The Imperial War Museum, London

Stage 3

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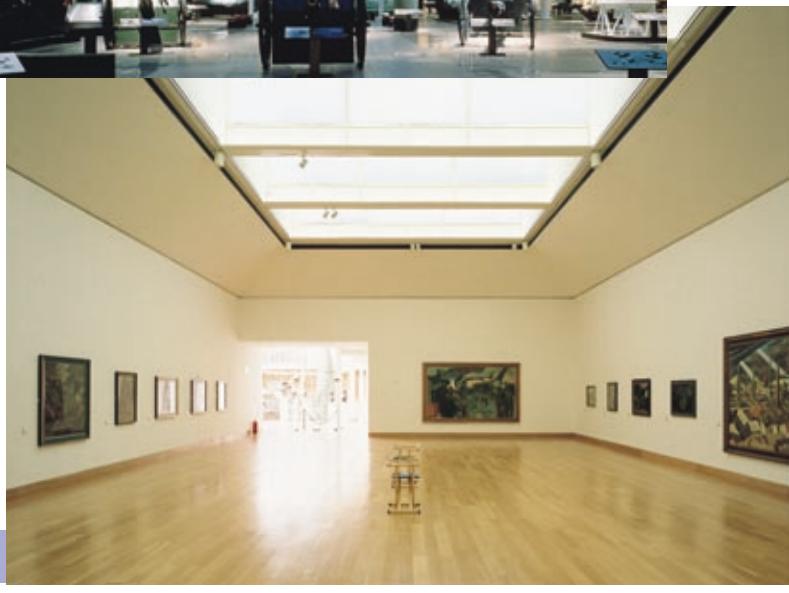
1. West façade of completed building.

2. below: Stage 1 exhibition gallery, before construction of Stage 3 extension to the barrel vault.



3. Stage 2 gallery space.

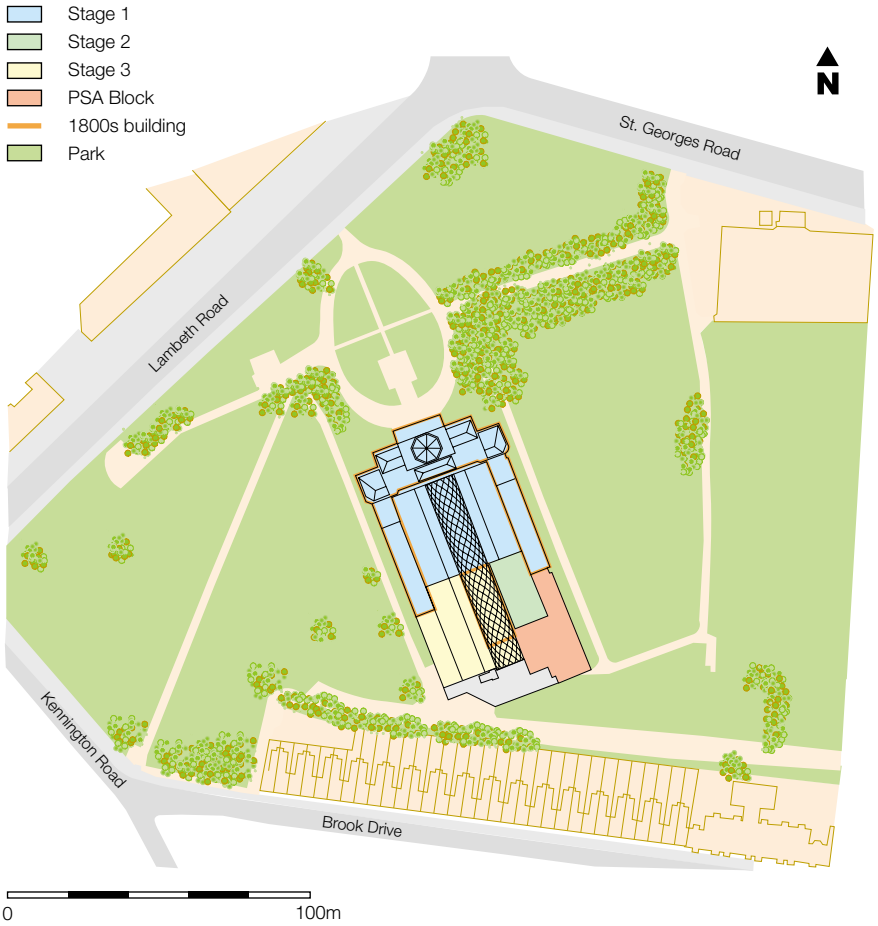
Introduction

Built in 1815 as the Bethlem Royal Hospital, the Grade II Listed building on Lambeth Road, Southwark, SE1, became home to the Imperial War Museum in 1936. In 1983 the IWM approached Arup Associates to explore the feasibility of developing the building into a world-class home to this national collection. The brief was for a masterplan and design that significantly increased the amount of gallery space, provided strict environmental conditions appropriate for a national museum holding a large and diverse collection, and improved visitor facilities. Arup Associates proposed a four-stage development, the first to be carried out whilst the Museum was closed to the public and subsequent stages realised when it was fully functioning, at later dates.

The scheme went ahead. Stage 1 created, as a focus to the Museum, a top-lit central exhibition hall plus various exhibition and art galleries around it, giving a total of 8000m^2 of museum space, 4600m^2 of it new. An exposed steel structure and diagonal lattice barrel vault provides support for aeroplanes and other large exhibits suspended in the main atrium space[1]. The second stage - completed six years later in winter 1994 - was the exhibition and art galleries in the south-eastern lightwell. This added another 1600m^2 of floor space and, as planned, was carried out with the Museum open to the public.

In 1995, the IWM asked Arup Associates to review the original masterplan with respect to the final development stages; approaches had been made both to and by the IWM for the Museum to house the UK's first permanent exhibition on the Holocaust. The brief was for a conceptual study to explore maximising exhibition space within the original masterplan's envelope, whilst not prejudicing the potential for a fourth and final stage of redevelopment.

4. Location plan.



The site

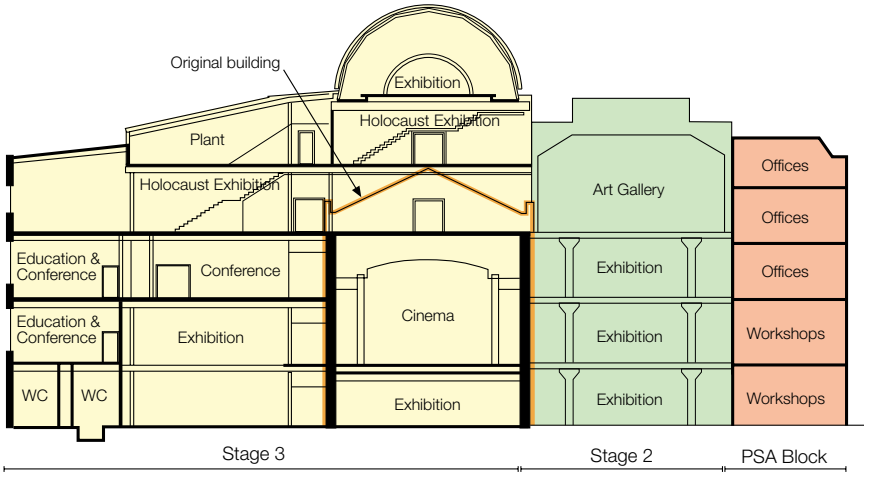
The Museum lives in several interlinked buildings within Geraldine Mary Harmsworth Park in Southwark. At the north is the horseshoe-shaped 1815 brick building of the Bethlem Hospital with its Stage 1 central infill. South-east of this is a 1960s brick and concrete building (the PSA block), containing document storage, offices, workshops, and other back-of-house facilities. In the centre is the cinema block - also originally part of the Hospital accommodation.

A courtyard originally between the PSA block and the Stage 1 area was infilled during Stage 2. There remained a double-storey gallery space to the western boundary - the only double-height exhibition space outside of the main, Stage 1, atrium. The area available for Stage 3 was the south-west corner of the building at the lower levels, to build out over the existing cinema building with an extension of the Stage 1 barrel vault roof.

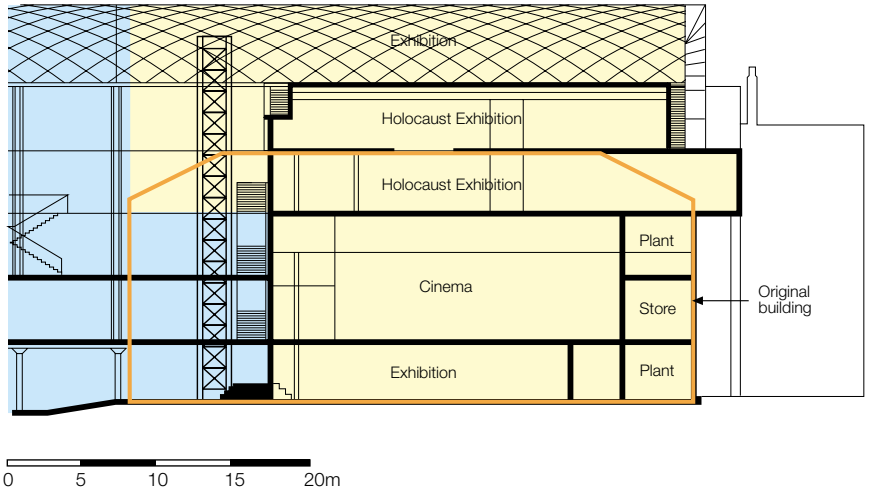
The Museum has tight site constraints. The Park is owned by Southwark Council and therefore unavailable for further building. Development was constrained by the boundaries of the existing Museum land and the height of the existing listed building, with its relationship to neighbouring residential streets. The nearness of houses to the south of the Museum stopped the building mass extending southwards to the boundary at the existing height; the southern extreme is the service yard, the only servicing and exhibits access point into the Museum, and enclosed by a single-storey wall. The fourth and final stage of development was proposed as building over the service yard, but during design of Stage 3 the IWM decided this was unlikely ever to progress.

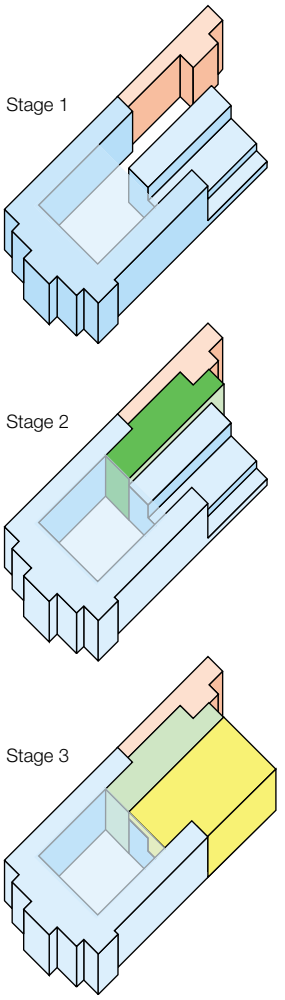
Construction in and around the existing, operating buildings was just one of the project's challenges. Beneath the Museum runs the Bakerloo Underground line, another constraint on the development, this time on its foundations.

5. Cross-section.



6. Stage 3 section.





7: Axonometric of IWM extensions.

8 & 9. Glass screen between gallery and atrium areas.

The brief

Building anatomy

- emphasis on the importance of the main stair plus its extension to the new upper levels
- a new, secondary, entrance for conference, disabled, and schools, with foyer space for gathering large numbers of schoolchildren together
- easy access to the schools' facilities from the schools' entrance
- closeness of the secondary entrance to the main stair to enable easy public orientation within the Museum
- prominence of Holocaust Galleries when first entering through the front entrance
- lengthening of the barrel vault to the southern extent of the Museum (as per the original masterplan) to both link the various stages together and create a proportionally pleasing roofline.

Accommodation

The Stage 3 brief was to provide a variety of spaces: exhibition areas; education facilities including classrooms, support office, dining hall, and WCs; conference facilities including cloakrooms and WCs; and a cinema. The cinema had in fact been refurbished in Stage 2 and was to be retained in Stage 3, although this would entail the partial demolition and reconstruction of the area and its finishes. The education facilities were to provide classrooms for the Schools Programme – an active part of the Museum's local and national remit - during term-time, and for conferences at other times, enabling the Museum to maximize its additional revenue potential.

Most of the exhibition space was for the Holocaust Galleries, with various additional areas for temporary exhibitions. This included reinstating a double-height gallery space at ground level for large and potentially heavy items.

The brief required spaces which, through their location and quality of finish, could provide this dual schools / conference role for the Museum, plus one that could be separately accessed for additional security and to provide out-of-hours and ticketed access.

As for building services, Stage 3 was to provide a variety of fully air-conditioned exhibition spaces, plus classrooms with natural ventilation supplemented by some comfort cooling to deal with the afternoon overheating that could occur because they faced west. The location of existing plantrooms, plus lack of capacity in the existing cooling, heating, and heat rejection plant, made a new plantroom necessary that did not heavily impinge upon available area for exhibition space. The main boilerhouse and chiller room was in the cinema block, and thus within the construction site of the Stage 3 works.

10. Close-up of main staircase at the upper levels, showing the link between the Stage 1 and Stage 3 barrel vaults.

The design - scheme

As the demand for a permanent Holocaust exhibition grew, so did the feasibility of constructing Stage 3, as funding was in place from several sources including the Heritage Lottery Fund, Jewish groups, and private individuals.

Early in the design, the team decided for three reasons that the external aesthetic should respond to that of the adjacent existing wing. Firstly, the development was not to upstage the Museum's main entrance, but be clearly integral to the whole. Secondly, the building's Grade II Listing would preclude an overtly high-tech scheme unless there was much consultation with English Heritage and the planners, and even then an acceptable Planning Approval could not be guaranteed. Thirdly, the brief's deployment of spaces was particularly suited to 'windows in a solid façade' rather than a predominately glazed elevation.

It was felt that, for the redevelopment's overall coherence internally, the structural language of Stage 1 should be continued. Stage 3 was thus developed as a lightweight, fully expressed steel frame with restraint given by concrete stair / lift elements. It was also necessary to maintain full structural separation from the existing adjacent west wing and cinema block.

The design team reassessed the servicing strategies developed during Stages 1 and 2, both for their relevance to the current and anticipated future Museum, and to test whether the Stage 2 modifications had proved appropriate for the spaces' eventual use.

As Stage 3 was a variety of spaces 'slotting in' around existing volumes, it was readily apparent that only the upper levels could supply the clear expanse of floor plate needed for the Holocaust exhibition. The ground floor level at the rear of the Museum (Level A) was actually the 'basement' level from the main entrance, enabling access at grade via the new schools' entrance on the west side.

(See panel below)

Similar patterns of movement were expected for conferences, so the two uses dovetailed and enabled a simple accommodation plan to be developed. The foyer / gathering space was proposed as an exhibition gallery immediately next to the new schools' entrance; the space was originally part of the Museum and not big enough for useful temporary exhibition space. The schools' dining area and classrooms were located along the western boundary where they could enjoy good natural daylighting and views out over the Park. These spaces wrap around the larger volumes of exhibition spaces and conference room.

For the first time at the Museum, Stage 3 was to include accommodation more than 18m above ground level. Usually, under Section 20 of the London Building Act, this would require the design to incorporate a fire-fighting stair and lift, but the Museum does not operate during a fire situation as a 'normal' office or public building. When a fire alarm is triggered, no immediate general alarm is sounded.

Patterns of movement planned for schoolchildren accessing the Museum

Around 80 schoolchildren per hour were expected, so clearly the logistics of moving, gathering, and servicing the children's needs would be the primary driver for the internal planning.

The flow would be:

Arrival -> cloaks -> WCs -> foyer gathering for briefing -> dispersal into Museum/classrooms

And subsequently:

Foyer gathering -> collection of lunch boxes from cloaks -> WCs -> dining hall -> dispersal into classrooms/Museum -> WCs -> exit.

'The galleries have been extremely popular, also the education facilities have enabled the Museum to expand its education programme as well as increase additional revenue through conference use.'

Instead, it shows as a warning in the main control room at the north end of the Museum, and a staff member is sent to investigate. If it is found to be a 'real' alarm, the control room is contacted by radio and the Fire Brigade advised. At this time evacuation messages are broadcast throughout the Museum, ensuring a quick staff-assisted evacuation away from the fire source.

A combination of the Museum's strict regime, plus negotiations between Arup Associates, Arup Fire, and the London Fire and Civil Defence Authority, enabled the requirement for a fire-fighting lift to be waived.

The floor area above 18m was minimal: with a small occupant capacity as it was classed as 'art gallery' not 'place of assembly'. A fire-fighting stair was located within the rear yard of the Museum, at the southern end of the Stage 3 works. This conformed in all aspects to the requirement, and gave access straight to Level E of the Museum. A separate straight stair then led from level E to F, the topmost floor.

This was in addition to a combined fire and accommodation stair on the Museum's west side leading direct to Level D, with associated (fire escape only) stairs then linking up to the northern end of levels E and F. Provision of two separate and discreet escapes from relatively small floor plates reassured the authorities that the Stage 3 design offered a safe alternative to the usual requirements.

The design – building

A 6.2m x 8-10m (ie variable) structural grid was adopted, accommodating the servicing strategy and structural rhythms set by Stage 1. Structural separation from the cinema block was achieved by inserting a 'table top' structure where its roof previously was. Two 2m deep box girder beams, each in two 11m lengths, were placed within the cinema walls, supported on CHS steel columns threaded through the existing floor plates and onto new pad foundations.

The box girders support primary and secondary steel beams, which in turn carry *Holorib* decking with concrete slabs. Elsewhere, the primary steel beams, carried on CHS steel columns, defined Stage 3's circulation routes which also carried the primary services routes from which each space teed-off. The secondary steel beams, above and at 90° to the primary beams, define the ceiling rhythm, and within this zone the air supply and extract ducts, plus the power and lighting tracks, run.

The 'aesthetic upgrading' of ceilings and services developed in Stage 2 had proved unnecessary, given how the Museum uses its exhibition space. Its designers develop the spaces as 'warrens' of story-telling, with ceiling details often masked by exhibition fit-out, so it was decided that the Stage 3 design should revert to the Stage 1 principles:

- exposed structural soffits
- exposed oval supply and return ductwork with linear slot diffusers
- lighting and power tracks running between the air ducts to provide fully flexible cabling to exhibits
- acoustic absorptive material between the services elements on the slab soffit to create an acoustically comfortable space
- electrical services floor boxes on a regular grid to allow connection of display cabinets once exhibition designs have been finalised.

Museum galleries require stable environmental conditions, within a narrow band of temperature and especially relative humidity to help preserve exhibits. However, heat and moisture loads within these spaces vary dramatically as groups of visitors move *en masse* from one exhibit to another. Simultaneous control of conditions is maintained by triple redundancy temperature, humidity and CO_2 space sensors controlling a variable volume air system. Carbon filtration is provided to maintain clean air supplies for the protection of exhibits.

The classrooms are naturally ventilated with supplementary cooling. The meeting and conference rooms are mechanically ventilated and fan coil units provide supplementary cooling / heating. The restrictions of the refurbished cinema and its requirement for flexibility of use suggested the design of high-level supply diffusers with low-level extract at the front of the stage and the rear wall of the cinema. New air-handling plant was provided behind the stage area. The trademark 'style' of the previous stages was reinforced within the Stage 3 design. The requirement for flexibility of spaces, and nature of the exhibits, produced an aesthetic where the structure and services elements generated the architecture.

The design – enabling works

Prior to the Stage 3 works, the Museum had four major plant areas:

- Level A boilerhouse - at the south end of the building and housing boilers, chillers, and pumps serving the whole Museum
- roof-top cooling towers – above the southwest wing
- Stage 1 air plant – in the roof void above the east and west wings to either side of the main atrium
- Stage 2 air plant – south of the Stage 2 infill works.

Some of this plant thus fell within the area to be redeveloped in Stage 3, and a major enabling works package lasting six months was required. This entailed inserting new cooling towers at roof level above the Stage 2 works, the removal of a standby chiller outside the main boilerhouse, and the termination of all mechanical and electrical services which fed from the Stage 1 and 2 areas into the Stage 3 site area.

All this was exacerbated by a lack of detailed records of service runs / connections, plus the complexity of the main boilerhouse area, which had never been thoroughly overhauled – redevelopment had previously been piecemeal, generally within restricted spaces, without all the redundant service runs being taken out. The removal of chillers / boilers to new locations in order to insert additional chillers, plus re-locating all the pump sets to a new pumproom created immediately adjacent to the boilerhouse, was all carefully planned and implemented.

The Museum was in continuous operation and services had to remain live to maintain environmental conditions. Routing the new service connections between the new cooling towers, the re-modelled boiler / chiller room, and the Stage 3 plantroom was complex but rewarding. It is a testament to the planning and design that the Museum did not have a single day with any compromise to the environmental levels.

The Stage 3 plantroom – housing air-handling plant, water treatment tanks, and lift motor rooms - was located at Level E, beneath the roof like the Stage 1 plant. The difference, however, was that in Stage 3 the area east of the plantroom was part of the Holocaust Exhibition Gallery, with stringent acoustic separation criteria.

The cinema could not stay in use during construction - due both to the structural insertions and the services connections, which had to be incorporated beneath the cinema stage - so the Museum relocated cinema facilities to the art gallery designed by Arup Associates in Stage 2. This considerably reduced the number of interfaces between the public and the construction site. Similarly, the schools' facilities to be lost during construction were re-housed in temporary accommodation in the Park east of the Museum. This freed the Museum's west side for contractor access and facilities only - maintaining a healthy separation between children and the site.

Construction

The length of the construction programme for Stage 3 - three years - reflected the various complexities of working around an existing building, working within a fully functioning museum open to the public throughout, inserting new foundations and structures around existing 19th century foundations, and working with existing services and modifications to these services.

11 & 12. The Holocaust exhibition.

Conclusion

The Stage 3 extension, with particular attention on the Holocaust Galleries, was opened by HM The Queen on 6 June 2000. The galleries have been extremely popular, with the Museum introducing timed ticket access to prevent overcrowding in the early months of opening. The education facilities have enabled the Museum to expand its education programme as well as increase additional revenue through conference use.

Reference

(1) AYIOMAMITIS, A *et al.* The structure of the Imperial War Museum extension. *The Arup Journal, 23*(4), pp2-6, Winter 1988/89.

The interfaces between the site boundary and the public were carefully monitored, with 'crash decks' built over the main stair, and a scaffold and insulation board 'wall' within the main atrium from D floor up to the underside of the barrel vault roof. This insulated the Museum from dust, noise, and thermal change for much of the works.

During construction, the Museum let the contract for the design and construction of the Holocaust Galleries. Several co-ordination meetings were held with the gallery designers (DEGW and Amalgam), but the base scheme's lighting, power, and air systems were flexible enough for the design to be carried out without alterations to the base scheme.

The structure and fabric of the building were kept simple:

- concrete pad foundations
- steel frame
- concrete cores for stability
- load-bearing masonry external walls with a lime mortar to match the original building and to preclude the need for movement joints
- *Holorib* decking with 150mm or 300mm concrete slabs
- tubular steel lattice barrel vault
- profiled metal roofing panels.

Complexities lay at junctions with the existing fabric: with 'soft' joints where floor slabs abutted, with the separate foundations, and in particular at the junction between the old and new barrel vault structures. The new barrel vault was delivered to site in sections, and then assembled on a framework built off the Level F floor slab and site-welded together. The northern sections were welded to the tubular 'hoop' at the southern end of the existing vault.

The Stage 1 vault had been covered in polycarbonate, but the team decided to roof the Stage 3 vault with a metal sandwich panel, for three reasons:

Firstly, 'new' polycarbonate contains additives to prevent discolouration, but the existing vault had yellowed over its 15-year lifespan, so the new could never match the existing.

Secondly, there are inhabited gallery spaces within the vault space (unlike Stage 1) and the cooling load that would be created by using polycarbonate was unacceptable both environmentally and physically.

Thirdly, fully daylit gallery space is not flexible for exhibitions, so would have been very restrictive to the usage of the Level F area.

Credits

Client:
Imperial War Museum

Designers:
Arup Associates with Arup specialists: Simon Barden, John Beckwith-Smith, Paul Dickenson, John Edgar, Chris Holmes, John Hopkinson, Rebecca Hutt, David Hymas, Daniel Jang-Wong, Mike Kinney, Dick Lee, Graham Ling, John E Miles, Terry Moody, Eric Owen, David Pearce, Annelise Penton, Terry Raggett, Alan Ross, Joe Solway, Geoff Stevens, Simon Webster, Jim Warren, Malcolm Wright

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2, 3, 9: Arup Associates
4-6: Claire Noble
7: Annelise Penton / Emine Tolga
11, 12: Courtesy IWM / Andrew Putler