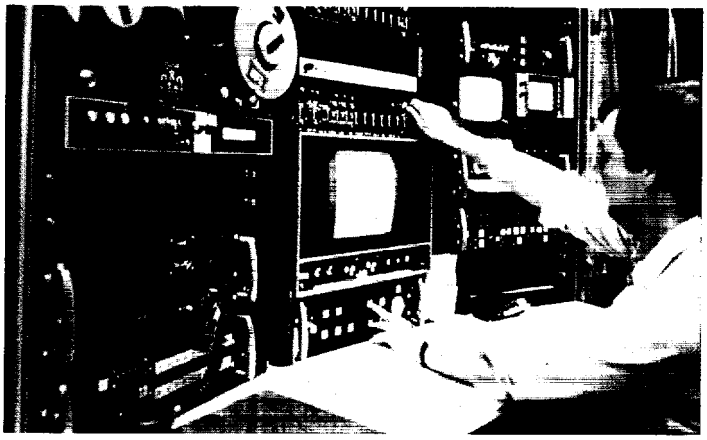


HERCULES
AEROSPACE DIVISION

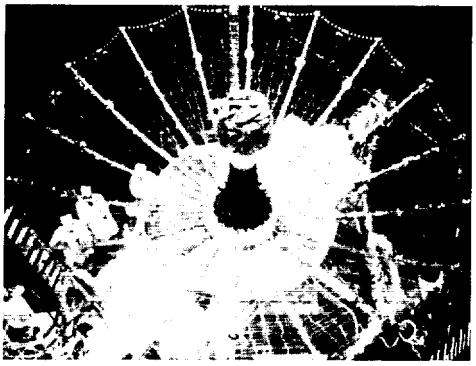
HERCULES



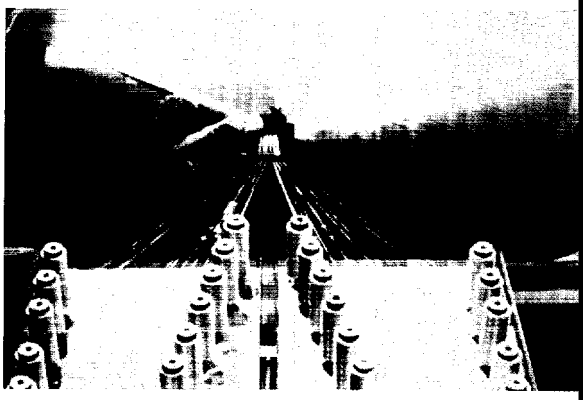
Rocky Mountain Scene in Autumn



Quality Assurance — High-energy, Real-Time X-Ray assists non-destructive testing efforts.



Graphite Structures — Antenna for tracking and Data Relay Satellite Systems uses graphite Struts and Ribs.



Manufacturing — Computer controlled filament winding machine laying aramid fiber on Trident C-4 motor.

The Hercules Challenge To You

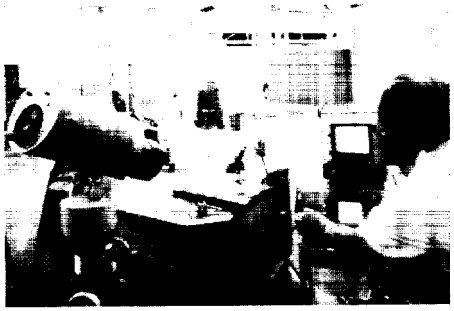
Selecting the company that provides the best opportunities for your career is one of the key decisions of your life. In order to evaluate Hercules and its opportunities, it is important that you know more about us, what we expect of you, and what you, in turn, can expect from us if you join our company.

Hercules is a large, diversified chemical company, multi-national in scope, with an excellent growth record. Our research and development efforts reflect the strong commitment we have for the future of our company, the nation, and our employees. Hercules has several business Divisions including the Aerospace Division located in Salt Lake City, Utah.

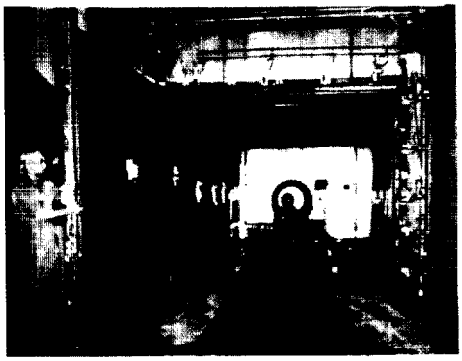
The Aerospace Division utilizes almost every branch of Engineering, as well as selected areas of Physics, Chemistry, Material Research, Computer Science, and other related scientific disciplines. Opportunities exist at the Hercules Aerospace Division for technical graduates at all levels — B.S., M.S., and PhD.

We are involved in the development, manufacture and operational support phases of high technology solid propellant propulsion systems. Unique capabilities exist at the Hercules Aerospace Division for design and development of high technology items such as thin wall graphite/kevlar composite cases, high performance propellants, lightweight carbon nozzles, and thrust vector control systems. Additionally, we are one of the largest producers of continuous graphite fiber in the world; we are the only fully-integrated producer capable of composite structural design, fiber production and resin-impregnation, and manufacture of complex graphite composite structures.

Graphite Structures support truss for applications satellite, was first primary space structure made from graphite.



Product Engineering — Infrared thermography test to locate composite defects.



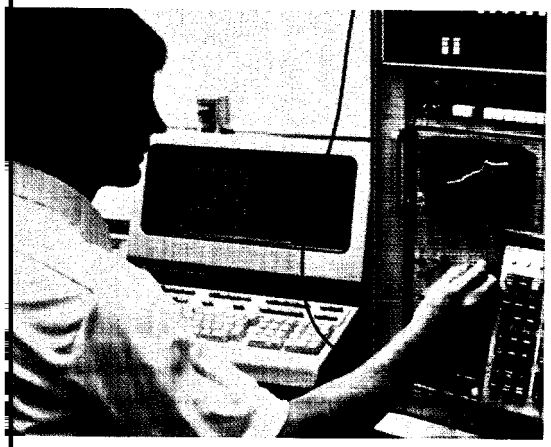
Manufacturing — Microwave ovens greatly reduce cost of curing motor cases.

Manufacturing — Filament winding layup of rocket motor cases. Clearfield facility.

What does Hercules expect of you? Technical competence in your field, diligence, and above all, the willingness and desire to grow in your profession. Broadly speaking, the technical aspects of your work at Hercules will pose some of the same challenges that were presented in your university coursework with the added dimension of application to product development and technical support applications encompassing a broad range of industries and customers. The principles and techniques you have mastered are often directly transferable to Hercules' programs.

At the Bacchus Works of the Aerospace Division near Salt Lake City, Utah, professional engineers and scientists constitute approximately 20% of the Plant's employees. The plant is large enough to have the finest facilities for research and development, yet small enough to encourage cross-fertilization of ideas. Our size and diversity of interests provide opportunity for our people to have a wide variety of technical interactions, experiences, and career development avenues. We emphasize personal interchange and minimize organizational boundaries. We also encourage continuing education, development of technical skills, outside contacts, and seminar and meeting attendance. While most of our personnel are located at the Bacchus Works in Magna, Utah (a Salt Lake City suburb), there are also a number of our people located at our Clearfield Plant about 30 miles north of Salt Lake City.

The Bacchus Works is divided into a number of major technical departments. A brief description of each follows.

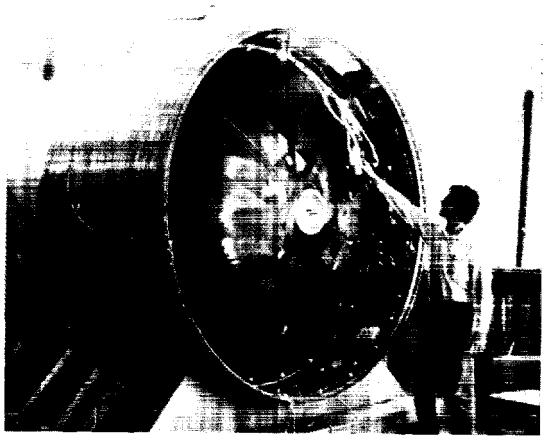


Quality Assurance — *Shock/ vibration data analysis system.*

Computations/Product and Tool Engineering — *CADAM analysis and design.*

Product Engineering — *Testing advanced nozzle design.*

Product Engineering — *Testing hardware fit on MX 3rd stage prototype.*

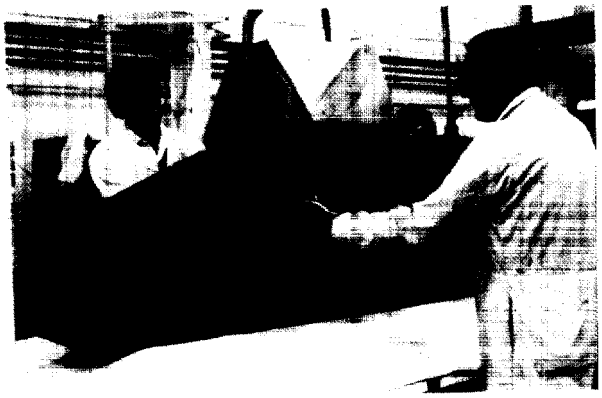


Product Engineering

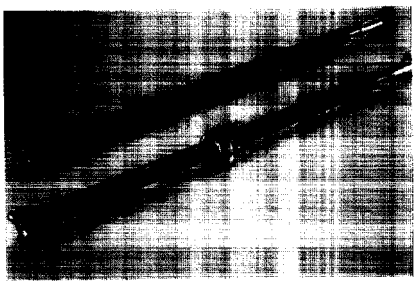
The Product Engineering Department is comprised of specialized high technology sections involved in design analysis, and development work. The latest in finite element methods and computer support equipment are used in performing ballistic, heat transfer, combustion, fluid flow and stress analyses in the design of rocket motor components. This department uses state-of-the-art computer graphics analysis techniques to design and analyze composite thin walled rocket motor cases, insulators, propellant grains (properties and internal shape), flewseals, nozzles, TVC (thrust vector control), hardware and various composite structures. Manufacturing drawings are created by computer-aided design programs whether as an output from automated design synthesis programs or by designers interfacing with the computer via computer graphics.

Once the design is initially established using the above analysis and computer-aided design techniques, development engineers coordinate component fabrication, development testing and performance analysis. Component design integrity is experimentally verified or redesign is indicated, based on evaluation of the test data. The design engineer has the responsibility for definition and analytical support of the designing and the development engineer has the responsibility of converting the design into a form (drawings, specs, manufacturing plans) understood by the factory of our suppliers. Analytical and development-type support continue through the production and operations support phases.

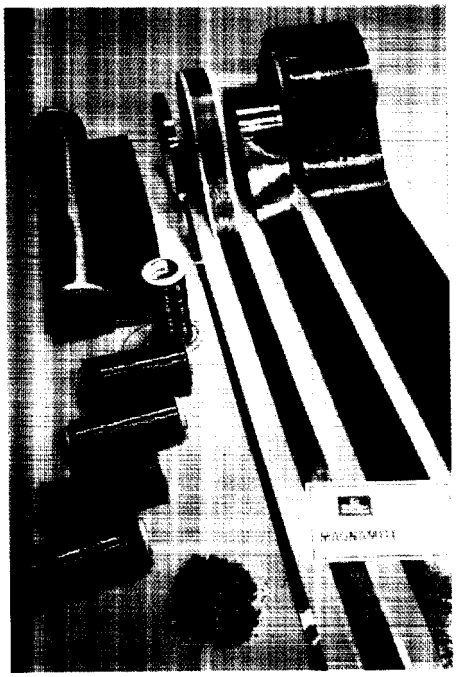
Product Engineering personnel interface constantly with customers, associate contractors and suppliers. They get a broad background in project management, planning and control as well as technology. Opportunities exist for advancement along technical or management lines dependent upon individual preference and ability.



Graphite Structures- Car chassis Mandrel disassembly.



Graphite Fibers — Industrial line of graphite fiber products — cloth, prepreg tape, and yarn.



Graphite Structures — Formula 1 racecar chassis.

Structures — Graphite shaft reinforcement increases stiffness, reduces weight and improves stability and performance.

Materials Technology

The chemical formulation for new or modified products with superior performance is the responsibility of the Materials Technology Department. Members of this group specialize in either propellant research or resin compound development.

Through the expertise of this department and others, Hercules has long been a leader in the development and formulation of tough high-energy solid propellants. We strive for better performance in rubber-based insulation materials and bonding agents. Continuing research in epoxy, acrylate, and other resins has given us the capacity to design many unique properties into present and future graphite-based products.

Materials Technology is a valuable member of our team in staying ahead of our competition, developing materials for our other technical departments and economizing processes for production.

Graphite Fibers

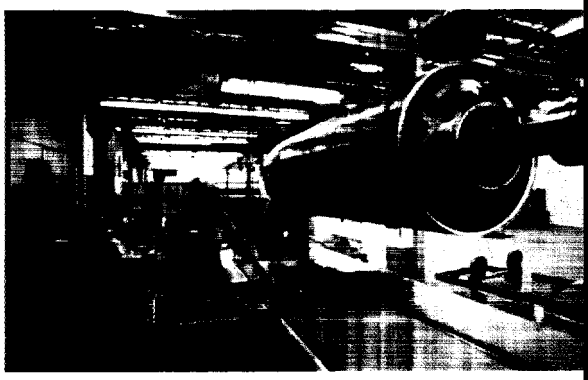
The Bacchus works of Hercules, Inc. is the largest producer of graphite fiber products in this country. Graphite fiber is a remarkably versatile construction material. It can be used by itself, bound in a thermosetting resin matrix or employed as a reinforcing or stiffening agent to other structural materials (most metals, fiberglass or other synthetic fibers, metal threads, etc.) in composite systems. This fiber demonstrates exceptional lightness (in composite form, about 80% lighter than steel) yet retains very high tensile (up to 400,000 lbs./in.^{2}) and stiffness characteristics.

The fibers are used extensively in the newest generation of vehicles in the structural members and control surfaces of both commercial and military high performance and fuel-efficient jet aircraft, in fuel-efficient automobiles, in sporting goods and in other applications where low weight and extreme stiffness are required. Hercules supplies industry with graphite filaments (yarn), several widths of resin-impregnated tape, woven cloth, and chopped graphite fiber.

Graphite Composites

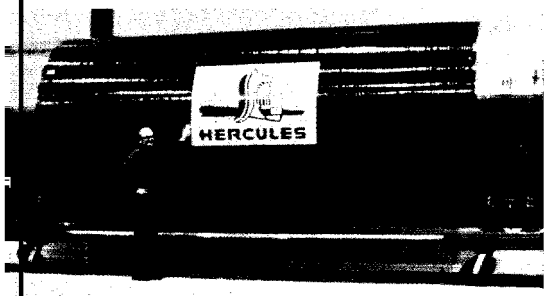
Our engineers at the Bacchus Works are designing simple and complex graphite composite structures to meet our customers' specification requirements. Graphite composites have excellent fatigue life, high chemical, corrosion and creep resistance, and a very low friction coefficient (self-lubrication properties). Graphite composite structures demonstrate an insignificant coefficient of thermal expansion. These structures can be formed to final shape through many manufacturing processes, including filament winding, hand lay-up injection molding, pultrusion, mandrel winding and vacuum molding, without many of the limitations and hid-

Quality Assurance — Precision computerized gauging equipment used for tolerance and runout tests.



Graphite Structures — Driveshaft (top). Steel driveshaft (bottom). Weight savings with hybrid truck driveshaft approached 70%.

Quality Assurance/Research & Development Lab. — Advanced testing and formulation of resin compounds and constituents.



Manufacturing — 23 foot MX cannister (launch tube) section.

Quality Assurance — Stress, tensile and other physical properties are routinely tested on our fibers and resin products.

den costs (high energy and labor, machining loss, etc.) of competitive metal products and their production processes.

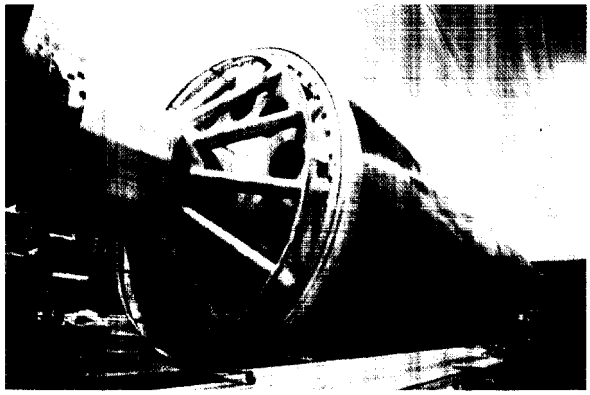
We've produced space vehicle frameworks and antennas, aircraft floor support beams, automotive driveshafts and internal engine parts, Formula I race car chassis, and the MX cannister/launch tube (70' long, 98" diameter, walls 1-1/2" thick). Hercules was the first to use fiber composite materials in pressure vessels/rocket motor cases. Graphite fibers now comprise a portion of the structural material used in our motor cases and nozzle designs.

Quality Assurance/Testing

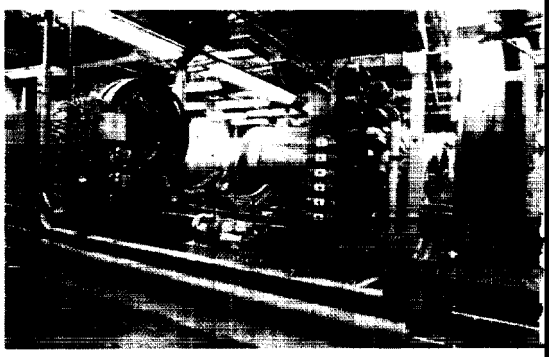
The Quality Assurance Department is a highly diversified department motivated to improve and maintain an exceptionally high level of quality and reliability in our product lines. Our Quality Control Engineers achieve this goal through process and materials control; design and calibration of many different precision measuring tools (often one-of-a-kind tools); development and performance of many unique testing procedures, both of a destructive (motor firing, hydroburst tests, etc.) and non-destructive (real-time high energy x-ray, laser, infrared thermography, acoustical holography, and ultrasonic) nature.

The department is staffed with chemists and technicians who perform a number of routine and non-routine chemical tests to assure the continuing quality of our raw materials, resins, and fibers.

Computer-supported data reduction techniques are commonly used to assemble data into usable form. A statistical support group performs reliability studies to assist our team of quality assurance engineers in maintaining the quality levels we've come to expect from our products.



Manufacturing — 46 foot graphite MX Cannister (launch tube) prototype.



Manufacturing — MERZ pneumatic drilling machine for first stage Trident motor.

Quality Assurance Receiving Lab — checking quality subcontracted work.

Manufacturing — Inspection of finished C-4 Trident motor.

Research and Development

Analytical Chemists and Applied Physicists comprise most of our Research and Development Department, where answers to specific complex questions are sought out and solved on a non-routine basis. A scientist in this department typically is involved in venture projects; research into new areas never before attempted by one or more of our development departments. The majority of the work is in the formulation, testing, and analysis of new and highly advanced rocket motor propellants in cooperation with one or more of our other departments. This overall team approach develops higher performance and better reliability in our rocket motor systems.

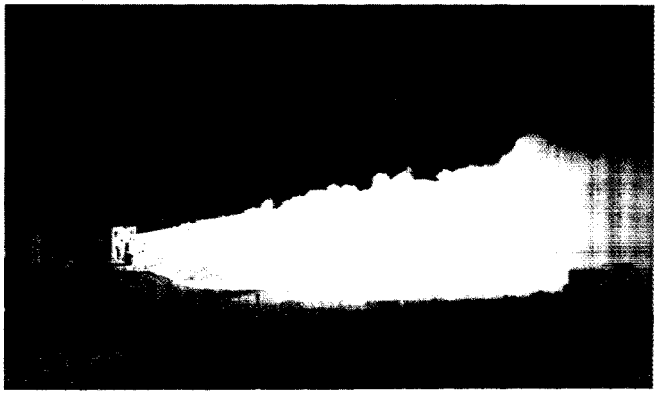
Manufacturing

Our Manufacturing Department is actually two separate engineering groups responsible for translating developmental prototypes and theories into actual production line manufacturing processes and finished products.

Our plant, located 30 miles north of Salt Lake City in Clearfield, Utah, houses our large filament winding and machining equipment and has approximately 9 acres of work area under one roof. At Clearfield, we manufacture our composite rocket motor chambers (pressure vessels) and other large filament-wound structures. The resin curing of these structures is accomplished in the world's largest microwave ovens.

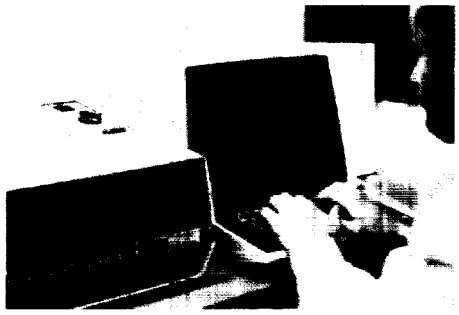
The manufacturing process at the Bacchus Works in Magna includes preparing the rocket motor chamber for the mixing, curing, and casting of the propellant charge (grain). The internal grain configuration is controlled through the use of a complex precision fin core tool placed in the chamber prior to the casting operation. The bore grain design controls the ultimate burning surface area and the resulting pressure and thrust curve characteristics. The nozzle, ignitor, external insulation and brackets, are then mounted to complete the manufacturing process.

Our engineers working in these manufacturing engineering operations are developing equipment and processes to acquire the high quality products and production volume our customers have come to expect. This is an engineering area that requires creativity, initiative and a good amount of hands-on engineering work.



The Tekol test range near Bacchus is one of the most modern in the free world.

Quality Assurance — Statistical reliability analysis group monitors performance of our product.



Tooling — CADAM design and analysis of the tools required in testing and production areas.

Works (Plant) Engineering

Operational support to our technical departments is supplied by the Works Engineering Department. These engineers are involved in the design, construction, and maintenance of the physical facilities, tooling, machinery, power equipment (electricity, steam and climate control circuitry) and energy conservation efforts on plant. This department generally employs the widest group of engineering disciplines on plant, including Civil, Manufacturing, Electrical and Mechanical Engineers. This is another group that exposes engineers to hands-on work.

Other Engineering Groups

In addition to the aforementioned groups, the Bacchus Works also employs a number of other engineers doing specialized work. They include:

Industrial Engineers are involved in performing advanced time and motion studies using the computer method MOST, planning plant and office equipment requirements and layout schemes, analyzing cost saving suggestions formulating feasibility studies for a number of special projects, performing human factor studies, and completing many other non-routine studies as required.

Safety Engineers monitor processes or construction activities to ensure a safe working environment free of fire, explosion, or other chemical or physical hazards detrimental to our work force.

Program Office Engineers develop and administer programs as necessary to comply with our customers' needs and requirements. They provide an open liaison function to solve engineering problems, maintain schedules and control cost on all major programs. This function includes management support of all missiles in the field.

Computations — The Bacchus Works is a major Hercules computer center.

Computations — changing tape drive for IBM computer.

Computations/ Computer Systems Division

This department is composed of personnel with skills in math, statistics, electronics, mechanics, logic and computer programming. Its activities include the development and maintenance of instruments and instrument/computer systems performing mathematical and statistical data reduction to assist researchers in Hercules laboratories, engineering analysis groups and production departments.

The computations group specializes in direct technical problem-solving support of our engineering and scientific groups, often using sophisticated computer software packages developed in-house to aid in the analysis and design of rocket motor components. A strong mathematical background through partial differential equations, numerical analysis, and FORTRAN programming skills are required in this area.

Computer Services Division is responsible for the systems analysis and business-related computer support on plant. They require COBOL, JCL(IBM), IMS, or other data base management knowledge as minimum skills.

Beyond Your Salary

When you are deciding on a company, you should consider total compensation in the factors affecting your decision. A liberal benefits package, one that completes your financial security picture, can be viewed as the equivalent of additional income. The Hercules Employee Benefits Program offers a comprehensive medical plan and a dental expense assistance plan for you and your family; group life insurance and long-term disability insurance for you; savings and pension plans; and, to encourage your professional and personal development, an excellent tuition reimbursement program.

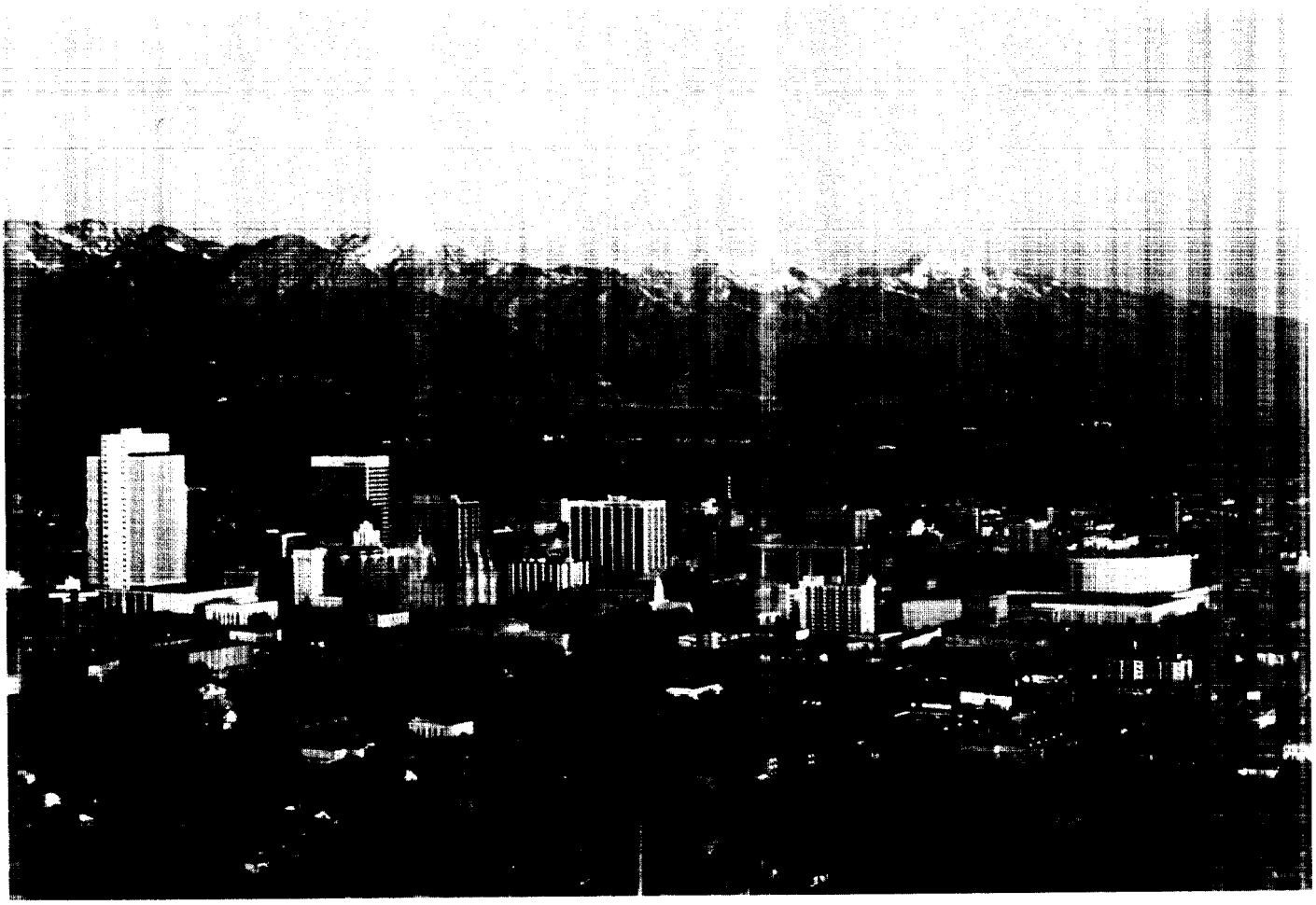
The medical, life insurance, and tuition plans are available to you shortly after your employment. Also, after 12 months of company service you will be entitled to two weeks' vacation. If you start working before July 1 of any calendar year, you will receive a week's vacation during that year.

The dental plan, group long-term disability, and savings plan are available after one year of credited service.

The Hercules Employee Savings Plan is designed to provide a convenient, systematic method of saving money. A year after you start work, you become eligible to begin investing up to 10% of your monthly gross salary in a number of different investment modes. As an incentive for you to participate, Hercules contributes 25 cents to your fund for every dollar you invest. The company contribution is invested in Hercules common stock.

The pension plan is funded entirely by Hercules, and after working only five years, you will have the right to receive a pension from Hercules upon retirement, no matter where your career may lead you.

Hercules pays the full cost of some employee benefits, while the costs of others are shared with you.



About Salt Lake City, Utah

Metropolitan Salt Lake City, the largest city in Utah, has a population of approximately 500,000, making it one of the largest cities in the Mountain West. Salt Lake City is located on the western slope of the Rockies and is becoming the home of an increasing number of corporations and industries. It is one of the fastest-growing areas in the country, due to an abundant supply of energy resources and stable workforce with a very strong work ethic. Salt Lake City has an unexcelled standard of living and life-style.

Housing

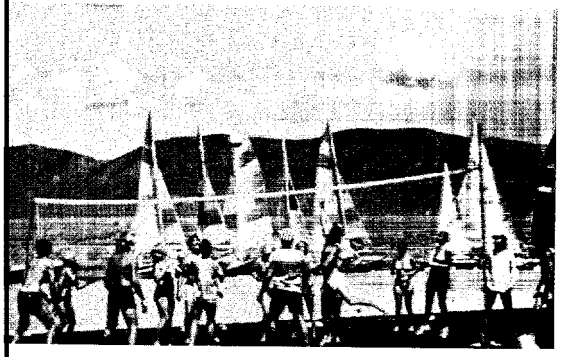
Housing is readily available in all parts of the city at reasonable cost. While most of the city's housing consists of single family dwellings, an abundant supply of apartments, condominiums, and rental units are available with many of the commonly desired amenities.

Schools

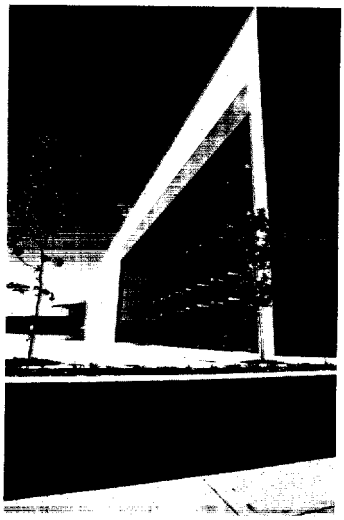
Salt Lake City has one of the nation's few growing populations of school-aged children. Historically, Utah and the surrounding area has been recognized for its exceptional educational system, placing more individuals per capita into colleges than any other state. Utah also invests a major part of its tax revenue in its educational system — one of the highest education dollar per taxpayer in the United States.

There are three universities within a 50-mile radius of the Salt Lake City area. The University of

Garden City — Sweetwater Resort on Bear Lake.



Salt Lake City — Bicentennial Arts Center (Symphony Hall).



Southern Utah — Water skiing on Lake Powell where there are many beautiful deserted canyons.

Hiking in the High Uintah mountains.

Skiing at one of Utah's many winter resorts.

Utah, located in Salt Lake City, with enrollment of approximately 25,000 full-time students, currently has many graduate programs available and evening courses for the working community. Brigham Young University is located 40 miles south, in Provo, and is approximately the same size as the University of Utah. BYU also offers a number of extension courses in the SLC area each semester. Weber State College is located 35 miles north in Ogden. The close proximity of these large universities provides strong intrastate sports rivalries and cultural activities and allows our professionals to continue their education in advanced coursework.

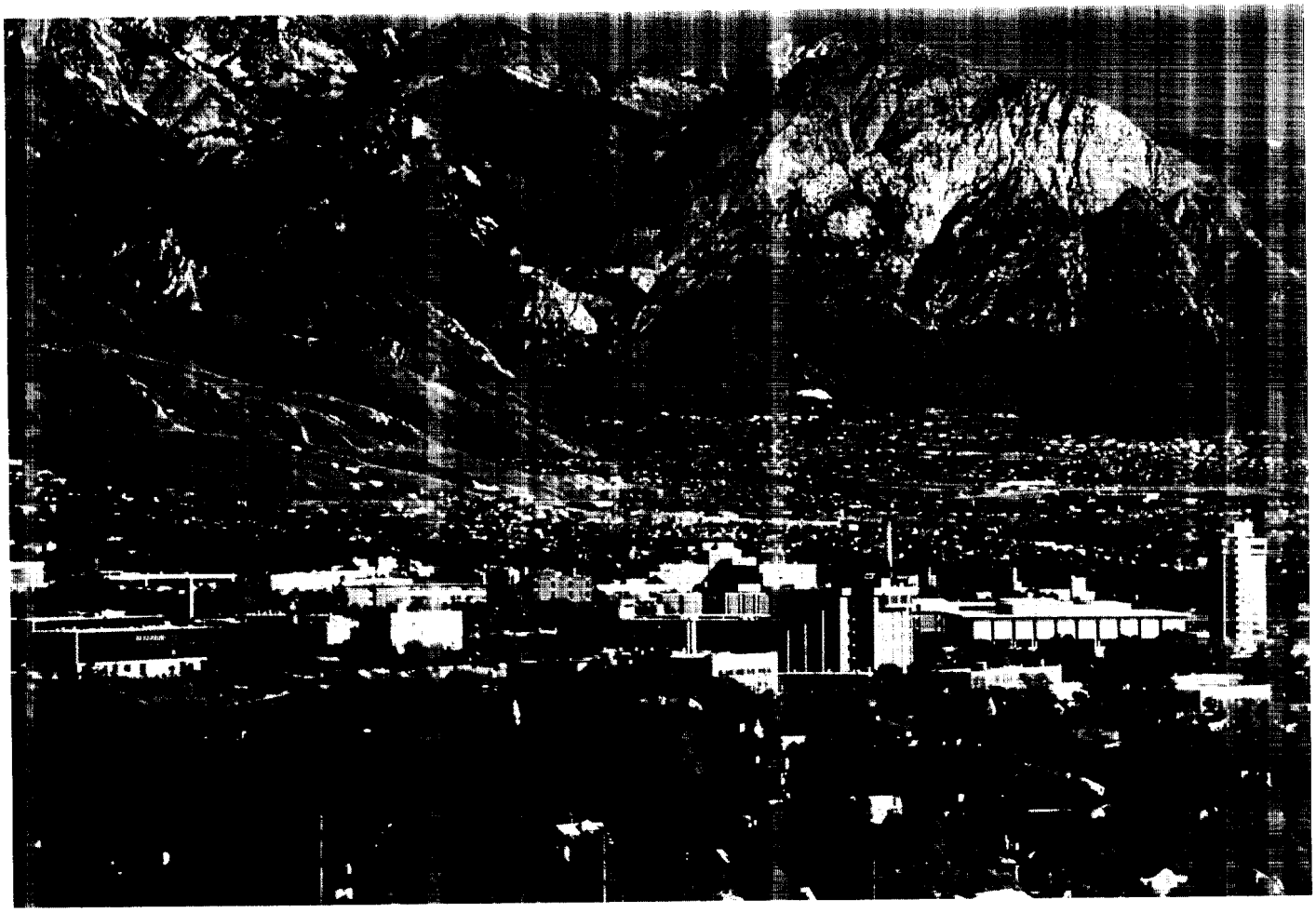
Cultural Activities

SLC fosters a very strong cultural environment, far out of proportion with its population base. Facilities are available for large displays and exhibits, concerts, and professional sporting events (NBA Basketball, Central League Hockey and AAA Baseball teams). The Utah Philharmonic Orchestra, Ballet West, repertory theater companies, and a local opera company have production schedules each season. Several Utah cities sponsor Shakespearean festivals, melodramas, and other special events each summer. The Mormon Tabernacle Choir performs twice weekly for the public, free of charge. Art, cultural, and historical museums are available throughout the area.

Recreational Activities

Tourism is Utah's largest industry. The state is unequaled in its scenic splendor and diversified terrain. Utah has numerous National and State Parks, mountain ranges, forests, sandstone canyons and formations, deserts, and lakes; all open for hiking, camping, and fishing activities throughout the summer months.

Winter brings the skiers to Utah; we have seven major world-class ski resorts within a 30-45 minute drive of the city, all exhibiting the best powder skiing available. Utah is known for its excellent big and small game hunting and fishing opportunities. Recreational vehicles abound in Utah's wide open country. SLC is known for its friendly, open, and active people and its mild climate and beauty.



UNIVERSITY OF UTAH

A Word About Opportunities

Everyone in top management at Hercules learned early in their profession the importance of human resources. For that reason, a major effort is made to create a working atmosphere that will attract and keep the talented people we need. Job satisfaction is paramount. Another measure of the importance we place on people is the salary and other compensation that our employees receive. Should you receive a salary offer from us, be assured that it will be fair and reasonable, and that it will take into full account your academic achievements and applicable work experience. If you should choose to join us, your future compensation will be directly related to your own efforts and ambition. With the Aerospace Division of Hercules, Inc. there is a unique combination of opportunity for professional job satisfaction, excellent working benefits and off-the-job lifestyle.

The Bacchus Works is one of the original Hercules plants, beginning production in 1915 to produce powder and dynamite for the mining industry in the intermountain area. In the late 1950's, research and development work was started on solid propellant rocket motors for the Polaris and Minuteman systems — Missile work has been the emphasis of our work since that time including continual development of Navy Fleet Balistic Missiles.

Hercules Aerospace Division
Bacchus Works
P.O. Box 98
Magna, Utah 84044
(801) 250-5911

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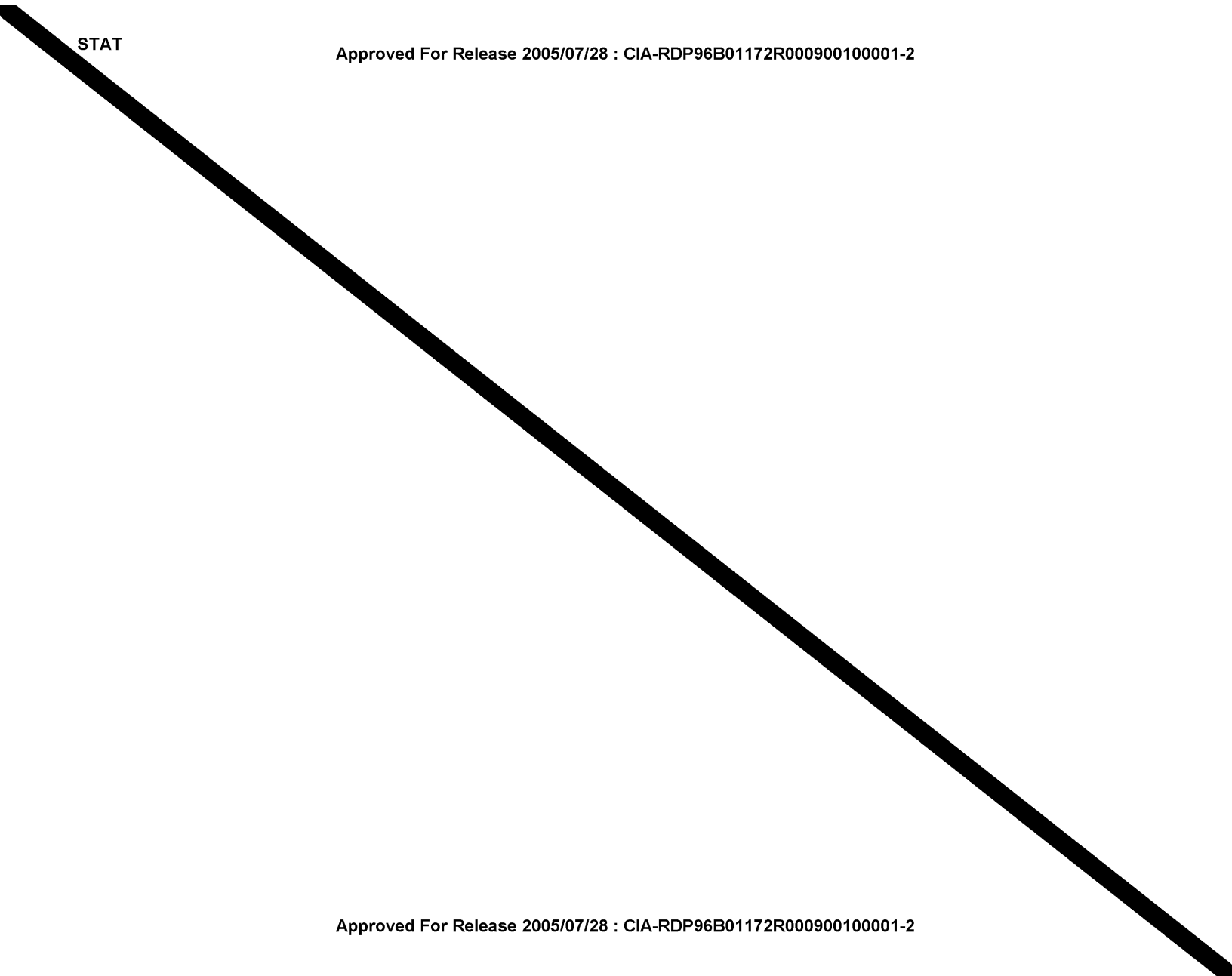

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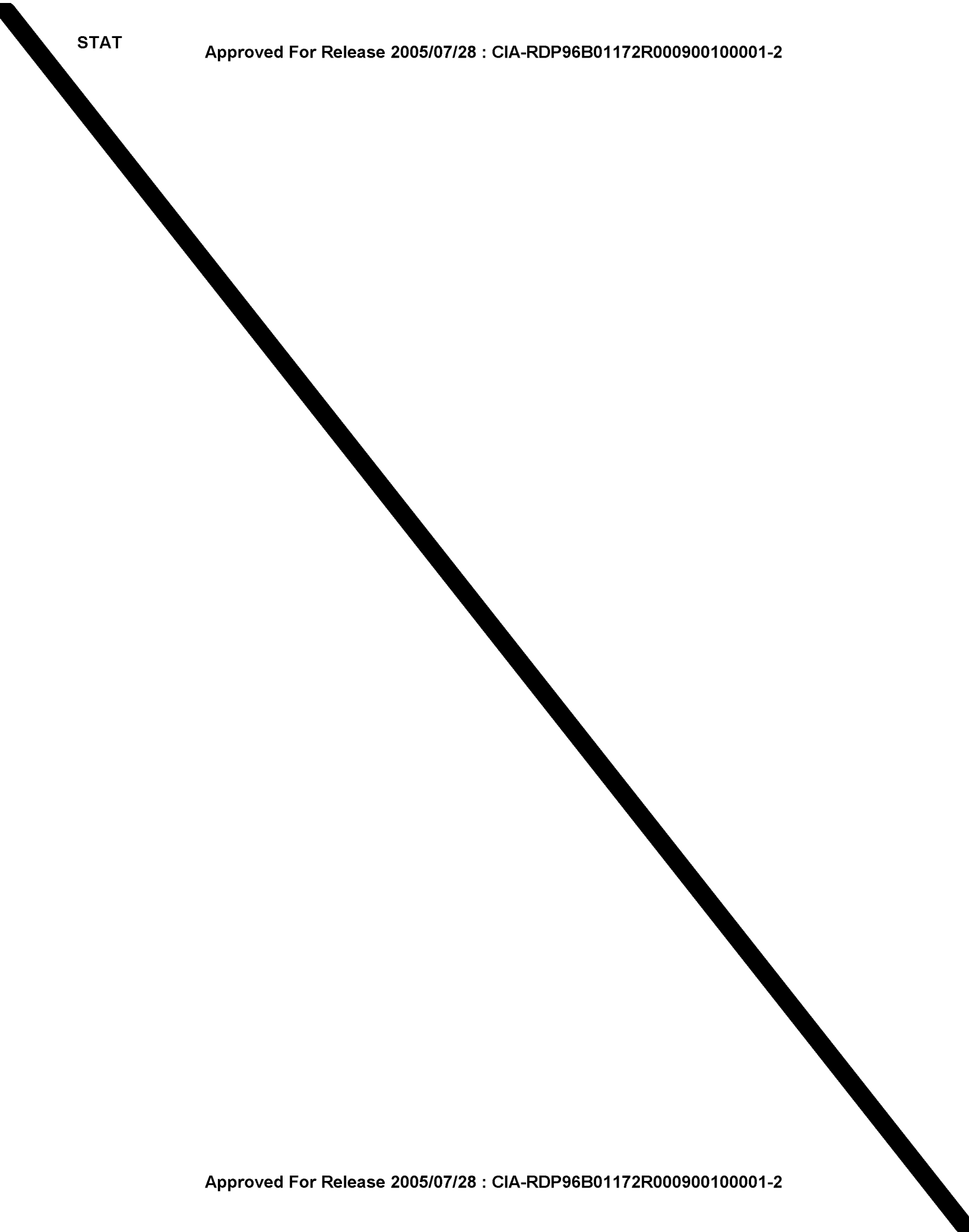

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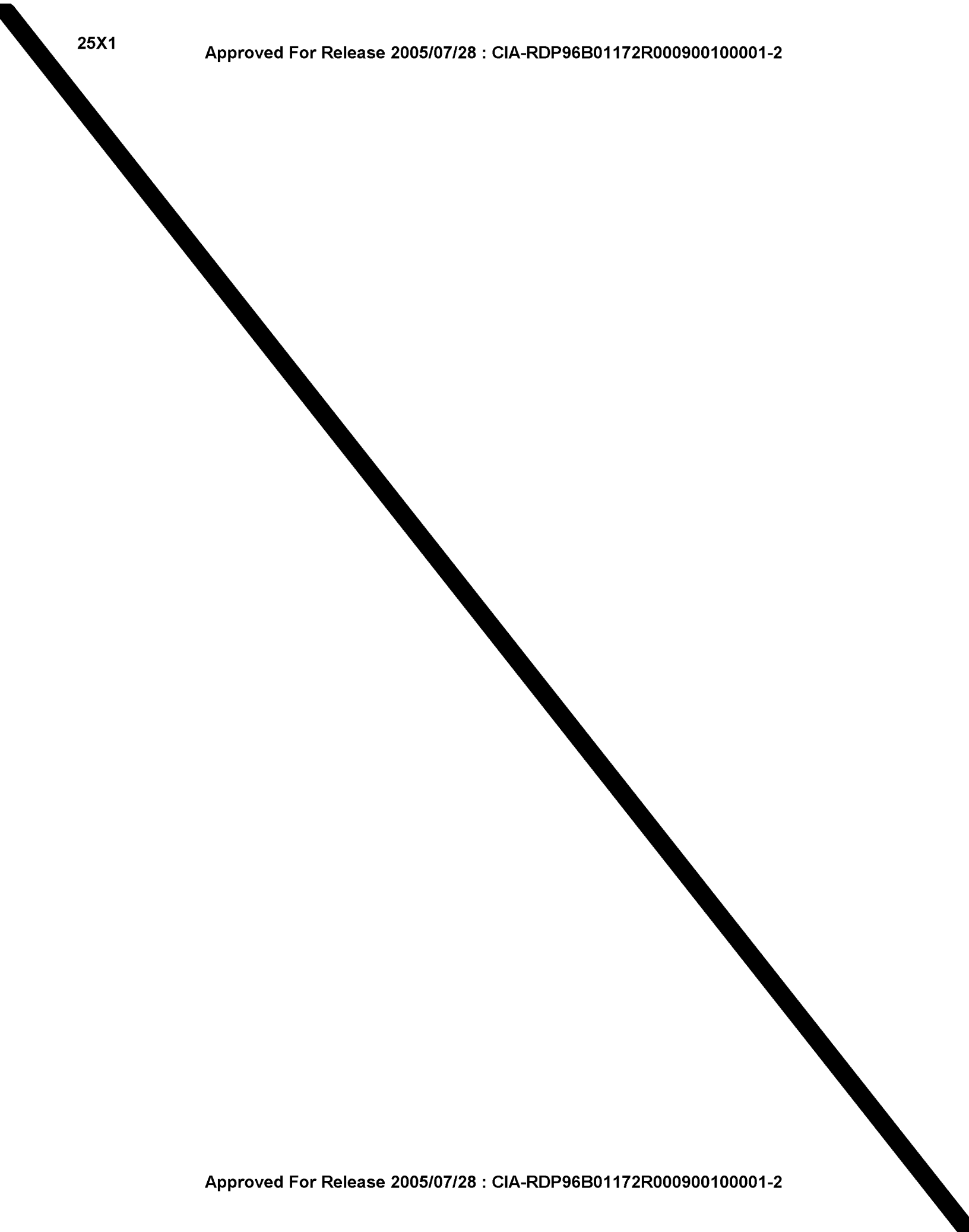

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DESTRUCTION CERTIFICATE

BW-1000/487 (3-66)

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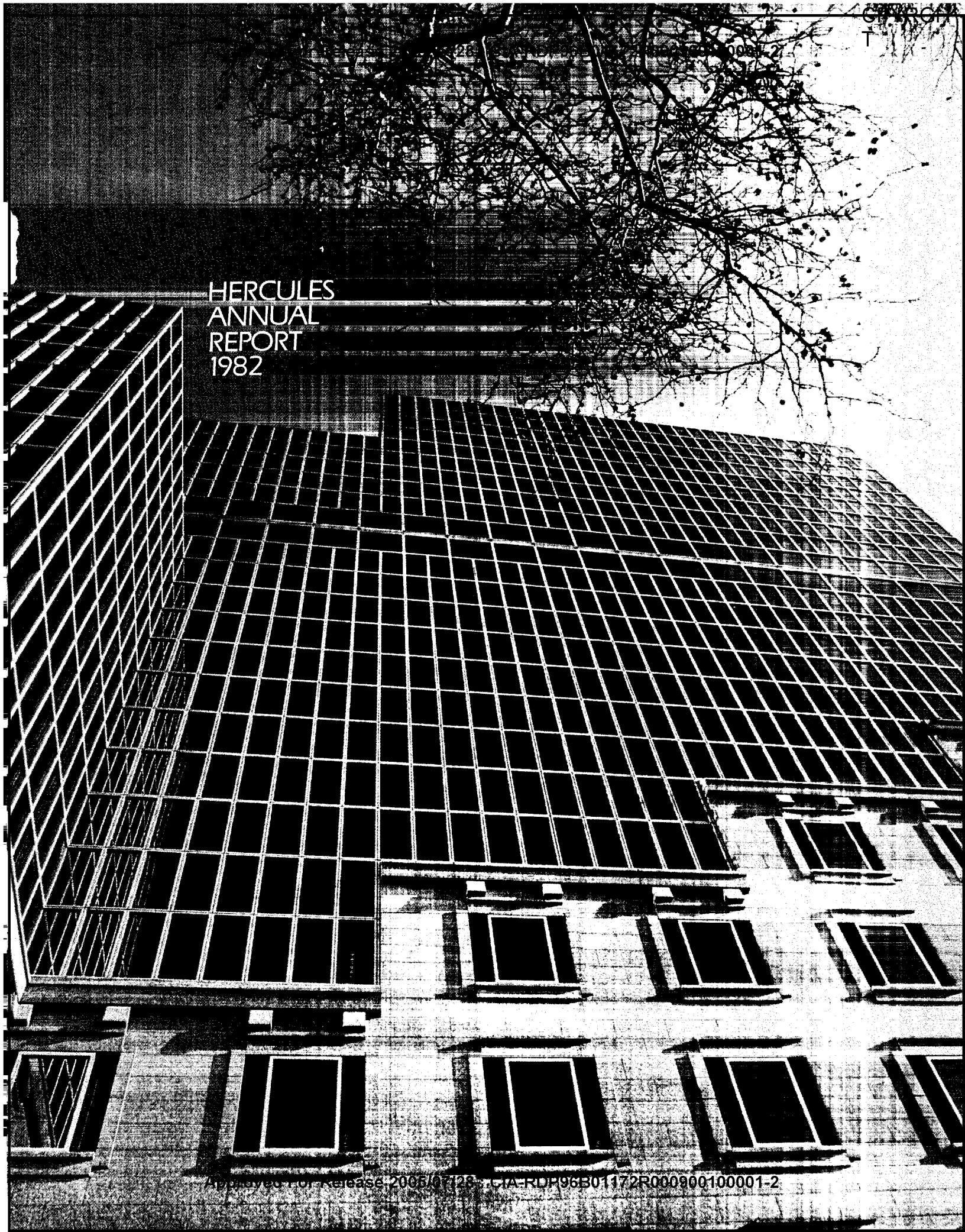
DESCRIPTION (Include subject or title, date of document, etc. Identify so as not to reveal classified information)	CLASS.	COPY NO.

DESTRUCTION CERTIFICATION	WITNESS
I certify that I have this date destroyed the document(s) described above in accordance with DOD Industrial Security Manual.	WITNESSED BY (SIGNATURE)
DESTROYED BY (SIGNATURE) DATE	DATE

HERCULES ANNUAL REPORT 1982



ABOUT THE COVER

Hercules' new corporate headquarters building at 13th and Market Streets in downtown Wilmington is nearing completion. Relocation to the building is scheduled for second-quarter 1983.

Located on the banks of the historic Brandywine River, the building was designed as an architectural statement of quality to enhance Hercules' image in the community as a leading international chemical company. It incorporates the most modern communications, energy conservation, and office automation equipment to enhance office productivity and at the same time provide a pleasant environment for Hercules employes.

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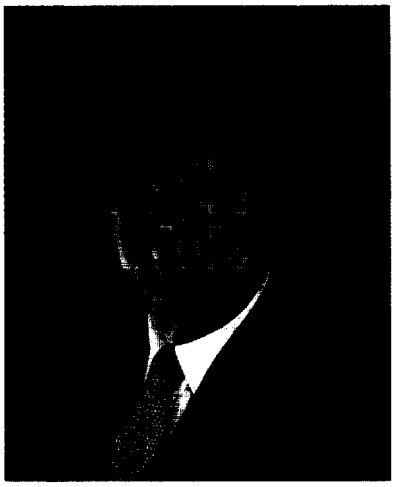
Selected Financial Data

(Dollars and shares in millions, except per share)

	1982	1981	1980	1979	1978
For the Year					
Net Sales	$2,469.0	$2,718.4	$2,485.2	$2,345.4	$1,946.5
Profit from Operations	113.7	211.7	154.9	211.5	186.2
Income Before Taxes	83.6	180.4	114.7	238.4	157.8
Income Before Extraordinary Gain	86.8	136.5	114.0	172.5	103.3
Extraordinary Gain	11.6	—	—	—	—
Net Income	98.4	136.5	114.0	172.5	103.3
Dividends	56.9	53.6	50.9	45.6	42.4
Per Share of Common Stock					
Earnings Before Extraordinary Gain	1.97	3.09	2.60	3.89	2.36
Extraordinary Gain	.25	—	—	—	—
Earnings	2.22	3.09	2.60	3.89	2.36
Dividends	1.32	1.26	1.20	1.075	1.00
Research and Development	70.7	61.4	53.5	46.7	40.1
Depreciation and Amortization	120.5	118.8	114.5	106.5	106.7
Capital Expenditures	165.0	167.2	229.2	186.0	115.8
At Yearend					
Working Capital	431.4	518.9	386.7	379.4	332.7
Ratio	2.2	2.5	2.0	1.9	1.9
Property, Plant and Equipment — at cost	2,079.7	2,018.6	1,882.3	1,703.5	1,615.4
Total Assets	2,001.4	1,997.1	1,889.7	1,761.2	1,596.6
Long-Term Debt	431.9	454.4	334.5	280.6	296.0
Stockholders' Equity	1,078.9	1,051.4	1,009.7	945.4	818.5
Per Share	24.18	24.73	23.79	22.31	19.31
Common Shares Outstanding	44.6	42.5	42.4	42.4	42.4
Number of Common Stockholders	35,390	37,696	37,263	37,744	38,199
Number of Employes	21,598	22,777	22,928	24,387	24,431



Alexander F. Giacco, chairman, president and chief executive officer

To Our Shareholders

The year 1982, the second year of the longest business decline since the 1930s, was certainly a continuing test of our strategy. In the 1975 recession, Hercules was unable to completely earn its dividend payment, which was nevertheless paid. This year it was earned in just over eight months, reflecting the many improvements we've made in our operations.

For 1982, we reported net income of $98.4 million, equal to $2.22 per share, compared with $136.5 million, or $3.09 per share, in 1981. Sales for 1982 were $2.46 billion, down from $2.71 billion in 1981.

During the past four years, we have worked hard at reducing the cost of doing business, and over the past few years we have lowered our break-even level by at least 10 percentage points. In July, our plants reached their low point in capacity utilization, operating at under the 55 percent level, yet we were still able to generate an operating profit. To break even five to seven years ago would have required our facilities to operate at 65 to 68 percent of capacity. An important reason for this improvement has been a significant decline in overhead costs. Selling, general and administrative expenses (ex-research and development), SG&A, have been reduced from an average of 11 percent during most of the 1970s to under 10 percent during the 1980s. If 1982 sales had remained at the same level as those of 1981, the average would have dropped well below 9 percent. However, because of the sharp decline in sales caused by the recession, the SG&A percentage of sales actually increased. Nonetheless, in terms of dollars, SG&A expenses declined in 1982 from those of 1981. Accordingly, our upside earnings potential has been considerably enhanced as the business recovery results in higher sales levels.

As part of our previously announced effort to improve operating efficiencies, in 1982 we accomplished a significant reduction in the total number of people in Operations without sacrifice to either the quality of our products or the safety of our employes. There is no simple formula for an excellent safety record. We believe it to be the result of positive and active concern expressed both in words and action, which translates down the line into day-by-day, minute-by-minute awareness of safety in each worker's mind. This translation, reinforced by continuous training, is the path to continued excellence. In 1982, Hercules achieved its best record since its inception in 1912. For the year, the accident frequency rate of 0.12 is the equivalent of less than one injury for every 1.5 million man-hours worked. By comparison, this accident frequency rate is approximately four times lower than the chemical industry average accident frequency rate for 1982.

During the year, we continued to make strides in reducing the volatility of our earnings. Prior to the 1970s and our heavy commitment to commodity petrochemicals, Hercules earnings had been quite stable and on a solid growth path. In the four years following the 1973 OPEC oil embargo, our earnings averaged $1.56 from the continuing business, but during that same time period there was a range of plus or minus 51 percent variation around this average. The reason for this was that a large percentage of our revenues was from petrochemical commodity products.

At the very heart of our strategic plan and management philosophy is the idea of minimizing these wide earnings fluctuations and thereby making our earnings more predictable. A greater degree of financial stability is of immeasurable value in the strategic planning process. We have demonstrated progress in this vital area. For instance, between 1978 and 1982, our earnings, affected by two recessions, averaged $2.74 per share from the continuing business, with a range of plus or minus 24 percent variation around the average. There is room for further gains, and we are working to achieve them.

A positive change in investors' perceptions of and expectations for Hercules has been reflected in the performance of our stock in 1982. The price:earnings ratio at yearend stood at 15, one of the highest among the major chemical companies and an indication that we have regained our position among the leaders in our industry.

During the year, we cut our capital spending program from an originally forecast amount of $200 million to an actual

$165 million. It is our intention to finance capital projects through internally generated funds rather than through borrowing. We are essentially still on target for our $1.4-billion, six-year investment program, which we announced in 1978, although we have delayed a number of projects rather than borrow money to finance them.

Between 1960 and 1970, Hercules was transformed from a relatively small domestic producer of value-added chemicals to a worldwide manufacturer of chemicals with a very large petrochemical commodities exposure, which accounted for 43 percent of the asset base in 1975. By 1984, we will have completed a second major transformation that will have minimized our commodities exposure to 19 percent of our asset base, and that will be based on products and markets unknown to the company in the early 1970s.

In almost all cases, these new products will perform a specific function such as covering, filling, protecting, strengthening, or thickening. We will not be making a direct one-on-one substitution for an existing product, as was the case with the petrochemical commodities. Rather, our new products will be bringing additional properties or functions to the marketplace.

Graphite fiber is a prime example of one of these new products. You will read more about it in this report, under Explosives & Aerospace. It is truly a new material and does things no other material has done before. Polypropylene films are another example, and several other new value-added polypropylene products are further testament to our concept of selling chemicals as properties rather than as a cheaper substitute for existing products.

A number of our businesses continued to make progress in 1982. Aerospace and Electronic Products reported improved sales and profits over 1981, as did PFW, a small but important segment of our specialties business. Film also had increased sales, although profits were about the same as those of last year. Adria Laboratories, jointly owned with Montedison S.p.A., reached the $100 million sales level for the first time, and is now poised for real growth.

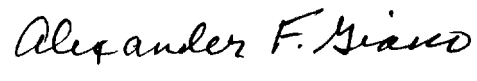
In the third quarter, we exchanged 2,038,154 shares of our common stock for $50 million of Hercules' 6.5 percent convertible debentures. The debentures were selling at a discount, which enabled us to generate a book gain on the transaction, while at the same time reducing debt and interest expenses and increasing equity, thereby strengthening the balance sheet with only a nominal dilutive effect on future earnings per share. Total debt at yearend declined over that of 1981, and the debt:equity ratio stood at 45 percent, a sharp reduction from the peak of 78 percent reached in 1975.

Once again, it is appropriate to comment on the Agent Orange litigation. A Phase 1 trial is now set for June 1983, to determine, among other things, whether the U.S. Government "knew as much as or more than the defendant about the hazards to people that accompanied use of Agent Orange." We are optimistic that Hercules and the other manufacturers will be able to demonstrate that there was no significant risk, and that in any event, the Government's knowledge was at least equal and probably superior to our own. If we are successful in the Phase 1 trial, most of the litigation will be terminated at the U.S. District Court level, subject, of course, to appeal.

In August, we announced the retirement of John R. Ryan, senior vice president and a member of the Board of Directors since 1967. At yearend, Stephen R. Clarke, senior vice president and a member of the Board of Directors since 1971, elected to take early retirement effective February 1, 1983. The many years of dedicated service to the company by these men have been greatly appreciated.

Special mention should also be made of the loyalty and devotion of each member of the Hercules family, who have contributed to implementing our strategic plan. They have faced difficult problems and to a large measure have solved them, with Hercules emerging stronger and with a sense of purpose that will carry it forward through the '80s and beyond.

As the new year begins, the economy is giving many indications that the recovery process is already underway. We are anticipating relatively modest GNP growth in 1983, with the economy gaining strength throughout the year and into 1984.

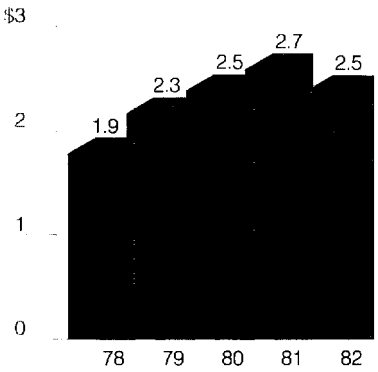


Alexander F. Giacco,
Chairman of the Board,
President and Chief Executive Officer

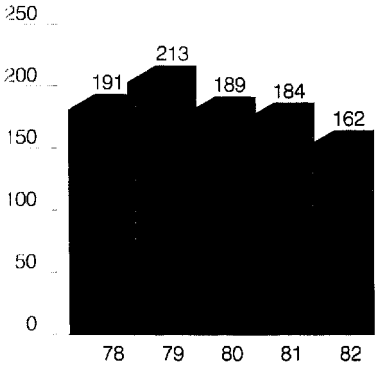
February 1, 1983

Management's Discussion and Analysis of Financial Condition and Results of Operations

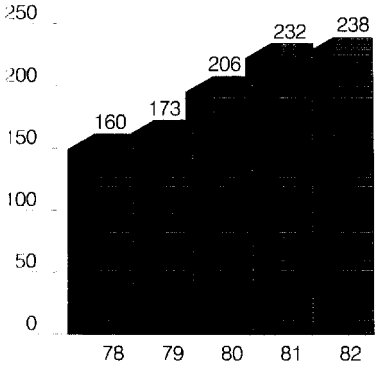
Net Sales
(Dollars in billions)



Physical Volume
(1967 = 100)



Selling Price
(1967 = 100)

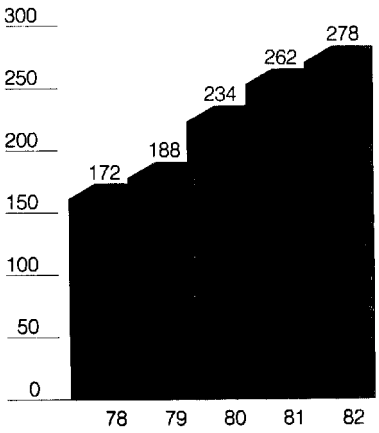


Results of Operations

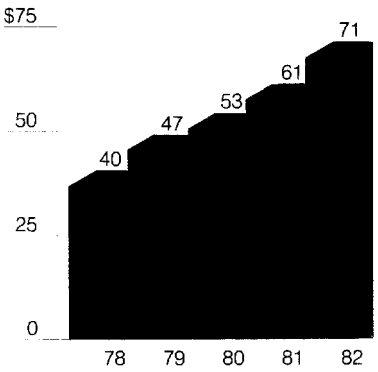
Consolidated Net Sales for 1982 were 9% lower than 1981, and approximately the same as 1980. As can be seen on the adjacent chart covering the most recent five years, sales have shown steady growth over the years, resulting in an average growth rate of 8%. The increase from 1980 to 1981 was the result of a 12% increase in selling prices and a 3% decrease in sales volumes. During 1982 the decline in volume continued by 12%, while sales prices in a generally poor business environment improved by a modest 3%. The charts to the lower left demonstrate relative volume and price performance over the past five years.

Profit From Operations was 46% lower in 1982 than 1981. In 1981, profit from operations had increased 37% from 1980. The 1981 improvement over 1980 was the result of slightly better gross margins as well as an improved relationship between sales and selling, general and administrative expenses. These improvements during 1981 were the result of concentrated efforts in cost effectiveness and our ability to increase prices. The unit cost chart to the right demonstrates our efforts during 1981 when, despite increases in raw material costs of 12% and energy costs of 15%, the rate of increase in costs lessened. During 1982 the rate of increase in raw material and energy costs declined significantly (particularly in the last quarter) and our aggressive attitude toward cost control continued. However, as noted earlier, sales volumes declined appreciably. This decline in sales volumes effectively offsets the gains achieved in gross margins and operating margins during 1981, causing the decline in profit from operations. Research and development costs, which represent future-oriented expenses, have experienced healthy growth over the past five years, as demonstrated on the chart to the right. These costs account for all of the dollar increase in selling, general and administrative expenses in 1982.

Cost per Unit
(1967 = 100)



Research and Development
(Dollars in millions)



Nonoperating Income was relatively stable during 1980 and 1981; however, during 1982 it increased by 32%. Most of this increase resulted from interest income received on tax refunds; gains on sale of know-how and fixed assets also contributed.

Interest and Debt Expense in 1982 increased 9% over 1981. The increase is primarily the result of higher debt levels experienced during the first six months of 1982. The 25% increase experienced in 1981 over 1980 was the result of the very high interest rates prevailing during the period.

Provisions for Income Taxes reflected an effective income tax rate of 24% for 1982, 28% for 1981, and 20% for 1980. The major cause of the reduction from the statutory rate of 46% is investment tax credits; however, the details of the causes for the respective tax rates are covered in Note 6 of Notes to the Financial Statements.

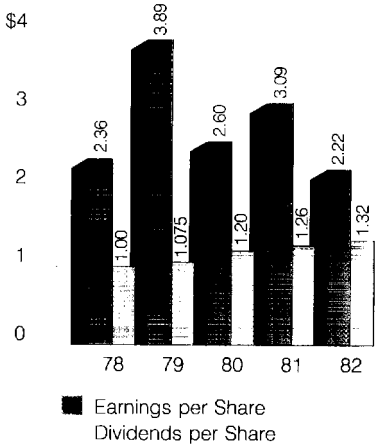
Equity in Net Income of Affiliated Companies for 1982 increased, thereby reaching levels achieved in years prior to 1981. The primary cause of the increase in earnings is the disposition of certain ventures that affected 1981 results negatively and, to a lesser extent, increased foreign currency translation gains.

Earnings per Share results were under recessionary pressure during the past two years. An analysis of the change in per-share earnings, which highlights factors discussed earlier, follows at the upper right:

	Per-Share Earnings Variance Increase (Decrease)	
	1982 vs 1981	1981 vs 1980
Profit from Operations		
Increased selling prices	$ 1.11	$ 5.43
Reduced volumes	(1.28)	(.32)
Manufacturing costs	(1.21)	(3.67)
Depreciation	(.03)	(.08)
Other	(.05)	(.06)
Increase (decrease) in gross profit	(1.46)	1.30
Increased research and development	(.15)	(.14)
Decrease (increase) in SG&A	.06	(.16)
Increase (decrease) in profit from operations	(1.55)	1.00
Other Causes		
Increased other income, net	.08	.32
Increased interest costs	(.07)	(.17)
Lower (higher) effective tax rate	.07	(.32)
Increase (decrease) in equity income	.35	(.34)
Increase (decrease) from other causes	.43	(.51)
Extraordinary Gain	.25	—
Increase (Decrease) in Net Income	$ (.87)	$ .49

Earnings and Dividends per Share of Common Stock

(Dollars per share)

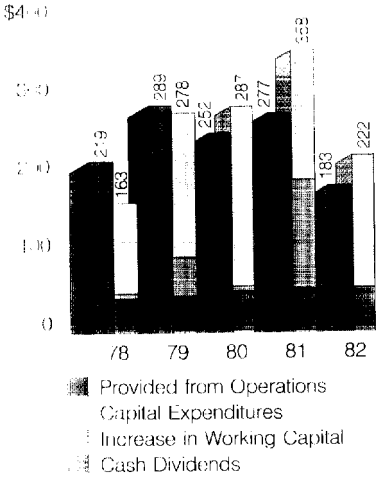


The chart shown to the left demonstrates a rising trend in earnings per share from 1978 to 1981, with the business slowdown causing a decline in 1982. In addition, dividends represented an average payout of 42% and increased slightly year to year.

In addition to the preceding discussions, more specific information is presented regarding business segments, international business, research and development, and energy costs within their respective sections of this report. The impact of inflation is included in Note 13 of Notes to the Financial Statements.

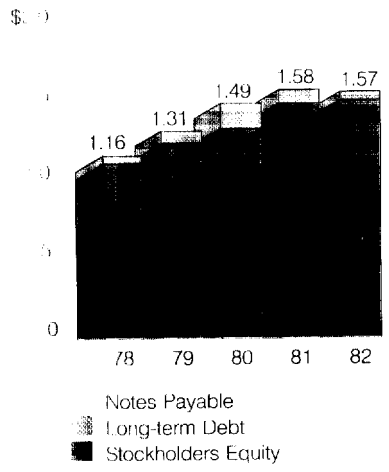
Internal Sources and Principal Uses of Funds

(Dollars in millions)



Total Capitalization at Yearend

(Dollars in billions)



Financial Condition

Liquidity must be considered from both the short-term and long-term perspectives. Accordingly, in discussing the company's relative strength, the current position as well as the ability to generate funds internally and externally is considered.

Hercules' quick ratio (current assets, excluding inventories divided by current liabilities) during the 1980 to 1982 period was consistently above "one," while the current ratio during the same period improved from 2 to 1 to 2.2 to 1. In addition, the company maintains sufficient credit lines to support its short-term financing needs. Short-term lines available at December 31, 1982, totaled $126 million.

Hercules' most important source of funds is the positive inflows from operations (mainly net earnings plus depreciation) which aggregated $183 million in 1982, $277 million in 1981, and $252 million in 1980. On the upper left chart, internally generated cash is shown alongside the primary uses — i.e., capital expenditures, increases in working capital, and cash dividends for the most recent five years. Both capital expenditures and dividends are discussed later in more detail, but the five-year comparison demonstrates the company's ability to substantially satisfy these requirements internally.

An additional significant requirement of funds that deserves comment is the near-term maturity of the $100 million 8¼% notes. Hercules has maintained flexibility in the manner in which refinancing and other obligations, such as shortfalls, shown in the top chart (1981), may be satisfied. The company's overall financial policy is to fund capital expenditures, working capital, cash dividends, and other operating cash requirements, primarily from internally generated funds, with prudent use of debt as our total capitalization expands (see following Capital Structure discussion). Consistent with the maintenance of the appropriate level of debt, the $100 million will be refinanced. In order to maintain this flexibility, the company has entered into revolving credit agreements with several banks, $200 million of which was available at December 31, 1982.

In addition to the more traditional sources of funds just discussed, Hercules has assured itself of relatively low-cost funds (through the deferral of Federal income taxes) in significant amounts over the next fourteen years. This was accomplished by purchasing tax benefits from other companies in 1981.

The Capital Structure of Hercules has remained sound and relatively constant. As can be seen by reference to the chart on the lower left, total capitalization has increased at a steady pace without disproportionate increases in any of the individual elements. During 1982, however, the company exchanged 2,038,154 shares of its common stock for $50 million principal amount of long-term convertible debt.

Changes have occurred during recent years in the makeup of the debt portion of the structure. During 1981 the company reduced short-term debt substantially in favor of long-term variable-rate financing. During 1982 Hercules replaced much of its variable-rate debt with fixed-rate foreign currency denominated debt. The foreign debt is in currencies of countries in which we maintain assets. In the future the company intends to continue to reduce its exposure to fluctuations in interest rates by undertaking long-term fixed-rate financing as favorable market opportunities develop.

The Quarterly Dividend, which was increased to $.30 per share in the first quarter of 1980 and to $.33 per share during the third quarter of 1981, totaled $1.32 per share in 1982. The total amount paid was $57 million during 1982 and represents a payout of 58% of net income.

Capital Expenditures for 1982 totaled $165 million, compared with $167 million in 1981 and $229 million in 1980. The decline during the most recent two years represents adjustments made by the

company as a result of generally poor business conditions. During 1982 about 35% of capital expenditures pertained to increased production capacity, compared with 50% in 1981 and 60% in 1980. Most of the remainder relates to "savings projects," which are intended to lower costs of existing products through efficiencies or technological developments. The relative increase in savings projects not only reflects Hercules' commitment to improved profitability but also is an indication of adjustments made in our spending programs as a result of the prolonged recession.

Major construction during 1982 included completion of expansion projects for *Natrosol* hydroxyethylcellulose at Hopewell, Virginia, *Herclor* epichlorohydrin elastomers at Hattiesburg, Mississippi, and carrageenan at Copenhagen, Denmark, as well as continuation of graphite fiber expansion at Magna, Utah. In addition, projects for nitrocellulose upgrading at Parlin, New Jersey, and carboxymethylcellulose upgrading and expansion at Alizay, France, were begun.

For 1983 capital expenditures are expected to approximate $200 million. This amount includes funds to complete the projects just mentioned and pectin expansion at Vero Beach, *Merigraph* photopolymer expansion at Middletown, Delaware, and several aerospace projects at Magna, Utah.

As discussed earlier, Hercules expects to generate the majority of funds required internally, with the balance to be met by additional debt without significantly changing the capital structure of the company.

Common Stock and Dividend Data

Hercules Incorporated common stock is listed on the New York Stock Exchange. It is also traded on the Philadelphia, Midwest, and Pacific Stock Exchanges.

The approximate number of holders of record of common stock ($\$^{25}/_{48}$ stated value) as of January 24, 1983, was 34,877.

Market Price Range	First Quarter		Second Quarter		Third Quarter		Fourth Quarter		Year	
	High	Low	High	Low	High	Low	High	Low	High	Low
1982	23½	17⅞	22¼	17⅝	22	16⅞	28¾	20⅛	28¾	16⅞
1981	26⅜	18¾	26¼	22⅝	25¼	19⅛	22⅝	19⅞	26⅜	18¾

Dividends Paid per Share	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Year
1982	$ .33	$ .33	$ .33	$ .33	$1.32
1981	$ .30	$ .30	$ .33	$ .33	$1.26

Operating Results by Quarters

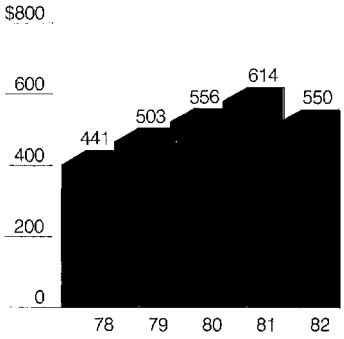
(Dollars in millions, except per share)

	Net Sales		Profit From Operations		Net Income		Earnings per Share	
	1982	1981	1982	1981	1982	1981	1982	1981
First	$ 640	$ 668	$ 29.8	$ 51.2	$ 21.9	$ 42.9	$ .50	$ .97
Second	651	712	29.9	69.0	22.3	41.4	.51	.93
Third	602	690	25.4	60.8	31.8*	36.1	.72*	.81
Fourth	576	648	28.6	30.7	22.4	16.1†	.49	.38†
Year	$2,469	$2,718	$113.7	$211.7	$ 98.4*	$136.5	$2.22*	$3.09

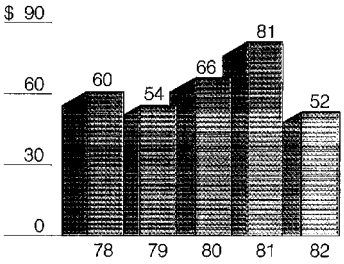
*Includes extraordinary gain of $11.6 million ($.25 per share) from an exchange of common stock for debt securities and charge of $5.0 million ($.11 per share) for writedown of investments.

†Includes $9.0 million ($.20 per share) income from "safe harbor" lease transactions and $12.3 million ($.27 per share) charge for writeoffs, essentially of investments and disposal of facilities.

Sales
(Dollars in millions)



Profits
(Dollars in millions)

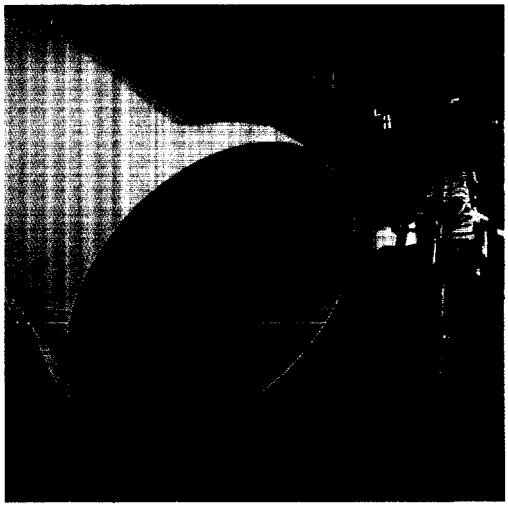


Organics group products, including resins, paper chemicals, and elastomers and specialty chemicals, had total 1982 sales of $550 million and profits of $52 million. This compares with 1981 sales of $614 million and profits of $81 million.

The **Resins Business Center** saw a 6 percent decline in sales and a 15 percent decline in gross profits in 1982, compared with 1981, as the weak world economies depressed major markets. Slowdowns in the adhesives, automotive, construction, minerals processing, and chemical intermediates markets resulted in lower demand for resin. Similarly, the world's naval stores market saw severe price reduction as mounting inventories pushed down the selling prices of rosin and its derivatives.

Despite the current weak market demand, the business center continued to follow its strategic objectives of forward integration to higher value end uses, improvement of geographic balance, continuation of cost reduction programs, and development of a renewable and expandable raw material base for wood rosin.

Two key markets selected for growth are adhesives and graphic arts. During the year, a new resins dispersion plant to produce adhesive tackifiers became operational at Jefferson, Pennsylvania. A proprietary line of tackifiers for newly developed hydrogenated block copolymers was also introduced in October. In addition, a proprietary Hercules adhesive is under evaluation as a carpet-backing adhesive designed to replace latex.



Rosin produced by the Hercules Pinex process is an expandable, renewable agricultural raw material for all of the company's organics-based products.

Hercules paper chemicals are used in the manufacture of high-quality commercial grades of paper for the publishing industry.

In graphic arts, Hercules has introduced three ink vehicle systems to supplement its existing extensive ink resin portfolio. A patented fusion ink system that allows printing without solvents at low energy requirements is nearing full-scale commercialization. A vehicle for use in water-based ink systems is under evaluation in the United Kingdom, and a family of paste ink vehicles is nearing commercial development status.

The geographic balance of the resins business was improved in 1982 when the Rika-Hercules Incorporated joint-venture resin plant at Tokushima, Japan, began operations in February 1982. We also have begun a significant expansion of the hydrocarbon resin operations at Middelburg, The Netherlands, adding hydrogenation and C_5 resin capability to this existing facility.

With regard to cost effectiveness, work is underway to improve the tall oil fractionation unit at Franklin, Virginia, and similar upgrading is beginning at Savannah, Georgia. Additional savings were achieved through consolidation of the hydrocarbon resin plant from Clairton to Jefferson, Pennsylvania, and transfer of the resin operation from Erith, England, to the existing Netherlands facility at Zwijndrecht.

To provide a renewable and expandable raw material base for the rosin-based products, the Pinex process was developed to stimulate the formation of rosin deposits within living trees. In July, a full-scale plant trial was run at the Hattiesburg, Mississippi, plant that justified expectations for the process. The trial confirmed that stumps from trees that had undergone Pinex treatment yield wood rosin and its ultimate derivatives that meet all commercial specifications. Yield of rosin and subsequent derivatives reached anticipated levels. Nonetheless, our task remains to provide an inexpensive mechanical harvesting technique to achieve the low-cost potential for this important raw material. In the meantime, Pinex-treated wood is currently being used on a regular basis as raw material at both Hattiesburg, Mississippi, and Brunswick, Georgia. Significant quantities of Pinex-treated wood will be harvested in 1983 to supplement existing aged-stump feedstocks.

Concrete contains several Hercules products, including hydrocarbon resins in curing compounds and *Vinsol* rosin soap as an air-entraining agent.

The **Paper Chemicals Business Center** reported a 6 percent decline in worldwide sales from 1981, reflecting decreased production in the paper industry. Gross profits were also down 9 percent as price/cost pressures in the manufacture of paper and paperboard were passed back down the supply line.

In addition to its short-term economic needs, the paper industry also has longer term demand for cost-effective products. These needs reinforce the dedication of Hercules' ongoing programs of developing new products and systems that will give papermakers the capability of producing paper that is lighter in weight, yet stronger; higher in water resistance, yet lower in cost; and at higher production rates, with reduced energy consumption.

Hercon and *Aquapel* alkaline sizing products are used in virtually every grade of paper and paperboard produced throughout the world, and newly developed members of these product families are being readily accepted by the papermakers. Sales of *Kymene* wet-strength resins also continue to grow as this versatile product is used to improve paper milk carton durability and to make soft, yet strong paper towels. Hercules' new foam technology system is now being commercialized and offers the papermaker the benefits of increased production rates and improved paperboard quality at lower cost.

To assist in keeping these programs in step with industry needs, Hercules has just completed a multimillion-dollar Emulsion Technology Center at the Savannah, Georgia, plant that will expedite development of new products. This facility and the new pilot paper machine at the Kalamazoo, Michigan, plant are designed to coordinate with the needs of the seven worldwide paper chemical laboratories and to assist in the production of new paper chemicals in each of Hercules' 26 production plants located in the papermaking centers of the world.

The developing nations of the world also offer good growth markets for paper, and thus modern paper chemical technology. While Hercules is already well established in many of these developing nations, it is moving to strengthen its position as a high-technology supplier in these markets.

The **Elastomers & Specialty Chemicals Business Center** reported a reduction in sales and gross profits in 1982, because two primary markets, automobiles and residential construction, were severely weakened by the continuing recession.

Sales were down 22 percent compared with 1981, most of which was due to lower rosin emulsifier sales to the depressed synthetic rubber industry. Gross profits for the business center were down 19 percent from 1981, all of which is attributable to lower sales for rosin-based emulsifiers. Gross profits increased on the nonrosin portion of the business, which includes cross-linkers, elastomers, catalysts, synthetic lubricants, and coupling agents.

During the year, a second production facility at Hattiesburg, Mississippi, for *Herclor* elastomers was completed on time and well under budget. This specialty polymer is used extensively for engine compartment components on Japanese-, European-, and American-built automobiles because of its outstanding heat- and fuel-resistance properties. The startup of the facility has been delayed, pending recovery of the worldwide automobile industry. In the interim, product development has been escalated in such nonautomotive applications as printing press rolls, pond liners, and fuel delivery hose.

After years of design, testing, and negotiations, the Belgian Government has allowed Hercules to use 1,500-kilogram stainless steel bulk tanks for shipment of *Di-Cup* dicumyl peroxide from the Paal, Belgium, facility. These specially designed tanks are equipped with a heating system so the contents can be melted without contamination, a major step forward in quality control for the European wire and cable industry.

Azide coupling agents, now in production at a new specialty chemicals plant at Brunswick, Georgia, continue to show growth in treating mica for polypropylene reinforcement applications. During the year, a number of new automotive parts were designed around the concept of azide chemistry because it allows the use of low-cost filled polypropylene in applications that formerly required more expensive engineered plastics or metal.

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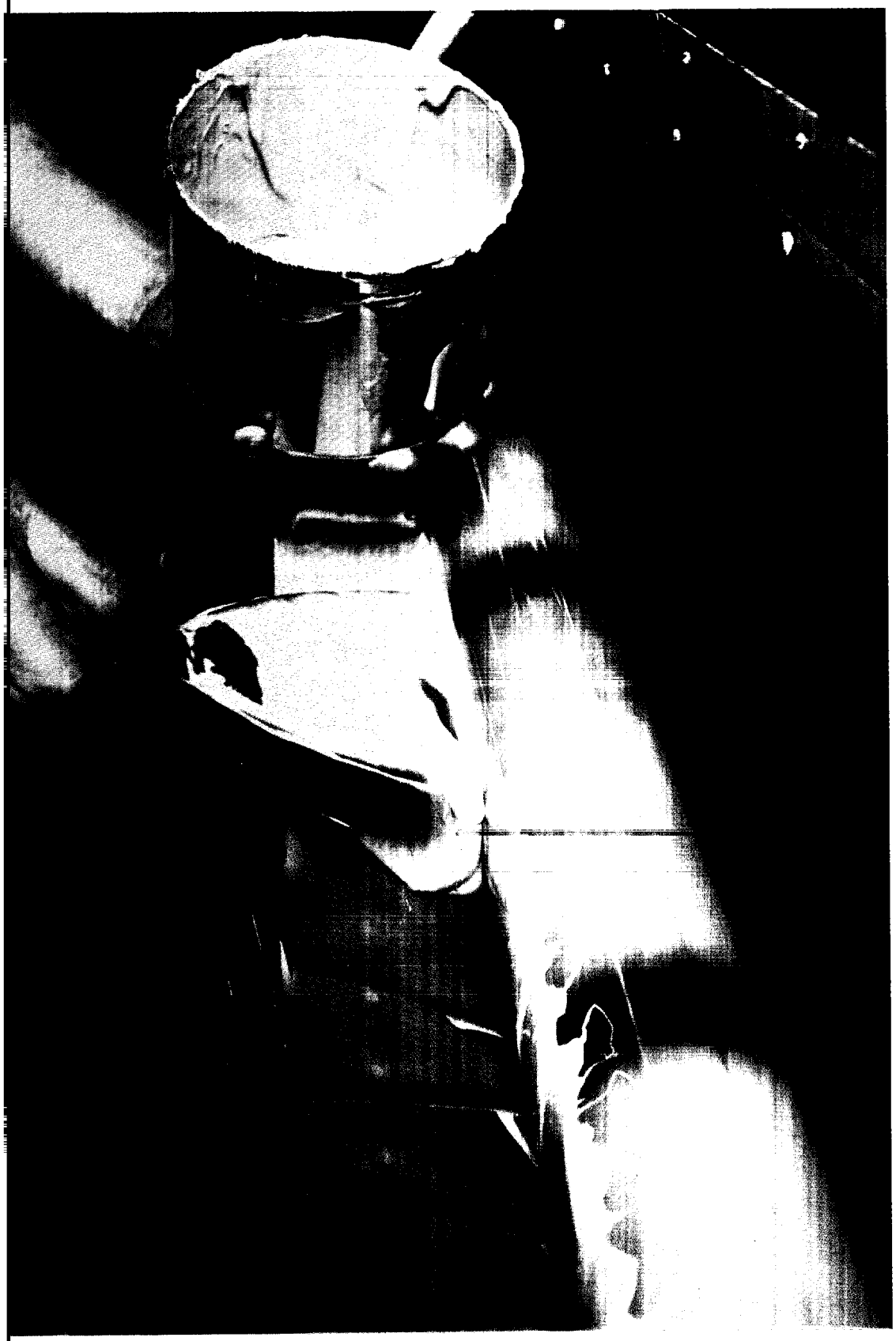


PRODUCTS

Hydrocarbon resins for use in adhesives, paints and varnishes, printing inks, and rubber compounds.

Rosin resins for use in the formulation of floor tile and linoleum, adhesives, varnishes, natural and synthetic rubber, and printing and ceramic inks.

Synthetic resins for use in adhesives, chewing gum, floor polishes, inks, and toners.

Herclor and *Parel* high-temperature, fuel-resistant synthetic rubbers.

Di-Cup and *Vul-Cup* peroxides for polymer cross-linking.

Dresinate rosin emulsifiers used in the manufacture of synthetic rubber.

Hercoflex and *Hercolube* synthetic high-performance lubricants.

Echo vulcanizing agents; azide coupling agents.

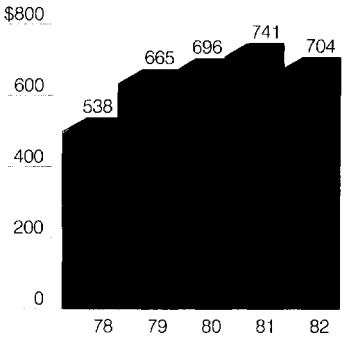
Aquapel sizing agent and *Hercon* sizing emulsion used in the manufacture of paper and paperboard.

Kymene wet-strength resins and *Paracol* emulsions to impart water resistance to paper and paperboard.

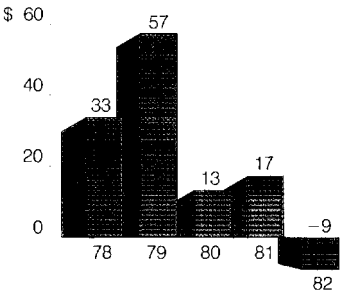
Defoamers and release agents to facilitate production processes of paper and paperboard.

A variety of Hercules resins are used in the formulation of printing inks, including those used in the printing of this annual report.

Sales
(Dollars in millions)



Profits
(Dollars in millions)



Plastics operations include resin, film, fiber, and plastic products, all of which had 1982 sales of $704 million and a loss of $9 million. This compares with 1981 sales of $741 million and profits of $17 million.

Our plastics business strategy is to add value to basic polypropylene polymer by downstream integration, and to balance the business in terms of product mix and geography. The goal is to consume one-third of our polymer internally through film, fiber, synthetic pulp (discussed under Other Products), and plastic products; to sell another third of the product as specialty higher profit copolymers; and to sell one-third as homopolymer, a large portion of which are higher-value-added products rather than general-purpose resins. At the same time, we have aimed for a worldwide position in markets, plants, and raw materials in order to take advantage of changing worldwide conditions.

Primarily as a result of the U.S. recession, worldwide sales for the **Plastic Resins Business Center** decreased 5 percent from 1981, and gross profits declined 32 percent. In order to compensate as much as possible for the lower sales volume, 1982 efforts were concentrated on cost reduction, which included improving production yields and reducing raw materials consumption, inventories, and indirect costs. Monomer-to-polymer yields have essentially reached the limit at all plants, with values ranging from 99.3 to 99.9 percent. In addition, cost reduction projects have lowered plant costs by about $.03 a pound from 1979.

Another aspect of the strategy is to be balanced geographically. In the U.S. and Canada, we have a large portion of the total polypropylene polymer sales as well as downstream value-added products. In Taiwan, the joint-venture polypropylene resins facility is the sole producer. During the fourth quarter, a joint-venture resins facility at Rio Grande do Sul, Brazil, began startup and will soon be supplying product to the South American market. In Europe, a low-cost, efficient production facility at Paal, Belgium, serves the European markets.

There has been considerable activity in technology, especially in new catalysts and processes. Hercules has made advances in high-mileage (long-lasting) polymerization catalysts, which produce very high yields of desired isotactic polypropylene. In addition, a number of alternative systems are being offered by others for license, and these are being evaluated also. Such new systems soon will be introduced into present plants, with the prospect of further considerable cost savings. In addition, there appear to be major gains obtainable by relatively minor modifications to present plants to enable use of simplified new processes. All in all, Hercules polypropylene technology is poised to make notable gains in the next few years.

Both sales and gross profits for the **Film Business Center** increased slightly over 1981 in spite of the poor economy. Major segments of the flexible packaging industry served by Hercules films, packaging for snackfoods and tobacco products, showed essentially no growth this year. We were able to improve our performance through introduction of new products from the new capacity brought on in the United States and Canada last year.

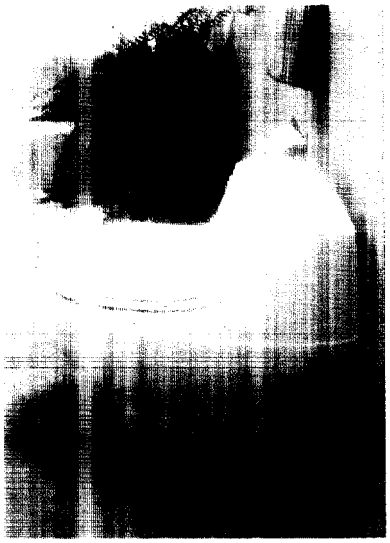
Although sales of traditional tubular products did not grow significantly, profitability was maintained by reducing operating costs and by marketing emphasis on higher value products.

The new white opaque films have broadened our market base, as sales for this unique product developed in such areas as gift wrap, candy wrap, and soap packaging. This product line continues to show the same growth potential for opaque packaging as demonstrated in the past by transparent films for clear packaging. In addition, sales of heavier gauge film from the new tenter lines continued to grow in stationery supplies, photo albums, and cable wrap.

In other film plants situated in strategic world markets, we have experienced major market and profit improvements. This year we enjoyed a full year's operation of oriented polypropylene film at the Varennes facility in Canada. Sales increased sharply in the latter part of the year because of the shutdown of a competitor's Canadian cellophane plant.

The film plant at Brantham, England, began producing Hercules' unique tobacco-grade film this year, and showed growth in sales as the European markets accepted the new wrap for cigarette production. Polo Industria e Comercio Ltda.,

Hercules 75-gauge MWB (multiwall bag) film is used as a liner in dogfood packaging for its grease- and oil- resistance as well as its high moisture barrier properties.



our joint venture in Brazil, introduced oriented polypropylene films to the converting industry in Brazil, with initial success in biscuit packaging.

Developing new products to fit the needs and requirements in the marketplace continued to be a major objective for the film business worldwide. This year, products that have been developed since 1979 represented 12 percent of sales. By 1986 they are expected to contribute more than 30 percent. These new products are important to the future development of better flexible packaging for food and drug products. Both of these industries, based on consumer demand, continue to look for superior protection for their products, and Hercules intends to be the leader in meeting their needs.

The tank and bowl lining of the Delta 4000 series Aqualite water closet is made with Hercules polypropylene resin. The one-piece water closet weighs 30 pounds, compared with 100 pounds for china models, a weight saving that is achieved in large part through the use of polypropylene.

Delnet nonwoven fabric is the nonadherent facing used on intravenous pads and other surgical dressings. Intravenous syringes are also made with Hercules polypropylene resin.

For the year 1982, sales for the Fibers Business Center declined from those of 1981 by 16 percent as a result of the recession, and gross profits were down 33 percent, in part from the poor economy, but also because of continuing new plant development costs.

The basic strategy for the business center is to add value to polypropylene through the product mix and keep costs low. The two chief areas of concentration are new products for nonwoven disposable fabrics, most especially thermally bonded fabrics for disposable-diaper cover stock and related uses; and proprietary products such as multi-ply yarns for the contract carpet market and spun yarns for velvet upholstery.

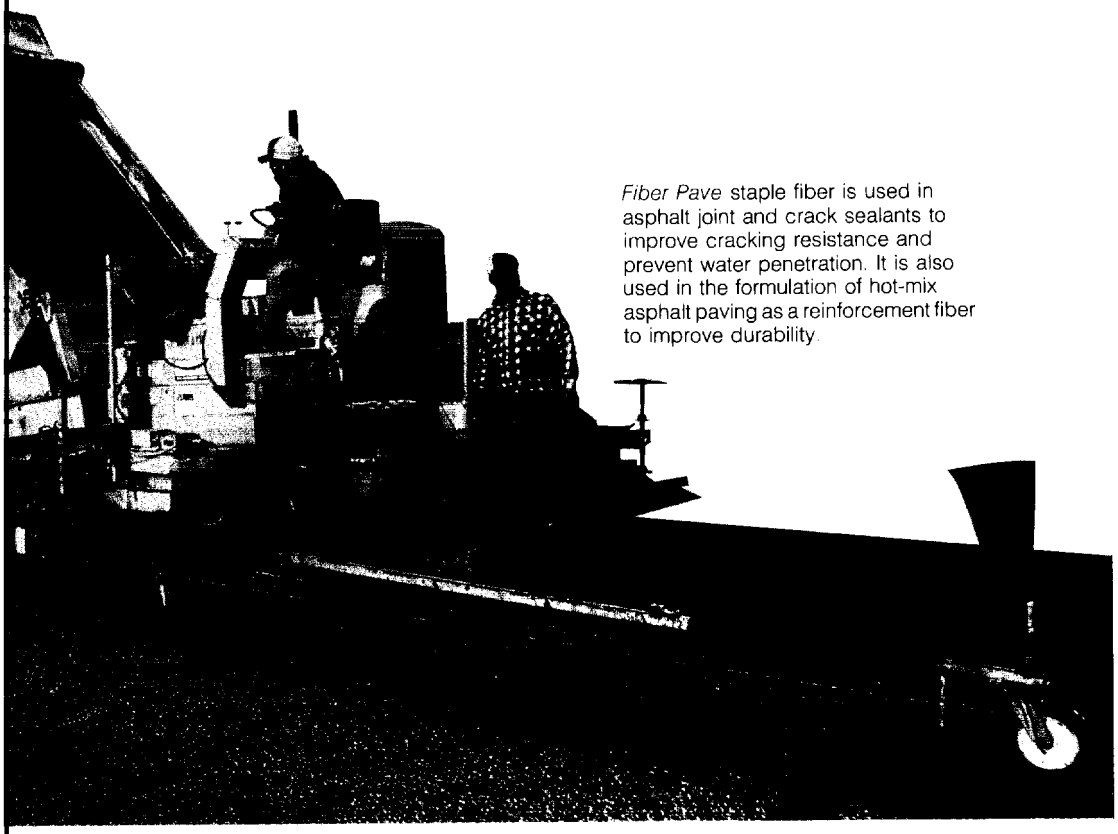
Up to the present time, the market emphasis has been strongly on the side of textiles, mainly carpets and upholstery. However, by 1985, we expect nonwovens to make up 50 percent of the total, substantially reducing dependence on the cyclical market of traditional textiles.

In 1982, despite the recession, we improved gross profit margins in textiles, although this was offset by new process development in the staple fiber plant at Oxford, Georgia. These new process problems have now been solved, and the volume of staple sales to nonwoven markets is increasing, mainly for thermally bonded 100 percent polypropylene cover stock fabrics, which offer superior performance and lower cost over existing materials.

Hercules is the only supplier of thermally bondable polypropylene fiber for this application in the U.S., and current forecast demand should take 50 percent of the rated plant output by the end of 1983. There are, of course, other uses besides this specific one, and there is good reason to believe that the 100-million-pound-per-year capacity of the new staple plant will be utilized rather quickly, and that Fibers will be a major profit contributor to the Plastics Group.

Sales in the Plastic Products Business Center were 14 percent lower than in 1981, but gross profits declined only 9 percent owing to good control of plant costs.

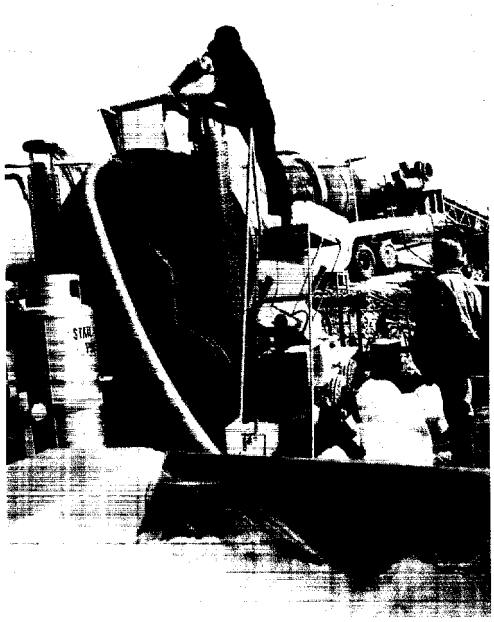
We were successful in getting Underwriters Laboratories approval for a cable construction based on the proprietary *Exar* insulations for use in certain segments of the large plenum cable market. These cables,



Fiber Pave staple fiber is used in asphalt joint and crack sealants to improve cracking resistance and prevent water penetration. It is also used in the formulation of hot-mix asphalt paving as a reinforcement fiber to improve durability.

manufactured by the wholly owned Champlain Cable Corporation, are installed in the space above false ceilings in buildings, and are used for signal transmissions for computers, telephones, and other low-voltage applications. This is a large market and should lead to significant new sales.

In 1982, several promising new products were introduced. One of these, wide-mouthed oriented polypropylene jars, has been sold in commercial quantities for use in packaging instant tea, replacing the glass jars previously used. These oriented polypropylene jars provide a clear package that effectively blocks moisture vapor transmission. In addition, they weigh only 10 percent as much as glass jars of equal size and are practically unbreakable. Oriented polypropylene jars are expected to replace glass jars for packing such products as dehydrated fruit drinks, nonaromatized coffee, and certain other food products. A second new product line now being evaluated for commercial use is based on our family of modified polypropylenes that bond well to metals, glass, and other plastics. Films of these bonding resins applied to steel and aluminum show promise of providing a cost-effective internal and external protective barrier for food cans. There is active interest by canmakers in this application in the U.S. and overseas.



PRODUCTS

Polypropylene resins, including many grades and types of both homopolymers and copolymers: Broad uses include film; fibers; injection molding applications for the automotive industry; housewares; appliances; and general extrusion uses.

Nonsealable films: For laminations with cellophane, paper, foil, and other films for food packaging, as are Hercules' sealable, composite, and barrier-sealable films.

Sealable, composite films: Coextruded heat-sealable polypropylene films used alone and in laminations.

Barrier-sealable films: Polypropylene films with saran coating to provide high oxygen barrier.

White, opaque films: A replacement for glassine and specialty papers in food packaging.

Herculon polyolefin fiber, continuous and bulked multifilament yarns for upholstery, carpets, and industrial applications.

Herculon polyolefin staple fiber, used in nonwoven fabrics and spun yarns for disposable diapers and other health care products, home furnishings, automotive interiors, vinyl substrates, filters, and screens, as well as for other industrial uses.

Exar irradiated wire for the aircraft, rapid transit, appliance, and instrumentation industries, and high-temperature wire for the aircraft and computer industries.

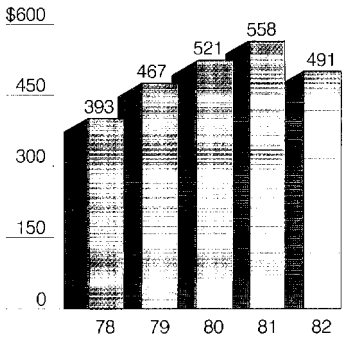
Oriented polypropylene bottles used in the food-packaging, household chemicals, and pharmaceutical industries.

Thermoformed rigid polypropylene containers such as cups, bowls, trays, and lids for the food and pharmaceutical industries.

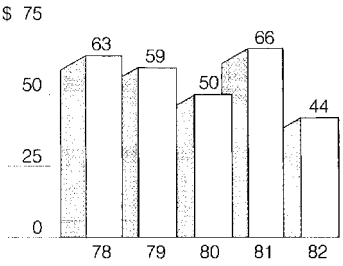
Delnet nonwoven lightweight fabric for filtration, health care, and textile applications.

Water-Soluble Products

Sales
(Dollars in millions)



Profits
(Dollars in millions)



Water-soluble products, including water-soluble polymers, coatings, PFW products, and water management chemicals, had total sales of $491 million and profits of $44 million, versus 1981 sales of $558 million and profits of $66 million.

For the past ten years, **Water-Soluble Polymers** has been a growth business for Hercules. Sales increased at 15.2 percent per year, compounded from $80 million in 1972 to $286 million in 1982. During this same period, gross profit grew at a compounded rate of 11.7 percent. Profitability, as measured by return on total operating assets, has been well above the corporate average in spite of the capital intensity of the business. In view of the historical performance, 1982 has been disappointing in that it was the first down year since 1972, even though it was the third best year in history. Sales were down 18 percent from 1981 and gross profits declined 20 percent.

There were two reasons for this lower performance: the depressed state of the worldwide economy and the major reduction in oil and gas drilling activity in the United States, combined with corresponding inventory adjustments by customers, the oilfield service, and drilling mud companies.

Although 1982 was a disappointing year, water-soluble polymers remained profitable, and the future looks bright. New product lines such as guar derivatives and mixed cellulose derivatives, including hydroxypropyl hydroxyethylcellulose, carboxymethyl hydroxyethylcellulose, and hydrophobically modified hydroxyethylcellulose, have been developed to serve the needs of key markets: the oilfield service, food, building material, coating, textile, pharmaceutical, and personal-care industries.

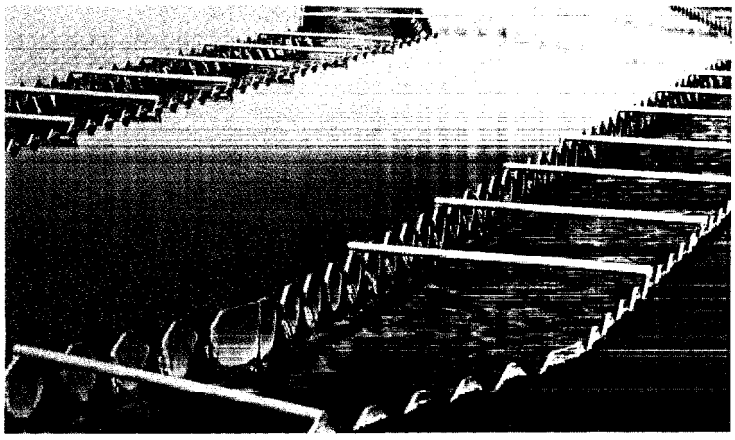
Specialty businesses such as water-soluble polymers are best served by flexible multipurpose plants. The hydroxyethylcellulose plants at Parlin, New Jersey, Hopewell, Virginia, and Zwijndrecht, The Netherlands, have undergone process improvements and modifications to produce the new mixed water-soluble and guar derivatives so that Hercules can develop new segments within key markets at very low risk.

Hercules must lower its production costs and is constantly developing new ways to reduce them. In 1982, major expansions of the carboxymethylcellulose (CMC) facility at Alizay, France, and the hydroxyethylcellulose plant at Parlin, New Jersey, were authorized. Both projects will include new technology that will markedly reduce operating costs. Also, in 1982, the largest plant for water-soluble products, Hopewell, Virginia, was reorganized, resulting in a reduction in management as well as the personnel required to operate the facility.

The markets for water-soluble polymers offer significant growth potential. Hercules is in a very strong position to capitalize on these opportunities when the economy begins to recover.

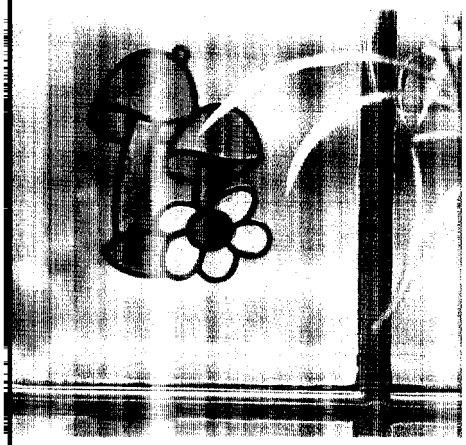
Sales for the **Coatings Business Center** in 1982 were down 10 percent and gross profits declined 22 percent, compared with 1981.

Although the products in this business center are considered mature, the average growth rate in sales over the past ten years was 11.2 percent, versus 9.8 percent for the corporation as a whole. During this same time period, the business center has generated positive cash flow. Its



Hercules water management chemicals are major contributors to improved and purified industrial and municipal water supplies.

Klucel hydroxypropylcellulose is used in the formulation of tablet coatings and as a granulation aid for pills and vitamins.



Natrosol hydroxyethylcellulose is used as a thickener in shampoos.

PFW fragrance creations are used in the formulation of fine perfumes as well as in air fresheners such as Sparklers, highly fragranced stained-glass miniatures based upon technology developed jointly by PFW and the Alberto Culver Company.

principal products are nitrocellulose and ethylcellulose, which are high-value-added specialty products. In addition, it manufactures *Parlon* chlorinated rubber, also a high-value-added specialty film-former.

The largest segment of the Coatings Business Center is nitrocellulose, which offers the biggest opportunity for profit growth. The production process for nitrocellulose at the Parlin, New Jersey, plant is being modified to improve product quality and to lower production costs, thus enhancing Hercules' competitive position worldwide. At the same time, the nitrocellulose capacity for smokeless powders is being expanded by 40 percent to supply internal and customer requirements for both commercial and growing military requirements. We have been sold out for the past year, and already have long-term supply contracts to support the expansion that will be completed by the end of 1983.

Hercules is the only U.S. producer of chlorinated rubber, used in the formulation of maintenance paints. Through our marketing efforts, about half the states in the United States have approved the use of chlorinated rubber in traffic paint.

The revitalization of the coatings business will return healthy dividends. During the next five years, it is anticipated that gross fixed assets will increase by $38 million, most of which is directed toward savings projects with high returns and quick payouts.

The **PFW Business Center** is a worldwide organization dedicated to the creation and supply of flavors, fragrances, and water-soluble gums for food products and perfumed articles. Operating profits prior to 1980 were erratic, owing to expansion startups. However, the worldwide base for this business is in place, and since 1980, profits have climbed steadily. Sales increased 17 percent and gross profits rose 27 percent over those of 1981.

Over the next five years, the range of specialty chemicals will be extended to add diversity and uniqueness to existing flavors and fragrances. Other avenues are also being examined that might strengthen and broaden product lines and raw material base.

PFW has a positive future and will continue to make a contribution to Hercules' total profit picture as new concepts and products coming from the laboratories fill the needs of a changing environment.

Sales and gross profits of **Water Management Chemicals** increased 9 and 8 percent, respectively, from those of 1981, despite weakness in the key automotive and mineral processing industries.

Although sales of boiler water and cooling water treatment chemicals grew marginally in 1982, profit performance improved 7 percent, primarily because of cost-control efforts. An expanded customer base was established during the year, but full income potential was not realized because of the continuing economic slowdown. Sales of water-conditioning chemicals will benefit directly as customer operations improve in the future. Major product and marketing development projects were completed in 1982 and will provide advanced programs in the coming years. *Conductor* cooling water products will be introduced in 1983, and these are expected to satisfy the sophisticated technical needs of the marketplace.

Sales of flocculants increased 14 percent over 1981, a growth shared by all major product areas, in particular the *gamma* gel line of water treatment chemicals. Most of the sales growth occurred in municipal, mining, and paper industries in spite of the depressed condition of the latter two. Startup of the expanded *gamma* gel polymer production facility at Dickerson, Maryland, was completed in the fourth quarter. This new facility will provide additional capacity, as well as greater flexibility and production efficiency.

PRODUCTS

Carboxymethylcellulose (CMC), or cellulose gum: A thickener and stabilizer in ice cream, toothpaste, oil well drilling fluids, petfoods, textile sizing, and detergents.

***Natrosol* hydroxyethylcellulose:** Used as a thickener and stabilizer in latex paint and oil well service fluids.

Pectin: A gelling agent for jams and jellies and an ingredient in pharmaceuticals.

Carrageenan: A thickener and stabilizer in a wide variety of food products and toothpaste.

Guar and derivatives: Used in many food products and oil well fluids.

Nitrocellulose: A coating and film-former in high-quality furniture lacquers, inks, adhesives, and nail polish.

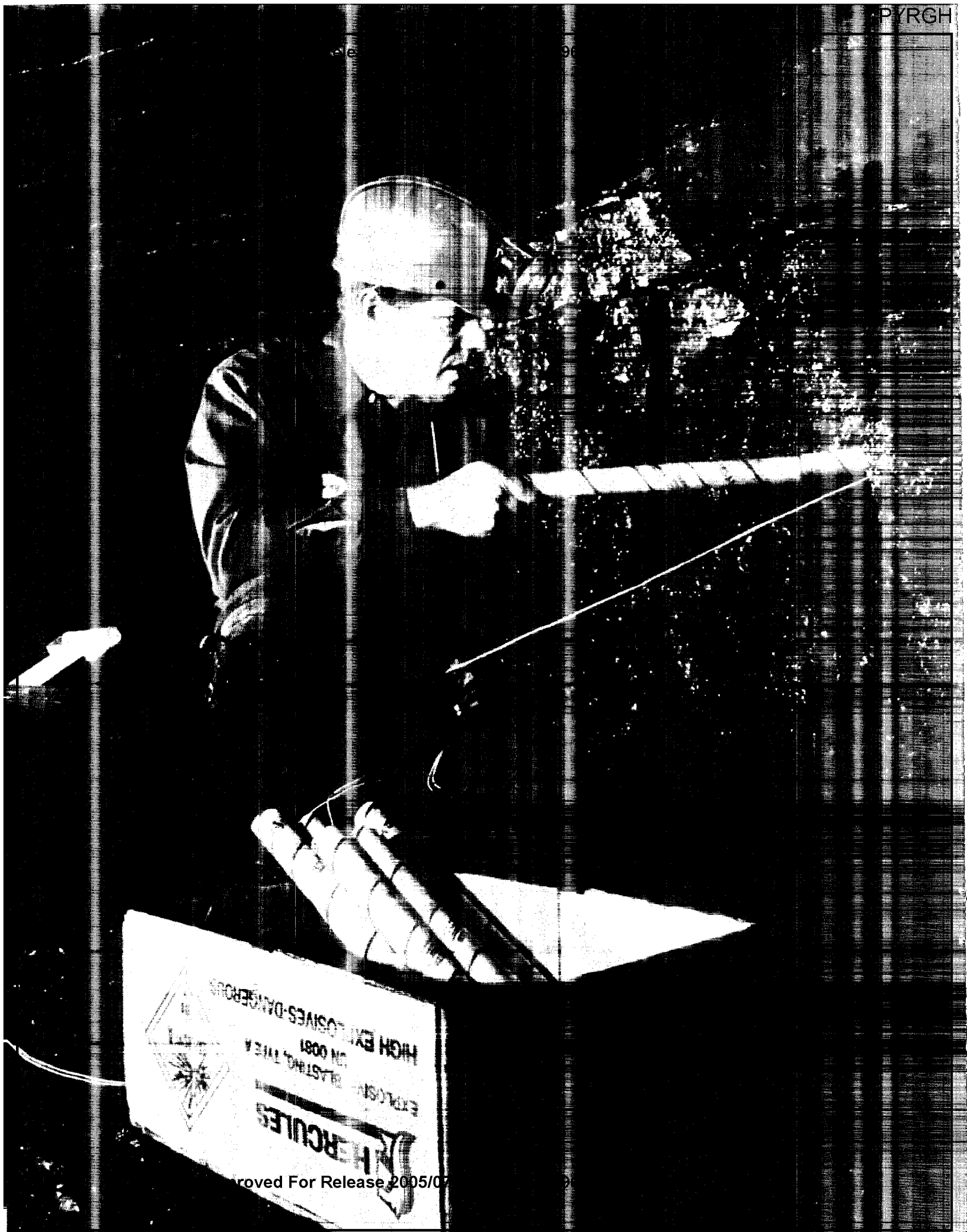
***Parlon* chlorinated rubber:** Used in high-performance paints for highway markings, marine finishes, and swimming pool paints.

***Hercofloc gamma* gels:** Used in wastewater treatment and enhanced oil recovery applications.

Flavors: Used in meat products, confectionery, pharmaceutical products, baked goods, snackfoods, cigarettes, gravies, and soups.

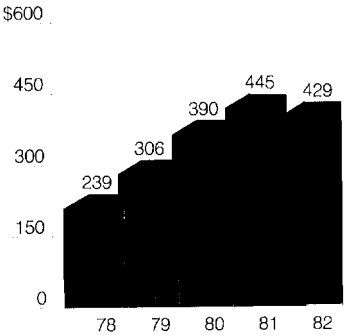
Fragrances: Used in couturier perfumes, hair care products, shaving lotions, deodorants, and soaps.

CMC warp size is used in the weaving process to make high-quality bed linens.

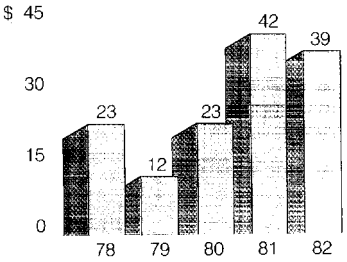


Explosives & Aerospace

Sales
(Dollars in millions)



Profits
(Dollars in millions)



Sales of Explosives, Aerospace, and Graphite Fiber products totaled $429 million, with profits of $39 million for the year. This compares with 1981 sales and profits of $445 million and $42 million, respectively.

The **Explosives & Nitrogen Products Business Center** serves mining and construction, oil and gas exploration, and commercial and military ammunition industries through four distinct business units. In 1982, sales and gross profits declined 18 and 5 percent, respectively, from those of 1981.

Without question, commercial product sales were adversely affected by the current recession. This is particularly true of products used by the mining, construction, and oil exploration industries. On the other hand, the military business in the ammunition, detonator, and fuse areas is at an alltime high, which greatly reduces the cyclicality of the explosives business. Furthermore, although the commercial explosives plants operated at only 55 percent of capacity, close control of manufacturing cost, working capital requirements, and indirect expense provided better profit margins this year than last. We are in a position to take full advantage of increased business activity as the recession subsides.

A five-year capital expenditure program begun in 1980 to improve the efficiency of facilities and provide manufacturing capability for several new products is underway. One is nonnitroglycerin dynamite, a product that retains most of the high-energy characteristics of conventional NG dynamites while significantly reducing several objectionable features related to their use and handling. Another is the *Hercudet* nonelectric detonator system, which provides safe, reliable initiation of explosives under the most adverse field conditions, such as those caused by lightning, static electricity, and stray electrical currents.

In **Aerospace**, the largest unit of the group, 1982 sales increased only slightly and gross profits 2 percent over those of 1981. The forecast of Aerospace sales over its principal product lines is 50 percent growth over the next five years, with growth expected in all segments.

The rocket propulsion forecast reflects real growth as new propulsion systems now being developed displace systems currently in the field. The submarine-launched Trident I missile is now in production; the land-based ICBM Missile X and Pershing II tactical missile are well along in development, and advanced development is in progress on Trident II. The manufacturing facility for the submarine-launched Polaris A3 missile is being reopened, and Hercules will again produce the second stage for the British Government.

Another important segment is advanced composite structures, blends of reinforcing fiber and plastic resins formed to provide specific structural shapes. Opportunities exist for composite structures anywhere high strength and light weight are product requirements, such as in missile launchers, aircraft, and spacecraft. Hercules pioneered the development of filament-wound rocket

To save weight over metal components without compromising strength or stiffness, the engine nacelle, or housing, on the Douglas DC-9 Super 80 airplane is made entirely from *Magnamite* graphite fiber prepreg.

Hercules nonnitroglycerin explosives are used extensively in coal mining operations because of their improved handling characteristics and high-performance qualities.

motor cases in the 1950s, and based on the experiences of these composite structures, Hercules entered the graphite fiber business, which provides far greater opportunity for the manufacture of products other than just rocket motor cases.

While the future of Aerospace is subject more to requirements of the Government than the general market or our own management actions, we view the future with optimism. We have a sound backlog of existing programs. The Government is committed to upgrading the Nation's defense capability and its posture in space. All of the product lines are closely linked to these commitments.

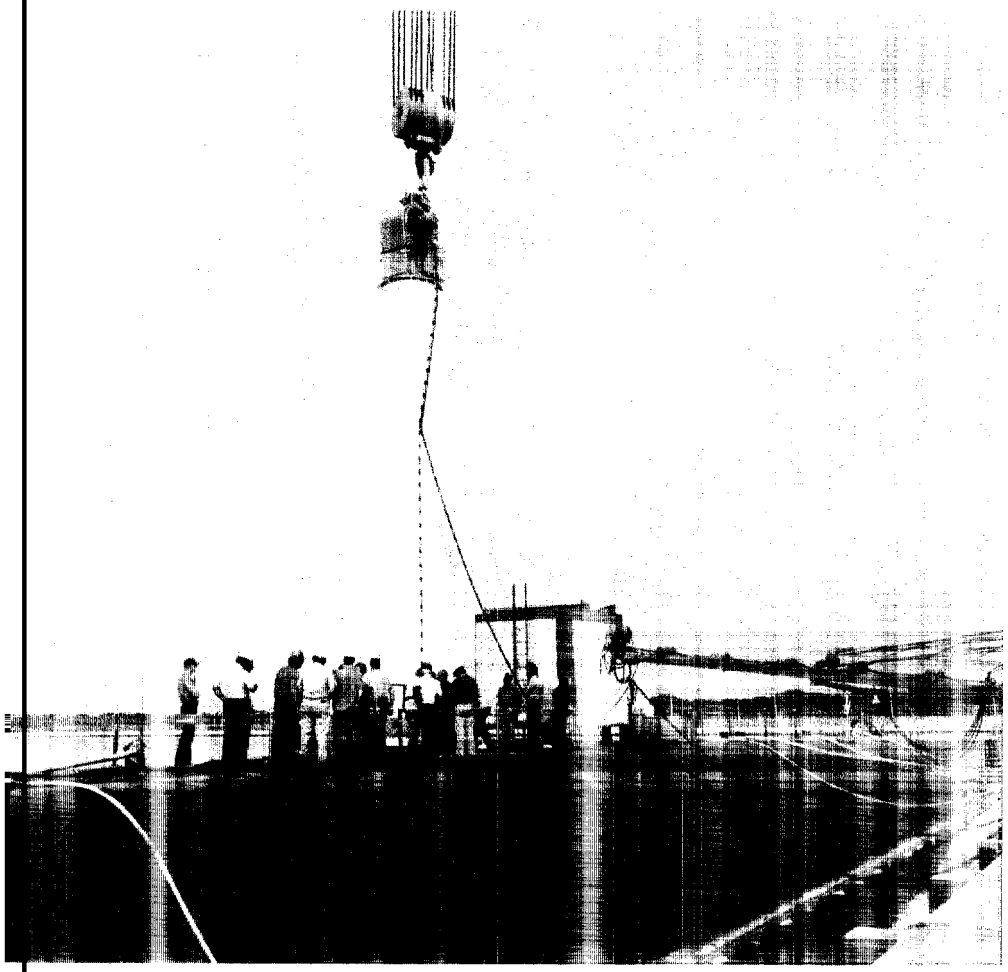
Graphite Fibers sales increased 44 percent over those of 1981, and over the next five years are expected to grow by at least 35 percent per year.

The most important market is the U.S. military airplane industry, which uses larger quantities of graphite composites to increase system performance, reduce energy consumption, and lower component costs. The F-16, the F-18, the B-1 bomber, the new advanced bomber, and the space shuttle booster rocket cases are just a few of the major military and aerospace projects benefiting from graphite fiber's performance.

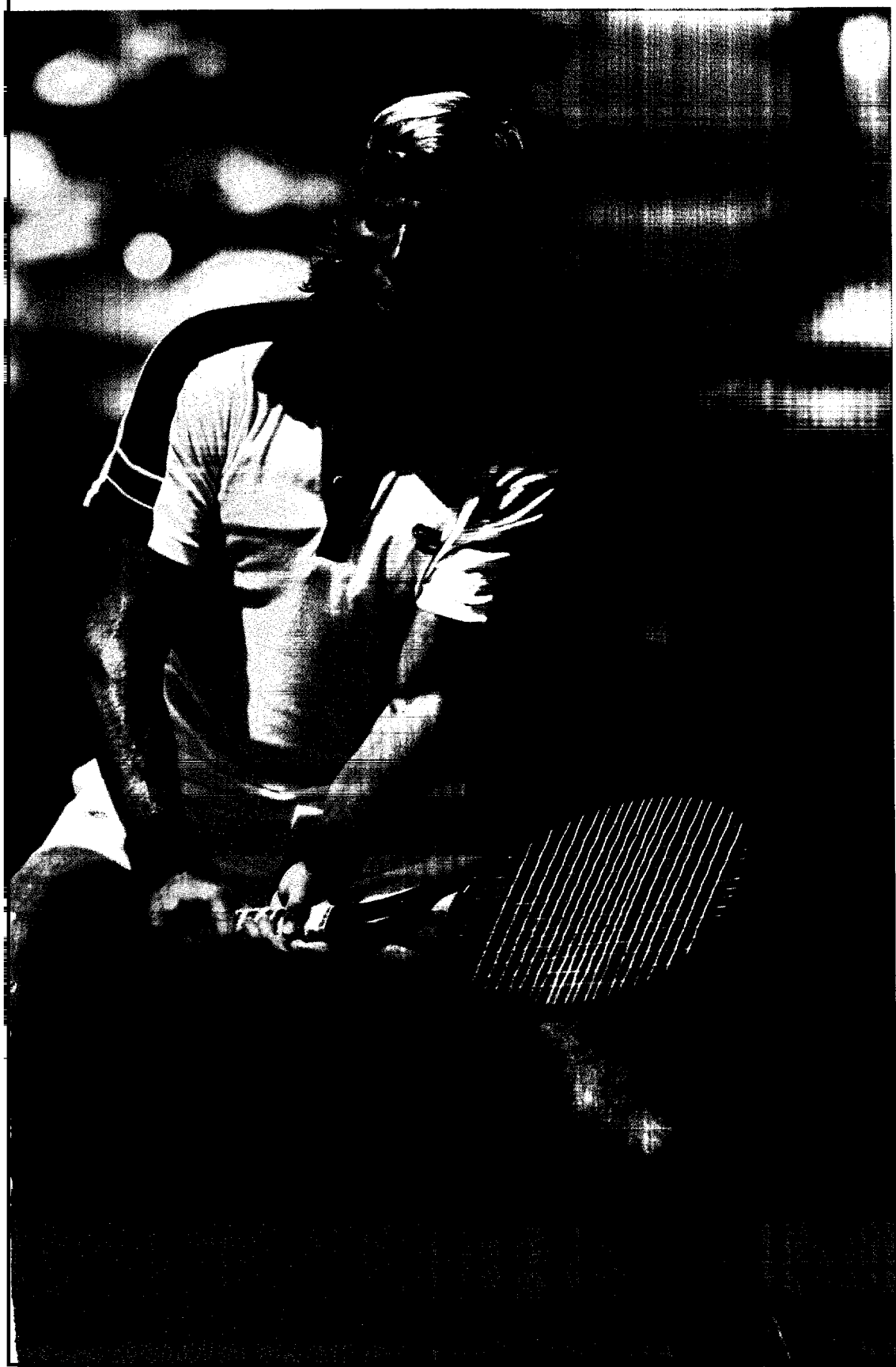
The European market offers important development activity for graphite aerospace applications. In May, Hercules and Pechiney Ugine Kuhlmann of Paris announced a new joint-venture company to manufacture graphite fiber near Grenoble, France. This full-scale, 500,000-pound-per-year plant will start up in early 1984.

Sumika-Hercules Company, Ltd., the profitable joint venture with Sumitomo Chemical Co. in Japan, has fulfilled another primary goal for the group: solid backward integration for polyacrylonitrile (PAN), the raw material for graphite fiber. During the year we began production at a new 2,200-ton-per-year facility in Okayama, Japan.

In 1982 the advanced composites industry grew to $80 million. We are in the formative stages of an emerging multi-billion-dollar, high-technology industry. The next major growth area will be in primary structures for the aircraft industry, and Hercules is strategically positioned to capture a major share of the anticipated growth.



The Hercules/Thiokol joint venture is the propulsion contractor for all three stages of the Trident I, C-4 missile, shown here being transferred from a handling canister into a Trident I submarine.



PRODUCTS

Explosives Products: Dynamites, blasting agents, slurry explosives, and blasting accessories for mining, construction, quarrying, and seismic exploration for oil and gas reserves.

Industrial and Military Detonators: Used to initiate commercial explosives and military ordnance.

Smokeless Powders: For sporting ammunition, ammunition reloading, and propellants for military ordnance.

Nitrogen Products: Ammonium nitrate prills and solutions, and nitric acids for blasting materials and industrial and agricultural applications.

Specialty Nitration Products: PETN (pentaerythritol tetranitrate), used for explosives core loads and priming charges, and PETN-lactose for use in cardiovascular medicine.

Solid propellant rocket motors for defense systems.

***Magnamite* high-modulus graphite fiber.**

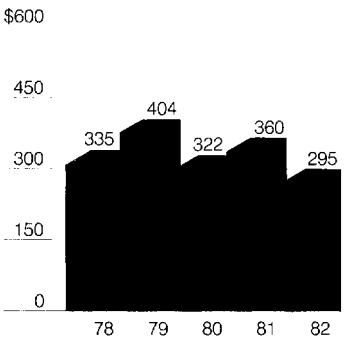
Graphite prepregs used to fabricate composite structures and components.

Graphite structures designed and fabricated by Hercules to customers' specific requirements.

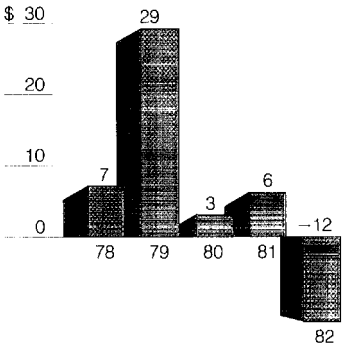
The same qualities of high strength:weight and stiffness:weight ratios that have made Hercules graphite fiber the advanced composite material of choice in the aerospace and aircraft industries have led to its wide use in tennis rackets for both professional and amateur players.

Other Products

Sales
(Dollars in millions)



Profits
(Dollars in millions)



Sales from other Hercules businesses, including Hercofina products (Hercules' pro rata share), electronic products, and synthetic pulp, totaled $295 million, with a loss of $12 million. This compares with 1981 sales of $360 million and profits of $6 million.

Operations of **Hercofina**, the terephthalate joint venture with American Petrofina, were significantly affected by the worldwide softness of the polyester fiber business, which uses terephthalate as its raw material.

Combined sales volume of dimethyl terephthalate (DMT) and purified terephthalic acid (PTA) was down 24 percent from 1981, and the price was soft, owing to lower raw material costs for para-xylene and a weak export market. Hercofina's net income was significantly below 1981 results, and was affected by several unusual gains and losses, including gain on sale of the Burlington, New Jersey, DMT plant, which was sold to Bombay Dyeing and Manufacturing Company, Bombay, India, and a writedown of Hercules investment in Hercor Chemical Corporation.

During the year, the Hanover, North Carolina, operation was restructured to accommodate the depressed level of business and to position the company to take full advantage of an upturn in the economy. Despite a 24 percent drop in production, productivity remained essentially equivalent to 1981 levels. Two major energy savings projects were under construction at Hanover during the year. Both are expected to be completed by mid-1983 to provide for more cost-effective operations.

St. Croix Petrochemical Corp., Hercules' joint venture with Hess Oil Virgin Islands Corp. in St. Croix, Virgin Islands, operated satisfactorily throughout the year at levels sufficient to meet internal raw material requirements and sales commitments. For the Mexican joint venture, Petrocel, S.A., in Tampico, sales volume and equity income were at an alltime high, despite the impact of peso devaluations in February and August. A 40 percent expansion of the plant's 137-thousand-metric-ton-per-year capacity was completed on schedule and within budget during the year, and the plant is now producing DMT for the Central American market.

The **Electronic Products Business Center** had increased sales of 16 percent over 1981, and gross profits rose 23 percent. All three product lines contributed to the improvement: *Magnox* magnetic iron oxides, used in audio, video, and computer tapes; *Merigraph* photopolymer plate systems for the printing industry; and *Aqua Mer* dry film photoresists, used primarily to make printed circuit boards.

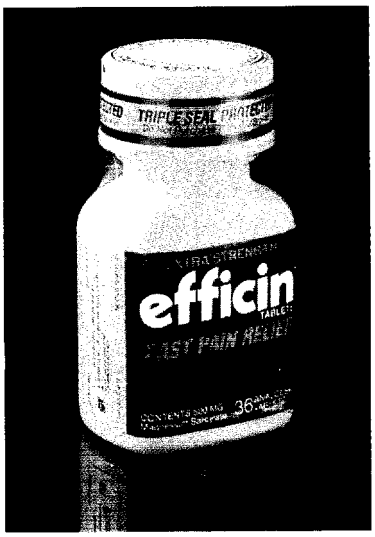
In spite of relatively weak market demand, the *Magnox* magnetic iron oxide business had improved profitability over that of 1981 because of greater cost control at the Pulaski, Virginia, plant. The more efficient production at Pulaski was instrumental in Hercules' decision to supply Asian customers from Pulaski and terminate operations of Hercules Magnetics Limited, an 85 percent-owned joint venture in Japan. Positive response to the market development program for products of Japan Magnetics, Ltd., the 50-50 joint venture with Sakai Chemical Industry Co., Ltd., has led to initial sales of these new high-performance particles in the Far Eastern market.

The *Merigraph* system continued its unbroken string of yearly sales increases from its introduction in 1973. Continued growth in flexographic printing of corrugated containers and multiwall bags was particularly encouraging. Sales of *Aqua Mer* increased fourfold from 1981, and continuing growth based on its unique performance properties is anticipated.

The **Synpulp Business Center** is responsible on a worldwide basis for the manufacture and sale of polyolefin pulps. Sales in 1982 were $6.5 million. The business continues to operate at a

Pulpex polyolefin pulps are a component of asbestos-free sheet vinyl flooring.

Other Products (contd.)



Triple-sealed for tamper protection, *Efficin* extra-strength pain reliever was introduced commercially during the year by Adria Laboratories, our pharmaceutical joint venture.

loss, although recent gross profits have been positive.

Initially directed toward replacing asbestos in low-temperature applications, synthetic pulp is now beginning to make significant inroads in such traditional asbestos markets as sheet vinyl flooring, textured paints, and food filters. More recently, *Pulpex* polyolefin pulps have begun to replace asbestos in cement products. Cement roofing tiles, slate, building panels, corrugated sheets, and pipe are the major worldwide users of asbestos.

Pulpex is also being used commercially in embossed wallpaper, battery separators, and nonwovens, and as a heat-seal medium in the production of teabags throughout the world.

New high-volume uses, including absorbent products, food packaging, and reinforcing composite structures for automotive, home, and office use, show continued growth. Several lower volume, high-technology applications are in the advanced commercial development stage.

Nonetheless, it is anticipated that total growth of Synpulp's product will be relatively slow because of full field test requirements, and we expect that our plant will probably not get to capacity until 1986. The business itself is expected to become commercially profitable by 1984.

Adria Laboratories Inc., Hercules' 50 percent-owned joint venture with Montedison S.p.A., of Milan, Italy, had sales in 1982 of $98 million, up from $90 million in 1981. (Sales and profits are reported in our accounts on an equity basis and are not included in this business segment.)

In its nine-year history, Adria Laboratories has achieved all of its original objectives. It has become a fully integrated pharmaceutical company possessing a full range of functions, from product research through clinical investigation, manufacturing, and marketing. This goal was achieved a full year ahead of schedule through carefully directed growth of the original organization and through acquisition of the resources of Warren-Teed Pharmaceuticals, Inc. in 1977. The Warren-Teed acquisition brought to Adria a diversified product line, an impressive research capability unique for a company of its size, a fully developed manufacturing facility, and an effective sales force to organize Adria's ability to market products outside its original base of anticancer drugs.

Adria started in 1974 with one product, *Adriamycin* doxorubicin hydrochloride, a very effective anticancer drug. It was also given the development rights to nine other potentially marketable products. Since that time, the research pipeline has expanded to include many products in various stages of preclinical and clinical investigation from a variety of sources, including Montedison, Hercules, Warren-Teed, internal synthesis, and outside sources.

Adriamycin still accounts for more than half of Adria Laboratories' sales, but Adria is poised on the brink of a rapid expansion program involving R & D and production capabilities that will give the company a much broader product base. Other new anticancer drugs under clinical investigation also hold promise for significant growth in sales and profit during the next five years.

PRODUCTS

Polyester raw materials: Dimethyl terephthalate (DMT) and purified terephthalic acid (PTA) are used in the manufacture of polyester for clothing and home furnishings.

***Magnox* magnetic iron oxides:** Used in coatings for magnetic tapes and disks for the computer and recording industries.

***Merigraph* photopolymers:** Form clear, soft-to-hard printing plates from ultraviolet light for use in printing newspapers, paperback books, telephone books, catalogs, corrugated cartons, and flexible packaging.

***Aqua Mer* dry film photoresist:** Used to process printed circuit boards for the electronics and computer industries.

***Pulpex E* high-density polyethylene pulp:** Used for its heat-seal characteristics as a bonding agent for nonwovens in such applications as teabags and automotive carpeting.

***Pulpex P* polypropylene pulp:** Used primarily for its bulking characteristics in high-temperature applications such as asphalt coating and molded parts for automobiles and battery separators.

***Adriamycin* doxorubicin hydrochloride:** Manufactured by Adria Laboratories, it is the largest selling cancer drug in the United States.

***Efficin*:** An extra-strength over-the-counter analgesic for the relief of symptoms caused by flu, colds, muscular aches, and arthritis.

The *Merigraph* photopolymer printing plate system is used throughout all segments of the printing industry to make letterpress, flexographic, and dry offset plates directly from photographic negatives.

At Taiwan Polypropylene Company Limited, a joint-venture company, *Pro fax* polypropylene resin is packaged in sacks woven from Hercules' own polypropylene.

In 1982, more than 39 percent of Hercules' profits were derived from operations outside the United States through both exports and products manufactured by overseas affiliates and subsidiaries. Sales outside the United States, including those of affiliated companies, were 37 percent of total Hercules sales. In 1981, 41 percent of profits and 37 percent of sales also were derived from overseas business. Of the overseas results for 1982, Hercules Europe contributed approximately 45 percent of sales and 65 percent of profits; Hercules Americas, 26 and 25 percent, respectively; and Hercules East, 29 and 10 percent, respectively.

Export sales from the United States in 1982 were $264 million, of which $142 million was to customers and $122 million in raw materials for resale or manufacture into finished products by subsidiary and affiliated companies. This compares with 1981 export sales of $322 million, of which $179 million was to customers and $143 million to subsidiaries and affiliates.

Despite the recessionary environment, **Hercules Europe** subsidiaries reported increased sales and profits in local currencies of 12 and 3 percent, respectively, over those of 1981. In dollar terms, sales and profits were down 2 percent and 15 percent, respectively, from 1981 because of the relative strength of the dollar.

The plastic resins business improved its profitability over 1981, although an acceptable profit level has not been achieved. The facility at Paal, Belgium, primarily produces commodity-grade homopolymer, and we are working on plans to produce more high-value-added copolymer to improve profitability. In other polypropylene-related products, the fiber joint venture, Neofil S.p.A., Milan, Italy, performed satisfactorily, but film sales from the Brantham, England, facility were affected by strong European price competition.

The organics businesses again made a contribution to Hercules Europe's performance, although these, too, were affected by poor business conditions throughout the continent. Paper chemicals showed a slight volume downturn in reaction to the overall paper industry's performance of falling 5 percent below its production estimates. The resins business also fell below forecast, reflecting the depressed state of the industries it serves. Resins were also affected by high raw material costs associated with the strength of the U.S. dollar. To alleviate the dependence on U.S.-based raw materials and to allow for greater flexibility in product mix, the resins facility at Middelburg, The Netherlands, is undergoing significant expansion. This dual-purpose hydrogenation plant will afford Hercules Europe a strong position in the large, growing European resins market.

Overall sales of elastomer chemicals continued at unacceptable levels, although sales of *Herclor* epichlorohydrin elastomers progressed to an alltime high. Peroxides also showed some volume recovery, but profit margins still require improvement.

The European water-soluble polymers business benefited from sales and profit improvement over those of 1981. Sales of hydroxyethylcellulose increased as expanded production facilities at Zwijndrecht, The Netherlands, came onstream during the year. As noted in the report on Water-Soluble Polymers, Phase 1 of the expanded CMC facility at Alizay, France, began production during the year. A further expansion is to be completed in 1984. The food ingredient business had a good year, aided by a high level of export activity and sustained by increased production capability for pectin and carrageenan at the Lille Skensved, Denmark, facility.

As noted in Explosives & Aerospace, we formed a joint venture with Pechiney Ugine Kuhlmann to manufacture graphite fiber at a new facility under construction near

Grenoble, France. The plant will produce a range of fiber products for the aerospace and sporting goods industries.

Hercules Americas and Hercules East were combined into Hercules Americas/East, effective February 1, 1982. This merged business center manages Hercules' consolidated and affiliated business interests, seeks new business opportunities, and optimizes exports in Canada, Central and South America, and the Pacific Basin area.

Sales of the consolidated companies increased 5 percent in 1982, largely because of new polypropylene film and resin business in Canada. However, operating profits declined 67 percent, owing to severe price erosion in polypropylene resin in Canada, primarily in the fourth quarter, and to reduced overall volumes in Brazil as the marketplace reacted to that country's recession. Most of the sales increase is attributable to new oriented polypropylene film business in Canada.

Affiliated companies' operating profit increased 13 percent over that of 1981 on a sales increase of about 2 percent. The recent startups of Polo Industria e Comercio Ltda.'s film plant at Varginha, Brazil, and of Taiwan Polypropylene Company Limited's second polypropylene resin line at Kaohsiung were major contributors to this increase.

Polypropylene film, manufactured by our Brazilian joint venture, is used to wrap confectionery as well as snackfoods and cigarettes.

PPH — Companhia Industrial de Polipropileno, the Brazilian affiliate to manufacture polypropylene resin, began startup of its new facility in Rio Grande do Sul in December. The plant was completed on schedule and within budget.

Total Hercules U.S. exports into Americas/East areas declined about 20 percent in 1982 as a result of worldwide recession and Mexican import restrictions. On the positive side of the Mexican situation, we are actively pursuing investment opportunities that have resulted from the peso devaluation and exchange controls. Hercules Americas/East has new joint ventures under study in Japan, Taiwan, Thailand, and South America, and numerous expansion/diversification studies underway throughout the world.

International Operations Summary

(Dollars in thousands)

	1982		1981		1980	
	Consolidated Subsidiaries	Affiliated Companies	Consolidated Subsidiaries	Affiliated Companies	Consolidated Subsidiaries	Affiliated Companies
Sales						
Hercules Europe	$416,951	$ 75,716	$425,626	$ 91,894	$449,221	$ 93,948
Hercules Americas/East	136,255	558,362	130,454	548,785	127,382	515,835
PFW and Hercofina	28,174	217,190	25,304	283,816	54,938	212,151
Total	$581,380	$851,268	$581,384	$924,495	$631,541	$821,934
Profit from Operations						
Hercules Europe	$ 39,605	$ 4,812	$ 46,346	$ (1,417)	$ 56,892	$ 2,425
Hercules Americas/East	3,182	31,298	9,729	27,806	13,068	43,308
PFW and Hercofina	3,286	27,566	8	23,108	(7,054)	17,336
Total	$ 46,073	$ 63,676	$ 56,083	$ 49,497	$ 62,906	$ 63,069
Hercules Equity	$ 46,073	$ 29,083	$ 56,083	$ 22,828	$ 62,906	$ 27,347

Hercules has undertaken an aggressive expansion of research and development since 1978. Research & Development has grown from 900 in 1978 to over 1,200 today. This growth has resulted in 34 percent of the professional staff being less than 35 years old. The balance of eager, aggressive professionals and experienced researchers provides excellent resources for today and tomorrow.

Research and development will play an important role as Hercules moves into the future, with increased focus on properties of value. This corporate strategy requires that R & D achieve a deeper technical insight into how Hercules products are used, as well as continual development of new products. The expected results of this effort are new businesses having a greater return on investment.

Total technical expenditures for 1982 were $89.9 million, of which $71 million was spent on research and development. A conscious effort has been made to increase the proportion of longer range research. In 1983 an estimated 40 percent of the total effort will fit this category. Exploratory research has been increasing, and we are projecting a level of 10 percent in 1983. New-business R & D has grown substantially, from 18 percent in 1980 to a projected 30 percent of the total in 1983.

The increase in R & D effort emphasizes materials science and applications technology. These disciplines focus on the structure/property relationships of materials and provide the basis for new, value-added products. The implementation of this strategy requires a multidisciplinary approach as well as a thorough understanding of the industries that Hercules serves. The results are market-driven development programs that address customer needs. Products from these programs will have value in use because of the physical functions they perform.

As a consequence of this increased commitment to R & D, a number of products serving the ink, adhesive, paper, petroleum, and food-packaging markets are in late-development or early-commercial status. Examples include nonvolatile paste ink vehicles, polypropylene composite structures, controlled-rheology water-soluble polymers, and water-based adhesives. The fusion ink concept was developed to reduce the energy used to dry paste inks, significantly reduce air emissions, and improve press performance by eliminating press cleanup. The fusion ink technology was developed and patented by Hercules during the past few years. The polypropylene composites were developed to combine the desirable properties of other materials. This is accomplished by a series of unique proprietary materials that will bond polypropylene to metals and to other plastics. Particular examples of end uses are food- and medical-packaging.

Throughout the text of this report, you have read about many of our more recent R & D efforts that have reached full-scale commercialization and are now part of the Hercules product line. Opaque films to replace glassine; mixed cellulosic derivatives for a variety of applications; nonnitroglycerin dynamites and a non-electric detonating system for the explosives industry; and synthetic pulp as a replacement for asbestos are just a few of the important ideas that were nurtured in the laboratory and that have grown to use in the marketplace.

As we look ahead, we are encouraged by the potential number of new business opportunities emerging from research and development. The focus on longer range R & D was expanded in 1982 and will be continually strengthened in 1983 and beyond.

The future growth of Hercules is dependent on new products and refinements of more established ones. In 1982, Hercules spent $71 million on research and development.

Energy Conservation & Raw Material

During 1982, Hercules continued to maintain its low level of energy consumption per unit of product, even though production volume declined 14 percent from that of 1981. Despite these lower production levels, in 1982 Hercules used about 36 percent less energy per pound of output than it did in the base year of 1972. That is equivalent to a cost avoidance of more than $100 million annually at 1982 energy prices.

The energy conservation program has three primary goals. First is the elimination of energy waste. That we reduced the base energy loads of the plants and produced at nearly the same unit energy consumption as in 1981 at lower production levels in 1982 is an indication of our efforts to meet this goal. In addition, comprehensive energy audits conducted at four plants identified an aggregate potential saving of $2 million per year.

Second is energy conservation by process modification. Hercules is committed to modernizing its production facilities, using state-of-the-art, onstream analyzers and computer-based process control systems. Modernization programs improve product quality, lower operating costs, and prevent technical obsolescence. In the last quarter, the Hopewell, Virginia, plant started up a computer-based control system, using onstream analyzers to control thirteen distillation columns. Modernization of this complex of columns will cut energy costs by 10 percent and will improve product quality. The joint-venture DMT plant at Wilmington, North Carolina, continued its conservation program by installing off-gas expanders to reduce electrical requirements, and is beginning work on a major process energy conservation project that will further reduce unit consumption by about 15 percent. During the third quarter, an electrical energy savings program was implemented at Plant 3 at the Lake Charles, Louisiana, facility that has the potential for about $1 million per year savings.

The third goal requires operation of facilities on less costly fuels. Lake Charles achieved remarkable savings by using a short-term abundant surplus of natural gas in place of oil. Brunswick, Georgia, has completed conversion to purchased wood chips to provide independence from fossil fuels. The Parlin, New Jersey, plant has been converted to coal.

In 1982, quarter-to-quarter raw material price increase rates peaked in the second quarter, with sharp declines thereafter. For the year, raw material prices were slightly below 1981. The energy index likewise peaked in the second quarter, with increases moderating throughout the rest of the year. At yearend, the composite index (energy and raw materials) stood at its lowest point since the second quarter of 1981. As in 1981, this index performance was due to the business cycle slowdown and continuing implementation of new purchasing approaches at Hercules.

The network of regional purchasing managers continued to perform well. In 1982, we saved a total of about $5.8 million by purchasing many of our supplies through national accounts. The worldwide purchasing network was extended during the year to include cellulosics, adding to the rosin-purchasing network already in place.

In 1982, supplies in all areas were ample, with little or no supply/demand pressure. The outlook for 1983 is for adequate supplies of materials, with little change in yearly price on an average-quarter-to-average-quarter basis. Allowing for projected inflation rates, it is anticipated that materials will decrease in constant dollars compared with 1982.

Consolidated Statement of Income

(Dollars in thousands, except per share)

	Year Ended December 31		
	1982	1981	1980
Net sales	$2,468,971	$2,718,366	$2,485,226
Cost of sales	2,040,968	2,198,111	2,038,806
Selling, general and administrative expenses (Includes research and development expenses: 1982—$70,697; 1981—$61,410; 1980—$53,462)	314,305	308,599	291,519
	2,355,273	2,506,710	2,330,325
Profit from operations	113,698	211,656	154,901
Nonoperating income			
Interest	22,225	11,144	12,573
Miscellaneous	7,050	11,043	7,099
	29,275	22,187	19,672
Nonoperating expenses			
Interest and debt expense	50,707	46,673	37,356
Miscellaneous	8,678	6,726	22,479
	59,385	53,399	59,835
Income before taxes on income	83,588	180,444	114,738
Provision for taxes on income	20,244	51,062	23,361
Income before equity earnings	63,344	129,382	91,377
Equity in net income of affiliated companies	23,517	7,099	22,623
Income before extraordinary gain	86,861	136,481	114,000
Extraordinary gain	11,553	—	—
Net income	$ 98,414	$ 136,481	$ 114,000
Earnings per share			
Income before extraordinary gain	$ 1.97	$ 3.09	$ 2.60
Extraordinary gain	.25	—	—
Net income	$ 2.22	$ 3.09	$ 2.60

The accompanying accounting policies and notes are an integral part of the consolidated financial statements.

HERCULES INCORPORATED

Consolidated Statement of Changes in Financial Position

(Dollars in thousands)

	Year Ended December 31		
	1982	1981	1980
Funds Provided From Operations:			
Sources:			
Income before extraordinary gain	$ 86,861	$ 136,481	$114,000
Depreciation and amortization	120,487	118,839	114,472
Deferred taxes on income	(15,193)	15,092	12,243
Equity in net income of affiliated companies in excess of dividends	(12,972)	2,704	2,477
Writedown of facilities	3,544	3,880	8,600
	182,727	276,996	251,792
Uses:			
Property, plant and equipment:			
Capital expenditures	164,997	167,189	229,163
Currency translation	(26,899)	(26,561)	—
Net book value of property, plant and equipment sold	(2,148)	(5,782)	(3,158)
	135,950	134,846	226,005
Increase in investments	42,978	14,754	23,903
Net change in working capital (excluding cash, marketable securities and notes payable)*	(109,217)	70,689	88,908
	69,711	220,289	338,816
Net Funds Provided From Operations	113,016	56,707	(87,024)
Financing Transactions:			
Change in long-term debt:			
New borrowings	177,247	247,270	123,664
Reductions	(199,684)	(150,444)	(69,753)
	(22,437)	96,826	53,911
Net change in notes payable	(15,125)	(75,243)	62,043
Exchange of common stock for debt:			
Increase in capital accounts	38,845	—	—
Extraordinary gain	11,553	—	—
Cash dividends	(56,874)	(53,567)	(50,915)
Net Financing Transactions	(44,038)	(31,984)	65,039
Changes in Foreign Currency Translation Adjustment	(54,054)	(44,956)	—
Other Sources (Uses)	(8,318)	11,084	2,365
Net Increase (Decrease) in Funds	6,606	(9,149)	(19,620)
Cash and Marketable Securities at beginning of year	27,556	36,705	56,325
Cash and Marketable Securities at end of year	$ 34,162	$ 27,556	$ 36,705
*Net Change in Working Capital by Component:			
Accounts and notes receivable	$ (39,223)	$ 1,945	$ 10,731
Inventories	(38,619)	74,239	16,127
Accounts payable	(10,179)	2,247	13,363
Accrued expenses	7,400	(35,648)	2,378
U.S., foreign and state taxes on income	(28,596)	27,906	46,309
	$(109,217)	$ 70,689	$ 88,908

The accompanying accounting policies and notes are an integral part of the consolidated financial statements.

HERCULES INCORPORATED

Consolidated Balance Sheet

(Dollars in thousands)

	December 31 1982	1981
Assets		
Current Assets		
Cash	$ 28,855	$ 26,700
Marketable securities (At cost and accrued interest which approximates market)	5,307	856
Accounts and notes receivable		
Customers — trade	327,969	361,024
Affiliated companies	8,033	6,040
Other	49,440	57,311
	385,442	424,375
Less allowance for doubtful accounts	4,918	4,628
Total Accounts and Notes Receivable	380,524	419,747
Inventories		
Finished products	195,757	237,564
Materials, supplies, and work in process	172,531	169,343
Total Inventories	368,288	406,907
Total Current Assets	782,974	854,210
Property, Plant and Equipment		
Land	20,481	20,171
Buildings and equipment	1,892,965	1,895,685
Construction in progress	166,222	102,730
	2,079,668	2,018,586
Accumulated depreciation and amortization	1,155,992	1,110,853
Net Property, Plant and Equipment	923,676	907,733
Investments and Advances		
Affiliated companies — at equity	215,351	176,525
Other — at cost or less	21,933	4,809
Total Investments and Advances	237,284	181,334
Deferred Charges and Miscellaneous Assets	57,420	53,867
Total Assets	$2,001,354	$1,997,144

The accompanying accounting policies and notes are an integral part of the consolidated financial statements.

	December 31 1982	1981
Liabilities and Stockholders' Equity		
Current Liabilities		
Accounts payable	$ 161,226	$ 151,047
Notes payable and current maturities of long-term debt	57,943	73,068
Accrued expenses		
Payrolls	40,072	38,136
Other	49,416	58,752
U.S., foreign and state taxes on income	42,910	14,314
Total Current Liabilities	351,567	335,317
Long-Term Debt	431,919	454,356
Deferred Taxes on Income	119,254	134,447
Pension Liability	19,703	21,667
Stockholders' Equity		
Series preferred stock (Without par value, issuable in series: authorized 2,000,000 shares)	—	—
Common stock ($\$^{25}/_{48}$ stated value: authorized 75,000,000 shares, reserved for sale to Savings Plan trustee 1,000,000 shares, for awards under Restricted Stock Incentive Plan 404,600 shares, and for conversion of debentures 1,428,543 shares; issued, 1982 — 44,620,299 shares, 1981 — 42,521,017 shares)	23,240	22,146
Additional paid-in capital	129,808	90,834
Foreign currency translation adjustment	(96,744)	(42,690)
Retained earnings	1,022,727	981,187
	1,079,031	1,051,477
Reacquired stock — at cost (6,589 shares)	120	120
Total Stockholders' Equity	1,078,911	1,051,357
Total Liabilities and Stockholders' Equity	$2,001,354	$1,997,144

The accompanying accounting policies and notes are an integral part of the consolidated financial statements.

HERCULES INCORPORATED

Consolidated Statement of Stockholders' Equity

(Dollars in thousands)

	Three Years Ended December 31, 1982				
	Common Stock	Additional Paid-In Capital	Translation Adjustment	Retained Earnings	Reacquired Stock
Balances at January 1, 1980 (Shares: Common — 42,386,717; and reacquired — 3,689)	$22,076	$ 88,225	$	$ 835,188	$ 67
Net income — 1980				114,000	
Dividends paid — $1.20 a share				(50,915)	
Restricted stock awards — 65,350 shares	35	1,257			
Reacquired stock — 2,900 shares					53
Balances at December 31, 1980 (Shares: Common — 42,452,067; and reacquired — 6,589)	22,111	89,482		898,273	120
Net income — 1981				136,481	
Dividends paid — $1.26 a share				(53,567)	
Foreign currency translation adjustment:					
Beginning balance			2,266		
Current year			(44,956)		
Restricted stock awards — 68,950 shares	35	1,352			
Balances at December 31, 1981 (Shares: Common — 42,521,017; and reacquired — 6,589)	22,146	90,834	(42,690)	981,187	120
Net income — 1982				98,414	
Dividends paid — $1.32 a share				(56,874)	
Foreign currency translation adjustment			(54,054)		
Restricted stock awards — 61,100 shares	32	1,191			
Common stock exchanged for convertible debentures — 2,038,154 shares	1,062	37,783			
Conversion of debentures — 28 shares	—	—			
Balances at December 31, 1982 (Shares: Common — 44,620,299; and reacquired — 6,589)	$23,240	$129,808	$(96,744)	$1,022,727	$120

The accompanying accounting policies and notes are an integral part of the consolidated financial statements.

Summary of Significant Accounting Policies

Principles of Consolidation

The consolidated financial statements include the accounts of Hercules Incorporated, all wholly owned subsidiaries with the exception of finance and insurance subsidiaries, and Hercules' pro rata share of the Hercofina joint ventures. The accounts of wholly owned foreign subsidiaries are included on the basis of their fiscal years ended November 30 (October 31 for Hercofina) adjusted for intercompany transactions to December 31. These fiscal years were adopted to allow sufficient time to include these companies in the consolidated financial statements.

Investments in affiliated companies, owned 20% or more, are accounted for on the equity method, as are wholly owned finance and insurance subsidiaries (due to their dissimilar business activities). Accordingly, consolidated net income includes Hercules' share of their net income.

All significant intercompany transactions are eliminated in consolidation.

Inventories

Inventories are stated at the lower of cost or market. Substantially all domestic inventories are valued on the last-in, first-out (LIFO) method, and foreign inventories are valued principally on the average cost method.

Property and Depreciation

Property, plant and equipment are stated at cost. For financial accounting purposes, Hercules depreciates the major portion of its processing facilities, using a modified declining balance method, whereby the cost of the facilities is depreciated over their estimated remaining useful lives, generally a moving 10-year period. Estimates of useful lives are reviewed annually. For new technology product facilities, the units of production method is used during the initial periods. Remaining facilities of Hercules and facilities of consolidated subsidiaries are depreciated or amortized principally on the straight-line method.

Maintenance, repairs, and minor renewals are charged to income; major renewals and betterments are capitalized. Upon normal retirement or replacement, the cost of property (less proceeds of sale or salvage) is charged to accumulated depreciation.

Pensions

Hercules and its consolidated subsidiaries have various pension plans covering substantially all employes.

Hercules' policy is to fund currently accruing normal cost in full and estimated prior service costs, not covered by the pension liability, over a 30-year period. The pension liability for periods prior to 1964 will be paid to the trustees of the plan not later than 1993. Substantially all employes of international subsidiaries are covered by insured plans.

Taxes on Income

Deferred taxes on income are due to timing differences between amounts reported for financial accounting and income tax purposes.

Investment and research and development tax credits are taken into income under the "flow-through" method of accounting in the periods when qualifying capital and research expenditures are incurred.

The company provides taxes on undistributed earnings of subsidiaries and joint ventures included in consolidated retained earnings to the extent such earnings are planned to be remitted and not reinvested permanently.

Long-Term Contracts

For financial accounting purposes, the percentage of completion method of accounting is used for major long-term space and defense contracts.

Notes to Financial Statements

(Dollars in thousands, except per share)

1. Extraordinary Gain

In September 1982, Hercules exchanged 2,038,154 shares of common stock for $50,000 principal amount of 6½% convertible subordinated debentures. The extinguishment of the debt resulted in an extraordinary nontaxable gain of $11,553 ($.25 per share) which was recognized in the third quarter of 1982.

2. Foreign Currency Translation

During 1981 Hercules adopted Statement of Financial Accounting Standard No. 52, Foreign Currency Translation, which provides for the determination of functional currencies based on business and economic environmental considerations. With the exception of operations in highly inflationary countries, the local currencies of Hercules' foreign entities have been designated as the functional currency and accordingly financial statements are translated at current rates of exchange with gains or losses resulting from translation included in a separate component of stockholders' equity. Hercules previously translated nonmonetary accounts such as inventories and property, plant and equipment at historical exchange rates and included translation adjustments in income. The effect of adopting the new standard was to increase net income in 1981 by $25,600 ($.56 per share). Due to immateriality, 1980 was not restated.

Gains or losses on foreign currency transactions (denominated in currencies other than the local currency) and translation of balance sheets of operations in hyperinflationary economies (whose functional currency is the U.S. dollar) are reflected in net income. The foreign currency gain, net of taxes, in income is $6,929 in 1982 and $6,418 in 1981. These results are included in nonoperating expenses for consolidated companies and equity in net income for affiliated companies.

The allocation for income taxes included in the translation adjustment to stockholders' equity for 1982 and 1981 was not significant.

3. Earnings Per Share

Earnings per share are calculated on the basis of the following average number of common and common equivalent shares:

1982	45,618,872
1981	45,365,511
1980	45,277,368

Net income has been adjusted to reflect the elimination of interest expense, net of taxes, on the 6½% convertible debentures in the following amounts:

1982	$2,925
1981	3,510
1980	3,510

4. Inventories

Inventories valued on the average cost method would have been $153,000 and $158,700 higher than as reported on the LIFO method at December 31, 1982 and 1981, respectively.

5. Pensions

Total pension expense for 1982, 1981, and 1980 was $43,600, $53,700, and $51,000, respectively. During 1982 changes in actuarial assumptions resulting from the establishment of certain dedicated portfolios returning 13 to 19% reduced pension expense by approximately $11,100.

A comparison of the actuarially determined present value of accumulated plan benefits and plan net assets determined as of the valuation dates is presented below:

	January 1 1982	January 1 1981
Accumulated plan benefits:		
Vested	**$312,200**	$370,800
Nonvested	**16,800**	17,400
Total	**$329,000**	$388,200
Net assets available for benefits	**$559,700**	$504,600

The assumed rate of return used in determining the actuarial present values of vested and nonvested accumulated plan benefits was 8% for both 1982 and 1981 except for the dedicated portfolios described above, which are the principal reason for the decline in accumulated plan benefits.

6. Taxes on Income

Income before taxes on income is:

	Year Ended December 31		
	1982	1981	1980
Domestic	$ 39,644	$120,994	$ 66,182
Foreign	43,944	59,450	48,556
Total	$ 83,588	$180,444	$114,738

The provision for taxes consists of:

	1982	1981	1980
Currently payable			
Domestic	$ 6,850	$57,976	$13,871
Foreign	13,650	17,602	9,757
Deferred			
Domestic	9,981	(11,704)	9,754
Foreign	(788)	(2,246)	8,002
Investment credits	(9,449)	(10,566)	(18,023)
Total	$20,244	$51,062	$23,361

Deferred taxes relate to the following timing differences:

	1982	1981	1980
Accelerated depreciation	$ 13,880	$ 9,438	$13,060
Pension expense	(1,295)	1,289	(7,418)
Long-term contracts	15,554	(34,154)	6,497
Capitalized interest	5,608	5,877	6,394
Investment credits	(20,188)	—	—
Other — net	(4,366)	3,600	(777)
Total	$ 9,193	$(13,950)	$17,756

A reconciliation of the U.S. corporate income tax rate to the effective rate follows:

	1982	1981	1980
U.S. corporate income tax rate	46%	46%	46%
Investment credits	(11)	(6)	(16)
Research and development credits	(6)	—	—
Benefits from export sales companies	(7)	(3)	(4)
Income of foreign subsidiaries not tax-effected	(7)	(2)	(5)
Tax benefit from partnerships	—	(5)	—
Foreign dividends net of credits	10	—	—
Other	(1)	(2)	(1)
Effective tax rate	24%	28%	20%

The undistributed earnings of subsidiaries and joint ventures on which no provision for foreign withholding or U.S. income taxes has been made amounted to $285,800 at December 31, 1982. U.S. and foreign income taxes that would be payable if such earnings were distributed would be substantially lower than the U.S. statutory rate because of the availability of foreign tax credits.

Investment tax credit carryforwards available for tax purposes approximate $20,200, of which $2,100 is available to reduce taxes payable through 1995, $8,600 through 1996, and $9,500 through 1997. Foreign tax credit carryforwards total $6,200 and can be utilized until 1987.

U.S., foreign and state taxes on income includes deferred tax liabilities of approximately $31,600 and $7,600 at December 31, 1982 and 1981, respectively.

Notes to Financial Statements

(Dollars in thousands, except per share)

7. Debt

A summary of short-term and long-term debt follows:

	1982	1981
Short-term:		
Commercial paper	$22,916	$46,824
Banks	30,268	23,733
Other	4,759	2,511
	$57,943	$73,068

Pertinent data relating to interest rates and the amount of short-term debt carried throughout the year are as follows:

	1982	1981	1980
Average interest rate at yearend			
Commercial paper	9.0%	12.8%	18.9%
Banks	13.8	13.9	15.2
Other	6.2	6.8	5.6
Average interest rate during year (a)			
Commercial paper	12.7	16.7	13.2
Banks	17.0	18.7	15.2
Other	10.0	9.1	7.2
Average amount outstanding for year (b)			
Commercial paper	$25,176	$ 68,258	$113,060
Banks	29,962	23,474	26,569
Other	2,007	4,151	3,082
Maximum amount outstanding at any monthend			
Commercial paper	47,422	154,616	134,823
Banks	33,336	27,525	32,476
Other	4,759	5,008	3,821

(a) Actual interest costs divided by average debt amounts.

(b) Commercial paper is average daily amount outstanding while Banks and Other are average monthend balances.

Commercial paper (including master notes) is issued or renewed for varying periods, with interest at prevailing market rates. Bank borrowings represent primarily foreign overdraft facilities and short-term lines of credit, which are generally payable on demand with interest at various rates. Both bank borrowings and other short-term debt include current maturities of long-term debt.

At December 31, 1982, Hercules had $126,150 of unused lines of credit that may be drawn as needed, with interest at the prime rate. Lines of credit in use or supporting commercial paper at December 31, 1982, were $44,900.

In connection with the lines of credit agreements, Hercules maintains compensating cash balances of 5% on certain unused credit facilities. At December 31, 1982, cash in the consolidated balance sheet included $2,350, maintained as compensating balances.

	1982	1981
Long-term:		
6½% convertible subordinated debentures due 1999 (a)	$ 50,000	$100,000
8¾% notes due 1983 (b)	100,000	100,000
Term loans due 1987-1990 (c)	111,033	209,237
Foreign currency term loans due 1983-1989 (d)	72,834	—
Revolving credit notes (e)	32,250	23,000
Capital leases (f)	62,023	31,919
Other	21,203	5,100
	449,343	469,256
Current maturities of long-term debt	(13,981)	(6,937)
Industrial Revenue Bond funds held by trustees	(3,443)	(7,963)
Net long-term debt (g)	$431,919	$454,356

(a) The subordinated debentures are convertible into common stock at $35 per share, and are redeemable at the option of the company at varying rates. Beginning in 1985, the debentures require a sinking fund in annual installments of $5,500. The requirements for years 1985 through 1993 and a portion of 1994 were provided for as a result of the exchange of common stock for debentures during 1982.

(b) Notes are classified as long term due to the intention to refinance. Currently, Hercules plans to utilize a portion of the amount available under revolving credit agreements to satisfy repayment.

(c) The term loans are with several banks and bear interest at various rates (prime rate or an agreed-upon spread over the lender's cost of funds).

(d) Foreign currency term loans in Dutch guilders, Japanese yen, deutsche marks, and Swiss francs are at various interest rates (7 to 12¾%).

(e) Hercules has revolving credit agreements with certain banks, some of which are in foreign currencies, maturing in 1986 through 1990, under which Hercules may borrow up to a total of $232,250 (of which $200,000 was available at December 31, 1982) at various interest rates (prime rate with an added spread in later years, an agreed-upon spread over London Interbank offered rate (LIBOR), or an agreed-upon spread over lender's cost of funds). The foreign currency credit agreements provide for conversion to fixed-rate term loans.

These agreements contain certain restrictions, including the payment of cash dividends. Such dividends may be paid only out of retained earnings since December 31, 1973, which amounted to $519,000 at December 31, 1982.

(f) Hercules is committed under net lease agreements whereby existing plant facilities, costing $98,500, and facilities under construction, financed from either notes or the sale of Industrial Revenue Bonds, are leased for periods expiring in 1984 through 2007. The bonds and notes, bearing interest at fixed rates from 5.0 to 14.875%, or at rates which are lower than and vary with the prime rate, will be retired by periodic payments, which are equivalent to interest and debt retirement requirements. At December 31, 1982, the aggregate minimum lease payments amounted to $108,600 (including interest of $46,500), of which $9,200 is payable in 1983; $17,300 in 1984; $14,400 in 1985; $7,500 in 1986; and $5,700 in 1987. Under certain conditions, Hercules has the option to purchase these facilities for amounts that will be sufficient to redeem and retire all outstanding notes or bonds.

(g) Amounts due on long-term debt in each of the next five years are as follows (foreign currency loan repayments are included below at yearend exchange rates):

1983	$13,981
1984	37,660
1985	33,736
1986	22,418
1987	65,193

8. Interest Expense

Interest and debt costs totaled $68,457 in 1982, $60,273 in 1981, and $51,256 in 1980, of which $17,750, $13,600, and $13,900, respectively, was capitalized.

9. Incentive Compensation Plans

(a) Unit Incentive Plan:

The Unit Incentive Plan, adopted in 1972, provides that units may be granted to key employes, with a maximum aggregate number of 1,200,000 units outstanding at any one time. Units are credited to the grantee's account at the fair market value of an equal number of shares of common stock at the date the units are awarded. Benefits for each unit will be equal to dividend equivalents, interest, and market appreciation of a share of common stock over a period not exceeding 5 years from date of award. Benefits vest and are payable upon retirement or 5 years after date of award.

During 1982, 137,650 units were granted, 229,570 units vested and were paid, and 1,160 units were canceled. The charge to income was $3,925 in 1982, $3,714 in 1981, and $1,597 in 1980. There were 839,460 units outstanding at December 31, 1982.

(b) Restricted Stock Incentive Plan:

The Restricted Stock Incentive Plan, adopted in 1980, provides for the award of shares of common stock of the company to key employes, subject to certain restrictions until distribution is made.

The maximum aggregate number of shares to be awarded under the Plan is 600,000, with a maximum to any single employe of 40,000 shares. Awards may not be granted under the Plan after March 31, 1986.

During 1982, 62,100 shares were awarded, 35,300 shares were distributed and 1,000 shares were canceled. The charge to income based on amortization of the compensation expense over the related periods of restriction was $1,593 in 1982, $853 in 1981, and $251 in 1980. There were 160,100 awarded shares outstanding at December 31, 1982.

10. Commitments

(a) Leases:

Hercules has certain operating leases, including office space and transportation and data processing equipment, expiring at various dates. Rental expense relating to these leases was $41,100 in 1982, $37,300 in 1981, and $31,200 in 1980.

At December 31, 1982, minimum rental payments under noncancellable leases aggregated $436,450 (most of which relates to an operating lease for new corporate office facilities), of which $25,050 is payable in 1983, $19,000 in 1984, $19,100 in 1985, $16,750 in 1986, and $13,600 in 1987.

(b) Capital Expenditures:

Capital expenditures are forecast at $200,000 for 1983.

11. Contingent Liabilities

(a) Litigation:

Hercules, four other large chemical companies, and others are defendants in over five hundred Federal District Court civil cases in which veterans of the Vietnam War, their spouses and some minor children claim injury because of exposure to "Agent Orange" (a mixture of 2,4,5-T and 2,4-D used as a defoliant during the Vietnam War) which allegedly contained a contaminant, "dioxin." Plaintiffs seek (1) injunctions against the continued manufacture of contaminated herbicides (which does not affect Hercules since it is no longer in the agricultural chemicals business), (2) damages for personal injuries in generally unstated amounts and (3) the creation of a corporate trust fund as a reserve against the claims of any plaintiff. The suits continue to grow in number. In late 1980, the District Court indicated that there may be a complete defense available to a Government contractor such as Hercules, which furnishes material to the Government at the direction of the Government, in accordance with Government specifications, and if it can be shown that the Government knew as much as or more than the contractor about human health hazards associated with the product. This issue is scheduled for trial in June 1983, and although the outcome is uncertain, the company is optimistic.

There are pending against Hercules and its consolidated subsidiaries various other lawsuits and claims arising out of the normal course of business with respect to commercial matters, consisting primarily of product liability and environmental regulation matters. Certain of these actions purport to be class actions seeking damages in large amounts. Any actual liability is not determinable as of December 31, 1982, but management believes, based upon the opinion of the company counsel, any liability resulting from such lawsuits and claims will not materially affect the consolidated financial position of the company.

(b) Guarantees:

At December 31, 1982, Hercules was contingently liable as guarantor of notes payable of affiliated companies aggregating $22,350.

12. Investments, at Equity

Consolidated retained earnings include undistributed earnings of affiliated companies owned 50% or less of $51,514 at December 31, 1982 and $46,234 at December 31, 1981.

Dividends received from affiliated companies amounted to $10,545 in 1982, $9,803 in 1981, and $25,100 in 1980.

During 1981 Hercules established Hercules Credit Inc. (formerly Hercules Finance Incorporated), a wholly owned finance subsidiary, for the purpose of engaging in various financing activities. Hercules Credit's contribution (principally from safe harbor leases) to equity income is $3,461 in 1982 and $9,009 in 1981.

A summary of assets, liabilities, and results of operations for all affiliated companies accounted for on the equity method is as follows (dollars in millions):

	December 31		
	1982	1981	1980
Operating Subsidiaries Not Consolidated:			
Net sales	$ 123	$ 121	$ 111
Profit from operations	10	13	10
Net income (loss)	3	(1)	3
Hercules equity	2	(1)	1
Current assets	46	57	63
Other assets	19	24	25
Total assets	65	81	88
Current liabilities	(25)	(34)	(34)
Other liabilities	(4)	(7)	(12)
Minority interest	(15)	(17)	(17)
Hercules equity	21	23	25
Finance and Insurance Subsidiaries:			
Net income	$ 8	$ 12	$ 1
Current assets	57	12	10
Other assets	—	58	—
Total assets	57	70	10
Current liabilities	(18)	(5)	(7)
Hercules equity	39	65	3
Other Companies Accounted for on the Equity Method:			
Net sales	$ 872	$ 941	$ 840
Profit from operations	61	41	65
Net income	40	1	48
Hercules equity	14	(4)	20
Current assets	328	368	374
Other assets	403	367	355
Total assets	731	735	729
Current liabilities	(198)	(258)	(270)
Other liabilities	(190)	(168)	(158)
Interest of others	(188)	(171)	(167)
Hercules equity	155	138	134

13. Supplementary Information on the Effects of Inflation and Changing Prices (Unaudited)

For a number of years, the United States has experienced relatively high rates of inflation, which causes difficulty in measuring performance and comparing financial statements over periods of time. Current accounting rules require that financial statements be prepared on the basis of historical costs, which are the dollar values at the time an asset is acquired. For example, investments in property, plant and equipment made over an extended period of time are aggregated as though the dollars from these periods were common units of measurement. Depreciation of these prior period expenditures does not represent the current cost of assets consumed and thereby does not follow the principle of matching current period expenses and revenues.

To focus on the effects of inflation on historical cost financial statements, Statement of Financial Accounting Standards No. 33 requires companies to adjust certain historical cost financial statement elements by applying the principles of constant dollar and current cost accounting. During 1982, the Financial Accounting Standards Board amended Statement No. 33 with the issuance of Statement No. 70. Under Statement No. 70, enterprises with foreign operations carried at functional currencies other than U.S. dollars may omit the constant dollar requirements.

The current cost information presented reflects the effects of changes in specific prices of the resources actually used in Hercules operations. The historical cost of these assets is restated into the current cost that would be incurred if they were acquired during the current year. New or improved technology is not considered in these calculations.

Notes to Financial Statements

(Dollars in thousands, except per share)

The current cost of production facilities is calculated based on domestic and foreign industry construction indexes applied to historical cost by year of asset acquisition. Current cost depreciation expense is calculated by applying the same methods and depreciable life assumptions as in the historical cost financial statements. Land has been valued based on estimates of local market values.

The current cost of inventories has been determined by applying, primarily, the moving average cost method of valuing inventories. After considering inventory turnover, it is believed the amount reported reasonably approximates cost levels experienced near the yearend and is substantially higher than their historical cost, which is principally stated at last-in, first out (LIFO) value. Current cost of sales is calculated by the LIFO method, which charges off to operations the current cost of inventories consumed during the year.

For Hercules' foreign operations, the Purchasing Power Gain and the Holding Gain or Loss have been determined by the Translate-Restate method which restates changes in these amounts to reflect the effect of U.S. inflation utilizing the Consumer Price Index for all Urban Consumers — (CPI-U).

Purchasing Power Gain

During inflationary periods, monetary assets, such as cash and receivables, lose purchasing power because these assets will purchase fewer goods or services in time. On the other hand, monetary liabilities gain purchasing power because dollars with less purchasing power will be required to satisfy these obligations. Since the monetary liabilities at yearend were greater than the monetary assets, an unrealized purchasing power gain is shown.

Holding Gain or Loss

Indexes such as the CPI-U, which measure the general inflation rate, are based on the general market basket of goods and services. The additional increase (gain) or decrease (loss) in asset values resulting from holding specific assets of property, plant and equipment and inventories, as opposed to holding a representation of the general market basket of goods and services, is presented separately and is not included in the supplemental calculation of income.

Review of Information

In calculating current cost net income, depreciation expense and cost of sales reported in the primary financial statements have been adjusted to reflect changes in specific prices of the resources actually used in Hercules' operations. The comparatively lower earnings on a current cost basis are due primarily to higher depreciation costs resulting from adjusting depreciable assets to reflect the cost that theoretically provides for the maintenance of current production capacity. Adjustments to historical cost of sales were relatively small because of Hercules' principal use of the LIFO method for inventories, which results in current costs being reflected in the primary financial statements. For 1982, current cost of sales was slightly lower than historical costs because of the overall decline in the current cost of inventories for the year.

Purchasing power gains and holding gains should be considered real economic benefits during inflationary times even though they are not included in current cost net income in accordance with Statement No. 33 requirements. The purchasing power gain declined from 1981 because of the reduced rate of general inflation in 1982. The fact that the increase in specific prices was approximately the same as the increase in general price level is an indication that the increase in the current cost of chemical company assets kept pace with the general rate of inflation.

The provision for taxes on income has not been reduced because the inflation adjustments are not deductible for income tax purposes. However, the impact of inflation can readily be seen by comparing the effective tax rate of 24% under historical cost accounting with the effective tax rate of 85% under current cost accounting.

In terms of today's dollars, net assets are substantially undervalued on the historical cost balance sheet due primarily to the inflationary impact on property, plant and equipment values and to a lesser extent, inventories. When adjusted to a current cost basis, net property, plant and equipment and inventories are $419 million and $156 million greater than their historical cost, respectively. As a result, current cost balance sheet measurements are significantly different from historical cost and illustrate the need to reevaluate the use of traditional guidelines (from noninflationary periods) to measure current liquidity and to measure a firm's ability to utilize borrowed capital. For example, Hercules' historical cost current ratio of 2.2 and percentage of total debt to equity of 45 become 2.7 and 30, respectively, under current costs.

Even though the supplemental data presented are prepared on a reasonable basis, they should not be interpreted as a precise measurement of the effects of inflation and, accordingly, a critical analysis of the information and the theory upon which it is based is required before judgments can be made.

Statement of Income and Other Financial Data Adjusted for Changing Prices

For the year ended December 31, 1982

	As Reported in the Primary Statements	Adjusted for Changes in Specific Prices (Current Cost)
Net sales	$2,468,971	$2,468,971
Cost of sales[a]	1,930,078	1,924,444
Depreciation and amortization	120,487	185,979
Selling, general and administrative expenses[a]	304,708	304,708
All other — net	6,593	6,593
Provision for taxes on income[b]	20,244	20,244
	2,382,110	2,441,968
Income before extraordinary gain	$ 86,861	$ 27,003
Gain from decline in purchasing power of net amounts owed (purchasing power gain)		$ 16,955
Effect of increase in general price level		$ 67,917
Increase in specific prices of inventories and property, plant and equipment held during the year — net[c]		67,861
Excess of increase in general price level over increase in specific prices (holding loss)		$ 56
Foreign currency translation adjustment		$ 61,660

(a) Excluding depreciation expense.
(b) No adjustment has been made to the provision for income taxes. The effect is to increase the effective tax rate from 24% reported in the financial statements to 85% in 1982 current cost calculations.
(c) At December 31, 1982, current cost of inventory was $524,273, and current cost of property, plant and equipment, net of accumulated depreciation, was $1,342,303.

Selected Supplementary Financial Data Adjusted for Effects of Changing Prices (Current Cost)

(In average 1982 dollars)

	1982	1981	1980	1979	1978*
Net Sales	$2,468,971	$2,885,021	$2,908,821	$3,114,664	$2,881,344
Income Before Extraordinary Gain	27,003	66,057	35,212	116,902	
Earned per Share of Common Stock Before Extraordinary Gain	.66	1.54	.87	2.68	
Dividends per Share of Common Stock	1.32	1.34	1.40	1.43	1.48
Net Assets at Yearend	1,632,713	1,648,441	1,799,383	1,839,932	
Foreign Currency Translation Adjustment	132,653	75,345			
Purchasing Power Gain	16,955	39,446	48,599	57,042	
Holding Gain (Loss)	(56)	40,091	(34,697)	30,749	
Market Price per Common Share at Yearend	27.21	23.12	21.16	25.83	23.23
Average Consumer Price Index	289.1	272.4	247.0	217.7	195.3

*Additional current cost information for 1978 is not readily determinable.

14. Operations by Industry Segments

(Dollars in millions)

	1982	1981	1980
Net Sales			
Organics	$ 550	$ 614	$ 556
Plastics	704	741	696
Water-Soluble Products	491	558	521
Explosives and Aerospace	429	445	390
Other Products	295	360	322
Consolidated Net Sales*	2,469	2,718	2,485
Profit from Operations			
Organics	52	81	66
Plastics	(9)	17	13
Water-Soluble Products	44	66	50
Explosives and Aerospace	39	42	23
Other Products	(12)	6	3
Consolidated Profit from Operations	114	212	155
Interest and Debt Expense	(51)	(47)	(37)
Other Nonoperating Income (Expense) — Net	21	15	(3)
Income Before Taxes on Income	84	180	115
Identifiable Assets			
Organics	271	302	300
Plastics	635	676	658
Water-Soluble Products	381	356	369
Explosives and Aerospace	155	143	125
Other Products	181	200	122
Total Identifiable Assets	1,623	1,677	1,574
Investments and Advances — Affiliated Companies	215	177	161
Corporate Assets	163	143	155
Total Assets	2,001	1,997	1,890
Capital Expenditures			
Organics	32	35	30
Plastics	28	60	126
Water-Soluble Products	61	39	45
Explosives and Aerospace	33	29	19
Other Products	11	4	9
Total Capital Expenditures	165	167	229
Depreciation and Amortization			
Organics	20	20	19
Plastics	53	53	53
Water-Soluble Products	25	26	20
Explosives and Aerospace	14	12	12
Other Products	8	8	10
Total Depreciation and Amortization	120	119	114

Corporate assets are cash and time deposits, marketable securities, nontrade accounts receivable, other investments and advances, and deferred charges and miscellaneous assets.

*Transfers between industry segments are insignificant.

15. Operations by Geographic Areas

(Dollars in millions)

	1982	1981	1980
Net Sales — Customers			
United States	$1,888	$2,137	$1,853
Europe	438	445	503
Other	143	136	129
Transfers Between Geographic Areas			
United States	87	101	97
Europe	18	18	14
Other	2	2	2
Adjustments and Eliminations	(107)	(121)	(113)
Consolidated Net Sales	2,469	2,718	2,485
Profit from Operations			
United States	68	156	92
Europe	42	46	50
Other	4	10	13
Consolidated Profit from Operations*	114	212	155
Identifiable Assets			
United States	1,249	1,270	1,139
Europe	318	354	362
Other	129	136	127
Adjustments and Eliminations	(73)	(83)	(54)
Total Identifiable Assets*	1,623	1,677	1,574
Export Sales from the United States			
Europe	66	70	89
Other	198	252	193
Total Export Sales from the United States	264	322	282

Transfers between geographic areas are accounted for at approximate market prices.

Consolidated foreign subsidiaries had net assets of $332 at December 31, 1982 and $389 at December 31, 1981 and 1980, and net income of $37 in 1982, $46 in 1981, and $34 in 1980.

*See reconciliation to Income Before Taxes on Income and to Total Assets in Note 14 — Operations by Industry Segments.

Ten-Year Digest

(Dollars and shares in thousands, except per share)

		1982	1981	1980
Operating Review				
Net Sales		$2,468,971	$2,718,366	$2,485,226
Profit from Operations		113,698	211,656	154,901
Income Before Taxes on Income		83,588	180,444	114,738
Provision for Taxes on Income		20,244	51,062	23,361
Equity in Net Income of Affiliated Companies		23,517	7,099	22,623
Net Income		98,414 *	136,481	114,000
Dividends Paid		56,874	53,567	50,915
Per Share of Common Stock				
Net Income		2.22 *	3.09	2.60
Dividends		1.32	1.26	1.20
Research and Development		70,697	61,410	53,462
Depreciation and Amortization		120,487	118,839	114,472
Capital Expenditures		164,997	167,189	229,163
Financial Review				
Working Capital		431,407	518,893	386,658
Current Ratio		2.2	2.5	2.0
Property, Plant and Equipment — at cost				
Gross		2,079,668	2,018,586	1,882,348
Net		923,676	907,733	872,656
Long-Term Debt		431,919	454,356	334,530
Debt:Equity Ratio	%	40	43	33
Stockholders' Equity		1,078,911	1,051,357	1,009,746
Return on Average Stockholders' Equity	%	9.2	13.2	11.7
General Statistics				
Number of Common Stockholders		35,390	37,696	37,263
Number of Common Shares Outstanding		44,614	42,514	42,445
Average of High and Low Prices for Hercules Stock		22.81	22.56	20.06
Number of Employes		21,598	22,777	22,928
Wage, Salary and Benefit Costs		679,309	667,055	630,418

*1982 includes extraordinary gain of $11.6 million ($.25 per share) from an exchange of common stock for debentures.
†1979 and 1976 include $.62 and $.66, respectively, relating to gains on sale of facilities.

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1979	1978	1977	1976	1975	1974	1973
$2,345,425	$1,946,477	$1,697,787	$1,595,956	$1,413,111	$1,525,489	$1,154,775
211,519	186,156	124,004	160,040	77,179	170,173	162,572
238,388	157,745	91,242	188,322	37,455	131,155	151,737
86,421	74,491	48,149	94,130	8,191	52,575	66,018
20,566	20,010	14,837	12,609	3,195	13,444	5,904
172,533	103,264	57,930	106,801	32,459	92,024	91,623
45,562	42,383	42,383	35,987	33,579	33,426	29,656
3.89†	2.36	1.36	2.44†	.77	2.17	2.19
1.075	1.00	1.00	.85	.80	.80	.71
46,701	40,081	37,361	35,389	30,025	30,021	24,542
106,517	106,683	93,839	89,228	85,582	81,541	68,918
185,998	115,807	127,484	150,294	151,370	217,086	144,140
379,413	332,655	327,521	313,267	244,879	275,657	201,441
1.9	1.9	2.2	2.2	2.0	2.0	2.0
1,703,481	1,615,368	1,537,050	1,432,234	1,414,793	1,280,239	1,077,222
772,889	714,286	721,292	699,383	712,178	654,607	522,456
280,619	295,969	329,443	326,368	334,224	348,818	177,511
30	36	43	44	50	53	30
945,422	818,451	757,570	742,020	664,910	656,067	596,055
19.6	13.1	7.7	15.2	4.9	14.7	16.2
37,744	38,199	33,200	29,082	27,683	26,196	25,381
42,383	42,383	42,383	42,383	42,194	41,813	41,732
19.44	15.44	21.63	31.00	28.13	32.50	34.38
24,387	24,431	24,002	23,957	23,476	25,335	24,063
601,796	546,051	490,296	444,440	383,802	393,733	328,355

Management's Report

The management of Hercules Incorporated is responsible for all the information and representations contained in the annual report, including the financial statements. Management believes that the financial statements have been prepared in conformity with generally accepted accounting principles. In preparing the financial statements, management makes informed judgments and estimates of the expected effects of events and transactions.

Hercules maintains a system of internal controls to provide reasonable assurance as to the reliability of the financial records and the protection of assets. The internal control system is supported by written policies and procedures that communicate the details of the control system, by careful selection and training of qualified personnel, and by an extensive internal audit program. In addition, the company's business ethics policy requires employes to maintain the highest level of ethical standards in the conduct of the company's business, and their compliance is regularly monitored.

The company's financial statements have been examined by Coopers & Lybrand, independent certified public accountants, as stated in their report below. Their examination was made in accordance with generally accepted auditing standards, and included such study and evaluation of the company's system of internal accounting control as they considered necessary to determine the nature, timing, and extent of the auditing procedures required for expressing an opinion on the company's financial statements.

The Board of Directors, acting through its Audit Committee composed exclusively of outside directors, is responsible for reviewing and monitoring the company's financial reports and accounting practices. The Board of Directors, upon the recommendation of the Audit Committee, appoints the independent certified public accountants subject to ratification by the stockholders. The Audit Committee meets periodically with management and the internal auditors, as well as the independent accountants. The independent accountants and internal auditors have full and free access to the Audit Committee and meet with it to discuss their audit work, the company's internal controls, and financial reporting matters.

Auditors' Report

COOPERS & LYBRAND

To the Shareholders and
the Board of Directors of Hercules Incorporated
Wilmington, Delaware

We have examined the consolidated balance sheets of Hercules Incorporated and subsidiary companies as of December 31, 1982 and 1981, and the related consolidated statements of income, stockholders' equity and changes in financial position for the years ended December 31, 1982, 1981 and 1980. Our examinations were made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the financial statements referred to above (pages 34 to 49) present fairly the consolidated financial position of Hercules Incorporated and subsidiary companies as of December 31, 1982 and 1981, and the consolidated results of their operations and changes in their financial position for the years ended December 31, 1982, 1981 and 1980, in conformity with generally accepted accounting principles consistently applied during the period except for the change in 1981, with which we concur, in the method of accounting for foreign currency translation, as described in Note 2 to the consolidated financial statements.

Coopers + Lybrand

1900 Three Girard Plaza
Philadelphia, Pennsylvania 19102
January 31, 1983

Directors

Alexander F. Giacco
Chairman of the Board
President and Chief Executive Officer

Stephen R. Clarke*
Senior Vice President

Eugene D. Crittenden, Jr.
Divisional Vice President

David S. Hollingsworth
Group Vice President

Robert J. Leahy
Divisional Vice President

Guy T. McBride, Jr.
President
Colorado School of Mines

Arthur C. Nielsen, Jr.
Chairman and Chief Executive Officer
A. C. Nielsen Company

John R. Petty
President of Marine Midland Banks Inc. and President and Chief Executive Officer of Marine Midland Bank, N.A.

Marcus V. Pratini de Moraes
Chairman of the Board
Grupo Peixoto de Castro; Olvebra, S.A.; and PPH—Companhia Industrial de Polipropileno

John R. Ryan†
Senior Vice President

*Mr. Clarke retired effective February 1, 1983.
†Mr. Ryan retired effective September 1, 1982.

Committees of the Board

Executive Committee

Alexander F. Giacco
Chairman

Stephen R. Clarke*
Eugene D. Crittenden, Jr.
David S. Hollingsworth
Robert J. Leahy
John R. Ryan†

Audit Committee

John R. Petty
Chairman

Guy T. McBride, Jr.
Arthur C. Nielsen, Jr.

Nominating Committee

Alexander F. Giacco
Chairman

Guy T. McBride, Jr.
Arthur C. Nielsen, Jr.
John R. Petty

Finance Committee

Stephen R. Clarke*
Chairman

Alexander F. Giacco
Guy T. McBride, Jr.
Arthur C. Nielsen, Jr.
John R. Petty
Marcus V. Pratini de Moraes

Compensation Committee

Arthur C. Nielsen, Jr.
Chairman

Guy T. McBride, Jr.
John R. Petty

Management Executives

Officers

Alexander F. Giacco
Chairman of the Board
President and Chief Executive Officer

Stephen R. Clarke*
Senior Vice President

John R. Ryan†
Senior Vice President

Eugene D. Crittenden, Jr.
Divisional Vice President
Water-Soluble Polymers/ Operating Services

Arden B. Engebretsen
Divisional Vice President and Treasurer

Robert J. Leahy
Divisional Vice President
Marketing/International

S. Maynard Turk
Vice President and General Counsel

Richard R. P. Morrow
Secretary

George MacKenzie
Controller

Daniel F. Desmond
Assistant Treasurer

Alexander L. Searl
Assistant Treasurer

Charles W. K. Gamble
Assistant Secretary

Paul M. Kendall
Assistant Controller

Vice Presidents

Fred L. Buckner
Group Vice President, Organics

David S. Hollingsworth
Group Vice President, Polypropylene

Lucien G. Maury
Vice President, Technology

Henry A. Schowengerdt
Group Vice President, Aerospace/Explosives

Kenneth A. Wagner
Vice President
Human Resources

Ross O. Watson
Vice President, Information Resources

Advisory Council

William O. Baker
Chairman of the Board
Bell Laboratories, Inc.

Robert K. Mueller
Chairman of the Board
Arthur D. Little, Inc.

James F. Thornton
Former Chairman of the Board
Lummus Co.

Edward O. Vetter
Former Executive Vice President
Texas Instruments, Inc.

Principal Associated Companies

Consolidated, Wholly Owned Subsidiaries

AUSTRIA
Patex Chemie GmbH, Traun

THE BAHAMAS
Hercules International Trade Corporation Limited (HINTCO), Nassau

BELGIUM
Hercules Chemicals N.V., Beringen

BRAZIL
Hercules do Brasil Produtos Quimicos Ltda., São Paulo

CANADA
Hercules Canada Limited, Montreal

DENMARK
A/S Københavns Pektinfabrik, Lille Skensved

ENGLAND
Hercules Limited, London
PFW, Ltd., Perivale

FINLAND
Oy Hercofinn Ab, Helsinki

FRANCE
Hercules France S.A., Paris

GERMANY
Hercules GmbH, Hamburg
Pomosin AG, Grossenbrode

ITALY
Bewoid Italiano & Callegaro, S.p.A., Milan
Cesalpinia S.p.A., Milan

JAPAN
Hercules Far East K.K., Tokyo

MEXICO
Quimica Hercules, S.A. de C.V., Mexico, D.F.

THE NETHERLANDS
Hercofina Europe, Rijswijk
Hercules BV, Rijswijk
Hercules Chemie BV, Rijswijk
PFW Nederland BV, Amersfoort

SPAIN
Ceratonia Sociedad Anonima, Tarragona

SWEDEN
Hercules Kemiska Aktiebolag, Gothenburg

UNITED STATES
Champlain Cable Corporation, Wilmington, Delaware
Hercofina, Wilmington, North Carolina
Hercules Chemical Corporation, Wilmington, Delaware
Hercules Overseas Corporation, Wilmington, Delaware
Hercules Trading Corporation, Wilmington, Delaware
Lexteco, Inc., Wilmington, Delaware
Solteco, Inc., Wilmington, Delaware

Affiliated Companies

(Percent Owned by Hercules)

AUSTRALIA
Australian Chemical Holdings Limited, Botany, New South Wales (60%);
Hercules Chemicals Australia Pty. Ltd., Melbourne (60%)

BERMUDA
Curtis Bay Insurance Co., Ltd. (100%)

BRAZIL
Companhia Brasileira de Produtos Quimicos Bononia, Rio de Janeiro (46%);
Polo Industria e Comercio Ltda., Rio de Janeiro (49%);
PPH — Companhia Industrial de Polipropileno, Porto Alegre (40%)

CANADA
Adria Laboratories of Canada Ltd., Toronto (50%)

ENGLAND
The Holden Vale Manufacturing Company, Limited, Haslingden (50%);
Nelsons Acetate Limited, Lancaster (50%)

FRANCE
Société Européenne de Fibres et Composites, S.A. (S.E.F.C.), Paris (40%)

GERMANY
Abieta Chemie GmbH, Augsburg (50%)

INDIA
Herdillia Chemicals Limited, Bombay (22%);
Indian Gum Industries Limited, Bombay (49%)

ITALY
Neofil S.p.A., Milan (50%)

JAPAN
DIC-Hercules Chemicals Incorporated, Tokyo (50%);
Japan Magnetics, Ltd., Tokyo (50%);
Rika-Hercules Incorporated, Osaka (50%);
Sumika Hercules Company, Ltd., Osaka (50%);
Teijin Hercules Chemical Company Limited, Tokyo (49%)

MEXICO
Petrocel, S.A., Tampico (30%);
Taloquimia, S.A., Chihuahua (49%)

NEW ZEALAND
A. C. Hatrick (N.Z.) Ltd., Auckland (60%)

PAKISTAN
Dawood Hercules Chemicals Limited, Lahore (40%);
Pakistan Gum Industries Limited, Karachi (49%)

PUERTO RICO
Hercor Chemical Corporation, Ponce (37%)

TAIWAN
Taiwan Polypropylene Company Limited, Taipei (40%)

UNITED STATES
Adria Laboratories Inc., Columbus, Ohio (50%);
Boots Hercules Agrochemicals Co., Wilmington, Delaware (40%);
Hercules Credit, Inc., Wilmington, Delaware (100%);
Texas Alkyls, Inc., Deer Park, Texas (50%)

VIRGIN ISLANDS
St. Croix Petrochemical Corp., St. Croix (37%)

Major Domestic Plants and Sales Offices

Plants

ORGANICS
Baton Rouge, Louisiana
Brunswick, Georgia
Burlington, New Jersey
Chicopee, Massachusetts
Franklin, Virginia
Gibbstown, New Jersey
Hattiesburg, Mississippi
Kalamazoo, Michigan
Louisiana, Missouri
Milwaukee, Wisconsin
Portland, Oregon
Savannah, Georgia
West Elizabeth, Pennsylvania

PLASTICS
Bayport, Texas
Calhoun, Georgia
Covington, Virginia
Crowley, Louisiana
Lake Charles, Louisiana
Marshallton, Delaware
Middletown, Delaware
Oxford, Georgia
Terre Haute, Indiana
Union, Missouri
Winooski, Vermont

WATER-SOLUBLE PRODUCTS
Brunswick, Georgia
Harbor Beach, Michigan
Hopewell, Virginia
Louisiana, Missouri
Middletown, New York
Parlin, New Jersey
Vero Beach, Florida

EXPLOSIVES & AEROSPACE
Bessemer, Alabama
Carthage, Missouri
Donora, Pennsylvania
Ishpeming, Michigan
Kenvil, New Jersey
Louisiana, Missouri
Magna, Utah
McGregor, Texas
Port Ewen, New York
Rocket Center, West Virginia

OTHER PRODUCTS
Deer Park, Texas
Middletown, Delaware
Pulaski, Virginia

Government-Owned Plants Operated by Hercules Incorporated
Radford Army Ammunition Plant
Radford, Virginia
Sunflower Army Ammunition Plant
Lawrence, Kansas

Sales Offices

MIDWESTERN REGION
Regional Office—Chicago, Illinois
Sales Offices
Akron, Ohio
Cincinnati, Ohio
Detroit, Michigan
Green Bay, Wisconsin
Kalamazoo, Michigan

NORTHEASTERN REGION
Regional Office—Wilmington, Delaware
Sales Offices
Bedford, New Hampshire
Chicopee, Massachusetts
Paintsville, Kentucky
Paramus, New Jersey
Port Ewen, New York
Richmond, Virginia
Waterville, Maine

SOUTHERN REGION
Regional Office—Atlanta, Georgia
Sales Offices
Charlotte, North Carolina
Dallas, Texas
Houston, Texas
Jacksonville, Florida
Mobile, Alabama
Shreveport, Louisiana

WESTERN REGION
Regional Office—San Francisco, California
Sales Offices
Denver, Colorado
Portland, Oregon

Investor's Quick Reference Guide

Hercules Common Stock
Ticker Symbol: HPC
Listed: New York Stock Exchange
11 Wall Street
New York, New York 10005
Traded: Philadelphia, Midwest, and Pacific Stock Exchanges

Annual Meeting
Tuesday, March 22, 1983, 11:00 a.m.
at The Grand Opera House
818 Market Street Mall
Wilmington, Delaware

Annual Report
Mailed usually 7 to 8 weeks after fiscal yearend, December 31.

Quarterly Reports
Mailed usually the fourth week after the end of the quarter ending March 31, June 30, and September 30.

Shareholder Inquiries Questions About Hercules Call or Write:
William W. Bewley
Chief Corporate Economist and
Director, Investor Relations
910 Market Street
Wilmington, Delaware 19899
Telephone: 1 (800) 441-9274

SEC Form 10-K Report
Hercules Incorporated will furnish to any shareholder, without charge, a copy of its most recent annual report on Form 10-K as filed with the Securities and Exchange Commission. Written requests should be directed to:
Hercules Incorporated
Attention: Secretary's Office
910 Market Street
Wilmington, Delaware 19899

Hercules Mailing Address and Telephone
910 Market Street
Wilmington, Delaware 19899
Telephone: 1 (302) 575-5000

Dividend Declaration Date
Usually the first month of each quarter to shareholders of record approximately the first week of March, June, September, and December.

Dividend Payment Date
Usually the last of March, June, September, and December.

Dividend Disbursing Agent
Manufacturers Hanover
Trust Company
P.O. Box 24935
Church Street Station
New York, New York 10249

Dividend Reinvesting Agent
Citibank, N.A.
Automatic Dividend Reinvestment
Sort 5710
New York, New York 10043

Dividend Record
Hercules has paid a cash dividend each quarter since its inception.

Stock Transfer Agents and Registrars of Stock
Manufacturers Hanover
Trust Company
P.O. Box 24935
Church Street Station
New York, New York 10249

Wilmington Trust Company
Wilmington, Delaware 19899

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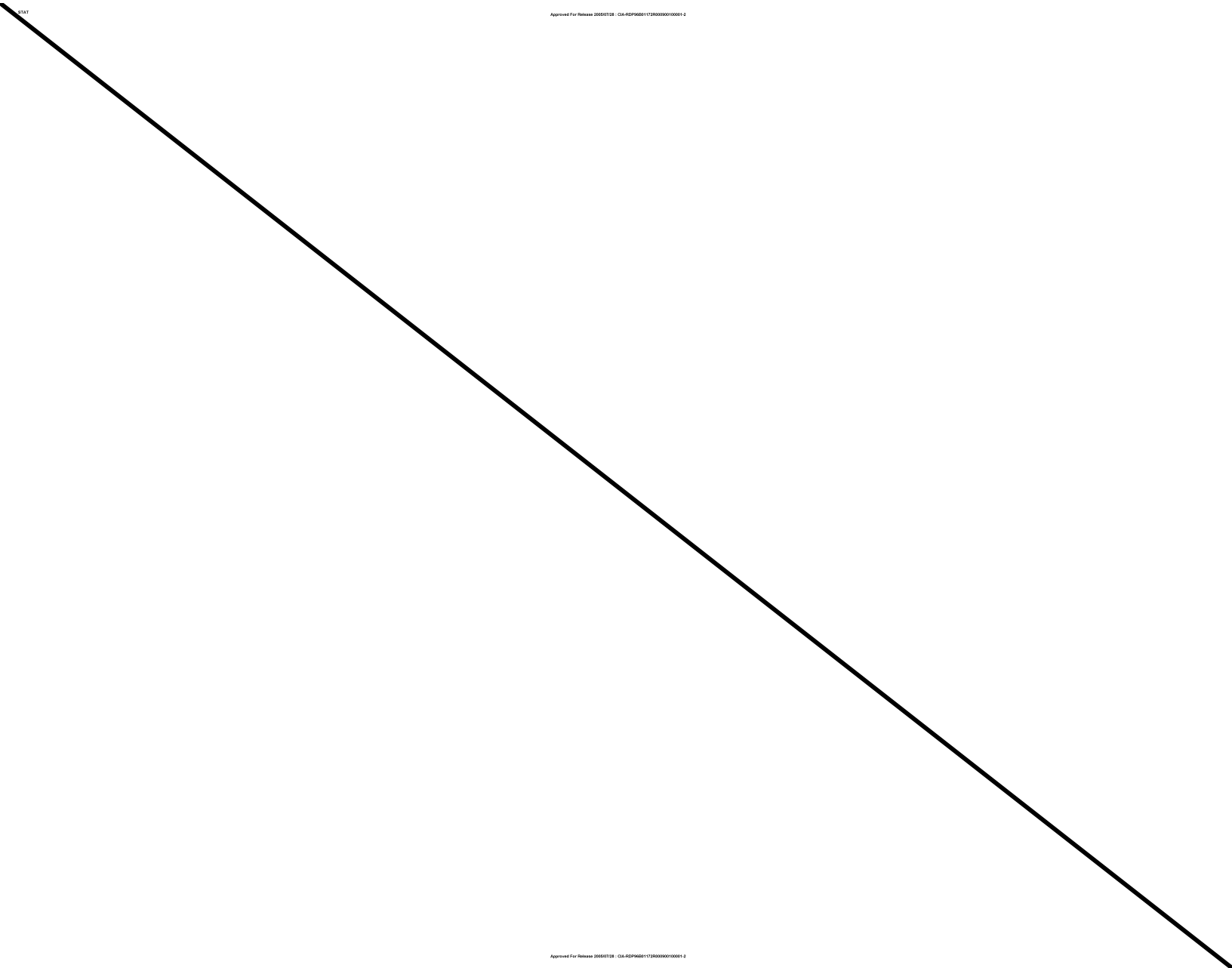

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