experimental disciplines throughout the experiment. For instance, in the design and construction of Marvel, great care was taken to achieve an 'ideal calculable shock tube,' that is, a smooth tunnel surrounded by homogeneous media (alluvium) with a minimum of discontinuities. This was done in order to minimize the assumptions required for numerical simulation of the experiment.

In addition to the design and construction of Marvel and the dynamic and postshot experimental results, this paper describes the numerical codes, the initial conditions for the calculations, and the results of the calculations.

1. GENERAL DESIGN AND CONSTRUCTION OF THE EXPERIMENT

The original excavation for Marvel consisted of a vertical access shaft 1.2 meters in diameter, which terminated at a depth of 176 meters below the surface in a working room with dimensions approximately 6 × 4 × 4.5 meters high (see Figure 1). Later, the nuclear energy source was placed in this room at a position designated as the 'working point' in Figure 1. A main drift with a cross section of 1.5 × 2.1 meters was excavated horizontally for approximately 122 meters from the working point. Four alcoves, each 6 meters long and 1.5 × 2.1 meters in cross section, were excavated at right angles to and off the main drift. The centers of these alcoves were located at distances of approximately 30, 61, 83, and 102 meters from the working point. At the end of the main drift, a fifth slightly larger alcove was located in line of sight with the working point. The fifth alcove was used for early-time luminosity measurements. The results of these measurements have been reported [*Glenn and Crowley*, 1970].

Vertical cased holes for instrumentation cables were drilled from the surface to the back of each alcove. When instrumentation of the alcoves was completed, the alcoves and vertical cable holes were solidly backfilled with a grout that closely matched the density of the surrounding alluvium (~1.7 g/cm^3). After backfilling, only a volume of approximately 10 m^3 in the end of the fifth alcove remained, which permitted access by personnel at a later time.

To construct the final tunnel, 0.45-meter sec-

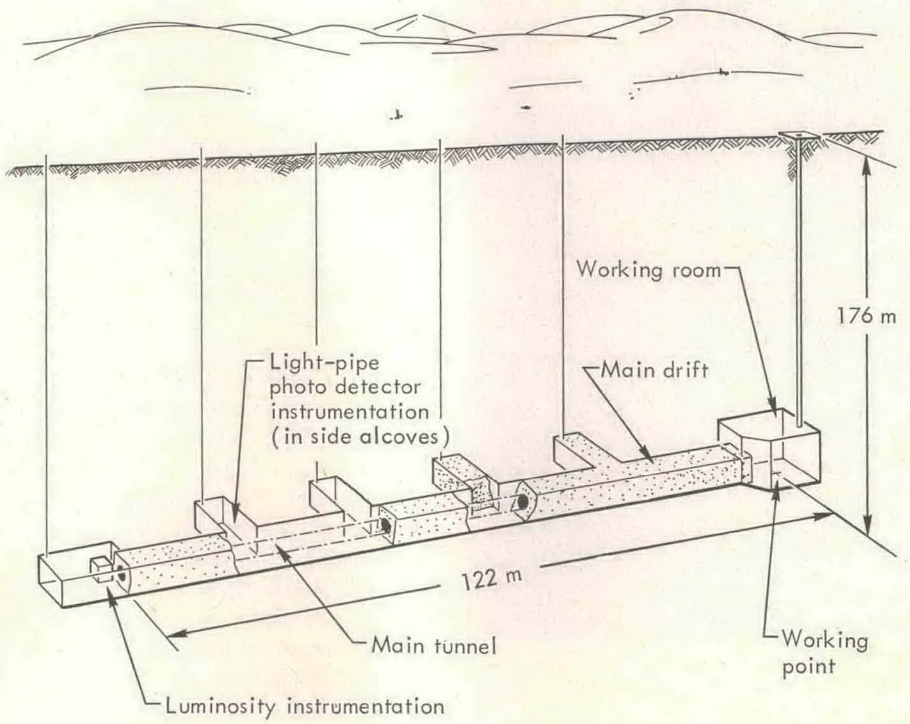

Fig. 1. General design of the Marvel experiment.

tions of circular Transite pipe (1.0 meter i.d., 1.07 meters o.d.) were placed along the 122-meter drift (Figure 2). In addition, five wall sections containing chemical tracers were located at specific distances from the working point. Details of these tracer sections and their use in obtaining ablation information are discussed in the next section. All the Transite and tracer sections were carefully joined with epoxy cement. A final examination of the 245 Transite and tracer sections in the assembled 122-meter tube showed an average offset in the joining of the sections of less than 0.3 cm. The remaining portion of the drift outside the Transite tunnel was then completely backfilled with the density-matching grout.

The energy source was placed in a specially designed cylindrical canister, 1.0 meter in diameter and 1.5 meters long. This canister was so designed that when the shock left the canister (1) the energy source would be homogeneous (i.e., the pressure would be nearly the same throughout the canister); (2) the shock down the tunnel would be a plane hydrodynamic shock (i.e., the emerging shock would span the diameter of the canister); and (3) the initial shock starting into the alluvium from the working point would be cylindrical. These requirements on canister design were made in order that the assumptions required to model the energy source region numerically would be minimized. The canister design was achieved by studying the effects of the arrangement of various materials within the canister on numerical calculations (L. A. Rogers, private communication, 1968; G. Pelsor, private communication, 1967).

After installation of the nuclear energy source, the working room was completely sandbagged. The main access shaft was then stemmed with gravel.

Thus, considering practical limitations (see Figure 2), great care was taken to achieve an 'ideal-calculable-shock-tube' design with a homogeneous source and no significant discontinuities in either the final tunnel or the surroundings. As discussed in Section 3, this design is readily adaptable to numerical modeling.

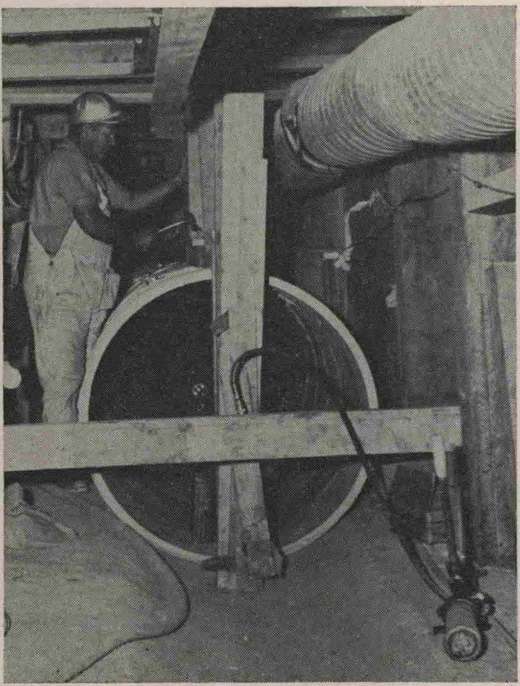

Fig. 2. Installation of the Transite pipe in the main drift. The concrete trough was first poured and cast to facilitate proper alignment of the Transite pipe sections.

2. Experimental Measurements

Dynamic Measurements

Instrumentation for obtaining dynamic data was installed along the 122-meter tunnel as well as in the alluvium above the detonation. The tunnel instruments included: (1) light-pipe photodetector systems [*Glenn and Crowley*, 1970] and tourmaline crystal gages; (2) slifers [*Heusinkveld and Holzer*, 1964] along the tunnel as well as perpendicular to the tunnel into the four alcoves; (3) stress-history gages in each of the four alcoves; and (4) specially designed cavity gas-pressure instrumentation at a position 100 meters from the device. The free-field alluvium instruments included slifers and stress gages placed in a vertical instrument hole parallel to the access shaft and 9.8 meters from the working point. Figure 3 shows the relative positions of the instrumentation used to measure the dynamics of the shock.

Air-shock time-of-arrival detection at the four alcoves. The time of arrival (TOA) of the air shock down the tunnel was determined at each of the four alcoves with a light-pipe photodetector system. A tourmaline crystal gage was mounted adjacent to these optical systems in