

AD-A115 427

WEAPONS SYSTEMS RESEARCH LAB ADELAIDE (AUSTRALIA)  
A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF SMALL ARMS--ETC(U)

F/6 19/4

FEB 82 K H ADAMS

UNCLASSIFIED

WSRL-0256-TM

NL

1-1  
1-1



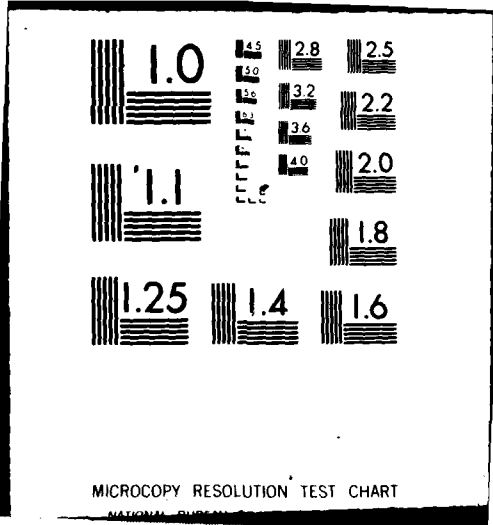
END

DATA

FILMED

7-82

DTIC



WSRL-0256-TM

AR-002-813

12



AD A 115427

**DEPARTMENT OF DEFENCE**  
**DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION**  
**WEAPONS SYSTEMS RESEARCH LABORATORY**

DEFENCE RESEARCH CENTRE SALISBURY  
SOUTH AUSTRALIA

**TECHNICAL MEMORANDUM**

WSRL-0256-TM

**A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF  
SMALL ARMS AMMUNITION**

K.H.J. ADAMS

**DTIC**  
**ELECTE**  
**JUN 10 1982**  
**S** **D**  
**E**

Technical Memoranda are of a tentative nature, representing the views of the author(s), and do not necessarily carry the authority of the Laboratory.

Approved for Public Release

DTIC FILE COPY

COPY No. ....

FEBRUARY 1982

82 06 10 052

UNCLASSIFIED

AR-002-813

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

WEAPONS SYSTEMS RESEARCH LABORATORY



TECHNICAL MEMORANDUM

WSRL-0256-TM

A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF  
SMALL ARMS AMMUNITION

K.H.J. Adams

S U M M A R Y

A compact ballistic range has been set up for measuring action time, in-barrel pressures and muzzle velocity for small calibre ammunition. Inexpensive commercial sky screens have been modified to provide a very accurate velocity meter.



Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

POSTAL ADDRESS: Chief Superintendent, Weapons Systems Research Laboratory,  
Box 2151, GPO, Adelaide, South Australia, 5001.

UNCLASSIFIED

## TABLE OF CONTENTS

	Page
1. INTRODUCTION	1
2. DESCRIPTION OF RANGE FACILITY	1
2.1 Summary	1
2.2 Projectile catcher	1
2.3 Velocity meters	1
2.4 Gun firing platform	4
2.5 Instrumentation	5
3. ACKNOWLEDGEMENTS	8
TABLE 1. TYPICAL RESULTS FROM THREE VELOCITY METERS (A, B AND C)	4

## LIST OF FIGURES

1. Layout of ballistic range	1
2. Schematic of commercial sky screen (actual size)	2
3. Arrangement of screens on an optical beam	2
4. Construction of modified screen	3
5. Universal platform for small calibres	4
6. Instrumentation room	5
7. Schematic arrangement of instrumentation	6
8(a). Pressure time plot from IBM 370	7
8(b). Pressure time plot from HP9825 onto an HP9872	7

### 1. INTRODUCTION

A ballistic range (Range D) is being established within WSRL for the research and development of propellants which are used in rounds up to 40 mm calibre. Propellants for larger calibre weapons will need to be proven on a range outside the laboratory area.

It was evident that a compact range for assessing small arms ammunition (up to 9 mm) was also needed to cater for the extensive firing programmes proposed. This ballistic range has now been established. It embodies a miniature and very accurate muzzle velocity meter which has been developed from inexpensive commercially available electronic chronometers, and a digital data acquisition system for in-barrel pressure measurement. The latter system initially stores pressure data on tape (cassette) and thence via a secondary tape it can be analysed in the DRCS IBM 370 computer. This system, it is considered, might have further application where trials data are recorded at ranges outside the Laboratory area. More usually the data are processed in situ in a small dedicated desk top computer and the results plotted locally.

### 2. DESCRIPTION OF RANGE FACILITY

#### 2.1 Summary

The small arms Ballistic Range comprises four adjacent rooms (figure 1) which house a projectile catcher, velocity meters, a gun mount and instrumentation respectively.

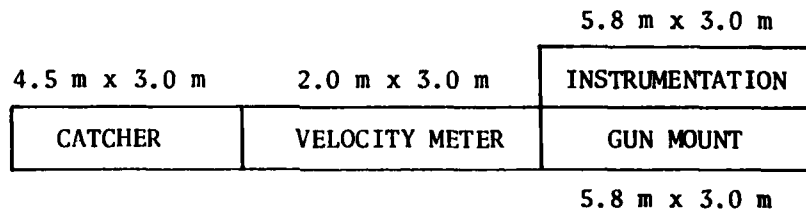


Figure 1. Layout of ballistic range

#### 2.2 Projectile catcher

The catcher comprises a simple wooden box (1.25 m x 0.65 m x 0.6 m). The first 0.6 m is filled with sawdust and the remainder with gravel. A 25 mm steel plate is mounted at the far end of the catcher at an inclination of 45° to the line of fire. The whole unit is contained in a concrete walled room.

#### 2.3 Velocity meters

The velocity meters embody Oehler type II sky screens which have been modified to improve accuracy and artificial illumination has been provided. The Oehler sky screen comprises a silicon detector diode contained in a housing which collimates light onto the diode by means of two slits as shown in figure 2.

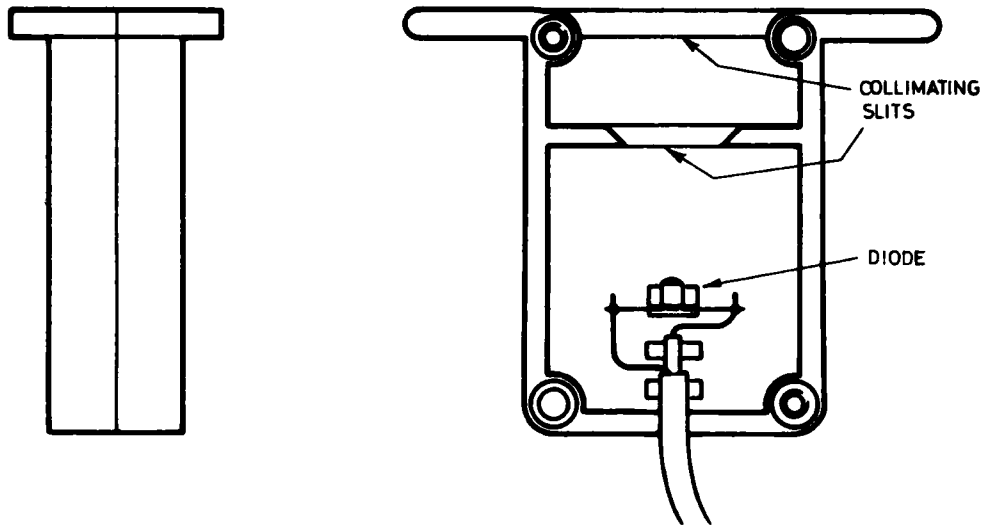


Figure 2. Schematic of commercial sky screen (actual size)

The diode is reverse biased and conducts only when illuminated. A projectile passing above the slit (within an angle of approximately  $40^\circ$  subtended symmetrically at the diode) reduces the radiance falling on it ephemerally and hence the current. The small current change is amplified and starts a one megahertz clock contained in an associated chronometer; a second sky screen at a known distance from the first stops the clock. The time of flight between the two screens is thus timed and the velocity computed.

Three pairs of screens have been employed to provide redundancy and a cross check on accuracy. They are mounted on a two metre long optical bench and each pair has been set at 1.5 m apart.

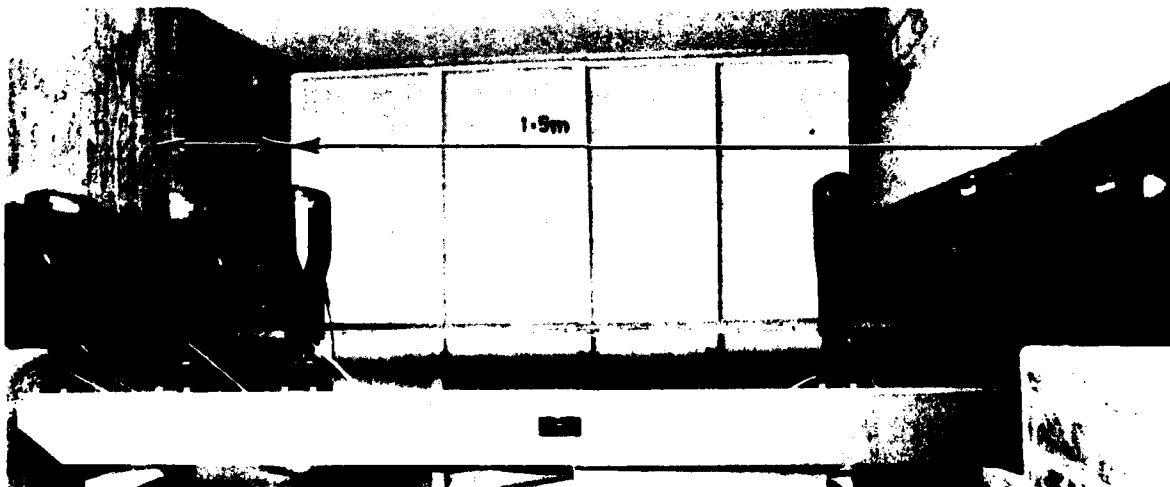


Figure 3. Arrangement of screens on an optical beam

Artificial illumination is achieved indoors by mounting a 500 W quartz iodine strip light above each screen. The accuracy of measurement of muzzle velocity by this method depends on the accuracy with which the screens can be positioned relative to one another and the precision with which they sense the passage of the bullet above them. Each screen should trigger the clock when the projectile is in precisely the same position relative to it. The following steps have been taken to optimise the accuracy.

(a) The diodes in the screens were preselected to have near identical electrical and optical characteristics.

(b) The radiation falling onto each detector diode was collimated precisely by placing a cylindrical reflector behind the quartz lamp and a convex lens on the front face of the screen (figure 4).

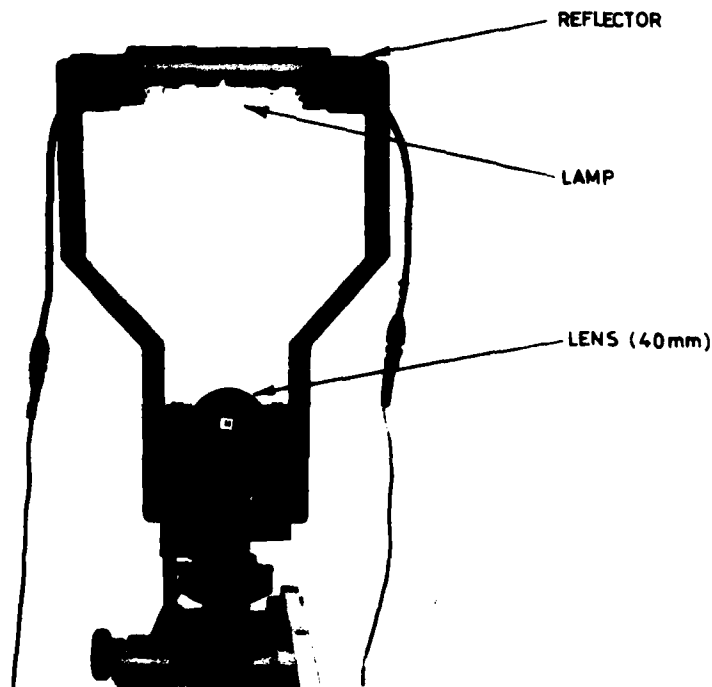


Figure 4. Construction of modified screen

(c) The intensity of illumination was adjusted to produce the same current in each diode at the maximum sensitivity.

(d) Accurate separation of the screens to  $\pm 0.1$  mm was achieved by mounting on the optical bench.

These four modifications have improved the accuracy from about 1% to better than  $\pm 0.05\%$ . The accuracy was judged by comparing the differences between three pairs of screens. Typical results are shown in Table 1.

TABLE 1. TYPICAL RESULTS FROM THREE VELOCITY METERS (A, B AND C)

Firing No.	Velocity (m/s)		
	C	B	A
1	839.8	839.3	839.3
2	848.8	849.3	848.4
3	867.0	867.0	866.5
4	846.5	846.9	846.0
5	850.3	849.8	849.8
6	859.5	859.1	859.1
7	852.7	853.2	852.7
8	855.6	855.6	855.1
9	873.6	873.1	873.6
10	866.0	865.5	865.5

Some spurious triggering of individual screens was observed. Much of this was due to electrical pickup in the unshielded leads from the chronometers to the screens. Replacing the leads with triaxial cable eliminated most of the problem.

#### 2.4 Gun firing platform

All barrels are mounted on a locally designed platform shown in figure 5. The proof barrels are dimensioned to fit into the V blocks on this platform which also allows the use and measurement of controlled recoil. The firing mechanism comprises a conventional bolt action (P14 Rifle) and trigger.

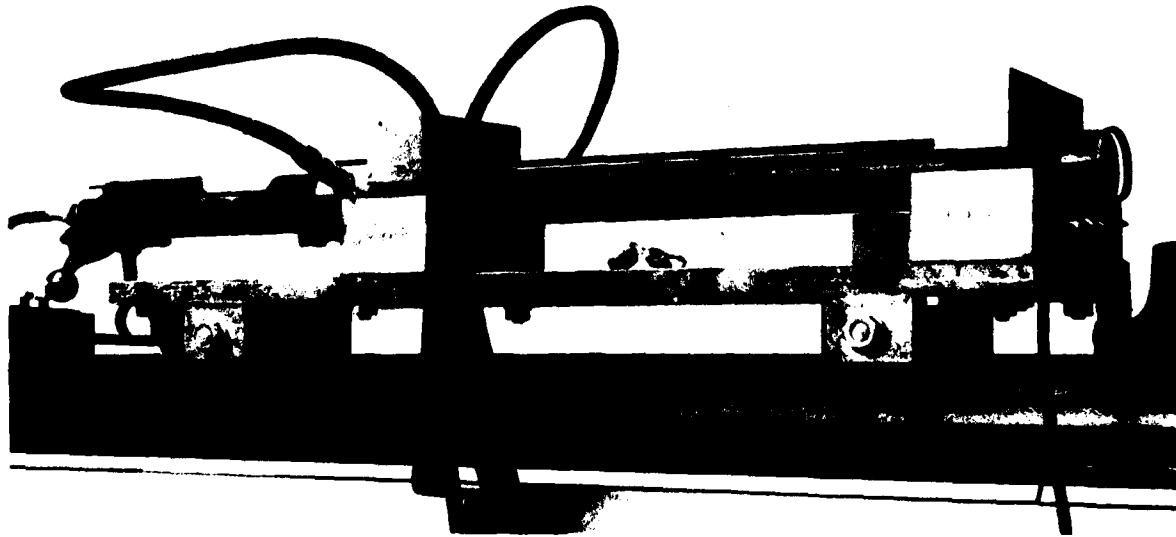


Figure 5. Universal platform for small calibres

Figure 5 shows a 5.56 mm proof barrel in place with two Kistler type 6203 quartz pressure gauges mounted diametrically opposite one another at the cartridge case mouth. The gauges are calibrated to 500 MPa. Currently up to four pressure transducers can be installed in any arrangement of positions on a barrel and the pressure versus time transient recorded. Action time is also measured and is defined as that time interval between primer strike and muzzle exit. The former is measured by insulating the firing pin in the bolt from the remainder of the equipment. The instant when the firing pin strikes the primer can then be detected electrically and the event recorded. Muzzle exit time is recorded by detecting the ionized gases which accompany the bullet when it emerges from the barrel. This is achieved by placing, at the muzzle, an insulated copper ring. It becomes negatively charged by the gases to a preset potential to operate a Schmidt trigger.

### 2.5 Instrumentation

The electronic equipment to record and process the outputs from the velocity screens, the pressure gauges and the action time circuits is housed in an adjacent room (figure 6).

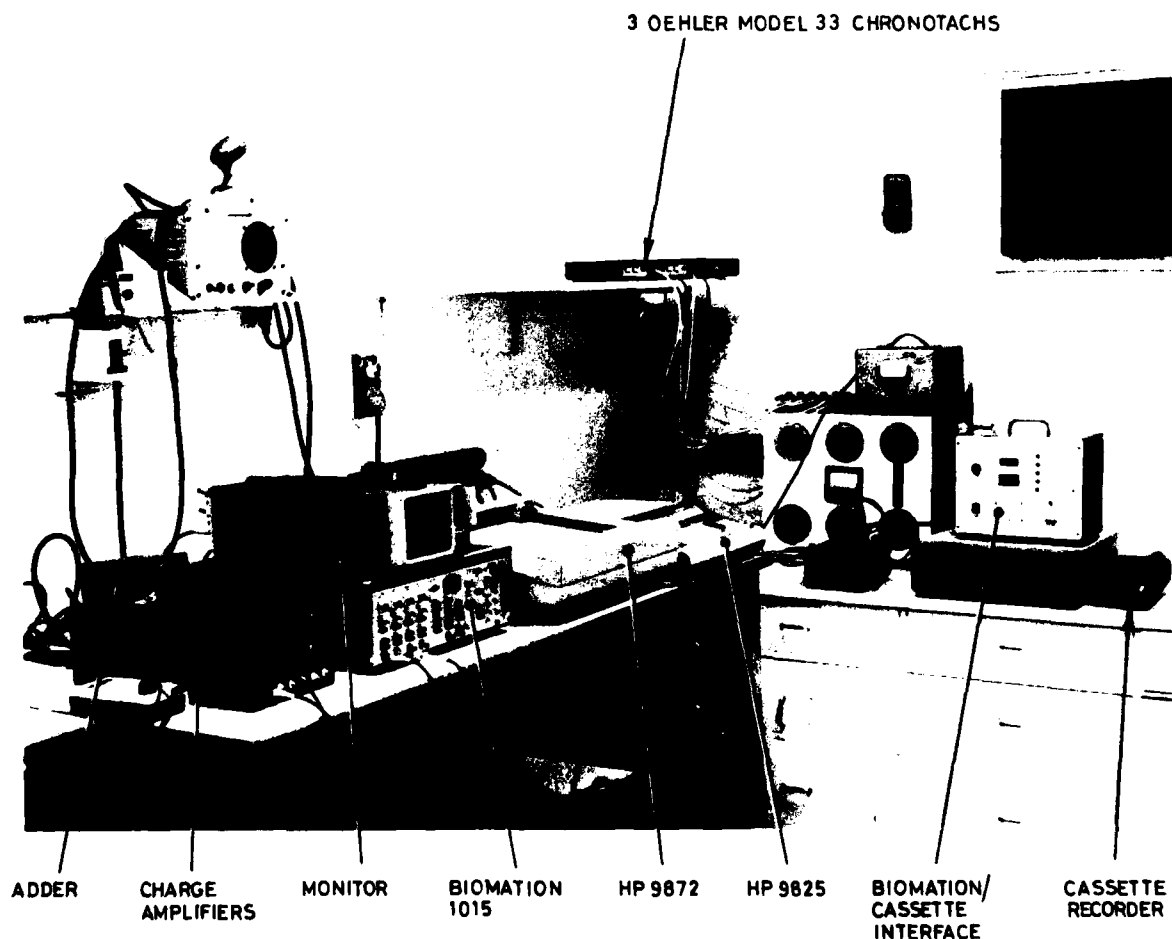
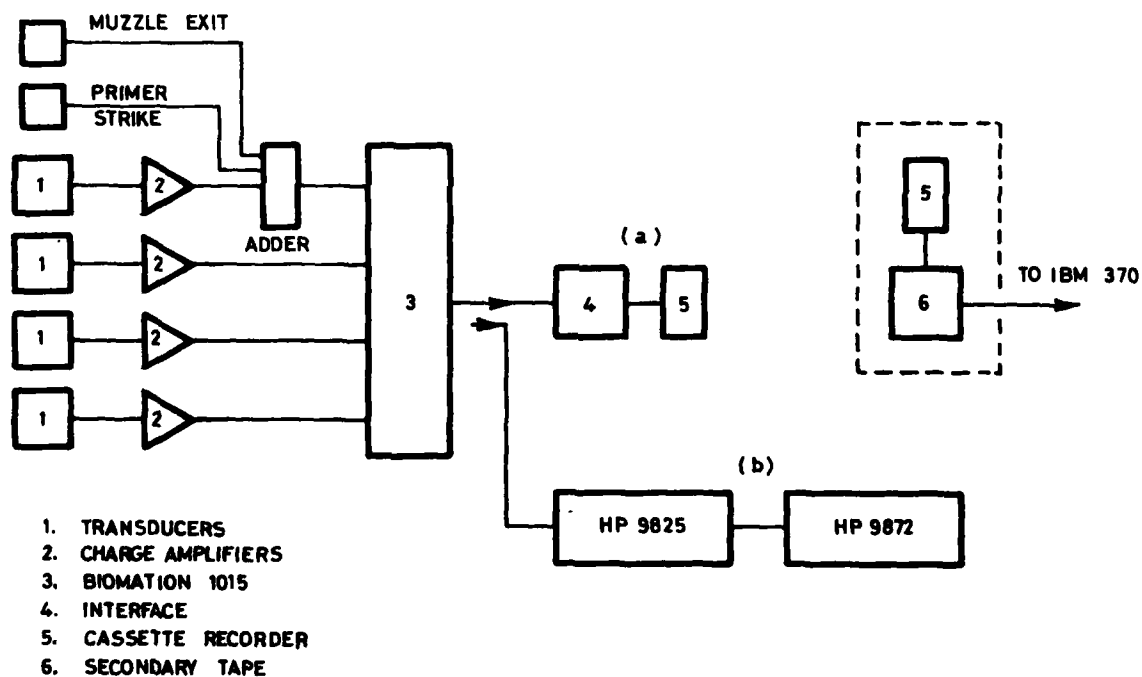


Figure 6. Instrumentation room

The three chronometers associated with the velocity screens are housed in this bay. They embody a 1 MHz clock and microprocessor. Each value of velocity is stored in the microprocessor memory. Statistical data are then calculated from a batch of firings.

Signals from up to four pressure gauges are preconditioned in charge amplifiers (Sundstrand, PCB or Meclec) and then stored in a digital transient recorder (Biomation type 1015). The digitised pressure data are then transferred to magnetic tape via a locally designed interface and thence via a secondary tape to the DRCS IBM 370/168 computer as a data set. This data can then be accessed by any range user at any computer terminal in DRCS for further analysis.

However, data are usually transferred to the memory of an HP9825 desk top computer which is housed in the instrumentation room and processed in situ. The pressure time curve is plotted on an HP9872 plotter. A schematic of these two alternatives is shown in figure 7.



(a) IBM 370

(b) HP9825

Figure 7. Schematic arrangement of instrumentation

Typical plots from both systems are shown in figure 8(a) and (b).

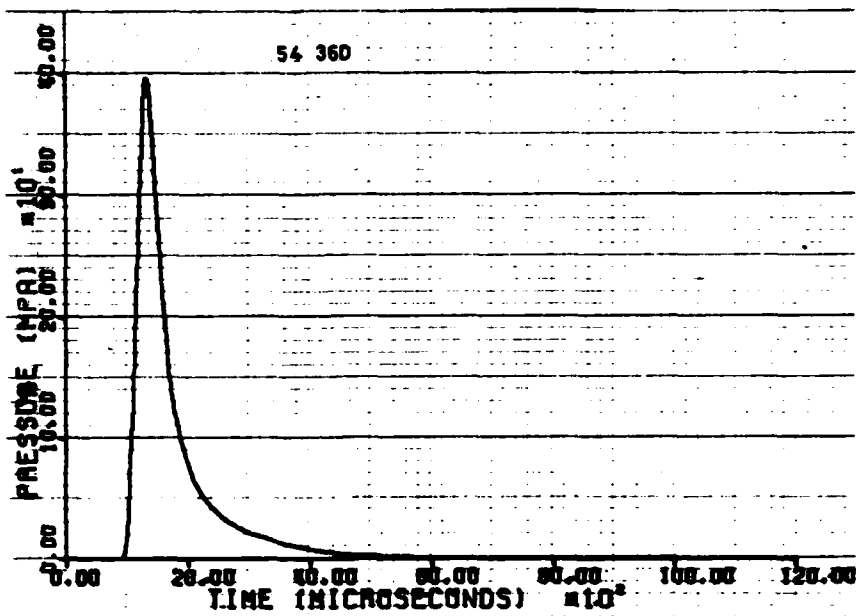


Figure 8(a). Pressure time plot from IBM 370

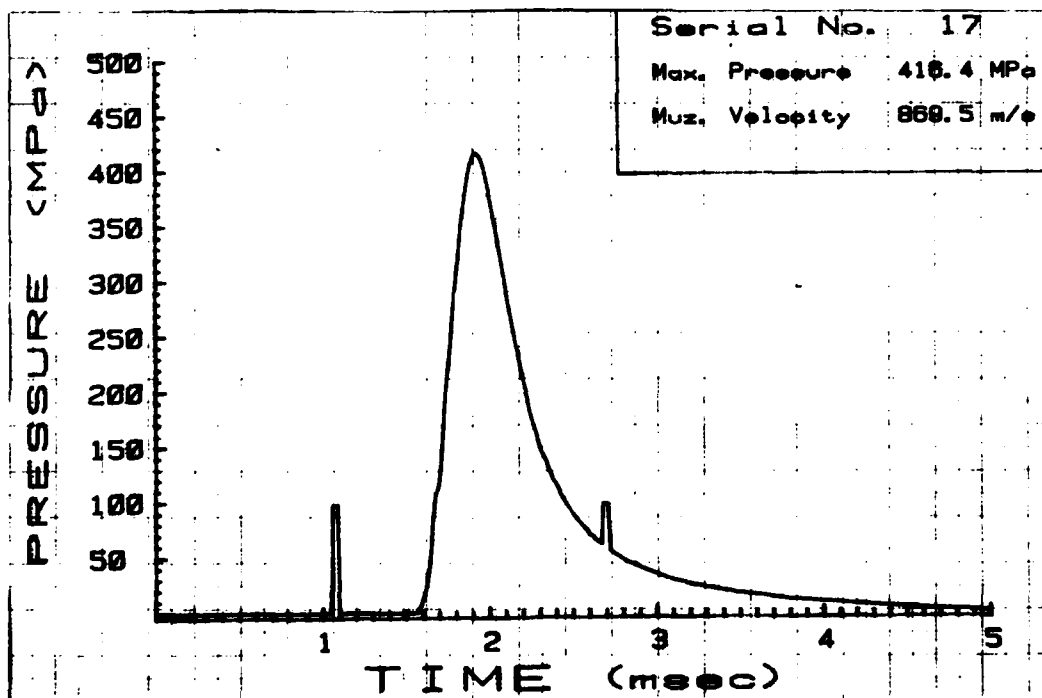


Figure 8(b). Pressure time plot from HP9825 onto an HP9872

### 3. ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of Messrs J.H. Holcroft, R.T. Hammond and W.D.A. Preston in setting up the range, the Electronic Workshops (AEL) who designed the Biomation cassette interface, Mr D.R. Kirk who developed the associated software and to Dr A.R. Rye who programmed the HP9825.

## DISTRIBUTION

	Copy No.
<b>EXTERNAL</b>	
<b>In United Kingdom</b>	
Defence Science Representative, London	No Copy
British Library Lending Division Boston Spa York	1
<b>In United States of America</b>	
Counsellor, Defence Science, Washington	No Copy
National Technical Information Service	2
<b>In Australia</b>	
Chief Defence Scientist	3
Deputy Chief Defence Scientist	4
Superintendent, Science and Technology Programmes	5
Director, Joint Intelligence Organisation (DSTI)	6
Army Scientific Adviser	7
Navy Scientific Adviser	8
Air Force Scientific Adviser	9
Document Exchange Centre Defence Information Services Branch (for microfilming)	10
Document Exchange Centre Defence Information Services Branch for:	
United Kingdom, Ministry of Defence, Defence Research Information Centre (DRIC)	11
United States, Defense Technical Information Center	12 - 23
Canada, Department of National Defence, Defence Science Information Service	24
New Zealand, Ministry of Defence	25
Australian National Library	26
Director General, Army Development (NSO), Russell Offices for ABCA Standardisation Officers	
UK ABCA representative, Canberra	27
US ABCA representative, Canberra	28

	Copy No.
Canada ABCA representative, Canberra	29
NZ ABCA representative, Canberra	30
President, Australian Ordnance Council	31
Director, Armaments and Electronic Material (Army Office)	32
First Assistant Secretary, Computing Services	33
Army Quality Assurance Division	34 - 35
Defence Library, Campbell Park	36
Library, Engineering Development Establishment	37
Library, Aeronautical Research Laboratories	38
Library, Materials Research Laboratories	39
Department of Industry and Commerce	
Deputy Controller, Munitions Supply Division	40
Manager, Explosives Factory Mulwala	41
Manager, Explosives Factory Maribyrnong	42
Manager, Explosives Factory Albion	43
Manager, Ammunition Factory Footscray	44
Manager, Munitions Filling Factory St Mary's	45
Director Industry Development, Regional Office, Adelaide	46
<b>WITHIN DRCS</b>	
Chief Superintendent, Weapons Systems Research Laboratory	47
Superintendent, Propulsion Division	48
Research Director, Gun Propulsion	49
Principal Officer, Gun Propulsion Research Group	50
Principal Officer, Rocket Propulsion Research Group	51
Principal Officer, Propulsion Systems Group	52
Principal Officer, Nitrocellulose Propellants Group	53
Principal Officer, Composite Propellants and Explosives Group	54

	Copy No.
Mr N.V. Ayres, Nitrocellulose Propellants Group	55
Dr P.J. Carson, Gun Propulsion Research Group	56
Dr C.W. Fong, Nitrocellulose Propellants Group	57
Mr M.R. Grivell, Gun Propulsion Research Group	58
Mr R.T. Hammond, Gun Propulsion Research Group	59
Mr J.H. Holcroft, Gun Propulsion Research Group	60
Mr I.R. Johnston, Gun Propulsion Research Group	61
Mr D.R. Kirk, Nitrocellulose Propellants Group	62
Dr R.M. Lough, Propulsion Systems Group	63
Dr A.R. Rye, Gun Propulsion Research Group	64
Mr I.L. Thompson, Propulsion Systems Group	65
PD Library	66 - 67
DRCS Library	68 - 69
Author	70
Spares	71 - 76

DOCUMENT CONTROL DATA SHEET

Security classification of this page

UNCLASSIFIED

<p>1 DOCUMENT NUMBERS</p> <p>AR Number: AR-002-813</p> <p>Series Number: WSRI-0256-TM</p> <p>Other Numbers:</p>	<p>2 SECURITY CLASSIFICATION</p> <p>a. Complete Document: <b>Unclassified</b></p> <p>b. Title in Isolation: <b>Unclassified</b></p> <p>c. Summary in Isolation: <b>Unclassified</b></p>
<p>3 TITLE</p> <p>A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF SMALL ARMS AMMUNITION</p>	
<p>4 PERSONAL AUTHOR(S):</p> <p>K.H.J. Adams</p>	<p>5 DOCUMENT DATE:</p> <p>February 1982</p> <p>6 6.1 TOTAL NUMBER OF PAGES 8</p> <p>6.2 NUMBER OF REFERENCES.</p>
<p>7 7.1 CORPORATE AUTHOR(S):</p> <p>Weapons Systems Research Laboratory</p> <p>7.2 DOCUMENT SERIES AND NUMBER</p> <p>Weapons Systems Research Laboratory 0256-TM</p>	<p>8 REFERENCE NUMBERS</p> <p>a. Task: DST 20/050</p> <p>b. Sponsoring Agency:</p> <p>9 COST CODE:</p> <p>333 361965</p>
<p>10 IMPRINT (Publishing organisation)</p> <p>Defence Research Centre Salisbury</p>	<p>11 COMPUTER PROGRAM(S) (Title(s) and language(s))</p>
<p>12 RELEASE LIMITATIONS (of the document):</p> <p>Approved for Public Release</p>	

Security classification of this page:

UNCLASSIFIED

UNCLASSIFIED

13 ANNOUNCEMENT LIMITATIONS (of the information on these pages):

No limitation

14 DESCRIPTORS:

a. EJC Thesaurus  
Terms

Ranges (facilities)  
Interior ballistics  
Small arms ammunition  
Velocity measurement  
Muzzle velocity  
Gun propellants

b. Non-Thesaurus  
Terms

15 COSATI CODES:

19040

16 SUMMARY OR ABSTRACT:

(if this is security classified, the announcement of this report will be similarly classified)

A compact ballistic range has been set up for measuring action time, in-barrel pressures and muzzle velocity for small calibre ammunition. Inexpensive commercial sky screens have been modified to provide a very accurate velocity meter.

UNCLASSIFIED