1. INTRODUCTION

The testing of gas turbine components at simulated flow conditions poses equivalent problems to those associated with reentry flow, in that large power levels and facility and components made of sophisticated materials or cooled by complicated systems, etc., are required. Extensive development of intermittent facilities has been made, however, to overcome these problems in hypersonic flow testing (Ref. 1) by reducing to to an insignificant amount the time over which the high power levels are applied and, since wall temperature rises during a test are small enough that materials used in everyday applications can be used, eliminating the materials problems. Only recently have such methods been applied extensively to turbomachinery problems (Refs. 2, 3, 4).

The Mach numbers achieved in turbines are close to unity causing the test section size to be of the order of the throat size. For a useful test section size the nozzle volumetric flow rate must hence be large. The temperature level required to simulate correctly the gas-to-wall temperature ratio of an advanced gas turbine (1600 K gas temperature with 1000K blade temperature is usual) using ambient temperature models is only a modest 500-600 K. The requirements of a short duration facility for simulating advanced turbine conditions should thus be that a large volumetric flow rate of gas heated to a modest temperature should be maintained for times of the order of 1/10 second so that meaningful measurements of pressure and heat transfer rate could be made in the running time.

At first, shock tunnels were adapted for this application (Refs. 2, 3). More recently, a new type of facility, named the Isentropic Light Piston Tunnel (ILPT) has been devised by Jones, Schultz and Hendley of Oxford University mainly for turbomachinery applications (Ref. 5). This group has now started operation in a hot cascade version of this concept with a test section of 14cm x 7cm.

A pilot facility using this concept has been installed at VKI in which work on heat transfer and film cooling of turbine surfaces is in progress. A hot cascade facility, similar to that at Oxford, but with a test section size of 20cm x 10cm, is being installed at VKI for operation in Summer 1976. An opportunity is taken in this short course to describe the Isentropic Light Piston Tunnel concept and give a progress report of the present activities in the VKI facilities.

2. THE CONCEPT OF THE ISENTROPIC LIGHT PISTON TUNNEL

2.1 Description of cycle

The principle of the facility is illustrated in figure 1. The test gas is contained in a tube and is compressed and heated isentropically by a piston which is propelled by gas entering the tube from a high pressure reservoir. When the test gas has been compressed, and hence heated to the required temperature, it is allowed to flow through the test section and the pressure within the tube may be maintained constant if the volumetric flow rate of gas into the tube from the high pressure reservoir is the same as that leaving through the test section. The facility is then operating in what is known as the "matched" mode. The starting of the test flow is normally by the breaking of a diaphragm or the quick opening of a shutter valve.

The result of the cycle, in theory, is initially to create a monotonically rising pressure in the tube, which then remains constant between the time that the test flow starts and the piston reaches the end of the tube. After this latter event the pressure in the tube then continues to rise until the reservoir gas flow is stopped. The pressure, and hence temperature, variation seen in the test section is then expected to follow a step-like variation as illustrated in Fig. 1. Such a behaviour of flow is most suitable for the application of transient techniques for measuring heat transfer rates on surfaces, but at the same time has a long enough running time that a wide range of not necessarily highly sophisticated pressure transducers can be used.

The theory of the concept has been thoroughly dealt with in reference 5 and in the following paragraphs only the main features are presented.

2.2 Theory of an ideal facility

The simplest configuration to consider is that the reservoir has an infinite volume and choking occurs at the