BRAINERD MILL

ARCHAEOLOGICAL INVESTIGATIONS AT THE
BRAINERD MISSION MILL AND BIRD'S MILL

BY

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AND
JEFFREY L. BROWN

A REPORT SUBMITTED TO THE TENNESSEE VALLEY AUTHORITY
IN ACCORDANCE WITH CONTRACT TV52669A BETWEEN TVA
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THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA

1983
ACKNOWLEDGEMENTS

The research at the Brainerd Mill was the result of many people working together to keep the project going. I want to thank all those people who helped to make this project possible. Although the site had not been recorded prior to the start of the Brainerd Levee, TVA was quick to act when the mill remains were noted. J. Bennett Graham of TVA saw the value of the site and contacted Dr. Jeff Brown of UTC who undertook the excavation.

The conditions at the site were certainly less than ideal! To the crew who worked uncomplainingly in mud and water up to their knees, and even waists, a heartfelt thank you. These stalwart souls were Tim Andreae, Charles Berry, Thomas Hand, Robert Pate, Joe Smith, Carla Yount, and Charmaine Yount.

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Jeff was very excited about the Brainerd Site and was working on the research when he died. He had many ideas and plans for this project, and I know that I have not done it justice. I only hope that some of what Jeff wanted to say came through.
To the memory of Jeffrey Lawrence Brown, my teacher and dear friend, this report is dedicated.
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1- INTRODUCTION

The Brainerd Mill Site is in Hamilton County, Tennessee, on the west bank of South Chickamauga Creek. The site lies approximately 800 feet south of Lee Highway (U.S. 11) and 2100 feet north of Interstate 75. Brainerd Village Shopping Center lies directly to the west of the site (Figure 1).

The mill site was a portion of the Mission to the Cherokees established by the American Board of Commissioners for Foreign Missions in 1817. Construction of Brainerd Village and the adjacent Eastgate Mall destroyed most remnants of the Brainerd Mission except for the Cemetery and the mill site. At the time of investigations at the mill in 1979, the lower portions of a log crib dam, the mill foundation and a possible canal were visible.

The construction of a flood relief program for the South Chickamauga Creek watershed was proposed in the late 1960s by TVA. The project consisted of a levee, generally of earth fill, about 3.9 miles long. Levees on low-lying land were to be about 30 feet high, with an average of about 23 feet in height. The levee was designed with a top width of 14 feet and side slopes of 2.5:1.0. The channel
Figure 1: Site Location
of South Chickamauga Creek would be widened and relocated to restore flood capacity lost by leveeing the west flood plain, and old channels would be refilled. The proposed realignment of the sharp turn in the creek at the site of the mill would directly impact the archaeological remains (TVA 1967).

In 1973, a surface survey, performed by TVA, failed to locate any prehistoric sites along the affected waterway. Remains of the mill were not noted at that time.

In February of 1979, the existence of the site was called to the attention of TVA by Mr. Thomas Williams, a local historian. At that time construction on the flood relief plan was well underway. The Institute of Archaeology at UTC was contacted to perform salvage data recording at the site.
Excavation and salvage recording of the site was undertaken from July 18 to August 17, 1979, under the supervision of Dr. Jeffrey L. Brown, Director of the Institute of Archaeology.

Preliminary processing of artifacts was undertaken in the Fall of 1979, under the direction of Kenneth Wild, laboratory assistant. Archival research was conducted under the direction of Dr. Brown.

In the Spring of 1980, a preliminary report was submitted to TVA by Dr. Brown. Work was progressing on the final report when Dr. Brown became ill. Dr. Brown's field notes and initial work on the final report were unfortunately lost in the closing of his estate.

Work was resumed on the report in the summer of 1981 by the author. Conservation of some metal and wood artifacts was performed by Ms. Diana Werner, Laboratory Supervisor for the Jeffrey L. Brown Institute of Archaeology at UTC. The larger metal gears and turbine parts were processed by Mr. Robert Johnson of Whistles-in-the-Woods, Rossville, Georgia.

The section of this report on excavation and procedures, excepting the discussion of the missionary dam, was written by Dr. Brown. This section is basically as he wrote it in his preliminary report to TVA.
Theoretical Orientation

The wealth of archaeological data from Bird's Mill and the lack of data from the Mission period can serve as a guide for archaeologists and preservationist looking at water mills in the area. While a glance at documentary evidence may indicate that a license to build a mill at the site was obtained at a given date, this does not mean that the present structure or ruin dates from that period.

The documentary data from the Mission period is very extensive and for the later periods of Bird's and Plemon's occupancy is very sparse. The archaeological data is in inverse ratio to the documentary data, exhibiting a need for attention to both sources to document the history of the site.

Rapid advances in water-power technology in the last half of the nineteenth century should be taken into account when documenting the presence of a mill. As new technology became available, the structures were modified or rebuilt to house the updated machinery.

Undoubtedly the Mission Mill with its wooden gearing and probable exterior wheel, bore little resemblance to the mill later built by Bird. The introduction of low head turbines made many of the marginal mill seats more feasible as continuing mill locations. The fact that a license had been granted for the location, and the questions of riparian rights already determined, were other factors in keeping mills at the same locations, as was the presence
of roads or other routes to the mill and the knowledge
by customers of the mill's location.

The investigations at the Brainerd Mill were
undertaken using the technique of indirect methods (Brown
1978).

Brown, in his application of "indirect methods" to
industrial archaeology, states that the documentary
record is generally incomplete and contradictory, and
may, as well, be inconsistent with the archaeological
records. The anthropologically trained archaeologist will
be aware of the contradictions and inconsistencies in the
data and realize that contradictions and inconsistencies
are basic attributes of human thought and behavior.
"Differences between real events and ideal standards provide
opportunities to explain complex levels of human behavior..."
(Brown 1978:13).

Indirect methods focus on the discovery and explan-
ation of inconsistencies among archaeological and document-
ary data and seek to understand past behavior indirectly
through comparisons of these data. This method assumes
that historical documents often reflect ideal behavior
or standards rather than real events (Brown 1978).

While frequently the mechanics of an industry are
well documented, the actual work patterns and impact of
the working place on the people is not documented. Indus-
trial sites can provide information about the physical
organization of a workplace, which can then be used to determine something about the hierarchical structure of work, the actual tasks performed, and perhaps even about the social values involved in the visible work processes (Newell 1978).

The examination of industrial sites can offer "insights into the levels of technological sophistication and, hence, the process of diffusion of technological innovation" (Newell 1976). Patterns of technological change can lead to analysis of the impact of change on the work place, the community and the society at large (Newell 1978).

Investigations of industrial sites can tell us something of the resource base when the site was developed (Newell 1978), and perhaps the impact of the exploitation of that resource base.

Newell (1978) has pointed out that industrial archeologists have tended to focus on the successful and unique sites, and those which are works of prominent architects and engineers. There has been little search for and examination of the experimental and transitional stages of development, or even of the failures.

Brainerd can be viewed as a site which examines both failure and success at the same site and through time. Without the documentary evidence, it is possible that the mission efforts would have been totally forgotten.
The obliteration of the race leading to the old dam would have allowed the presence of an earlier attempt to go unnoticed. The paucity of artifacts from the mission period would, as well, have allowed this period to be undetected.

In the case of Brainerd, the integration of archival and archaeological data was used to discover the total picture of the mills' development. A picture of hopes and frustrations, technological successes and failures, and the changing impacts of water-milling.
The South Chickamauga Creek watershed lies in the Ridge and Valley Physiographic Province. This drainage basin occupies 464 square miles and drains all of Catoosa County and parts of Walker and Whitfield Counties in Georgia, and part of Hamilton County, Tennessee (TVA 1967). The primary drainage feature, South Chickamauga Creek, flows in a northerly direction for approximately 30 miles emptying into the Tennessee River at mile 468.2 (TVA 1967) near Chattanooga, Tennessee. There is considerable fluctuation in the size of the creek, which ranges from a sluggish, slow moving stream in late summer to a raging torrent capable of inundating hundreds of square acres in the spring (Brown and Evans 1977). At maximum size, the creek is larger than several of the streams designated as rivers in lower Georgia, and several early writers refer to it as the Chickamauga River (Haywood 1825).

The Ridge and Valley region in Tennessee is known as the Great Valley of Tennessee. The ridge-valley topography trends north-northeast, displaying many striking geomorphic features, with a marked parallelism of ridges and valleys. The valleys are mostly flat and alluvium-filled at general elevations of about 600 feet, and the ridges are much dissected and extend to about 900 feet in elevation (DeSelms and Brown 1977). In the southern section, the ridges are not so numerous and there
is no division into an eastern and western valley belt. Longitudinal drainage is more prevalent in the south (Thornbury 1965).

The Ridge and Valley topography displays a conspicuous influence of alternating strong and weak strata upon topographic forms. A few major transverse streams, with notable development of subsurface streams, give to many areas a trellis-like drainage pattern (Thornbury 1965). The uniform elevation of the ridge tops has been explained as being parts of a former widespread erosion surface, or peneplain. This surface was uplifted, and the ensuing renewal erosion has cut the extensive valley (Shimer 1972), and the numerous water gaps and wind gaps which attest to past cases of stream diversion (Thornbury 1965).

The soils of the Ridge and Valley system are ranged in alternating bands trending northeast to southwest. The most prevalent soil is that from the Knox dolomite. These are heavy clay soils, varying in texture and amount of chert. They are fertile and durable (Vanderford 1897).

Alluvial soils deposited in the river valleys as a result of floods build up over a period of years, providing a fertile agricultural base. The larger flood plains are those that extend along most of the Tennessee River and its principal tributaries. The soils are deep and fertile and are renewed by frequent floods. Crops such as corn can be grown year after year without damaging the soil (Case 1925).
The growing season is from 207 to 208 days in length, with the first killing frost around November 1 (Tenn Agricultural Extension Service 1975). The average temperature in July 1978, was 81.2°, and the average January temperature was 30.3°, with a low of 23.2° (NCC 1978).

The rains are well distributed throughout the year, with short dry spells, occurring mainly during late August, September, and October. The heaviest rains are in March and May (Case 1925). The mean annual rainfall for the last 101 years is 52.36 inches. The maximum amount on record was 72.37 inches, recorded in 1929, and the minimum amount was 32.68 inches, recorded in 1904 (TVA 1979).

The most important flood season is during the winter and early spring when the frequent migratory storms bring rains of high intensity. During this period widespread flooding and local flash floods can occur. Heavy thunderstorms in summer can produce local flash flooding as well (Dickson 1960).
Flooding on South Chickamauga Creek can come from headwater floods or from backwater from the Tennessee River. Backwater flooding has been reduced since 1936 by the construction of reservoirs on the Tennessee River by TVA. Headwater floods remain a serious problem, and in the period 1928-1958, occurred an average of five times a year (TVA 1958).

The highest recorded headwater flood was at 20.73 feet on March 30, 1951. Bankful stage is 10 feet on South Chickamauga Creek. Records of the 1867 flood indicate that it was the highest known backwater flood with an approximate level of 30 feet. This flood occurred on March 11, 1867 (TVA 1958).

South Chickamauga Creek has a slope of 1.9 feet per mile between miles 8 and 14, 3.8 feet per mile from Mile 14 to Mile 20 (Graysville), and 5.0 feet per mile from Graysville to Ringgold. Spring Creek has a slope of 3.9 feet per mile in the 6.5 mile reach above its junction with South Chickamauga Creek (TVA 1958).
The Cherokee nation in 1809, was located primarily in northwest Georgia, southeast Tennessee and northeast Alabama. The area they occupied encompassed 24,000 square miles, "generally of an excellent soil, in a fine healthy climate, variegated with mountains and plains, watered by the Tennessee" (Morse 1822).

As a condition of the Treaty of Tellico in 1805, parts of the lands ceded to the United States by the Cherokees were set aside as "school reserves". These reserves or tracts of twelve square miles were to be sold by the United States, and the proceeds were to be used by the President in the manner he judged to be the best way to provide for education among the Cherokees east of the Mississippi River (Morse 1822).

In light of this interest in educating the Native Americans, the American Board of Commissioners for Foreign Missions (ABCFM) associated with the Congregational Church established its first Mission to the Cherokees in 1817 in the Chickamauga District. A Cherokee mission had previously been established at Spring Place, Georgia, in 1801 by the Moravian Brethren; and in 1803 the Rev. Gideon Blackburn had established a school which served as a forerunner to later, more permanent establishments (Morse 1822).

The ABCFM had been organized in 1810 to provide Christian missionaries abroad. When the Board was criticized for sending missionaries to India when there were "thousands of
heathen people near its door", the Board took the criticism to heart and sent Cyrus Kingsbury to investigate the prospects of opening a school for the Cherokees (Walker 1931).

The Rev. Mr. Kingsbury was present at the Council Meeting at Turkeytown in September of 1816, at which time boundary lines were settled and a treaty was ratified. After the business between the Indians and the government was completed, General Andrew Jackson introduced Rev. Kingsbury who spoke about the need for schools. He outlined the plan for a boarding school where the children would be taught "their duty to parents, to their fellow creatures, and to the Great Spirit, the Father of us all" (ABCFM Oct. 15, 1816).

After hearing the presentation, the Council voted to accept the offer and hoped to see the school established. Kingsbury wrote to the Board (1816) that

"At first it will be expensive but the prime articles of living can be raised in this fine country with the greatest ease, and I am confident that in a few years if things are managed properly, the school may be supported at comparatively small expense."

(Walker 1931:19)

In travelling to the Council meeting, Kingsbury passed through country that was

...one of the finest by Nature that I have ever seen. But its rude inhabitants appeared hardly to have felt the genial influence of civilization though their situation is said
to be much better than was formerly. It was truly affecting to see so many people and large families of children entirely destitute of instruction, and living without hope and without God in the world. (Walker 1931:17-18)

The Mission at Brainerd, named after the missionary David Brainerd, was on the south side of the Tennessee River, and 15 miles upstream on the Chickamauga Creek (6 miles in a straight line). The creek was navigable to the mission (Morse 1822).

The mission was founded near the old Cherokee town of Chickamauga (Goodspeed 1887). Chickamauga (Fig 2) had been established by Chief Dragging-canoe and his followers who were dissatisfied with the treaties of peace they had been forced to sign in 1777. In 1779, Colonel Evan Shelby and Colonel Montgomery were sent to Chickamauga when word came that the Cherokees from Chickamauga were starting on a march against the North Carolina border settlements (Walker 1931). The town was surprised and burned to the ground.

The mission area was purchased from a Scotsman, McDonald, who had married into the Cherokee nation and established a plantation. He offered his plate which included buildings, improvements and 25 acres of cleared land for five hundred dollars. The plantation was said to be convenient to a mill and water course (Walker 1931). The McDonald plantation had been shown to the Moravian Missionaries 16 years earlier,
Figure 2: Location of the Cherokee Town of Chickamauga.
but they had rejected it as having the reputation of being unhealthy (Walker 1931).

The South Chickamauga Creek area, while having been the site of a large Dallas population, was not heavily populated in prehistoric times (Brown and Evans 1977). While many historians say that the town was abandoned due to Shelby's raid, other towns in the area which had also been burned were reoccupied shortly thereafter. The Cherokees themselves said they left Chickamauga due to the many witches in the area. Crawfish Spring in Chickamauga was reportedly called by the Cherokees "Spring of Dead-man's Land". In 1849, a writer reported that "chills and fever prevail on the waters of the Chickamauga" (Brown and Evans 1977).

The location may have been chosen less with a regard for its past history than because it was convenient to a population of Indians but not near a town. The prevailing thinking at the time was that the towns were a bad influence on the Indians. The Moravians wrote that

At present only that portion of the Cherokee nation, which is confessedly the most indigent and degraded, continues to live in towns. The greater and more respectable part live on their plantations, and thus acquire those habits of industry and sobriety, which are uniformly countered by their congregating together. Hence it has become a principle of sound policy in the government of the United States, to employ all its influence to wean them from that habit, and to encourage the plantation system. (Morse 1822:155)
Kingsbury also wrote to the ABCFM in 1816 that

The children should be removed as much as possible from the society of the natives, and placed where they would have the influence of example, as well as precept. This can be done only by forming the school into one great missionary family where they would be boarded by the missionaries and teachers, be entirely under their direction and have their pious, orderly and industrious example constantly before them. (WAiKer 1931: 22-23)

Despite the attitude that the Cherokees were not capable of managing either themselves or their children, by the time the Mission was established the Cherokees were a united nation with law and organization. The Laws of the Cherokee Nation, passed in 1820 (Morse 1822), provided for eight districts with a Council House in each District. There was a judge and marshal in each district, with a Circuit Judge presiding over every two Districts.

Other acts provided for poll taxes which would defray the cost of Council business. Storekeepers were required to obtain a license from the National Council, and the sale of liquor was strictly forbidden; Cherokee slave owners being required to see that their slaves did not obtain liquors. It was further decreed that any white man who took a Cherokee wife had to marry her legally, and could not gain rights to her property.
The Council also took pains to guarantee that the parents of students attending the mission schools would reimburse the missionaries if the children ran away from the school.

The first missionaries to arrive, in addition to Cyrus Kingsbury, were A.E. Blunt and John Vail. They began clearing ground for the mission in January, 1817 (Morse 1822). Loring Williams and Moody Hall arrived in March, 1817, shortly after the others (Goodspeed 1887).

The Secretary of War had been authorized by President Madison to instruct the Indian agent to erect a school house and a house for the teachers. The Government contractor failed to build the houses and soon the missionaries were making brick, burning lime, digging cellars and a well, and conveying corn 40 miles to be ground (Goodspeed 1887).

By May, 1818, the school consisted of 47 students. The buildings erected at government expense prior to 1819 were the mission-house, a school-house, dining hall and kitchen, several smaller buildings and a grist-mill (Morse 1822). In a letter from the missionaries in July, 1818, they listed expenses for some of the building:

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<tr>
<td>To pay the two men who are hired by the year</td>
<td>320</td>
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<tr>
<td>To pay laborers for digging well, building dam, finishing houses</td>
<td>250</td>
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To purchase articles of food for the ensuing year...

100 bushels wheat @ 1.00 100
150 bushels rye @ .75 112.50
1000 bushels corn @ .50 500
7000 lb pork @ .06 220

(ABCFM 1818)

By 1819 there were about one hundred Cherokee children of both sexes lodged, fed, instructed and largely clothed at the expense of the mission (Morse 1822). In May 27 of that year, during a tour of the area, President Monroe appeared unannounced at the door of the mission. He apparently liked what he saw and ordered a school house built for the girls at government expense (Goodspeed 1887).

In December of 1819, Ard Hoyt, the new superintendent of the mission, wrote to the Board requesting that they hurry and build the planned mill and saw mill which would help defray their heavy expenses (BML 1819). Added to the need for income was the problem that the corn had to be carried 40 miles to be ground.

While at that time in the Cherokee Nation there were six grist and two saw mills owned by natives, and 14 or 15 grist and two saw mills owned by white men who had married into native families (Morse 1822), the large amounts of grain purchased in 1818 is an indication of the need for a mill close by.

Not everyone saw the necessity of establishing mill, however, Mr. Friderici, a Seventh Day Baptist living
Figure 3: Location of Brainerd Mission (Finley 1829).
with the Cherokees near the Hiwassee Town said of the proposed mill of Mr. Hildebrand to be built near the town:

The mill about to be built nearby is unnecessary, mills only served to make people live more comfortably to themselves and not to the Lord; each one could pound his grain or grind it in a hand mill. (Williams 1928: 483)

Perhaps Mr. Friderici felt that mills were unnecessary, but the people who depended on them felt otherwise. Entries in the Journal of the Moravian Mission at Spring Place show the importance of the mills to the local people:

May 21, 1802 A millwright was at Vann's to help Vann look for a place for building a mill. They located several places, but finally settled on a place a half mile from the Vann place. The millwright agreed to build the mill for $133.50, if the Negroes would build the dam and the house under his supervision. Vann had already engaged someone, but should he fail him the latter would be permitted to build it. He decided to begin its construction in June for at that time the Negroes would be the least busy (sic) and would be able to bring the millstones from Tellico. We have the prospect of a mill less than 3 miles from our place...
July 29, 1802: Vann brought two millstones from Tellico. When they were being loaded into canoes one of them overturned the canoe and fell into the river. It is likely to remain there, and now the whiskey which more than likely contributed toward the accident has to contribute toward relieving the shock.

August 1, 1803: Steiner rode 20 miles to speak to Chas. Hicks about serving as an interpreter for him... He recently returned from Philadelphia... Hicks showed Steiner a hand mill for grinding corn by which two persons could grind as much corn as 20 could do by the conventional method of crushing it by hand. He told about having a mill built which could be operated by a horse. As soon as that was done he would put up a still and that he had already ordered two still kettles...

August 17, 1804: Heavy rains caused the dam at Vann's mill to break in two places.

January 26, 1807: In the afternoon (came) a fairly old man, Thomas Bagly from Tennessee, who had resided with Mr. Hicks and built a mill for him. He offered to place his two daughters in our school while he was building a mill for Mr. Vann at Big Water.

October 21, 1807: A number of Indians stopped with us
for lodging...Short of meal and unable to grind corn at Vann's mill because of the lack of water some of our guests ground the needed meal by hand.

July 18, 1808: We were glad to hear that Vann's mill was again operating for we had been obliged to grind the corn we needed by hand.

April 3, 1811: We heard that a severe rain had overturned Charles Hicks' mill and washed some of it away, a serious loss to us, for now we will have to grind our grain by hand.

July 16, 1811: Byham and John Cambold (took) part of our wheat by wagon to Mr. Hildebrand's mill to be ground. They returned from Higtwer (Hiwassee) on the 19th.

June 1, 1814: The boys returned from the mill. We were glad because of the broken down mills we were forced to work from early morning until late into the night crushing corn by hand.

December 18, 1814: Because of the severe rain of yesterday and today, we were very much concerned for Br. Crutchfield, who had gone in an open wagon laoded with corn to have it ground at Br. Hick's mill. We were delighted to see him when he returned this evening with meal for two households. We were glad the tiresome task of the children stomping corn every day had ended.
The April 10, 1820 journal entry for the Brainerd mission stated that the millwright had examined several places for the mill and decided that there was only one place where the dam could be built. At that point the creek was not wide and a firm rock extended from bank to bank. The fall at the site of the dam would not be sufficient to locate the mill there as well, necessitating the construction of a race 3/4 mile long. The race would cut off about 300 acres of good farm land in the bend of the creek (ABCFM).

The dam was built, or in the process of being built when one end of the dam gave way, (July 5, 1820). The millwright had supposed he had driven the timbers to the rock, but it was gravel instead (ABCFM).

The inventory of the Mission as reported to the Secretary of the War Department on October 1, 1820, included a fish-trap, well, and garden valued at $200.00; a bridge over an arm of the mill pond and canoes valued at $55.00; and the mill which was valued in its unfinished state at $3000.00. The mill was both a "gristmill and a saw mill turned by a canal 3/4 mile in length, which conducts the water from a branch of the creek in the neighborhood..." (ABCFM).

A letter from Ard Hoyt to Evarts on October 17, 1821, reveals that expenses were running high at the mission, in spite of an entreaty from the Commissioners to watch expenditures carefully. The missionaries had reviewed the areas of expense and felt that work on the mills should not be
stopped. There had already been a good deal of money expended on the grist mill and it was felt that the old grist mill would not be likely to be sufficient for the needs of the mission much longer. (Whether this mill was a new structure or just the milling apparatus itself is not known. It may have been a new structure as the foundation of the saw mill failed after only one month and it had to be moved.)

After these mills were moved, "founded on a rock", and operable, the missionaries expected that they would begin to see a return on their investment. Until that time, there would have to be an increase in the stipend from the home office for the support money for the school would have to be diverted. As well as depleting the treasury by paying large amounts on the mills, the money due from the government had not been paid, leaving the choice of either laying in supplies or lessening the support to the school. (Plate 1)

By 1823, a black-smith shop had been established which was finally beginning to pay for itself (BML 93). The same could not be said for the mills however; despite considerable expense, the grist mill was still only grinding enough to supply the mission. The sawmill was apparently also a source of disappointment. The sawmill had been placed in operation on January 5, 1821, and by February 5, 1823, had sawn only 85,125 board feet of timber. Of this amount, only 33,000 feet were sawn after the mill was removed to its new location. The absence of a sawyer to oversee the operation
Plate 1

Figure 4

Brainerd Mission As It Appeared About
The Year 1822 (Walker 1931).
was considered to be the biggest contributing factor in the lack of a profit from the sawmill.

An additional expense would also be incurred in the deepening and widening of the race, if sufficient water was to be provided.
to keep the trip hammer and mills in operation. The present race was providing barely enough water to power one of the mills, and its walls were in need of repair to keep the bank from falling in on the flume (BML #93).

If a reliable miller could be found, it was felt that the problems with the mill would be solved. To that end, the Brothers began searching for someone to fill the post. They wrote to a Mr. Shelton to come and tend the mills. When he did not arrive as expected, it was discovered that he had never received the letter and had made other plans (BML #96).

The Mission was again in need of money when Ard Hoyt sent a report to the Commissioners on May 26, 1823:

But God in his providence does not will upon these exertions. You did not expect the sum of $3,000 would support the mission with its seven schools, but doubtless looked to the farms, mills, shops and etc, for very considerable aid. I think I may say in the years that these have all failed—yea more, that our very exertions to obtain support for ourselves have caused a great addition to the expense of the mission—everything we have undertaken has been a bill of expense—even the stock of cattle and hogs from which so much was expected, is likely to do very little—the hogs run wild and we lose them—and the cattle fail for want of food in the winter. The black-smith shop seems likely to do well, but you
will see from the monthly report how much profit the funds of the mission have derived from it. We have lately paid $100 for iron, about $200 for transportation of iron and etc from Boston and are now called on for $150 for coal. (BML 99).

Mr. Shelton, the millwright was finally able to settle his business and arrived at the mission in June. He was to deepen the mill-race according to the original plans and, as well, build an extensive flume in the race in front of the mills and shop. The cost of this project was estimated at from 75 to 100 dollars (BML 101).

In addition to the continued problems with the mills and dams, the missionaries were finding the area to be an unhealthy place to live. Dean wrote in November of 1824 (BML 299) that he had been afraid that they would never enjoy health at the mission, blaming the condition on the "effusive" arising from the pond. He later decided that their diseases originated from (unnamed) things around them.

At about this same time, the missionaries hired a Mr. Parker to tend the mills and the ferry (BML 127). Mr. Parker's wife was not well, however, and could provide him no assistance; it was thought that she had consumption.

The litany of dam troubles continued and on February 3, 1825, the mill dam failed again (BML 130). This time the damage appeared worse than usual and the missionaries
wrote again for instructions. Meanwhile they expected that they would have to travel 10 miles to a mill.

Mr. Parker, the miller, and his family were forced to move from their assigned cabin, as the dampness from the creek was further deteriorating Mrs. Parker's health, and he had to be away from the mill frequently to nurse her. Due to the unrealibility of Mr. Parker's presence (and possibly to unburden themselves of the continued troubles with the mills), the Board was asked to give some definite instructions about renting the mills and dam. The mills were providing enough grain for Mission use, but no excess. The missionaries were anticipating that as soon as the water fell, they would be "destitute". The grist mill was leaking badly and needed a new roof before summer (BML 131).

The construction of a new dam was still of major concern in April of that year when Br. Elsworth wrote that the question of whether not to build a stone or log dam was being debated (BML 132). Mr. Shelton, who helped in building the old dam, thought a stone dam should be built and that the wall should be extended. He felt that a part of the bottom might be a kind of quick-sand. Another millwright had looked at the dam and recommended logs. The missionaries were afraid that if the new dam was built where the old one had been, that the cracks in the rocks at the bottom would continue to cause trouble, and hoped to find someone who was well acquainted with building dams in
the area.

Br. Elsworth was tied down by the demands of the school, and could not search for someone to examine the creek (BML 132). He had however, thought that Mr. Dean, who had been the chief mechanic, could be put in charge of the mills and dam and tend the shop at the same time.

By April the race was dry and would continue that way until the rains came. The missionaries were anxious to have the dam built as soon as possible due to the "dangers of fever and ague". They hoped that if Mr. Dean could undertake the job it would be better if—Mrs. Dean's health permitting—they would live at the mill house. Br. Elsworth would prefer that they contract out the job and that the person who took it should have no communication with the family at the Mission house "remembering that 'Evil can corrupt good manners' ". He was also reluctant to board the workers, feeling that they already had more people underfoot than they could oversee. Besides "in a job like this some men would prefer throwing up a rough cabin near their work and have a black girl to cook for them" (BML 132).

A postscript to Br. Elsworth's letter states that Mr. Chamberlain had been to the site and thought that the new dam should be built about 4 or 5 rods below the head of the race. At this point there was a solid rock almost all the way across the creek. Mr. Dean had returned and agreed with this decision (BML 132).
Mr. Dean evidently did begin overseeing the construction of the new dam, but was compelled to return north in July because of Mrs. Dean's failing health (Walker 1931). By September the mills were successfully operating, and within two months, 94 bushels of corn had been received in toll (BML 136).

Despite high water in the Spring of 1826 impeding completion of the dam, the missionaries were apparently beginning to have hopes that the mills would finally pay off (BML 138). Mr. Elsworth requested that the Board send a bolt for the mill. About 500 bushels of wheat were in the fields that summer, and more would
be raised if there was only some way to sift the flour. He hoped
the Board would let him know as soon as possible if one could be supplied
before the next growing season so that the farmers could plan to
save more seed (BML 140).

Shortly after this letter, on July 14, 1826, Mr. Elsworth again
wrote regarding the bolting apparatus. He had in the meantime seen
a millwright regarding the expense of installing the bolt. If
operated by water the cost would be $50.00, but if turned by hand
the cost would only be $10.00. The cloth would not be expensive,
so a small hand-turned bolt was being installed at once. A regular
bolt was still requested, but the small bolt would serve for the inter-
rim (BML 141).

In December, the blacksmith shop burned and the only thing
salvaged was the lower frame. It was hoped that a new shop could
be built on the foundations as soon as possible (BML 311).

The estimate of property at Brainerd in 1827, listed the value
of the mills and race at $4,000 (BML 139). The mills were doing
well at this time, but little was expected of them in the way of
supplies for the coming year (BML 87).

A visit from David Greene of the Board to the Mission in
April, 1828, resulted in the following comments in a long report
to the Board:

All seem extremely pleased with Mr. Parker's
management in the Mills, and he seemed in his element
and apparently the busiest man on the grounds. He
has sawed from the 20th of Feb. to the close of
Dec. 41,351 ft. the value of which is near $420, while
the expenses of the Mill in repairs, has been but less
than $90. In the grist mill he has taken more than 610 bushels of toll, in corn and wheat, the value of which here is about $350 besides what he has ground for the families, the toll of which would have been $52.80. The repairs on this mill have cost in the time mentioned about $38.81. The whole income of the Mills has been, then in ten months and a half, about $815 and deducting the expenses, about $687, without taking into view the time of the tender, or the interest on the capital.

The race must be cleaned, and the banks repaired in one or two places this coming season. Some of the gearing also, which though put in new but a short time since, must be renewed again, considering how quickly the timber of this country decays, I suspect there would be a savings of expense in five years by having the gearing of the Mill wholly of cast iron. Mr. E. will ascertain what the expenses of casting will be in Tennessee and communicate it to you for your decision. Perhaps better and cheaper ones might be forwarded from Boston, and Mr. Worcester could easily make drawings to be forwarded as models, if that should be the fact.

Mr. Parker is much embarrassed by the ferry, which often causes the mills to stand still. I have forgotten
The numbers of thousands of horses, wagons and men which he has ferried over, while, as all people living in the nation go free, the income has been but little more than nine dollars. (BML 325).

The mills were finally performing as the missionaries and hoped. The presence of the sawmill, however, may have been the source of unexpected friction. Mr. Greene goes on to say that:

...I think there is danger that the missionaries at the small stations will feel that they must imitate the spacious and commodious buildings at Brainerd. I think I have seen a propensity to do so; and a feeling of being unfairly dealt with, when attempts are made to dissuade them from it. They do not see that the mere fact of having a sawmill is a reason why one family should live in ceiled houses, while they are surrounded by rough logs, battened or daubed with clay (BML 325).

There seems to be a difference in the amounts accounted for from the mills by David Grenne and, later in the year, by A.E. Blunt. Blunt reports in December:

You probably have the impression the mills are going well, and to considerable profit. I will give you an estimate of what Mr. Parker and myself thought they would bring yearly. The grist of corn 400 bushels worth $100, wheat 60 worth $45 added 145 yearly expenses $25 leaves $120 profits. Profits of the saw mill $257 expenses $116 leaving $141 which added to that of the grist mill makes $261, for the support of Mr.
P's family and interest of the money they cost—I say
nothing of the worth of the corn ground for our family,
which if it were tolled at another mill would cost
something like $10. This estimate is as we may
expect from the Mills (BML 119).

It seems that success with the mills was not to last however,
In 1829, Luke Fernal, the blacksmith, reported to the Board that
the shop had appeared to be getting lower to the water. It was
discovered that the foundations were so decayed that it was feared
that the building would fall in. The mills had both begun to break
apart and before too much more time had passed, it was felt they
would be in four pieces. Mr. Fernal deducted $150.00 from their
value in the Mission accounts (BML 317).

The flume was as well was suffering from the "timber-killing
influence of the water". As a matter of course, it needed rebuilding
every 4 to 5 years. The water flow was next to nothing from June
to October. The blacksmith finally disposed of using the flume, and
had given up the water blast in the shop the previous year (BML 316).
The usual summer complaint of the millers was that there was no water in the race due to the scarcity of rain. In 1830, the weather turned capricious and pelted the Mission with heavy summer rain. As a consequence of this, not only were crops destroyed in the fields due to high water (BML 80), but the dam broke again (BML 84). By the end of October, the weather was still not favorable for the repairs to be started.

The dam broke again in the fall of 1831 and February of 1832, requiring the missionaries to go 18 miles to the grinding done (BML 87). Mr. Elsworth reported that the break was about the same extent both times, but the winter break would be more costly to repair, as more rock must be used. As usual, repairs would be delayed until the weather was warmer.

In late May, the dam had still not been repaired and it was probable that it would be fall before anything would be done (BML 89). The missionaries were finally realizing that the location would never be suitable for their purposes. They were not in the best of health, and the doctor had advised them that if the water stood on the crops again that year as in previous years, they could expect a "Malignant sickness" to follow. Br. Elsworth felt that while it was important to keep the mills in operation, it should be accomplished without too much expense of money and health and perhaps even their lives.

The repair of the dam was now considered of doubtful effect. The creek was cutting away the bank and the channel was changing and undermining the wing of the dam. Mr. Elsworth, despairing of the
permanance of any repairs, wrote

Were it possible and would the state of the nation ascent to it, I would heartily advocate the disposal of this whole establishment, and remove to some more retired and healthy spot among the Cherokees, where our strength and labors might be applied solely and directly to the great object for which we came.

As the summer progressed, Mr. Elsworth advised the Board that if the mills were to be kept in operation, it would be best to operate them at the point where they stood on the creek and remove the old dam (BML 92). This would relieve the expenses of continually repairing the flumes and digging out the race. While they were well aware that it would cost more if this plan was enacted, they also felt that they might at least have some relief from the constant failure of the dam. There was also a rumor that, if the mills could be operated, there might be a person interested in buying them (BML 92).

By the end of summer 1832, rumor was fact, and a Mr. Stales had not only made an offer for the mills, but had also made an offer of $2500 for all the Mission property (BML 93). Mr. Elsworth, in reporting this offer to the Board, said that he had told Mr. Seales that the Board should not take less than $3000. The Board had not yet decided to sell, and were waiting to see what the Cherokees would do (BML 93).

The times were unsettled for the Cherokees and the missionaries as well. Brainerd was the first of the ABCFM missions and was considered the "mother church" to later missions established in Georgia.
Several of the early missionaries to Brainerd had in fact, left to serve these later missions. Moody Hall left in 1820 to begin the school at Taloney, GA. and Samuel A. Worester, who came to Brainerd in 1825, left in 1827 to go to New Echota in Georgia (Walker 1831).

The missionaries in Georgia would be the first to feel the force for Indian removal which was pressing in on the Cherokees. On December 20, 1828, the Georgia Legislature had enacted a law extending the sovereignty of the state over all white persons living in Cherokee territory. The law also provided that after June 1, 1830, all resident Indians were subject to Georgia laws and declared that all laws made by the Cherokee Nation were null and void (Phillips 1902). When the Legislature further declared that, after March 1, 1831, all white persons resident in Indian territory must have a license from the Governor, the missionaries felt that this law was directed at them (Phillips 1902).

The Cherokee Nation appealed to the Supreme Court for an injunction against the State of Georgia on the grounds that they were protected by the Federal treaties still in effect. Chief Justice John Marshall, in the majority decision, denied the injunction on the grounds that an Indian tribe within the United States was not a foreign state and could not maintain an action in the United States courts, and the case, as presented, merited a denial (Marshall 1830).

The Indians had previously appealed to the Federal government to abide by their own treaties, but were rebuffed. Andrew Jackson
was pro-removal and based his refusal to support the Cherokee Nation
on the fact that the Cherokees had established an independent government
within the State of Georgia (Jackson 1829). He was also encouraging
the voluntary removal of the Cherokees to the West. He reasoned
that the Indians by "persuasion and force...have been made to retire
from river to river and from mountain to mountain". Already numerous
tribes had become extinct in the face of civilization, and "that
this fate surely awaits them (Cherokees) if they remain within the
limits of the States does not admit of a doubt. Humanity and national
honor demand that every effort should be made to avert so great a
calamity".

On December 29, 1830, the missionaries working among the Cherokees
met at New Echota and drafted a Resolution concerning the Cherokee
crisis (Worster et al, 1830). The Resolution included the following
statement:

RESOLVED,

Resolved, Therefore, that we view the removal of this
people to the west of the Mississippi, as an event to be
most earnestly deprecated; threatening greatly to retard,
if not totally to arrest their progress in religion,
civilization, learning, and the useful arts: to involve
them in great distress and to bring upon them a complication
of evils, for which the prospect before them would offer
no compensation.

Shortly after the missionaries drafted this resolution, the
Georgia guard arrested several missionaries for residing in
Cherokee territory without a permit. Samuel A. Worcester was one of those arrested and was convicted.

Worcester appealed to the Supreme Court, and in the case (Worcester vs The State of Georgia), the court declared that the acts of Georgia were repugnant to the Constitution, laws, and treaties of the United States. The court overturned his conviction (Marshall 1831), and he returned to Brainerd in 1834 (Walker 1931).

Even with the unsettled state of the Cherokee Nation, in February of 1835, a Cherokee inquired about purchasing the mills (BML 105). The Georgia Indians were moving into Tennessee and the missionaries thought they might now have a market for the property.

In the Spring of 1835, Br. Blunt requested that he be removed from service to the Board. The Missionaries were very reluctant to have him leave as he was the one person who had any skill in repairing the mills (BML 106). Although Blunt did not leave, Worcester left to go west with those Cherokees who had decided to go ahead and move (Walker 1931).

Ironically, the threatened removal of the Cherokees finally brought about the operation of the mills at a profit. The speculators and settlers moving into the former INdian lands in Georgia were keeping the sawmills running behind demand (BML 111).
Even though the Cherokee Nation appealed to the courts to protect their rights, the clamor for removal was increasing. Finally in 1835, a minority fraction of the Cherokees, wearied by the constant threats to their lives and property, signed the Treaty of New Echota, and the Cherokees were driven west (Reed 1979). The Indian lands were deeded to the states in return for land in the new territory.

On August 19, 1838, the last service was held at the Brainerd Mission (Walker 1931).

John Vail, who had served as a farmer at the mission for 19 years, elected to stay in the area, and purchased the property. At the same time, Thomas Crutchfield had also entered the property. They settled the ownership of the disputed property by entering a deed of agreement in February, 1842, in which they agreed to hold the property and all improvements in joint ownership (Hamilton Co. E-92). Half of the money each had paid to the State of Tennessee was returned. The tract in question held the mill and mill house, and was described as the SW quarter section of Section 21, Range 3, Township 6, Ocoee District.

Vail resided on the property and in March, 1843, used the land as collateral in a transaction with Ainsworth Blunt (Hamilton Co. E-286). Blunt, although no longer in the service of the ABCFM, remained in the area and in 1840, purchased the old mission cemetery for the Board in order to protect the graves of the missionaries (Walker 1931).

In 1844, Vail sold his half interest in the property along with half of the grist and saw mills with all fixtures to Samuel and
George Williams for $1200 (Hamilton Co F-46). This sale was apparently invalidated at some later time, as in 1849, Thomas Crutchfield brought a suit against Vail. There was insufficient personal property to satisfy the debt, and a sheriff's sale was held with Vail's half share of the property sold to the highest bidder. The highest bidder was coincidently, Thomas Crutchfield, who paid $1,030 for the tract (Hamilton Co. G-364).

Crutchfield retained the property until 1852, at which time he sold it to Philemon Bird (Shepherd 1911). Bird built a new dam at the site of the mill structure. He also built a new and larger mill at the site.

Bird had large holdings in Georgia and Alabama, as well as Tennessee. He lived with a free Black woman whom he purchased in Harrison, TN. Mary was the mother of Gus, Philemon's second son (Shephard 1911).

During the war, Bird went south to keep out of the hostilities (Shepherd 1911). The mills were operated for some of this period by the Federal government (Times 1933). After the Battle of Chickamauga, Forrest's Cavalry was ordered into camp at Bird's Mill on September 23, 1963. On the following day, Forrest had his troops prepare for their next action by shoeing horses, checking equipment and cooking rations. This rest stop was of short duration,
as on Friday the 25th, the cavalry was ordered out to Harrison to meet a supposed advance of Burnside's corps coming from the direction of Knoxville (Henry 1944).

The mill evidently survived the war with little damage. J.T. Trowbridge (1866) on a tour of the South to describe the battlefields, ruined cities, and to give an account of "confederate misrule", visited the Federal commander at Chattanooga. On a ride to Lookout Mountain, he met a farmer and his son who were laboring to get their wagon over the rough road at the base of the mountain. The farmer had one bag of grist in the wagon which he had gone 12 miles to have ground at the mill "away beyant Missionary Ridge:. Although there was a mill on Wahatchie Crick (sic), it was a "powerful bad hill t\o pull up", and he preferred the 24 mile round trip to Bird's Mill.

Philemon Bird died in 1871 and left the mills to his sons, Sam and Gus. (Bird 1871). A Guardian was later appointed for Gus Bird (Hamilton Co. B. 29-458), as a lease filed in September 21, 1876, lists Samuel A. Conner as his guardian.

The lease was a rental agreement between Sam and Gus Bird and J.J. Bryan. The three-year lease provided that Bryan would pay $600 per annum for the 70 acre tract which contained the corn mill, flouring mill and saw mill. These mills were all contained in one structure.

Mr. Bryan was also to make repairs on the sawmill which would enable it to have a cutting speed equal to that it had when new. He was also to put a new bolting cloth in the old flouring mill and make a new water wheel for that mill.
Plate 2

Figure Bird's Mill.
In 1889, flour-milling was the leading industry in the state (Goodspeed 1887). There were 990 flour and grist mills with an annual product of $10,784,804, making Tennessee the leading milling state of the South.

Bird's Mill, during Bryan's tenancy, shared in that milling boom. The 1880 census listed the mill as having four turbines developing 36 horsepower, operating with a 6 foot fall. The mill capacity was 210 bushels a day, with a yearly revenue of $13,206.

The mill in 1887 (Goodspeed) had 3 run of burrs, a bolting apparatus and a saw-mill. The water-wheel capacity was equal to 75 horse power.

Gus and Sam attempted to carry on the milling and farming business, but apparently were not successful, even with the advice of an estate trustee and Gus's guardian. They sold off the farm lands in an attempt to keep the mills, beginning with the property across the Creek from the Mill (Hamilton County). They also borrowed money and mortgaged the property (Shepherd 1911).

The brothers built a dance hall at the mill, which was the scene of a killing in which one of the brothers took part (Scott 1979). This scandal, coupled with the foreclosure of the mortgage (Shepherd 1911) caused them to lose the estate.

The heirs of E.E. Hampton purchased the mills and operated it profitably (Shepherd 1911). The mills then passed to a Mr. Plemons and finally to Joe Walters (Scott 1979) before being torn down in 1921 (Hyde 1944).
Plate 3: Bird's Mill. A Metal Turbine is Visible in the Uncovered Turbine Bay.

Plate 4: Bird's Mill. Mill is Expanded and the Turbine Bay is Fully Covered.
Man's first knowledge of grinding grain was attributed to Ceres in ancient myth and fable (Bennett and Elton 1898). Handstones were the earliest "mills" and underwent little change in form from prehistoric times to the Roman age.

In ancient Greece, the preparers of grain were called "pounders". This name was adopted by the Romans and survived as "pistores" into the Middle Ages, long after millers ceased to "pound" (Bennett and Elton 1898). Pistores were introduced into Rome around 167 B.C. when, after the defeat of Perseus, a group of captive Greek "pounders" were brought to Rome. Grinding then became a commercial craft and a male occupation (Bennett and Elton 1898).

The quern, an Italian invention of about 2000 years ago, was one of the earliest grinding machines. It consisted of two stones, with the upper stone revolving on a pin on the lower stone. The original querns had a conical lower stone, with the upper stone convex in shape to fit over it. These gradually flattened to the shape of millstones as we know them today. The top stone was drilled through at the top to form a hopper. The quern embodied a simple change from the thrusting or pounding motion of handstones and saddlestones to a continuous revolving motion which revolutionized classic milling. Some larger querns were operated by slaves or animals (Bennett and Elton 1898).
Water mills—"mola aquaria"—were the earliest power-mills in the world. One of the earliest allusions to a watermill was in 85 B.C. in Thessalonica. Water mills were slowly coming into operation at the time of the destruction of Pompeii, yet, due to the abundance of slaves, manual mills were not phased out for four more centuries (Bennett and Elton 1898).

The Greek water mills had a vertical shaft which was bedded on a rock in a stream bed or channel. The shaft supported a horizontal wheel which lay on the water and was turned by the current. The shaft passed through the lower mill stone and was fixed to the upper stone. The wheel, the shaft and the upper stone all revolved together. There was no gearing, and one revolution of the wheel made one turn of the stone (Bennett and Elton 1899).

The Greek mills were generally superceded by the Roman mill in the eight century B.C. The Roman mill, possibly invented by the engineer Vitruvius, had vertical water wheels and cog-gearing (Bennett and Elton 1899).

The Norse mill was the horizontal Greek type with vertical shaft. These mills were in operation until well into the Middle Ages, with some isolated examples still in use in the late nineteenth century. They were usually housed in small huts which were built directly across small streams (Bennett and Elton 1899).
Norse Wheel With Recurved Blades (Bennett and Elton 1899).
The last development of water milling, the turbine, seems to be a direct descendant of the Norse mill.

MECHANICS OF WATER MILLING

Beginning about the sixteenth century, the typical mill consisted of a waterwheel beside or beneath the mill building; a dam at some point upstream to divert the flow into the headrace, to increase the amount of fall and to create a pond for storage of water; a canal called a millrace or headrace, or a flume to carry the water from the dam to the mill; a penstock or sluice, with controlling gates to convey the water to the wheel; and a tailrace to carry the discharged water from the wheel back into the stream (Hunter 1979).

A mill-seat or water privilege was the point of marked descent in the bed of a stream where the concentration of fall simplified the harnessing of the flow (Hunter 1979). While having a pronounced mill seat was a favorable factor in locating a mill, occasionally the fall was not so pronounced, necessitating the construction not only of a dam, but of a long race to convey the water.

Sometimes as well, the topography of the area dictated that the mill itself be at a distance from the dam, again requiring a long race. Races could be well made with portions of their length stone lined or timber lined (Lautzenheiser), or could be merely earthen ditches which had to be redug periodically.
Dams as well could be elaborate or flimsy depending on the terrain and the needs of the mill. In cases where the supply of water was large and a high fall was not needed, a temporary dam composed of large stones was sometimes thrown across the stream in a diagonal direction (Leffel 1881). Such a dam was cheap and quick to build, but had to be frequently replaced, especially after heavy rains.

In building a permanent dam, the most important consideration was the foundation. A good foundation would be constructed to protect the dam against breaks and from the burrowing of animals such as muskrats (Hughes 1862).

Dams could be built of stone or logs depending on the river bottom and the availability of each material. Stone dams have the advantage of not rotting, and if properly constructed are relatively permanent. If timber was abundant log dams were most economical. They were also better adapted to a soft bottom (Leffel 1881).

A log dam is made by laying a log foundation with log cribs at each bank to anchor the dam. The dam could then either be a full crib dam or be built up with a series of log layers. The upstream side of log dams should be covered with upright planking extending from the top log down to the apron and pinned or spiked to the logs. Filling the upstream side with rubble protects the pilings from being washed out by the whirlpools formed around them (Leffel 1881).
Figure 9  Crib Dam With Plank Covering (Leffel 1881).
The power developed by a water mill is determined by both the amount of water available and the head, or fall. The "Fall" of water means the natural fall or drop in the course of a stream. The "head" is the vertical distance between the surface of the water at the dam down to the surface of the water where the wheel or turbine is located (Leffel n.d.).

The available head and the amount of water flowing in the stream measured at cubic feet per minute, are the absolute factors in computing the power (Leffel n.d.). The greater the head, the more power a given amount of water will produce.

The usual mental picture of a water mill is one of a graceful vertical wheel turning beside the stream. Although an overshot wheel is usually brought to mind, there are actually three types of these vertical wheels; overshot, breast, and undershot, with the overshot wheels being more common.

Overshot wheels receive water from a flume directly above them. These wheels were quite efficient and in ordinary usage, had a range of efficiency of from 50 to 85 percent. With falls of from 15 to 35 feet, the overshot wheel with a diameter close to the height of fall, operated at an advantage which made it the preferred wheel. With
falls of 8 feet or less, however, they lost efficiency (Hunter 1979). These wheels must be set at least 6 inches above the tail water to prevent the wheel dragging in the back current (Figure 19). For this reason, overshot wheels were not well adapted where the water level varies (Grimshaw 1882). These wheels were generally used where the volume of water was relatively low, but the fall or head, was great (Mike LaForest pers. comm.).

Undershot wheels receive water beneath the wheel. They are not driven by gravity as in the case of the overshot wheel, but by the impulse action of water flowing against the paddles or "floats" placed around the circumference of the wheel. They can develop as much as 60 percent of the potential power of the water, but are limited by the velocity of the stream (Grimshaw 1882). The introduction of a channel which conducted the water directly to the undershot wheel was an improvement that permitted greater utilization of the potential water power (Mead 1915). These wheels were generally used where the volume of water was great, but the fall was low (Mike LaForest pers. comm.).

Breast wheels receive water midway between the top and bottom of the wheel. They operate by gravity. Breast wheels require a large portion of total fall to be used as
Installation of Overshot Water Wheel (Grimshaw 1882).
head (Grimshaw 1882). Breast wheels turned with the direction of the stream flow giving them an advantage to overshot wheels in times of high water in the tailrace, as the breast wheel did not have to work against the current (Mike LaForest pers. comm.)

These different types of wheels were used according to the characteristics of the stream on which the mill was located. All of these exterior wheels were subject to damage or impediment by ice forming on them (Grimshaw 1882).

**Tub wheels**

The tub wheel was an early type of vertical shaft wheel. Tub wheels have horizontal wheels with vertical shafts which, in grist mills, passed through the lower stone and turned the upper stone (Hunter 1979). Tub wheels were generally made of wood with floats set into the vertical shaft (Figure 1). A tub wheel is reminiscent of the Norse mill except that, rather than being turned by the current, water was carried by an inclined trough and directed so as to strike the floats or buckets tangentially at one side of the wheel (Hunter 1979).

Tub wheels were simple and inexpensive to construct. They were adaptable to small mountain streams and were practical for use by a single household. No cog or gear wheels were required, and dams were not always necessary; a small canal could serve to divert water from the stream into the wooden trough (Hunter 1979).

The smaller tub wheels developed no more than a fractional horsepower, and the large ones might develop
Plate 8
Figure 4 Tub Wheel c. 1900 (Hunter 1979).
2 or 3 horsepower. The wheel was only about 10-15 percent efficient, and was unsuitable for the demands of commercial operation in flour-milling (Hunter 1979).

Despite their waste of water, tub wheels were frequently employed for continuous-process methods on account of the regularity of their motion (Hunter 1979).

The tub wheel was the inspiration for the reaction turbine; both having horizontal wheels with vertical shafts and being quick-running. Hydraulically they were different, with the strike-and-splash off action of the tub wheel contrasted with pressure-reaction character of the turbine. The reaction turbine operated submerged, while the tub wheel could operate only above the tail water (Hunter 1979).

The last development of water-milling was the introduction of the turbine. The turbine seems to have been directly derived from the action of the primitive Norse mill (Bennett and Elton 1899). The similarity of the working of the voluted cone wheel to the turbine is apparent, but the Norse wheel is driven in one direction by the direct force of the water, while the turbine is turned in a reverse direction by the reaction of the current.

Turbine wheels were refined and developed by various French inventors early in the nineteenth century (Mead 1915), but the person usually created with the invention is Fourneyron, who developed a turbine in 1823 (Bennett and Elton 1899).
A reaction turbine is a horizontal wheel usually operating on a vertical shaft and differs from the vertical impulse turbine in that the whole turbine is acted upon by the water at the same time and continuously. In a reaction turbine the water is directed against all points of the circumference at once, and the action of the water on any one bucket is repeated simultaneously all around (Grimshaw 1882).

Turbines can be reaction or impulse turbines. The impulse turbine receives energy through the reactive pressure on the buckets caused by changing the direction of flow of the moving mass of water. Impulse turbines operate with the discharge above the tail water, and do not require a draft tube (Mead 1915).

Reaction wheels are better adapted for low and moderate heads, especially where the height of the tail water varies (Mead 1915).

Reaction turbines consist of a runner and shaft which are the rotating parts, the gate or guide casing, and a discharge cylinder or draft tube (Leffel n.d.) (Figure Plate 9). Turbines were first introduced into the United States in 1842, and gained rapidly in use in the next two decades (Hunter 1979). Hughes (1962) claims that the reaction principle is purely an American invention. By 1880, the turbine was described as the most popular water wheel in general use. The tub wheel, however,
Fig. 1 shows the American Turbine out of the case.
Fig. 2 represents our small wheels and cases complete, ready to set in a penstock.

Plate 9
Figure 12: Turbine, Both in and out of Case (Hunter 1979).
survived until recently in parts of southern Appalachia and other less developed regions of the western world (Hunter 1979).

Turbines could develop 80 percent or more of the useful effect of the water, being able to utilize the full head, while an overshot wheel must be set above the tail water, thus reducing the available head. An 11.5 inch turbine could give more power than a 22 foot overshot wheel. In addition, in an overshot wheel, the water begins emptying before it reaches the bottom, thus losing another portion of the water's potential energy (Grimshaw 1882).

The turbine receives water from a penstock, which is built up to the flume and is seated in the base of the penstock. The floor timbers for these turbine pits should be placed in the direction of the current, with their upper surface at the height of the standing tail-water. The pit under the turbine should not be less than 2 feet below the floor timbers, and from 3 to 6 feet for larger turbines. The pit should extend several feet beyond the outside of the penstock and then gradually slope upward to the general level of the bottom of the tailrace. If there is not enough room for discharge, it will react upon the turbine and impede its movement (Grimshaw 1882).
The modern mixed-flow turbine was an American development. This design was the blending of the inward flow principle with the downward discharge of tub wheels. The mixed-flow turbine was the result of many years of evolution of turbines. These large capacity wheels were exemplified by the 1876 "Hercules" built by John McCormick. The buckets were deeper and protruded below the band allowing the outward discharge. These turbines had the advantage of being high-speed models with high rates of efficiency (Safford and Hamilton 1922).
Plate 10
Figure 13: Installation of Turbine (Grimshaw 1882).
The great advantages of turbines over the old style water wheels were summarized by Mead (1915):

Turbines occupy a much smaller space.

On account of their comparatively high speed they can frequently be used for power purposes without gearing and with a consequent saving in power.

They will work submerged.

In consequence of the ability to work submerged, the turbine can efficiently utilize considerable variations in head, to which condition the old style water wheel is not applicable.

Turbines may be utilized under almost any head or fall of water. They have been used under heads as low as sixteen inches and as high as 670 feet.

Turbine water wheels are built of much greater capacity than is practicable with overshot wheels.

By means of turbines, water powers of much greater magnitude can now be developed than would be possible with the older classes of water wheels.

Turbines are more readily protected from interference of ice.

GRIST MILLS

Grist milling was probably the single most important use of water power, especially in the early days of this country. Licenses obtained in one Tennessee county, in the period 1793-1804 to operate mills were overwhelming granted for grist mills. Permission to construct mill was granted for 12 grist mills, 10 (unspecified) mills, three...
grist and saw mills, and one sawmill (Blount Co.)

The initial use of the water wheel was to turn the mill stones. Originally one wheel operated one run of stones, but with the addition of gears and belts, additional runs of stones could be powered by one wheel. With even more gears, other equipment could be run off the wheel as well.

In the early 1800s, Oliver Evans invented the elevator, conveyor, drill, descender and hopper-boy (Bennett 1899). These means of conveying the grain and meals throughout the various processes eliminated the need for manually transporting them throughout the mill. All of these devices could be run off the wheel with appropriate gearing. Bolters as well were no longer required to be hand-turned, but could be driven by the wheel. Bolters were sieves used to produce the various grades of flour and to eliminate sands, grits and other impurities (Bennett and Elton 1898).

**MILL STONES**

Mill stones are considered the heart of grist mills, and as befits such an important item, are the subject of much literature and the subject of folklore as well.

For many years, the "French bulb" was considered not only the best mill stone, but the only one of any notice. These stones were quarried in France, and originally each stone was cut from a single block. They were a hard silicious material, and the ones with large even pores were the prime choice. Originally they did not contain furrows, relying on the texture of the stone to do the grinding (Hunter 1979).
Evans, however, was not really interested in the smaller mill operations. The community custom-toll operation provided no market for his milling equipment, and his techniques were therefore not generally accepted until considerably later (Hunter 1979).
"English stones" were developed around 1800. They had smaller pores and contained chiseled furrows to enhance their grinding ability (Hughes 1862). Originally, French buhrs were cut from a single block, but as the source of supply began to be depleted, stones were fitted together in sections and held together with iron bands. These blocks were brought to America as ballast in sailing ships (LaForest 1981). American importation firms such as Morris and Trimble of Baltimore would fit the blocks together, finishing them with cast-iron eyes. The stones from Morris and Trimble were destined for markets in Virginia, North Carolina, and Tennessee (Hughes 1862). This practice of piecing together the imported stones led to the belief that any banded stone was a French buhr (Ketner 1981).

Good mill stones were selected for their even grit, even texture, and color and by their close resemblance to one solid piece of stone with the joints being nearly indistinguishable (Grimshaw 1882).

Even when native stones began being used, the feeling that "French stones" were better persisted; if a stone was imported, it had to be better than native stones, no matter what its true quality was. Actually, even French buhrs came in many grades from excellent to unusable. The fine white stones were the best, with blue stones good for corn milling. Although blue stones were harder to dress, they held the dress better when properly handled. The trickster stone was the "Fox-burr", a yellowish stone which, while still a French buhr, was nearly worthless (Hughes 1862).
Actually, the size and weight of millstones made the cost of importation impractical for the average miller. Hunter (1979) reports that good French buhrs were selling in 1850 for £48 in England. Local stones were therefore not uncommon. The *Knoxville Gazette* of May 11, 1812, tells of several quarries of "Burr" millstones having been discovered in Grainger and Hawkin Counties (Tennessee). A millstone quarry was reportedly located on Walden's Ridge, Sequatchie County, Tennessee (A. Hoodenpyle pers. comm.), and Grindstone Mountain in western Hamilton County evidently received its name from being a source of millstones.
The rural blast furnaces and forges, village foundries, tilt hammers or large blacksmithies were almost invariably driven by waterwheels (Hunter 1979). Having a smith as part of the grist or saw milling operation was a sensible procedure. While the smaller mill irons could be made at the common blacksmithies, larger parts such as sawmill cranks and the heavier wheel gudgeons and millstone spindles could be forged effectively only at the larger smithies equipped with water-powered trip-hammers (Hunter 1979).

In small rural establishments, bellows or blowing tubs and forge hammers were operated directly from the water wheel shaft by means of cam tappets or by cranks. Generally an independent power source was used for each major piece of iron-working equipment. For example, the Springfield Armory in Virginia, the Ordnance Department's principal source of small arms, was run by multiple waterwheels. In 1824, three of the five workshops employed 27 waterwheels to drive the trip hammers and other operations. These wheels, mostly undershot or tub wheels, developed several horse power to supply the blast and drive the forge hammer (Hunter 1979).
Plate 11
Figure 14 Blacksmith's Trip Hammer (Hunter 1979).
SAWMILLS

The early settlers recognized the value of sawmills and welcomed them. Unlike England, where the large labor force and scarcity of timber had combined to force opposition to sawmills, the pioneers in the New World were eager to establish sawmills (Hunter 1979).

Log cabins were the norm for shelter until sawmills could be built. Food and shelter were the first things to be provided for in the new country, and in early records of frontier settlement, grist and sawmills were often paired. Later, however, sawmills began to outnumber gristmills.

The location of gristmills was determined only by the location of a mill seat, and, if necessary, grain could be carried on foot or horseback to the mill. Sawmills on the other hand, required a location which would facilitate the delivery and transport of logs and lumber. As late as 1880, sawmills were the most numerous and widespread of all industrial establishments (Hunter 1979).

The old method of building sawmills was to attach the water wheel and saw to the same shaft (Hughes 1862). This caused a stiffness which reduced the actual power when used in connection with a crank. Gearing was later used to convey the rotary motion of the wheel to the required motion of the sawmill.
Tub wheels were frequently used in sawmilling in the up-and-down mill. Here it served as a convenient means of powering the log-carriage return at the end of the cut. This carriage return was known as the goback (Evans 1836).
MILL REGULATIONS

Probably as soon as the first canal was built to divert water to a mill, laws concerning water rights and locations of mills and dams were instituted (Bennett and Elton 1899). As early as 398 A.D., there were laws against diverting the water source for a mill; but by 485, there were evidently so many mills pulling water out of the streams that it became illegal to divert freshwater supplies to private mills.

In Rome the College of Pistors was the trade guild associated with milling. The pistors were millers for life, and were not allowed to leave the profession (Bennett and Elton 1899). Not only did this rule apply to the miller, but to his sons and his daughters' husbands as well. This ruling ensured that there would be enough millers to supply the needs of Rome.

In 536, the water to the mills of Rome was intercepted by the Goths, reducing the city to near starvation. The Commander Belisavius devised a mill to float on the Tiber River, using a wheel between two boats with the stones in one boat (Bennett and Elton 1899). These boat mills were so successful that similar mills were in widespread use until the beginning of the nineteenth century (Bennett and Elton 1899), and were common in this country in the early days of settlement (Straight 1980).
The stringent laws for the protection of mills on the continent were attributed to Clovis (c. 481) and were well entrenched in the time of Charlemagne, who confirmed and consolidated them in 798. The Ancient Laws and Institutes of Wales were codified in the ninth and tenth centuries. They show a mill to be a valuable possession which established for their owners the milling "soke" (Bennett and Elton 1899).

The soke was a Saxon term meaning privilege or liberty (Bennett and Elton 1900). The feudal laws of milling soke gave the lords the sole right of building and working mills upon their own estates (Bennett and Elton 1898). Tenants were compelled to attend the mills of the lord, and the use of domestic querns was prohibited, forcing the tenants to use the mill for all their grinding.

In the Domesday Survey, 1080-1086, there were several thousand Saxon mills recorded (Bennett and Elton 1899), and the mills existing at that time were forever free from tithes. The "Anomalous Laws of Wales", ascribed to the tenth century, contained the dictum that a manorial lord owned the toll of his mills (Bennett and Elton 1898).

Tolls were originally "handfulls" and were not uniform until the thirteenth century (Bennett and Elton 1900). The standardized toll was generally 1/16 to 1/20 of the whole. Weighing of the grain to be ground was made compulsory in London in 1281.
Hostility to the exclusive milling privileges of manorial lords reached its height in the sixteenth and seventeenth centuries in England. In one area discontented burgesses set up a horse mill in defiance of the lord's mills (Bennett and Elton 1898). This discontent led to the final abolition of soke laws.

Handmills returned to general use after the soke laws were abolished. These differed from the old querns, in having simple machinery, such as cranks. Cogwheels were driven from the crank in much the same way as a water mill was driven from the water wheel (Bennett and Elton 1898).

The medieval laws concerning milling and mill rights were remarkably similar to the laws established in the New World. In Tennessee the location of mills and mill dams was of early concern to the young state. Individual owners were regulated in regard to where they could build a mill (Cannon 1842). The basic concern of the lawmakers was that dam and mill ponds not interfere with navigation or that the impounded waters did not overpower another person's property.

If a prospective mill owner did not own both sides of the water course, or have permission to flood the lands above the proposed mill, he could petition for condemnation of the property, paying a just settlement. He must then build and have the mill in operation within three years, or the land would revert to the original owner (Meigs and Cooper 1858).
All navigable waters in the State were considered public highways, and any person obstructing the navigation of main channels by building mills or erecting dams unless authorized by law, was liable to a penalty (Meigs and Cooper, 1858). The State Constitution defined the method in which mills could be built. The individual counties were given control over the review of applications of prospective mill owners (Nye, 1836).

Every person erecting or having erected a mill dam was required to maintain a gate or slope in the dam to allow passage of water craft. In the case of the Ocoee River, for instance, the gate was to be 40 feet wide (Harris, 1840). On the Duck River the dam could not be higher than 7 feet. If a dam was higher than 7 feet, a 40 foot wide slope must be provided. Mill owners on the Duck were required to pay for any damages done to water craft if their dams were higher than seven feet, except for that portion of the river between Columbia and Williamsport, where dams could not exceed 3 feet (Cannon, 1842).

Public mills were defined as any grist mill which had ever ground meal for toll. Each miller was required to bolt the flour ground at his mill (Meigs and Cooper, 1858), and millers were required to grind grain in the order in which it was received. Toll was established at 1/7 for a steam mill and 1/8 for a water mill. For chopping grain the toll was 1/14. The millers were required to keep sealed measures of one half-bushel and one peck, and proper toll dishes for each measure (Meigs and Cooper, 1858).

These regulations changed very little over the years, and were virtually the same in 1884 (Milliken and Ventress).
Test excavations at Brainerd Mill were undertaken from July 18 to August 17, 1979. Because the mill site was not reported until construction work was well underway, investigations at the mill assumed the character of salvage archaeology.

When archaeological work began, the lower portions of a log crib dam, mill foundation, and canal were visible. The canal appears to have emptied into South Chickamauga Creek approximately 100 feet north of the visible mill foundations, possibly indicating that the original missionary mill was located at the canal mouth rather than at the foundation ruins. At this location a fall of approximately 10 feet could have provided power for an overshot wheel.

Despite the salvage nature of the project, enough documentary data was available to provide guidelines in determining research objectives. The overall research objective was to test the proposition that there were two separate mills at different locations, and to determine specific data regarding mill construction and operation. Specific objectives were:

1. To excavate at the assumed site of the Missionary Mill in order to locate structural features.

2. To excavate in the canal bed to determine dimensions and other characteristics of this structure, and to locate artifacts associated with the Missionary Mill or other aspects of Mission life.
Figure 4: Site Map-Brainerd Mill/Bird's Mill.
3. To conduct intensive mapping and photography of visible Bird Mill remains to determine structural data.

4. To excavate selected areas of Bird Mill to further define structural data. In particular, to note construction details of the dam site and possible connections between the canal and mill site.

PROCEDURES

Excavations at the mill site were initially undertaken to uncover remains of the Brainerd Mill. Evidence of this structure, however, was not obtained. It is now assumed that the Brainerd Mill was largely, if not completely, destroyed by Bird's Mill. A second set of procedures was then initiated to answer questions concerning the structure and operation of Bird's Mill. Test pits were placed along the dam and mill sills to determine construction sequences. Excavations along the mill walls were conducted for the same purpose. The mill race was searched for artifacts that would indicate the technology used to produce, transmit and utilize energy. The preliminary results of these investigations are as follows:

1. Construction sequence- As the dam was known to have been constructed c. 1852, it was possible to trace inter-connection of members in order to date other structural remains.

As a result of these investigations, it can be stated with
a high degree of certainty that all remaining portions of the mill date from 1852 and later. No certain evidence of the original mill was recovered other than a millstone fragment contained within the fill of the 1852 dam. Excavations along the stone walls of the mill also confirmed a mid-nineteenth century construction date.

2. "Canal" excavations- Excavations of the "canal" revealed a modern concrete-lined drainage ditch. Historic photographs and documents obtained during the period of investigations eliminated the "canal" as a historic feature.

3. Tail race explorations- The discharge of a mill is known as the tail race. In the case of Bird's Mill, the tail race consists of those portions of the creekbed once beneath the mill. As this area was under water at the time of the investigations, it was necessary to retrieve artifacts with a magnet. Low visibility, silt and modern rubbish compounded the difficulties of this operation. However, several hundred artifacts relating to the generation of power, the mechanical transmission of power, sawing, milling, and miscellaneous mill-related activities were recovered.

The most significant of these objects for the understanding of mill operations are portions of three vertical water wheels, or turbines.
Several fragments of a cast iron turbine or turbines were found. These may be remains of a turbine shown in a historic photograph of the mill (Plate 3).
As stated, the canal was thought to be the location of the race serving the missionary mill. The testing of this canal ruled out the possibility. This still left the question of the location of the race to be solved.

The missionary letters discussed the construction of a three quarter mile long race from the dam to the mission mill site. There was no evidence of an earlier dam in the vicinity of the mill and all visible traces of the race had been obliterated by the construction of Brainerd Village and Eastgate shopping centers.

In December of 1979, the presence of a stone dam at the junction of Spring Creek and West Chickamauga Creek was reported to Dr. A. Brown by Mr. Donavan Boutz. At the time of investigation, high water on West Chickamauga Creek prevented recording of the entire structure. Visible remains, which were felt to be the majority of the surviving structure, were a limestone dam or wall 34 by 6.5 feet.

The dam may have originally been on the smaller Spring Creek. The combination of the mill dam and a current beaver dam, has resulted in the silting in of the mill pond. Spring Creek appears to have sought a new channel, now entering West Chickamauga Creek several hundred feet upstream from the dam.

Interstate construction in the area immediately adjacent to the head of the race has left some confusion as to the original bed of Spring Creek and to the direction of the race.
Figure 5: Location of Mission Dam (TVA 1965).
Available topographic maps indicate that there are two possible routes for the race to have taken. One route would follow the curve of the creek, and the other would follow a more direct route, running almost due north to the mill site. The more direct route would come closer to being the 3/4 mile that the missionaries described. With the exception of a small area near its head at the mill pond, the race is under the Interstate, Eastgate Mall and Brainerd Village Shopping Centers.

It is hoped that additional work can sometime be done in the area of the Missionary Dam.
The dam at the site of Bird's Mill was the one which had been built by Bird in 1852 to replace the Missionary Dam. The stone Mission dam had provided water to the mill by means of a three quarter mile race. When Bird replaced the dam, he built it at the site of the mill itself.

The elevation of the dam was 656.35 feet and the step bearing for the turbine was at an elevation of 650.65 feet. The step-bearing, the seat for the turbine, would represent the maximum head under which the turbine would operate. This 6 foot head corresponds with the information in the 1880 Census.

Bird's dam was of timber crib type construction, similar to that in Figure 4. In constructing such a dam, a timber or log foundation is laid down on the bottom and the superstructure of the dam is constructed to the desired height. Cribs are built into the banks to anchor the dam. Bird's dam was a full crib dam with rubble filled crib units composing nearly the entire structure.

The dam extended 97 feet across the creek. From the south bank, the dam extended 29 feet before encountering a stone construction, possibly a foundation. This area of the dam was broken down to a great extent, and the presence of crib walls was not noted in the upper levels. Beyond the stone foundation, six cribs comprised the remainder of the dam. These cribs varied from 8 to 12 feet wide along the north-south axis. The three cribs at the north bank were the best preserved of the dam cribs.
Plate 12: View of Bird's Mill Dam Before Excavation.

Plate 13: Upstream View of Dam Showing Plank Covering.
with both upstream and downstream limits definable. The top of the dam was 13 feet wide at these three cribs, and it is assumed that the remainder of the dam was also 13 feet wide.

As can be seen in Figure 17, planking was placed on the upstream side as a solid sheathing against the dam. This corresponds to the construction procedure defined by Leffel (1881).

Due to high water, the dam was not excavated, but was cleaned to determine the construction mode. With the exception of the mill stone fragment which was found as a component of the rubble fill, the majority of the items recovered from the clean-up of the dam were of twentieth century origin.
The fragment of mill-stone recovered from the excavation is thought to be the one artifact which can reasonably be associated with the Mission Mill rather than Bird's Mill. The stone was recovered from the rubble fill of the mill dam which had been built by Bird around 1852, after he took over operation of the mill.

The stone fragment is 6.5 inches thick, and from the edge of the eye to the outer edge measures 1.6 feet. Allowing approximately 4 inches for the eye, the stone would have had a diameter of 3.5 feet. The fragment was dressed in the straight quarter dress style (Grimshaw 1882).

Early mill stones relied on the porous texture of the stone to provide a cutting edge for grain; the job of the stones was not to crush or rub the grain, but to cut it. As the supply of good quality stones diminished, a means to provide poorer stones with a cutting surface was needed, and the practice of dressing stones was developed.

Furrows were cut into the stone in a set pattern, providing air to the grain to cool it. They also distributed the chopped grain between the faces of the stones and then carried it out. The pattern of the dress depended on the speed, direction and material of the stone, as well as the nature of the grain and the milling method to be employed (Grimshaw 1882).

The straight quarter dress used on the Brainerd Mill fragment was one of the earlier styles, and Grimshaw in 1882 refers to it as a "barbarism". He felt that the quarter dress should be eliminated, but it was still at that time much used in the South and Great Britain.
Plate 17
Figure 19  Fragment of Mill Stone.
The stones at Bird's Mill were gold or yellow (Scott 1979). These stones were hard granite and supposedly good stones, so it is assumed that they were native stones rather than the worthless Fox-burrs.
CRIBS

The areas designated Cribs One, Two, and Three comprise the turbine bay on the west bank of the creek below the dam. The turbine bay was an enclosure 18 feet on the west or bank side and 28 feet on the creek side where the bay was connected to the dam (Fig. 15).

Crib One, the area upstream nearest the dam, was the least productive of the cribs. This unit contained four wire nails, seven cut nails, one brick fragment, ten window glass fragments, and four unidentified metal objects. The major portion of all three cribs was underwater, and the items recovered from Crib One were mainly recovered from the bank. The proximety of this crib to the mill house would possibly account for the presence of these structural remains.

Crib Two was the enclosure for the turbine recovered from the excavation (Plate 16). The turbine will be described separately. In addition to the turbine, Crib Two contained two saw mill rollers (Plate 17).

Except for the tailrace, Crib Three was the unit farthest downstream, and again except for the tailrace, contained the largest number of artifacts. The artifactual distribution at the site appears to cluster around the downstream areas of the tailrace and the turbine bay.

Crib Three contained 84 cut nails, 14 wire nails, and five bottles plus four bottle fragments. In addition, this unit contained 62 metal artifacts. While many of these were assorted
Plate 15

Figure 2a  Turbine Bay With Wooden Turbine and Spur Gear in situ.
Plate 149

Figure 247 Recovery of Turbine. Wooden Sill at Right Extends to Dam.
Figure 28. Top and Side Views of Sawmill Rollers.
Plate 17
nuts, bolts, and unidentifiable metal fragments, several other items were definable pieces of mill equipment.

A babbited thrust-top bearing to fit over a shaft end (Ketner 1981) was recovered from the Crib as was a bearing backing plate for a quarter box bearing. A shaker bit for a bolting mill (Johnson 1979) provides direct evidence that flour was being ground and processed at the mill.

Crib Three also contained six fragments of vanes (#29) and what was possibly a portion of a metal turbine housing (#43). This metal turbine housing would indicate that at least one other type of turbine had been in use at the mill besides the wooden tub-type turbine recovered.
The glass artifacts recovered from the mill site consisted of bottles (whole and fragments) and window glass fragments. Crib Three contained five intact bottles and fragments from two others. The intact bottles included two clear glass bottles; one small (4.5 inches high) bottle with a threaded top and a flask-shaped blown-in-mold bottle with no identifiable markings. Two brown bottles were recovered, one a "Coke" bottle and one from E.R. Betterton and Co. Distillers, Chattanooga, TN dated 1885. The last bottle from Crib three was a straight-sided Mason jar. This name on canning jars had become generic, with jars bearing this designation dating from the 1880s to the 1900s (Toulouse 1971).

Dam area One contained a glass bottle fragment dating from the period 1870-1900 (Toulouse 1971). Other areas of the dam contained another brown "Coke" bottle, a La Roma soft drink bottle (Chattanooga, TN) and a "Chattanooga Milk" bottle from the period 1915.

The glass artifacts are all from the period 1880-1920. They can all be located horizontally, but due to the recovery techniques in the underwater areas, few of them can be ascribed to a controlled vertical context. For this reason, the glass artifacts were felt to be of little value in analysis.
Plate 18

Figure 23  Bottles Recovered From Mill Site.
The major artifact recovered from the Brainerd Mill was a simple reaction wheel of a previously unreported type. This wheel, and a shaft for a second wheel, combine features of the traditional tub wheel and the turbine. Figure 2 is an artist's reconstruction of the wheel in its enclosure. The wheel consists of a central drive shaft 1.4 feet in diameter made of southern pine. Connected to the drive shaft by means of slots are nine cast iron buckets or vanes. The depth of the mortises for these vanes is 0.5 inches and the width is 0.473 inches. The buckets are attached, again by means of slots, to an outer tub made of white pine. The tub is composed of curved sections which are grooved to receive the blades. They are also recessed at top and where wrought iron hoops hold the tub together. The slats of the tub are c. 8 inches by 8 inches. Five of these sections survived (Figure 7).

The entire wheel is 2.8 feet in diameter. The superficial resemblance of this specimen to traditional Appalachian tub wheels is obvious (see Wigginton 1973). The Bird's Mill wheel, however, operated in a submerged enclosure, as is true of all turbines.

The upper portion of each bucket is curved in an opposite direction than the lower portion. This feature is in contradistinction to the buckets of the tub wheel. The presence of this reverse curve is the most curious feature of the wheel. Robert
Figure 6: Brainerd Mill Turbine and Enclosure (Artist's Reconstruction).
Plate 19: Close-up of Turbine Showing Vanes Mortised to Wooden Shaft.

Plate 20: Turbine With Mortises For Vanes.
Figure 7: Brainerd Mill Turbine and Base.
Vogel (pers. comm.) feels that the forward curve at the top would do nothing but reduce the efficiency very considerably. The curve in the operating direction, however, is far greater than that in the negative direction, so the wheel would certainly have run.

The buckets of these wheels are interesting from another point of view; they are made of cast iron. This fact suggests that they were the product of an iron foundry rather than a local blacksmith. As a foundry is a rather complex operation involving the ability to melt iron, prepare molds and patterns, and pour the molten iron, it is likely that the buckets were prepared for wider use than one turbine. Ketner (1981) states that several companies in the late nineteenth and early twentieth centuries did provide turbine "kits," where the runner assembly could be ordered separately and later, money permitting, the cast iron shafting could be added. None of the turbines he described, however, contained only the buckets; most were entire turbines requiring only a shaft.

Turbines for low heads were usually of cast iron or cast iron with steel buckets, while high head wheels could be of cast iron, cast bronze or cast steel. It is possible to obtain a higher surface finish of the bucket when it is cast separately, but such separate cast iron buckets must be strongly banded, since there is a tendency for the buckets to work loose. Such buckets were only satisfactory under low heads and where the vibration was
Turbine runners were abraded by the action of sand or other material carried in the water. Cast iron and cast steel resisted this action better than other materials (Mead 1915).

The wheel from Brainerd is a reaction wheel (Ted Penn pers. comm.) and is a very rare example; appearing to be a rare missing link between the impulse tub wheel and the reaction turbine. The true turbine was the result of two separate lines of water wheel development. The first was the lawn sprinkler type and the second was the pressurized wheel that probably resulted from running a tub wheel submerged. The Brainerd wheel is an example of the second type.
The shaft is very large in relation to the tub diameter. Vogel feels that two possible reasons could be given for this; either a mechanical one of providing that much more area at the hub for setting and holding the inner edge of the blades, or the realization that very little of the wheel's effect came from the section at the center, so why not make it as strong as possible.

Penn would not expect a wheel like this to be installed in any New England mill as late as the 1850s. The possibility exists that the wheel, or one like it was installed when Bird rebuilt the mill, in which case the wheel would probably reflect frontier millwrighting. If the wheel had been installed during the missionary period, it would have been a very advanced form of turbine.

The turbine sat in an enclosure (Fig. ) roughly 4 feet square, abutted on the east by a beam or sill 9 feet long. This enclosure, designated Crib Two, was part of a larger enclosure or turbine bay 18 feet on the west (bank) side and 28 feet on the east or creek side where the bay was connected to the dam. The bay was 8 feet wide.

A bay of this size could have held more than one turbine, and in fact, the wooden shaft for another, similar turbine was found in the bay.
Figure 8: Brainerd Mill Turbine Enclosure.
Plate 21: Turbine and Enclosure.

Plate 22: Turbine and Enclosure.
Plate 23
Figure 27 Turbine With Iron Vanes and Wooden Tub Exposed.
TAILRACE

The tailrace is the area where the water is discharged after powering the wheel, and is generally deeper than the surrounding stream. Items which are deposited in the tailrace are subjected to the current of the stream and of the discharged water; many lighter objects would probably have been moved downstream by this water action. Artifacts were located in the tailrace by use of a magnet to find metal, and by "feel". The water had not been diverted prior to the excavation, and was also quite murky. These conditions dictated the mode of retrieval.

The total number of artifacts recovered from the tailrace was 212, excepting three boxes (3x5x7 inches) of cut and wire nails. Of this total, only nine items were non-metal; seven window glass fragments, one stoneware shard, and one bottle. The remainder of the artifacts (96%) were of metal.

The tailrace was the area of greatest concentration of artifacts, even allowing for the skewing in favor of metal items. The artifacts in the race tended to be portions of gearing, shafting, and assorted mill machinery.
A. Mill Pick

A mill pick (#190) 0.4 foot by 0.12 foot recovered from the tail race was identified by Mr. Scott, former miller at Bird's Mill, to have been the pick, or one similar to the one which he had used to dress the stones at the mill.

Mill picks or pickhammers were of cast steel, and were of necessity quite hard. The stones were redressed or sharpened periodically depending on the type of stone, whether they were being run close together, and the type of grain being ground. If the stones were being run daily, they might be dressed every month. Clyde Ketner of Ketner's Mill dresses his stones every six months; the job takes him about a week to complete. The stones at Bird's Mill (Scott 1979) required two to three days to sharpen.

Dressing roughened the stone where the friction of grinding had worn it smooth. It removed as well the grain residue which also made the stones slick. The feel of the flour or meal was the determinant in deciding when to dress the stone (Ketner 1981).

The quality of the steel pick was most important in dressing the stone. The picks had to hold a good edge to keep them from rapidly becoming dull. The tempering of the pick was all important in determining how fine an edge could be achieved, and recipes for tempering solutions were considered equally important. Hughes (1862) published the following scientific formula for
tempering cast steel mill picks:

3 gallons water
3 oz spirits of nitre
3 oz spirits of hartshorn
3 oz white vitriol
3 oz sal ammoniac
3 oz alum
6 oz salt
A double handful of hoof-parings.
Plate 24
Figure 36 Views of Mill Pick.
B. Truss

The truss (#202) is an iron rod 9 feet long with a bolt head at one end and screw threads with a nut and washer on the other end. Although this item had been identified as a roof truss (Brown p.c.), the 9 foot length would perhaps indicate an alternate use. The truss could perhaps have run from an interior wall or beam, but it is unlikely that a work area would have been only 9 feet wide.

An alternative use would have been to support the penstock. Trusses ran from the floor timbers below the turbine to the timbers at the top of the penstock (Grimshaw 1882).

Similar trusses were found in situ in the penstock for two turbines recovered from Trigonia Mill along Nine-Mile Creek, Tellico Reservoir (Lautzenheiser 1982).

Allowing from 2 to 3 feet for the wooden structural members, the head of water would have been from 7 to 6 feet. This is consistent with the head for Bird's mill reported in the 1880 Census.
C. Turbine Fragments

A fragment of a mixed flow turbine runner (#189) helps to identify the type of turbine from which pieces were recovered. Turbines can be classified in accordance with the direction of water flow in reference to the wheel (Mead 1915). A radial flow turbine is one in which the water flows through the wheel in a radial direction, and an axial flow turbine is one in which the general direction of the water is parallel to the axis of the wheel. A mixed flow turbine has flow which is partially radial and partially axial.

Twelve other fragments of a turbine or turbines were recovered. These fragments could represent portions of runners, housing or draft tubes. All of the turbine and gear fragments were of cast iron.

D. Gears

With the exception of a large spur gear located in situ in the bank above the turbine bay, all remaining gears and gear fragments were recovered from the tailrace. Figure 25 shows a spur gear 16.5 inches in diameter, and Plate 26 is a beveled spur gear 21 inches in diameter. Both these gears were in good condition, however, neither gear was recovered with any portion of shafting.

Eleven fragments of gears were recovered from the tailrace. Figure 27 is a sample of typical gear fragments.

No identifiable shafts were recovered apart from the one attached to the spur gear. However, six collars or shaft mounts were recovered. In addition to shaft mounts,
Plate 25: Spur Gear.

Plate 26: Beveled Spur Gear.
Plate 27

Figure 27 Fragments of Gears Recovered From Tailrace.
a babbitted top-step bearing (#269) was found. Babbitt is a soft antifriction metal alloy of tin, antimony, lead, and copper, which is still used as a bearing in water mills (Ketner 1981).

Wedges are metal pieces used to fill the space between the gears and shaft to provide a tight fit and to center the gear. The process of driving iron wedges between the hole in the gear and the shaft was called "staking" (Penn 1981). Seven wedges were recovered from the tailrace. Gear keys and wedges were only found in the tailrace. Seventeen keys (#241) were found in the race, including one which was recovered still attached to the gear. Figure shows a fragment of a gear hub (#270) with the key slot shown. The key slot of this gear was lined with copper.

The water flow to the turbines is regulated by means of a control gate. A portion of this control gate mechanism, a fork (#200), is shown at the top of

A variety of small tools was found in the tailrace, and represented all the small tools recovered from the site. In addition to the previously mentioned mill pick, small tools included a chisel, a wood chisel, two files, two rat-tail files and a wrench.
Plate 28
Figure 3-7
Gear Hub Fragment With Copper-Lined Key Way

Figure 3-7
Gear Key
Plate 29
Plate 30: Top-Control Gate Fork. Bottom-Fragments of Turbines and Gears Recovered From Tailrace.

Plate 31: Wood Chisel.
The selection of a site for the Brainerd Mission appears to have been made on the basis of availability and price, with little regard for the suitability of the site to provide the mission with a profitable working base. The mills were expected to not only provide for the needs of the mission, but supply an excess which would help defray the costs of running the mission and eventually place it on a self-supporting basis. It would seem then that finding a location with a suitable mill seat would have been an important factor in site selection.

Mill seats are, according to Hunter (1979), more numerous and sharply defined in hilly terrain and the upper portions of a river system than in the lower valleys with their gentler slope and typically sedimentary character. The location of the mission along the South Chickamauga Creek was just such a lower valley area and better suited for growing grain than grinding it.

From the evidence of the original dam and 3/4 mile race, it would seem that the mission mill was operated by an overshot or breast wheel. The difference in elevation from the dam to the tailrace below the mill is c. 10 feet on current maps. This would provide 10 feet of head to the wheel.

The obliteration of the original mill by Bird's
rebuilding and the destruction of the race by modern construction, leave unanswered the question of whether or not the gristmill, saw mill and blacksmith were operated from one wheel or a combination of wheels and tub wheels.

The original wheel would have been all wood as would the gearing. Greene's letter to the Board requesting iron gears, as the "timber-killing" influence of the water was necessitating replacement of the wooden gearing quite often, indicates that they still had wooden gears.

An earlier letter from Ard Hoyt in 1823 detailing the need to import iron at a cost of $100 plus $200 for its transportation indicated that at least some iron products were being used. Unfortunately the type of iron was not specified, but with the blacksmith available, it is possible that pig iron was being imported. The need for $150 worth of coal in the same letter raises another interesting question. At such a price, and with the abundance of wood for fuel, it is unlikely that coal would be imported for cooking or heating purposes. Rather it can be assumed that the coal was for use in the smithies.
The missionaries were importing iron and coal in 1823 for some use. They had the capacity for forging, but it would seem from Green's letter that by 1828 they were forging mill gears, and indeed hoped to order them from the north. It would seem then that while they could forge some items, the capacity to cast iron was beyond the range of their operation.

The location of the blacksmith shop would have been near the water supply to operate the trip hammer. No recognizable evidence of the blacksmith operation was recovered.

The continual problems with the mill can possibly be attributed partly to the lack of water-milling knowledge by the missionaries and partly to the physical setting of the mill.
A Journal entry for July 5, 1820, describes the dam failing:

One end of the mill dam gave way. The millwright supposed he had driven the timbers to the rock. It now appears that what he took to be a rock was only gravel. The water found its way under and carried away the bank about a rod wide. This is a painful disappointment, and the repair will necessarily require considerable additional expense. (ARMSM 1820)

Interestingly, investigations of the interceptor sewer line along South Chickamauga Creek revealed a 'buried forest' of water logged organic material. This material, carbon-14 dated at 10,270±, was theorized to have been deposited during a massive flood, and quickly sealed over with a level of alluvium. This organic level, which occurred at a depth of 14.5 to 17.2 feet, overlay a gravel deposit thought to have resulted from a similar event (DeSelms and Brown 1977).

Since this gravel deposit was discovered in two locations only a few miles downstream from the mill, it can perhaps be inferred that the gravel deposit which caused the downfall of the mill dam was a portion of this same level and a result of a Pleistocene flood (ARMS 1820).
The insistence of the missionaries on retaining the dam in its original location almost certainly contributed to the nearly continual problems with the mill. Bird's removal of the dam to its present location at the mill ended the problems with dam failures.

The selection of building material also played a large part in the success or failure of the dam. A significant portion of the original mission dam is still intact; however, it is that portion of the dam which was not subject to undercutting by the current, and has been silted in.

The sections of the dam most susceptible to the current have long since washed away, with the creek forming a new channel in the process of finding the weakest foundations.

Bird's dam, which is still in reasonably good condition, was constructed of log rather than stone. This dam is very similar to the log construction described by Leffel (1881). Leffel stated that log dams were better adapted to a soft bottom.
The retrieval of substantial quantities of gearing indicates that the mill was still using gears rather than belt drives as a mechanism to connect the power source to the machinery.

Cast-iron gearing and shafting had been introduced to the New England textile industry in 1830 (Penn 1981). This system and the earlier all wooden format both suffered from "vibration and bending at every revolution" causing considerable breakage.

Between 1817 and 1818, a change in power transmission was pioneered in England by Fairbanks and Lillie, which replaced the cast-iron shafting with high-speed shafting of wrought iron (Penn 1981). The new technology required nearly a quarter of a century to be integrated into American factories. The shaft attached to the large spur gear recovered from the bank of the turbine bay is cast iron, indicating that high-speed shafting was not used.

Leather belt main drive systems were developed in the second quarter of the nineteenth century (Penn 1981) and were combined with high-speed shafting during the second half of the nineteenth century. High-speed shafting was necessary for the successful operation of the leather belt main drive system. Even though the leather belts and wooden drums on which they turned might not have been preserved, the absence of wrought-iron shafts and the presence of many gear pieces imply that Bird was not taking advantage of the belt drive system.
Early settlement of many areas was partially determined by the availability of water-power for grist and saw milling. Hunter (1979) states that the wide scattering of settlements in small rural areas corresponded for many years to the location of small water power sources on the creeks and brooks.

Mills were important to the settlers in the area of Brainerd, but this area was not a leader in innovations in water power technology. As can be seen from the accompanying chart (Table 1), New York and Pennsylvania led the states in patents granted for water wheels. New York residents were granted 248 patents or 26 percent of the total, and Pennsylvania residents received 114 patents or 12 percent of the total. Tennessee inventors registered only 12 patents or 1.2 percent of the total. One patent was granted to J.S. Lightfoot who operated a mill on Chickamauga Creek near Bird's Mill (Wilson 1976).

While the number of patents can not be taken as the sole criteria for technological leadership, it can certainly be considered a factor.
PATENTS FOR WATER WHEELS ISSUED FROM THE UNITED STATES PATENT OFFICE FROM 1790-1873

Patents listed by state of residence of inventor.

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Table 1: Water Wheel Patents
The fact that Bird succeeded at the site is evident in the reminiscences of William Lightfoot (Wilson 1976). In April, 1886, a flood swept away Bird's Mill, and Lightfoot's mill had to work night and day to take care of customers which would have normally gone to Bird's. There was a waiting line of ox teams, horses, mules, wagons and even boats—sometimes a half mile long.

Business was obviously booming, and Bird's location was suitable for his operation. Bird's Mill Road, later reformed Brainerd Road, was a major artery running from Chattanooga to the mill and north to Cleveland, Tennessee. This road is indicative of the amount of travel to Bird's Mill.

The question can be asked, why did the missionaries fail so miserably at their milling attempts, when Bird did so well? Certainly the newer technology available at the time Bird purchased the mill contributed to his success. Turbines, which could operate successfully under low heads made the Brainerd site more workable. The fact that a mill seat had already been established at that point, made it more convenient to build at the same site. Moving the dam contributed as well to Bird's success.

The missionaries's failure is harder to explain. The technology of mill operation was certainly available and successfully employed in their native New England. Did they perhaps not come prepared to apply that knowledge
to their new home, did their missionary zeal cloud their concepts of reality in attempting the operation of a mill. Or perhaps they attempted to impose their techniques on the new environment without taking into account the actual physical properties of the new location.
The turbine recovered from the turbine bay at the mill was of a more primitive design than one would expect to find in a large commercial mill of the late nineteenth century. While the horsepower of this turbine has not been determined at this time, both Penn and Vogel feel that the device operated very inefficiently.

The 1880 Census described the mill as having four turbines with a combined horsepower of 36. Goodspeed (1887) described the mill as having water wheel capacity equal to 75 horsepower. Even if this horsepower level is an exaggerated claim, it was unlikely that four turbines of the type recovered would have provided the mill with 75 horsepower, or even with 36.

Parts of other turbines were recovered from the tailrace, and a metal turbine is pictured in an historical photograph of the mill (Figure 3), indicating that at least one other type of turbine was in use. If additional, newer turbines were at the mill, it is likely that they were removed for use elsewhere or later salvaged for scrap.

It is not uncommon for millers even today (Ketner 1981) to allow an unused turbine to remain in situ long after it is no longer used, if the space is not needed for additional turbines. Removing a turbine from a covered turbine bay is not particularly easy, and if there is no need to remove the turbine, it can be left in place. This is possibly what happened to the turbine recovered from Bird's Mill; this older turbine was left at the mill, while
the newer turbines were removed when the mill closed.

Examination of the photographs of Bird's Mill accompanying this report, especially figures 3 and 4, show a progressive enlargement of the mill. The turbine bay shown uncovered in figure 7 and covered in figure 6, provides sufficient room for the four turbines reported in the 1880 Census. In fact, in figure 6 a metal turbine can be discerned.

The area under the mill to the right of the turbine bay in figures 2 and 4 appears to be an older turbine bay. This area, immediately adjacent to the bank, and corresponding to the location of the excavated turbine bay may have been abandoned when the new bay was built and the old turbines remained in place.

If such was the case, it can be speculated that the wooden turbine and the second wooden shaft recovered from the excavation were from the period of Bird's first construction of the mill, and prior to the 1880 Census. It can be inferred, that if the missionaries had had sufficient water-power knowledge to have a very advanced model for the time, they would as well have had sufficient knowledge to properly locate the dam and race in relation to the mill. While the turbine in question could have been the result of pioneer engineering, a development of operating a submerged tub wheel; given the operational history of the missionaries, it does not appear likely that they developed the model on their own.

The true turbine was not introduced into America
until 1842, and it can be safely assumed that the frontier settlements did not receive the technology for several more years.
The artifacts at the mill site were distributed with the greatest abundance of items in the tailrace and turbine bay. This distribution reflects the probable location of equipment, gears, shafts, and etc., over the turbine bay. The main drive shafts and spur gears are generally located under the mill, connecting the powering mechanism with the milling equipment. This equipment would tumbled into the turbine bay and tailrace when a mill burns down or is dismantled. An abandoned mill which has been vandalized would also show this distribution pattern, as the easiest method of destruction of heavy gears and shafts would be to roll them down the bank to the tailrace. Even large gears and shafts could be rolled down hill with relative ease, but retrieval would be more arduous, and certainly less satisfying.
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Notes to Typist:

1st—my apologies for my lousy typingD!(see)!

Headings— 1st order, chapter heads;
Centered, All caps

2nd order
Left margin, underlined, First letter caps

3rd order (only in Tailrace section)
Centered, underlined, caps first letter only

Paragraphs—many are indicated to be joined. I used a line and arrow to indicate which ones were to be combined.

Pages—I have to retype, rewrite etc, thus having pages of strange lengths. I have tried to indicate that more was coming by drawing an arrow down to the bottom of the page.

Page numbers—red page numbers are of course, just to keep it in order and have no significance.

Think that's it—good luck!
BRAINERD MILL
TUB WHEEL ENCLOSURE
SCALE: 1" = 1'
BRAINERD MILL
TUB WHEEL AND ENCLOSURE
(ARTIST'S RECONSTRUCTION)
BRAINERD MILL
TUB WHEEL AND BASE
SCALE: 1" = 1'
TUB WHEEL

Scale —— = .5 ft
TUB WHEEL AND BASE

Scale ←→ = .5 ft.