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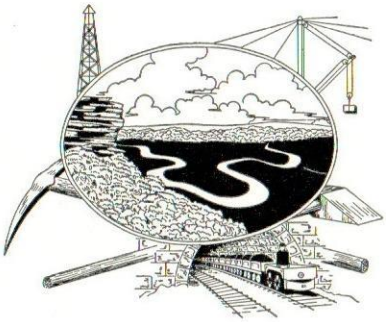
THE MARBLE INDUSTRY OF TENNESSEE

By
STUART W. MAHER and JOE P. WALTERS



NASHVILLE, TENNESSEE

1960

STATE OF TENNESSEE

BUFORD ELLINGTON, Governor

DEPARTMENT OF CONSERVATION AND COMMERCE

J. BRENTS McBRIDE, Commissioner

DIVISION OF GEOLOGY

W. D. HARDEMAN, State Geologist

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PREFACE AND ACKNOWLEDGEMENTS

This report on Tennessee's marble industry is one of a series of studies by the Division of Geology designed to acquaint the general reader with the State's mineral resources. The marble industry is one of the oldest continuing operations in Tennessee and is a significant contributor to its mineral economy.

Portions of this study were submitted by Walters as a thesis for the Master of Science degree to the Department of Geology and Geography, University of Tennessee. This thesis was done under the supervision of Prof. H. C. Amick. The present report was prepared under the supervision of W. D. Hardeman, State Geologist.

Representatives of the marble industry supplied much of the information given herein, discussed the report with the writers, and assisted in many ways.

Especial thanks are due Robert J. Floyd, of the Tennessee Division of Geology, for editorial criticism.

THE MARBLE INDUSTRY OF TENNESSEE

By

Stuart W. Maher[1] and Joe P. Walters[2]

HISTORY OF DEVELOPMENT

The Holston marble of East Tennessee has been utilized since the Eighteenth Century, although the industry must be dated from 1838. Prior to the latter date it was used for tombstones in Knoxville (for example, to mark the tomb of Gov. Blount, died 1800). In 1838, largely owing to the interest of Gerard Troost, Tennessee's first State Geologist, the Rogersville Marble Company was formed. This company was headed by Orville Rice and S. D. Mitchell. Gordon (1924, p. 16) states that the quarry was " . . . about seven miles north of Rogersville." This is probably the quarry indicated on the Burem quadrangle (180-NW) just northeast of Tennessee Highway 70 about 0.5 mile south of bench mark F 55. Stone from this quarry was used by Rice to furnish the interior of a tavern, known as Marble Hall (Pressmens Home quadrangle, 171-NE), on a stage road (now U. S. Highway 11 - W). Perhaps the best known stone from the quarry is the two blocks quarried in 1848 for use in the Washington Monument. These blocks were shipped by boat down the Holston and Tennessee Rivers to Chattanooga and transported by rail to Washington (Gordon, p. 16).

Safford (1869, p. 508) reports: "These blocks attracted the attention of the Building Committee of the National Capitol, who, although they had numerous specimens from all parts of the Union before them, decided in favor of the East Tennessee marble." As a result a quarry was opened under Federal contract by Hugh Sissons and William Dougherty of Philadelphia, Pennsylvania. This quarry, termed the "Old Dougherty" or "National" quarry, began operating about 1851 and is on the west end of Potato Hill, just south of relocated U. S. Highway 11-W near Galbraith Springs, on an arm of Cherokee Reservoir (Russellville quadrangle, 171-SW). About half the ornamental marble used in the National Capitol came from this quarry. It was shipped by river to Chattanooga and thence by rail. Gordon (p. 17) says the quarrying was all by hand, no derricks

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were used, and horses or mules moved the massive blocks. This quarry operated until 1891, although it was idle during the War Between the States.

The third of the quarries near Rogersville was the "Cave" or "Hasson's" quarry, located about 4.5 miles northeast of the Dougherty, which was opened by John Hasson in 1857. Hasson used the first derricks and channeling machines in Tennessee. His quarry supplied marble for the city hall in Baltimore. Other well-known quarries in this area were the Stamps Star quarry (1874-1892), the H. B. Stamps (ca. 1887-1920), and the Evans. Altogether about 20 quarries were developed in the Hawkins County area. The first mills were small steam mills erected in Rogersville, which operated only a short time (Gordon, p. 18), and the Stamps Mill, near Galbraith Springs, which was built in 1900 and was closed in 1912.

The marbles from this district were all dark red to pink, mottled varieties suitable chiefly for interior finishes and for use in marble-topped furniture. A decline in demand for such stone resulted in no production after 1912.

Although the Hawkins County industry was destined to close, it demonstrated the potential of Tennessee marble deposits and created a demand for such stone. This led to the establishment of the present industry in the Knoxville area, which is closer to markets, transportation, and labor.

The industry in the Knoxville area dates from 1852 when James Sloan opened a quarry " . . . about two miles north of Knoxville, near the . . . Southern Railroad" (Gordon, p. 19). This appears to be the quarry indicated by the symbol just north of Caswell Park on the Knoxville quadrangle (147-NW). Safford (p. 237) states that this quarry produced the marble used in the Capitol in Nashville and some used in the Ohio Capitol building. This quarry, like those in Hawkins County, produced a variegated dark-red stone, and was idled when the vogue changed.

However, a demand for the lighter gray and pink tints of marble had been created. Consequently, John Williams opened a quarry, containing such stone, shortly after Sloan's quarry was developed. This quarry, the Williams or McMullen quarry, is no longer operating and appears to be represented on the Knoxville quadrangle (147-NW) by depression contours on Marble Hill just east of the Knoxville waterworks. Stone from this quarry was used in the Memphis Customhouse.

In 1872 the U. S. Government decided to build the Knoxville Customhouse and Post Office (now referred to as "the old Post Office") of local marble. "A quarry was opened near the forks of the river, a small mill erected, and here all the marble used in the building was quarried and sawed" (Gordon, p. 19). This quarry was subsequently purchased by G. W. Ross and William Patrick, who founded the Knoxville Marble Company. Gordon (p. 19) says that the quarry operated for 12 or 15 years. Its location is indicated on the 1953 Knoxville quadrangle, and it is now The Appalachian Marble Company's quarry. Killebrew and Safford (1874, p. 254-255) state that the operation employed 30 men, who used steam derricks and 80 steam-powered saw blades. They also report the stone to have been sawed "within ten feet" of flat boats and thus conveyed to the railroad in Knoxville. Patrick, a native of St. Louis, introduced the marble there as well as in the Northeast. Killebrew reports the stone sold in St. Louis for $3 to $6 a cubic foot for mantles, moldings, etc. This quarry also supplied ". . . about one hundred car loads for the New York State Capitol at Albany" (Gordon, p. 19-20).

Other pioneer marble producers were J. J. Craig and Company (1878), Knoxville Marble Company (1881), Republic Marble Company (1886), and Evans Marble Company (1886; dissolved in 1917). For information on other early producers the reader is referred to Gordon (p. 19-22).

Various short-lived efforts have been made to develop marble operations in Middle Tennessee. Notable among these are quarries mentioned by Safford (1869, p. 506-507) in Henry County, Franklin County, and White County. From his account, these quarries supplied tombstones and materials for local buildings.

A quarry for dimension marble was opened in Lincoln County in Gin Hollow about 1886 (Min. Res. of U. S., 1886, p. 543). This quarry is not mentioned again until 1916, and then it appears in the 1917, 1918, 1927, and 1928 volumes of the Mineral Resources series. Apparently these ventures were all unsuccessful. The quarry is shown on the Flintville quadrangle (80-SW).

The World War I period was a difficult time for the industry. Some companies closed and others were merged, so that some quarries were abandoned. Gordon, writing in 1923, lists 11 active companies which were operating 26 quarries.

Another difficult time came with the severe economic depression of 1929 and ensuing years; Government projects involving large public buildings materially aided the industry at this time. However, the net effect was to reduce the number of companies and quarries, so that at present 7 companies are actively engaged in the marble trade. Of these, 5 operate quarries and mills, 1 is entirely a milling operation, and 1 is a quarrying concern only. Details concerning these operations are presented in the following section.

PRESENT INDUSTRY

The marble industry in 1959 consisted of 7 companies which operate 14 quarries centered around Knoxville. These companies and their quarries are briefly described and located as follows:[1]

APPALACHIAN MARBLE COMPANY, KNOXVILLE:

Present owner: Mr. Thomas J. Deane, Jr. Founded in 1910.

Operates two quarries and a mill. A third quarry is operated as a lime source under a lease to an independent company.

Bluegrass quarry: Knox County; 138-SE, 538,100N., 2,575,000E.

Asbury quarry: Knox County; 147-NE, 578,000N., 2,637,500E.

CANDORO MARBLE COMPANY, KNOXVILLE:

Established in 1914 by J. J. Craig, F. C. Anderson, W. J. Donaldson, and A. S. Rogers.

Operates a mill in Knoxville processing most of the J. J. Craig Marble Company's quarry production and substantial amounts of imported rough marble.

ENDSLEY MARBLE COMPANY, FRIENDSVILLE:

Organized in 1949 by Leonard Endsley.

Operates the Endsley quarry and mill near Friendsville, Blount County.

Endsley quarry: Blount County; 138-SW, 500,400N., 2,555,000E.

GRAY KNOX MARBLE COMPANY, KNOXVILLE:

Founded in 1917 by J. B. Jones, Sr. Now managed by G. R. Shoffner and J. B. Jones, Jr.

Operates a mill in Knoxville on the site of the old Empire Marble Company (this mill was built 1875). This company operates 1 quarry in Knox County, 2 in Blount County, and owns 1 idle quarry in Knox County.

Gray Knox quarry: Knox County; 147-NE, 578,400N., 2,641,000E.

Brown quarry: Blount County; 138-SE, 507,100N., 2,559,400E.

French Pink quarry: Blount County; 138-SE, 514,200N., 2,566,400E.

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[1] Locations given for quarries are made by reference to the 7½-minute topographic quadrangle series of the U. S. Geological Survey and the Tennessee Valley Authority, and to the Tennessee 10,000-foot grid. The first number is the quadrangle number; for example, 138-SE. The numbers following refer to the location in the 10,000-foot Tennessee coordinate system; for example, 538,100N., 2,575,000E. Grid reference coordinates are shown along margins of quadrangles.

IMPERIAL BLACK MARBLE COMPANY, KNOXVILLE:

Established in 1944 by J. B. Jones, Sr.

Now owned by J. B. Jones, Jr.

This company operates the quarry located near Thorn Hill, Grainger County, but does no milling. This is the only marble produced from rocks other than the Holston formation in Tennessee.

Imperial Black quarry: Grainger County; 162-SW, 731,600N., 2,753,400E.

JOHN J. CRAIG MARBLE COMPANY, KNOXVILLE:

Founded in 1878 by J. J. Craig.

Primarily a quarrying company, using Candoro Marble Company's mill. Now operating 4 quarries, all in Blount County. The company also leases the Andres quarry (idle in 1959), and operates a gang saw mill and terrazzo mill in Blount County.

Marmor quarry: Blount County; 138-SE, 509,200N., 2,561,200E.

Lee quarry: Blount County; 138-SE, 504,100N., 2,557,000E.

Hamil quarry: Blount County; 139-NW, 496,000N., 2,550,000E.

Crisp quarry: Blount County; 139-NW, 489,500N., 2,544,500E.

TENNESSEE MARBLE COMPANY (DIVISION OF GEORGIA MARBLE COMPANY), KNOXVILLE:

Organized 1934, as successors to the Gray-Eagle Company, and later affiliated with Georgia Marble Company. The company operates a mill in Knoxville and 3 quarries, 1 each in Knox, Union, and Blount Counties.

Luttrell quarry: Union County; 155-NW, 670,500N., 2,665,500E.

Eagle quarry: Knox County; 147-NE, 579,200N., 2,644,700E.

Blount quarry: Blount County; 139-NW, 492,800N., 2,547,300E.

PRODUCTION

TENNESSEE

Much of the production from early quarries is unrecorded. In 1882 the U. S. Geological Survey began to publish annual data in a series known as the Mineral Resources of the United States. In 1924 this publication was taken over by the U. S. Bureau of Mines and continues to the present as the Minerals Yearbooks. However, the first recorded data for Tennessee is the 1880 census report which shows $173,600 worth of marble sold. The Mineral Resources first reports Tennessee production in 1886 and lists 269,486 cubic feet of marble valued at $404,229. The 1889 volume notes that 22 quarries in Knox, Loudon, and Hawkins Counties produced $419,467 worth of marble. In 1913 the value exceeded $1 million for the first time.

The record is summarized below:[1]

Year(s)	*Cubic feet*	*Value*
[2]1880	No data	$ 173,600
1881	do.	No data
1882	do.	Do.
1883	do.	Do.
1884	do.	Do.
1885	do.	Do.
1886	269,486	404,229
1887	No data	520,000
1888	do.	225,000
1889	do.	419,467
1900-1910	[3] 6,772,100	[3] 6,042,631
1911-1920	5,472,320	10,372,318
1921-1930	13,818,200	32,467,136
[4] 1931-1940	3,203,160	13,731,268
1941-1950	2,293,370	16,094,490
1950-1957	3,172,512	24,110,125
	35,003,148	$104,386,664

[1] U. S. Bureau of Mines data. Includes foreign marble processed and sold by Tennessee producers.
[2] U. S. Bureau of Census data.
[3] Estimated.
[4] No data for 1936.

UNITED STATES

States producing marble include Alabama, Colorado, Georgia, Maryland, Missouri, North Carolina, Tennessee, and Vermont. Tennessee, Georgia, and Vermont are the largest producers. Recent production and value statistics are as follows:[1]

State	1956	1957	1956	1957
	Production (cubic feet)		*Value (dollars)*	
Alabama	(2)	(2)	(2)	(2)
Colorado	1,902	7,851	11,312	28,762
Georgia	190,297	(2)	2,594,366	(2)
Maryland	(2)	(2)	(2)	(2)
Missouri	(2)	(2)	(2)	(2)
North Carolina	(2)	(2)	(2)	(2)
Tennessee	571,492	632,130	3,508,648	3,909,953
Vermont	(2)	(2)	(2)	(2)
Undistributed	476,121	1,182,732	5,983,671	10,133,642

[1] U. S. Bureau of Mines data.
[2] Data confidential; included in Undistributed.

LOCATION AND OCCURRENCE

Tennessee's commercial marbles are chiefly associated with the Holston formation of geologic maps and reports. (See pl. 1.) Exceptions are the Imperial Black deposit, and the Middle Tennessee deposits mentioned by Safford.

The Holston formation, or rocks lithologically identical to it, is well developed in the Great Valley of East Tennessee in a series of northeastward-trending belts that are generally several hundred feet wide and some tens of miles long. The principal areas of production are along Clinch Valley from Luttrell southwestward; from the junction of the Holston and French Broad Rivers at Knoxville southwestward into Loudon County; from Strawberry Plains southwestward through Knox and Blount Counties; and the long inactive belt in Hawkins County northwest of Rogersville. As previously noted, the presently active quarries are concentrated in the Knoxville area.

The Holston deposits are associated with limestones and limy shales of Middle Ordovician age (Chickamauga limestone and Ottosee shale of reports). The marbles occur as beds and lenses in the limestones, shales, and sandstones, most commonly in the lower and middle parts of the "Chickamauga" limestone. Except for the Imperial Black deposit, no economically important zones of marble are found north of Clinch Valley.

GEOLOGY

Tennessee's marble deposits comprise coarsely crystalline limestones and are essentially unmetamorphosed. This has led some to question the validity of calling the rocks marble—purists wish to restrict the term to metamorphosed carbonate-rich rocks. However, the term marble has long been applied by the industry and by field geologists to any crystalline carbonate rock which takes a high polish, is suitable for either ornamental or high-grade construction, and possesses a dense structure. The Tennessee marbles easily meet these requirements; indeed, they surpass certain metamorphic marbles in these respects. Furthermore, metamorphism acting upon carbonate rocks does not necessarily produce marbles. Consequently, the writer believes that usage and physical properties alike amply justify applying the term marble to Tennessee stone meeting the specifications cited.

The marbles are generally grayish-white to dark-red (cedar), coarsely crystalline rocks of nearly pure calcium carbonate. Fossils are common to abundant and are beautifully preserved. In deposits such as these, bedding is commonly obscure and the rocks are massive and uniform.

In other places, however, the stone is crossbedded, fossils are broken, and the rock is not so massive. Such deposits are forming today in shallow, warm seas which support large colonies of reef-building organisms. Deposits composed of fragments broken from the reefs by waves and currents form at the base of the reef mass. The reef itself may be buried by sudden inflows of mud so that the reef-building organisms die. Thus are formed both massive and fragmental bodies of marble "raw materials" overlain by shales or limy shales. Such an origin is thought to explain the Holston, for in the Ordovician period (some 400,000,000 years ago) East Tennessee lay beneath a warm shallow sea that supported abundant reef-building animals.

After burial and compaction, the reefs and lime sands were lithified and, with other rocks in the area, were folded, elevated, and locally faulted to produce the patterns seen today. In parts of the area erosion has removed the marble; in other places the deposits were exposed and made accessible. In some instances erosion has operated below land surface to form caves and sinkholes in the marble. Indeed, such features are forming now but generally very slowly.

QUARRYING OPERATIONS

Many factors must be considered in selecting a quarry site to produce dimension marble. Obviously, the site must lie within a belt of marble, but the occurrence of marble itself is not sufficient. The stone must be sound, not shattered and fractured nor extensively cut by mud seams or shale splits; the volume of sound stone must be sufficiently large to support production for a period of years. When these requirements are satisfied, color and demand for a given variety of texture must be considered. Other factors are the amount and character of overburden to be removed, angle of inclination (dip) of the marble beds, volume of water encountered in quarrying, transportation facilities to the mill, and relationships between land surface and the planned quarry face. Each quarry thus presents its individual problems, and no two are entirely alike.

If sufficiently sound stone is available, perhaps the most important of the other factors previously listed are the volume of stone which is uniform with respect to texture and color, the attitude (inclination) of the beds, and the amount of overburden. If the beds range greatly in appearance, large orders for a given variety cannot be filled. If the beds are tilted at high angles, the quarry must be either excessively deep or long and narrow. Depth and cost are directly related, owing to hoisting costs, hazards encountered by workmen at depth, and increased inflow of water. Long, narrow quarries require the removal of large volumes of overburden with consequent cost increases. If the beds are level or dip gently, the removal of large volumes requires extensive stripping of overburden. Thus, in all circumstances the depth and character of the overburden and the attitude and character of the beds are significant factors in planning the quarry. These factors are evaluated in most instances by surface examination and mapping followed by drilling closely spaced core holes.

After a desirable site is located and explored the overburden is removed. If soil, it is stripped by earth-moving equipment insofar as possible. In many places, however, the soil-rock interface is highly irregular and large machines cannot be used. In this event the soil is removed by hand from between pinnacles of rock. If the overburden consists of rock it must be carefully drilled, shot, and then removed. Care must be exercised not to damage the underlying marble.

Once the surface of rock is cleaned of overburden, drilling and channeling to free large blocks of marble begin. Most such drilling is done with a device known as a bar drill. This machine consists of a pneumatic drill mounted on a steel bar so that the drill can be moved horizontally. Adjustable legs permit elevating or lowering the drill in the vertical plane. With this machine a series of holes is drilled at intervals of about 2½ inches, so as to outline the block.

Formerly this delineation of the block was done chiefly with a channeling machine, a device which wears a continuous trench or channel in the stone. The pneumatic drill has largely replaced this device since World War II owing to the greater speed of the drill.

After the block is outlined by drill holes, the remaining narrow bands of stone between holes must be broken. This process is termed "wedging" or "broaching," depending on the method em-

ployed. Wedging involves the driving of tapered steel rods into the drill holes, between two flat wedges called feathers, until the block is split free. The rods are driven by hand, and great care is taken to distribute the stress uniformly so that the block breaks evenly. In broaching, the bands of stone between drill holes are cut by a vibrating steel blade attached to the pneumatic machine used in drilling. Broaching is employed to free the block along the side opposite the surface to be cut, but wedges are used for the other surfaces and along the base.

The block now freed from the quarry is ready to be hoisted and loaded for delivery to the mill. The block averages 7 feet in length, 4 feet in height, and 6 feet in width (168 cubic feet), and weighs approximately 33,600 pounds. To lift these blocks large derricks with fixed steel masts and rotating booms are used. The booms are generally 90 feet long and can support 30 to 50 tons. The derricks are powered by 440-volt, 50-horsepower electric motors (earlier derricks were steam-driven). The block is notched, grabhooks are made fast, and the block is lifted to the truck, railroad car, or to the stockpile.

The greater portion of the block marble reaches the mill by rail, although some is carried by trucks. In Blount County and in certain other areas not adjacent to rail lines the block is hauled to the track by truck. It is estimated that rail miles represent 60-70 percent and truck miles 30-40 percent of the total distance traveled from quarry to mill.

Operators report that losses in quarrying range from 50-80 percent. Much stone is lost to fissures, joints, and crevices which occur in the rock and cannot be avoided. Intercalated beds of poor quality present problems in some quarries and require selective quarrying, as do clay-filled solution openings.

FABRICATION

Sawing

The mill blocks as received from the quarry must be cut, polished, and if necessary shaped to the buyers' specifications. Generally, the block is first sawed into large slabs by a gang saw if it is to be used for dimension stone. In one instance preliminary trimming with a wire saw is done at the quarry.

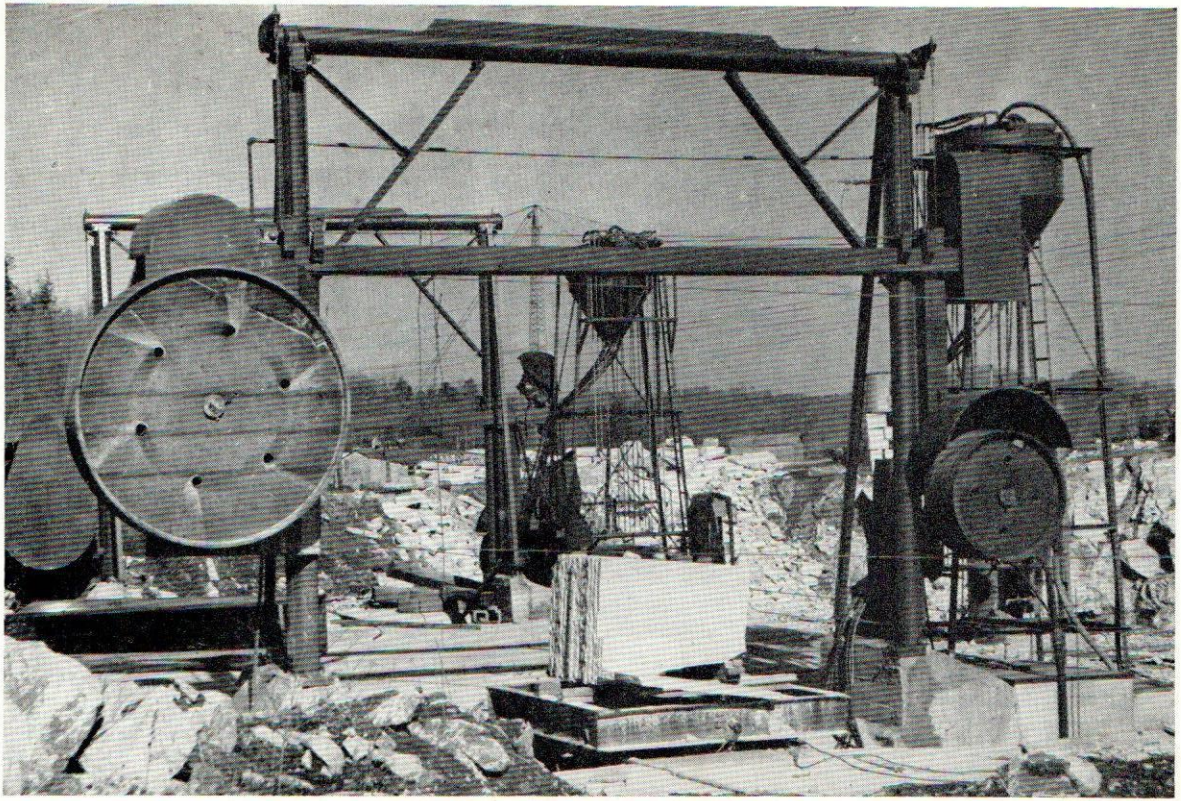

FIGURE 1. Wire saw used to cut split face marble. *(Photo courtesy Ty-Sa-Man Machine Co., Knoxville)*

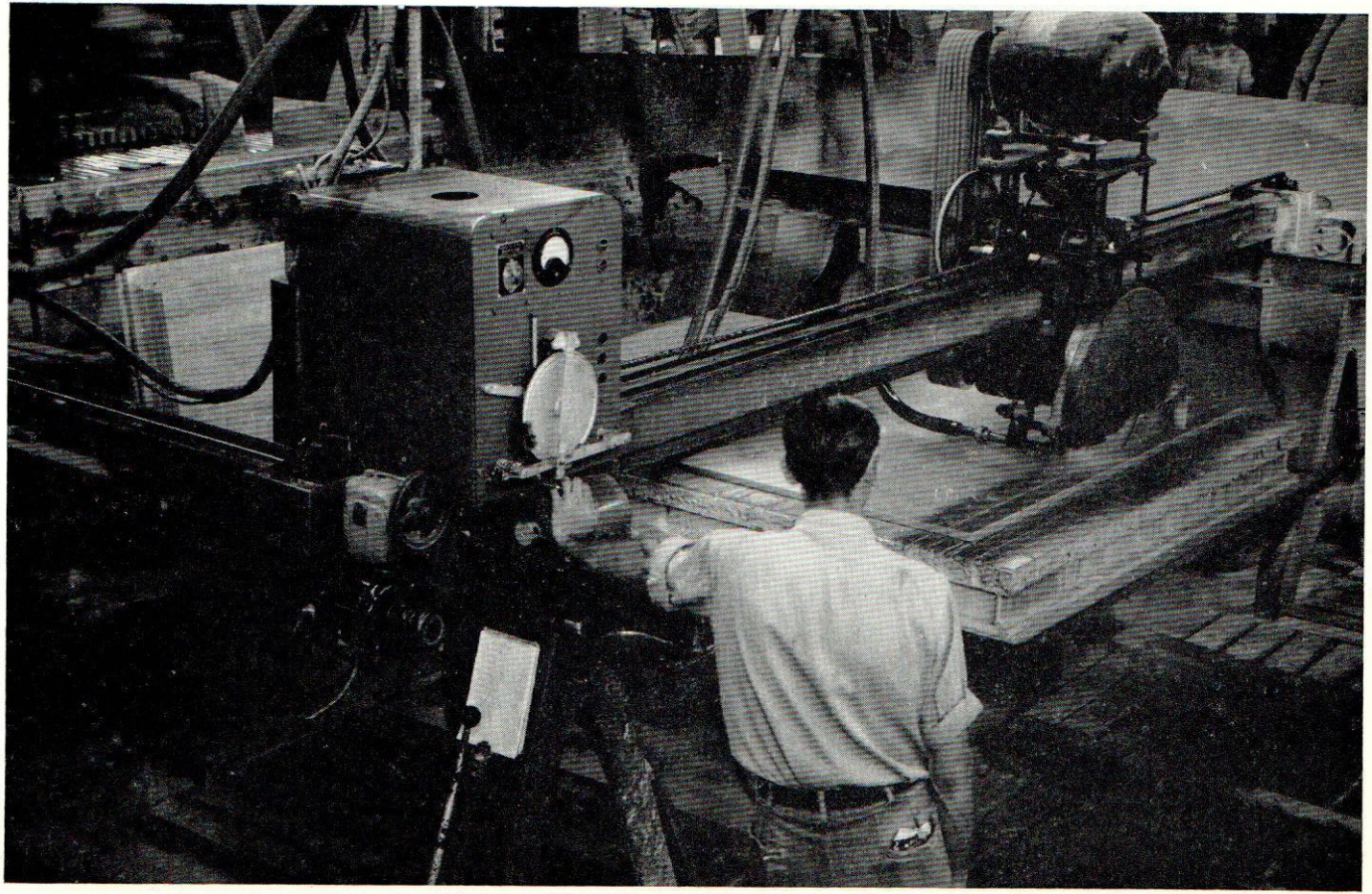

FIGURE 2. Coping saw for trimming marble. *(Photo courtesy Ty-Sa-Man Machine Co., Knoxville)*

The wire saw, as the name suggests, uses a circular loop of wire rope about one-fourth inch in diameter driven by a power wheel and guided by pulleys. The block is forced against the revolving wire, and a slurry of water and abrasive is fed into the channel cut by the wire. This device is used to remove irregular projections from the mill blocks or to trim off ends or sides to remove fractures. Two mills use wire saws to saw thin blocks destined to be used for split face stone (fig. 1).

Either after wire sawing or as received at the mill, blocks to be used for dimension stone are gang-sawed. The gang saw consists of a series of steel blades mounted parallel to each other in a forward-and-backward-moving frame. The blades are spaced to produce the desired thickness of marble. As with wire sawing, an abrasive slurry, usually sand, is used. The cutting rate is about 1 inch per hour.

The slabs from the gang saws are next sent to the coping saws, which are used to remove rough edges and to cut the slabs to the final size. A coping saw is comprised of a circular steel blade set with diamonds on the cutting edge; the blade is mounted in a frame that allows the saw to cut at any angle or in any direction (fig. 2).

POLISHING

The marble from the coping saw is now ready to be polished. The first step in this operation is performed by a rubbing machine. This device is a cast-iron circular turntable that rotates on a steel shaft. The surface of the table is supplied continuously with a slurry of uniform size pure sand, which smooths sawmarks and irregularities from the marble slab.

After this rough polishing, the slab, especially if it is for interior use, is further polished to a mirror-smooth surface. This treatment is accomplished by buffers covered with felt and a series of successively finer abrasives (fig. 3). The earlier abrasives are generally emery powder, the use of which the operators refer to as "gritting." The marble is now quite smooth, but the surface is dull. The final high sheen observed on interior stone is produced by further buffing with a dust composed of aluminum oxide and sulfur.

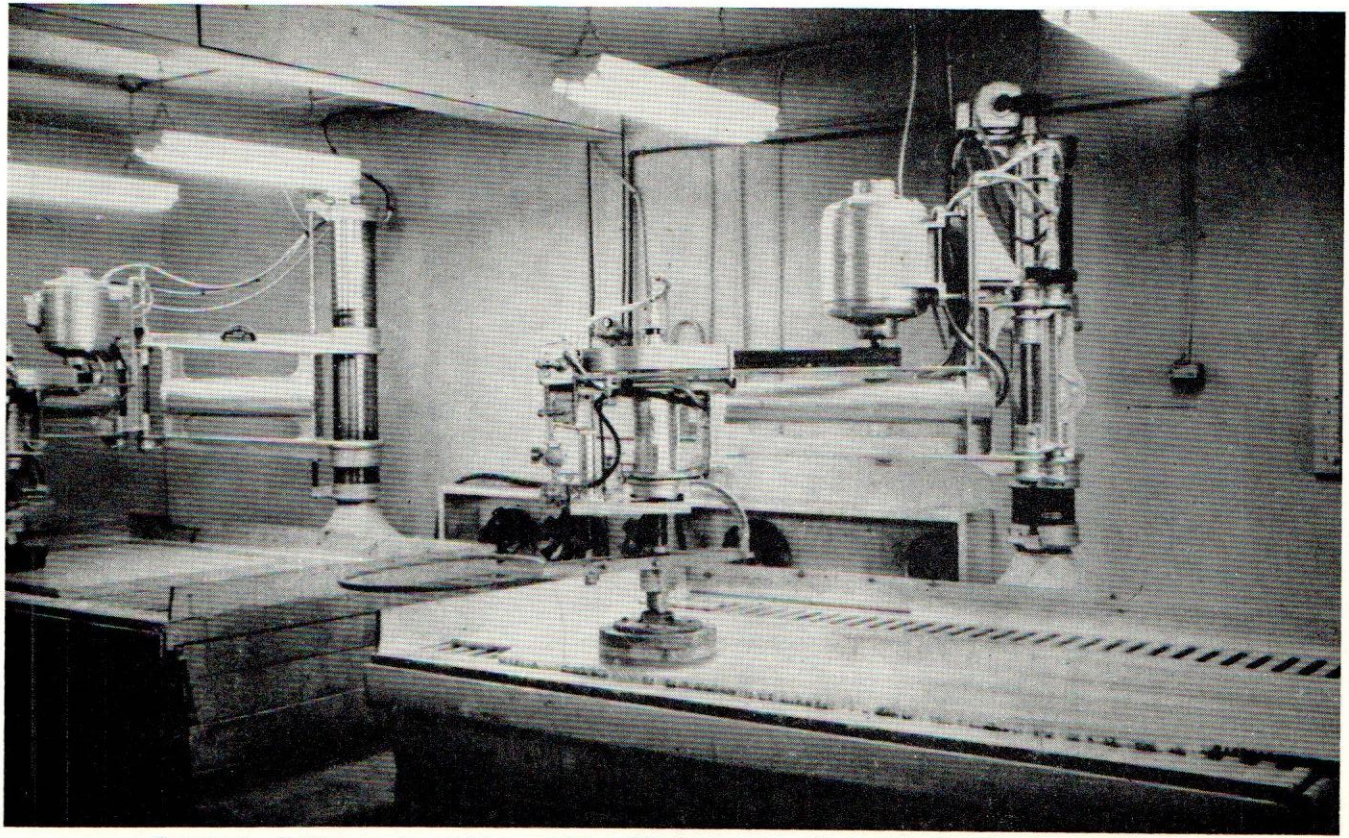

FIGURE 3. Gritting and polishing marble. *(Photo courtesy Ty-Sa-Man Machine Co., Knoxville)*

The procedures outlined above comprise the steps in producing dimension marble slabs for exterior and interior construction. If, however, the stone is to be used for mouldings, columns, or other purposes that require special shapes, it is sawed to the approximate size and then shaped on a machine that uses carborundum cutting and grinding tools (fig. 4).

Stone used for monumental purposes and art work is similarly sawed, and shaped insofar as possible by pneumatic tools. Usually, however, some hand tools are required for this delicate work.

MARKETING

Prices for dimension stone are relatively high because stone is comparatively difficult to work and requires a large amount of skilled labor. However, costs have risen proportionately little in recent years despite increased production charges. This reflects improved manufacturing methods, mechanization, the development of by-product materials, and intense competition from foreign marble producers with a low-paid labor force.

The price history for dimension marble sold in the United States is summarized below:[1]

Year	*Value (per cubic foot)*
1930	$3.67
1935	4.63
1940	4.25
1945	5.93
1950	8.65
1955	9.02
1956	6.14
1957	6.17

This table represents all marble sold for dimension uses by U. S. producers, including interior, exterior, and monumental stone; and imported marble processed by U. S. fabricators.

Owing to variation in grade, color, degree of finish, and type of finished product sold, it is not feasible to fix unit prices for Tennessee marble as sold. Shaped and interior stone are obviously more

[1] U. S. Bureau of Mines data.

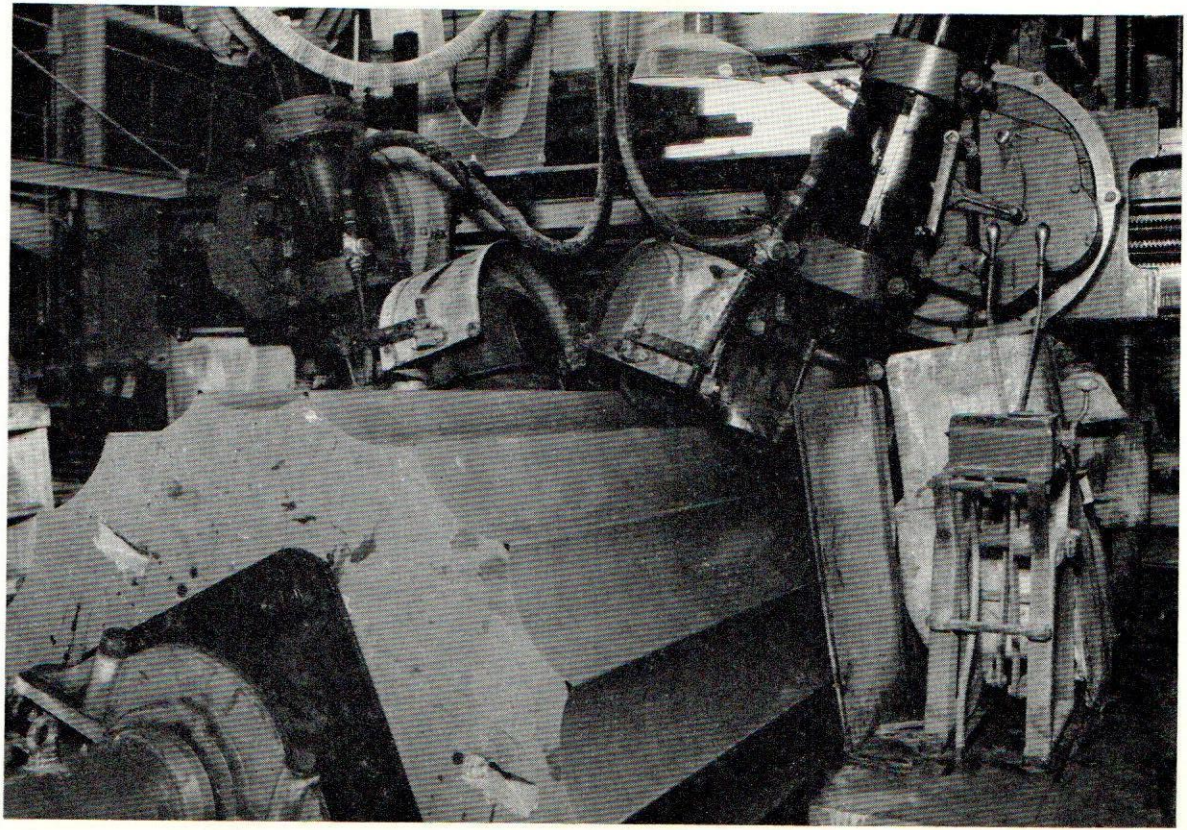

FIGURE 4. Machine used to form special shapes of marble. *(Photo courtesy Ty-Sa-Man Machine Co., Knoxville)*

expensive than exterior rough finished block; by-product stone sold as terrazzo or split face marble is even cheaper. Prices for dimension stone are generally quoted on a square-foot basis, whereas terrazzo and split face are quoted by the ton. In 1958 seven-eighths inch interior dimension slabs sold for about $1.80 per square foot (depending on grade and color); split face slabs of various sizes and quality ranged from $27.50 to $40.00 per ton; irregular-shaped flagstone, averaging 15 inches by 21 inches, sold for $0.35 per stone, or $15.00 per ton for random sizes, f. o. b. plant.

The major use of dimension stone from Tennessee in recent years has been for interior furnishings. The cost of a marble interior is generally about 2 to 4 percent of the total cost of a building (J. B. Jones, Jr., personal communication). Shipments for large public building exteriors are also made, and the use of split face stone is increasing. Three companies currently produce split face stone from material unsuited to dimension use and formerly wasted.

Most companies maintain sales offices both locally and in metropolitan centers or act through inter-industry sales organizations with national representation. To a considerable degree the companies must depend upon the architect and designer who sets the specifications for the materials used in large public buildings or homes. Inasmuch as transportation costs are a significant portion of the delivered price for a bulk material, Tennessee's marble must be demonstrably superior to local stone to attract users at points some distance away from the producing area. In this connection it is interesting to note that the companies report a large volume of orders originate in New York, Ohio, Pennsylvania, Illinois, Indiana, and Michigan. A number of large buildings in Washington, D. C., contain significant amounts of Tennessee marble. A small portion, probably less than 1 percent, of Tennessee's production is sold in foreign countries.

The table below lists representative buildings that contain appreciable amounts of Tennessee marble:

Florida

Terminal Station, Jacksonville
Duval County Courthouse, Jacksonville

Georgia

Fulton National Bank, Atlanta

Iowa

Hubbell Building, Des Moines

Massachusetts

Metacomet National Bank, Fall River

Michigan

Durant Hotel, Flint
General Motors Building, Detroit

New York

Albany County Courthouse, Albany
Buffalo City Hospital, Buffalo
Grand Central Station (interior), New York City
J. P. Morgan Library, New York City
Maine Monument, Central Park, New York City

Ohio

Huntington National Bank, Columbus

Pennsylvania

Union Arcade Building, Fittsburgh

Tennessee

State Capitol (interior), Nashville
Volunteer State Life Building, Chattanooga
East Tennessee Baptist Hospital, Knoxville
Main Post Office, Knoxville
Cordell Hull Building, Nashville
State Office Building, Nashville
Ft. Sanders Presbyterian Hospital (interior), Knoxville

Texas

Federal Reserve Bank, Houston
Sam Rayburn Library, Bonham

Washington, D. C.

National Art Gallery
Taft Memorial
Capitol Building
Lincoln Memorial (in part)

ECONOMIC SIGNIFICANCE

Uses of Marble

Marble has been used since ancient times by man for those buildings and works of art deemed most important. Thus, the Greeks and Romans built their temples, theaters, and many of their monuments of marble. Such uses continue today because no other material is as well suited to lend dignity and beauty to large buildings, is as durable, or is as low in maintenance costs combined with beauty.

These uses, exteriors and interiors of buildings, and monumental works, long were the only uses for marble except for table tops, lamps, etc. However, some material formerly discarded is now utilized for split face, terrazzo, grit for fowls, crushed stone, and lime. One company is packaging marble tiles and fireplace-trim sets for "do it yourself" installations.

Dimension Stone

The term dimension stone applies to marble used for exterior blocks and also to sheets used for interior wainscoating, paneling, window sills, floors, base boards, bathroom partitions, molding, etc. Such interior uses consume most Tennessee marble, and such materials bring the highest prices but require the most fabrication.

Split Face Marble

This term is applied to rectangular slabs laid up in walls with the broken edge facing the observer. The material is made from blocks sawed and found unsuited for dimension stone. The stone is prepared on wire saws or gang saws and cut into lengths on a guillotine.

Monumental Stone

This term is applied to marble used for monuments, statues, art works, and grave markers. The mills in Tennessee employ artisans who fabricate such pieces to order (fig. 5). The companies also sell sawed blocks to monument companies.

By-products

Crushed chips of waste marble are sold for terrazzo floors. Marble chips and other colored stone materials are placed in freshly poured cement. After the cement hardens, the floor is ground smooth and polished. Such floors are extensively used where dampness and insects would destroy wood rapidly.

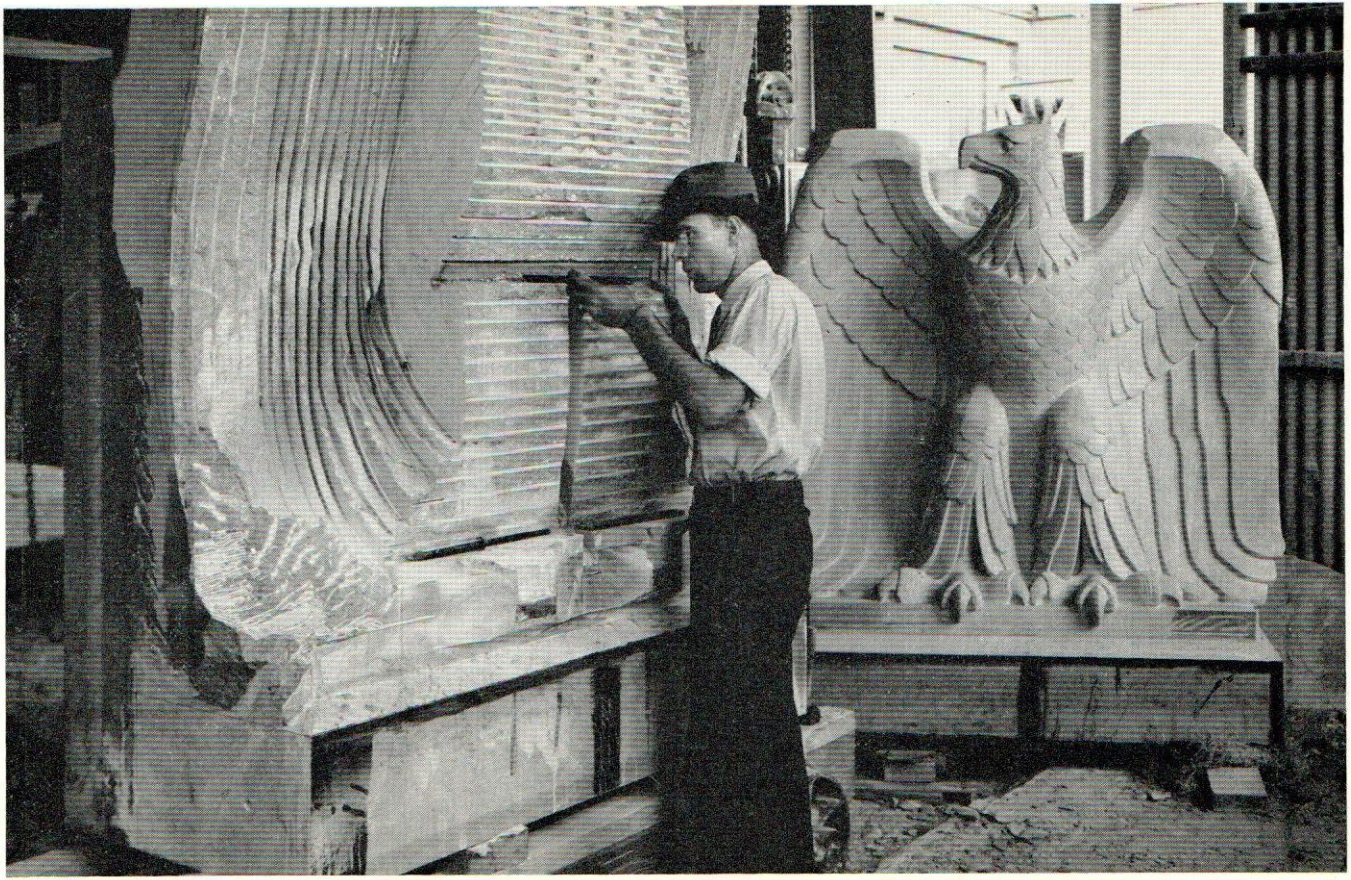

FIGURE 5. Craftsman producing eagle figure from marble. *(Photo courtesy Ty-Sa-Man Machine Co., Knoxville)*

Fowl grit is an important use for fine-sized marble waste, owing to its high chemical purity.

In 1957 producers sold 17,905 tons of crushed or broken marble. Some scrap marble is sold for agricultural lime, crushed stone uses, and other construction purposes. One quicklime company operates on waste purchased from a marble mill, supplemented by marble quarried by the lime company itself.

High Quality of Tennessee Marble

Significant properties of dimension stone can be considered under two broad categories: appearance and physicochemical strength. The appearance of Tennessee stone has been described previously, so this section will deal with the latter properties.

The physical properties of marbles result chiefly from mineral constituents and arrangement of the component grains as well as molecular structure. Impure stone does not wear or weather uniformly, tends to stain as unstable minerals break down, and loses cohesive strength owing to uneven thermal expansion of differing mineral grains. Loosely aggregated, porous stone absorbs dirt, weathers rapidly, and is not inherently strong.

Properties usually studied are crushing strength, absorption, and durability. Specifications for some of these properties are established by the American Society of Testing Materials, and studies have been made by the U. S. Bureau of Standards (Kessler, 1919, 1927, 1931); however, general specifications are not available, and the designer sets his own. In many instances very exacting requirements are established.

Tennessee marbles possess high crushing strengths. Tests by the U. S. Bureau of Standards are presented by T. N. Dale (1924, p. 131-133), who notes that the range is 14,908 pounds per square inch to 18,274 pounds per square inch. This is higher than most saccharoidal calcite marbles. Similar tests for tensile strengths gave values which averaged 1,334 pounds per square inch for Holston marble and 911 pounds per square inch for a saccharoidal Alaskan marble.

Perhaps of greater significance today, owing to extensive interior use, are the results of absorption tests. These tests measure resistance to staining or penetration by liquids and therefore are indicators of ease of maintenance, sanitary properties, and possible rate of weathering. These tests, summarized from Dale (1924, p.

136) showed absorption by Tennessee marbles ranges from .035 to .091 percent and averages .06 percent, whereas tests on Italian stone gave 0.47 percent, and saccharoidal Alaskan marbles averaged 50 percent greater absorption than the Holston.

Dale, in commenting on these properties and on the susceptibility to high polish, resonance, and uniform resistance to abrasion shown by the Holston, believes its desirable character reflects its manner of formation. In the section on geology, the crystalline and fossiliferous nature of the stone was indicated. Dale (1924, p. 139) concludes that the fossils, randomly oriented, plus variation in crystal sizes make for great strength and density.

Chemically, the Holston is a very pure limestone, or high-calcium limestone. It consistently averages 97.5 percent or more $CaCO_3$, less than 0.2 percent $MgCO_3$, and less than 0.2 percent SiO_2. The iron content, which produces the red color of some of the marbles, is surprisingly low, ranging from 0.17 percent in light-gray stone to 0.4 percent in dark stone. The uniformity of composition and high calcium carbonate content make the Holston useful for lime, grit, and cement rock.

Expenditures by the Industry

The capital investment made in Tennessee by the marble industry is very substantial. It is virtually impossible to arrive at an exact figure, owing to the imponderables of the value of a given quarry, fluctuations in the value of a given type of stone, and depreciation of mill equipment. To construct a large modern mill costs in excess of $1,200,000 and to open a new quarry costs not less than $50,000.

The industry in 1958 employed 337 quarry workers and 619 people over all. The combined payrolls in that year were $2,300,000 (data from companies).

In 1954 the U. S. Bureau of the Census questioned mining and quarrying companies concerning their operating expenses. Tennessee marble producers reported the following:

Value of shipments	$3,078,000
Value added in processing	$2,238,000
Number of employees	547
Man-hours worked	1,269,000

Total expenses	$2,225,000
Hourly wages	$1,170,000
Other wages	$ 124,000
Imported stone and supplies	$ 723,000
Fuel	$ 17,000
Electricity	$ 87,000
Machinery	$ 44,000
Capital expenditures	
Construction	$ 4,000
Machinery	$ 12,000
Used equipment	$ 15,000
Energy used (kwh equivalents)	9,000,000

Expenses in 1958, based on data supplied by the companies, are shown in the following table. These figures represent district averages that vary from quarry to quarry and mill to mill; they are also subject to change. This table does not reflect losses in quarrying and milling.

To quarry stone	$ 3-5 per cubic foot
Gang sawing	$0.09 per square foot
Coping	$0.24 per square foot
Rubbing	$0.20 per square foot
Gritting and polishing	$0.26 per square foot
Crating and loading	$0.26 per square foot

Additional costs arise in transporting the stone from the quarry to the mill. In most instances both truck and rail hauls are involved. Truck operating expenses are of the order of $0.50 per load mile; rail costs are reported to be about $28.00 per 50-ton car from the Forks of the River district east of Knoxville, and about $57.00 per car from Blount County quarries to Knoxville.

Other unevaluated expenditures are made for goods and services. Most of this is income to area merchants and manufacturers. Further, tax payments are not shown.

POTENTIAL AND OUTLOOK

Tennessee's future as a major marble producer is dependent upon economic and style factors. A strong industry with a large installed milling capacity is in being. Reserves of marble are very large, although supplies of a quite special type may not be abundant. To a degree demand must be created by architects and designers and by the consuming public. Obviously, the factor of cost enters such considerations and, except for public buildings, generally prohibits the use of marble for supporting members in construction. Thus, most marble in use today is for interiors, although the use of ashlar and split face for exterior work is increasing in proximity to mills. Transportation costs limit the distance to which bulk materials such as split face can be feasibly shipped.

Foreign competition is a major problem for domestic companies. Water transportation to seaboard metropolitan consumers and low labor costs price foreign stone much below delivered prices for U. S. producers. The Tariff Act of 1930 established a tariff of $0.65 per cubic foot on rough block marble and $1.00 per cubic foot on sawed or dressed stone. Manufactured marble goods were dutiable at 50 percent ad valorem. These provisions have been considerably modified by trade agreements and the General Agreement on Tariffs and Trade (1951). As a result rough blocks are dutiable at $0.355 per cubic foot and sawed or dressed stone at $0.50 per cubic foot (Bowles, 1956).

Any large increase in production and profits by the marble industry depends upon lowering costs to meet foreign competition and reducing losses from waste. The industry is meeting these requirements by modernization, especially of mills, and by the development of by-products from scrap.

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