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Chapter 10

Conservation of the German WWII Rocket Collection at the Aerospace Museum, Cosford, England*

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Introduction

The story of the quantum leap in rocket technology in Germany during the Second World War, with the deployment of the V-2, the world's first long-range missile, plus the development of many smaller guided missiles, has been told many times in popular books.[1,2,3] Most concentrate on the V-2, but others [4,5] also mention the other rocket projects pursued by the engineers of the Third Reich.

At the end of the war, the Allies sent a number of organized (some would say 'disorganized') intelligence teams into Germany to gain the knowledge of the German rocket engineers. Whole truckloads of reports, drawings and hardware

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were gathered up and transported to the various Allied countries. Hordes of German engineers were recruited to work on rocket technology in Allied countries. The USA and then the USSR were the main recipients, with smaller amounts going to Great Britain and France.[2]

Varying degrees of use were made of this treasure, but, as time passed away, technical interest in the rockets faded and many were scrapped or simply allowed to rust away. Others found their way into museums, where they reside as icons of the past and as primary sources of information for the historian. Unfortunately, however, many of these rockets have been restored and repainted so extensively and enthusiastically that most, if not all, of the original evidence is lost forever. We cannot know what is original and what has been replaced, while valuable inscriptions and inspection stamps have been lost under the influence of the sandblaster and copious coats of paint.

There exists at the Aerospace Museum at Cosford in England the best collection of German WW2 rockets in the world (see below), including a V-2 that has essentially escaped the attention of the enthusiastic volunteer restorer, or the curator and designer who wants his object repainted to fit in with an imagined color scheme. In 1997, John Francis, Manager of the Aerospace Museum, initiated a contract with a conservation scientist, Sheila Fairbrass, and a rocket historian, John Becklake, for the conservation of this V-2. The story of this work and its findings are the subject of this paper together with a listing of the other important German WW2 rockets which reside in the collection.

The Aerospace Museum, Cosford

The collections at the Aerospace Museum have arrived from a variety of sources over a period of more than 25 years. The museum, which houses aircraft as well as missiles and rocket engines, came into being initially as a RAF regional collection. Pressure from enthusiasts to be allowed to see the items led to the creation of a museum. The rocket and missile collection arrived from 6 principal sources:

- British Aircraft Corporation and its successors
- Aircraft and Aeroplane Experimental Establishment, Boscombe Down
- Royal Aircraft Establishment (initially Rocket Propulsion Establishment) Westcott
- RAF College, Cranwell
- RAF Cosford Training School
- RAF Newton.

The conditions in which the artifacts have been stored vary considerably as does the amount of time they have been in store. In some instances, they have been in air conditioned, climate controlled environments for most of their life, but in others they have been exposed to the elements or stored in unheated and non-weather proof buildings. As a result the level of preservation is very variable.

The missile and rocket collection has not always been seen as a central part of the museum's collection and high priority has not been given to its care. In addition, expertise in this area is not as common as that for aircraft from the 1940s onwards (which make up the bulk of the collection). These factors had combined to obscure the true importance of the collection.

A survey was undertaken of the missile collection in 1996 and 1997. This was intended not only to identify and catalogue all the objects, but also to assess their significance and estimate the amount of effort required to conserve the objects in as near original condition as possible. The decision to embark on a conservation program followed directly from this survey: objects of great significance were in danger of disappearing forever.

The decision to conserve, rather than restore, was an important departure. Previously, the bulk of effort within the museum had gone into restoration, with little effort being made to either record the restoration or to document and preserve the material which was necessarily discarded. The fact that conservation is generally a longer, and thus a more difficult and costly option, also presents a problem: within a fixed budget fewer objects will be conserved over time than if a restoration project had been undertaken.

If the decision to conserve rather than restore was not taken without difficulty, then the choice of where to start the program was even more problematic. There are several items that are unique, or nearly so, and a great variety of others which would have provided a more gentle start than that which was chosen: the V-2. The rocket and its ancillary equipment are among the largest items in the missile collection: they are also on public display. It was decided that the opportunity to conserve them while still on display, together with the high visibility that the weapon enjoys, would actually be an advantage. This would raise the profile of the museum's rocketry collection and provide a new type of display for the visitors. Eight months into the task this seems to have been borne out. Interest in the conservators' activity is high among the visitors and the opportunity to explain the processes involved allows greater interaction with them.

A further decision, to use museum technical support to carry out much of the work under the direct supervision of the conservators, has also proved benefi-

cial. Both volunteers and full-time staff are benefiting from exposure to new techniques and the level of skills among the volunteers has proved an asset.

Cosford's V-2

The V-2 at Cosford was one of the eight rockets built by German labor under British supervision for Operation Backfire, at Cuxhaven on the North Sea coasts of Germany in 1945.[6] Three of these were fired and the other five brought back to Britain in late 1945 or early 1946. The whereabouts of the Backfire V-2s are given later in the paper.

The British had difficulty in obtaining certain components, mainly relating to the control compartment and, in the example at Cosford, this is clearly evident. The quality of the finished structure of this compartment is not to the standard of the rest of the rocket. Sand particles and small pebbles have been overpainted inside the panels of the compartment. Several factors—the painting of the propellant pipes and the sectioning of the LOX and alcohol tanks, for instance—leads us to suspect that this V-2 was the one used in the "museum" at Cuxhaven and fabricated from non-flightworthy parts. We have found some items, such as the LOX vent valve, where a hole in the component (a shell hole?) has been filled, in this case with aluminum paste. It was also seen, when the tank section body was dismantled, that small patches had been welded, again presumably to fill existing holes.

The rocket body sections when captured would have been painted in the V-2 operational colors for the latter period of the war—olive green.[7] This was then repainted at Cuxhaven in the black and white livery of the Backfire V-2s. We have, in fact, found the original olive green camouflage paint underneath some test sections when we slowly removed the paint layer by layer to see what was underneath.

The history of this V-2 has still to be totally established, but we know that it was in Cuxhaven in the Autumn of 1945, was transferred to the Ministry of Works (MOW) Eltham, near the Woolich Arsenal in London, by 1946 and arrived at the newly-formed British Guided Projectile Establishment (GPE) at Westcott between April 1946 and early 1947. It remained at Westcott, with various trips out for display—for example, to Manchester in 1951—until it was transferred to Cosford in 1974/75. So for most of its life the Cosford V-2 has been stored under cover—at Westcott and Cosford—although it is evident that, at some stage, it has spent time outside, as water had gathered at its lowest point, where extensive rust has been found.

Figure 1: V-2 rocket at Cosford before conservation, with German Enzian and Hs293 missiles in the foreground.

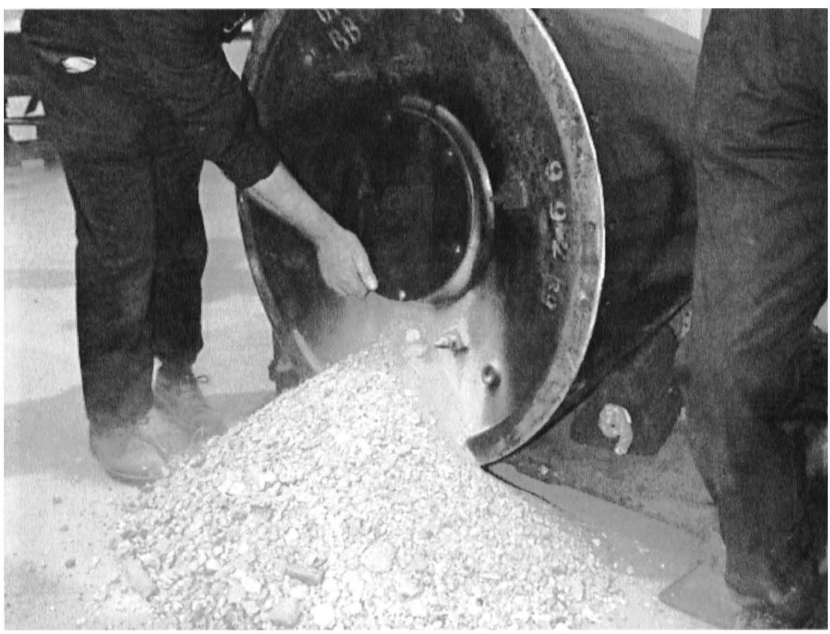

Figure 2: When the warhead was removed it was found to be full of Cuxhaven sand and pebbles, presumably to match the weight of the explosive charge that would have been fitted.

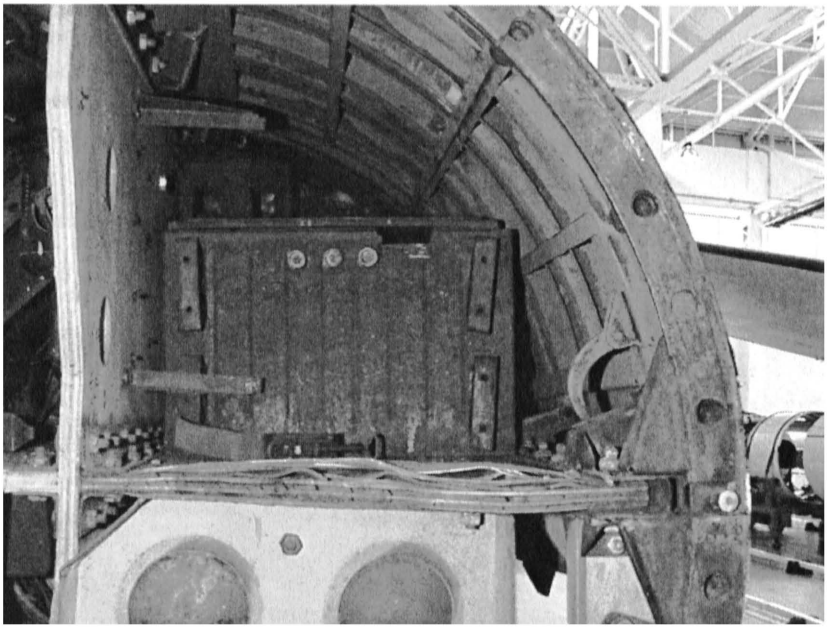

Figure 3: There was severe corrosion in the control compartment. Note the plywood struts.

Figure 4: Asbestos paste was found in the engine compartment, which had to be removed by professionals.

Sources at Westcott[8] are fairly confident that no repainting or dismantling of the V-2 was done there, and discussions with past staff and volunteers at Cosford indicate that no major work has been done there, either. However, it is obvious that some work has been carried out on this V-2 during its time at Cosford. Unfortunately, there is no documentary evidence to substantiate this.

We know, by comparison of pictures taken of its arrival at Cosford with those taken when it was being demonstrated on its Meilerwagen during the Aerospace Museum Airshows in the mid-1980s, that the paint scheme has been subtly altered. The black and white square color scheme was the same, but its proportions had changed.

When, and by whom, this repaint was done, and how much of the rocket was repainted in this time frame, is still unknown, but we are tracking down and interviewing volunteers working at the museum during the relevant period. It does, however, illustrate the need for complete documentation of any repairs, restoration or conservation work done on any object. There is also evidence that several components from the Control Compartment—the control amplifier, one battery and the time switch—were removed between 1985 and 1995 and that, at some time, some body work repairs were done on the fin section, with aluminum replacing steel. However, again, there is no written information about this.

However, apart from this, we are confident that we have an original, unrestored V-2 as assembled by the British/German Backfire team in 1945, which has remained assembled since that time. Albeit it is not an operational model and was used as a demonstration piece, it is, still, original. The inspection stamps, manufacturers' labels and inscribed part numbers on the various components can still be plainly identified. Most of the existing V-2s—see below—are either only shells or have had extensive restoration work carried out on them, both externally and internally, with no documentation. We estimate that there are, at the most, five V-2s in the world where the original evidence of its build, quality control and inspection markings are still available to the historian.

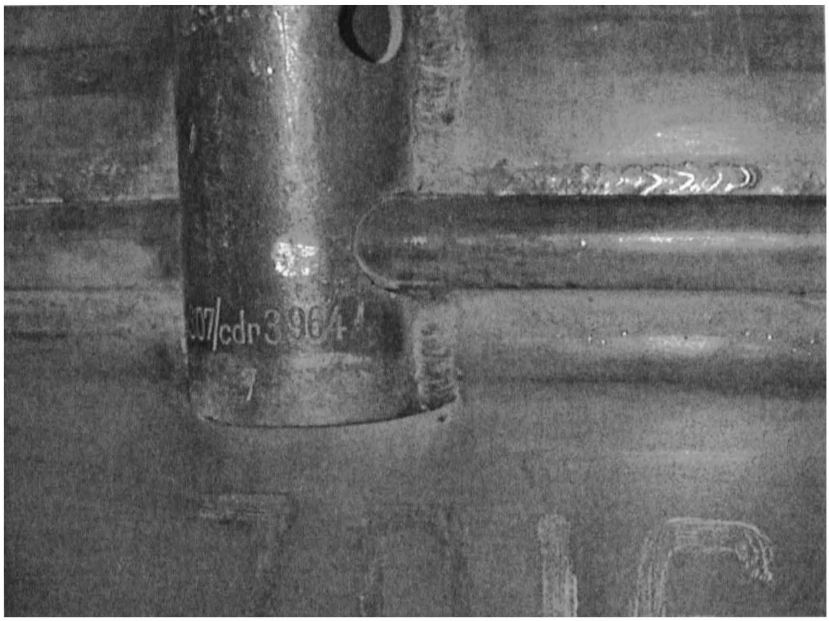

Figure 5: When cleaned, the original German stamps and markings were found on many parts of the rocket. This figure shows markings on the combustion chamber.

Figure 6: The inside of the tail section being treated with corrosion inhibitor - Trustran 40.

Conservation

The conservation of a large object poses several problems, which need to be addressed before any work can begin. The rocket is some 14 meters long and approximately 2 meters in diameter. For any meaningful conservation treatment to be carried out, the V-2 would have to be dismantled into some of its original components. These included the tail section, the engine, the central section containing the fuel tanks, the control compartment and the war head. Thus, the large, compact object which was being displayed at the far end of the museum would inevitably be changed into many separate, large objects spread around several hundred square meters of the floor space, where they would remain for about a year while the work continued. The option to carry out the conservation in an empty storage hanger was rejected, since it was felt that any inconvenience caused by the operation was far outweighed by the opportunity to display and explain a novel, on-going conservation project to the museum visitors.

The decision to carry out the work inside the museum immediately imposed severe restrictions on the range of treatments which could be safely carried out. Sand blasting or any heavy mechanical cleaning, or even the use of large amounts of solvents, were obviously totally forbidden on health and safety grounds, since it would be either impossible, or prohibitively expensive, to protect the general public from the dust or fumes. In fact, the decision to carry out the cleaning on the rocket without the use of sand blasting techniques had already been taken, for reasons which will be discussed later.

One further major problem, which had to be resolved, was to decide who was going to carry out the work. The museum already had an experienced technical team, well versed in the stripping down and repair of aircraft. They also had a resourceful and enthusiastic Society of Volunteers who were content to don overalls a day or two a week and help with the day to day maintenance of the museum and its objects. However, it was realized that conservation practice and techniques had moved on since the days when it was usual to hand over an object to the apprentices—who would strip it down, liberally cover it with paint and perhaps section it to show the working parts. Most major museums now include a dedicated conservation department to care for their objects, and in Europe and North America conservation training programs normally lead to a Master's degree. It should be mentioned here that the exception to all of this is in Japan, where they still insist on a thirteen year apprenticeship. The museum therefore hired a practicing conservator/conservation scientist to direct the conservation program. It was rightly assumed that new ideas and techniques formulated during the conservation of the V-2 would be assimilated by the technical team and applied to other projects undertaken in the museum.

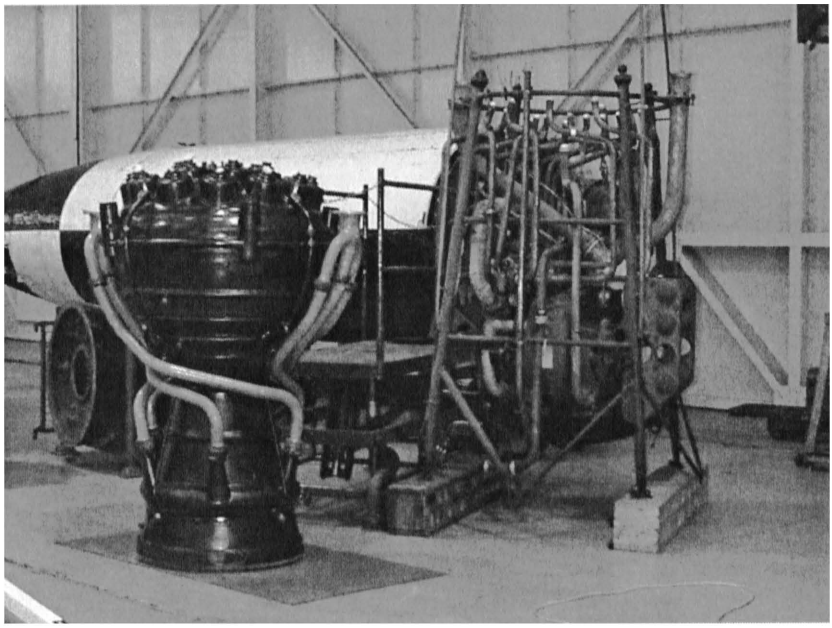

Figure 7: The treated combustion chamber stands beside the untreated engine pipework.

Figure 8: Glass wool insulation was packed around the fuel and oxidant tanks and held in with chicken wire.

When faced with a large object which is obviously rusting and in need of repair, the first, instinctive, response is to roll up the sleeves and get on with dismantling it completely, so that it can be cleaned up more easily. The justification for this plan of action is generally twofold. It is naturally felt that the object can only be repaired properly if every single component is taken apart and treated. There is also the more basic impulse to strip something mechanical down to its bare essentials and find out how it works. Modern conservation theory and practice, in fact, run contrary to these two instinctive responses.

The first question which has to be answered in regard to any object is: "when does its history stop?" If we use the paintwork on the V-2 as an example, this object was painted by the Germans, repainted by the Germans at Cuxhaven under British supervision, probably had some sections repaired and repainted by the technicians at Westcott and was certainly "retouched," at the minimum, by the volunteers at Cosford. All these processes represent an episode in the history of the object. The fact that the latest retouchings are now considered unsightly, and are relatively new, should not automatically result in their removal. They do not constitute any danger to the structure of the rocket and, although their elimination would enhance the visual quality of the object, it would also destroy evidence of the treatment it underwent in the 1960s and 1970s.

The same approach has been taken to the dismantling of the rocket. During any operation of this sort, it is inevitable that bolts will sheer, washers get broken and there will be some damages. The irreplaceable loss of even a small part is as important to the whole object as the loss of a major component. For this reason, each stage of the dismantling has been carefully considered and the removal of components kept to the absolute minimum required to provide access for cleaning.

At least 25% of the time spent on the conservation of the rocket has been devoted to record keeping and documentation. The exact location of each part which was removed has been photographed and recorded, and each item has been designated its own catalogue number. This is true, even down to small screws and washers. Large items are stored on racking, small items in individual bags and boxes. When the rocket is re-assembled, it is hoped that it can be done using only the original parts. The aim is to reconstruct the rocket in its entirety and have no small parts left in the box. The success of this approach depends, to a large extent, on the decisions and planning which take place at the beginning of the project.

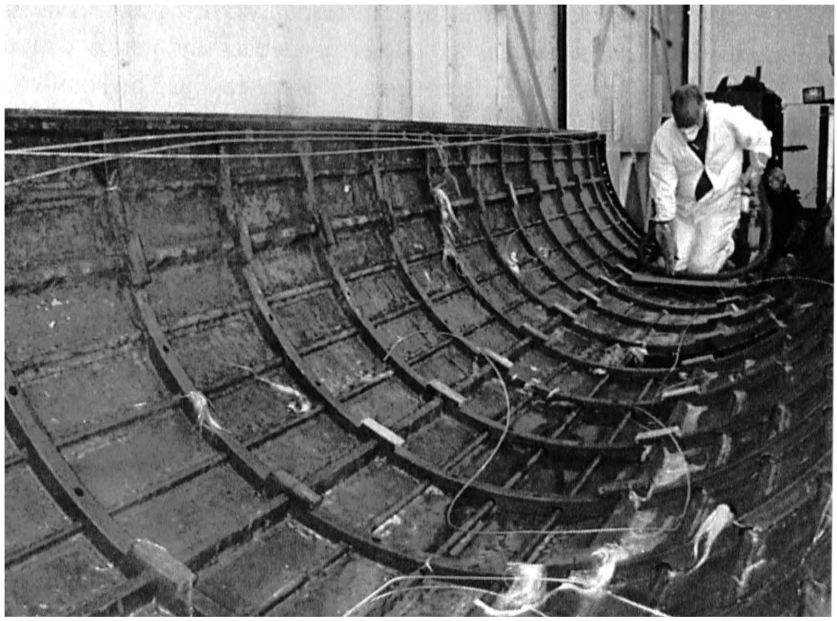

Figure 9: Tail section of the Cosford V-2 showing body corrosion.

Figure 10: Separating the V-2 tank section body reveals the propellant tanks and the glass wool insulation.

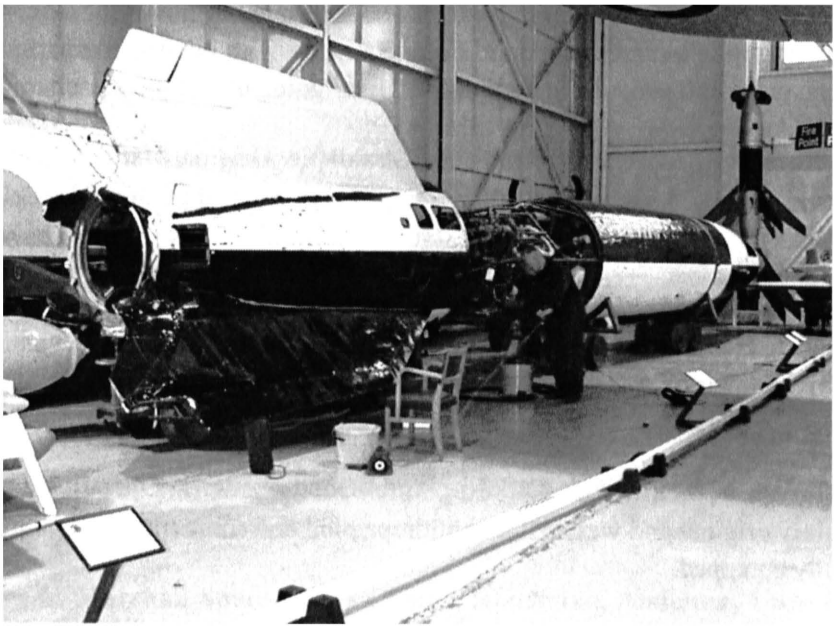

Figure 11: The V-2 in the course of assembly, after being treated, but prior to external painting.

The whole operation is being photographed and documented in detail as it proceeds. This should result in several CD-ROMs of reproducible images, a documented history of the V-2 rocket with special reference to the one held at Cosford, a detailed condition report and conservation record and a complete catalogue of the parts used to construct the rocket, along with their manufacturers' marks and quality control and inspection stamps. It is expected that the latter record especially may be useful to future researchers and historians.

Where Are They Now?

Some 6,000 plus V-2s were built in Germany during WW2, with about 3,600 being fired in anger against targets in Great Britain and Continental Europe. Around 300 were used in test firings and about 2,300 were still on the ground at Peenemünde and Mittelwerke at the end of the war.[2] Of these, we can find only 18 left, of which many are only shells. Of these, 8 are in the USA, 5 in Great Britain, 2 in Germany, 2 in Australia and 1 in Holland. In addition to this list, there is a possibility that one still exists at the Redstone Arsenal in Huntsville, USA.

Aerospace Museum, Cosford, England: Good example. Original Backfire version in black and white color scheme. Fully equipped with control compartment electronics, tanks and propulsion equipment. Undergoing complete conservation.

Science Museum, London, England: Good example. Original Backfire version in black and white color scheme. Fully equipped with control compartment electronics, tanks and propulsion equipment. Good condition.

RAF Museum Hendon, London, England: Good example. Probably an operational model. Heavily restored and painted - olive green color scheme. Fully equipped with control compartment electronics, tanks and propulsion components.

Imperial War Museum, London, England: Good example. Operational version. Mainly original and well restored but repainted and some replacement parts. Fairly fully equipped.

DEODS, Chattenden, Kent, England: Good example, but in poor condition. Probably a mostly original operational version but in need of treatment.

Deutsches Museum, Munich, Germany: In good condition but missing control electronics. Came from White Sands following its restoration for a von Braun movie. Probably a mongrel made up of spare parts.

Luftwaffenmuseum, Berlin, Germany: A "present" from England, according to the curator, and probably a Backfire model. Shell only on display but components in store. No electronic components for the control compartment. Restored in 1986 by Luftwaffenwerft.

Legermuseum, Delft, Holland: Interesting example, put together from parts salvaged in Holland at the end of the war. Heavily restored with sections missing. Definitely a mongrel.

RAAF Museum, Point Cook, Victoria, Australia: Only a shell, but supposedly pulled from the Polders in Holland. Carries the distinctive straight line camouflage of late 1944/early 1945. About to start restoration.

Australian War Memorial, Canberra, Australia: Good example, in good condition. Complete with all components and in original condition. Probably a Backfire example, although the curator says it is painted all white. Transferred from Woomera in 1957.

NASM, Washington, DC, USA. Relatively complete but mongrel version, including parts from the Aerospace Museum, Cosford. Restored in 1976 for the opening of the National Air and Space Museum.

White Sands Missile Range, New Mexico, USA: Poor condition, with some internal components but filled with concrete. Has been repainted many times, displayed outside.

Kansas Cosmodrome and Space Center, Kansas, USA: Good example in complete condition. According to the curator "probably the most complete of any in this country." Original color all white, now white and black. Came from the Redstone Arsenal in 1989.

Alabama Space and Rocket Center, Huntsville, USA: Shell only. Recently restored by the Kansas Cosmodrome and Space Center.

George C. Marshall Space Flight Center, Hunstville, Alabama, USA: No reply from this Center and no information apart from the fact that one exists there.

Fort Bliss, El Paso, Texas, USA: Shell only and in poor condition. Displayed outside, repainted many times, warhead not original. White with black fins.

Patrick Air Force Base, Cape Canaveral, Florida, USA: No response to repeated letters and telephone calls, although reports indicate that this V-2 is relatively complete and about to undergo restoration in-house.

Wright-Patterson Air Force Base, Dayton, Ohio, USA: Poor condition, but with engines and tanks intact, on Meilerwagen. Transferred in 1998 from Aberdeen Proving ground. Original olive green paint. About to undergo restoration.

The Cosford Collection

The Cosford Collection forms part of the larger collection of the RAF Museum at Hendon in London, but the artifacts referred to in this section are either on display or in store at Cosford. There are also several German WW2 rockets in the main RAF store at Cardington, but these will not be discussed here. The Cosford Collection is described in three sections for ease of explanation: V-2 related items, objects on display and objects in store.

V-2 Related Objects

The Collection contains a number of V-2 handling machines, plus a selection of rocket components, many of which have been sectioned for display, possibly at Cuxhaven. All the objects mentioned in this section are in store at Cosford unless otherwise noted. There are, however, no examples of V-2 support vehicles, such as the LOX and alcohol tankers, in the collection.

The V-2 handling equipment comprises:

Strabo Lifting Crane and Beam: For lifting V-2s from their railway transport trucks onto Vidalwagens for transfer to the launch preparation site.

Vidalwagen: transporting vehicle

Meilerwagen: used to carry un-fueled V-2s to the launch site and erect them vertically on the launch platform.

Launch Platform and Flame Detector Assembly Bogies: Four off, for movement of V-2 body sections during assembly. Presently on display and being used for supporting the body sections of the V-2 during conservation.

These items, with the exception of the bogies, have been repainted and serviced by the Society of Volunteers at Cosford and are all in working order.

V-2 Rocket Sub-components: There are 50 plus of these, mainly small pressure and solenoid valves, but many items are extremely rare and of great interest to the historian. Among these are:

1. V-2 control receiver, used for radio controlled cut-off of the engine from the ground[9]
2. Numerous sectioned components, including peroxide tank, steam generator chamber, alcohol valve and LOX filling valves.

Display Objects

Most of these have unfortunately been the subject of extensive restoration by the Society of Volunteers, or by what was called, in Britain, Manpower Services Commission workers under the supervision of a technician, in the late 1970s / early 1980s. The rockets were stripped to bare metal and repainted, often in unrepresentative colors. Probably more importantly, no records can be found of what was done and when, or of any markings or inscriptions found. Some items are also mainly shells, although a number of the missile powerplants and electronics components are to be found in the storage collection. They are of lim-

ited value to the historian but they do make striking displays and some of them are extremely rare, to say the least.

V-1 pulse jet: Surface-to-surface missile

BV246 (Hagelkorn): Unpowered air-to-surface guided glide bomb. Has concrete wings.

Enzian: Surface-to-air missile with boosters, painted in red and yellow segments.

Fritz X: Unpowered guided bomb

Hs293: Rocket powered air-to-surface guided missile.

Tiafun: Small, unguided mass bombardment anti-aircraft missile. Examples of both liquid and solid fuelled versions.

Feuerlillie 55: Experimental high speed test rocket.

Rheinbote: Multistage, solid fuelled, unguided surface-to-surface missile. Color scheme green and black. Un-restored Rheinbote in store.

Rheintochter 1: Solid fuel surface-to-air guided missile.

X4: Wire guided air-to-air missile. Unrestored example in store.

Hs117 (Schmetterling): Liquid fuelled surface-to-air guided missile.

Hs284: Liquid fuelled, air-to-air guided missile.

V-2 Combustion Chamber: Sectioned and painted.

Walter: Cold thrust RATO.

Walter 109-509C: Twin thrust powerplant for the Me163 rocket powered aircraft.

Treasures in Store

As is often the case with museums, their stores are treasure troves and that at the Aerospace Museum is no exception. The objects in store include several items which are either unique (in that we know of no other examples in existence) or extremely rare. The other good thing about these items is that, although they are severely corroded in some cases, they appear to be in their original paints. Prime among these objects are:

Rheintochter III: The body, less control and radio compartments and boosters, of the liquid fueled version of the Rheintochter surface-to-air missile developed

by Rheinmetal Borsig. We know of no other example of this liquid fuelled rocket in existence.

Wasserfall: Body and one control fin of the liquid fuelled surface-to-air missile under development at Peenemünde at the end of the war. We know of only one other example of Wasserfall in existence—at the Aberdeen Proving Ground in the USA. There is also an example of a heavy metal and wooden drop test model of the missile, plus a development injector head.

Walter 109-739 motor: Developed for use on the operational Enzian E2 and E3 surface-to-air missile. An order was placed for this motor, using SV Stoff (90% nitric / 10% sulfuric acid) plus brown coal benzene as propellants, in September 1943.[10] But it was not ready to be flown by the time Enzian was cancelled in February 1945.

Other interesting items include:

1. Control Joy Stick, designated Knuppel control Gcber Ge203. For use with the Hs117 (Schmetteriing) missile. Similar to the control units used for Enzian and the Hs293.
2. Two off variable thrust BMW 109-558 liquid fuel rocket motors as used on the HS117 (Schmetteriing) missile.
3. Sectioned main control valve assembly for the Walter 109-509 rocket motor for the Me163 fighter.

Conclusions

As already noted, the Cosford Collection of German WW2 rocket technology is the most comprehensive in the world and the Aerospace Museum has made a determined start towards conserving this collection in such a manner that it will be of use to future historians as well as presenting interesting display objects.

There must, however, be other museums and establishments in the world where important WW2 rocket technology is languishing, and even rotting away, in store, unknown to the rocket historian. During the work on the V-2 at Cosford we have identified many of the resting sites of WW2 rocket archives, but we have been concentrating on V-2 rockets alone. One of us, John Becklake, intends to expand this to cover all V-2 related objects: but we would still be nowhere near producing a complete inventory of all German WW2 rocket artefacts. This

should not be an impossible task and is one which, we feel, would be well worth the effort, especially if it meant that important hardware was identified and spared the attention of the enthusiastic dealer or the scrap merchant. Some recovered V-2 pieces were recently bought from a scrap merchant by the Legermuseum in Holland.

The dichotomy between a heavily restored and shiny, newly-painted rocket for display and a conscientiously conserved object which will be of value to future scholars is not half as great as perceived. The cost of conservation is likely to be more than for a standard restoration job, but the end product is of far greater value to future generations and this must be the aim of all his historians and curators: to preserve their objects in as original condition as possible and to document all work done on them.

Postscript

At the time of writing—end of July 1998, to comply with IAF regulations for the production of papers—the work on the Cosford V-2 has not been finished. The rocket has been dismantled in its major components:

1. Nose cone
2. Control Compartment
3. Two tank body sections
4. Two tanks
5. Fin assembly
6. Engine Pipework and
7. Combustion Chamber

No further dismantling will be done and the above components are to be treated as they are found. The treatment and cataloguing work on the nose cone, combustion chamber, engine pipework, control compartment and the inside of the fin assembly has been completed. What remains is the work on the inner surfaces of the tank body sections, the tanks themselves and the outer skin of the rocket.

Overall, the condition of the internal components of the rocket was extremely good. The tanks themselves and the pump/turbine assembly, for example, were found to be in excellent condition and require no treatment at all apart from minor surface cleaning. We hope to have the rocket completed by early 1999.

Since the preparation of this paper the official title of the Aerospace Museum, Cosford has changed to the RAF Museum, Cosford.

Acknowledgments

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