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PRODUCTION OF A WAVE GUIDE FOR THE DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT, DEPARTMENT OF NATIONAL DEFENCE, SHIRLEY BAY, ONTARIO

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PHYSICAL METALLURGY DIVISION

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SUMMARY

A precision casting method has been developed for the production of a wave-guide casting. A low melting point tin-bismuth alloy was used and several of the resulting pieces have been submitted to the Defence Research Telecommunications Establishment for testing.

The method should be adaptable to other shapes of wave guide if required.

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INTRODUCTION

A request was received on October 10, 1956, from the Defence Research Telecommunications Establishment, Department of National Defence, Shirley Bay, Ontario, represented by Messrs. D. R. Faire and M. Czaharynski, for assistance in the production of a wave-guide component. This consisted of a tapered rectangular section tube with the inside dimensions as shown approximately in Figure 1.

It was explained, by Messrs. Faire and Czaharynski, that the dimensions and surface finish of the wave guide had to be held to close limits and that various methods of manufacture previously attempted (e.g. assembly of machined parts, electroforming, etc.) had proved either unsatisfactory or much too costly.

A machined and nickel-plated male model of the cavity was supplied by the DRTE (see Figure 2A) and it was decided, as a first attempt, to cast an aluminium block with a slightly undersized cavity (using a graphite core to be made at the DRTE) and then to press the steel model into the cavity. It was hoped that this final hobbing operation would result in a cavity of the required surface quality and dimensions. However, when this was tried, the aluminium adhered to the steel, especially on the parallel section (see Figure 1) and made satisfactory withdrawal of the form impossible.

From these experiments it appeared that similar forming methods were not very promising, and it was suggested that a casting method using a low-melting-point alloy of the tin-bismuth type might prove successful. Although the electrical properties of these alloys are not suitable for the application, it was later proved that this difficulty could be overcome by silver-plating the cavity.

The remainder of this report, therefore, is concerned with the development of a method of casting the wave guide component in a bismuth-tin alloy.

INVESTMENT CASTING

The plated steel model core was first coated with wax to the required thickness (approximately 1/16 in. or 1/8 in.), and then invested with a plaster-of-Paris and water mixture in a cylindrical open-ended flask and the plaster allowed to set. After removing the steel core and wax, the mould was dried at a temperature of about

100°C (see Figure 2B). The mould was then cooled, the steel core replaced, and the assembly heated to a predetermined temperature for pouring.

The composition of the alloy selected was 58% Bi and 42% Sn ("Cerrotru" of the Cerro de Pasco Copper Corporation), and it was chosen because it suffers little or no change in volume on solidification. It is approximately of eutectic composition with a melting point of 139°C, and therefore has good casting properties.

The molten alloy was poured into the cavity left by the wax, the steel model acting as a core. Both top and bottom pouring were used, the gate being at the narrow end of the casting in each case. Bottom pouring appeared to give the better results.

The temperatures of the mould and steel core were varied independently from room temperature to about 150°C. However, although several promising castings (see Figure 2C) were produced (the best of these was submitted to the DRTE for examination), the plaster moulds were rather fragile and only two or three castings could be made in each. As it seemed likely that a considerable number of castings would have to be made in order to establish optimum conditions, more permanent, graphite moulds were designed.

In the course of the work, some difficulties were experienced with contamination of the surface of the core by the bismuth-tin alloy. This resulted in severe roughening of the surface of the core, necessitating frequent cleaning. The difficulty was overcome by coating the core with a thin layer of colloidal graphite.

Neither top nor bottom pouring was entirely satisfactory or convenient, and an alternative casting arrangement was adopted together with other improvements in technique which were incorporated in the final method used. This is described below.

CASTING IN GRAPHITE MOULDS

Graphite was selected as the material for the mould, for the following reasons:-

1. It is not wetted by the molten alloy.
2. It is easily machined to the required dimensions.
3. It is readily available.
4. It has sufficient strength for the purpose.

The mould cavity was machined as shown in Figures 2D and 3. It will be seen that the section was circular (for convenience in machining), so that the wall thickness of the casting varied considerably.

The mould and core were mounted for casting in a drill press as shown in Figure 4A. A rubber sheet was placed between the mould and the base of the drill press, in order to seal the bottom of the mould cavity.

The mould and core were usually preheated before casting. The parts were then assembled as shown in Figure 4A and molten metal was poured into the mould cavity. The core was then lowered into the mould, displacing molten metal, until the base of the core located itself in the countersink in the top of the mould. Figure 4B shows the core in position in the mould. (For the photograph, no metal was used.)

This method of casting avoided gating and running difficulties, the metal being quiescent when the core was inserted. Also, close control could be kept over core, mould and metal temperatures and over the speed of immersing the core.

In the earlier tests small laps were formed on the inside surface of the casting. These were minimized by placing the whole mould assembly on the table of a mechanical vibrator during the insertion of the core. (See Figure 4A and 4B.)

Some work was carried out to determine the optimum casting conditions; factors such as mould, core and metal temperatures being varied over a wide range. This showed that the method was relatively insensitive to casting variables, since reasonably satisfactory results could be obtained over a wide range of conditions.

However, further work would be necessary to establish the optimum values more exactly. Discussion with representatives of the DRTE indicated that changes would be made in the dimensions of the parts, so that further detailed work on the present wave guide seemed superfluous once the casting method was established.

The castings thus obtained (see Figure 2E), while still containing minor imperfections, were of acceptable quality and several were submitted to the DRTE for testing.

CONCLUSIONS

A method has been developed for casting a wave guide component in a low-melting-point tin-bismuth alloy. The method appears to be capable of yielding a part having the desired dimensional accuracy and surface finish; it appears to be adaptable to a fairly wide range of sizes, and could give high productivity for this class of work.

Further work on the project will depend on the future requirements of the Defence Research Telecommunications Establishment.

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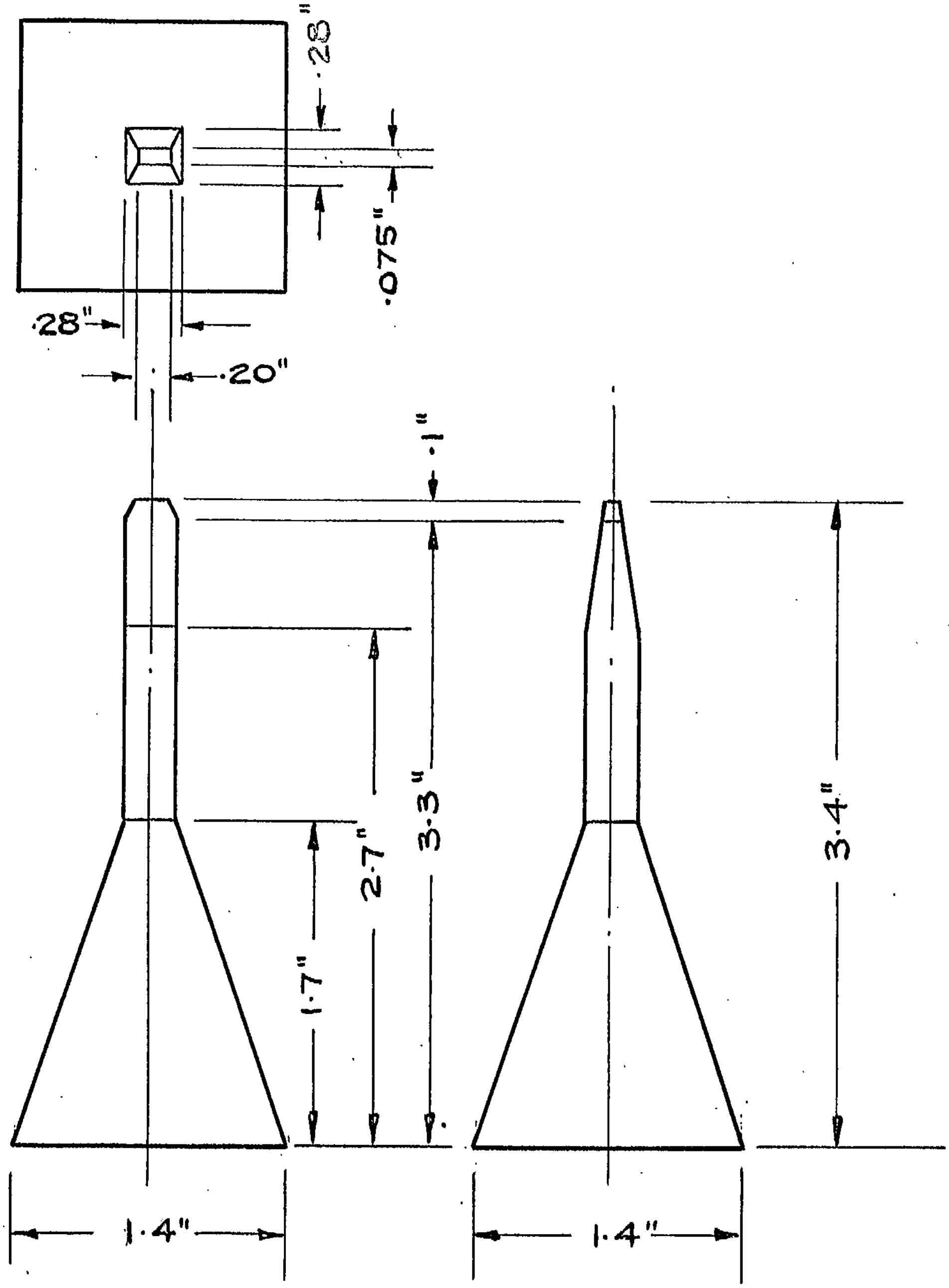
(Figures 1-4 follow,)
(on pages 7 to 10.)

FIGURE I. SKETCH TO SHOW APPROXIMATE INTERNAL DIMENSIONS OF WAVEGUIDE COMPONENT



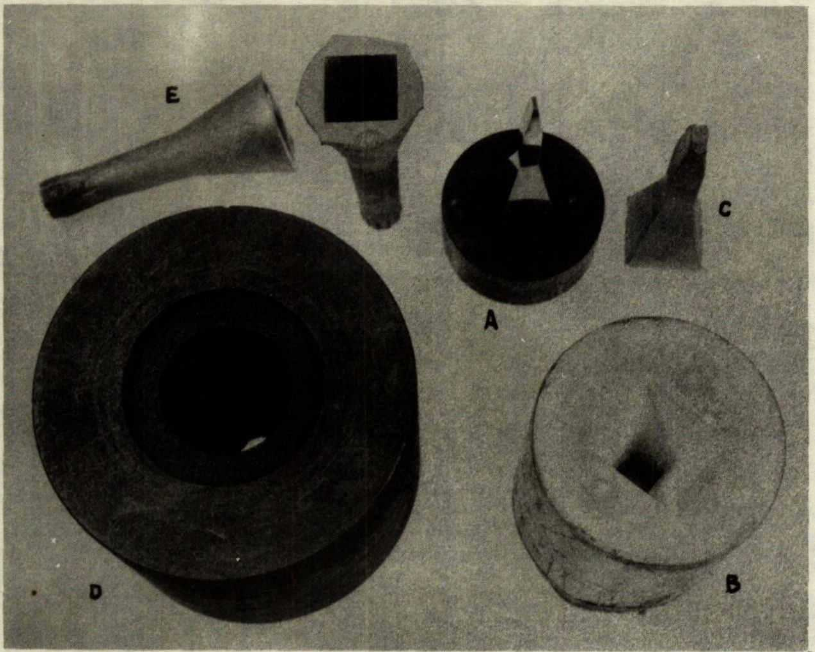


Fig. 2.

A. - Steel core.
B. - Plastic mould.
C. - Wave guide casting made in plaster mould.
D. - Graphite mould.
E. - Wave guide castings made in graphite mould.

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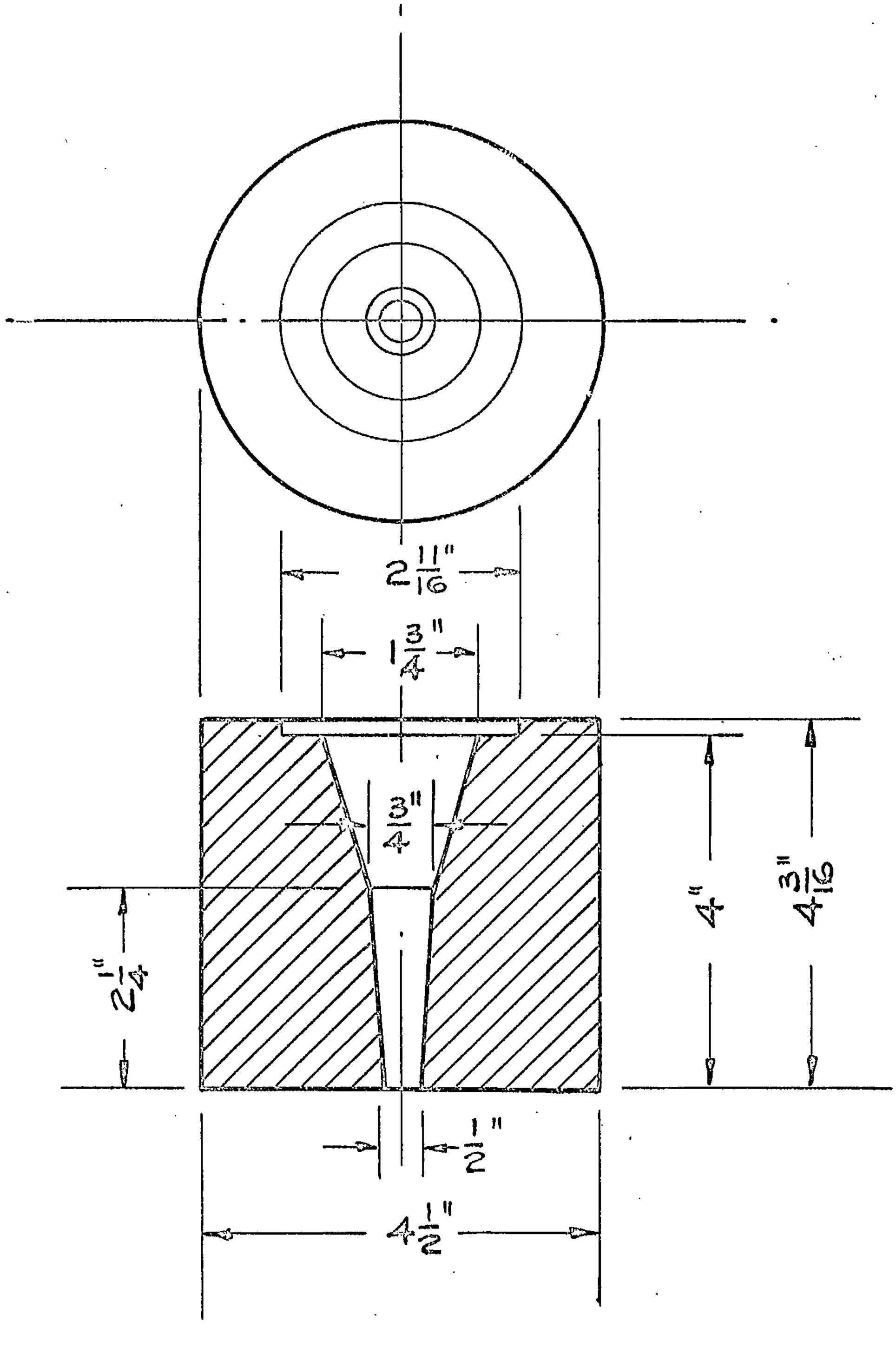
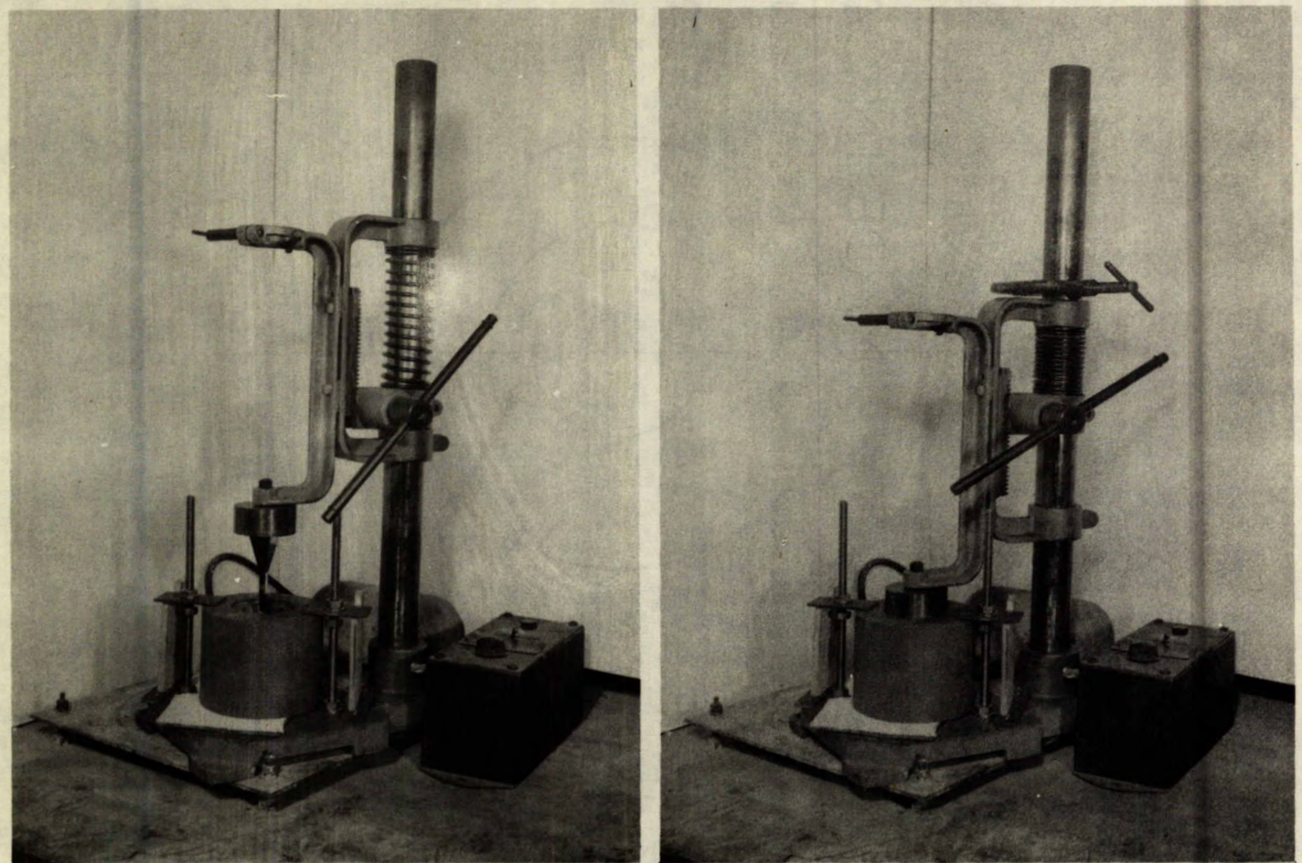


FIGURE 3. SKETCH TO SHOW DIMENSIONS OF GRAPHITE MOULD



A. B.

Figures 4A and 4B. General arrangement for casting in graphite mould. The core is mounted in the moving head of the drill press (raised in A, lowered in B) and the assembly is resting on the table of the mechanical vibrator.

(For the photograph no metal was used.)

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