

# METRO-NASHVILLE

*FIRST STEP IN CITY*

**Design — BARGE, WAGGONER and  
General Contractor — CFW**

## **The Problem**



Photo courtesy of the NASHVILLE BANNER.

Nashville, like most similar cities, is plagued with the increasing problem of inadequately sized storm drainage facilities to handle the flash flooding caused by heavy rains of short duration. The basic reason for the growing flood frequency is simple — nearly every improvement within a given drainage area tends to increase the amount of storm water to be handled.

The Wilson Spring Tunnel project is almost a classic example. James Robertson, Nashville's founder, in 1778 chose for his stockade a location on the Cumberland River bluff, with a small creek nearby. As land clearing expanded from Fort Nashboro, one of the early settlers named Wilson selected the head water of this creek, "a pure

limestone spring," as his ground. Thus the creek came to be known as "Wilson Spring Branch."

The watershed for Wilson Spring Branch, containing about 630 acres, is kidney shaped and has an average slope of 3.5 percent from its highest point (on Reservoir Hill) to the river. This is quite typical of Nashville's terrain, with the soil overlaying limestone outcroppings, except along the flood plains of the river and its tributaries.

As the settlement prospered, Nashville's early commerce centered along the river near the mouth of the creek, in the vicinity of First and Broad Streets. Since the basic transportation was by riverboat, all merchants needed to be close by. Then, with business and

industry preempting the lower area, the uplands were subdivided into blocks and finally into city lots. By the time of the Civil War, the entire watershed was considered fully developed. The city's first hospital (now General Hospital) and the predecessors of Vanderbilt, Peabody College, and Montgomery Bell Academy, as well as some of Nashville's first homes, were located in it.

At that time, Nashville's public water system was spring fed and quite rudimentary. The sanitary facilities were worse, consisting of pit privies, or individual or private group pipes to the nearest stream. Thus, epidemics were common, especially typhoid fever during the dry seasons. The populace had a real pollution problem.

# TUNNEL PROJECT —

## FLOOD CONTROL —

### SUMNER Inc., Engineers & Planners

### CONSTRUCTION CO., Inc.

After the Civil War and when the Yankee "carpet baggers" left town, the City undertook to construct a safe water and sewer system. Engineers designed and constructed a water plant up river from the city and soon afterward undertook to solve their sanitary woes. They built brick arch combination sewers in the stream beds and covered the creeks. The Wilson Spring sewer, completed in the 1880's, was one of the first large drainage area projects of the program. "Out of sight, out of mind" is the destiny of sewers unless there is a malfunction; and the Wilson Spring sewer was soon largely forgotten and buildings and other improvements were constructed over it.

In those days, when the best roadway pavements were either brick or cobblestone and every respectable family had a vegetable garden even if their lot width was only 40 feet, a design factor for storm water runoff of 30 percent was conservative. Not so now — for in the post World War II era, business just about eliminated residential use in the area, except for multi-family, and the watershed is nearly fully covered by concrete or asphalt pavements or roofs.

The Wilson Spring combination sewer served the community well for some 70 years, quietly transporting the sanitary waste and rainwater to the river. It was nearly maintenance and operation cost-free. But shortly after World War II, the Corps of Engineers constructed Cheatham Dam and Reservoir Project on the Cumberland River downstream from Nashville as a part of its flood control, navigation, and power development program; and the river suddenly was unable to serve satisfactorily as Nashville's sewage disposal system. Therefore, in the middle 1950's Nashville constructed a sewage treatment plant and interceptor sewers, and ceased to dump raw sewage into the river. A large regulator was built at the interceptor's junction with the Wilson Spring sewer to divert the sanitary flow to the new wastewater plant.

Concurrently, the upper section of the drainage area was changing from middle class residential and small shop commercial land use to sites for large commercial establishments. Several truck terminals, large warehouses, and even the main Sears-Roebuck retail store moved into the area. Most of these newcomers required large parking lots in addition to sizable buildings. With this redevelopment, the storm water run-off factor was more than doubled and complaints about flash flooding along the route of the Wilson Spring combination sewer began to flow to the City's Department of Public Works.

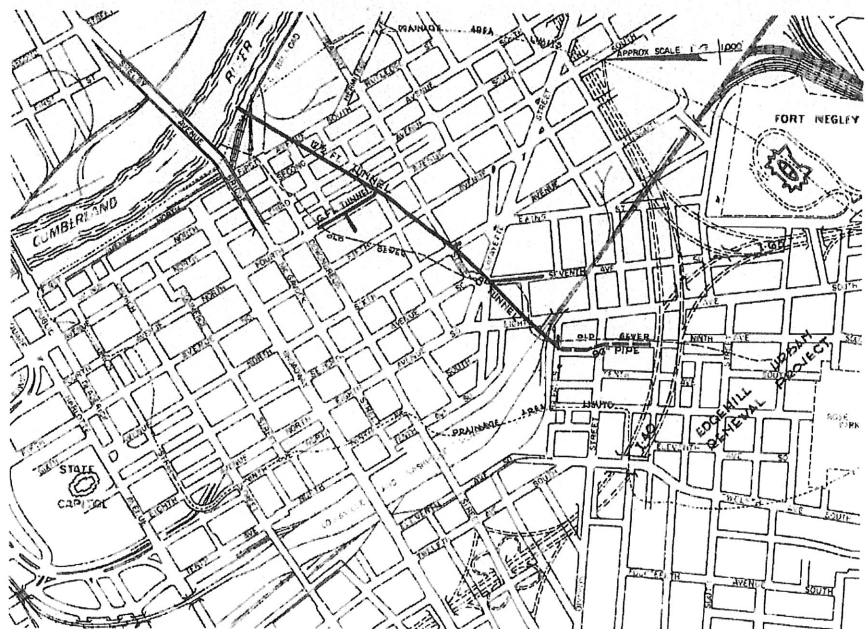
In March and again in September, 1962, particularly intense rain showers occurred in this section of town, and businesses over a 30-block area had flooding problems. With that the Department of Public Works authorized the firm of Barge, Waggoner & Sumner to make an engineering study to determine the most feasible solution to the problem.

From a survey of existing facilities, the problem was obvious. The existing

trunk sewers were grossly overloaded, some sections as much as 500 percent. Several rainstorms occurred during the study period, giving the Engineers good opportunities to observe first-hand the flooding conditions. By this time some of the businesses had become so used to the problem that signs were posted giving the employees specific instruction for damage preventive measures. Such instructions included that doors be closed and chinked, equipment moved, etc., once the flooding commenced. This procedure was workable because there was a ten minute or so lag between the time the trunk sewer would fill to capacity and begin to surcharge from the street inlets or manholes until the pounding of water reached the floor levels.

The Engineers concluded that the only answer was to increase the capacity of the storm drainage system. For example, the existing sewer was 84 inches in diameter at the river outfall, against a required 120 inch diameter for

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25 year design storm frequency. Corresponding increases were recommended along the entire route and the surface inlet capacity needed doubling in order to convey the runoff to the sewer without objectionable ponding.

Since the existing sewer had many buildings over it, and sanitary flow present at all times, it was not feasible to simply enlarge the existing sewer; nor were funds available to construct a separate sanitary system. Therefore, it was recommended to construct a new storm facility and let the existing sewer remain as a sanitary sewer.

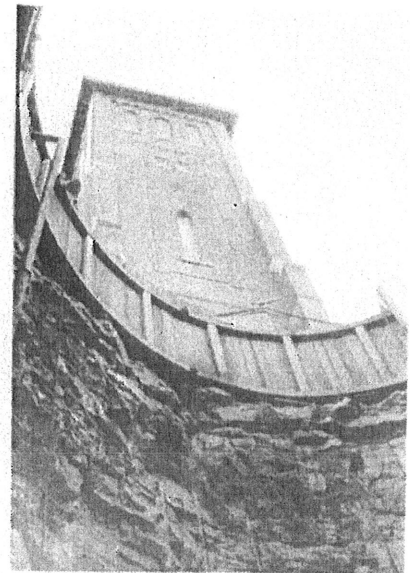
Because of extreme depths required to intercept the storm flow from existing lateral trunks, the installation of the new sewer would have required the closure of streets along its route during the construction period. This would have seriously interrupted many businesses, as well as created a severe traffic problem affecting the entire downtown area. Thus, the installation of a tunnel was selected as being the most economical construction method for the project. The tunnel was proposed from the river southwesterly to a point just beyond the L & N Railroad Yards, a distance of about 0.8 mile. A 12.5 foot horseshoe section on a 0.25 percent slope was proposed for the first half mile; then it was reduced to an 8.0 foot horseshoe on a 1.32 percent slope. It was proposed that the remainder of the trunk sewer be installed by open cut method in conjunction with an urban renewal project.

Subsurface explorations by the firm of Geologic Associates, local Consulting

Geologists, proved that the initially selected route, which generally followed the old sewer in street right-of-way (thus requiring no easements), did not present a favorable tunneling situation because of unstable subsoil, badly weathered rock, and considerable "mixed face" work. Working in conjunction with the Geologists, the Engineers selected a route which offered much sounder bedrock conditions and which was also 600 feet shorter because it traversed the area diagonally instead of following streets.

However, there was one disadvantage to the new route not paralleling the existing sewer more closely. The property owners along the old sewer were demanding the new sewer to relieve their flood problems, whereas in the location selected some of the owners were above flood and therefore not too anxious to be cooperative. Since Nashville has a policy of not paying for easements for storm drainage facilities which do not damage the property, the job of obtaining easements required extra persuasion.

The construction plans required the excavation of a minimum of 8 inches beyond the inside face of the tunnel, plus the thickness of all shoring, blocking, or lagging where unstable bedrock conditions required bracing and installation of a plain concrete lining. The contract was set on a lump sum basis, with adjustable allowances for steel bracing, rock bolts, and consolidation grouting. Junction chambers with stub-outs for future lateral trunks and sufficient new curb



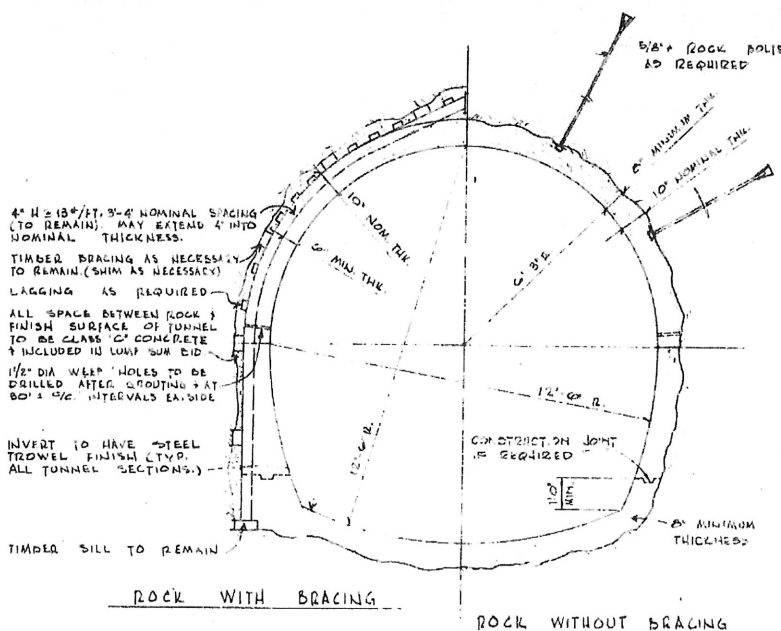
SHAFT - 4th & Franklin St.  
"Didn't knock off a brick"

inlets to receive the overflow from sub-areas were included. Special type manholes referred to as "bleeders" were designed for the existing combination sewers to retain the dry weather flow in the old sewer and divert the storm overflow to the tunnel.

In November, 1965, seven bids for the tunnel construction were received by the City for the project, with C.F.W. Construction Company of Fayetteville Tennessee, submitting the lowest responsible bid at \$1,749,000.

The Contractor elected to excavate the tunnel using two shafts, one about midway of the 12.5 foot section and the other midway of the 8 foot section. The advantage of this selection of shafts was that it permitted the operation to work both ways from each shaft and alternate drilling and blasting crews with excavation ("mucking") crews. Mine railroads were installed with lift-off car bodies to haul the excavation from the tunnel heading to the shaft. At the shaft a large crane simply lifted the ten-ton car body loaded with blasted rock, raised it some 40 or 50 feet to the ground surface, and dumped the rock into a waiting truck. Some 30,000 cubic yards of limestone rock were so handled. Working two 10-hour shifts, five days per week, the Contractor completed the excavation in approximately eight months.

The excavation work required extreme care in the blasting operations, especially where the tunnel passed directly under buildings. A minimum of claims for blast damage was experienced; and, in fact, the only significant claim on the project was for minor settlement cracks where the tunnel roof failed under the concrete block building. Many building occupants were unaware that the blasting was occurring beneath them.

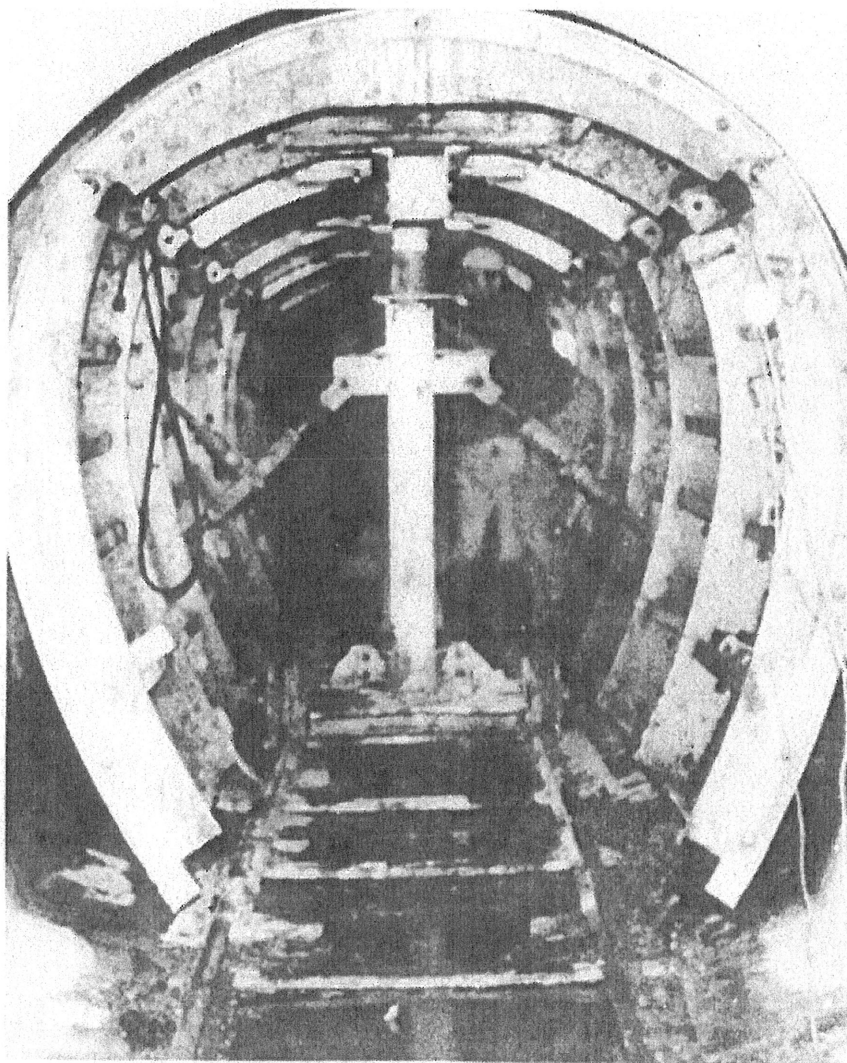


TYPICAL SECTION  
OF TUNNEL

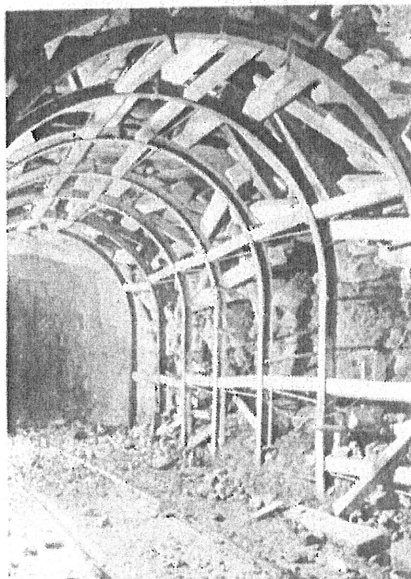


The 8 foot section, which required less excavation, was completed first in order to permit the concrete lining operation to commence at the high end of the tunnel. The base of the horseshoe section was poured first without forms except for the keyway for the wall and roof section. The metal inside forms used for the wall section were so designed that they could be collapsed and one 50 foot length pass through another. This permitted a pour nearly every working day. Concrete was placed against the limestone bedrock, which was scrubbed in an attempt to make it bond. No reinforcing steel was used in the concrete lining except in the vicinity of junction boxes or peculiar load situations. Concrete placement was handled by an "Airplaco" machine which used compressed air to transport wet material to the forms. Transit mix concrete was placed in special rail cars at the shafts, hauled to the location, and the railroad track dismantled as the base section was poured toward the shaft. Except for shrinkage cracks caused by excessive heat during curing, which problem was soon remedied by use of both a retarding compound in the concrete and large fans to circulate cool air, the concreting operation worked quite smoothly.

After completion of the concrete lining, holes were drilled in the top and sides of the tunnel at regular intervals and each was pressure tested with water to insure against voids between the concrete and bedrock. Where the test pressures indicated leakage of water, grout was pumped into cavities until the holes were sealed. As ex-



The metal form for concrete lining in a semi-collapsed position. It had just been threaded through a freshly poured section in the background.



Steel bracing was required to support the bedrock in weak zones. This "bad ground" section extended for less than 20 feet.

pected, grout acceptance was insignificant except in locations where the bedrock was so badly weathered that a large amount of bracing and shoring had been required. Weep holes were then drilled in the side of the tunnel about two feet above the invert to relieve the hydrostatic pressure on the structure.

The outfall for the tunnel was placed at the minimum Cumberland River elevation to reduce the sedimentation in the tunnel. Although the river stage fluctuates frequently, depending on rainfall and electric power generation at dams both upstream and downstream, enough hard rains are expected while the river is at low stage to occasionally flush out sediment caused by higher stages.

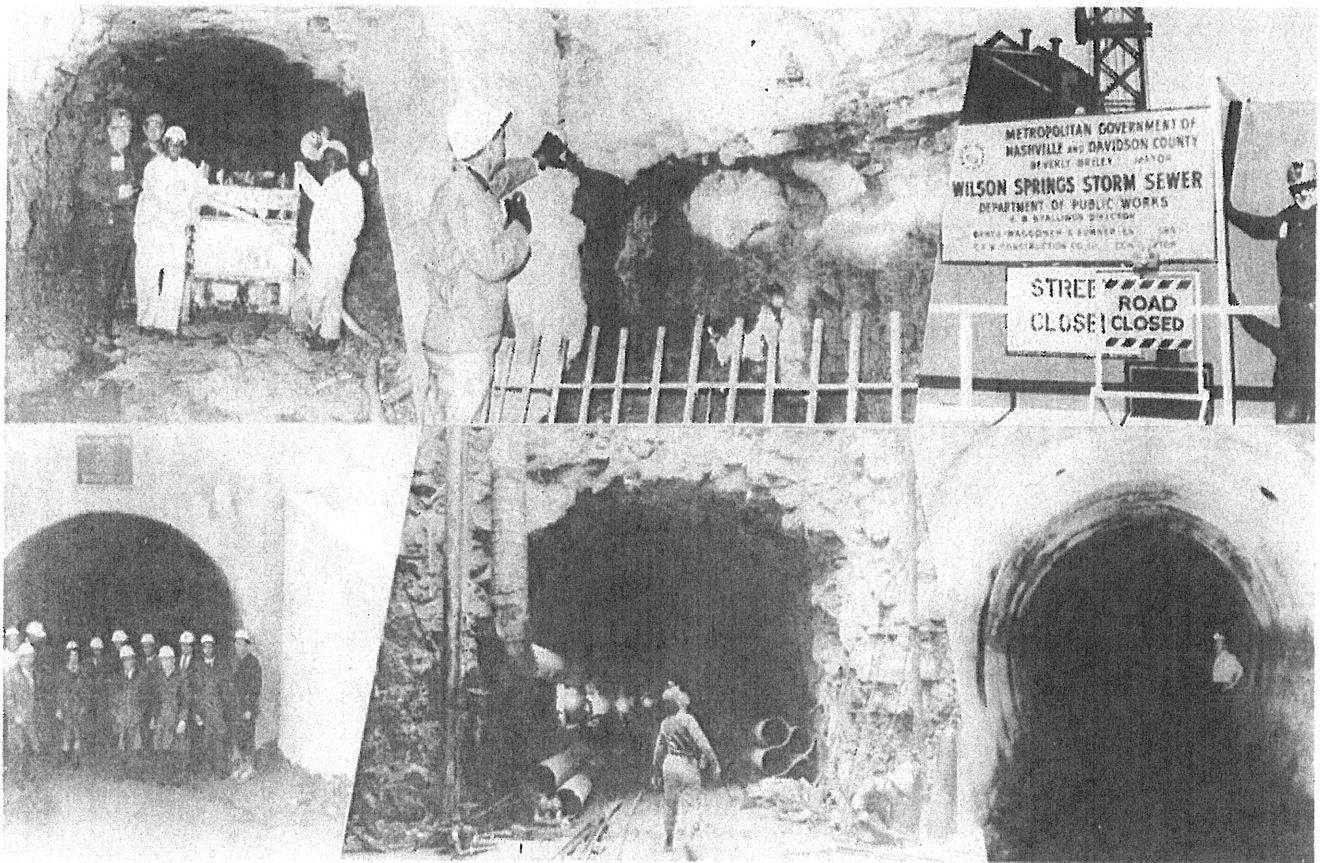
The Contractor waited until the main shaft was nearly complete before commencing the outfall structure, which required a coffer dam to dewater the construction area. His reason was to avoid delays by river floods. This

method of construction gave the Engineers some concern that a hard rain might suddenly fill the shaft with water and trap the workmen. The Tunnel Superintendent was careful to keep all inlets covered and connections to the existing sewers blocked, as well as to provide emergency pumping equipment to prevent this. His plan was justified because no sooner had they holed through to the river than it rose and completely flooded the tunnel for about half its length.

The tunnel project was completed in May, 1967; and although there have been several storms exceeding those previously observed to cause flooding, no complaints have been received from the former problem area. Annual inspections of the completed works have been made by representatives of the Department of Public Works, the Consulting Engineer, and the Contractor. The facility is apparently functioning well.

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W. R. Carter, P.E., and R. E. Whitmore, P.E., President and Vice President, respectively, of C.F.W. Construction Company, were in general charge of the construction and Ernie Moore was the Tunnel Superintendent. The late Karl B. Stalling, P.E., Director of Public Works for Metropolitan Nashville, administered the project. Dan Barge, Jr., P.E., had general charge of the study, location, and design, assisted by Thomas B. Lee, P.E. The Resident Engineer for the consulting firm was N. Turner Dunn, P.E.

In 1969 the firm of Walton Construction Company installed a 976 foot extension of 96 inch diameter storm drain from the end of the tunnel south to the Interstate 40 right-of-way. This project was handled as a site improvement contract for the Edgehill Urban Renewal Project under the administration of the Nashville Housing Authority. Its total construction cost was \$263,698.

The further extension of the system across the Interstate Highway is now under construction by Oman Construction Company. It is scheduled for completion in 1972. After the highway and subsequent urban renewal projects are completed, there will still remain two lateral trunks which must be replaced to completely solve the surface drainage problems in the Wilson Spring area.

## AESTHETICS—EFFICIENCY—ECONOMY

Maryland has become the first state in the nation to require underground wiring for virtually all utility wires in future construction. Halting the aesthetic destruction of the landscape is the major purpose of the new regulation, but the underground wiring is also expected to increase reliability and lower maintenance costs.

In several new subdivisions in Davidson County, telephone lines are below the surface.

In mid-July Maryville received its first two underground transformers to be used in the utility board's installation of underground electrical wiring in the downtown area.

Two Tennessee cities, Lawrenceburg and Brownsville, have adopted subdivision regulations drawn up by TSPC which contain the following:

"Utility lines including but not limited to electric communications, street lighting and cable television shall be required to be placed underground unless it is established that the installation is impractical or economically unfeasible. Except for street lighting, the subdivider is responsible for complying with the requirements of this section and he shall make the necessary arrangements with the utility com-

panies for the installations of such facilities..."

The requirements of this section are designed to reduce safety hazards, improve the appearance of the community and assist in enhancing and stabilizing property values...

## THE CEC/USA LIFE MEDICAL INSURANCE PLAN

The CEC-USA LIFE—Medical Insurance Plan has recently distributed an outstanding Fall 1970 Progress Report, which shows the Program is continuing to grow at an accelerated pace, having doubled in size for the fifth straight year!

The CEC Plan now offers its excellent coverage to U. S. employees overseas and they also cover "Third Country Nationals" employed by CEC firms around the World. For a copy of the new Progress Report, or other information, please contact John O. Felker, Administrator, 401 Pine Street, St. Louis, Missouri 63102.

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