# Skylark

## Britain’s First Space Rocket

by Robin H. Brand
BSc CEng MIET FBIS

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# About the subject

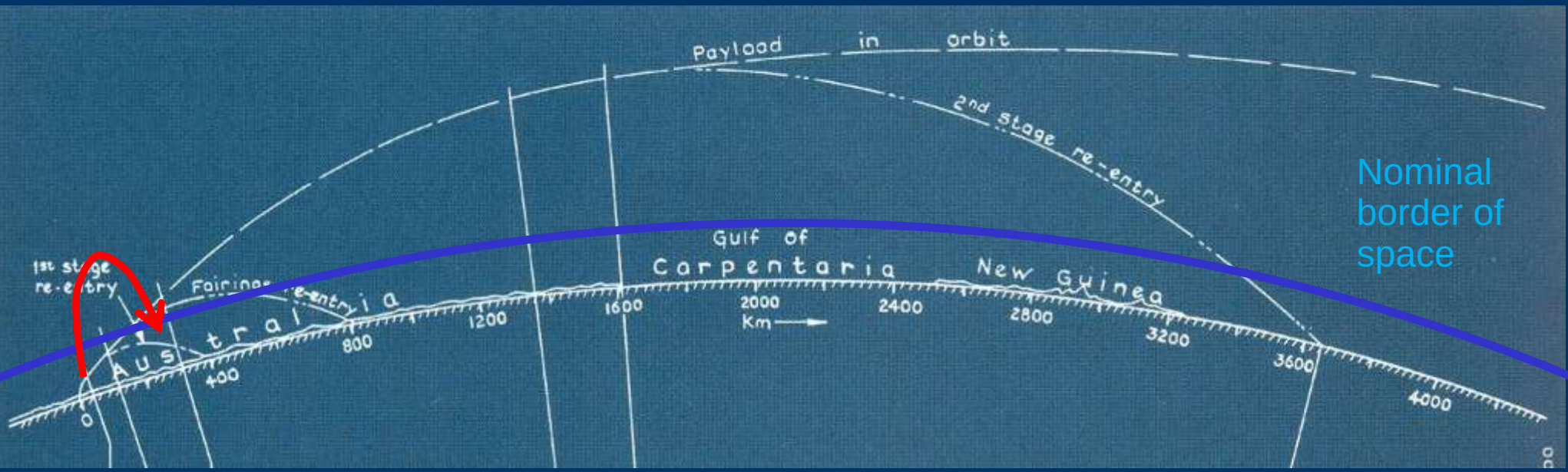
- On 13th November 1957, the Skylark sounding rocket was the first British rocket to reach space
- As shall describe, over the next 48 years, hundreds more were fired, measuring the upper atmosphere & launching thousands of scientific instruments into space
- This is a brief history of that rocket and some of its pioneering astronomical observations

# 1. Clarifications (a)

Skylark was a ‘sounding rocket’, and did not launch satellites

So what did a ‘sounding rocket’ do?

They were the sub-orbital ‘precursors’ to satellites and their launch vehicles




Black Arrow rocket trajectory as used to launch “Prospero” satellite in October 1971

# 1. Clarifications (b)

Skylark is no longer made, although it was in service from 1957 to 2005
(48 years & 441 launches, an excellent record)

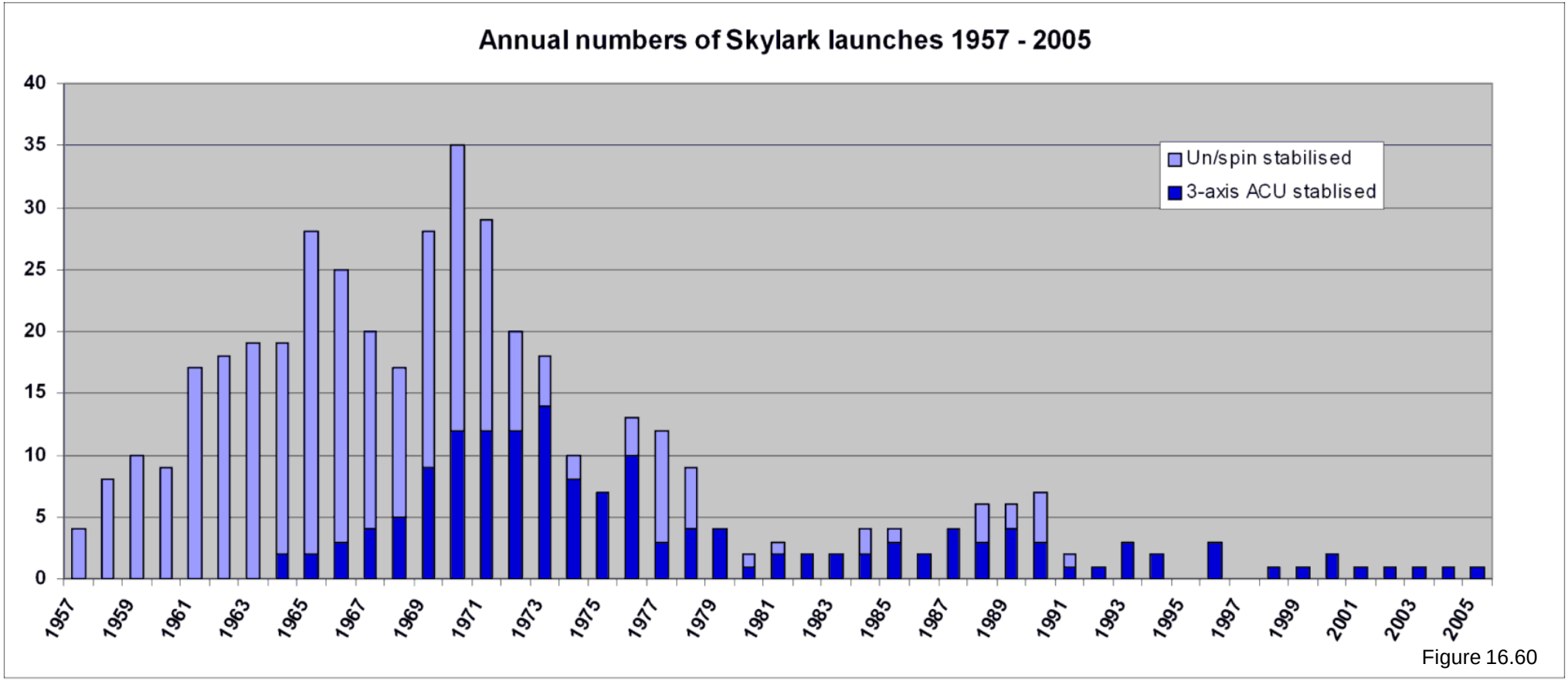



Figure 16.60

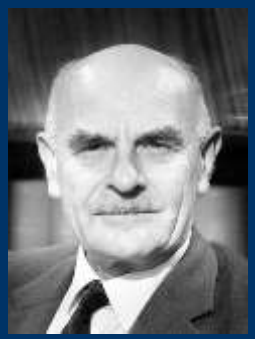
# 2. Skylark's family history

Figure 2.3

MILITARY: Beam riding CTV.1 at Larkhill, Salisbury Plain, May 1951

+

CIVILIAN:
Royal Society Gassiott Committee (chair Professor Harrie Massey of UCL) & Oxford Conference 1953



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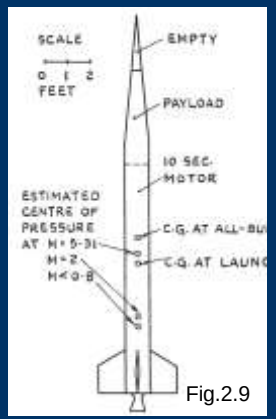


Fig.2.9

CIVILIAN: RAE Upper Atmosphere Research Vehicles report (D.G.King-Hele, 1954)

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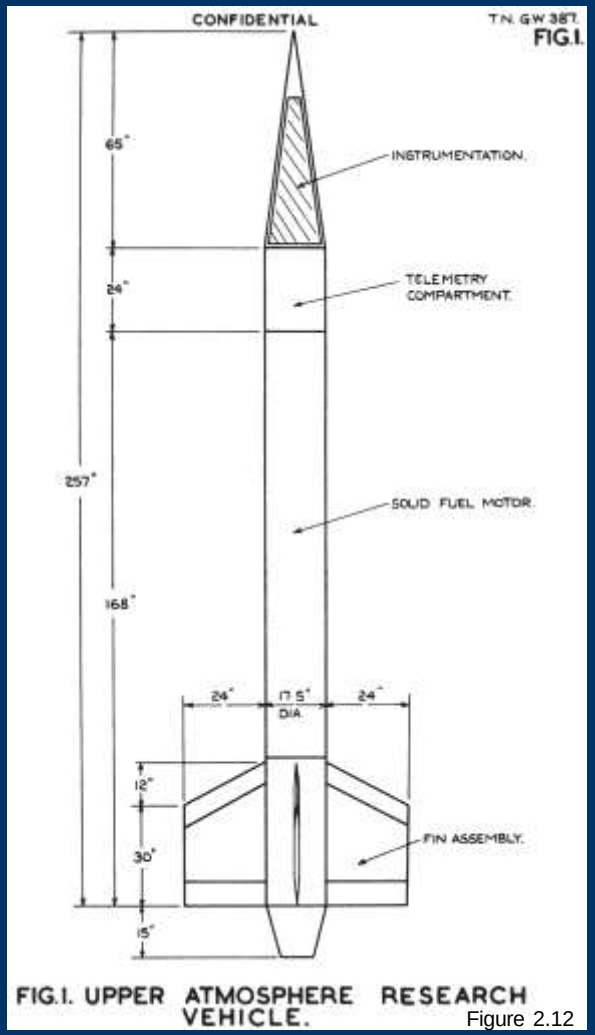



Figure 2.12

RAE "CTV.5 Series III" proposal (Dawton 1955)

# Designing a sounding rocket to reach space (100 km / 62 miles)

- Initial 4 year funding (£100K) obtained 1956 from UK treasury
- Original spec: 150 lb / 68 kg to 105 miles / 169 km
- “The ideal upper atmosphere rocket should be easy to manufacture, prepare and fire, and the total cost should be kept as low as possible”

Some of the designers (RAE Farnborough 1955):


J.F.Hazell, W.H.Stephens, E.B.Dorling, T.S.Moss, M.O.Robins, E.C.Cornford

# Designing a sounding rocket to reach space

The first version:

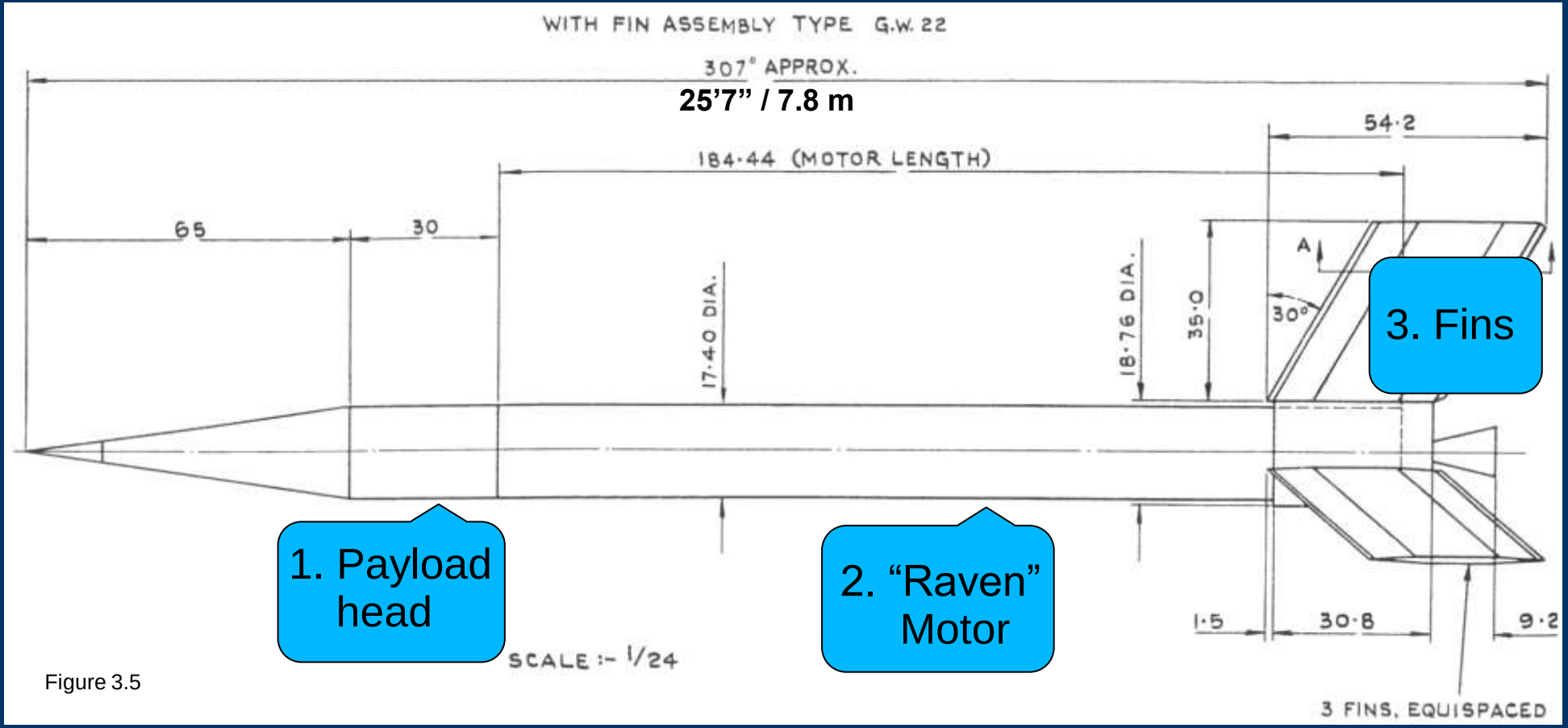



Figure 3.5

# Designing a rocket to reach space

Also needed – a launch tower. Why?

- Because Skylark had no active guidance system, & took off relatively slowly
- (the tower was the equivalent of a Nov. 5th milk bottle!)

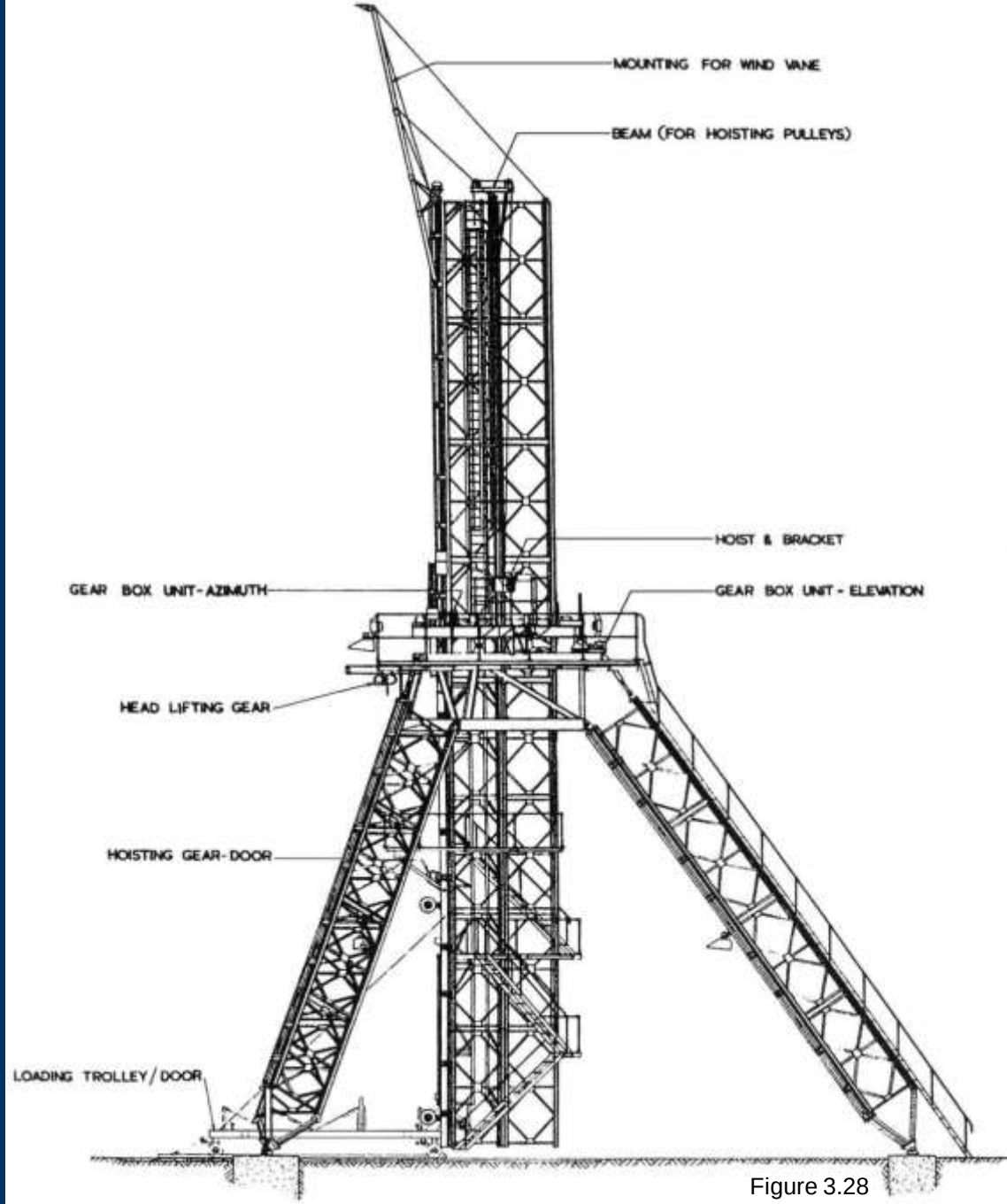
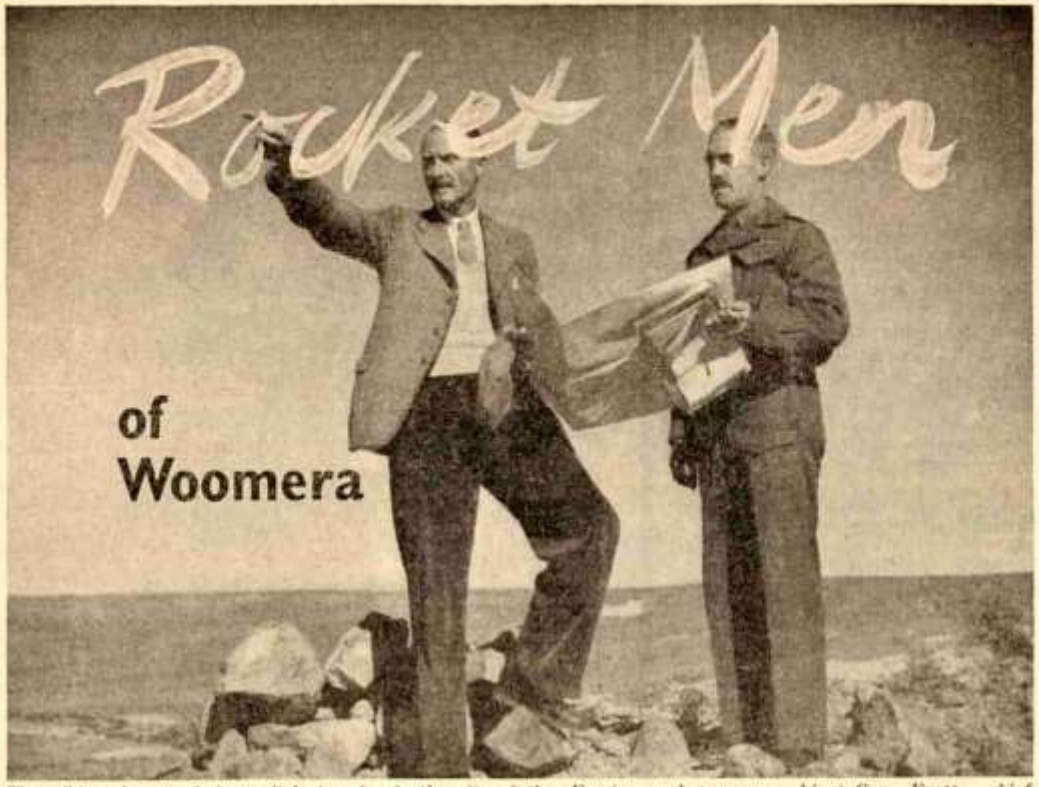



Figure 3.28

# Where to launch?

- There was no room in the UK
- The choice was "Woomera" in South Australia, where a large Anglo-Australian land-based experimental weapons range had been established in 1947




The gibber desert of Australia's interior is the site of the Empire rocket range. Lieut.-Gen. Evetts, chief executive officer, at left, with Brig. Edgar, plots the position of airfields, hangars, laboratories and workshops.

***To Australia has been assigned the most spectacular role of the Empire's rocket project—that of firing and testing the rockets as they come from the laboratories and factories of Great Britain.***

*Specially written for "Wings"*
by TOM FAIRHALL

OUT in the gibber desert of Australia's interior, scientists and engineers are establishing there the chief long-range weapons testing ground for the British Empire.

Significantly, they called it Woomera, after the device Australian Aborigines used to direct their spears and put greater force behind the throw.

And from Woomera in the not-too-distant future, new guided missiles, of which the Nazi "doodlebugs" of World War II were merely the shape-of-things-to-come, will zoom into space in trials to find the ultimate in defensive—and offensive weapons.

Stretching across our Continent, in some of the loneliest and most remote country in the world, will lie a chain of stations equipped with the newest gadgets devised by science to photograph and record every pitch and roll, every movement and change in acceleration of a rocket in its flight.

The Empire's rocket project is necessarily a long-term plan, as expansive as its gibber-desert range-head. Australia, joint partners with the United Kingdom in the project, will pay its share of the work from the Commonwealth Government allocation of £32,000,000 to be spent over the next five years on scientific defence works. So far about £5,000,000 has been spent in Australia.

In the initial stages, most of the rocket research and development work will be centred in Britain, but it is expected that Australia will also play its part in assisting in both research and development. The reason for this is obvious: if war comes to Europe again, additional responsibilities can be taken more readily by Australian factories and will not dislocate or seriously delay rocket development.

Naturally, Britain's rocket story cannot be told yet. Here, as in England and in other parts of the

2 WINGS, September 1, 1948

Figure 1.13

1949 map showing the planned extent of the Woomera range

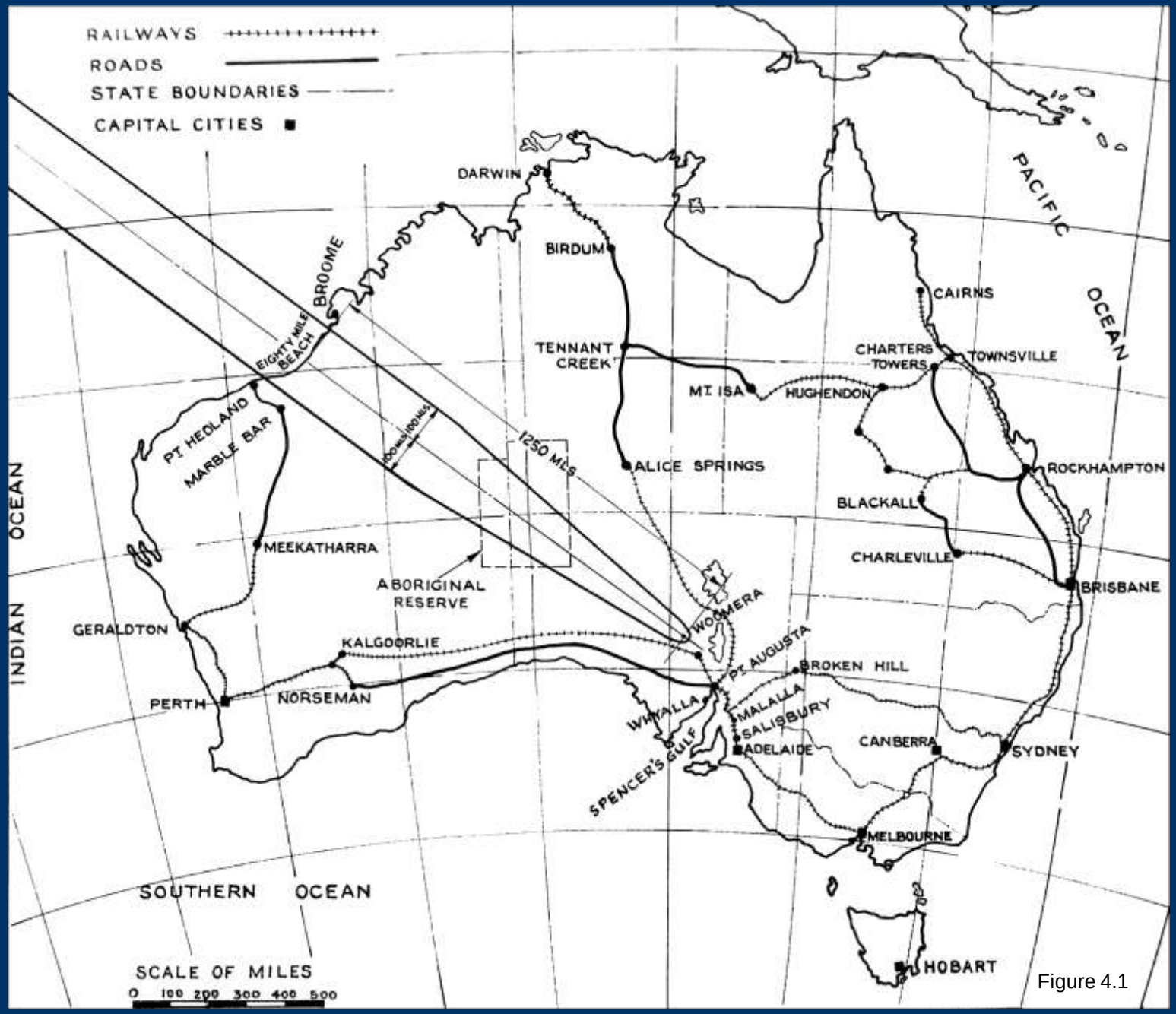



Figure 4.1

Range E as implemented, 1957-58. (Original 80’ Skylark launch tower)

# SL01 was the first Skylark launched, (13 Feb.1957). It carried no university experiments, only RAE test instruments to monitor performance

- Flight: deliberately low (12 km / 7.6 miles), lasted only two minutes
- Recovery: impact point located 47 km / 29 miles downrange, buried up to motor nozzle, so left in place
- Result: regarded as most successful, vehicle stable, tower worked, telemetry received satisfactorily

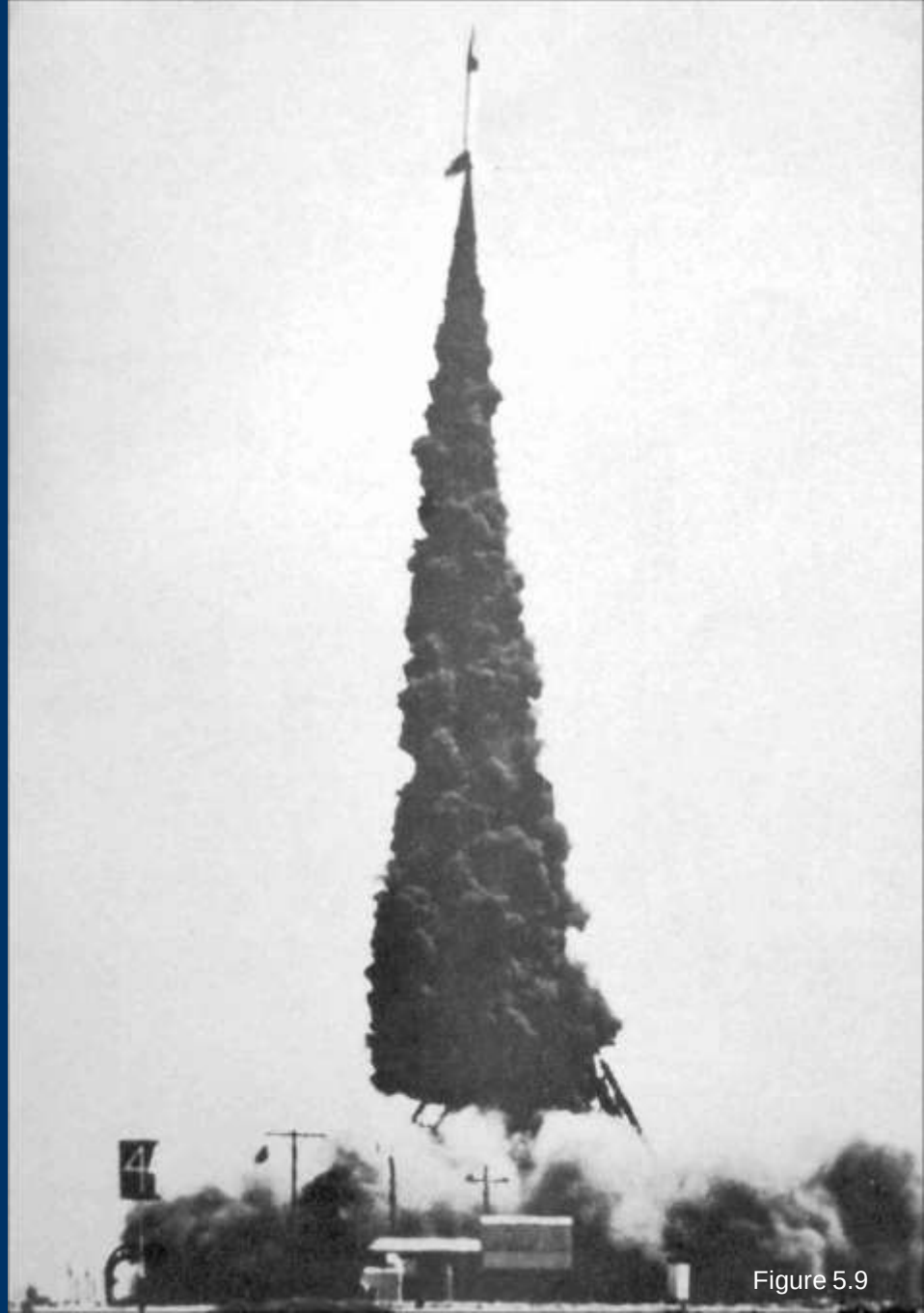



Figure 5.9


Next (all being well!): a 3 minute b&w film clip of the launch of SL01

(Was included in the BBC TV “The Restless Sphere” programme on the IGY, broadcast 30th June 1957, presented by the Duke of Edinburgh)

# Journey into Space!

SL04 was the 4th Skylark launched (13 Nov. 1957), and the first British rocket to reach space. Three university experiments were flight tested.

- Took place during a moonless night, so grenade flashes could be seen

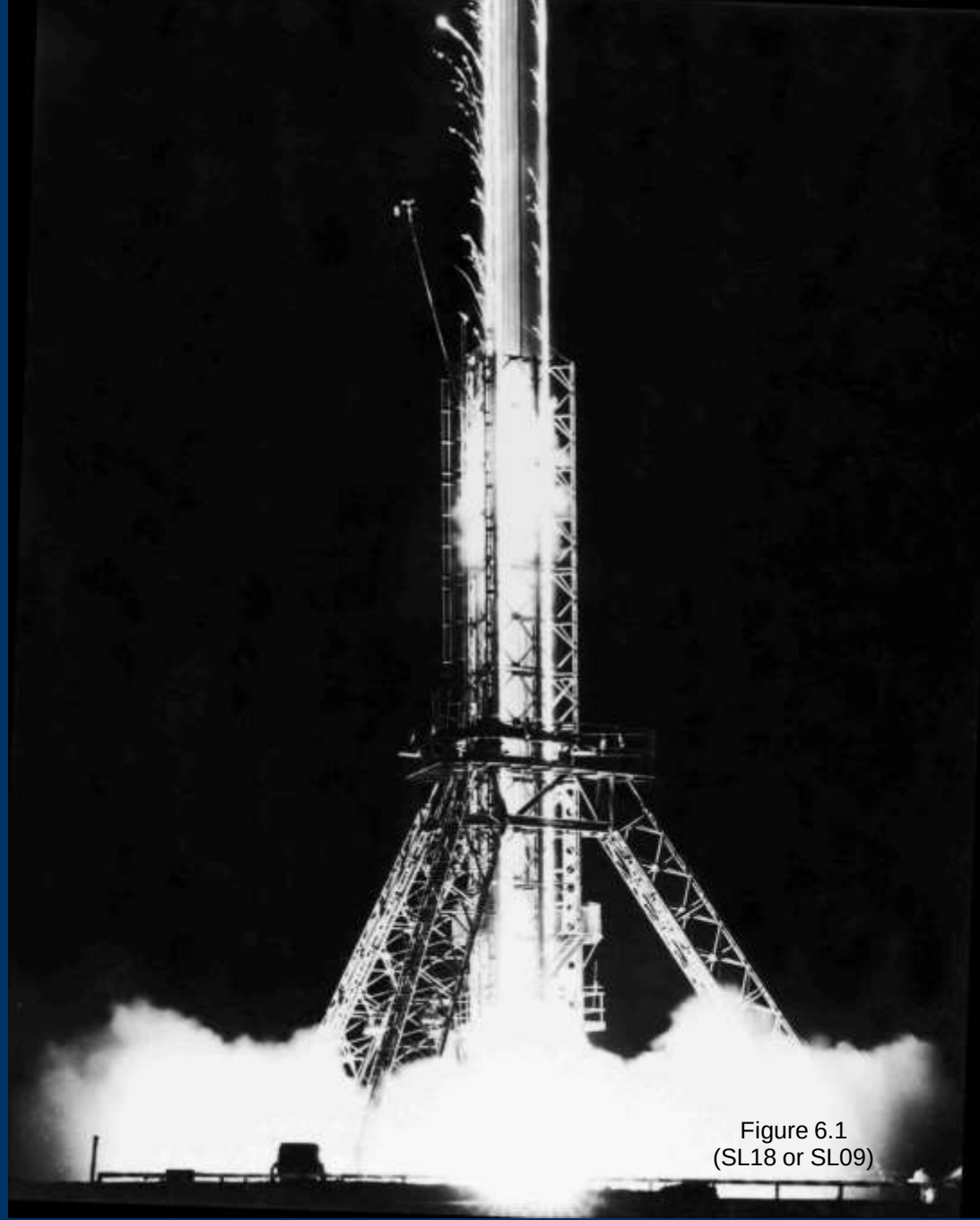


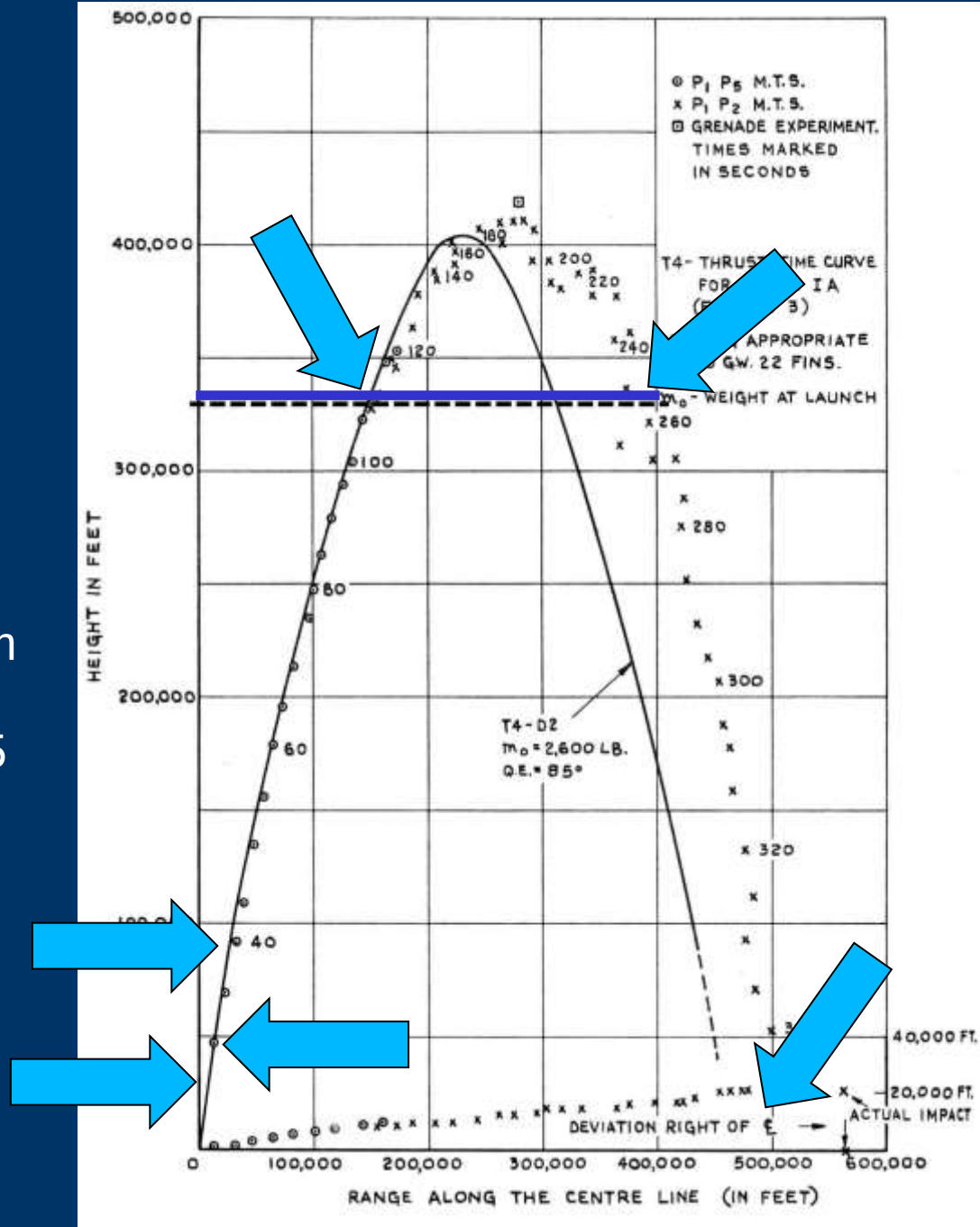
Figure 6.1
(SL18 or SL09)

# Estimated and actual Trajectory for SL04

- At 10 secs broke sound barrier
- At 20 secs 1500 mph & into stratosphere
- At 40 secs “all-burnt”, 3300 mph (1 mile sec) at 100,000 ft (19 miles / 30 km)
- At 110 secs reached space at 100 km (62 miles)
- At 255 secs left space after some 2.5 mins

- <u>Recovery:</u> 107 miles (172 km) downrange

- <u>Result:</u> Excellent, 2 out of the 3 university experiments returned good results



# Skylark SL04 – the University experiments

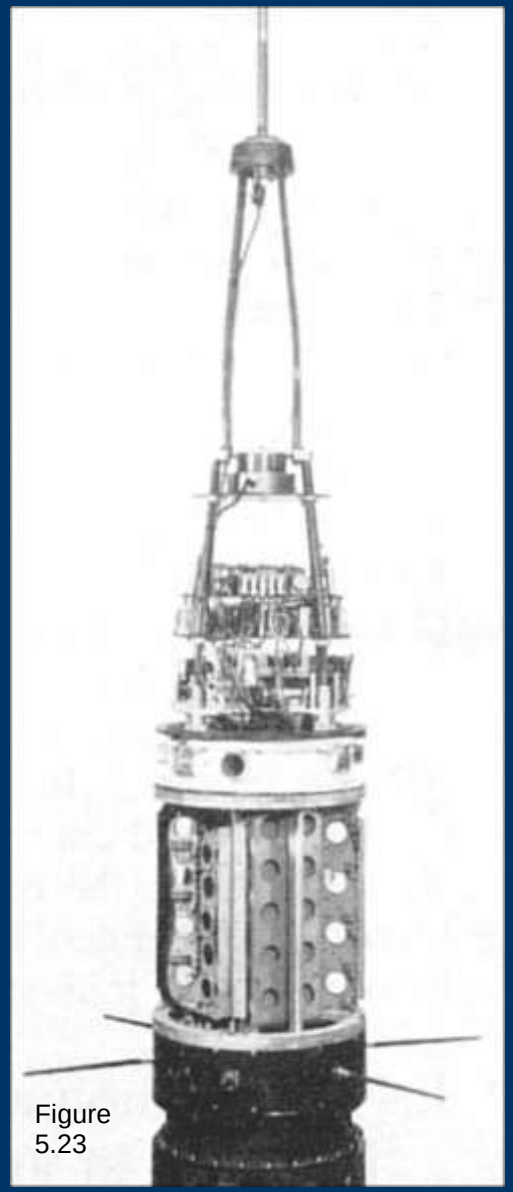


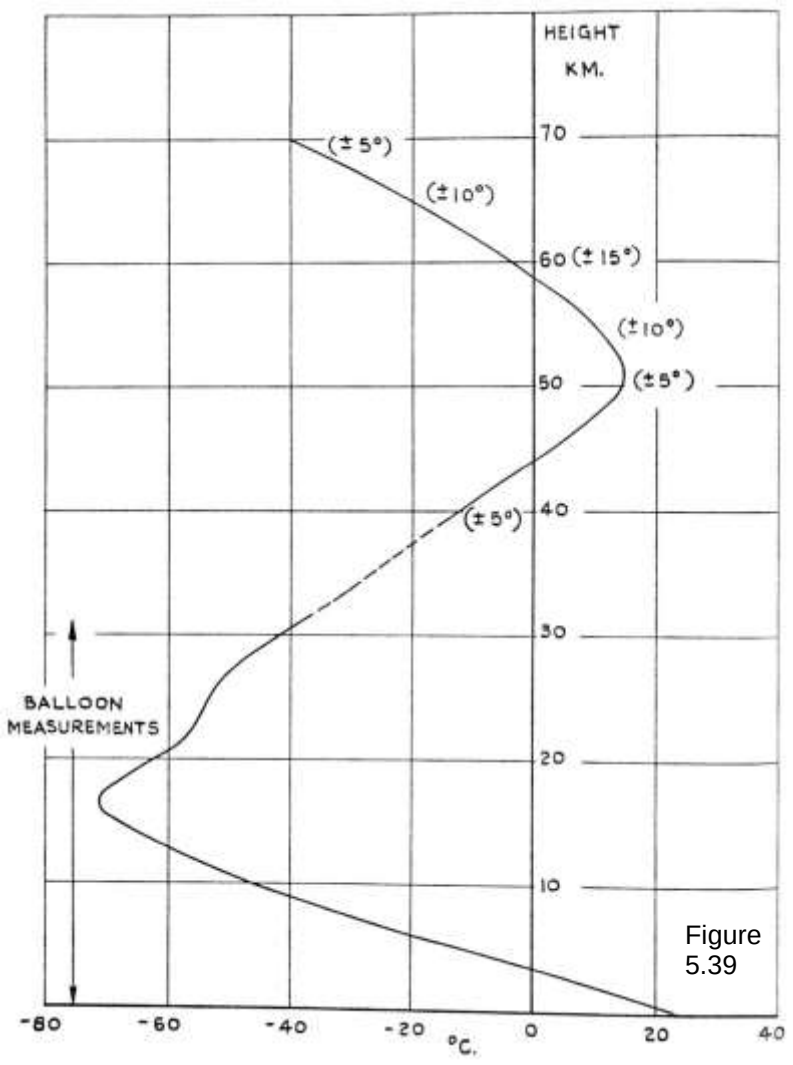
Figure 5.23

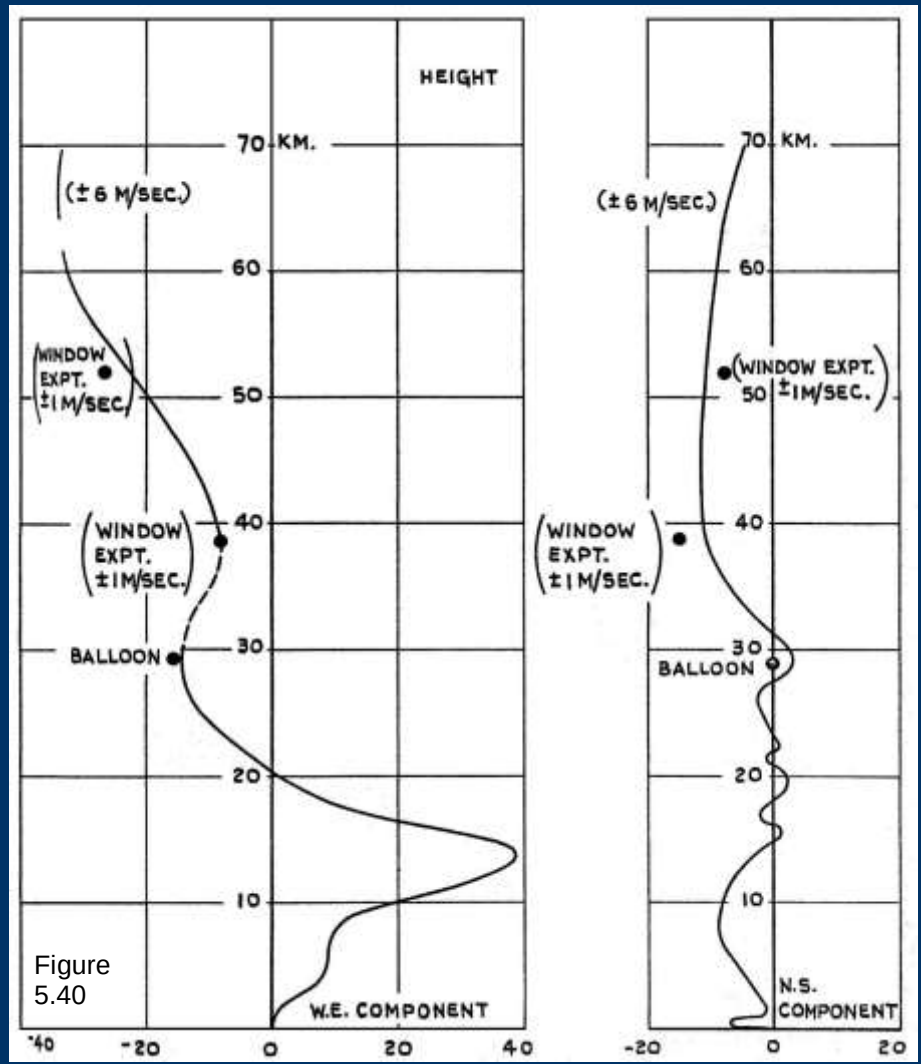
BEFORE: Under the nose cone – University of Birmingham experiment to measure electrical charge in ionosphere (probe & electronics)
In the “parallel bay” – (i) University College London experiment to measure atmospheric temperature, density & wind speed using grenades (ii) Imperial College experiment to measure wind speed using “chaff/window”

Figure 5.32

AFTER: Instant archaeology, or what happens when a man-made object returns from space without a parachute!

# Skylark SL04 – results from university experiments




Left: Temperature profile in deg.C

Right: Wind profile in metres/second
(40 m/s = 90 mph!)

# "Flying Telescope" to be Sent Up

**CANBERRA, Monday. — A "flying telescope" is to be launched from Woomera rocket range in a Skylark rocket soon.**

It will take pictures of the sky and measure the intensity of ultra-violet light.

Five scientists at London's University College have been working on the telescope for nine months.

The United Kingdom High Commissioner's office said today the flying telescope would soon be flown to Australia.

The research team hopes to "find out more about the stars and the atmosphere, and perhaps even discover new astronomical objects radiating ultra-violet light at present invisible to us."

It is not a telescope in the conventional sense, but consists of six amplifiers, each set into a cast metal framework at different angles to the verticle so as to look at a low angle of degree at the sky and measure the intensity of the ultra-violet light.

Six photo-multipliers work by building up a television-type picture of the sky.

This is then transmitted via a radio-telemeter back to the earth.

Scanning of the picture is achieved from the "yawing" rotary action of the rocket itself.

**The Skylark rocket will reach a height of up to 100 miles above the surface of the Earth before the pictures are taken.**

It is purely a research rocket, originally developed and built for carrying instruments into the upper atmosphere during the geophysical year.

Figure 7.21

- 'Space' experiments quickly followed on from the 'upper atmosphere' ones
  - SL43 launched the first Skylark 'Astronomy' experiment to observe the stars rather than the Sun
  - Designed by UCL for stellar UV observations, probably the first ever carried out in the southern hemisphere
  - Results radioed to ground by telemetry – still no recovery system!

# Space - why use Skylark to look beyond the atmosphere?

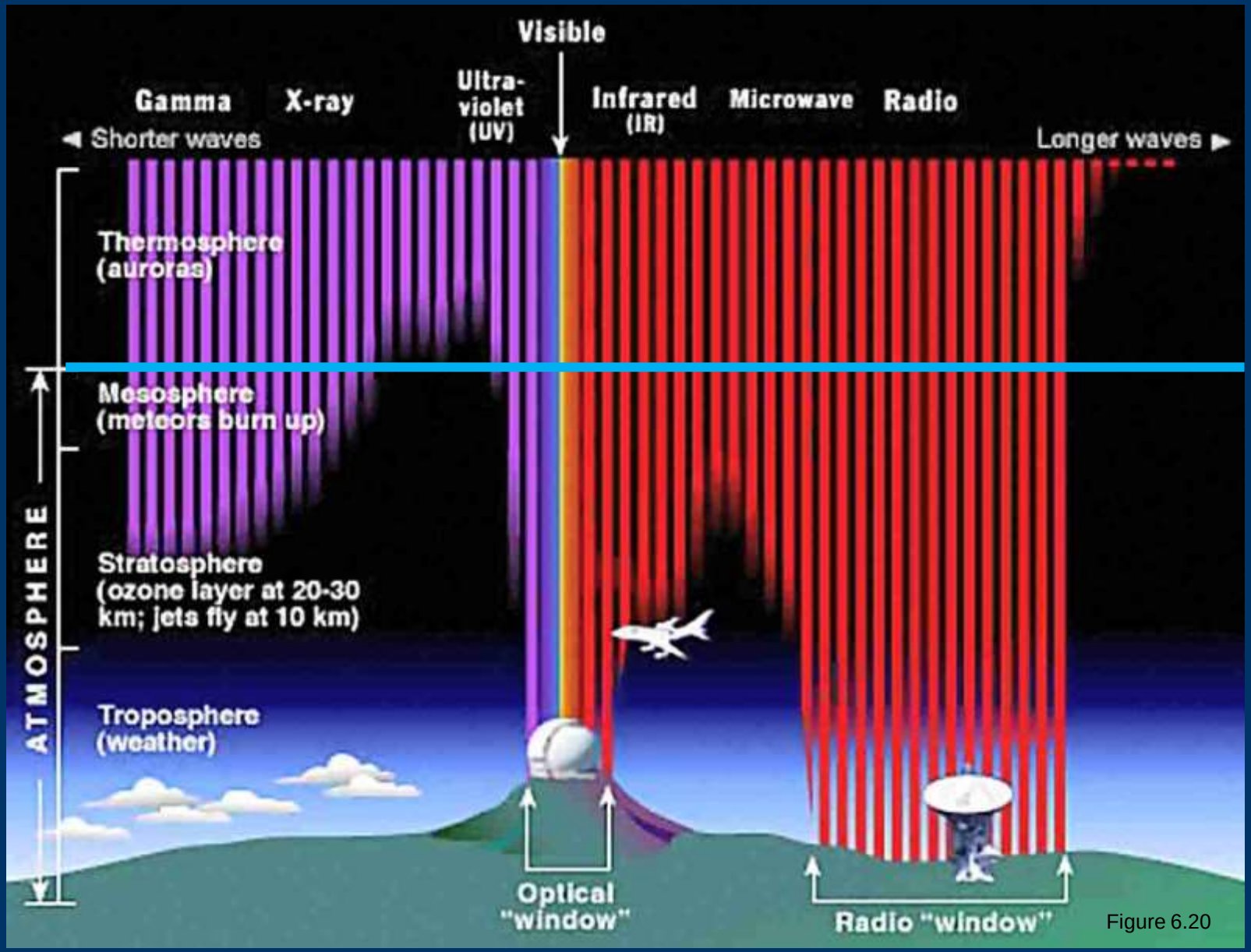



Figure 6.20

Nominal border of space


Figure 7.23

Model of SL43's UCL telescope in London's Science Museum large object outstation at Wroughton in Wiltshire.

The 5 photomultipliers were centred on 1900Å / 190nm (UV-C band)

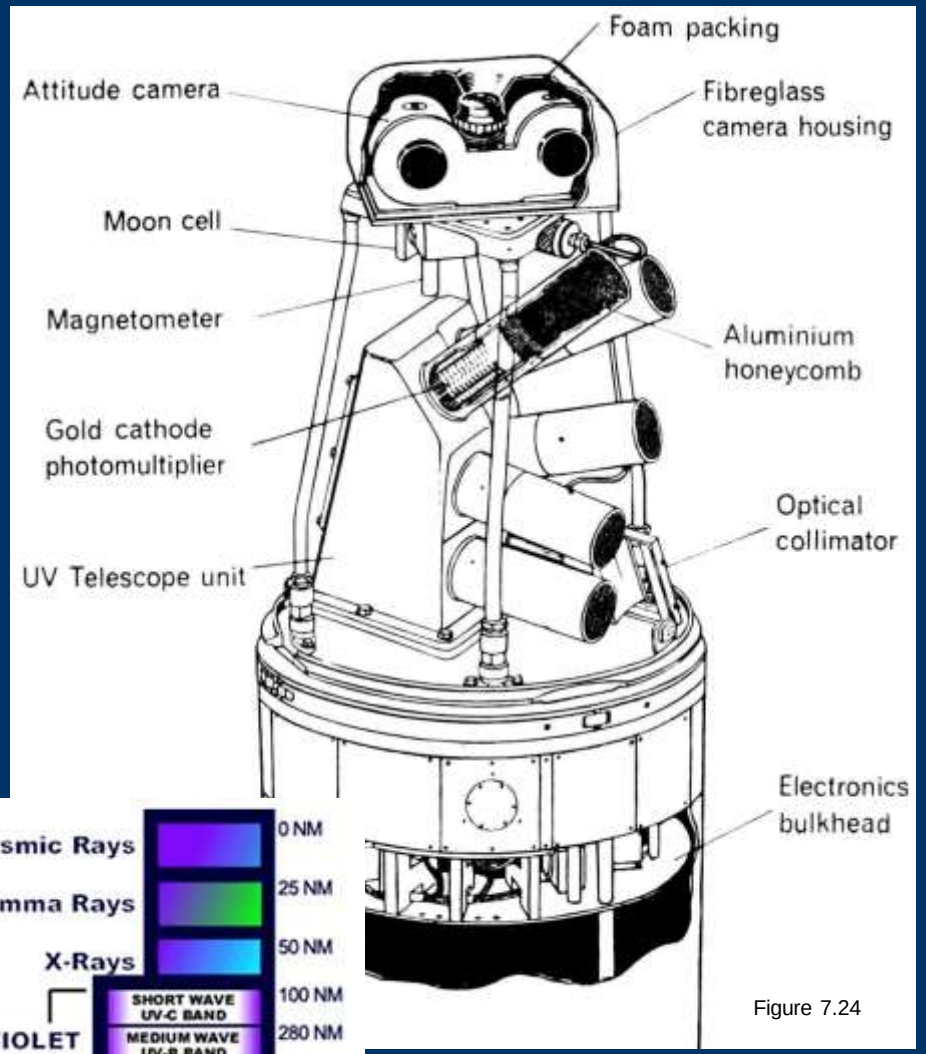
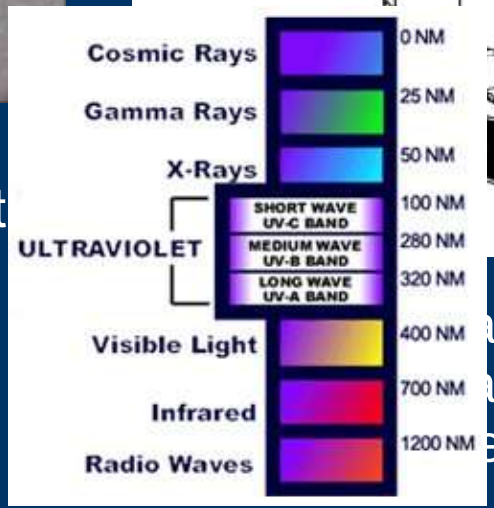



Figure 7.24




ay 1961 to 155 km (96
after 3 minutes, good
etry (no parachute!)

# Enhancements (i) - payload recovery


Figure 7.10


Figure 7.11


Figure 7.12


Figure 7.13

- The first two tests failed, but 3rd time lucky: SL36 at Woomera February 1961
- The first British object to be soft-landed after re-entry from space
- Successful again on SL34 in August 1961, “valuable equipment was recovered in an undamaged condition” (UCL UV camera)

# Enhancements (ii) - Attitude Control

- Until now, Skylark payloads had spun and rotated at random, because in the near vacuum of space the vehicle fins had no control
- This limited the payloads' use for astronomical observations
- Hence in 1962, formal development work started on the "Stage 1" Attitude Control Unit (ACU), designed to point the payload at the Sun with errors of less than two degrees
- First flight tested on SL301 in August 1964

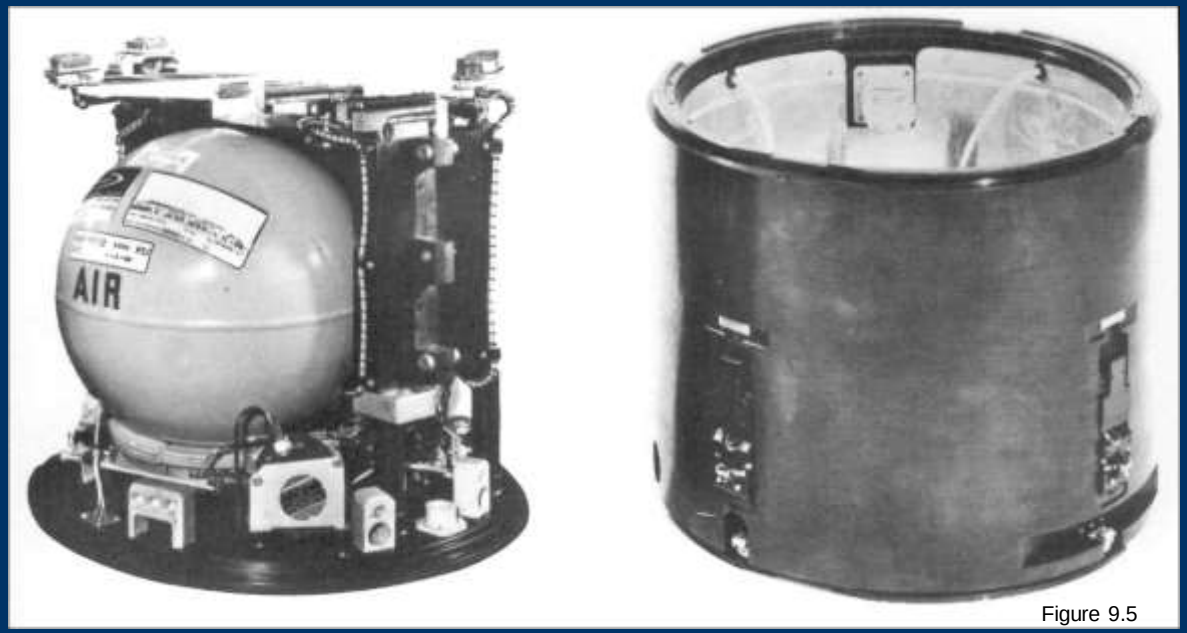



Figure 9.5

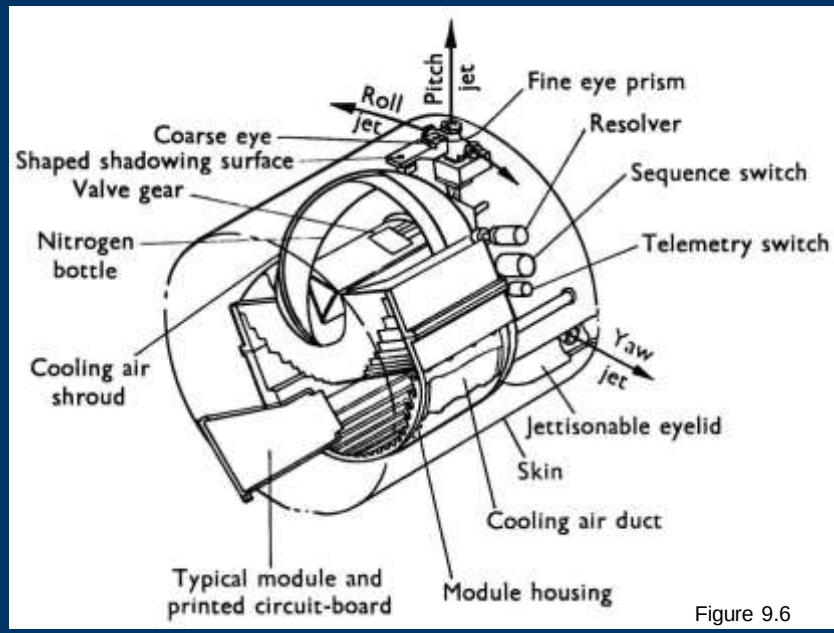



Figure 9.6

# Pioneering solar X-ray astronomy

- The second stabilised payload was on SL302 launched 17/12/1964
- This was the type of Leicester X-ray pin-hole camera used:
- And this was the resulting soft X-ray image:

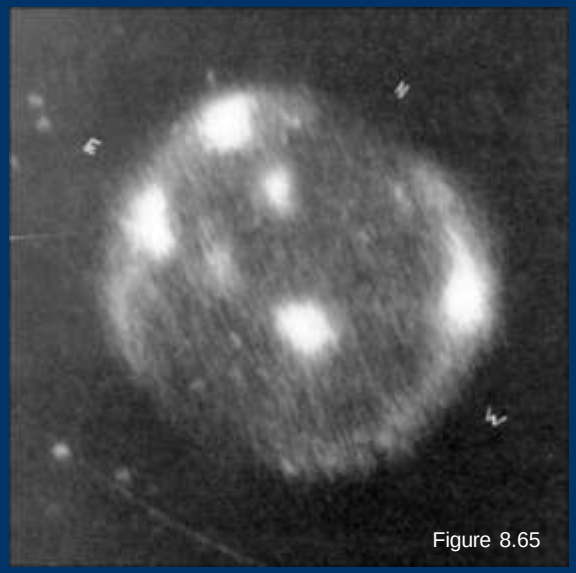


Figure 8.65

Figure 8.64

- The photos were the first non-smeared X-ray images ever obtained of the Sun

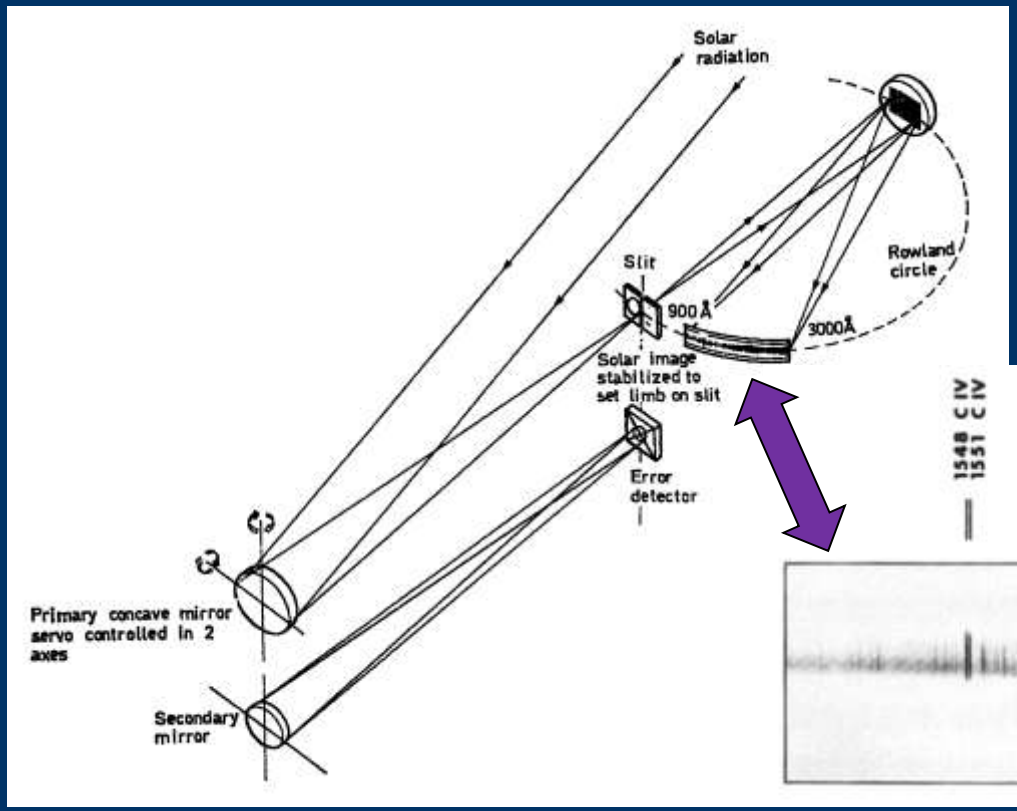
# Meanwhile…

- The first Skylark launch outside Australia took place
- S01/1 was fired from Sardinia on 6th July 1964
- It was sponsored by the newly formed ESRO (European Space Research Organisation)
- And was Europe's first cooperative space launch (7 countries involved)

Figure 8.51

# Pioneering - solar UV observations

- The third stabilised flight was SL303 on 3 April 1965
- The main Culham experiment included a sophisticated secondary optical alignment system for greater instrument pointing accuracy. This used polished fused quartz mirrors (six cm primary)
- During its 100 mile journey through space this stabilised the image of the Sun to 3 seconds of arc (1/1200 of a degree)




- The solar limb UV spectrum obtained was of outstanding quality
- Some of the 300 UV emission lines were new to science

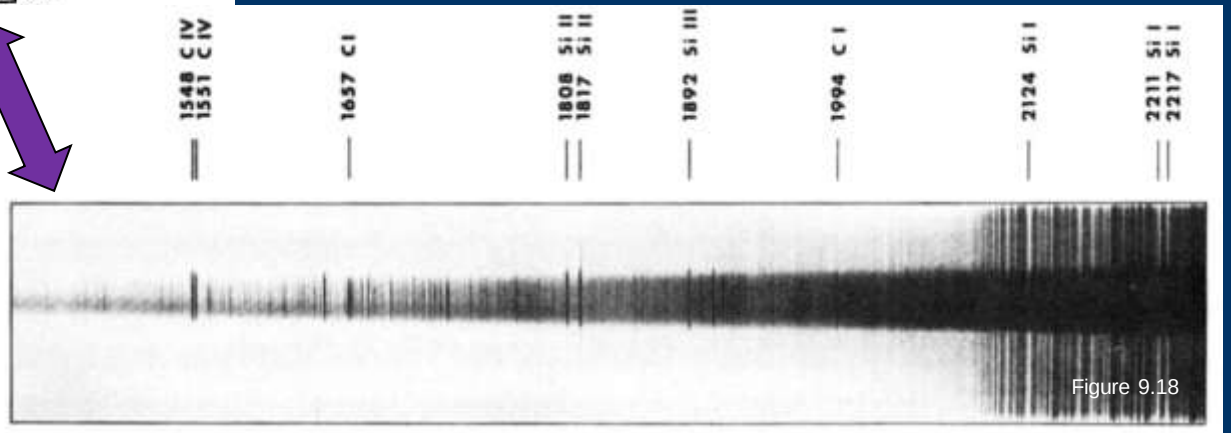



Figure 9.18

# However, not all missions were successful:


Figure 9.20

The “night of the seven launches” took place on 29-30th April 1965

Unfortunately, the evening did not get off to a good start, when the first, SL464, crashed after the Raven second stage failed to ignite

The morning after: where’s my rocket?

# Pioneering stellar UV astronomy

- SL48 was launched on 14 July 1965
- The main experiment was a UCL “UV Skyscan” instrument
- This used newly invented photomultipliers to obtain stellar UV spectra

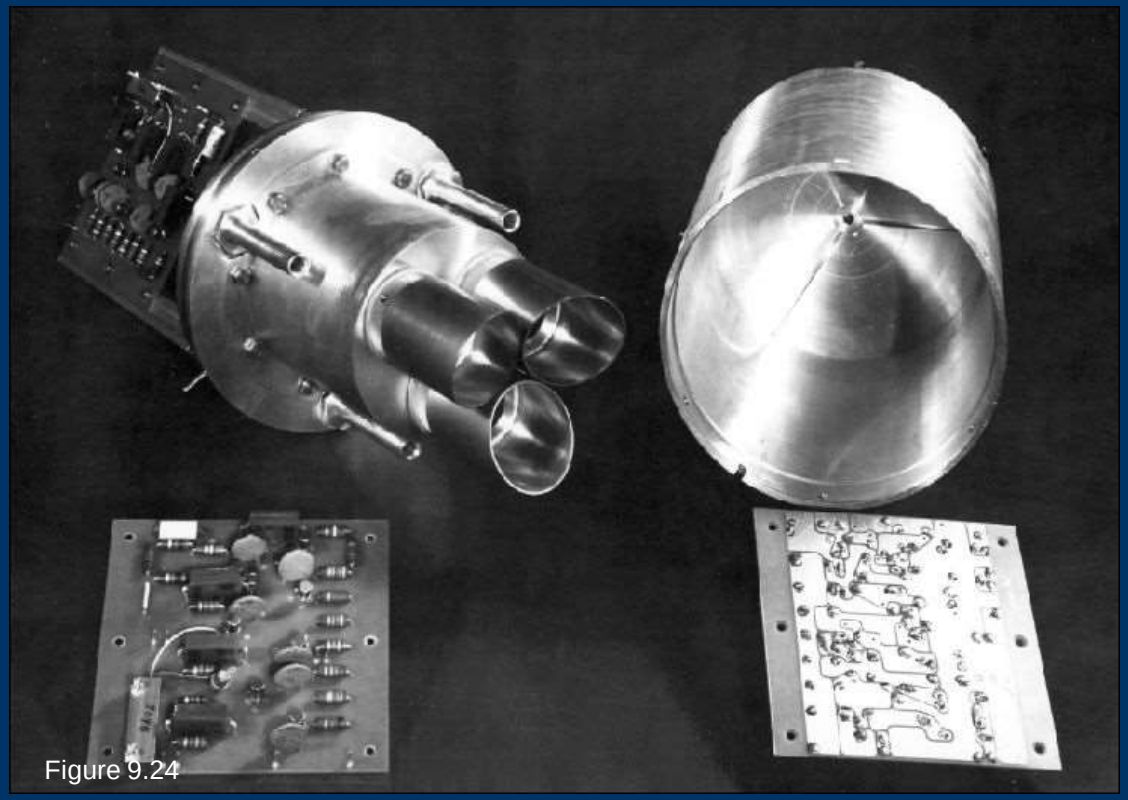


Figure 9.24

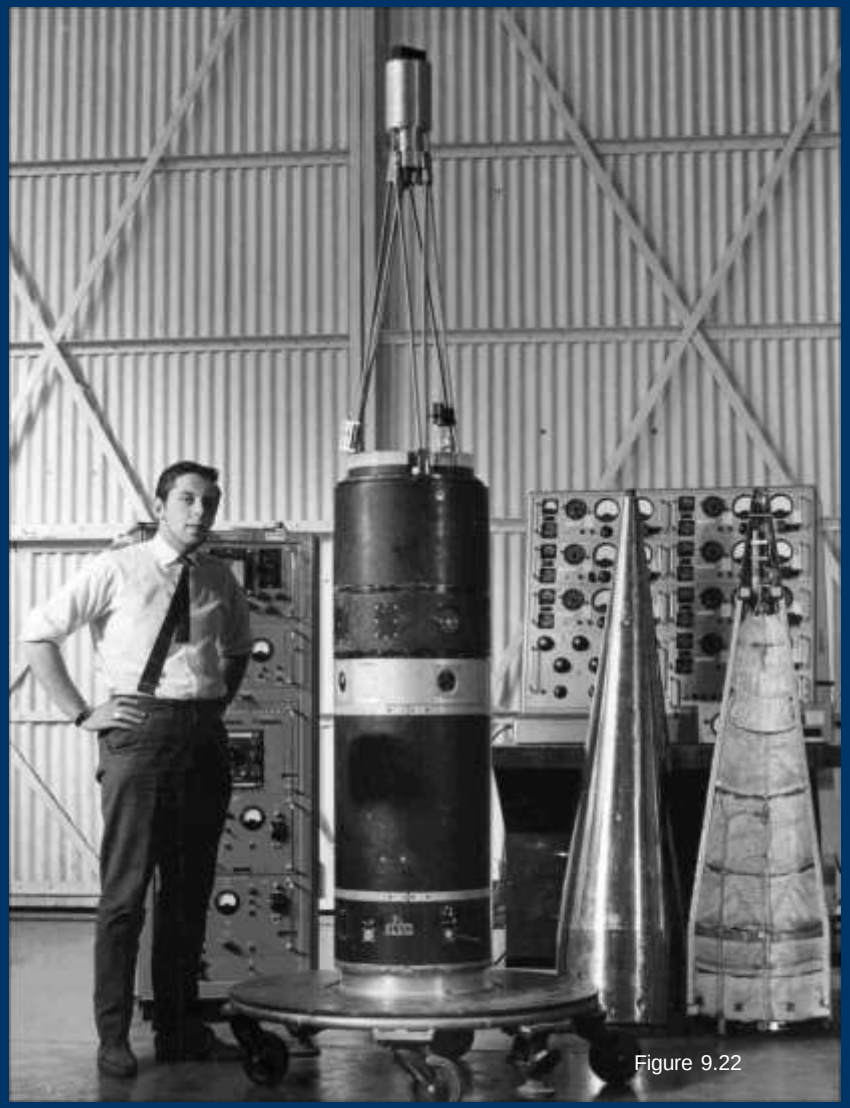


Figure 9.22

John Raymont at Woomera with the SL48 payload

# A new branch of astronomy – cosmic X-rays

- From the earliest days of Skylark, British scientists had considered the possibility that X-rays from beyond the Sun might be detectable
- But - if stars in general emitted X-rays at the same strength as the Sun, they would be far too weak for equipment of the time to measure. (By a factor of 100,000!)
- Undeterred, a group at UCL had proceeded with a the design of a measuring system that could be included in a satellite or Skylark rocket
- Then, in 1962, a US sounding rocket made the unexpected discovery of an astonishingly powerful X-ray source in Scorpio (Sco X-1)
- There was no known physical process that could account for this!
- The sky was then enthusiastically explored using rockets (including Skylark) and balloons until the first all-sky X-ray survey satellite (Uhuru) was launched in December 1970 by NASA

# 1967

April: 10 years since Skylark was first launched

May: MSSL (Mullard Space Science Laboratory) formally opened with a staff of 67

*"I recall, for example, our visit to see Dr Jones at Farnborough at the very start of the programme, and the excitement of discovering that we were to get not just a little rocket reaching 80 km, but one that, when fully developed, would reach about 300 km – Skylark as it became known, is still one of the best vertical sounding rockets in the world."* (Professor R.L.F. Boyd)

August: first Skylark launch under auspices of MSSL - a spectroheliograph on SL305

# A new type of X-ray telescope

- SL973 was launched from Woomera in October 1971 with a new type of X-ray telescope from MSSL
- This instrument was a “Rotating Modulation Collimator” (RMC), designed to provide more accurate observations of galactic sources
- An RMC instrument was being designed for the forthcoming UK5 satellite, and this Skylark mission helped gain experience in its use

Figure 12.9

# A new role for Skylark

- F24 camera view to the north east of Woomera
- Taken from about 250 km (155 miles)
- Lake Eyre at the top, in the middle distance clouds with their shadows
- Probably the highest resolution civilian photos from space to date (100 m res)

(Figure 13.1)

# Argentina

March 1973 : the view from SL1182 west from about 240 km (149 miles) above central Argentina

The snow capped peaks of the Andes with the Pacific beyond

(F24 large format, 127 mm lens, Kodak Aerochrome 2443 false colour infra-red)

# Meanwhile at Woomera

- In November 1973, SL1206 was launched, a Leicester solar-physics mission that worked in conjunction with the S-054 X-ray telescope on the NASA Skylab ATM
- Unusually, launch preparations were hampered by torrential & continuous rain - but there were also other problems:
- “Flocks of cockatoos were a never ending annoyance...they took a great delight in devouring the plastic covering used on the launcher air-conditioning system…”
- …firing rockets managed to account for a few of them…only the legs of the bird tenants remained, the claws still firmly holding on, while the bodies had gone with the wind.”

# SL1203 Galactic X-ray Survey

- February 1974: MSSL's SL1203 astronomy mission was designed to carry out a soft X-ray search of the southern skies, in particular the two large radio emitting structures "Loop I" & "Loop IV"
- The payload required considerable experimental, mechanical & electronic design activity (John Coker)

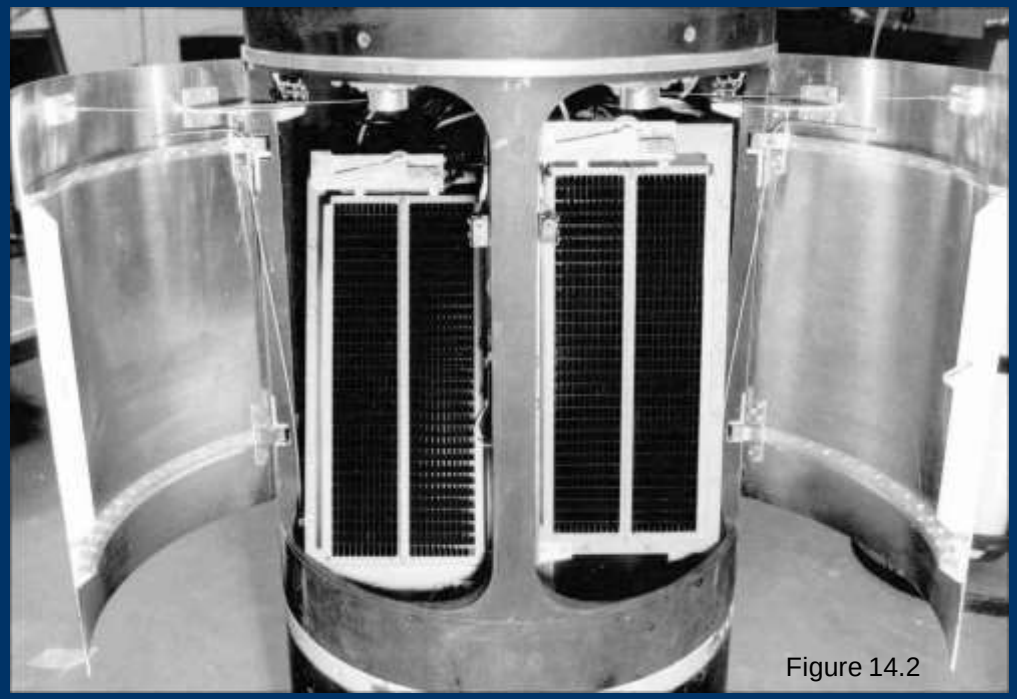


Figure 14.2

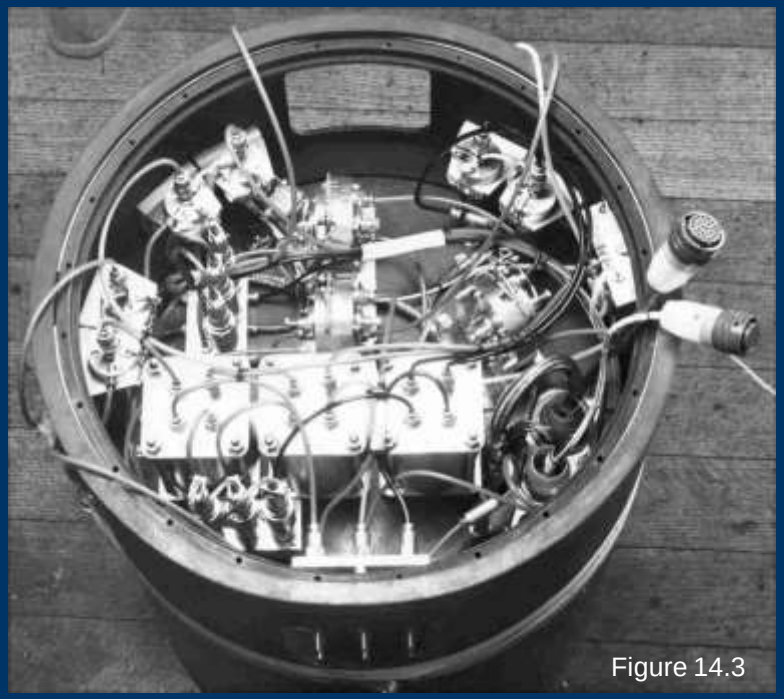
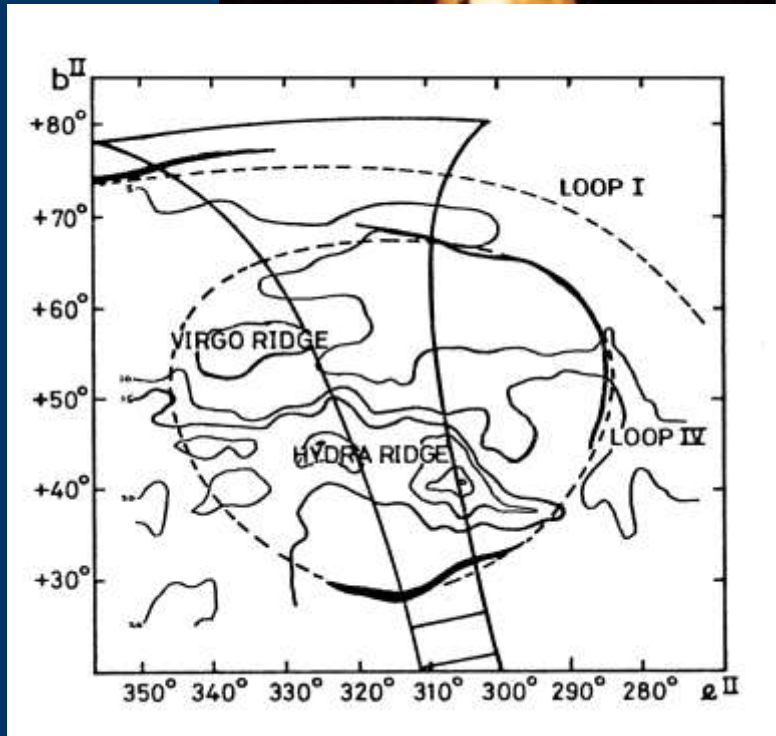


Figure 14.3

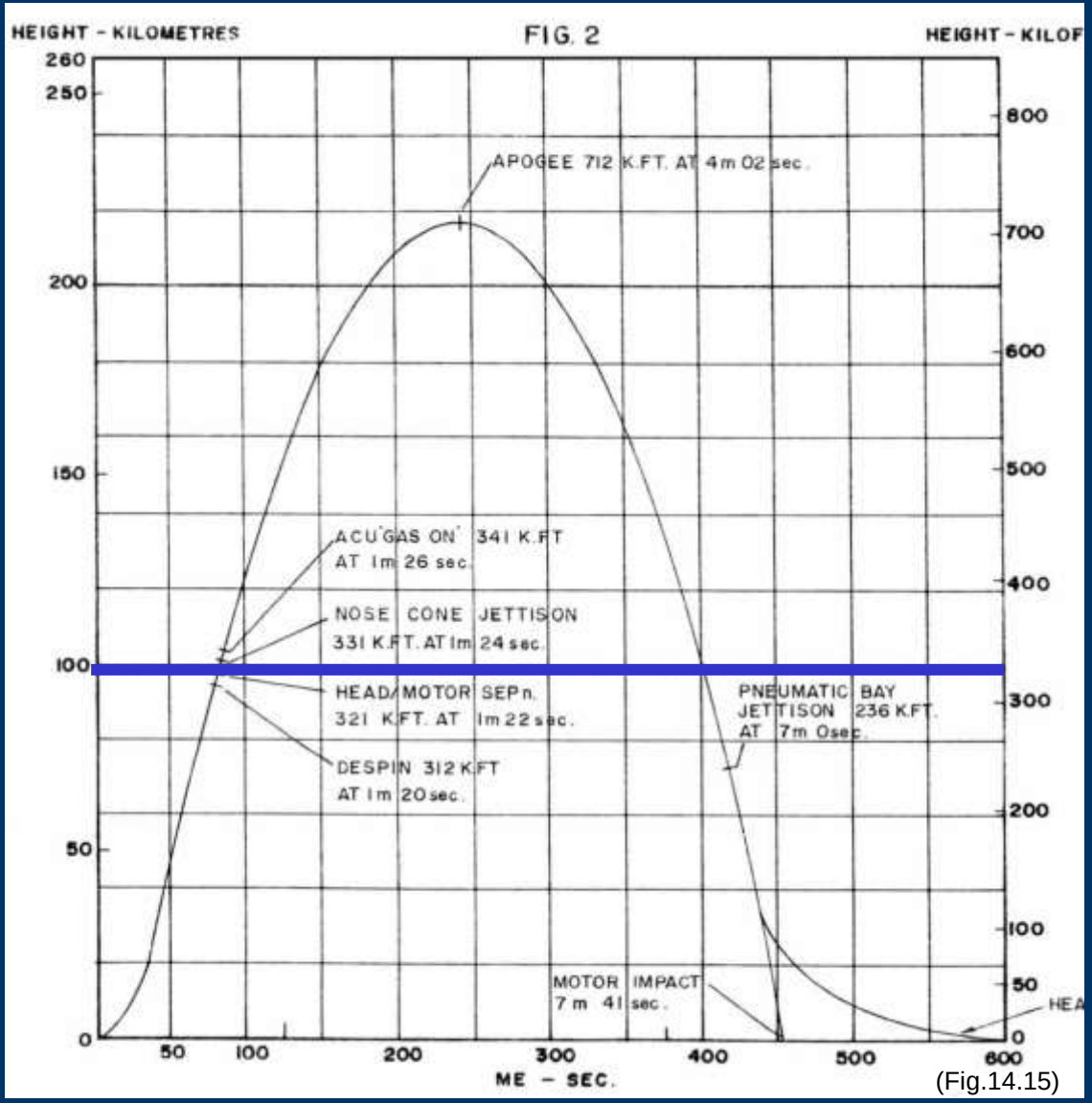

# SL1203

- At 335 kg the payload was the longest & heaviest flown on Skylark to date
- It was successfully launched on 5/2/74, reaching space 1.5 minutes later
- And made new X-ray discoveries about the radio loops & the Hydra Ridge (61 light years away)
  - Right: Detector 2 scan path



# SL1012 Supernova spectrum analysis

- SL1012 (5/10/74) carried an MSSL astronomy experiment to conduct a soft X-ray spectral analysis of a supernova remnant, the Cygnus loop
- The 100 page “Trials Instruction” document has come to light, showing the complications of even a relatively simple space launch



# SL1012 was launched from Woomera in October 1974

- Part of the Trials Instruction “Sequence/Countdown”:

Page 80B

TABLE 57

SEQUENCE/COUNTDOWN

| TIME RELATIVE TO ZERO MIN. | SEC. | SERIAL NO. | ACTION/EVENT | PERSON/POST RESPONSIBLE | REMARKS |
|---|---|---|---|---|---|
| | -15 | | 'Minus 15 seconds' Call | TCO | |
| | -13 | | U1-C1 and U1-C2 to high speed | MSU | |
| | -10 | | Long Peep<br>20 pps Contraves FL & SH pulses start | MSU<br>MSU | |
| | - 6 | | Contraves Start Recording | Operator | |
| | - 6 | | Vintens Start | Operator | |
| | - 5 | | Short Peep | MSU | |
| | - 4 | | Short Peep | MSU | |
| | - 3 | | Short Peep | MSU | |
| | - 2 | | Short Peep _ F95 Camera Start | MSU | |
| | - 1 | | Short Peep<br>CTD to TIM 100 Code<br>CTD to R1 or R2 - LR155 or LR100 | MSU<br>MSU<br>MSU | |
| | Zero | | Goldfinch Ignited<br>Check Operations of Gates<br>ITD to TIM 100 Code<br>Tele ITD - LR 105 | MSU<br>RTC<br>MSU<br>MSU | |
| | + 1 | | 1 second Counts to +10 seconds<br>U1C1 and U1C2 to Low Speed | MISCO<br>MSU | |
| | + 2 | | F95 Camera Stop | MSU | |
| | +20 | | 'Plus 20 seconds' Call and then every 10 seconds to +15 mins. | MISCO | |
| +1 | | | M40 T1 or T2 Stop | MSU | |
| +1 | 26 | | Chronos to 'High Speed' and OFF | MSU | |
| +2 | | | Contraves Pulses OFF | MSU | |
| +7 | 41 | | Motor Impact | MISCO | |
| +13 | 12 | | Head and Parachute impact<br>MSU OFF after Tele Signals Cease and Tele Recorders OFF | MISCO<br>MSU | |

Figure 14.17

- Next a 75 second recording, including audio of SL1012 launch, as introduced by Professor John Zarnecki in his 2007 OU lecture “50 years of Space Exploration”

# A Skylark in the hall!

- SL1302 was a solar-physics mission with an MSSL experiment intended to make X-ray observations of several features on the Sun's disc
- The payload was built in association with the Palo Alto research laboratory in California
- After many delays it was successfully launched from Woomera at 13:37 local time on 30/1/76, & reached 278 km (173 miles) in just under 5 minutes
- Unfortunately the ACU failed to achieve fine stabilisation, so after years of work no scientific results were obtained
- The payload was recovered in very good condition and returned to the UK

# A Skylark in the hall!

- The payload remains now reside in the hallway of MSSL's country house HQ
- The stairs provide a convenient facility for viewing the vehicle!

Figure A6.8

Figure A6.9

# X-ray study of Cygnus X-1

- In November 1976 the Leicester SL1306 team used an FM instrumentation recorder to obtain a rare (illicit) recording of the launch from inside the EC2 control centre (only the 2nd ?)
- The quality is VERY poor, but the regular ticks & timing beeps can be heard:
- "SL1306 test recording"
- "minus 25"
- "minus 15"
- ten second beep (long)
- 5,4,3,2,1 second beeps (short)
- Launch noise (quite quiet)
- Post-launch count to ten

Figure 14.67

# SL1305 – a solar physics mission

- SL1305 was the last British sponsored scientific flight from Woomera
- And featured a Culham-MSSL instrument to observe UV emission lines from the solar corona
- It was launched in May 1978, 21 years after SL01


Figure 15.14

# SL1305 – a solar physics mission

- Good data was obtained, which led to a similar instrument being accepted by NASA on a Shuttle Spacelab 2 payload
- This was eventually launched on Space Shuttle Challenger (STS-51F) on 29/7/85. (The same as the Birmingham XRT)


Figure 15.15

Left: the Spacelab 2 instrument pointing system (ILS) used for aiming telescopes & detectors

Right: Shuttle crews used a workstation to point the instruments – a far cry from the Skylark ACU!


Figure 15.16

# MASER 7

- MASER was a Swedish microgravity programme, funded by ESA
- The MASER 7 mission was launched from Esrange in Sweden on 3/5/96
- It included 5 microgravity experiments
- And also a video camera viewing externally
- The following 80 second (silent) film shows the view from the payload looking back

Figure 16.26

# The last Skylark launch

- The MASER 10 mission was launched from Esrange in Sweden on 2/5/2005
- It was the 441st & last launch, & carried a 351kg (774 lb) microgravity payload to 252 km (157 miles)

Figure 16.1

# The last Skylark launch


Figure 16.52

Figure 16.53

# Where can Skylark be seen today?

# Where can Skylark be seen today?

Australia:

1. South Australian Aviation Museum, Adelaide

2. Woomera Missile Park & Museums

3. Queen Victoria Museum, Launceston, Tasmania

# Where can Skylark be seen today?

4. Also many locations out in the bush!

Figure A.6.18

Figure A6.17

# Finally - for further information:

- A “readable reference book”
- Hardback, 704 pages, printed in colour with 740 photos and figures in colour and b & w
- Short-listed for a 2015 “Sir Arthur Clarke space activity award” in the media category
- £29.50 from Amazon and all good bookshops!
- (or contact robin@nfel.co.uk)