Schwabe-Hasait Cyclorama Lighting: a British failure but a window on a revolution in stagecraft

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Abstract

In 1923 at the London St Martin's theatre, the renowned theatrical producer Basil Dean demonstrated his new installation of Schwabe cyclorama lighting with an encircling Hasait cloth cyclorama. He was also supporting the importers, GEC, coining the name "Schwabe-Hasait" to describe and promote the combination. This name was a misnomer, the cyclorama and its lighting were independent and outside Britain were only known separately. Few systems were ultimately imported.

However, behind the Schwabe and Hasait developments was the early 20th century revolution in dramatic styles in Germany, driving scenographic and lighting development far ahead of the traditional British stage. Pioneers such as Fortuny, Brahm, Reinhardt, Appia and even Wagner were demanding a new realism and dramatic impact in stagecraft which German technologists provided. Dean recognised this and attempted to introduce elements of it to Britain. However despite other British visionaries such as Herkomer, Craig and Gray, the ideas were mostly lost in the conservative commercial British theatre before World War II.

This work investigates the origins and development of Dean's cyclorama and its lighting. The demand for visually realistic outdoor scenes with solid rather than painted scenery was driven by the theatrical styles of the new German drama and opera presentations. This required massive encircling cycloramas, with the challenge of construction and illumination as a convincing infinite sky being addressed by their suppliers, particularly Schwabe and Hasait. Early electrical lighting was key to this, eventually mixing up to seven colours to achieve tonal accuracy in an age when colour science and filter technology was still in its infancy.

Dedicated to the memory of
Jennifer Bertenshaw (1942–2023)

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1. Introduction

In 1975, the embryonic Society of British Theatre Lighting Designers (BTLD) held a meeting chaired by Richard Pilbrow, which included a lengthy discussion on the "Schwabe-Hasait"[1] cyclorama lighting introduced by Basil Dean in 1923 (Pilbrow et al. 1975). A recently discovered verbatim record of the meeting led to renewed interest in the fact that the Schwabe Horizont (cyclorama) lighting system used seven colours to provide a very broad range of tones. Rob Halliday reviewed the BTLD discussion in 2020, comparing the very early use of seven colours to modern LED stage luminaires that similarly blend multiple primary and secondary colours, rather than attempt to achieve everything with just three primaries (Halliday 2020). Ridge had considered the Schwabe system an "outstanding scientific achievement" in 1928 (Ridge 1928, 78). However few Schwabe-Hasait systems were installed in the UK, most cycloramas were lit with three or sometimes four (light and dark blue) primary colours in battens or floodlights.

The name Schwabe-Hasait was also a misnomer, a nickname coined by its promoter, producer/director Basil Dean. Dean had explored German theatre from 1911 to 1922 and was the first in the UK to use the Schwabe cyclorama lighting and projection system with a Hasait design of cloth cyclorama. There is no record of Schwabe & Co and Hasait collaborating in the design of this system, though they doubtless worked together on many theatre projects. Schwabe and their British agents GEC did promote the use of a cloth cyclorama, but of unspecific source. The name Schwabe-Hasait (sometimes unhyphenated) remained unique to a small circle of British commentators, and to GEC who marketed Schwabe lighting in the UK. Their marketing idea was not unique, the contemporary Swedish "ARS System" was essentially identical and appeared to have the same minimal success.

The BTLD meeting had further asked the question "what was stage lighting about between the wars?" The discussion noted not only the importation of the Schwabe-Hasait system but also some initial British use of auditorium spotlights, also copying German practice, though agreed there had been little British innovation. British theatre at the time was very conservative.

This paper investigates the background, origination and design of the system, together with the way in which artistic and technical innovation supported each other. It particularly focuses on cyclorama lighting as this was the essence of the Schwabe-Hasait system. Cycloramas themselves developed considerably from simple backcloths to encompassing circular cloths to solid screens and domes as inventors struggled to achieve an "infinite sky" effect within the limited confines of a stage.

A large amount of this material appears to be untold or is only accessible in the German language. In consequence it is necessary to investigate several narrative threads to establish how the technical and artistic situations arose, hence the essay's structure as a series of sections exploring the various issues. The study of lighting scenographic development as theatrical styles evolved is of course a very extensive field and cannot be done justice in a few paragraphs. The goal is only to identify and analyse those ideas and forces that influenced the technical development of German cyclorama lighting and cycloramas themselves.

Sections 2 to 4 first consider how the root cause of Dean's Schwabe-Hasait experiment was the very conservative British commercial theatre at that time, having changed little in the first

[1] Pronounced in English like 'Shvarber' and 'Hasite'.

quarter of the 20th century, despite several attempts at renewal. Early practical experiments by Herkomer, which clearly influenced the young Craig, failed to inspire change. Dean was one of a small vanguard of modern producers striving to lift dramatic and scenographic art above the lowest common denominator. By contrast the period from 1900–1933 in Germany was a cradle of dramatic style and stagecraft evolution where the majority of modern theatre forms were developed.

Sections 5 to 6 explore the extensive experimentation and development of cycloramas, from the initiatives by Asphaleia through to the Fortuny dome and ultimately the successful design of a smooth cloth cyclorama by Max Hasait at Dresden Opera. These also depended on the new electric light to effectively illuminate the large cycloramas on German Wagnerian stages. Here the Berlin stage lighting company Schwabe & Co. were early innovators, driven by the needs of leading directors such as Reinhardt.

Sections 7 to 10 explore Dean's and GEC's 1923 attempt to introduce Germanic stage lighting practice to Britain, under the guise of the Schwabe-Hasait system. This was promoted not just to theatres but the new cinema palaces as well, however ultimately it failed to make significant impact. The similar system from ARS, though very poorly recorded, is also noted.

The final sections explore the largely untold role of automatic carbon arc lamps in stage lighting, which initially enabled such large cycloramas to the illuminated, together with the almost unknown history of Schwabe & Co. Further cyclorama lighting development is described together with its necessity for localised acting area lighting. Finally an attempt is made to achieve a scientific understanding of the Schwabe seven-colour system, considered to be a great invention at the time, now being reinvented in the 21st century.

2. British Theatre in the Early 20th Century

Since the eighteenth century in theatre the painted scenic backcloth had ruled, particularly from artists such as Philip de Loutherbourg who painted with remarkable quality of apparent reality (Baugh 2013). It reached its apogee in the nineteenth century, greatly benefitting from the better illumination of gas lighting, with British artists such as Harker publicly feted and even given personal curtain-calls at performances (Southern 1964). Scenes were painted to be part of a living picture with elaborate costumes, with producers such as Henry Irving becoming renowned for his "stage pictures" or tableaux (Baugh 2013). In 1900 Herbert Beerbohm Tree staged a Victorian London version of *A Midsummer Night's Dream*[2] which was perhaps the epitome of this style, relying on painted backdrops and flats as shown in Figure 1 ("Scene from *A Midsummer Night's Dream*, Her Majesty's Theatre" 1900).

Figure 1. *A Midsummer Night's Dream* Her Majesty's Theatre[3], London, 1900. ("Scene from *A Midsummer Night's Dream*, Her Majesty's Theatre" 1900)

The scenic artists painted realistically, but it was always an illusion that collapsed when performers interacted with it. Dissatisfaction with this situation began to be challenged in a number of small independent theatres by the end of the nineteenth century, by such as André

[2] Beerbohm Tree played Bottom with Mrs. Tree as Puck. To try to improve the forest realism, live rabbits scampered around which of course upstaged the actors and reputedly once bit Tree ("Scene from *A Midsummer Night's Dream*, Her Majesty's Theatre" 1900). It caused George Bernard Shaw to quip "you can't see the Shakespeare woods for the Beerbohm Trees." (Baugh 2013, 27)

[3] Renamed His Majesty's Theatre in 1901 (and again in 2023) to match the gender of the new monarch.

Anton of the 1887 Théâtre Libre in Paris, W. B. Yeats' 1899 Irish Literary Theatre in Dublin, and Konstantin Stanislavski's 1897 Moscow Art Theatre (Baugh 2013).

Neither did German theatre immediately embrace the artistic freedom of the new electric light. Kranich (translated by Otto) describes the classic stage lighting at the turn of the century as a "mood-less illumination of painted canvas pieces" and continues:

> For daytime lighting, overhead, sidelights, footlights, offset, and banner were switched to "white-bright"; in addition, one or more "sun effects" were added from the working bridges on the left or right. For evening mood, red was added everywhere. One started with the back skylights; at the same time, white was withdrawn and gradually exchanged with blue, then red was slowly withdrawn again, and blue was intensified until the full night mood for moon and stars was achieved. Although small changes and shifts were necessary for each performance, this basically remained the lighting method for the arched and proscenium stage. (Otto 2023, 138; Kranich 1933)

However in Germany pictorial illusion was already being challenged successfully by such as Otto Brahm (1856–1912) at the Deutsche Theater, who in 1889 initiated the new "Naturalism" approach, where everything was as life-like as possible (Patterson 1981). But while disillusion with "Illusionist" presentation meant it was already dying out in Germany, leading through Naturalism to "Realist" and "Expressionist" styles, in Britain it remained staple fare, hence the excitement of such as Dean on his German visits (Dean 1970). The American critics Macgowan and Jones, when conducting a 1922 tour of European theatre, even decided to omit Britain due to its lack of development:

> the journey excluded England, because observation and reliable report showed little there that was not a faint echo of what was to be found on the Continent. (Macgowan and Jones 1922, vii)

Fuerst and Hume (Fuerst and Hume 1928b, 1928a) in their extensive 1928 catalogue of 20th Century western scenography listed under 5% of British entries and only German lighting equipment. Alex de Jonge also noted the startling comparison between English and German theatre in the 1920s:

> the impact of Berlin was utterly overwhelming; for the first time a visitor would encounter "modern" staging, theatre in the round, bare uncluttered formalistic sets, the repudiation of naturalism. The impact of Berlin theatre was as startling new to the English visitor as that of its traffic lights, another innovation. (de Jonge 1978, 18)

An early British reaction against this style was Herkomer's, who pleaded in an 1892 lecture that the scenic "makeup" should be a realistic as the actor's, railing against "layers of canvas hanging from the sky like so much washing on a line."[4] (Herkomer 1892,). The essence of his argument was:

> If you accept…a street scene painted on canvas and hung across the stage, upon which the shadows of the passing actors are thrown from the footlights – a sheet that moves like a sail by every draught of the stage – you ought in all truth accept an actor whose wig has been so badly put on that his own black hair shows.

British theatre was very conservative and before World War One (WWI) dominated by powerful actor-managers (Esslin 1995). Dean commented in 1911 that presenting new drama

[4] The frustration was reputedly later repeated by Max Reinhardt who, frustrated by the borders needed to hide the new overhead electric luminaires cried 'Will no one rid me of this dirty washing?*'* (Bay, Barker, and Izenour 2023, "The influence of Appia and Craig").

such as Ibsen was a sure route to box-office death[5] (Dean 1970). Marshall describes how a surge in demand for entertainment during WWI led to massive speculation in (esp. London) theatre properties, becoming commercially owned purely for profitable and now very expensive rental (Marshall 1947). The owners had no incentive to invest in modernity as long as they could find producers to fill the houses, and producers had no stake in the theatre so normally rented scenery and lighting to minimise costs. Further the audiences were predominantly middle-class due to the expense, so again naturally conservative in taste and averse to change.

By 1925 Marshall had concluded "the timidity of the theatrical manager and the tyranny of the Censor…between them were reducing the English theatre to a dead level of mediocrity." (Marshall 1947) The renowned English scholar, Allardyce Nicoll also concurred in 1928 "the English theatre at the present time is almost completely stagnant…a darkness of outworn tradition hangs over the professional theatre" (Nicoll 1928 (reprinted 1975)).

On being appointed Director of the new Liverpool Playhouse in 1911, Dean visited Germany and, in awe at the theatrical achievements there, railed in the British press against the artistic poverty in English theatre:

> Every German town of any size has a theatre, efficient, honoured, necessary to the civic life. Why cannot we have the same in England, so much the wealthier country. Why must the Englishman reduce everything to immediate £ s d instead of waiting for the perhaps more valuable after result? Why must our "man in the street" sneer at the efforts of those who are struggling to raise the English Theatre to the dignity of "public office", as necessary to the self-respect of our "civilised country" as apparently are the ill-assorted contents of the average English art gallery. (Dean 1911)

Smith, who researched the issue, similarly reported views from the interwar years that "expressionist drama would only find favour among those people who are not Christians" (Smith 1987, 309). He concluded:

> British theatre was still, in the thirties, very much the preserve of the "theatregoing classes", and the wish to return to the popular theatre of the Shakespearean period, or to emulate the democratic appeal of the modern German theatre, was all but impossible in Britain at this time…
>
> One of the greatest barriers…was the necessary admission that something interesting was coming out of defeated Germany at a time when there was nothing comparably original in the English-speaking theatre. This was particularly hard to accept in Britain, which had been used to seeing itself as the representative of the timeless standards of theatrical excellence. (314)

In contrast in Germany Brahm had established the first German Freie Bühne (Free Stage), an 1889 theatre club for new and often censored plays, which ultimately led to the explosion in Germany of the Freie Volksbühne (Free People's Stage) movement (Esslin 1995; Patterson 1981). Here working class subscribers enjoyed low cost, accessible theatre, with 305 Volksbühne clubs across Germany by 1930 demonstrating that the working classes were receptive to something other than "the commercial pap of variety shows" (Patterson 1981, 27). Working class theatre was further promoted in the Weimar era by such as Piscator with his "Proletarian Theater" and Piscatorbühne companies (Willett 1986). Many even gave free seats to the unemployed (though this did lead to financial problems).

[5] Though in practice he avoided this fate in Liverpool by adding dramatic storm scenes that everyone wanted to see. The comparison is stark with Germany where Ibsen was resident and one of the catalysts for change.

Jacob Grein's comparable British Independent Theatre Society ran from just 1891–7 and was always in financial difficulties due to low membership (Booth 1995). Following this and led by the 1899 Stage Society, British Sunday Theatre societies developed to put on new or censored plays to members (Marshall 1947). These used otherwise empty regular theatres on Sundays or when dark between shows, but inevitably could only play to few people.

German theatre had the advantage that, until the late 19th century, Germany had been a loose amalgam of separate kingdoms and principalities, each with their own self-sufficient court theatres supported by the local aristocracy; the most famous being the Duke of Saxe-Meiningen's Ensemble. While this often caused cultural limitations, the patronage supported regional excellence and more accessible seat prices. By the 20th century the ownership had been transferred to the cities or states[6] complete with their subsidy expectations and local support, maintaining provincial standards well above that of that of centralised countries like England (Willett 1986). British theatre was essentially unsubsidised until after World War Two (WWII), when CEMA[7] mutated into the Arts Council in 1946 providing grant aid. This was followed two years later by local authorities being empowered to levy a 6d rate to support local Arts.

Even though many British cities had local theatre companies, provincial shows were often tours from London companies. These too tended to drive down quality by expecting the receiving theatres to provide some or all local stock scenery, plus whatever lighting they had to hand, supplemented with some touring spotlights (Pilbrow et al. 1975).

James Fagan[8] wrote in 1919 that:

> I have not seen a single stage in this country which in my opinion was properly lighted…in Germany stage lighting is head and shoulders above the rest of the world (Fagan 1919).

Peters echoed this view in 1923:

> Speaking generally, we have not progressed beyond the row of footlights, the set of overhead lights, and the pair of fizzling, spluttering carbon lamps in the wings. (Peters 1923)

Groom[9] similarly observed in 1926 that:

> stage lighting…is generally treated more as a necessity and unavoidable evil than as, perhaps, the most important and vital adjunct to the play itself. (Groom 1926)

Ridge, writing probably the first British textbook on theatre lighting in 1928[10], echoed this lack of progress:

> some of the gas lighting, particularly by Irving, compared favourably with much electric lighting seen on the London stage today. (Ridge 1928, 72)

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[6] The transfer of theatre from aristocratic to state control occurred in stages over the 19th century with the initial Prussian Concession system from 1811 to 1871 before the unification of the Second Reich in 1871, with for example Berlin then having only three public theatres (Booth 1995; Grange 2004).

[7] Committee for Encouragement of Music and the Arts (CEMA) set up by Royal Charter in 1940. Encouraged by Dean, it subsidised wartime concerts (Dean 1973).

[8] James B. Fagan became Director of the Royal Court Theatre, London from 1920-23.

[9] H. Lester Groom ran the GEC Stage Lighting department selling Schwabe equipment. He had been educated in Heidelberg, and thus carried the 'obligatory' fencing scar (Bentham 1992).

[10] The more common 1930 second edition is identical to the 1928 first edition excepting a longer bibliography (Ridge 1930, 1928).

Dissatisfaction with the established bourgeoise theatre was not limited to the UK. The 1922 International Theatre Exhibition was conceived initially in Amsterdam, then toured to the UK in 1923 and afterwards New York. Eversmann considered it:

> originated in a critical attitude that wanted to elevate the masses and took a stand against theatre geared, not towards deeper aesthetic pleasure, but rather towards entertainment … characterised as sick concoctions of eighth-rate authors. (Eversmann 2007, 69)

While the exhibition featured a whole room to the work of Craig and Appia, a total of 95 other designers and architects contributed to the exhibition, In addition there was a series of lectures to which Craig contributed, while Dean also gave a lecture on "The Actor and his Workshop" in London (Dean 1922).

In fairness, early 20th century commercial British theatre was not totally unrelenting, lowest-common-denominator material. Nigel Morgan notes that Dean's efforts were in many ways matched by Charles Cochran, a fellow English thespian turned producer, who had worked his way up on the American stage and fallen under the spell of Max Reinhardt (Cleugh 1921). Cochran produced Reinhardt's *The Miracle* at Olympia in 1911 and brought much new work from Europe and America to the London stage (Morgan 2005). However Morgan still noted:

> Dean and Cochran set standards that few could reach or even aspire to. The gulf between the quality of their work and that of their contemporaries was huge. (Morgan 2005, 180)

The British Repertory Theatre movement, started almost single-handed by Annie Horniman,[11] also strove to present stimulating new works by such as Shaw and Ibsen (Esslin 1995). Dean had enjoyed his first director's role under Horniman's regime (Dean 1970). Other regional companies such as the Cambridge Festival Theatre under Terence Gray, Oxford Playhouse under Fagan and the Birmingham Repertory Theatre under Barry Jackson were similarly prepared to experiment in production and lighting (Morgan 2005). Chisholm considered Harold Ridge at the Cambridge Festival Theatre "did some of the best work the English theatre has seen. His use of Schwabe lighting with a cyclorama has been a revelation" (Chisholm 1934, 43). However Chisholm still gives one a feel of the times, describing an Art Theatre as "all Schwabe lamps and cubist settings". (9)

Marshall gives further credit to the London fringe, regional and repertory companies that managed to present more challenging and modern works, such as Nigel Playfair at the Lyric Theatre, Hammersmith and Lilian Bayliss at the Old Vic (Marshall 1947). While these companies in many ways emulated the German Freie Theater, they still had little impact on Metropolitan attitudes.

In 1932 Hasait conducted a tour of overseas theatres, and declared it hard to believe so many stages, especially in London, still used manual hemp flying, while modern stage lighting "is only now being recognised and installed" (Hasait 1932). He naturally noted that Dean had installed the "first modern stage lighting and circular cyclorama".

British Society's attitude to "challenging" drama was ultimately considered by Smith to be best summed up in Stella Gibbons' 1930s parody *Cold Comfort Farm:*

> In the evening, she proposed that the three of them should visit the Pit Theatre, in Stench Street, Seven Dials, to see a new play by Brandt Slurb called *Manallalive-O*! a Neo-Expressionist attempt to give dramatic form to the mental reactions of a man employed as a waiter in a restaurant who dreams that he is the double of another man who is employed as a steward on a liner, and who, on awakening and realising that he is still a waiter employed in a restaurant and not a steward employed on a liner, goes mad and

[11] Heiress of a vast tea fortune, thus able to indulge loss-making enterprises (Esslin 1995).

shoots his reflection in a mirror and dies. It had seventeen scenes and only one character. A pest-house, a laundry, a lavatory, a court of law, a room in a leper's settlement and the middle of Piccadilly Circus were included in the scenes.

'Why,' asked Julia, 'do you want to see a play like that?'

'I don't, but I think it would be so good for Elfine, so that she will know what to avoid when she is married.'

But Julia thought it would be a much better idea if they went to see Mr. Dan Langham in 'On Your Toes!' at the New Hippodrome, so they went there instead and had a nice time instead of a nasty one. (Gibbons 1932, Ch XIII; Smith 1987, 3)

3. The Cyclorama – a Canvas for Revolution

The dominance of the commercially motivated actor-manager did not go unchallenged in Britain at the end of the 19th century. Stokes describes how several voices protested against the perceived inadequate acting and presentation, while some such as Herkomer and Grein went on to show by example how it could be improved, though their experiments were short-lived (Stokes 1972).

Hubert von Herkomer[12] (1849–1914), already a very successful artist, had established an Arts school in Bushey, Hertfordshire. Having now the physical and financial resources to demonstrate solutions to his theatrical criticism's, he constructed the small[13] Bushey Theatre in 1886. Here he composed, designed and directed musical plays, while writing and lecturing on his ideas (Pick 2008; Herkomer 1889, 1892). His 1889 music play, *An Idyl* provided an opportunity to prove that solid scenery and a convincing infinite sky could be achieved, with Figure 2 his interpretation. The critics were delighted:

> an old English village with its half-timbered houses, its glowing sunset, its deepening gloaming, its distant landscape … is simply one of the most beautiful stage pictures that can be imagined. No horrible "sky borders", no descending rags and "battens" down at Bushey. ("The Playhouses" 1889)

Figure 2. Toward the close of day, Act 1 *An Idyl*, Herkomer, 1889. (Herkomer 1889)

He was in the British vanguard of a naturalism movement that strove to achieve natural lighting as well as scenography. In this regard, he felt that stage lighting must be achieved, or appear to be achieved, like normal lighting from the sky, and furthermore the sky must also

[12] Sir Hubert von Herkomer, RA, of German birth, he had immigrated to Britain as a young child with his parents but retained a strong love for his fatherland. A museum at Bushey still displays his work.

[13] Not so small. For *An Idyl* he extended the stage depth to 40 ft to accommodate the cyclorama and gauze (Mills 1923).

appear realistic. In consequence, and well before Fortuny's dome, he used an expansive cyclorama sky cloth fronted by a slanted gauze reaching the grid, on both of which bright and variably coloured limelights[14] were shone. He was probably also the first in Britain to use front-of-house stage lighting instead of footlights, albeit simple light boxes high on the auditorium sides shining towards the stage. He considered these had produced a more natural lighting than that from dress circle lights he later saw in America (Desprez 1913). Archer considered he had anticipated Fortuny (Fagan 1919). However unlike Fortuny and anticipating Craig and Reinhardt, Herkomer claimed:

> in no light in nature is every object fully lighted up at any moment … Pictorial brilliancy is obtained by the very economy of light. (Herkomer 1892)

Although Herkomer's work was clearly inspired by Wagner[15] with strong musical similarities, he rejected Wagner's idea that scenery need only be realistically painted (Stokes 1972). His achievement did not go unnoticed. Edward Gordon Craig attended his lecture and wrote of its value (Pick 2008). Aged just 17, Craig had also attended some of Herkomer's performances and about *The Idyl* wrote: "I saw it – most moving it was – perfect realism", while Craig's later British work clearly built on Herkomer's (Konstantinakou 2002; Pick 2008). Craig went on to work with Brahm in 1904 in Berlin, but disagreements aborted the project (Esslin 1995). Reinhardt was similarly influenced by Craig's theories however Craig's desire for total artistic control was the antithesis of Reinhardt's collaborative method, so they never worked together (Carter 1914; Esslin 1995). Craig's legacy, however, lies mostly in his writings rather than productions. Walton observed:

> Craig was certainly among the first to recognise that (electric light's) overriding potential lay in close control. He could also claim to have brought a painter's eye to the theatre, considering the atmosphere of the stage to be dependent less on dimming-down of the maximum, than on fading-up from the minimum. (Walton 1999, 14)

In the 18th and 19th century Germany there had also been a movement against the scenographic orthodoxy. Wiess and Nicoll describe how the artists and architects Catel, Hoffmann and Schinkel rejected footlights, unnatural lighting and flat scenery (Weiss 2009; Nicoll 1966). Then another relentless force appeared driving a new realism in scenography – Richard Wagner. Wagner's operas, and especially the 1876 Ring Cycle, had immensely imaginative and detailed scenic directions according to his concept of "Gesamtkunstwerk" (total work of art). For example, at the end of *Das Rheingold*, Wagner demands:

> Donner disappears entirely in an ever-darkening and thickening thundercloud. The stroke of his hammer is heard to fall heavily on the rock. A vivid flash of lightning comes from the cloud; a violent clap of thunder follows…Suddenly the clouds disperse; Donner and Froh become visible. From their feet a rainbow bridge stretches with blinding radiance across the valley to the castle which now glows in the light of the setting sun. (Wagner and Frederick Jameson (translator) 2021)

Wagner (1813–1883) had solely gas and arc lighting in his new 1876 Bayreuth theatre, the Festspielhaus, thus very limited ability to manipulate colour and visible space despite the renowned ingenuity of his technical manager Karl Brandt[16] (1828–1881). The fresh opportunities given by incandescent electric light did not arrive at Bayreuth until 1888, too late for both Wagner and Brandt (Carnegy 2006). However imaginative scenes were achieved

[14] It is unclear if these were actual limelights or electric arcs, since there was otherwise all electric lighting (Pick 2008).

[15] He painted Wagner's portrait and studied his music when composing for *An Idyl* (Mills 1923).

[16] Older brother of Fritz Brandt who trained Max Hasait in Berlin (Paysan 2016).

with gas and arc lighting, together with consummate effects provided by Hugo Bähr from Dresden, by the Ring's Bayreuth premiere in 1876. Despite these, Carnegy considered that it took until 1960 to achieve a technically satisfactory implementation of Wagner's "romantic illusion", a challenge now readily achieved with modern stagecraft, as shown in Figure 66 (Carnegy 2006).

Bayreuth became a pilgrimage trod by many. Wagner's operas also became staple fare for most German Opera houses and many other European stages, challenging the incumbent technicians such as Hasait at Dresden Opera. This chasm between imagination and reality spurred two particularly visionary pilgrims, Mariano Fortuny y Madrazo and Adolphe Appia, who both fell under Wagner's spell.

Appia (1862–1928) studied music and drama in Dresden from 1886-1890, and while there worked backstage at the Dresden Royal Court Theatre from 1889-90 as apprentice to Hugo Bähr[17] (Carnegy 2006; Palmer 2015). Although Appia had attended many Bayreuth performances from 1882 and became obsessed with Wagner and his ideas for renewal of a total performance, he found the settings artistically appalling (Roth 2009; Esslin 1995). He saw lighting as a means to provide shape and space, thus rejected static pictures painted on flats and drops. He also rejected the shadow-less wash of light from gas battens, instead demanding "active light", meaning light that gave form and direction and thus cast shadows (Palmer 2015). Appia wrote extensively on the issue from 1892, and in c.1902 lamented:

> How is the actor lit? Alas, he is not at all; the painting has taken everything for itself. These long lines of electric light, running parallel to the set and even around the stage, are designed to give a clear view of the painting, illuminating the actor from all sides at once... but is it Light? Would a sculptor have the idea of illuminating his bronze or marble dreams in this way? (Appia and Bablet-Hahn 1986, 359)

Appia drafted and proposed many scenic designs for Wagner operas, however his repeated attempts to change the Wagner family heirs' (esp. Wagner's widow Cosima) conservative Wagnerian staging failed, despite his close friendship with Wagnerite Houston Stuart Chamberlain. His persistence eventually resulted in exile from Bayreuth's inner court[18] (Osma 2015).

Fortuny (1871–1949) was already an accomplished artist when he first visited Bayreuth in 1892,[19] where he was also introduced to the Wagner family (Osma 2015).[20] Despite the new electric lighting, he also witnessed the inadequacy of the lighting and scenography, in particular attempts at weather-changing skies, sunsets, sunrises and rainbows (Osma 2015; Smith 2017). Fortuny remarked (quoted by Smith):

> They restricted themselves, as far as positioning was concerned, to doing electric lighting schemes in the same way as gas ones, which meant that electricity, which should have completely revolutionised the art of stage décor, was left in virtually the same state as before. (Smith 2017)

[17] Renowned in German theatre as the 'Father of light' and inspirational to Appia (Palmer 2015; Bablet 2009; Frank 2015; Kranich 1929).

[18] He still continued to attend the annual performance festivals until 1914 (Volbach 1968).

[19] Some scholars dispute this date, claiming 1891 or both (Barón-Nusbaum 2013).

[20] This was not his first exposure to Wagner. He was a close friend of the Spanish artist Rogelio de Egusquiza who had become passionate for Wagner's work after attending the Ring's premiere in 1876 (Osma 2015).

Following his visit to Bayreuth, Fortuny constructed a model stage[21] with working electric lighting in order to experiment and demonstrate his stage designs. As a skilled painter, he saw the stage lighting problem as requiring a means of painting in light, and developed the idea of reflecting light off diffuse white or coloured surfaces to achieve shadow-less illumination, as if lit by the sky (Osma 2015). Further, since this could be electrically changed at will, it could dispense with cumbersome sky cloths, and was patented extensively between 1901–09. In 1899 he devised a system of an encompassing dome cyclorama with this indirect lighting (Smith 2017). After initial experiments in Venice, he moved to Paris[22] by the end of 1901 where a 5 m diameter model was constructed in his workshop in 1902 to test the ideas and for demonstration, shown in Figure 3.

Figure 3. Demonstration dome in Fortuny's studio workshop, Rue St Charles, Paris, 1902. ("Fortuny Dome at Rue St Charles, Paris" 1902)

Appia was introduced (probably by Chamberlain) to Countess Zichy, a Hungarian, in the spring of 1901. She was fascinated by the artist and his work and soon introduced him to a friend in Paris, Comtesse de Béarn (Martine de Béhague[23] (Volbach 1968). She had a private theatre in her mansion, and intrigued by his ideas, agreed to him staging some of his Wagnerian ideas (particularly *Tristan und Isolde*), even paying him an honorarium. However Appia's ambition outstretched his capabilities, with problems obtaining performance rights and a suitable conductor with lead performers, compounded by the need to considerably enlarge the stage and orchestra pit. These difficulties dragged on, eventually resulting in a programme of just concert pieces and excerpts from Schumann's *Manfred* and Bizet's *Carmen* over three performances in March 1903.

Appia and Fortuny were introduced apparently by coincidence. Appia had a cousin Alfred Guy-Claparède, an electrical engineer employed by the Compagnie Générale d'Electricite (CGE) with whom Fortuny had signed a contract in 1901, and who provided Fortuny with a larger workshop (Appia and Bablet-Hahn 1986; Fortuny Ltd 2019). Appia then learned and

[21] The model, restored and functional, is still accessible in the Museo Fortuny in Venice.

[22] It is unclear exactly why he relocated to Paris, but several reasons exist. It was his childhood home and remained the home of his close artist friend Egusquiza. Osma also notes that he was encouraged by a famous French lawyer Clery who had seen some of his work (Osma 2015). He further signed a contract with CGE about this time, though it is unclear if this was before or after his move. He also met his future wife there in 1902.

[23] From the Singer sewing machine family and thus very wealthy (Volbach 1968).

was enthusiastic about Fortuny's ideas and introduced them to the Comtesse[24] to include in his plans for the Comtesse's production. They had hoped to use Fortuny's dome and lighting, but it was not ready in 1903. Instead it was probably lit by Lucien Jusseaume, the renowned stage designer who Appia had also met and persuaded the Comtesse to engage for the *Carmen* setting (Appia and Bablet-Hahn 1986; Volbach 1968).

The 1903 production was considered a success[25]. However Appia's hopes of further commissions from the Comtesse came to nothing, she clearly tired of him and ceased to answer letters (Appia and Bablet-Hahn 1986). Fortuny's work finally came to fruition in her private theatre (which had been rebuilt again[26]) where the first dome and lighting installation was made in 1906 (Smith 2018; Bablet 2009; Esslin 1995). The dome had an opening of 10 m, height of 15 m and depth of 7 m (Desvaux and Stasi 2003). The opening public performance of two spectacles including a ballet[27] with music by Widor, shown in Figure 4, was a noted success. Widor enthused: "This dome is the canopy of heaven, a limitless horizon, the air we breathe, the atmosphere, life itself." (Osma 2015, 113)

Figure 4. Widor's ballet under Fortuny's dome at Comtesse de Béarn's private theatre, 29th March 1906. (Fortuny 1906)

This successful installation attracted international and especially German interest both before and after opening, with engineer Schloss from AEG visiting to inspect the design in 1904[28] (Desvaux and Stasi 2003). By the end of 1905 Reinhardt and Hugo von Hofmannsthal had

[24] Fortuny's father Mariano Fortuny y Marsal (1838-1874) had been a renowned artist. Since the Comtesse already owned one of his paintings, this ensured that his son was also respected as a skilled artist (Desvaux and Stasi 2003).

[25] Even Sarah Bernhardt blessed it with her attendance (Appia and Bablet-Hahn 1986).

[26] The stage had been specially enlarged and exceeded that of the Comédie-Française (Osma 2015). In 1910 the dome was mounted on rails so it could be retracted to make room for larger sets, then in 1998 the still intact dome was rediscovered during research on Comtesse Martine de Béhague (Desvaux and Stasi 2003). The building is now the Romanian embassy and a listed historical monument.

[27] Fortuny also designed and printed the dancers' dress fabric (Desvaux and Stasi 2003).

[28] In 1904 Fortuny also wrote an essay published as a book entitled Éclairage Scénique: Système Fortuny, but it is no longer accessible (Desvaux and Stasi 2003).

also visited, while Fortuny recorded "Emperor Wilhelm II, having heard of my inventions, ordered the German ambassador in Paris to visit me" (Desvaux and Stasi 2003). Despite this successful installation in Paris, no other French installations ensued.

Fortuny had earlier used a few elements of his system plus a very inventive stage design for *Tristan und Isolde* at La Scala, Milan[29] in 1901 (Smith 2015). Though this greatly impressed Siegfried Wagner, Bayreuth never adopted his scheme (Smith 2017).

While Fortuny and Appia initially cooperated on several Wagnerian projects[30], their views differed in what the lighting and staging should deliver. Fortuny wanted to retain a more painterly, naturalist illusion whereas Appia wanted the music of the opera to dictate the scenic mood, i.e. more expressionistic and abstract. Also Appia felt alienated by both the Comtesse and Fortuny (though Fortuny actually remained courteous), thus their ways had separated by 1905 (Smith 2018; Roth 2009; Appia and Bablet-Hahn 1986).

Fortuny's concept of a flexible dome is shown in Figure 5, rising from the stage floor in his 1904 French patent (Fortuny 1904b). The prototype in Figure 3 had suffered from the canopy supports disturbing the smooth interior surface. This was resolved and the inner visible surface kept smooth and free of visible fastenings by drawing a partial vacuum between it and a rear outer cover.[31] The concept was that the dome, once reflated and closed, could be moved out of the way for other scenes. The resultant massive folding dome is illustrated in Figure 40 from the first full-sized 1907–9 installation at the Kroll Opera in Berlin. The rear frames fold down in the manner of a perambulator hood for storage.

Adolf Linnebach[32] considered that Fortuny's dome had been predicted by earlier US patents, while he (Linnebach) had proposed a domed cyclorama in a model for a theatre in Halle before 1903 (Kummer 1913). However he accepted that Fortuny with AEG was the first to produce a working system.

[29] Fortuny proposed an extended height cyclorama, dispensing with soffits and scenery and illuminating indirectly to achieve the effect of a great expanse. However the antiquated La Scala technology greatly limited what he could achieve in lighting effect (Baumann 1988).

[30] There continues to be scholarly debate on the true extent of Fortuny and Appia's cooperation (Bablet 2009).

[31] Fortuny initially proposed an inflated outer cover to support via a partial vacuum the inner dome, changing in 1905 to the final hinged outer frame (Fortuny 1905). The vacuum needed was only 4 mm of water gauge (Rouche 1910).

[32] Royal Machinery Director and Technical Director at the new Schauspielhaus Theatre in Dresden, and Hasait's professional rival (Macgowan and Jones 1922).

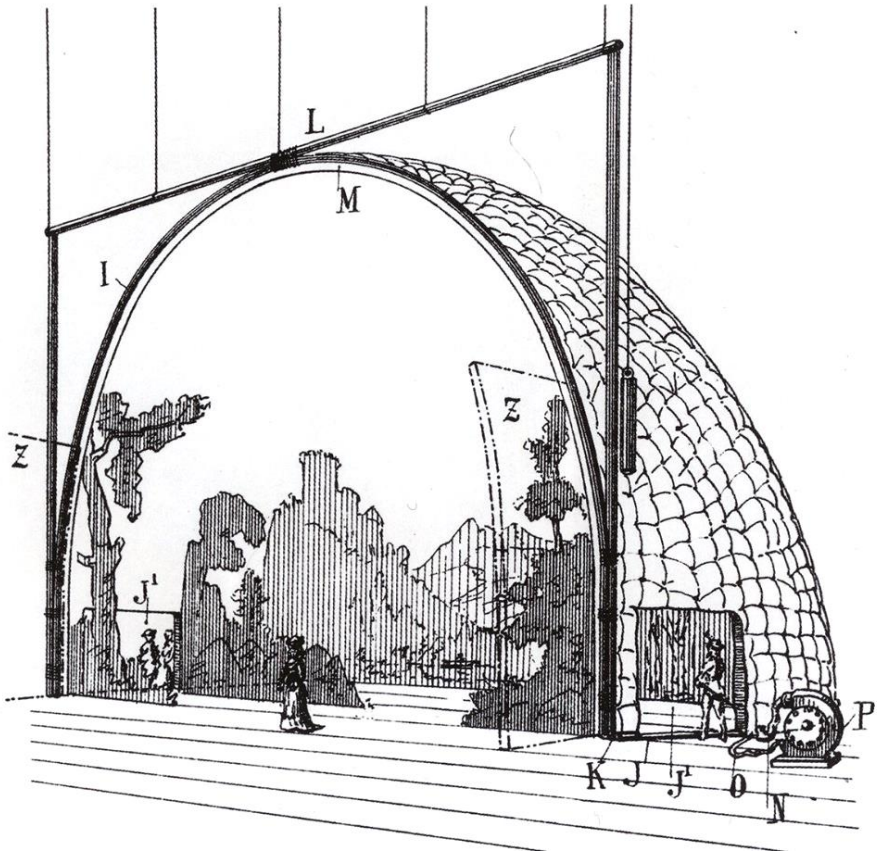

Figure 5. Fortuny's design for an artificial sky using an deflatable folding dome (Cupola pieghevole). (Fortuny 1904b)

Fortuny also conceived of a new method of indirect lighting. This used powerful, focussed and mechanically dimmed arc lamps with scrolling reflective coloured silk bands, as drawn by Fortuny in Figure 7 for the design installed in the Comtesse's theatre in Paris. Multiple units separately light the cyclorama and the stage with a very diffuse light, the later as if lit by the sky, as shown in Figure 6. Fortuny even developed a particular arrangement of the automatic arc lamp carbons and reflectors to optimise the light sources (Fortuny 1904a).

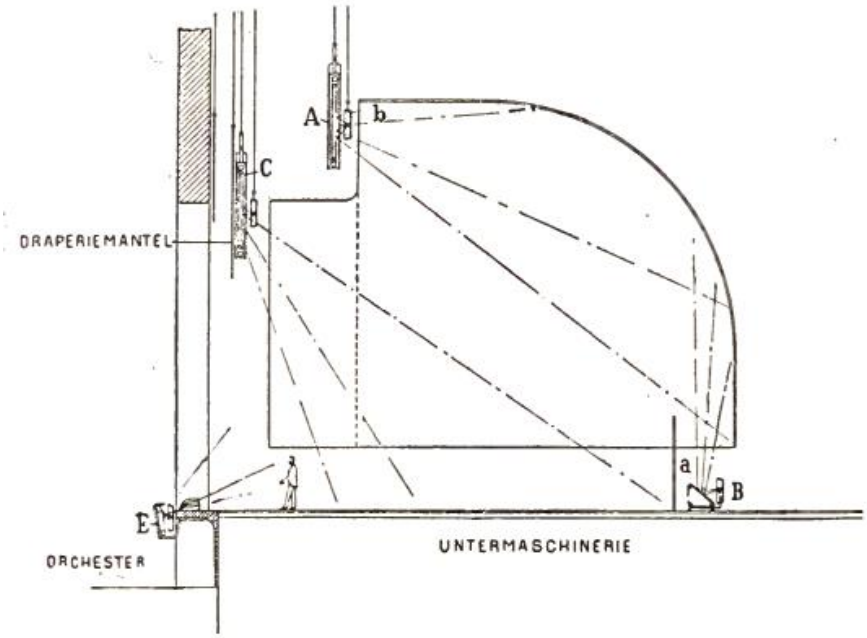

Figure 6. Arrangement of illumination[33] for upper dome (A), lower dome (B) and acting area (C). (Rouche 1910)

The colours were electrically controlled from a remote control desk described in section 15. By having separate sources, the simulated sky and acting area colour and intensities could both be individually dimmed and toned (Fortuny 1901). The number of colours was not prescribed by Fortuny, but clearly mixing of colours could only be of adjacent colours on the roll. The system also included cloud projections, achieved by painting negative cloud images onto mirrors then using them to reflect a dedicated arc light (nearly point source) onto the dome, giving a fuzzy cloud image.

[33] Original from Bühnenbeleuchtung System Fortuny (Beleuchtung System Fortuny G.m.b.H. c.1911)

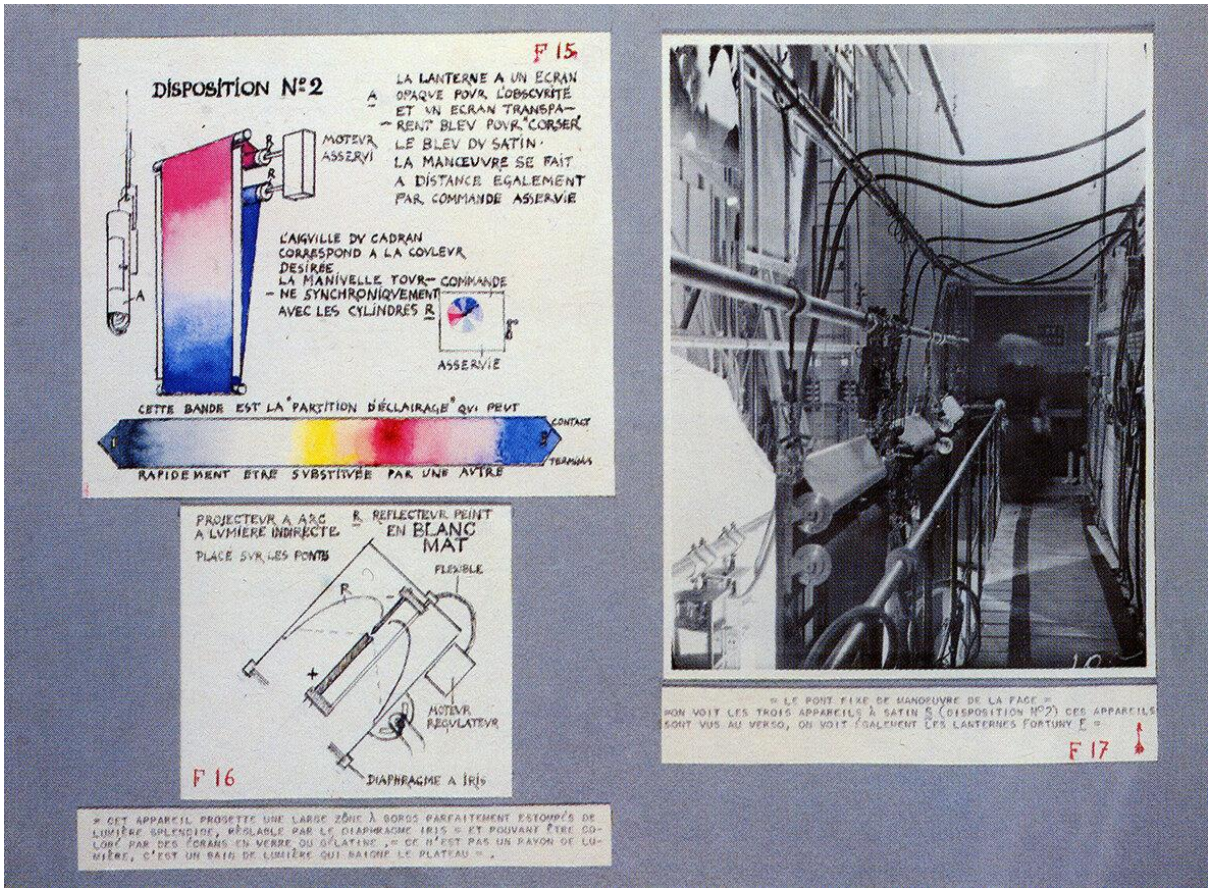

Figure 7. Fortuny's designs (F15 & 16) for indirect cyclorama lighting, with arc source (A) and diffuse/coloured reflector strip on rolls (R).
The installed reflectors are shown (F 17) on the 1906 Paris lighting bridge. (Fuso 2021)

The use of coloured silks to tint light was of course not new, they had been extensively used with gas battens in the nineteenth century and with electric light by Hartmann in America in 1902 to gradually blend a sunset-night-sunrise scene (Hartmann 1930 (repr 1970); Rees 1978).

Fortuny formed a joint company Beleuchtung System Fortuny GmbH with AEG (Allgemeinen Elektricitäts Gesellschaft) in Germany to manufacture and market his system in 1906. However the collapsible Fortuny dome proved troublesome on working stages, with visible dust settling in the folds when the canvas was folded up (Thormann 1950). Further, if the surface colour paint was too rigid, the colour would crack off, but if it was too elastic or plastic it would knead together with movement of the inner cover when closed, leaving unpleasant creases when the canvas was unfolded. This led to Charlottenburg Opera opting for a rigid dome in 1912, shown in Figure 14.

A number of important German theatres still installed either the folding or fixed dome, including some in Russia, while further stages just used the indirect lighting (Osma 2015). The only British Fortuny concept was experimentally installed in the Birmingham Repertory theatre in 1913 on a 50–60 ft domed plaster cyclorama claimed by Dean to be to his specification (Morgan 2005; Applebee 1946, 1935; Dean 1962). It was abandoned within one to two years due to the exigencies of repertory production on the shallow stage. In Sweden the Lorensburg Theatre in Gothenburg installed a fixed cemented dome but it too presented practical difficulties (Bergman 1977). In America Moderwell merely reports on the German Fortuny development in 1914, and while by 1921 Macgowan reported two domes had been

installed in America, he did not expect more due to their practical disadvantages (Macgowan 1921; Moderwell 1914). This was confirmed by Hartmann in 1930 who regarded them as impractical (Hartmann 1930 (repr 1970)). The last AEG dome sale was probably 1914 to the Volksbühne in Berlin.

In Italy the Fortuny dome did not quite die out until the late 1920s. La Scala was finally persuaded to purchase a collapsible dome in 1922 though it was little used, while a lightweight portable dome for a touring theatre was used by the Carro di Tespi company in 1929 (Commune di Venezia 1978).

But what did Appia contribute to Fortuny's work? Fortuny's ideas were not used in Appia's 1903 production and by 1906 Appia was off the scene. Bablet-Hahn does not think either significantly influenced the other's artistic ideas (Appia and Bablet-Hahn 1986). The answer is connections. Fortuny had apparently come to Paris without any particular theatre in mind, thus one must assume he felt that there would be a better reception in his previous home than in Italy. Appia's discovery of him though his cousin introduced him to a wealthy sponsor with a theatre not run on commercial grounds and prepared to experiment artistically. There is no evidence that he would have made the connection personally. Also, despite his contract with CGE who publicised the invention in 1902, the successful demonstration in 1906 and commercial interest from AEG, no other French theatre embraced his concept, remaining conservative in their ways[34]. So without Appia, Fortuny's ideas would probably have never come to fruition.

Meanwhile in Germany, a further key figure in the unfolding lighting revolution was Max Reinhardt[35] (1873–1943), pictured in his younger days in Figure 19. He was an outstanding character actor from Salzburg showing "originality and force", invited by Otto Brahm to Berlin to join his already famous Deutsche Theater in 1894 (Carter 1914). Reinhardt stayed with Brahm for seven years, but eventually became disillusioned with the drabness of Brahm's naturalistic style and left in 1901 to found a small satirical cabaret group "Schall und Rauch". He turned to directing, before finally taking over directorship and ownership of the Deutsche Theater[36] from Brahm in August 1905, becoming probably the first to completely embody the idea of a creative, collaborative artistic director (Esslin 1995).

[34] Volbach notes that "in Paris the first breakthrough did not occur until Diaghilev presented his stunning ballets in 1909 and the succeeding seasons. With them a new breeze blew through the Parisian theatre" (Volbach 1968).

[35] Reinhardt was born as Goldmann in Austria to Hungarian Jewish parents, and changed it to Reinhardt in 1904 (Poetzl and Weimer). He eventually owned the Deutsche Theater, Kammerspiele, Grosses Schauspielhaus and controlled many other theatres in Germany and Austria. Reinhardt left Austria for the USA permanently in 1937 due to Nazi persecution of Jews and never returned.

[36] He had to relinquish directorship of the Kleines Theater and the Neues Theater to do so (Schenk 2015). Reinhardt still purchased these theatres (and others in Berlin), installing his brother as commercial manager. However Patterson reports he only leased the Deutsche Theater (Patterson 1981).

4. German Realism

Patterson was unequivocable about Reinhardt's 1905 innovation:

> When in Max Reinhardt's production of *A Midsummer Night's Dream* in 1905 the lights went up on a slowly revolving woodland scene, the audience witnessed more than … a stage set, they were seeing the beginnings of a revolution in theatre itself. (Patterson 1981, 1)

Figure 8. *A Midsummer Night's Dream*, stage design model by Max Reinhardt and Karl Walser, Neues Theater, Berlin, 1905[37]. (Reinhardt and Walser 1905)

Marx described the production:

> A real Forest, a real Dream … an epochal turning point in the history of modern German theatre. In *A Midsummer Night's Dream* he transformed the audience itself into dreamers for whom the world danced before their eyes… To the sound of Mendelssohn's Scherzo, the fairies, who were no longer dressed in the obligatory bast skirts, but half-naked, slender girls covered only with green veils and holding hands, wound around and through the trees, up-hill and down-hill in an intoxicating sight. Light bulbs hanging and bouncing on threads of twine simulated fireflies, while the light of the moonlight spotlight threw striking reflections of light through the foliage of the trees onto the stage. In the background, part of the stage floor, perhaps 4 square metres in size, was replaced by thick panes of glass which, illuminated from below, lit the elves dancing on the

[37] After 305 productions from January 1905 at the Neues Theater, the play moved to the Deutsches Theater in 1906 and remained in repertory there until 1913 (Leyko 2014).

> mirror of this small lake in the water mists, which were also artificially created. (Marx 2007, 18)

Otto is equally enthusiastic about the importance of the event, breaking from the old drab naturalism, and makes an important observation in terms of its appeal to the German psyche, due to the cultural significance of the great romantic German forests (e.g. the Black Forest):

> This magic from the forest interior, the turning of the plastic trees in front of an endless star-studded horizon overcomes the Nordic naturalism with its alcoholics and starving people trapped in their closed room decorations and bourgeois morals… and creates in the commercial centre of Berlin the dream of a Greek summer night in the German forest. (Otto 2023, 146)

The end of the 19th century had emphasised naturalism lead by Otto Brahm attempting to make everything as natural and visually correct as possible. He had been a radical, breaking from the traditional court theatre (Kahane 1975). Having been dismissed as theatre critic from *Vossische Zeitung* for condemnation of the old-fashioned theatre, he then established the Freie Bühne (free stage), a membership theatre, to avoid censorship. On the strength of his work there promoting Ibsen, Strindberg and other contentious authors, Brahm was eventually invited to direct Berlin's most prestigious theatre, the Deutsche Theater in 1894 (Esslin 1995).

Brahm's naturalism was described by Kahane[38] as "an anti-theatrical style of performance, low-key, with an almost monotonous naturalness", whereas Reinhardt saw the theatre as "a way to escape from everyday greyness, from the gloom of Naturalism and social criticism; it was the mediator of joy, beauty and colour and light" (Kahane 1975). He thus looked towards a new "realism" for his 1905 *Midsummer Night's Dream*. Even though in real life of course a forest does not rotate, the solid set slowly turning during the action[39] ensured the audience understood that these people were really in a forest. Pine tree scent was even sprayed into the auditorium to make the impression complete – the age of traditional pictorial make-believe illustrated in Figure 1 was over in Germany (Marx 2007).

This change was not restricted to Germany; Andre Antione's Theatre Libre of Paris, Kanstantin Stanislavski's Moscow Arts Theatre and even Grein's less successful Independent Theatre Society in London all used new works to initiate a "Theatrical Revolt" (Grein 1921). Baugh observed that:

> a powerful and distinctly unifying feature of the disparate European avant-garde of the twentieth century has been an assertive, and occasionally violent, rejection of the values and scenography of the nineteenth century. (Baugh 2013, 32)

However the transformation of German theatre during the early 20th century was little appreciated in the UK since it did not depend on new writing, which could travel, but on styles of performance which remained local (Patterson 1981). This was enhanced by a much greater willingness for German directors and audience to embrace the new socially challenging works from such as Ibsen[40], also avidly embraced by other directors such as André Antoine in Paris and Stanislavski in Moscow (Nicoll 1966). This also brought with it the need for a proper Director, a single controlling mind to ensure a coherent artistic and

[38] Henry Kahane was the son of Arthur Kahane, Reinhardt's dramaturge for 30 years from 1902 (Kahane 1975).

[39] It was claimed to be the first use of a revolve in scenic action, but in fact the London Coliseum used its massive new triple concentric revolve to present simulated horse races in 1904 ("The London Coliseum, St. Martin's Lane, 1904" 2022).

[40] Probably helped by Ibsen living in Germany for some time while writing his dramas.

interpretive whole, of which Reinhardt was the archetypal example of the Gesamtkunstwerk concept (Esslin 1995; Kahane 1975).

The major shift in German scenic realisation was underpinned by "plastic" [41] scenery and demand for a realistic sky. Realistic portrayal of a sky required a cyclorama, cloth or solid, to envelop the stage rear and part of the sides, hence the German term "Rundhorizont" (literally circular cyclorama, though normally semi-circular) with lighting that could make it appear infinite like the sky.

In his 1902 production of Oscar Wilde's *Salome*[42], Reinhardt had already used an enveloping cyclorama night sky with star lights as shown in the design in Figure 9

Figure 9. Design for *Salome* by Max Kruse, director Reinhardt, Kleines Theater, Berlin, 1902. (Kruse 1902; Morwood 2018)

However he was unable to exploit it fully due to lack of powerful enough illumination, explaining his great enthusiasm for Fortuny's work (Bergman 1977). Styan considered that Reinhardt had even used "the new Fortuny system of indirect lighting" for this production on a sky-blue silk against a high cyclorama (Styan 1982). Since Fortuny was still only experimenting in Paris with his system, a replica seems unlikely, but it is probable that

[41] The scenic term 'plastic' extensively used pre- and early 20th century, meant having solid form such as from modelling or sculpture.

[42] Three years after Wilde's death, there was an unparalleled flowering of *Salome* on the German stage, created by awareness of Wilde's social fall and premature death (Davis 2001). It was banned by the censors until 1903 due to its portrayal of biblical characters, so had to be initially presented as a private production. Reinhardt had no fear of controversy, while Richard Strauss saw this production and was inspired to turn it into the now famous opera (Morwood 2018).

Reinhardt had similarly chosen to soften the glare of the necessary arc lights by diffuse silk reflectors, copying earlier gas lighting.

Reinhardt first saw and enthused about the Fortuny dome in Paris in 1905, then seeing it also being installed at the Berlin Kroll Opera, copied it[43] for his Deutsche Theater (Smith 2015; Baumann 1988). The cyclorama copy was made without the permission of Fortuny, but was solid rather than folding (Smith 2017). It is unclear if there was initially an actual dome rather than just a very tall cyclorama, Barón-Nusbaum does not think it was a dome (Barón-Nusbaum 2013). Williams however notes that Reinhardt installed a sky dome in the Neues Theater with the revolve, while Otto quotes Reinhardt as requesting "a sky dome above" for the 1905 *Dream* production (Williams and Hamburger 2011; Otto 2023).

Reinhardt however never embraced Fortuny's totally diffuse stage lighting, believing in light and shade as he is famously quoted:

> The art of lighting the stage consists of putting light where you want it and taking it away from where you don't want it. [44]

Reinhardt's scenography invited positive overseas reviews with Carter in 1914 describing the 1910 *The Bride of Messina* production thus:

> The scenes were … simple and impressive – a mere suggestion of a lofty hall, or two box-trees and an infinite blue or blue-black horizon, or a double row of old-gold walls seen in perspective running out to a thin streak of blue sky. (Carter 1914, 197)

Peter's was similarly very impressed with the night sky and battlements portrayal in *Hamlet* under the Deutsche Theatre's solid Fortuny dome,[45] but also noted its substantial drawbacks, with curtains across it having to be dragged backwards to obtain enough stage space for interior scenes (Peters 1923).

Reinhardt was a radical director, experimenting in perspective, colour and lighting, as well as the relationship between actor and audience (Carter 1914). He directed major productions in a variety of venues, such as the massive Frankfurt Circus Schumann arena (5,000 seats) before Poelzig remodelled the comparable Berlin venue for Reinhardt in 1919 as the Grosses Schauspielhaus, an arena stage with 3,500 seats and also a domed sky canopy[46]. But like Brahm before him, Reinhardt's star eventually waned and he left his Berlin theatres[47] for Salzburg in 1920 where he founded the Salzburg Festival (Esslin 1995).

The cyclorama as a powerful driving element in stage lighting did not cross the Atlantic to the most influential American producers/designers in the early 20th century, Belasco and Bel Geddes (Bogusch 1972). While Belasco and his technician Hartman strove to produce

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[43] On taking over the Deutsches Theater, Reinhardt modernised the stage, installing both the circular cyclorama and a revolving stage (Schenk 2015).

[44] While widely attributed to Reinhardt, an authoritative source for this quote cannot be found.

[45] The date is uncertain, but between 1909–13. Reinhardt's solid Rundhorizont (without a dome) still remains in the Berlin Deutsches Theater to this day, though Rorrison suggests it has scant appeal for contemporary directors (Rorrison 2009). Reinhardt was also an early advocate for revolving stages to allow rapid scene changes, wanting to eliminate the proscenium and curtains (Stern and Herald 1919).

[46] This incredible auditorium and foyers (which Reinhardt still called his *'Theatre of 5,000')* was demolished in 1988, but was also the inspiration for the iconic and now grade II* listed 1930 New Victoria Cinema in London (Wamsley 1998).

[47] Deutsche Theater, Kammerspiele, and Grosses Schauspielhaus were eventually 'offered to Germany' after Hitler came to power. In practice they were surrendered to the Nazi state since they had become financially unsustainable with a 1 million marks mortgage (Kvam 1988).

naturalistic results and sometimes used reflected diffuse light[48], Bel Geddes from the 1920s followed predominantly the expressionistic concepts of Appia utilising large arrays of spotlights. Plain and painted backdrops of course still existed, illuminated with banks of generic floodlights.

Realism in German theatre was not a static period. The challenge to the status-quo by such as Stanislavsky, Fortuny, Herkomer and Reinhardt, aided by the theories of Appia and Craig, was termed Proto-Modernist by Konstantinakou (Konstantinakou 2002). They initially demanded better realism in the whole production, requiring scenography that could emulate or create the impression of real buildings or wide open spaces, such as Ernst Stern's design in Figure 10 (Stern 1951; Stern and Herald 1919). Southern's age of realism or "anti-illusion" was arriving, with plastic scenery replacing painted cloths, together with a need for convincing skies not covered in actor's shadows (Southern 1964).

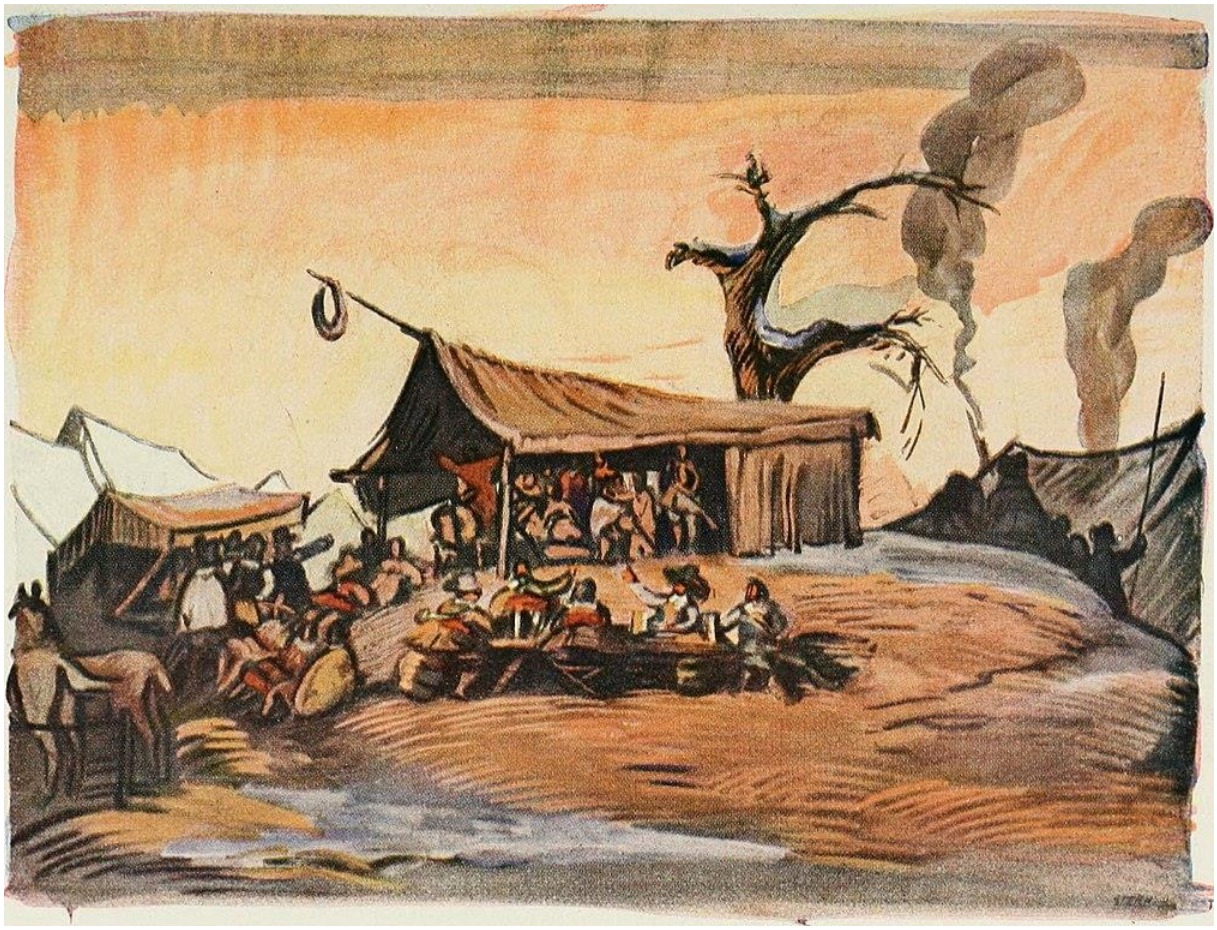


Figure 10. Stern's design for Schiller's *Wallenstein's Lager*, 1914. (Stern and Herald 1919)

Then as Cheney noted in 1928:

> The change in the last thirty-five years has been enormous… Painted perspective and painted illusion of things disappeared, and plastic elements crept into the scene. The next minor revolution initiated the movement toward simplification which has continued ever since. At first the picture was merely stripped of unnecessary detail. Then suggestion was added to simplification: the picture intimated more than it stated. Then design came in, consciously, and the wholly tasteful simple setting evolved. And as a final

[48] Dean witnessed this and brought back a sample reflector and paint formula to use on his stage in c.1922 (Dean 1970). However he is silent on the outcome.

> improvement in the picture mode, stylization was accomplished, austere or lavish, posteresque or reticent, historical or aesthetic. (Cheney 1928 (reprinted 1966), 136)

Stylized realism was itself just a stepping-stone to the full Expressionist theatre of the 1920–30s, and the idea of the scene as machine (Baugh 2013). This trend had been developing pre-WWI by such as Georg Fuchs in Munich with his anti-realistic staging (Balme 2003). The opening stage direction of Sorge's *Der Bettler* (*The Beggar*) provides a clear example of the new expressionist style, first staged by Reinhardt in 1917:

> An empty stage. There is no pretence, no construction to fill the space. The light tears out a piece of the great black space, which untouched and limitless, seems waiting to be filled. (Patterson 1981, 55)

The first World War had resulted in stricter censorship and straightened resources, but afterwards in the Weimar republic, experimentation continued in the growing German political theatre of abstractionism and primitivist, perhaps benefiting from the political turmoil. New directors such as Jessner and Piscator pushed forward, using the energy of socialist revolution to create ever more challenging theatre (Willett 1986; Patterson 2003). This period was accompanied by Brecht's epic theatre and the radical ideas flowing from Walter Gropius's Bauhaus Theater Department established in 1921 (Baugh 2013).

But despite this growing rejection of realism the development of stage technology, particular lighting and stage machinery, had already been driven by the earlier dominant demands of realism. By the 1920s, German industry had fulfilled its stage directors' needs for visually realistic encompassing skies, flexible area-based, directional lighting and stage machinery capable of massive plastic scenic transformations.

Then in 1933 German artistic development stopped as the Nazi's seized power, banning 'degenerate' art, with similar fates suffered under the fascist regimes in Italy and Spain. Many artists fled the country taking their ideas with them, leaving this flowering of German theatre to be destroyed over the next 12 years, first morally then finally physically in the resultant war.

5. The Circular Cyclorama (Rundhorizont)

Discussing the cyclorama (termed the "stage sky") in 1929, Kranich noted:

> Nothing has undergone such a great change and influenced the stage design, its structure and construction, the ground plan of the stage and the entire construction of the theatre as much as it has. (Kranich 1929, 189)

Of course an encircling painted backdrop has been known since the Greek Hellenistic Theatre, where the "hemikyklion", a semicircle of canvas depicting such as a distant city or sea was used. Nicoll identifies the great change in stage construction as the rise of the "Mechanical Theatre", when 19th century dissatisfaction with the Baroque theatre, demanded solid scenery rather than a simple series of flats, wings and backdrops (Nicoll 1966). This needed new and much more extensive stage machinery to achieve rapid scene changes.

Krzeszowiak reported the first gas lit circular cyclorama was used in the Munich Opera in 1869, termed the "ewiger Prospekt" (eternal prospect) (Krzeszowiak 1986). Wedemeyer considered this round horizon was actually nothing more than a "prospectus" bent over at the ends, whose wings were extended to the front wall of the stage (Wedemeyer 1922). It was initially painted as a blue sky with clouds, thus represented a kind of closed decoration for scenic stage sets.

A major promotion for the circular cyclorama came in 1882 from the "Project for a theatre reform by the society for constructing modern theatres, Asphaleia" (Baumann 1988).[49] In addition to the safety reforms, the proposers also proposed the circular painted cyclorama shown in Figure 11. Baumann considered this endorsement critical in spreading its adoption, and to achieving a flexibility of stage floor use, now unencumbered by the traditional lanes of Baroque scenery tracks (Baumann 1988).

[49] The Asphaleia Consortium in Vienna, responding to the catastrophic Ring Theater fire of 1881, promoted a new safer system of stage design. This used solely iron structures, hydraulic stage machinery and steel wires in place of traditional wood frames and hemp ropes, with electric lighting in place of gas. The plans were drawn up by four men who had professional and artistic interests in theatre reform: machine manufacturer Karl Drengg, court theatre painter Johann Kautsky, architect Franz Roth and engineer Robert Gwinner (Baumann 1988).

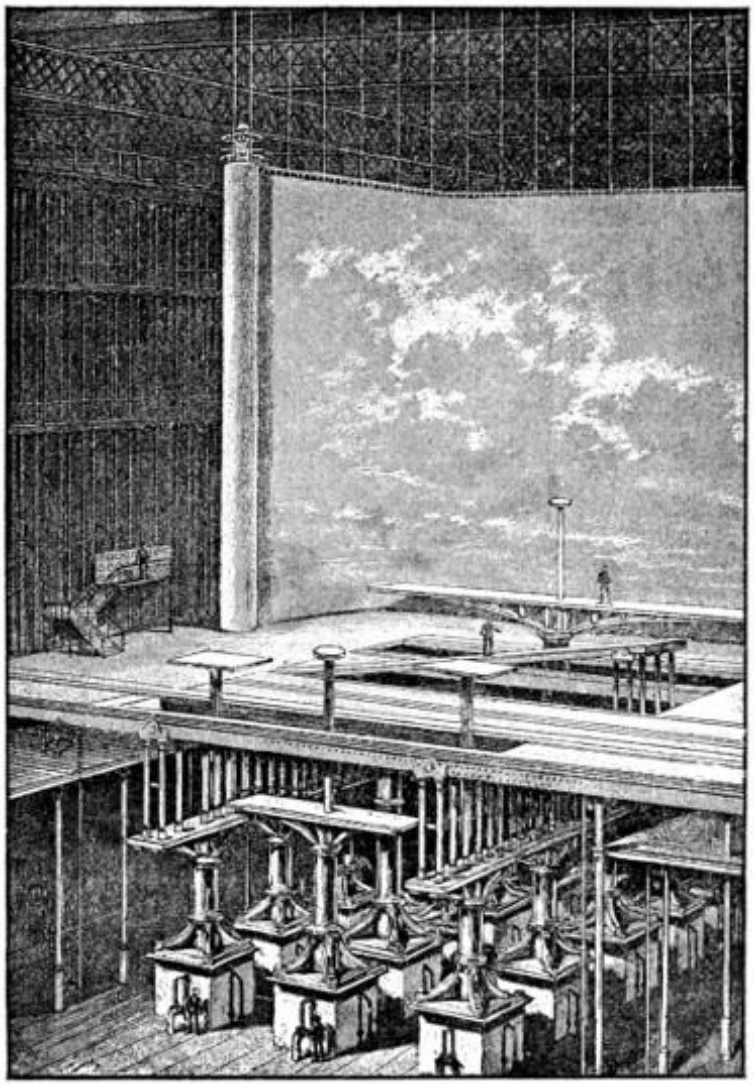


Figure 11. Asphaleia stage concept, 1897. (Hopkins 1897)

The first use of the Asphaleia staging system was Budapest Opera in 1884 with a panoramic cloth cyclorama which wrapped around the stage sides (Emden, Podmaniezky, and Leighton 1888; Baumann 1988). This was a continuous cloth 150 m long, 17 m high on rollers which carried three painted skyscapes, as shown in Figure 11 and Figure 12 (Leonhardt 1885; Bergman 1977). Stage illumination was by electricity from the beginning.[50]

[50] Budapest Opera initially employed gas for general lighting but electricity for stage lighting, using 1,200 incandescent lamps and 4 arc lights (Leonhardt 1885).

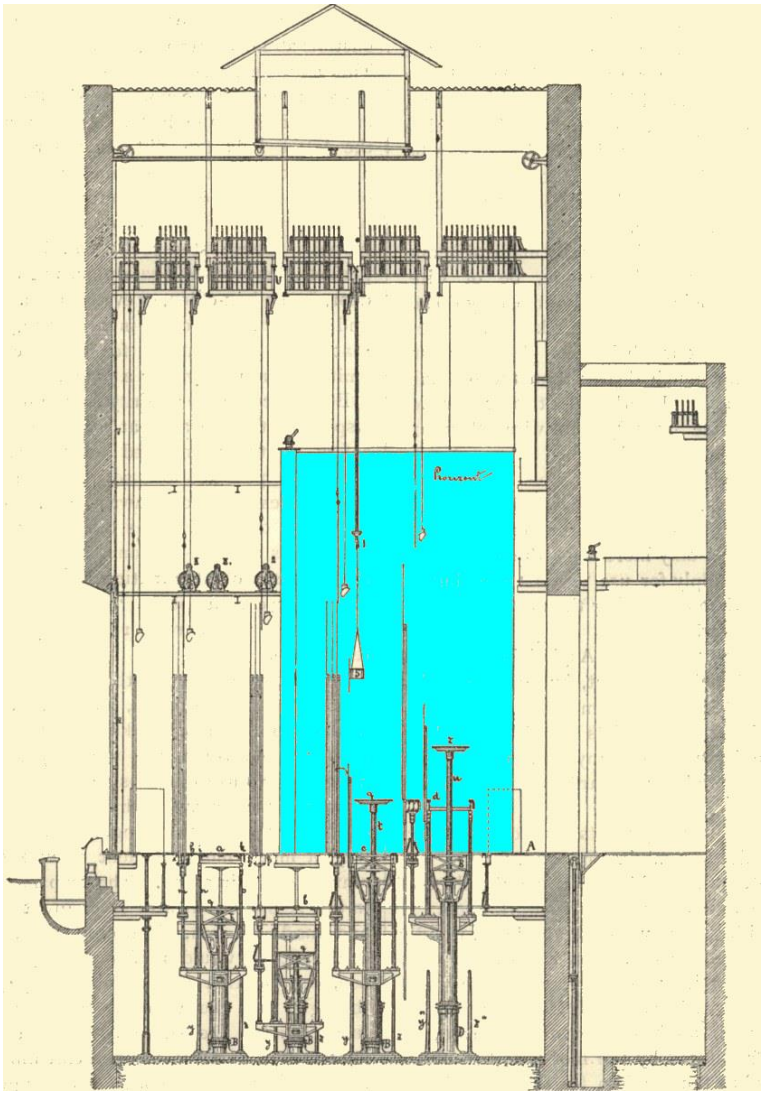


Figure 12. Budapest Opera Asphaleia stage machinery and encircling cyclorama (shown in blue), 1884. (Emden, Podmaniezky, and Leighton 1888)

Kranich summarised the development noting that almost until the 20th century, the sky and clouds were all painted, with moving clouds sometimes on gauzes (Kranich 1929). Then the new cyclorama formats made possible with electric lighting changed many times from quadrangular to arched and semi-circular, built from cloth or masonry. He considered the worst were the solid domes, unless mobile. By 1929 only eight major German stages had retained solid cycloramas, all others had cloth cycloramas, usually with several different cloths available. While most cloths ran in fixed tracks from side to side, ten stages hung them on hoists.

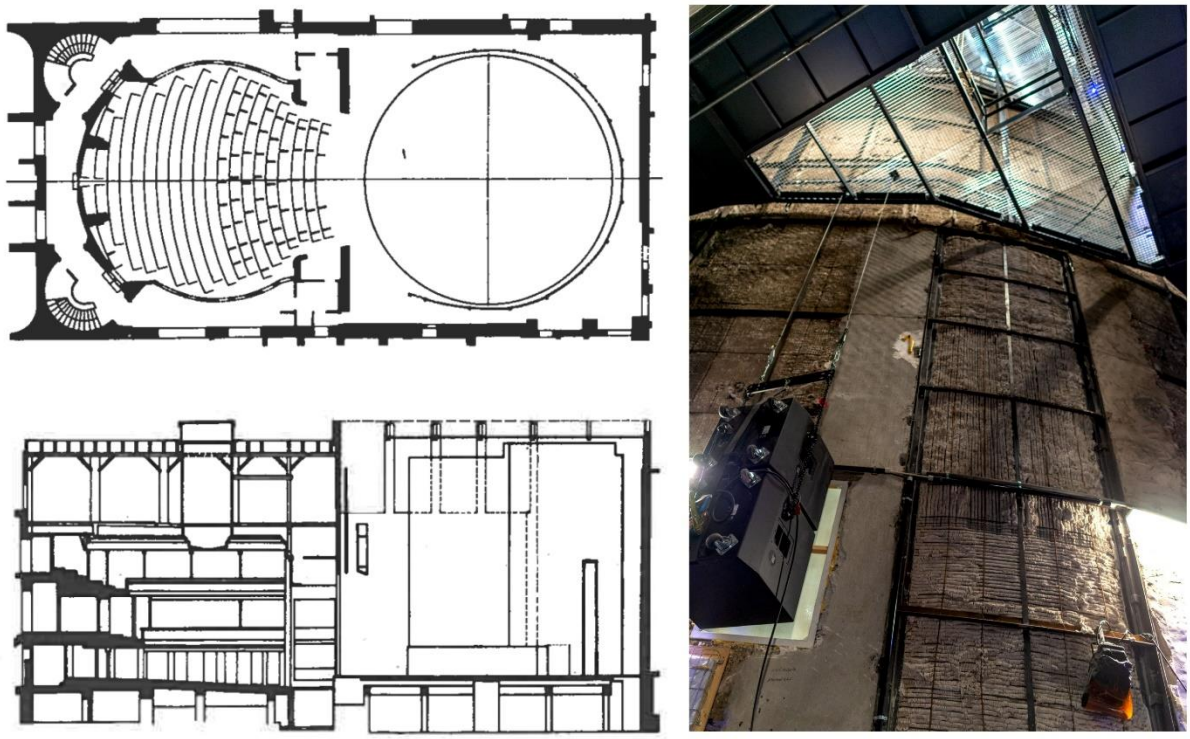


Figure 13. Deutsche Theater, Berlin stage plans (left) and current cyclorama rear view (right). (Cornelia Ernst Architekten 2020; Ahnert and Schmidt 1980)

Reinhardt's Berlin Deutsche Theater had an extensive, plaster-faced, steel framed fixed circular cyclorama shown in Figure 13. In c.1905 Reinhardt possibly installed a copy of the Fortuny dome in his theatre, which probably capped the existing cyclorama. Today the plain circular cyclorama extends to grid height.

In German opera houses and larger theatres, the cyclorama became a major feature, such as the enormous 2,300 seat, 1912 Deutsches Opernhaus in Charlottenburg[51] shown in Figure 14 (Engel 1926). Here the solid cyclorama with its rear dome (and central lighting) was suspended on rails and could be motor driven into a backstage to clear the main stage. This was the 1911 patented invention (Austria, France and UK) of renowned stage technologist Fritz Brandt (Brandt 1912). However it was more a hinderance than help. It blocked all rear exits, and when the overhead stage machinery was needed could only be retracted very slowly[52] (Baumann 1988).

[51] Charlottenburg was then a wealthy independent city and not incorporated into Greater Berlin until 1920, after which the Opera was renamed the Städtische Oper. The building was destroyed in WWII. The modern West Berlin Deutsche Oper was built on its site in 1961, but without a permanent cyclorama.

[52] An earlier design could be tilted, as described in Brandt's patent, to allow rear stage wagons to move forward. However it failed and became jammed between walls in such a way that the entire 20 tonne construction had to be cut up to remove it (Baumann 1988).

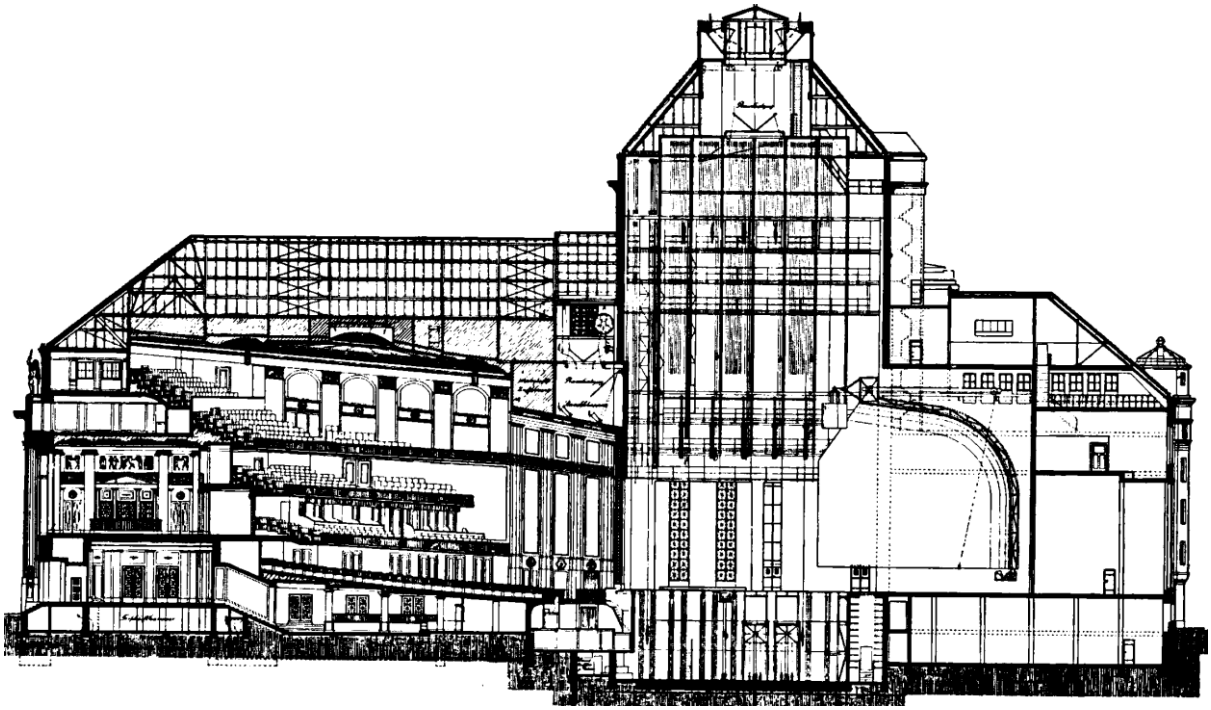


Figure 14. Deutsches Opernhaus, Charlottenburg, with tracked dome cyclorama, 1912. (Zucker 1926)

Hasait reported that, not counting the experimental Kroll Opera, his refurbished Dresden Opera house (described in section 6) was the first installation of a Fortuny lighting system on a circular cloth cyclorama (Hasait 1917). An existing cloth cyclorama had been present for many years, but inadequately lit by normal overhead lights. However with the Fortuny system Hasait claimed:

> a lighting system was found that was suitable for the illumination of the circular horizon and with which moods could be created that no stage had previously known.

By contrast, in 1913 Adolf Linnebach at the neighbouring new Dresden Royal Schauspielhaus[53] chose to install a fixed partially domed cyclorama with fabric side screens as illustrated in Figure 15, which with the dome being integrated in the rear wall, still allowed reasonable overhead access (Baumann 1988). Also shown are the three cyclorama lighting galleries.

[53] This theatre was destroyed in WWII, though the great hydraulic stage lifts survived due to being kept in the lowest position during air raids. The theatre was rebuilt close to the original design in 1948, retaining the structural semi-dome cyclorama (Frank 2021a). In plan view the dome is elliptical so the sides end parallel to the stage sides. This enables the complete stage to be closed off with white side cloth cyclorama screens which mate to the rear dome. A second black cloth cycloramas on two tracks also exists.

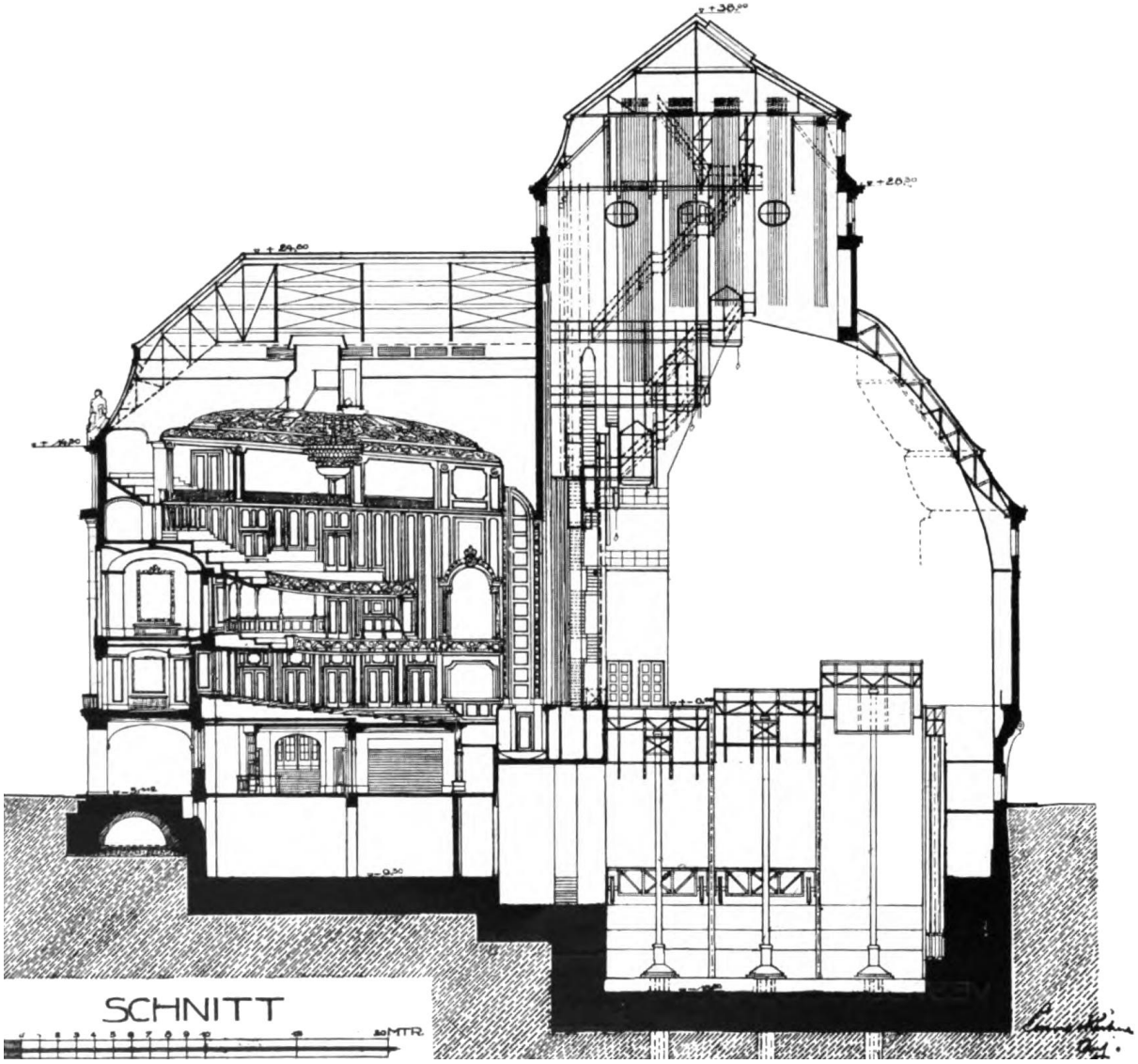


Figure 15. Schauspielhaus Dresden with fixed domed cyclorama, 1913. (Kummer 1913)

Schwabe & Co. extolled the virtues of the new circular cyclorama (horizon) in their c.1913 literature, especially when used with their lighting:

> A new and very significant improvement of the stage setting has been brought about by the artificial horizon. The circular horizon closes off an open landscape in a form that seems to correspond perfectly to the curvature of the outside sky. Since the view of the open landscape from all sides meets this circular horizon, side screens and backdrops can be left out. In general, the use of sculptural decorations and modern lighting methods has greatly simplified the stage set, as even a few objects placed on the stage create a closed impression, and it is much easier than in the past to achieve a great depth and captivating beauty of the stage set. It is therefore a mistake to believe that plastic decorations have caused a significant complication in the construction.
>
> On the artificial vault of the sky, which plays a very large part in achieving this effect, any of the numerous light phenomena we see in the sky in nature can be reproduced with perfect naturalness (Schwabe & Co 1929).

Baumann observed that the Fortuny dome proved to be ultimately a hindrance in practice due to all the drawbacks described in section 3 (Baumann 1988). He concluded that in Germany by 1922:

> The basic idea of Fortuny lighting was technically outdated and no longer in demand scenically, as a new style of staging had become established. This observation, however, does not diminish the fundamental importance that Fortuny lighting brought to stage lighting. (Baumann 1988, 202)

In the UK, Groom (speaking inevitably for GEC) considered that by 1926 the challenge of lighting the cyclorama had been achieved, and reported that by far the most important development of recent years had been the "representation of realistic and natural atmospheric effects on stage" (Winch 1956). Kranich by 1933 also considered the desire to illuminate the actors and stage with just simulated skylight was impractical (Kranich 1933). While Fortuny's dome cyclorama, termed the "Kuppelhorizont" had enjoyed a short period of interest, the earlier circular cyclorama, termed the "Rundhorizont" proved to be the more enduring.

6. Hasait and the Cloth Cyclorama

Max Emil Karl Hasait (1874–1951) was born in Charlottenburg (near Berlin) and studied civil and mechanical engineering at the local Technische Hochschule in Charlottenburg. However family poverty prevented him attending full courses with examinations[54] and was mostly self-taught (Kunze 2001). After an apprenticeship he finally become machinery director of the Royal Theatre in Berlin under Geheimrat Fritz Brandt[55], then spent four years as technical manager of the newly built City Theatre in Graz. In 1903 Count Graf von Seebach entrusted the Dresden Opera House (aka Semper Oper) to him where he served as Technical Director for 25 years. He is pictured contemporaneously in Figure 19.

He invented and filed 23 patents from 1912–1935 in his own right or assigned to ARS, most on stage machinery but was also an innovator in lighting, developing shadow projection systems similar to those now named after Linnebach ("ESPACENET - Hasait's patents" 2023). He was in charge of the major reconstruction of the Dresden Opera stage from 1909–13[56] but did not adopt a domed cyclorama as already used in Berlin Kroll Opera and then being partially installed in Linnebach's Dresden State Theatre (Schauspielhaus, see Figure 15) (Neumann 1914). Instead Hasait developed and installed a rolled cloth Rundhorizont system 22 m high and 60–70 m long in a horseshoe shape which maintained a clear floor for seven stage lifts and the flying system, shown in Figure 16 (Neumann 1914).

Despite Hasait's prolific patenting included special cyclorama tracks and a hoisting mechanism for a circular cyclorama, no patent can be found for the cut of the cloth or its coating. Hasait first patented the track in Germany in 1921 and claims a noiseless operation using a rope to pull the cloth off a drum (Hasait 1921). The system further claims that the rear section should be ellipsoidal, and with the downward inclination of the side rails 'the curtain is stretched by gravity so as to form a surface without folds.' It appears that it required users to adjust the articulated track height at various points to achieve this. In 1922 Hasait assigned a very similar US patent to ARS[57] (Hasait 1922b). The US patent for the cyclorama track is shown in Figure 17 as this version is clearer as to the intent.

[54] The lack of academic qualifications was probably the reason he didn't receive an honorary Professorship until he was 70, unlike most of his peers.

[55] Fritz Brandt (1846-1927) was a leading member of the famous Brandt family of theatre technologists (Paysan 2016). He developed new staging systems such as hydraulic podiums with parallel guides and the system of the lateral sliding stage. 'Geheimrat' was the title of the highest rank advising officials at the Royal Court, equivalent to Privy Councillor in the UK.

[56] A major work to replace the wooden stage and grid with steel for reduced fire risk and increase capacity, plus excavate the under-stage for seven major lifts, all done in phases during the five summer shutdowns (Neumann 1914).

[57] Morgan's assertion that Hasait learned this idea from ARS is incorrect, ARS was clearly licensing Hasait's inventions (Morgan 2005).

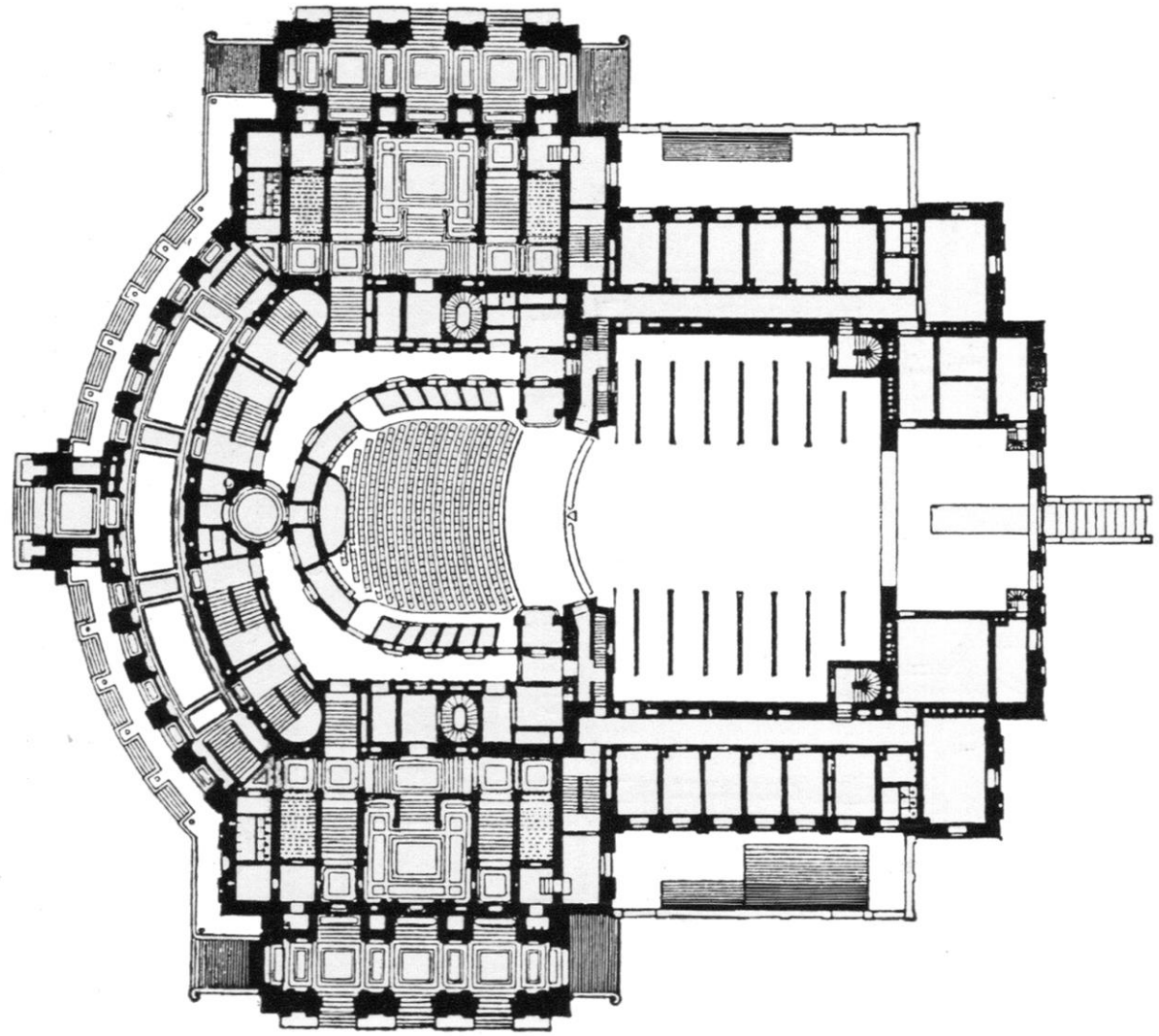


Figure 16. Dresden State Opera House, 1930s. (Kranich 1933)

Even today, Hasait's technique is in standard use. Gerriets advise that a circular cyclorama hangs wrinkle-free when the track in which it hangs is raked down four degrees to the back (Frank 2021b). This requires a special cloth cut only at the side edges, which would not be vertical if hung at an angle. Frank similarly advises that the cloth panels are cut tapered, wider at top than bottom. However, in his reminiscences to his daughter, Hasait described his invention a little differently:

> "But your inventions?" I interrupted him, "yes, of course my inventions, you can invent without a title. What do you think, how my first bigger one hit, my wrinkle-free round horizon, until then only stretched canvas sheets hung on the stage. And they destroyed all illusions, of course. The smoothness was the result of night-long calculations, not a semicircle, it had to be an ellipse, the very special treatment of the canvas." (Kunze 2001, 71)

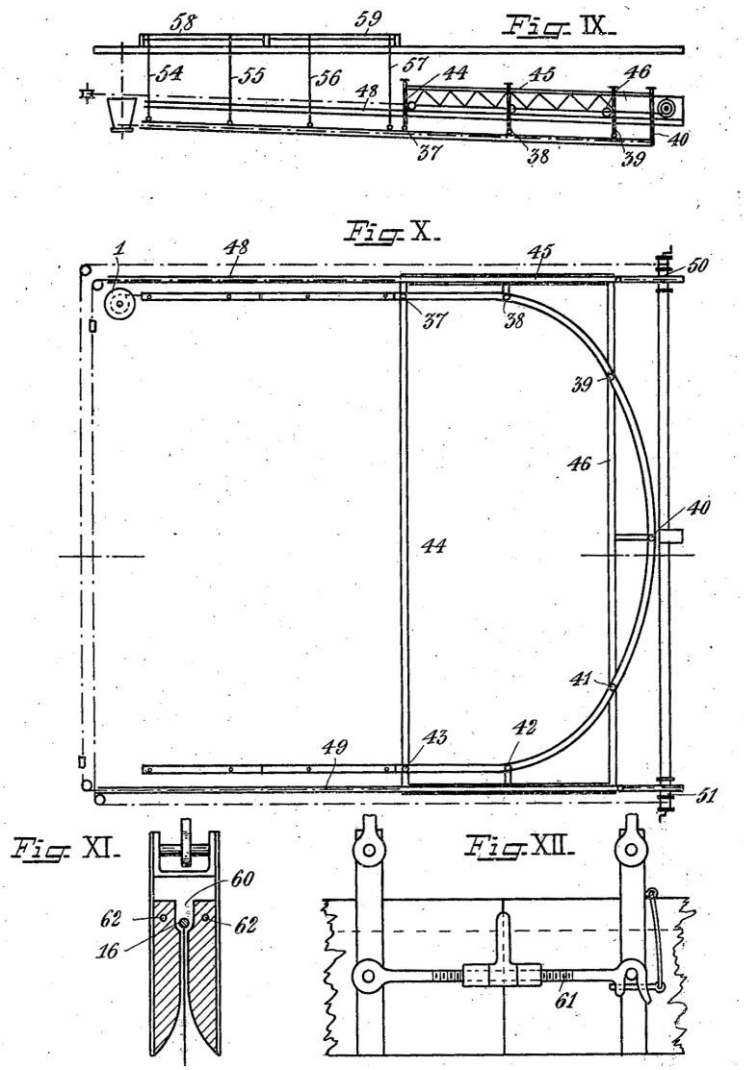


Figure 17. Hasait's patented curved and sloping cyclorama track rail. (Hasait 1922b)

There is further doubt regarding the authenticity of the Hasait cyclorama invention. Macgowan and Jones report that the rolled cloth cyclorama was a Swedish patented invention called the ARS System (from company Aktiebolaget Regi och Scenteknik), "working in association with German experts" (Macgowan 1921; Macgowan and Jones 1922). While there is no evidence they invented it, having obtained the US patent from Hasait, they were active in buying patents (described in section 10) and supplying systems.

A reported dispute exists between Linnebach and Hasait about who invented the technique of cutting and hanging the canvas so it hung smoothly (Macgowan and Jones 1922). Izenour also credits Linnebach with playing a part in the development of the now widely used track cyclorama that can be rolled up (Izenour 1988). Despite the Asphaleia panoramic cloth cyclorama installed in Budapest Opera in 1884, Hasait still pronounced in 1917:

> I would like to claim the right to have built and used the first wrinkle-free circular horizon without ceilings and completely encompassing the stage. All attempts to provide proof to the contrary have completely failed. The claim that the Asphaleia system already knew a circular horizon is not true either. The device that still exists in Budapest today, but is not used, is the usual one. (Hasait 1917)

Schwabe in c.1913 wax lyrically on the possibilities of a cloth cyclorama but make no mention of its inventor:

> This is achieved in our apparatuses by two arrangements, which work together: upper horizon lighting and lower horizon lighting.
>
> … The carefully illuminated round horizon is the ideal conclusion to a stage set conceived in the open air. Unfortunately, however, the great horizon itself has so far proved to be a rather treacherous object on stage. This horizon is not a hypothetical and intangible blue, like the natural vault of the sky, but it is, or has always been, a heavy, spacious body of stone or iron with a plaster coating. The fixed brick or mobile plasterboard horizon always meant a great constriction of the stage space. The entire transport of the decorative pieces to and from the stage had to squeeze around this obstacle and accommodate itself to it. The curvature was always perceived as a disturbing foreign body. In addition, the production costs for the massive structure were quite high.
>
> Now the general introduction of the artificial horizon, without which stage equipment can no longer be called modern, has been greatly facilitated by the fact that it has been possible to replace the solid horizon with a canvas horizon that leaves nothing to be desired in terms of perfect, wrinkle-free smoothness. the least to be desired. This horizon, which is usually rolled up on one side of the stage like a changing decoration on a tree, thus taking up no space at all, can be stretched out for use in a single minute and retracted again in the same time. The canvas, moved by motor power and guided only by a single worker, slides completely through a track and immediately hangs there in ideal smoothness. There is no need for re-tensioning or pneumatic smoothing.[58]
>
> This device also makes it possible for smaller theatres to introduce the modern circular horizon, because the roll-up screen does not constantly take up space for itself and because, furthermore, the significant expense for the fixed curvature is very significantly reduced. (*Moderne Bühnenbeleuchtung* c.1913)

A Hasait cloth cyclorama of British manufacture was installed in London's Royal Opera House in 1934, an event which merited the attendance of Hasait himself (with his bilingual daughter Lisa as translator) to technically assist the German director, Dr. Otto Erhardt (Bentham 1982). Regardless of the presence of Erhardt, Hasait seemed to take it on himself to design the cyclorama lighting, becoming both confused and exasperated by the British three primary colour system. There is no evidence of him being involved in the manufacture or supply of this installation, his role was most likely consulting engineer on the design. His presence was however notable, being pictured with Sir Thomas Beecham in newspaper reports such as Figure 18.

[58] A reference to the need to smooth Fortuny fabric domes by drawing a vacuum behind them.

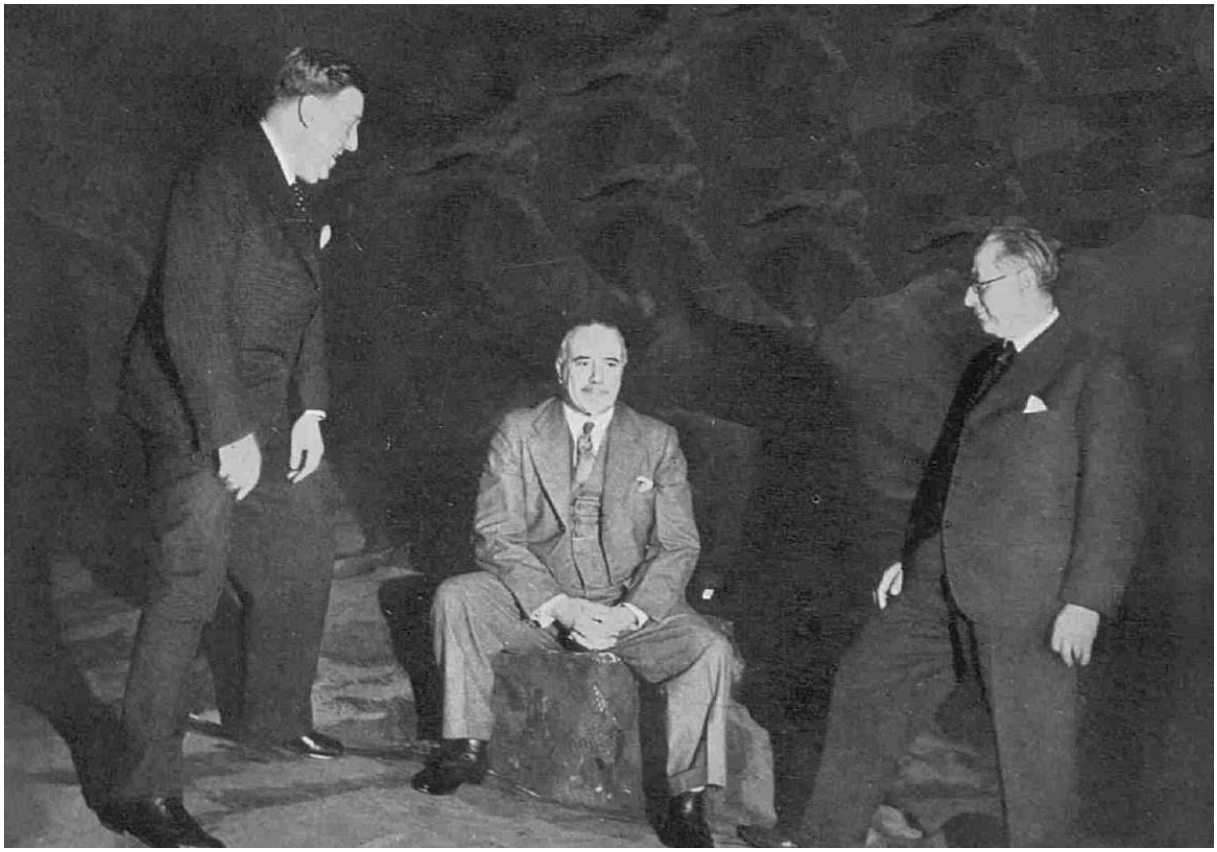


Figure 18. Dr. Erhardt, Sir Thomas Beecham, and Max Hasait (left to right) at Covent Garden, London, April 1934. ("People in the Public Eye - Men of Music" 1934)

There is apparent total lack of illustrations of the Hasait cyclorama, probably since a large area of blank canvas is not photogenic. Kranich only succeeds in illustrating a few cyclorama rolls backstage at the Dresden Opera (Kranich 1929).

By 1935 Ridge and Aldred had become dismissive of cloth cycloramas such as Hasait's, as being too intrusive, susceptible to movement from draughts, and easily damaged (Ridge and Aldred 1935). However by 1941 Siemens reported that in Germany the massive solid domed cycloramas had been mostly converted to readily removed cloth cycloramas for staging convenience (Johannsmeyer 1941). In 1952, the German term for cyclorama "Horizont" was standardised in DIN 56920 as something "fixed or moveable which covers the acting surface cylindrically or in a dome" (Deutsches Institut für Normung 1952). Today cycloramas continue mostly in cloth form due to the unacceptable intrusion of anything permanent other than a painted rear stage wall.

Hasait is credited with the novel design of the stage lighting for the 1927 German Theater Exhibition in Magdeburg. There he designed fireproof auditorium positions for spotlights to satisfy the strict fire regulations while still achieving improved light modelling (Wedemeyer 1928).

Hasait left the Dresden Opera in 1928 and continued as a respected international theatre designer and consultant for such as Teatro Colón in Buenos Aires and New York Metropolitan Opera. He also worked for the Deutsche Theatertechnische Gesellschaft (DTHG) for many years, writing, and teaching, finally becoming a honorary Professor[59] in 1944 on his 70th birthday (Unruh 1951). Then in 1945, the Dresden Opera and

[59] However it gave him little pleasure when it became a National Socialist award (Unruh 1951).

Schauspielhaus were destroyed in the war. Despite now being retired, after the war he was commissioned as technical Director of all Dresden theatres in 1945 to prepare an interim theatre recovery plan,[60] though his Opera house was not rebuilt until 1985.

There are some sources crediting (or implying) Hasait with supplying various stage machinery systems and/or cycloramas, as if he was a manufacturer (e.g. Bergman (Bergman 1977)). There is no evidence of this and his daughter's autobiography makes no mention of any manufacturing (Kunze 2001). The Dresden company Kelle & Hildebrandt[61] (K&H) was involved during 1911-1914 in reconstruction of the Dresden Opera stage under Hasait's direction, supplying at least the portal bridge (Frank 2022). When Hasait left Dresden Opera, K&H were known to be the suppliers for Teatro Colon, and probably other venues Hasait consulted for. They were not the sole contractor, for example British manufacturers were used for his 1931 London Adelphi Theatre *Grand Hotel* stage set[62] and the 1934 cyclorama at the Royal Opera House (anon 1931). Hasait's role was clearly always inventor, consultant and designer.

Hasait lost his home and work in 1945 and died embittered in an East German nursing home in 1951 (Unruh 1951). George Izenour praised him:

> It is sad to reflect how this generous and intelligent man came to his end, forgotten, alone and without means…He was a first-class stage technician, and always strove to serve the art…His ideas will live on, and we shall always honour his memory. (Izenour 1988, 74)

Walter Unruh, who's first stage employment was at Hasait's Dresden Opera, wrote Hasait's *Bühnentechnische Rundschau*[63] (BTR) obituary and was unstinting in his commendation:

> When I now receive the news of his passing and of his lonely journey from a retirement home to his final resting place, I am filled with sadness and shock at the end of my always highly respected teacher, and I know that I am at one with many colleagues whom he later gave the foundation for their lives in the courses in Dresden. Despite his untiring diligence and achievements, fate did not bless him with luck. He was always implacable against himself in the Ibsenian demand "All or nothing". Always striving for the highest achievement, he often could not find the balance to life's imperfections. What remained for him was not everything but nothing. Nothing in earthly goods, but everything in honour and remembrance of a great master of German theatre of the last decades. Hasait was a stage technician as he should be. Equipped with thorough technical knowledge, the work of art to be furnished was the main purpose of his work.
>
> ln the history of stage technology, the name of Max Hasait will be inscribed in golden letters as one of the great masters of the past generation, one of the tireless designers and inventors, one of the most zealous workers in the technical and social construction of a profession. (Unruh 1951)

[60] Since he was now retired and living on a state pension, he was not entitled to further consultancy fees by the GDR state, receiving only 550 Marks extra.

[61] K&H was taken over by the current company SBS Bühnentechnik GmbH which still retains some of the old records, though many were lost in WWII.

[62] This is known since he was called back in 1934 due to complaints of early wear, which he diagnosed as due to the local contractors using a poorer grade of steel than he had specified (Kunze 2001)

[63] Archive available online ("Bühnentechnische Rundschau Archive" 1903-2018)

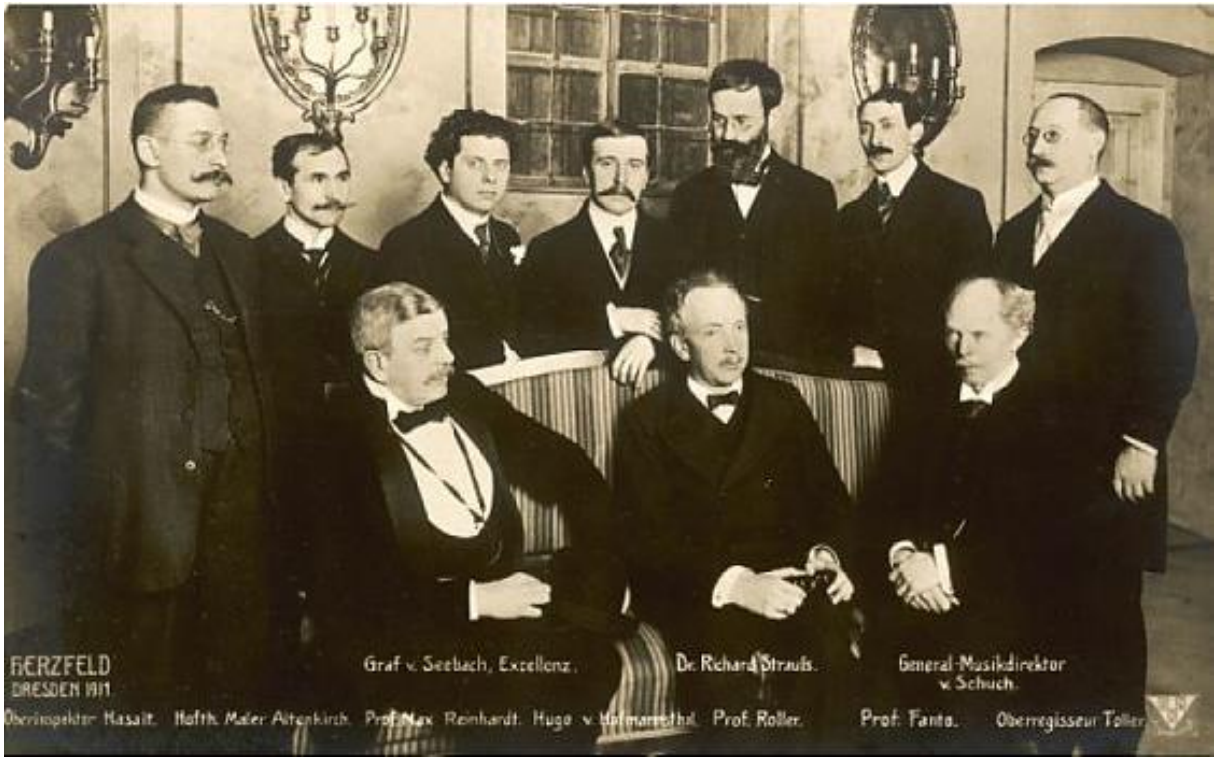


Figure 19. First night of Richard Strauss's *Der Rosenkavalier*, Dresden Opera, 26th January 1911, with Hasait (far left), Reinhardt (who directed[64], third from left, rear) and Strauss (centre seated). (Herzfeld 1911)

[64] Despite Strauss's request for Reinhardt to direct the opera, the Opera House initially preferred their in-house director. The resultant wooden dress rehearsal caused in a rapid change of heart (Craig 2015).

7. Basil Dean's Involvement with Schwabe and Hasait

As the first Director of the Liverpool Repertory Theatre, Dean visited London in 1911 to engage players for his new company. There he saw Max Reinhardt's *Sumurun* and was immensely impressed by how "colour, light and movement were combined to such brilliant effect" (Dean 1970). He immediately decided to visit the great man in Germany himself, witnessing Max Reinhardt's awe-inspiring production of *Oedipus Rex* at the packed 5,000 seat Circus Schumann in Frankfurt. Afterwards in the hotel he sat at the feet (metaphorically) of the great names of German theatre, Reinhardt, Hofmannsthal, Hollaender and others. (Dean 1970, 1911). He also visited Reinhardt's Deutsches Theater and Kammerspiele in Berlin to watch rehearsals and study the stage technology, especially the large encircling cyclorama with plaster dome and central light source. He recorded it "produced effects of space and light quite unlike anything to be seen at home at that time".

In the spring of 1912 Dean again visited Berlin and Reinhardt (who was now calling him his "English disciple"), taking his long-time designer, George Harris, with him to meet Reinhardt's chief designer, Stern. The pair also visited theatres in Munich and Vienna. As soon as possible after WWI in 1919, Dean again visited Berlin to renew acquaintances, but found Reinhardt had left for Vienna and that German theatre had suffered even more than Britain from war privations.

There is evidence that Dean immediately adopted some of Reinhardt's style of lighting when at Liverpool Repertory theatre from 1911-1913. Carter in 1914 writes from New York that:

> The Deutsches Theater system of lighting has found its way to England and may be trusted to undergo some development at the capable hands of Mr Basil Dean of the Liverpool Repertory Theatre. The lighting at this theatre is already attracting attention and is admitted to be the best in the provinces. (Carter 1914, 177)

Dean formed a London production company called "ReandeaN" in 1919 with an old friend, Alec Rea (Dean 1970). One of Dean's first ReandeaN productions was *The Blue Lagoon* in 1920 in the old Prince of Wales theatre. Aspiring to emulate Reinhardt's "imaginative use of light and colour", he erected an enormous cyclorama illuminated with automatic arcs placed in large custom semi-circular housings with colour filters, nicknamed "ash cans". Dean claimed later that Reiche from Schwabe adapted and commercialised this design, probably as the luminaire shown in Figure 51(d). Interestingly the programme credit for electrician was the then major London theatre lighting supplier T. J. Digby (Wearing 1984).

By 1922 Dean professed to be making annual pilgrimages to the Continent, stopping again in Berlin. There is no record that he met Hasait or even visited Dresden, though of course Hasait's developments were well known across Germany and beyond. In 1922 with Rea he met the Schwabe brothers where "Alec soon caught my enthusiasm for the latest lighting equipment made by Schwabe" (Dean 1970). They arranged for their chief engineer Reiche to visit London to prepare a Reinhardt style cyclorama system for installation at St Martin's.

Also in 1922[65] he was appointed "Advisor on stage lighting installations" to GEC (Dean 1925). His appointment letter shows that he was paid 250 Guineas annual retainer to allow GEC to use the St Martin's Theatre for demonstrations, plus a 2% commission on any sales he consulted on, so was clearly influential in persuading GEC to distribute Schwabe (Fletcher 1922). The appointment was for three years with a two year extension option.

[65] Much later in his autobiography Dean claims GEC only invited him to be advisor after the 1923 St Martin's demonstration (Dean 1970).

The lighting system was delivered and installed at St Martin's in 1923 costing £13,000 and having reportedly needed ten months to install, though Dean states it was installed during rehearsals for the next play ("New Stage Lighting - The Schwabe-Hasait System" 1923; Dean 1970; Morgan 2005). The installation at the London St. Martins theatre was a full Schwabe cyclorama lighting system with horizon lights (apparently the full seven colours), acting area lights,[66] cloud machine and panorama projector system, to use on a Hasait designed cloth cyclorama, shown in Figure 20 (Dean 1970, 1962). In addition there were "overhead flood lights illuminating the acting area of the stage" and still uncommon at this time, front of house spotlights on the dress and first circles ("New Stage Lighting - The Schwabe-Hasait System" 1923).

The smooth white cyclorama cloth ran in a semi-circular rail across the entire back of the stage, and was capable of rolling or unrolling in a few seconds by an electric motor ("New Stage Lighting - The Schwabe-Hasait System" 1923). The supplier of the cloth and track is unknown. Dean claimed 52 years later that Hasait had visited to install it at St Martin's and as far as the records show, this was probably the first time Dean and Hasait met (Pilbrow et al. 1975).

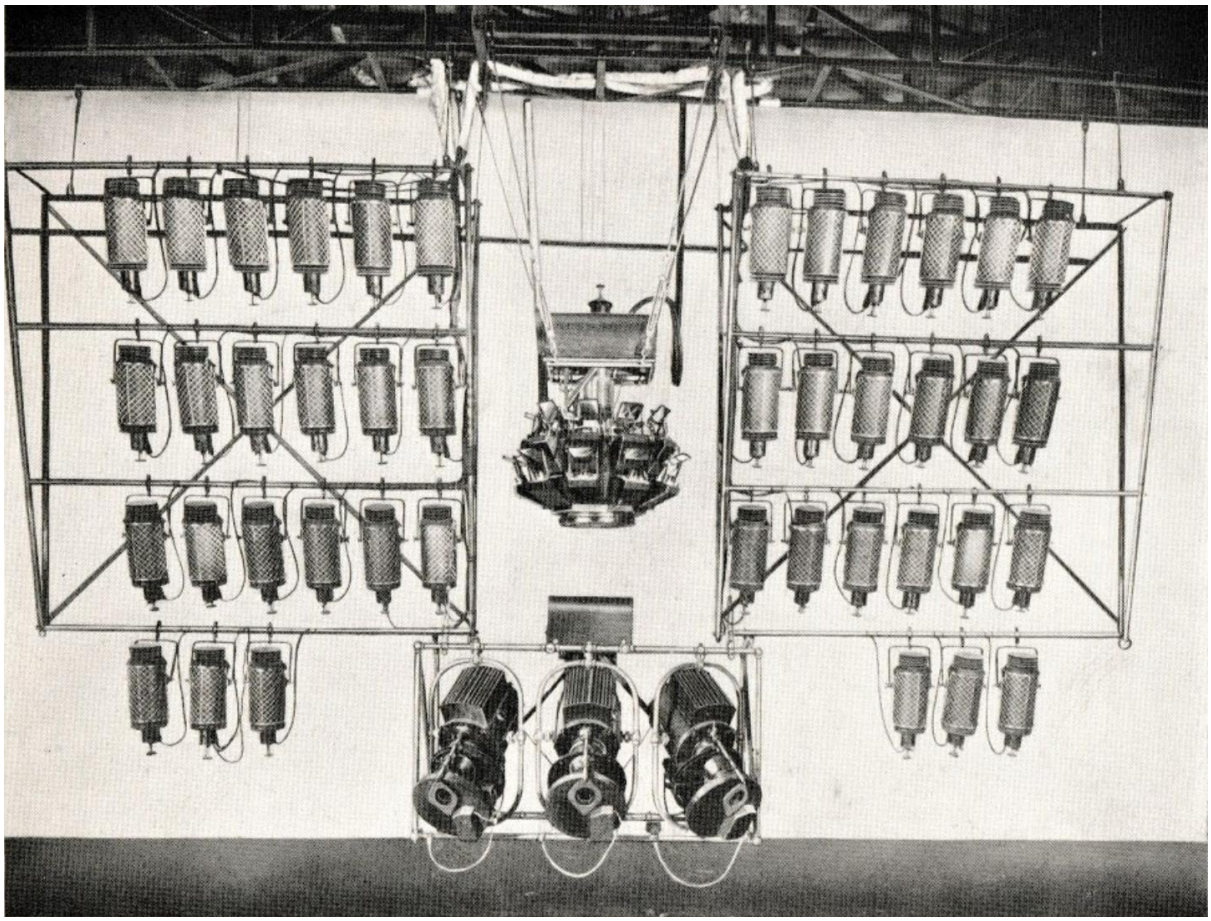


Figure 20. Schwabe apparatus at St Martin's Theatre, London in 1923, showing horizon lamps, cloud machine and panorama projectors. (*Modern Stage Lighting* 1923)

There is also no information on who paid for the system, the theatre owner or the lessee ReandeaN. The critic "Cockaigne" thought that Rea had financially assisted the installation

[66] Dean does not mention these, however later criticism by Peters makes clear that strong directional downlight was used (Peters 1924).

("Cockaigne" 1923). Dean admitted at the time that the system was still experimental, and afterwards that "full use of the equipment could not be made in our small theatre" (Dean 1970; "Cockaigne" 1923). He also initially claimed that one electrician could now do the work of six. Schwabe also supplied a tracker-wire operated resistance dimmer system (Wilkinson 1928).

The new system was first used for the A. A. Milne play, *The Great Broxopp* to provide the background evening garden scene for the last act. However this play was a mild comedy not in need of dramatic scenography and had only been put on due to the early demise of the previous production of *Loyalties*. That had had all internal scenes while *Broxopp* had just one final scene with a partial rear exterior view. Thus it is impossible to discern what Dean hoped the new installation at that time would achieve for either play, apart from some German "stardust"? Despite the new installation *Broxopp* flopped after just one month.

On the 8th March 1923, three days into *Broxopp's* run, Dean gathered the press and theatre representatives for a private demonstration, where he also handed out copies of GEC's catalogue *Modern Stage Lighting* (Dean and Peters 1924). "Tarn" of the Spectator described the event:

> The "day" began with a fine light-blue summer sky traversed by light fleecy clouds. These clouds gradually massed low on the horizon — dark, threatening, cumulus clouds with bright high-lights of white that rode high were crossed by a low, threatening cloud vapour. The wind got up, the sky grew blacker, there was distant lightning, and at last the thunderstorm broke with a wailing wind and torrents, sheets, veils, of driving rain. The Illusion was complete. (Williams-Ellis and (Tarn) 1923)

However Tarn was not totally won over:

> The colours were bad. A very beautiful violet was the only one that seemed to me satisfactory. The yellow was poor, the green absurdly bad, the reds lacked body … There were some beautiful greys and the violet aforesaid, while now and then in the cloud sky we saw a good greeny-blue.

Peters later complained that in *Broxopp* the bright background overwhelmed the lighting of the actors, which even the strong downlight could not rebalance (Peters 1924). However contradicting this, The Stage stated that the system was not used in *Broxopp* though this may just refer to the cloud projection system, which particularly impressed in the demonstration with the "remarkable and natural-moving cloudscapes" ("New Stage Lighting - The Schwabe-Hasait System" 1923).

The public demonstration however drew withering criticism from George Bernard Shaw, which Dean later took pride in repeating:

> I'll take good care you don't use any of these contraptions in my plays, young man. The audience would be so busy staring at the clouds they wouldn't listen to my words. (Dean 1962)

The critic "Cockaigne" wrote to America complimenting the demonstration, reporting that the system also included powerful acting-area lights, mobile spotlights plus wind and rain machines ("Cockaigne" 1923). New York's Variety magazine also reported on the event, observing that "by a series of electrical and optical effects it is possible to reproduce upon the stage practically every change of weather and season of the year." ("Cockaigne" 1923) It pointedly noted that no indication was given of its expense nor practicality for touring, given that installation had taken most of a year.

The demonstration and performances were operated by Walter S. Veness, later to become Managing Director of VenrecO (Wearing 1984). Dean also exaggerated the Hasait cyclorama's sophistication, claiming a special cut was used, whereas in reality as described in section 6, the cloth panels are just slightly tapered:

> The canvas was cut on the bias - as the seamstresses say - in accordance with measurements worked out with German precision on the drawing board beforehand. (Dean 1962)

Dean is also reported as claiming that St. Martin's was now:

> the best electrically equipped theatre in Europe … and that although the system is now used exclusively by the Reandean management, it would eventually be placed at the disposal of the entire theatrical industry in this country. ("New Stage Lighting - The Schwabe-Hasait System" 1923)

Dean was also riding a popular wave of new scenic projection ideas. In 1921 Hasait had applied for a German patent for "representing optically scenery and other objects on stages or the like by the aid of coloured shadows thrown upon curtains, hangings or the like." A comparable British patent was also applied for and granted in 1922 (Hasait 1922a). While the patent was solely a shadow projection system, akin to that by Linnebach but more complex, it sparked a flurry of press commentary suggesting that this new technology would obsolete cumbersome scenery and achieve economies in staging and greater rapidity of scene changes. Grein in 1921 waxed lyrically on the prospects and termed it the "Hasait" system, forecasting that "travelling companies will no longer be cumbered by cart-loads of scenery" (Grein 1921).

This idea of relying on projected scenery was also heavily endorsed by GEC[67] in their 1923 catalogue of Schwabe stage lighting (*Modern Stage Lighting* 1923). They claimed:

> We have already noted the defects of the ordinary methods, whereby few changes could be made without actual scene-shifting. It is now recognised that by scientific lighting much of this labour can be avoided, and many heavy pieces of scenery formerly regarded as essential are replaced by what we may term their "illuminating impression"; it is sufficient to suggest the outlines of a scene – a landscape, town, or building, a realistic result being obtained simply by the aid of light, correctly projected and modified.

Dean claimed that his 1923 production of *R.U.R.,* shortly after the Schwabe-Hasait installation, was the first to use scene projection[68] on a British stage (Dean 1973). He had also planned that his system would enable his matinee series of mid-week "Play-Box" plays to be presented more economically with limited scenery, relying on his new system for projected effect (Grein 1923). But by 1924, he concluded the ability to project various natural phenomena on the cyclorama was of "limited usefulness" (Dean and Peters 1924).

Dean used part of the system for his Christmas 1924 *A Midsummer Night's Dream* at the London Drury Lane theatre (Bentham 1992; Morgan 2005; Dean 1924). However Dean himself only describes installing "part of the system" and "an enormous cyclorama" which given the very short production time of just 4 weeks, must have been existing already (Dean 1970, 1975a). His "Lighting Requirements" notes show that he borrowed the ReandeaN Schwabe horizon batten and cloud projector and probably acting area lamps, otherwise the

[67] One suspects this was Dean's idea.

[68] This claim seems very unlikely to be true given British knowledge of the earlier work of Bähr, Linnebach etc. as well as the already extensive use of magic lanterns. In addition, R.U.R. used shadow projection, not optical imaging.

production used traditional London stage lighting with five battens, footlights, front batten spotlights and just 3 arc follow-spots in the auditorium (Dean 1924), Again Veness was chief electrician (Wearing 1984). It was a cross between "proper" Shakespeare and pantomime, replacing the traditional Drury Lane Christmas production. Dukes notes the show was essentially a "spectacular" with star traps and flying fairies, but complains that the show should be judged on its merits, not on claims of use of the Schwabe-Hasait system (Dukes 1925).

Reinhardt's staging achievements of course relied on much more than a spectacular sky, and was also dependant on the use of localised spotlighting to heighten the drama and direct attention (Palmer 2013). While Dean probably occasionally followed this style, there is no evidence that he used any special Germanic equipment for it before 1923. However he did in c.1920 import new spotlights with metallic grid filaments from the USA due to lack of comparable British versions (Dean 1970). These he installed in the auditorium of the St. Martin's, claiming to be the first in London, much to the consternation[69] of the London County Council licencing inspector.

ReandeaN was dissolved in 1927 with the departure of Dean, leaving Rea's new company "Reandco" to manage the remaining lease of the St. Martins (Dean 1973). This effectively brought Dean's Schwabe, Hasait and St Martin's Theatre episode to an end. Despite Dean's enthusiastic endorsement of Schwabe & Co, there is curiously no correspondence with them in his extensive personal archive at Manchester University, save one letter from GEC regarding them (Matheson 1997; Fletcher 1922). A summary of Dean's career is given in the Appendix.

[69] Due to the perceived risk of explosion, harking back to the days of gas and limelight.

8. The Schwabe-Hasait System in the UK

The term was a misnomer. The Schwabe system of cyclorama lighting was not dependent on the Hasait rolling cyclorama cloth or vice versa. Each could be used independently and often were. It should also be noted that while Hasait is credited with the design of many installations, he was never the manufacturer. The term Schwabe-Hasait was a nickname coined by Basil Dean, with the subsequent common British use of the term probably derived from Dean's and GEC's promotional material for it. Dean admitted in 1926:

> Stage Storms… Such developments as have been made are most attributable to what I once nicknamed "The Schwabe-Hasait" system of stage lighting, after the two chief inventors. (Dean 1926)

The GEC catalogue for Schwabe equipment, illustrating the St Martin's installation as shown in Figure 20 similarly referred to the system as Schwabe-Hasait (*Modern Stage Lighting* 1923). However there is no indication GEC sold the cyclorama or supporting track system, and the cyclorama itself was solely termed the "Artificial Horizon", which could be shaped as a cupola or cylindrical, solid or a cloth. Further when Groom from GEC gave a 1926 lecture on Stage Lighting, the Hasait cyclorama is not referred to by name, only Schwabe lighting (Groom 1926). The St Martin's Theatre was listed in 1930 with still a Schwabe Lighting System and a now permanent panorama ("Working Dimensions of London Theatre Stages in 1930" 1930).

The British popularity for the term was continued by the 1931 installation for *White Horse Inn* at the London Coliseum, where the Venre Co Ltd (aka VenrecO) claimed to manufacture British copies under license (Scott 2016). It is notable that VenrecO's Managing Director was by then Walter S. Veness, the St Martin's launch demonstrator for in 1923, while Alec Rea, who had parted from Dean by 1927, was now also a VenrecO Director ("Venreco" 2021). There are no records of Schwabe patenting their later equipment, while Hasait only patented special cyclorama tracks, so the claim appears to be an empty boast. Further the cyclorama was in fact supplied from Germany ("The London Coliseum's Revolve and Lighting Installation on its opening in 1904" 2022). The most likely scenario was VenrecO trying to get on the Schwabe-Hasait bandwagon by developing copies, but too late as interest was already dying.

Figure 21. VenrecO advertisement in the Sunday Referee, 5th April 1931. (Scott 2016)

The Schwabe-Hasait system went on to be installed in only a few London theatres, St Martin's and the Queens[70] in 1923, the Fortune in 1924 and a copy in the Coliseum in 1931 ("The Little Minister Back Again" 1923; Grein 1924; Chit Chat 1923). In 1926 Schwabe seven colour cyclorama overhead lighting plus three colour ground row system[71] was installed at Gray's Cambridge Festival theatre with a painted cement semi-circular cyclorama (Ridge 1928).

For its opening in 1934, Glyndebourne owner John Christie also installed a solid cyclorama with Schwabe[72] horizon tubular luminaires, for which he also bought the refurbished ex-Plaza cinema cloud projector second-hand (Bentham 1984b) [73]. Ridge reported that such two-tier cloud machines cost £600 new in 1930 and weighed 240 kg (Ridge 1928). The same year Covent Garden installed just a Hasait designed encircling cyclorama (of English manufacture) with a large array of Strand 1,000 W floodlights in 1934 in red, green and double wattage blue (shown in Figure 22) (Applebee 1946, 1935; Bentham 1992). In 1935 the Cambridge University Amateur Dramatic Club (ADC) theatre however installed Holophane three-colour cyclorama lights for their cloth cyclorama, Holophane Ltd then being the dominant colour mixing supplier for major cinemas (Tomlinson and Dyson 1935).

[70] Installation supervised by Dean, for a series of ReandeaN productions (Chit Chat 1923).

[71] Ridge attributes the dimming installation to ReandcO, however this was probably a mistake for VenrecO (Ridge 1928).

[72] Since Schwabe had ceased to trade by 1931, unless second-hand, these may have been the equivalent Reiche & Vogel units.

[73] This had failed or been damaged, and was quietly repaired by Strand Electric (whose products Christie wanted to avoid) before reuse (Bentham 1992).

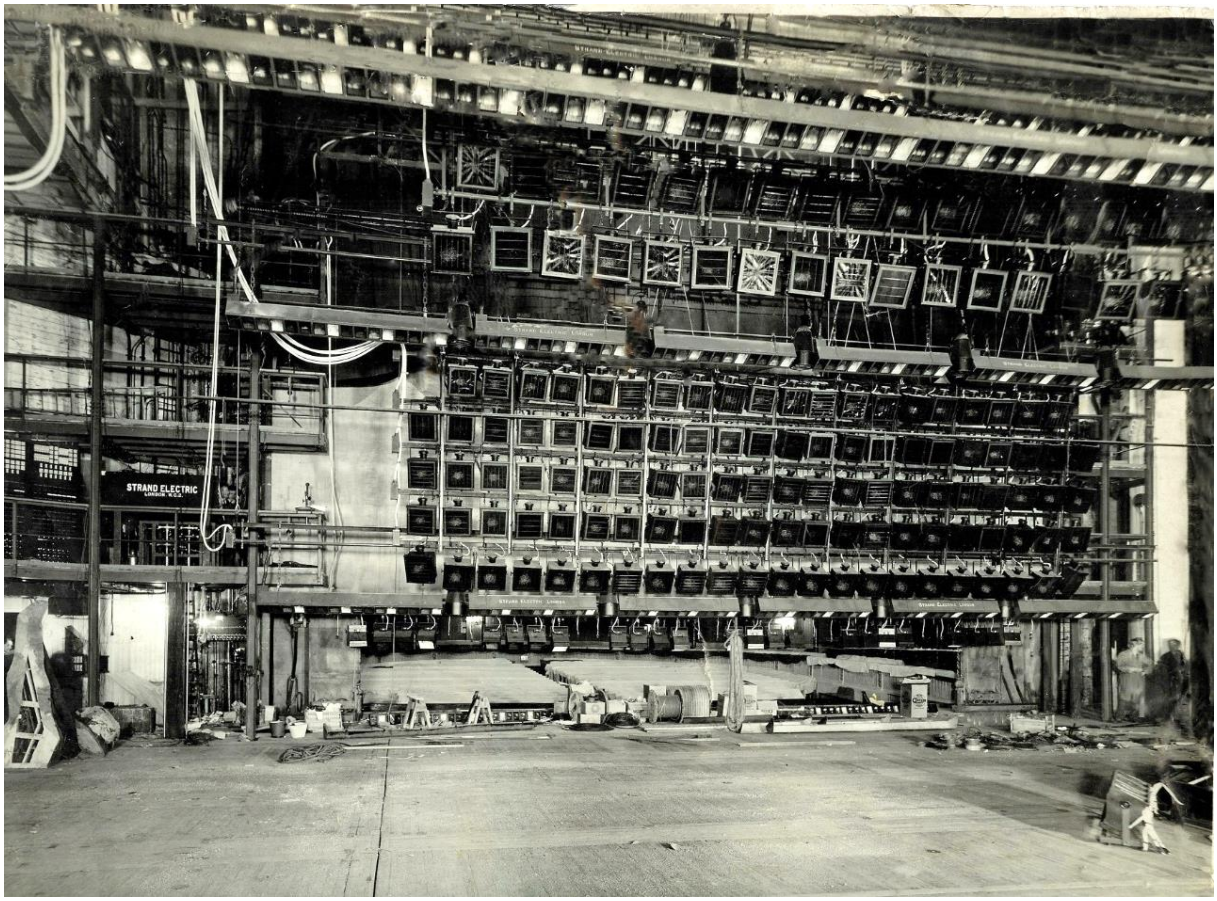


Figure 22. Strand Electric cyclorama floods, Covent Garden, London 1934. (Kelly 2006)

A few Cinema Theatres with a stage also installed the system for the cyclorama effects. The London Plaza in 1926 (shown in Figure 23) and its sister house, the Carlton in 1927 purchased systems, the later also installing Schwabe tracker wire controlled dimmers ("Spectacular Lighting - Modern Stage Lighting at the Carlton" 1927). The Sheffield Picture Palace was reported to have also used a similar system. Kinematograph weekly noted that by 1928 still only a few British picture theatres were equipped with the Schwabe cyclorama and cloud projectors, whereas “in Germany very great use is made of the cloud apparatus in picture theatre presentation.” ("Stage Lighting, Schwabe Equipment in England, G.E.C. Facilities" 1928).

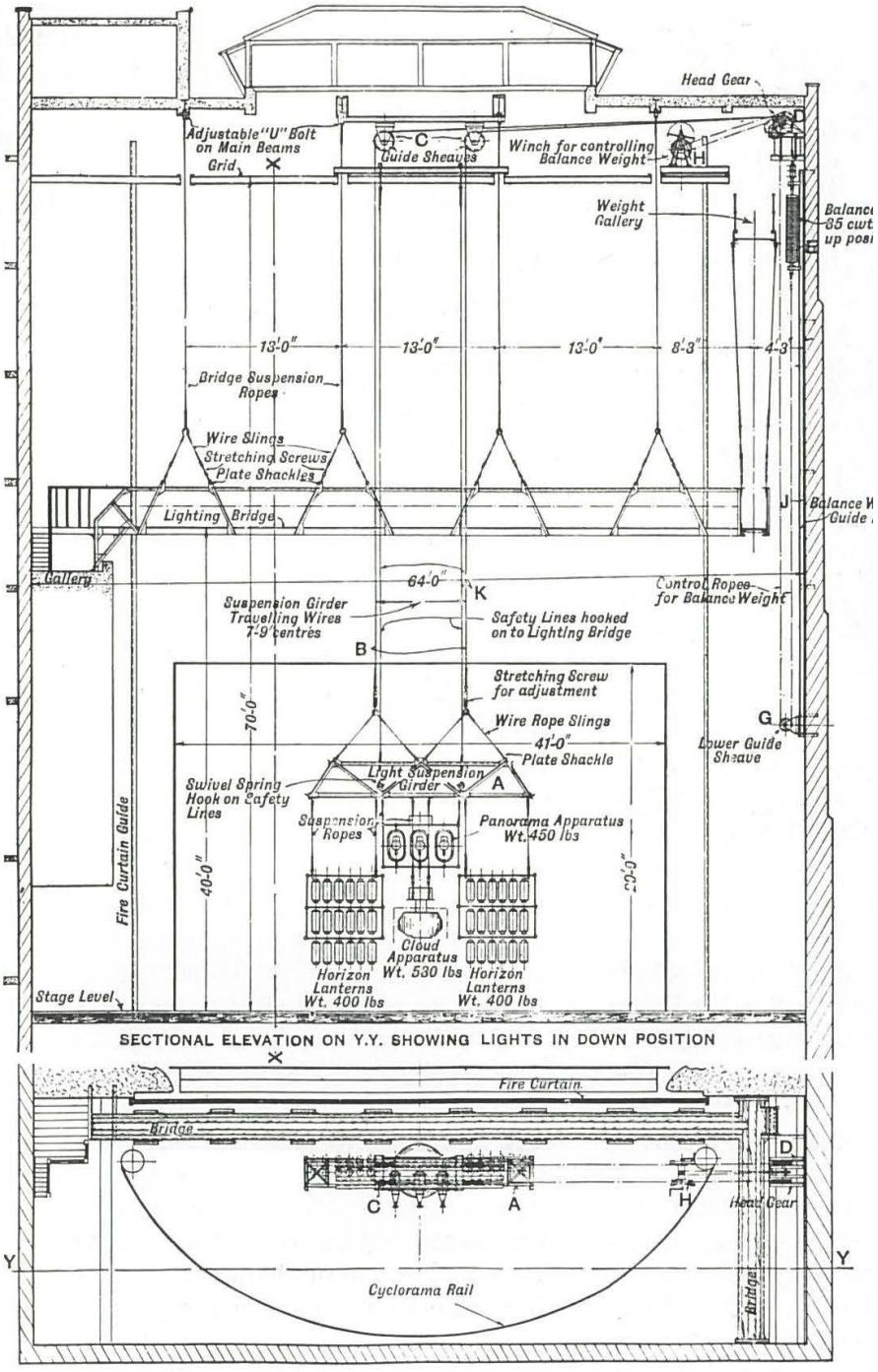


Figure 23. Schwabe lighting, London Plaza Cinema, 1926. (Ridge 1928, Fig 36)

9. The Schwabe-Hasait Legacy

Looking outside Britain, there is no conjunction of Schwabe and Hasait in any of the BTR journals from 1910 to present day ("ESPACENET" 2023). Similarly the extensive 1926 German reference books by Engel and Kranich do not use the term, nor the biographers and commentators of the early users of the Schwabe system – such as Reinhardt and Stern at the Deutsche Theater in Berlin (Rorrison 2009; Stern 1951; Stern and Herald 1919; Engel 1926). Further, despite Dean taking his shows to the USA, the magisterial US Theater Technology treatise by Izenour does not make the conjunction either (Izenour 1988).

There is one exception. Fuerst and Hume provide a typical illustration (no. 353) of the ranked lighting bridges behind a large German stage proscenium, and termed it a "Hasait-Schwabe" installation, presumably since it shows an array of Schwabe cylindrical horizon luminaires (Fuerst and Hume 1928b, 1928a). However the describing text merely refers to it as a Schwabe illustration with no mention of the cyclorama. One possibility for this term is that Hume was heavily involved in American theatre until 1925 and would have seen the American news articles on Dean's Schwabe-Hasait initiative, and maybe even GEC's literature.

Neither are there any Google search hits other than derived from British references. The nearly contemporary British 1928, 1930 and 1935 technical theatre textbooks by Ridge and Aldred provide extensive references to Schwabe cyclorama lighting (Ridge 1928; Ridge and Aldred 1935; Ridge 1930). However they make no conjunction of the two systems. Ridge however notes that "the best example … of cyclorama is the Hasait cloth, used extensively in Germany and in a few London theatres very occasionally" (Ridge 1928).

Regardless the conjunction continued to be repeated in Britain. Probably following the Dean/GEC and VenrecO publicity, Downs' 1934 voluminous guide to modern performance defined Schwabe-Hasait as a system of high powered lamps and projectors, mainly used to represent moving clouds etc., a claim repeated in the 1951 edition (Downs 1951a). However Downs' specialist contributors such as Ridge and Aldred make clear that Schwabe principally supplied cyclorama lanterns with exceptional colour ranges, with Hasait solely noted as a design of cloth cyclorama (not a person) (Downs 1951b).

Similarly in 2005 Morgan declared (but giving no authority) that Schwabe developed their seven colour cyclorama system with cloud and image projectors to suit the Hasait cloth cyclorama (Morgan 2005). It remains a peculiarly British misnomer.

But did Dean's initiative leave any lasting legacy in British lighting development? Sadly the answer is no. The Schwabe cyclorama lighting (with or without a Hasait cyclorama) was installed in very few theatres, as noted in section 8. The seven colour system was also seen as complex and expensive, and failed to displace the simpler three primary colour (sometimes four with light and dark blue) approach, which could be used in the ubiquitous battens.

Morgan summarised the British position up to WWII:

> The most common technique for lighting the stage was still to flood light with footlights, battens and wing floods. It was normal for London theatres to be fitted with sets of four colour battens and footlights as the standard rig. This would be supplemented by follow-spots to light the principals. Extra equipment, such as spots, was hired in by the show, which went some way to giving a changeable look to stage lighting. It was still common for a show to return its specials to the hire company after reviews were published as a way to cut costs…

> There is little evidence to suggest that most British theatre lighting pre-WWII made an artistic contribution beyond being merely a crude, coloured illuminant. Bentham recalled that lighting technique in the late 20s and early 30s was to put down washes of light and use a few spots as highlights, except of course in very dramatic scenes. Even so it is amazing how telling a couple or even one spotlight then could be. Joe Davis[74] noted that lighting in the early 1930s still had no need to make shadow, as it continued to be painted into the scenery. Painted cloths were the order of the day for most settings, and the general principle was that light should complement the atmosphere of the cloth, not alter it. Irving Wardle said that good atmospheric lighting was a great rarity on the pre-war British stage. (Morgan 2005, 69-70)

Strand Electric's Sales Director, Applebee, attempted to defend the "British" school of lighting vs the "Continental" in a 1935 lecture (Applebee 1935). However in doing so, he essentially admitted that British lighting was still being done cheaply with little invention:

> Despite the criticism of those who had witnessed some of the Continental productions, lighting in the English theatres was of a high standard when the cost and available apparatus were taken into consideration.

Meanwhile in continental Europe, especially Germany, an independent dramaturgy of light was developing, as described by Bergman (Bergman 1977). The concept of "Creative Light" promoted by Appia was moving forward in the work of Reinhardt, Jessner, Brecht, Piscator and Burian in the pre-war years. It is telling that Bergman does not mention any British innovator. However the seven colour system of Schwabe was found too complex even in Germany, and by 1932 Kranich was only describing four colour systems (Kranich 1933).

[74] Famed early lighting designer, noted as being the first to be credited in a British theatre programme in 1936 (Bentham 1984a).

10. The Curious Company of ARS

Somehow linking Schwabe and Hasait was a company in Stockholm called Aktiebolaget Regi och Scenteknik (Direction and Stage Technology Ltd) aka ARS, This traded in the 1910–30s and as per its name included lighting and stage machinery. Though based in Sweden, the company registered ten foreign patents in the period 1921-27, eight in the USA, one in Britain and one in Germany ("ESPACENET" 2023). Six of the eight in the USA were assigned from Hasait regarding stage machinery. The seventh was from Reiche for a multiple cloud projector with the eighth from a Gustaf Dahl for a different design of multiple cloud projector. The German and subsequent British patents were for a design of "Projecting Apparatus for Projection of Panoramic Views", having rapidly rotating segmental projectors so that the segmental images appear seamless merged.

The company was clearly attempting to position itself as an international stage equipment supplier, and in 1921 supplied a complete new circular cyclorama and lighting system with cloud machines and scene projectors (plus probably other stage equipment) to the Royal Swedish Opera in Stockholm (Jansson).[75] In Germany the BTR journal reported the cyclorama had been supplied by Hasait and the lighting for the cyclorama and general stage by Schwabe (Eckart 2021b). Schwabe included two stage pictures from Stockholm Opera in their 1921 catalogue (*Moderne Bühnenbeleuchtung* 1921). It was reportedly highly praised in the Nordic press. Curiously Bergman, despite writing from Stockholm, makes no mention of the ARS involvement and also mistakenly states the cyclorama was supplied by Schwabe & Co while the cloud machine was delivered by "the Hasait company" (Bergman 1977).

There are no online company records of ARS, but American critic Macgowan refers to the Hasait cyclorama with Schwabe lighting as the "Ars system" (Macgowan 1921; Macgowan and Jones 1922). This indicates that they were active outside Sweden and clearly targeting the USA from their patent activity. In 1921, Macgowan reported on the ARS promotion:

> A new system of background and lights…has been perfected since the armistice and put on the market by a Swedish company, the Aktiebolaget Regi och Scenteknik, working in association with German experts. The devices employed are referred to as the Ars system and consist of many ingenious lights added to a cyclorama… The cyclorama is of cloth, so prepared that it refracts the light in the same way as plaster and so weighted that it cannot wrinkle or stir. (Macgowan 1921, 60-61)

The system clearly used actual or copied Schwabe singular horizon luminaires, with a two-tier cloud projector and three panorama projectors. Installations were claimed in Dresden Opera, La Scala Milan and Stockholm Opera, although the Dresden and Milan installations were most probably direct purchases of the equipment, not via ARS. Izenour's extensive study of stage equipment covering both Europe and USA makes no mention of them, while Kranich solely records their cloud projector patent (Izenour 1988; Kranich 1933). Morgan in Britain also notes "the Swedish projection system called the Ars System" but then only describes the Hasait style cloth cyclorama (Morgan 2005).

[75] An interesting tale exists of its provision (Jansson). By a process of installing its directors in key positions in the national press (Svenska Dagbladet) to publicly lobby for more modern presentation, and in the theatre management to agree the need, they obtained in 1920-21 a state refurbishment contract worth around £2M in today's terms. There was later a six-week tour of *'English guest performances'* in 1924. This was intended to sufficiently impress the visitors to ensure ARS would win an order for a new stage lighting system for Covent Garden – to no avail.

11. Early Electric Stage Lighting

Any assumption that the first significant use of electric lighting on the stage dates from the Savoy Theatre, London in 1881 is misplaced (Rees 1978). While that event was the first theatrical application of the new carbon filament light bulb, significant use of electric arc lighting had preceded it. The electric arc as a source of light was first demonstrated by Davy in series of demonstrations between 1801–1809, powered by batteries (DiLaura 2006). However its uptake was hampered by the need for consumable batteries, difficult-to-make carbon electrodes, and the need for constant manual adjustment of the arc gap as the electrodes are consumed.

Figure 24. *Electra, or the Lost Pleiad* with arc lighting effects, Her Majesty's Theatre, London, 1849. (Read 1849)

The first British stage use was in a pantomime in 1848 as a floodlight, then following the French introduction (below), a more successful 1849 use in *Electra, or the Lost Pleiad*, illustrated in Figure 24 (Rees 1978; Read 1849).[76] From then on, attended arc lamps became a common alternative to the limelight for spotlighting and effects, replacing the fire and explosion hazards of oxy-hydrogen gasses with that of corrosive battery chemicals and electrocution. Both sulphuric and nitric acids were needed in the usual Bunsen cells. These gave off toxic fumes and had to be prepared before each performance, usually in a basement "electric room" (Rees 1978).

[76] The reviewers were not impressed by the initial pantomime's *'sickly glare'* but the *'The Lost Pleiad'* caused *'astonishment and delight'* (Rees 1978; Read 1849).

The arc electrode adjustment problem was initially resolved by French physicist Léon Foucault in 1849 with a current-controlled clockwork regulator of the electrode spacing to keep the current constant. (DiLaura 2006). The design was adopted and adapted by instrument maker Jules Duboscq to form the early automatic Foucault-Duboscq arc lamp, used by Duboscq for stage lighting effects at the Paris Opera from 1849 (Weil 1904; Morgan 2005; Moncel and Translated from the French by Routledge 1883).[77] While these lamps remained a specialty without a continuous power source, the Foucault-Duboscq design was also used by Hugo Bähr in Dresden for his renowned special lighting effects (Palmer 2015). In the 1860s steam powered electrical generators from Siemens, Gramme and Brush were developed which could provide a continuous supply of current, after which electric arc lighting quickly became popular. A total of 1,827 international patents were taken out on variations of "arc lamp" design between 1870–1920.

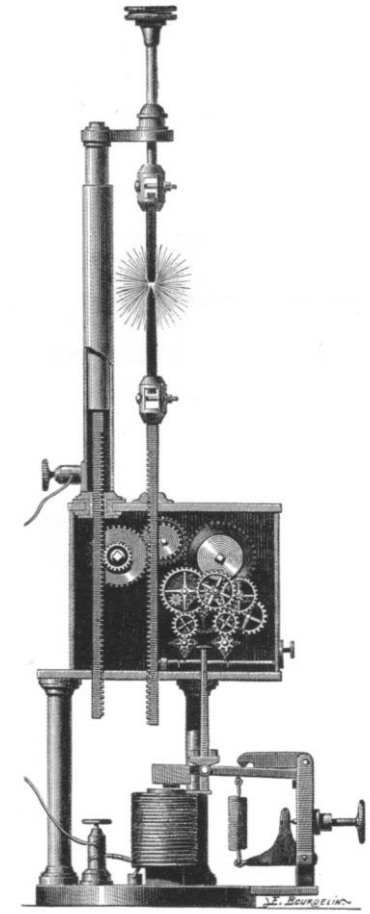


Figure 25. Foucault-Duboscq regulated arc lamp, 1867. (DiLaura 2006)

The most commonly recognised design was the 1876 Jablochkoff Candle,[78] being simply two carbons, insulated but alongside each other, which arced across at the end. It was simple, cheap and easily replaced when consumed, but only lasted hours, only operated on AC, was noisy and could not automatically restart if turned off. Consequently most inventors focused on automatic arcs which automatically moved the carbons as they burned to achieve a

[77] Duboscq was engaged by the Paris Opera to produce special lighting effects. From 1849 he simulated a rising sun in 'Le Prophète', projected a rainbow in 'Moise' in 1860 and devised lightning simulations (Moncel and Translated from the French by Routledge 1883; Schubin 2016; Rees 1978).

[78] Originally a Russian named Pavel Yablochkov, he moved to Paris in 1875.

constant light output, and which could be turned off and on again. The Jablochkoff Candle was still used quite frequently for auditorium lighting, and even for the footlights in Bellecour Theatre in Lyon in 1879, though it proved much too bright against the rest of the stage (Baumann 1988).

Eventually the preferred European arc lamp design became the 1878 differential regulated arc lamp, invented both by Friedrich von Hefner-Alteneck[79] of Siemens and by the Czech František Křižík[80] (the Plzeň lamp) ("1878: The differential arc lamp" 2021). These lamps. which become generally known as “automatic arcs”, measured both the lamp current and arc voltage and by keeping them in balance, effectively maintained a constant power in the arc. This allowed reliable operation both in parallel and series connection, while the stable power demand permitted easier regulation of the generator and its prime mover. Without power the electrodes closed, thus ensuring reliable re-ignition when turned on. In America, Charles Brush simultaneously invented an automatic arc light to use with his generators in 1879 (Eisenman 1967).

Another important development was the enclosure of the arc, shown by Siemens in Figure 26 with an opal shade for use in shops etc. By excluding fresh oxygen[81] the electrode consumption was considerably reduced, providing 100–150 hours unattended life before electrode replacement (van Bommel 2019; Jones 1911). This made it a practical lamp to use in unattended theatre luminaires. Regardless these lamps still needed either built-in or external ballast resistors (inductors for AC supplies) for stable operation. The lamp was too bright and probably too complex for domestic use[82] but became popular in shops and industry.

[79] He also invented the Hefnerkerze flame lamp standard of light intensity (HK), used in Germany from 1884 to 1940 (Bertenshaw 2020).

[80] Křižík won a patent claim against Siemens since he independently invented the device earlier.

[81] In practice a small amount of air was admitted to consume the vaporised carbon to prevent deposition on the enclosure (Jones 1911).

[82] The lack of public electricity supply also meant only large establishments able to install their own generators could use electric lighting. Lord Armstrong’s British house at Cragside with an arc lamp in the library supplied by his own hydro-electric generator was probably the first European private installation (Irlam 1989).

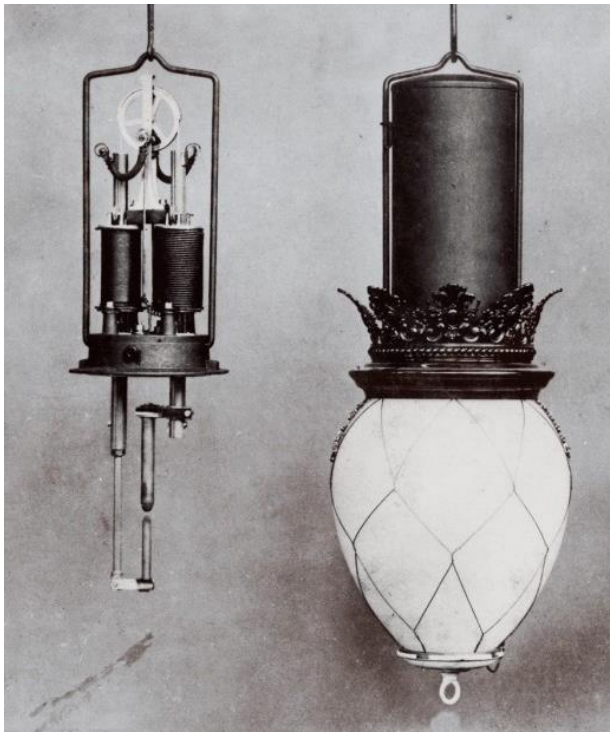


Figure 26. Siemens differential arc lamp with enclosure c.1887. ("1878: The differential arc lamp" 2021)

The arrival soon afterwards of the 1879 carbon filament incandescent lamp did not immediately replace arc lamps. The filament light output was low and yellow in colour, thus poorly simulating any outdoor lighting, whereas the arc had a much higher intensity and colour temperature (~3800 K). Table 1 provides an overview of the 1880–1913 development of incandescent lamps, compared to the arc lamp (Morris 1916). An important milestone for theatre lighting was the gas-filled lamp, then commonly termed the “Half-watt” which doubled the lamp’s efficiency and output for the same filament size. Half-watt lamps also had more compact filaments, thus increasing the light collection efficiency in luminaires. Though none approached the source brightness of an arc, the gas-filled lamp was finally able to provide a comparable total output, as well as better life, no flicker, no need for a ballast and could be electrically dimmed. It thus steadily replaced the arc.

Lamp filament	Date introduced	Efficiency (Candlepower/Watt)
Automatic carbon arc	1878	2.5 (est.)
Carbon in vacuum	1880	0.2
Nernst (heated ceramic tube)	1898	0.7
Osmium in vacuum	1902	0.6
Tantalum in vacuum	1905	0.5
Tungsten in vacuum	1904	0.8
Tungsten in inert gas ("Half-Watt" or "Nitra" lamps)	1913[83]	1.5

Table 1. Development in efficiency[84] of electric lamps. (Morris 1916; Jones 1911)

As noted at the start, incandescent electric lamps were soon adopted on the stage, replacing the gas lighting. The principal drive was safety, the last half of the 19th century had seen a rapidly rising toll of theatre fires occasioned by gas accidents, culminating in the catastrophic 1881 Viennese Ring Theater explosion and fire with over 384 deaths. The limitation was that there was no public supply of electricity at first, each theatre had to erect its own small power station nearby, which D'Oyly Carte at the London Savoy Theatre had done. In 1883, Hugo Bähr even set up a test installation at his own expense with a 16 HP steam engine, generator and 150 incandescent lamps in the Royal Court theatre in Dresden, "in order to be able to participate in the improvements that were still necessary at that time and to train practical people" (Baumann 1988). Berlin Opera was not able to install full electric lighting until 1887 due to lack of nearby space for the generators (Baumann 1988).

It can be seen it was not until the arrival of the gas-filled lamps that the incandescent lamp was able to challenge the shear brilliance of the automatic arc. Even then, when strong blue light was required, mechanical rather than electrical dimming of the incandescent lamp was necessary due to the filament colour's red shift when dimmed. This eliminated much of its benefit over the automatic arc. While the incandescent lamp rapidly became the main source of illumination, the automatic arc lamp was critical in the early development of the cyclorama, as shown in section 13. However by the 1920s arc lamps had been mostly replaced, though Dean still reported using automatic arcs inside prop. stage light standards to realistically light a street scene in 1922 (Dean 1975a).

[83] The first gas-filled lamps were higher powered models above 300 W, it took until 1914-15 to develop lower powered versions (Lokker 1963/64).

[84] The use of candlepower as an intensity measure in this era was poorly standardised, in that it could mean the maximum in any direction, mean radial or mean spherical.

12. Schwabe & Co. Berlin

Figure 27. Schwabe & Co. logos
(left) "Purveyors to the court of Emperor and King" (*Moderne Bühnenbeleuchtung* c.1913)
(right) 1930 ("Schwabe Advertisement" 1930)

There is no published history of Schwabe & Co, so this has had to be pieced together from references and their advertisements. The Berlin address books from that era also provide a useful series of snapshots of the company, since they include small company summaries (*Berlin Address Directories* 1799-1970).

Schwabe & Co. was founded in 1895 by two Schwabe brothers, Carl[85] and Hans; Hans ran the finances and Carl was technical (Pilbrow et al. 1975; *Berlin Address Directories* 1799-1970). Marshall and Dean in discussion described Carl as the person who developed the coloured glasses, and was technically competent but not theatrical (Pilbrow et al. 1975). However Dean in his writings considered Hans to be the able electrical engineer and ex-theatre technician (Dean 1962, 1975a). Applebee further thought the Schwabe family was of Dutch origin (Applebee 1946).

The c.1913 company logo in their literature declares they were Prussian Court purveyors, an award granted to the company owner (not the company), with permission to display the Emperor's coat of arms[86] (*Moderne Bühnenbeleuchtung* c.1913). There is no record for what and when it was awarded. After WWI the claim naturally disappeared from their literature.

In 1900, the company was listed providing electrotechnical supplies and a distributor for Siemens & Co, based at Blumenstrasse 70, Charlottenburg by Berlin. The directors were Carl Schwabe and B. Ringer. Ringer had his own listing as "Techniker" for Schwabe & Co,

[85] Not Karl as often spelled, though Karl is a popular variant in German.

[86] 'Middle Imperial' coat of arms of the German Emperor (two wild men with the Hohenzollern eagle) ("Coat of arms of Germany").

implying he was a Technical Director. In 1904 a Bibliotek gave an extensive description of the state-of-the-art of Germanic electric stage lighting (Weil 1904). The companies listed included Siemens & Halske[87], AEG, and Hugo Bähr but not Schwabe, thus they could not yet have been substantially active in stage lighting.

By 1906 they had engaged Eugen Vogel (role unstated) and in 1907 Arthur Reiche (1885–1955) as chief engineer, who together founded the theatre department ("Der Wolkenapparat im Vogtlandtheater Plauen" 2013; Pilbrow et al. 1975). By 1910, the company had moved to Märkischer Platz, Berlin, and was advertising electrotechnical supplies, carbons, incandescent lamps and special electrical lighting.

From these directory records, it seems the brothers set up business initially providing electrical equipment and installations in Berlin. At the time of their establishment, there would have been a growing business installing the new incandescent electric light, both commercially and domestically. But they were also in the right place at the right time for an explosion in electric stage lighting. Despite their dominance, companies such as Siemens and AEG were large enterprises with established products to sell; Schwabe was small and thus better geared to specialization, something always demanded in theatre.

The renowned actor and director Max Reinhardt arrived in Berlin in 1894. Schwabe's stage lighting product development reportedly flourished supplying the exacting demands of Reinhardt during his period in Berlin (Dean 1962; Pilbrow et al. 1975). While there is no support for this influence in any German sources, though it would have been natural for Schwabe to work closely with a notable client in the same city (Berlin), and Schwabe's 1921 catalogue pays homage to Reinhardt's influence (*Moderne Bühnenbeleuchtung* 1921).

Schwabe & Co. issued a stage lighting catalogue in c.1913, having just moved to its final address, Köpenicker Strasse 116 in Berlin (*Moderne Bühnenbeleuchtung* c.1913). This advertised cyclorama lighting using incandescent lamps, cloud machines, acting areas lamps, lens spotlights, scene projectors and lightning projectors. They also specialized in artificial fires and flaming torches, their largest being a massive fire effect for the 1911 performance of Reinhardt's *The Miracle* at London's Olympia hall, illustrated in their 1921 catalogue in Figure 28.[88] Installations are also claimed for theatres in Berlin and Dresden.

[87] Siemens & Halske AG merged with Schuckert & Co in 1903, after which its main electrical business including lighting was conducted by Siemens-Schuckertwerke GmbH, both referred to as Siemens in this paper. The logo was the double S.

[88] This was 15 m high, 18 m wide and 12 m long, used 1000 m^2 of silk fabric, needing 60 fans delivering 60,000 m^3 per minute to keep these masses of fabric 'flaming'. It was illuminated by 40 arc lamps (Carter 1914).

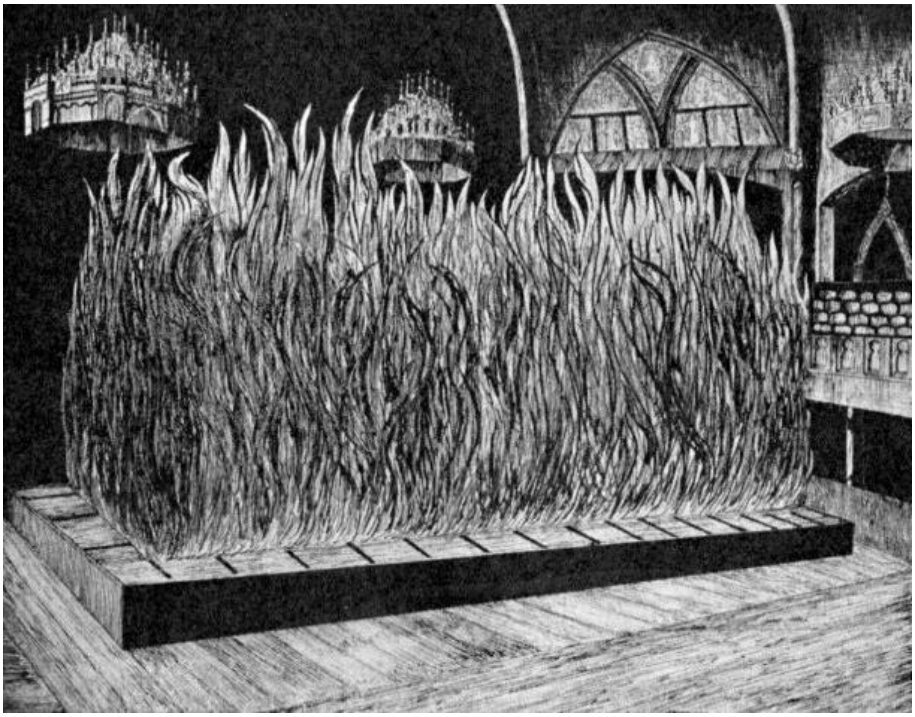


Figure 28. Portable fire effect used for *The Miracle* at Olympia, London. (*Moderne Bühnenbeleuchtung* 1921)

However by 1919 the theatre industry in Berlin was changing. While the entertainment industries had been supported during the war to boost morale, the post war era was economically dire with many actors and directors moving to more lucrative film employment (Stern 1951). Reinhardt left his Berlin theatres in 1920, thus a source of innovative stimulus to such as Schwabe was now missing, and fairly soon the founder Carl would die.

In 1920 Carl Schwabe was listed as sole director but by 1923 the list of directors expanded to Carl, Paul, Fritz and Hans Schwabe. In 1922 they were now advertising as specialties: Stage lighting, Modern cyclorama lighting, Electric torches, Electric flames, Steam generators without breathing difficulties for the actors, and moving clouds.

Schwabe & Co patented extensively with 49 patents, though none appear to be exceptional ("ESPACENET" 2023). Eight patents from 1896–1904 were all in the name of Carl Schwabe and curiously all British (excepting one Swiss patent), for various reflector improvements for tubular lamps. After 1900, Schwabe also started patenting only as Schwabe & Co. without a named inventor. From 1900 to 1930, 40 patents were issued, mostly in Germany plus 5 in Britain and 3 in Austria. The great majority concerned stage lighting, projection, artificial fire, fog, wind and dimmer control.

In 1921 Reiche patented a two-tier cloud projector in the USA, and assigned it to Aktiebolaget ARS of Sweden (Reiche 1921). This depended on an initial German patent application by Schwabe & Co, never completed. It is interesting in that the patent assignee is the same company used by Hasait and discussed in section 10. Another famous German stage engineer, Walter Unruh (1898–1973) who was initially technical assistant (and family friend) to Hasait at the Dresden Oper, worked for Schwabe from 1921–23. He left to become technical director of the Landestheater Karlsruhe ("Walther Karl Gustav Unruh" 2023; Eckart 2021a).

The company did not solely rely on theatres, the rise of cinemas and especially the talkies in the 1920s, provided a considerable extension of their market. They advertised extensively

through the 1920s in the Cinema trade press for auditorium and facade effects lighting, stage lighting, plus illuminated advertising (illuminated letters) ("Schwabe & Co advertisement" 1930). In 1929 they illuminated the exterior of the famous Berlin store KaDeWe for its "White Week" event, shown in Figure 29 (Schwabe & Co 1929).

Figure 29. Schwabe illumination of Berlin's KaDeWe store in 1929. (Schwabe & Co 1929)

Schwabe also developed considerable business supplying electric emergency lighting for theatres and especially cinemas as described in the 1911 cinema trade press:[89]

> The very well-known installation company Schwabe & Co … Their famous electric emergency lamps for theatres, cinemas, assembly rooms, department stores, factories, hotels, hospitals, etc., are in use in their thousands. The large and largest theatres and amusement establishments in Germany use them almost without exception. ("Die Notbeleuchtung im Theater" 1911)

Dean reported visiting after WWI in 1922 and discovered that Hans (probably meant Carl?) was no longer active, with the business now run by a son and nephew (Paul and Fritz?). He noted that Reiche was still in post, and now carried out all their R&D (Dean 1962).

In 1921 Schwabe issued a new 116 page catalogue *Moderne Bühnenbeleuchtung* (Modern Stage Lighting) (*Moderne Bühnenbeleuchtung* 1921). It was undated, but reviews in Elecktrotechnische Zeitschrift (EZ) and BTR date it at 1921 ("Besprechungen: "Moderne Bühnenbeleuchtung"" 1921; Ha 1922). No copies are listed in libraries, but one was found from a historian of Köpenicker Strasse ("Die Köpenicker Straße 116" 2023). This catalogue was more comprehensive than the 1913 catalogue but followed its style in avoiding technical details of the equipment, instead waxing philosophically on the dramatic effects that each product category could achieve. It begins:

[89] The journal also decried how many venues still relied on unreliable candle and oil lamps.

> By coloured reflection we have life…
> Man, a stranger placed in a world whose beginning, meaning and end he does not know, has in the main only one sensory tool to find his way in the environment. Through observation, which is further processed mentally, through looking alone, he recognises the world. He perceives a thousand different forms in it, over which the colourful miracle of colours is poured. ……
>
> The light must be available on the stage in millions of candles. The rays must pour over the dance on the summer meadow in a blaze of light; the ballroom must be bathed in a flood of brightness. But it is also necessary that every gradation can be made. The cold, grey light of dawn is just as necessary as the red radiance of the setting sun. It must be possible to go from a light glow to a glaring brightness very gradually, while another scene requires a very sudden change of light intensity. Individual places must be sharply emphasised by the lighting, while the changing ones lie dark. And in all this, the colours are to be set according to the will of the artistically sensitive director.

The EZ review observed how the catalogue extended far beyond the mere technicalities of the apparatus and sheds some light on the just how rough some of the mechanical dimming systems must have been:

> (It) gives a rather vivid account of the upheaval in stage lighting in the last decade, caused by the dome or circular horizon and the introduction of the gas-filled lamp in place of the arc lamp for lighting effects. The Fortuny lighting system still suffered from the cumbersome nature of the arc lamp and the difficulty of regulating its luminous flux. In contrast, with the gas-filled lamp it is possible to achieve the finest gradations of light at any point on the stage and thus lighting effects hitherto unimagined.

The 1921 catalogue also acknowledged Schwabe's debt to Reinhardt:

> Stage technology owes the practical introduction of the artificial sky, like many other improvements in lighting, to the ingenious thoughts and suggestions of the director Prof. Max Reinhardt. Just as he was a reformer of the art of acting, he also stimulated and promoted stage technology to the greatest extent.

It concluded with many illustrations of lit scenes, including Schwabe's demonstration stage at Köpenicker Straße shown in Figure 30, where clearly cycloramas and stage clouds dominate.

Figure 30. Demonstration stage in the Schwabe offices, Berlin, 1922. (*Moderne Bühnenbeleuchtung* 1921)

In 1923, the British GEC become the British (and its colonies) distributor for Schwabe lighting, issuing a catalogue titled (like Schwabe's) *Modern Stage Lighting* (*Modern Stage Lighting* 1923). This offered the cyclorama (horizon) floods, cloud machines and scene projectors, with an illustration of the St Martin's Theatre installation. Following the lead of the 1921 Schwabe literature it also waxed lyrically on the lighting effects that could be obtained but with little technical detail.

However also in 1923, the company founder, Carl Schwabe died. A short obituary was published in the BTR (original reference not accessible):

> Karl Schwabe has died. The founder of the well-known company Schwabe u. Co., Berlin, died on 23rd April after a short illness, recalled from a busy but successful life. From small beginnings, the deceased knew how to create a global company in the special field of stage lighting. If German stage art and stage technology are held in such high esteem at home and abroad, it is partly thanks to this tireless pioneer. All who knew this highly esteemed, hard-working and kind man will not easily forget him. ("Der Wolkenapparat im Vogtlandtheater Plauen" 2013)

Despite the death of Carl, the 1924 directory listing in Figure 31 shows the range of products had expanded to equipment for electrical stage and film lighting equipment, effects lighting, manufacturing and installation services, electrical equipment, incandescent lamps and carbons. Complete theatre installations continued to be supplied, such as the 1927 installation at the Magdeburg Theatre (Wedemeyer 1928). The last directory entry was in 1931, unchanged from 1924.

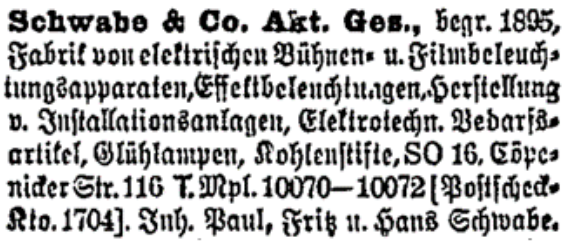


Figure 31. Schwabe & Co directory listing, 1924–31. (*Berlin Address Directories* 1799-1970)

Reiche and Vogel remained in post after Carl's death. They were Prokuristen, i.e. authorised signatories of Schwabe, but not directors ("Reiche und Vogel Leuchtkunst GmbH" 1931). Schwabe were clearly important stage lighting suppliers still by 1927, since they provided all the lighting for the experimental stage erected at the Deutsche Theaterausstellung[90] (German theatre exhibition) held that year in Magdeburg (Wedemeyer 1928). Here Reiche was identified as Chief Engineer.

Schwabe continued to develop new luminaires and dimmers and to advertise in 1930 a 200 A automatic carbon arc cyclorama luminaire (Horizontlantern) and new 10,000 W incandescent luminaire (Glühlampen) product, as shown in Figure 32 ("Schwabe Advertisement" 1930).

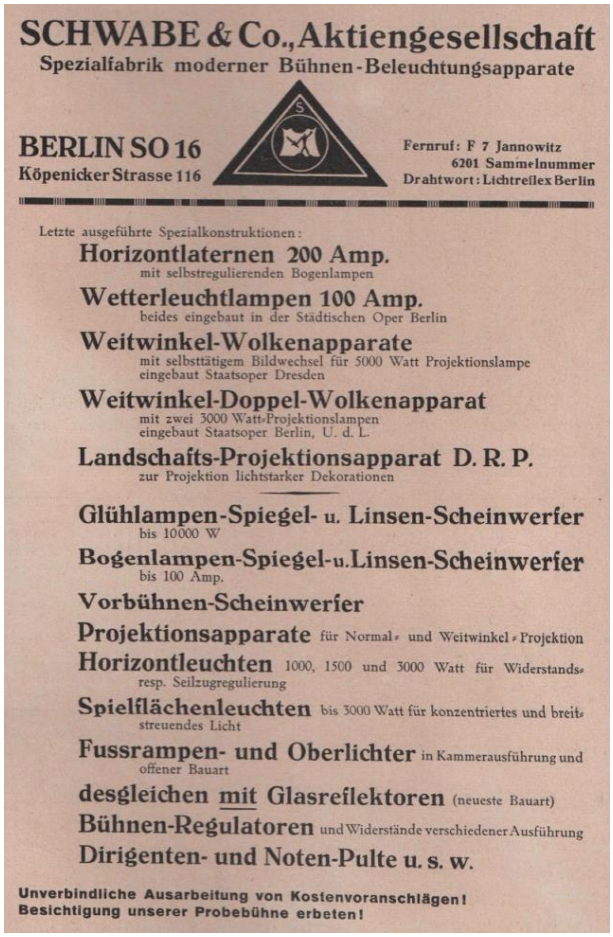


Figure 32. Last Schwabe advertisement in 1930 BTR. ("Schwabe Advertisement" 1930)

[90] This was a major event where one might have expected Siemens or AEG to dominate. An exhibition centre with a town hall, exhibition halls, test stage, a floating stage and the 61 meter high observation tower (today the Albinmüller Tower) was built in Magdeburg's Rotehorn Park.

The Schwabe company closed in 1930–31. The reason is not known, but clearly the remaining founder would have been aging. From 1931 Reiche and Vogel formed and ran their new company, Reiche & Vogel Leuchtkunst GmbH (Reiche & Vogel Lighting Art) from a new address, promising in Figure 33 “Stage Lighting Products of every kind, in the proven quality that has distinguished all products from Schwabe” ("Reiche und Vogel Leuchtkunst GmbH" 1931; "Der Wolkenapparat im Vogtlandtheater Plauen" 2013; "Chronik der DTHG" 1931). They further stated that they had acquired the technical facilities of Schwabe, indicating that the transfer was amicable, and even kept the same telegram address (Lichtreflex Berlin). The baton had been handed on.

Figure 33. Announcement of formation of Reiche & Vogel in BTR 1931. ("Reiche und Vogel Leuchtkunst GmbH" 1931)

Intriguingly there was also a private bank called Schwabe & Co AG (later listed as Jewish by the Nazis) at the same Köpenicker Strasse address as Schwabe & Co. and formed in 1923 ("Die Köpenicker Straße 116" 2023). Nothing more can be found however and Schwabe was a common name, so may not have been connected.

13. First Schwabe Cyclorama Lighting

Despite considerable German interest in the Fortuny indirect cyclorama lighting, there is no evidence that Schwabe supplied any such equipment. This was probably due to AEG having a commercial contract with Fortuny, and Fortuny having patented the system extensively. However circular cycloramas were common and other lighting solutions existed.

The need to light a large encompassing cyclorama predates Schwabe and the incandescent light bulb. As noted earlier, the first Rundhorizont was used in the Munich Opera (aka National Theater) in 1869. This coincided with a major installation of gas lighting (2,280 flames), where Schilling reports that when using "Panoramawänden" (panorama walls along the stage side), the rear soffit[91] can be fitted with side extensions to avoid shadows on the wall (Schilling 1870). Thus clearly cycloramas were initially gas lit, though the only floor lighting was the front footlights.

The need for batteries to power arc lamps before 1870 limited their use to effects and spotlights. The initial arrival of incandescent lamps merely resulted in emulation of the gas battens as shown in Figure 34. For example the new Cologne Stadttheater (also the Opera house) opened in 1902 using multi-colour battens[92] to light both the stage and circular cyclorama cloth (Rosenberg 1903). Weil in 1904 describes in considerable detail this current practice for stage lighting, but omits all mention of a cyclorama, describing only multi-colour battens (Weil 1904).

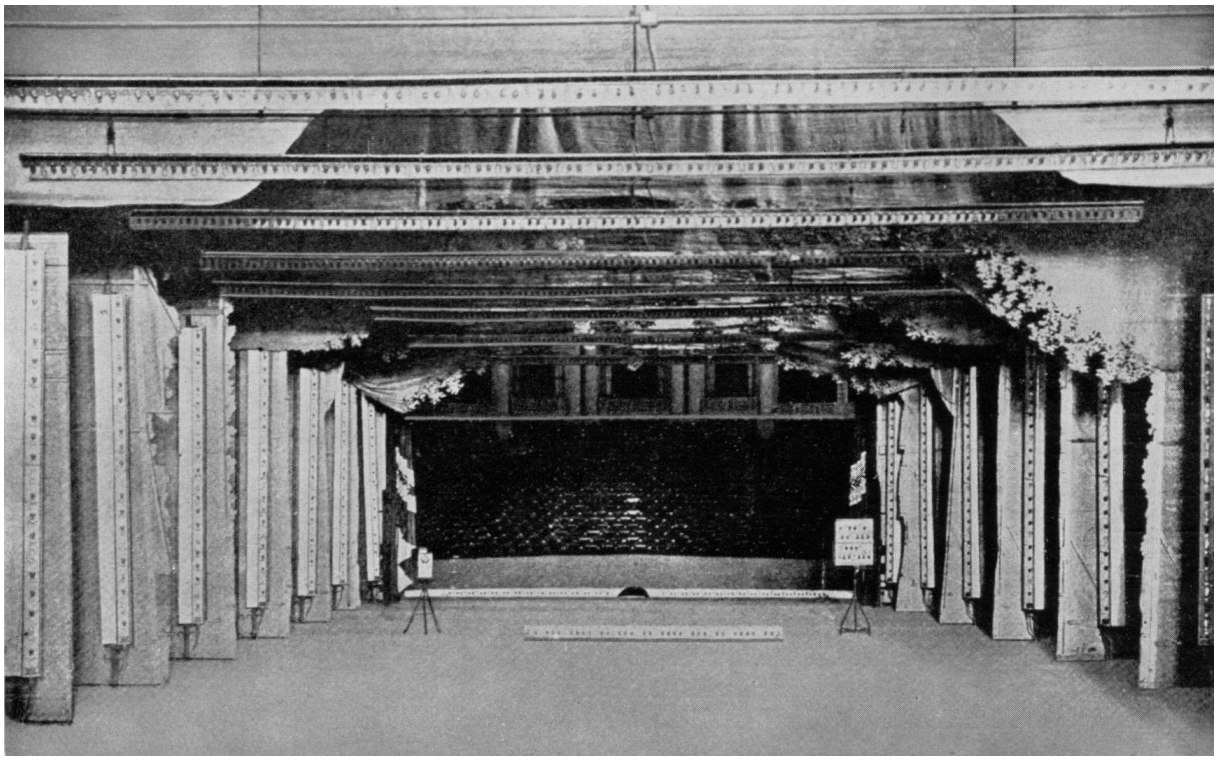


Figure 34. Early electric stage lighting, Germany c.1890. (Kranich 1933)

The first dedicated cyclorama luminaires (limelight or arc) in an actual theatre may well have been Herkomer's in Bushey in 1890 described in section 3. Baumann records that the

[91] In German theatres, overhead batten lighting is termed the 'Soffit', footlights 'Rampe' and vertical wing lights 'Kulissen'. All three are visible in Figure 34.

[92] The lighting system supplied by AEG was designed by the respected expert Rosenberg and used a total of 2,080 incandescent lamps with 50 arc lamps.

demonstration theatre erected by Asphaleia at the International Electric Exhibition in Vienna in 1883 used four 1,000 NK[93] arc lights without reflectors on the rear "Soffitenreihe" (batten), obviously to illuminate the cyclorama (Baumann 1988). However this was not repeated in the first Asphaleia installation at Budapest Opera in 1884 (though footlights were dispensed with).

After this Krzeszowiak described the arc lighting system (illustrated in Figure 7) invented by Fortuny in 1902:

> Before the introduction of high wattage incandescent lamps, arc lamps were used for cyclorama lighting, whose light was cast onto coloured, white, red, blue and yellow silk bands and diffusely reflected by these onto the cyclorama surface.
>
> The silk ribbons were movable and could be rolled up or down. One system of lamps illuminated the cyclorama from above, a second from below, so that all the colours of the sky found in nature could be reached. Dimming was achieved by black velvet and cover plates in front of the lamps. (Krzeszowiak 1986)

When Stern[94] joined Reinhardt as designer at the Deutsches Theater in 1906 the semi-circular solid cyclorama was already there, with central arc lighting (Stern 1951). He described it:

> A gigantic lamp hanging over the stage illuminated the cyclorama and mechanically changeable sheets of coloured glass in several tiers made it possible to illuminate the cyclorama in any desired colours or combination of colours. Another lamp flung white cloud patterns on the cyclorama, and they could be made to remain motionless or to move across the sky-line at will. (71)

The description by Carter, writing probably in the period between 1910–13[95], adds to that that from Stern:

> This heaven is lighted by an enormous "Oberlicht" (Overlight), placed above the centre of the stage and so constructed as to throw its rays of light horizontally and not vertically. In addition there are two large arc lamps placed on either side of the large light. The purpose of these lamps is to light the space immediately in front of the heaven, as the Oberlicht is meant to light the round horizon, and not the stage. The construction and working of the overlight is a profound secret. (Carter 1914, 176)

It is likely that Carter also observed a pair of early acting area arc lamps. They become very common due to the need to keep the actor's illumination off the cyclorama and are discussed in chapter 17. In 1918 (though doubtless reporting earlier observations) Stern and Herald similarly described Reinhardt's cyclorama lighting as a "large lantern-apparatus high over the stage middle" (Stern and Herald 1919).

However Kranich records it somewhat differently, and illustrates it in Figure 35 (Kranich 1933). It is probably the same device:

---

[93] Neue Kerze (New Candle), the term used in Germany when initially adopting the candela unit of light intensity in 1942.

[94] While Stern as designer was expected to also design the lighting, and described how in designing Büchner's *Dantons's Death* he chose to *'paint with light'*, this is virtually his sole description of lighting equipment in his biography (Stern 1951).

[95] Carter notes that Dean had already taken an interest in the lighting, though Dean did not visit Berlin to study Reinhardt's Deutsche Theater until 1911 (Dean 1970, 1974).

> In 1910, Gustav Knina[96] first used a stage-sky lighting system with 30 arc lamps for *Goethe's Faust II* in the Deutsches Theater, Berlin. The dimming of the lamps, which were arranged separately on three tiers, was operated by three motors at the rear... The left-hand guide rails carried the colour filters…the system remained in operation until 1929. (23)

Dean visited in 1911 and described the same singular device, whose "effect of space and light" was a revelation (Dean 1962). The luminaire appears to be an assembly of 30 automatic arcs of ~6 A each. Such arcs could start automatically and being enclosed had typically a 100 hr life. However Kranich's date of 1910 contradicts Stern's claim to have apparently seen the same equipment in 1906. Either Stern saw an earlier lighting installation, or the chronology is confused in his memoirs.

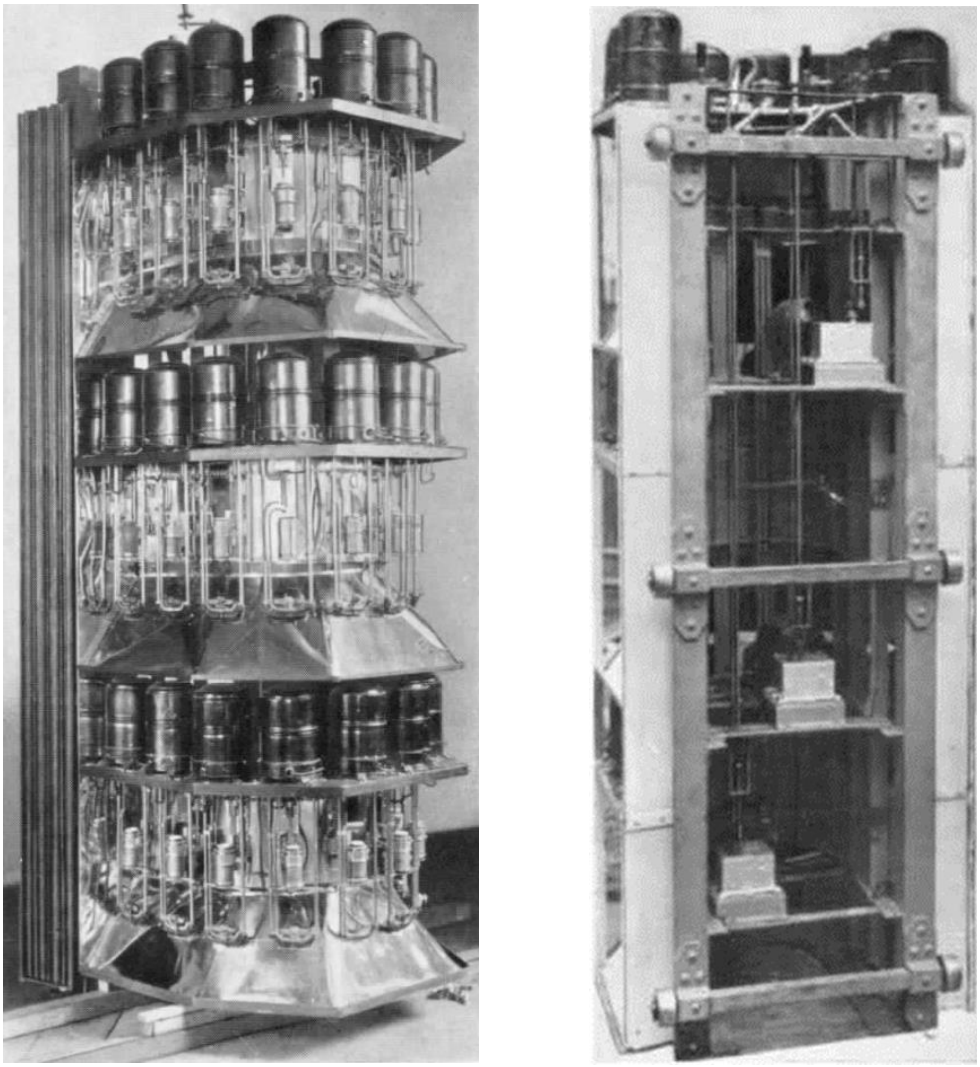


Figure 35. Schwabe 30 lamp central cyclorama luminaire at Deutsche Theater, Berlin 1910, (left: front, right: rear). (Kranich 1933, Abb 18)

While the contemporary accounts of the early Deutsche Theater cyclorama lighting are fairly consistent, they do not declare the manufacturer. However Dean is clear in attributing it to Schwabe & Co, who were charged with implementing the ideas of Reinhardt (Dean 1962).

[96] Wedemeyer describes Gustav Knina as Technical Director of the Reinhardt theatres (Wedemeyer 1922). He is also credited with designing several productions.

14. Schwabe Distributed Cyclorama Lighting

While Schwabe initially provided large central arc luminaires for cyclorama lighting, the convenience of the incandescent filament lamp and especially the more efficient, higher colour temperature, gas-filled lamps, encouraged movement to a more distributed lighting system in their c.1913 brochure (*Moderne Bühnenbeleuchtung* c.1913). The original brochure copy had a hand-written note of 1910, but it must date from at least 1913 since Schwabe was promoting the system shown in Figure 36 with half-watt lamps (unknown power), together with an early form of multi-cloud projector and some acting area lights. Matching footlights were also provided to light the cyclorama bottom. The cyclorama lights were wired in 5 circuits for 4 colours plus white, with colour balance controlled by normal electrical dimmers.

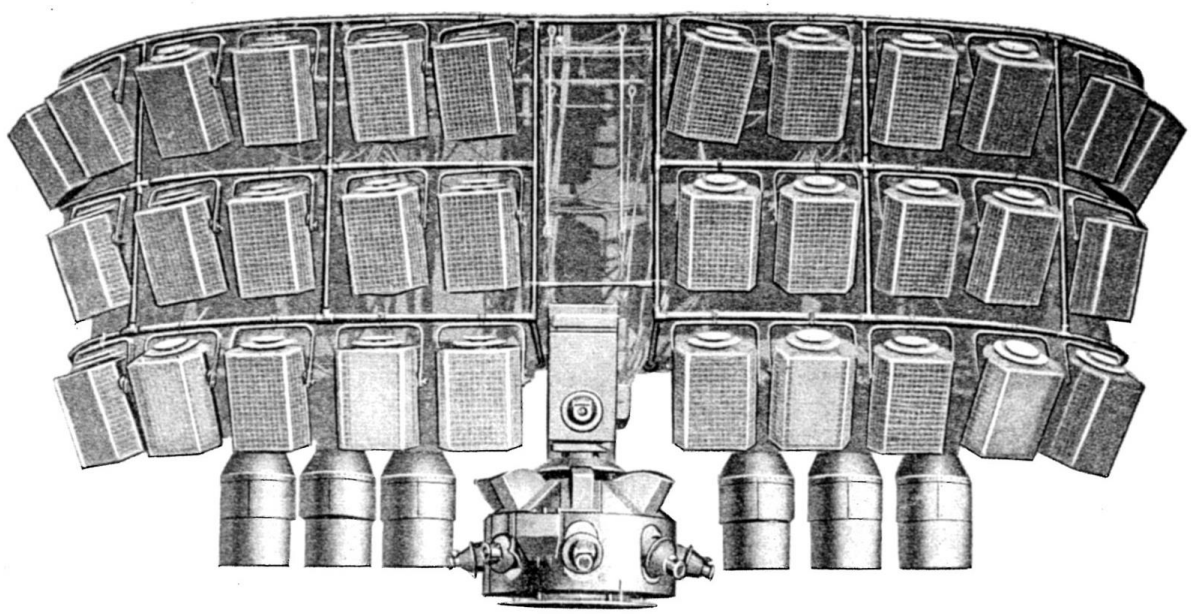


Figure 36. Schwabe cyclorama lighting with cloud projection, c.1913. (*Moderne Bühnenbeleuchtung* c.1913)

Schwabe's surviving literature solely describes their cyclorama lighting, waxing lyrically in c.1913 about the exceptional atmospheric effects that can be rendered on a cyclorama:

> This is achieved in our apparatuses by two arrangements, which work together: upper horizon lighting and lower horizon lighting.
>
> A clever lighting technician can create far more colours on the horizon than are actually available to him. For example, the group of colours for the azure blue of a clear sky in a semi-darkened state creates a beautiful green mood, which is necessary to represent the sky on moonlit nights. Another blue colour can be used to create a bright, deep blue when the candle is fully lit, as shown for example in the Italian southern sky, or to create such a warm blue atmosphere at night when it is darkened. By drawing in white and yellow and by combining them with the blue moods mentioned above, it is possible to create all the colours of the sky found in nature, to slowly present to the eye all the transitions to dusk, dawn, night or a thunderstorm mood. (*Moderne Bühnenbeleuchtung* c.1913).

The c.1913 design probably had the drawback that the flat emitting face implies a rather narrow beam angle. Lamp technology progressed and by 1923 when GEC imported the

Schwabe design to the UK[97], installed by Dean at the St Martin's theatre, it had achieved its familiar tubular shape shown in Figure 37 (*Modern Stage Lighting* 1923). In Britain, like Schwabe, GEC also waxed lyrically:

> For instance, in a very short interval of time a brilliantly starlit sky may give place to a rosy dawn, the dawn growing to a bright summer day with blue sky and fleecy, sailing clouds. A transition to stormy weather is accomplished with equal ease, the sunshine gradually fading to a dull grey, and the sky meanwhile becoming overcast by masses of threatening cloud until the whole horizon is a sullen confusion of gathering tempest.

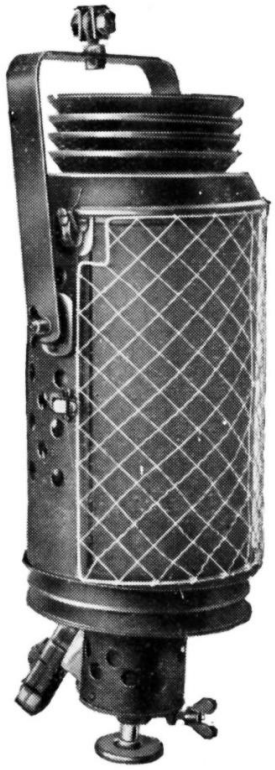


Figure 37. Schwabe cylindrical 1,000 W "horizon" lamp, 1921. (Ridge 1928, Fig 38)

The standard horizon luminaire design by Schwabe used a 1,000 W tubular lamp, base down (Engel 1926). British users recalled that the glass filters were sand-blasted for diffusion (Pilbrow et al. 1975). Many competitors manufactured competing systems, of which Kranich illustrates a selection in Figure 51 (Kranich 1933).

In 1926 Engel writes that Schwabe had just reintroduced a carbon arc based cyclorama luminaire due to the low blue light output of even gas-filled lamps, in the housing shown in Figure 51(d) (Engel 1926). This used a pair of 25 A automatic arcs in series behind a fresnel lens to convert the point sources to a line sources, thus enabling uniform mechanical dimming. The luminaire had glass filters with a facility for remote dimming but no colour change. Fuerst and Hume also describe this luminaire and note that 40 units were installed by Hasait in Dresden Opera house in 1926 (Fuerst and Hume 1928b, 1928a).

[97] The c.1913 Schwabe and 1923 GEC catalogues were both titled 'Modern Stage Lighting'. Curiously Strand Lighting in 1925 also chose to title their catalogue 'Modern Stage Lighting Apparatus' ("Strand Electric Catalogue" 1925).

Kranich and Dean also described Figure 51(d) as normally having three 1 kW incandescent lamps with 4 cable-operated glass colour filters and a dimming shutter (Dean 1970; Kranich 1933).

Kranich and Frank also described Schwabe's last design of central arc cyclorama luminaire shown in Figure 38, installed in the Städtische Oper, Berlin (Frank 2015; Kranich 1933). They were giant 200 A automatic arc lights, equipped with motorised control and housed in a domed steel casing. They are presumably the 200 A luminaires advertised in Figure 32. The light was emitted 180° sideways, 70° downwards and 20° upwards, through five curved glass discs (red, yellow, moonlight, light blue and dark blue), The glass panes were moved with a manual winch or by electric motor, while a diffusing screen protected by wire mesh covered the front. An electric motor-driven shutter with a running time of between 3 seconds and 3 minutes was used to dim the lamp. Its position and that of the colour filters was checked by a feedback device in the control room.

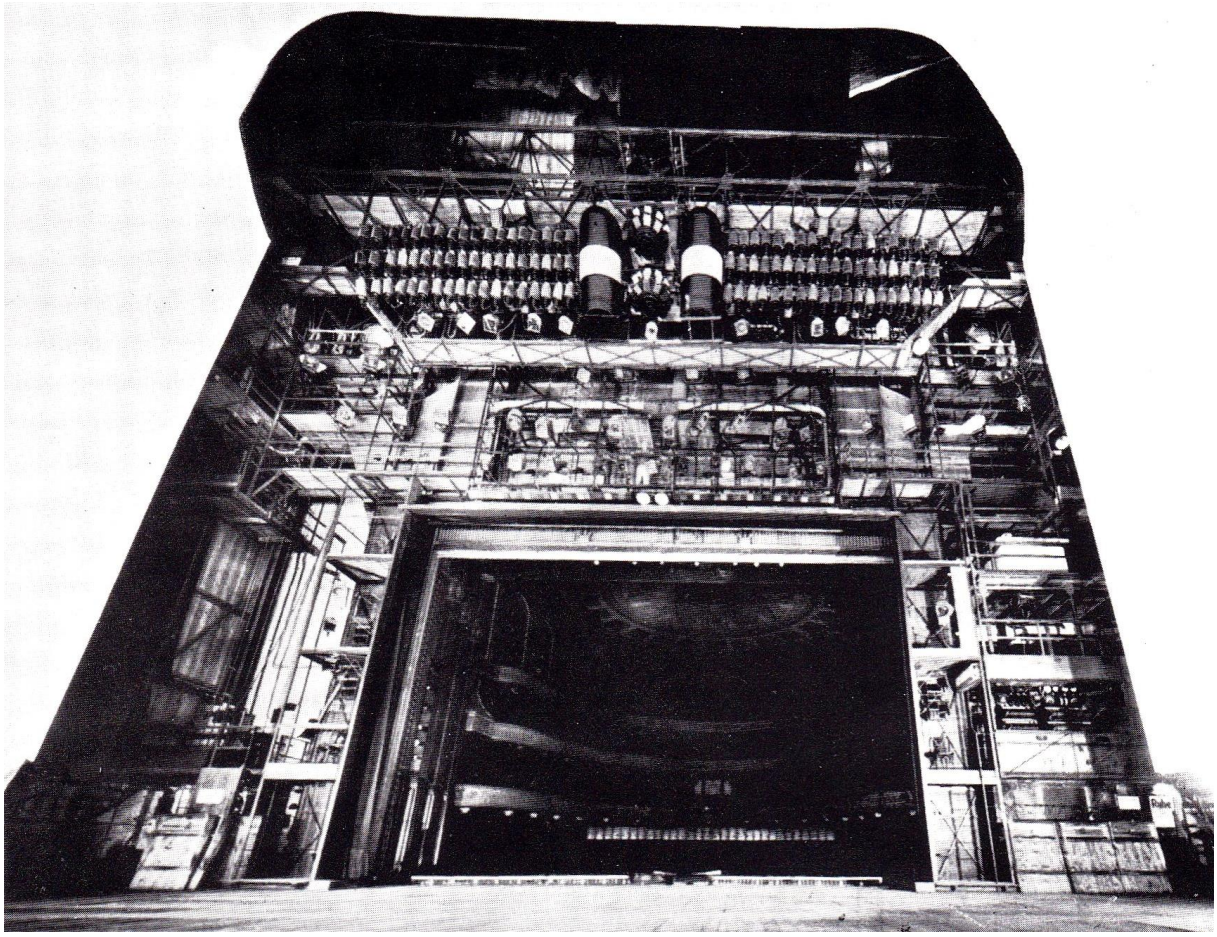


Figure 38. Stage lighting at Städtische Oper, Charlottenburg, Berlin, c.1930. Two central Schwabe arc cyclorama luminaires and a cloud projector mounted in front of conventional cyclorama horizon luminaires. (Kranich 1933, Abb 40)

It is notable that behind these two luminaires lie three ranks of classic individual horizon luminaires, indicating that both styles of cyclorama lighting were in use. Hasait was impressed by their capability:

> Two horizon lanterns…far exceeded the expectations of all parties involved. The two lanterns not only replace the 110 horizon lanterns with incandescent light installed years ago, but the light is so strong that switching on and off the entire 110 horizon lanterns cannot be perceived… In dark blue light, an arc-lamp horizon lantern produces an

> illuminance of 1.92 lux, while 24 incandescent-lamp horizon lanterns, which correspond to an arc-lamp horizon lantern in terms of electricity consumption, produce an illuminance of only 0.086 lux. (Hasait 1930)

However Kranich reported difficulties when using such a large central light source, since it caused shadows on the cyclorama if any scenery was more than a few metres high (Kranich 1933). He considered that rear-illuminated screens represented the best lighting solution, however it was distributed light sources that finally replaced the great arc-lamp powered "Oberlicht".

This appears to have been their last development, as by 1930-31 Schwabe ceased trading, handing the business over to Reiche & Vogel.

15. Fortuny-AEG and other German Cyclorama Lighting

Fortuny patented his ideas in 35 variants from 1901–1909 in Italy, France, Germany, USA, Spain, Switzerland and UK. He received the enthusiastic endorsement of Fritz Brandt,[98] and the attendance of the Inspector General of AEG at the 1906 Paris inauguration. Despite having signed an agreement in 1901 with the French CGE, Fortuny formed a joint German company with AEG in 1906 named Beleuchtung System Fortuny GmbH to market his system of cyclorama and indirect lighting (Commune di Venezia 1978; Desvaux and Stasi 2003). Fortuny invested 200,000 Fcs (French francs, today ~£2.4M) for a 40% stake in the company (Thormann 1950).

The company published a 32 page brochure on the system, now inaccessible[99] (Beleuchtung System Fortuny G.m.b.H. c.1911). The cover was designed by the famous AEG industrial designer, Peter Behrens (Osma 2015). Fortunately Paetow from AEG provided an extended description of the system in EZ of 1909 (Paetow 1909).

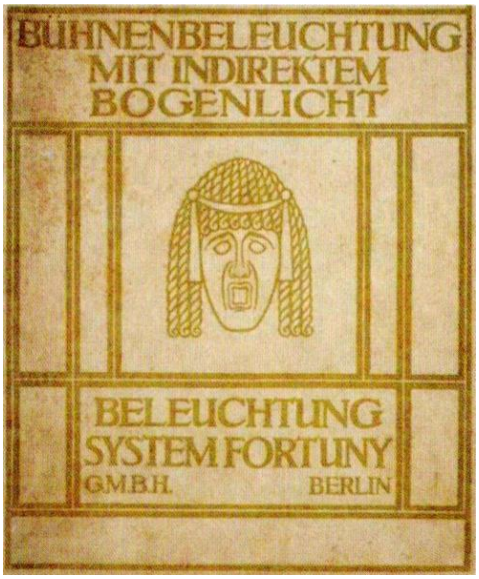


Figure 39. Beleuchtung System Fortuny GmbH brochure cover, 1907 (Stage lighting with indirect arc light). (Osma 2015, 114)

The partnership proved tumultuous, with the large engineering company demanding commercial results over than the artistic perfection of Fortuny, preferring solid domes and elimination of amateur craftmanship (Fuso and Mescola 1978). He was further incensed when AEG started using directly focussed incandescent lighting, rather than his indirect system (Osma 2015). Fortuny complained (particularly regarding Kroll Opera) “the Germans … did not achieve even the tiniest part of what they could and should have achieved” (Osma 2015, 116). He eventually abandoned the enterprise, returning to Venice and his other projects in 1907 (Smith 2017; "Mariano Fortuny invente la première cabine de régie" 2020; Osma 2015).

By 1907 AEG were marketing scrolling reflectors shown in Figure 41 to use with mechanically dimmed arc lamp sources (Unruh 1969; Baumann 1988). The first Fortuny-

[98] Younger brother of Karl Brandt and mentor of Max Hasait, from the famous Brandt family of theatre technologists. (Paysan 2016; Izenour 1988)

[99] The only listed copy is at Yale University, though they cannot locate their copy. Probably another exists at the Museo Fortuny in Venice but is uncatalogued (Beleuchtung System Fortuny G.m.b.H. c.1911). The rather hagiographic description by Roche provides some technical detail (Rouche 1910).

AEG system was installed at the Berlin Kroll Opera in 1907 but found to be too “weak” for the large stage (Baumann 1988). After substantial re-engineering by AEG, the system was reinstalled in 1909, however Thormann reports there were limited sales of the system afterwards (Thormann 1950).

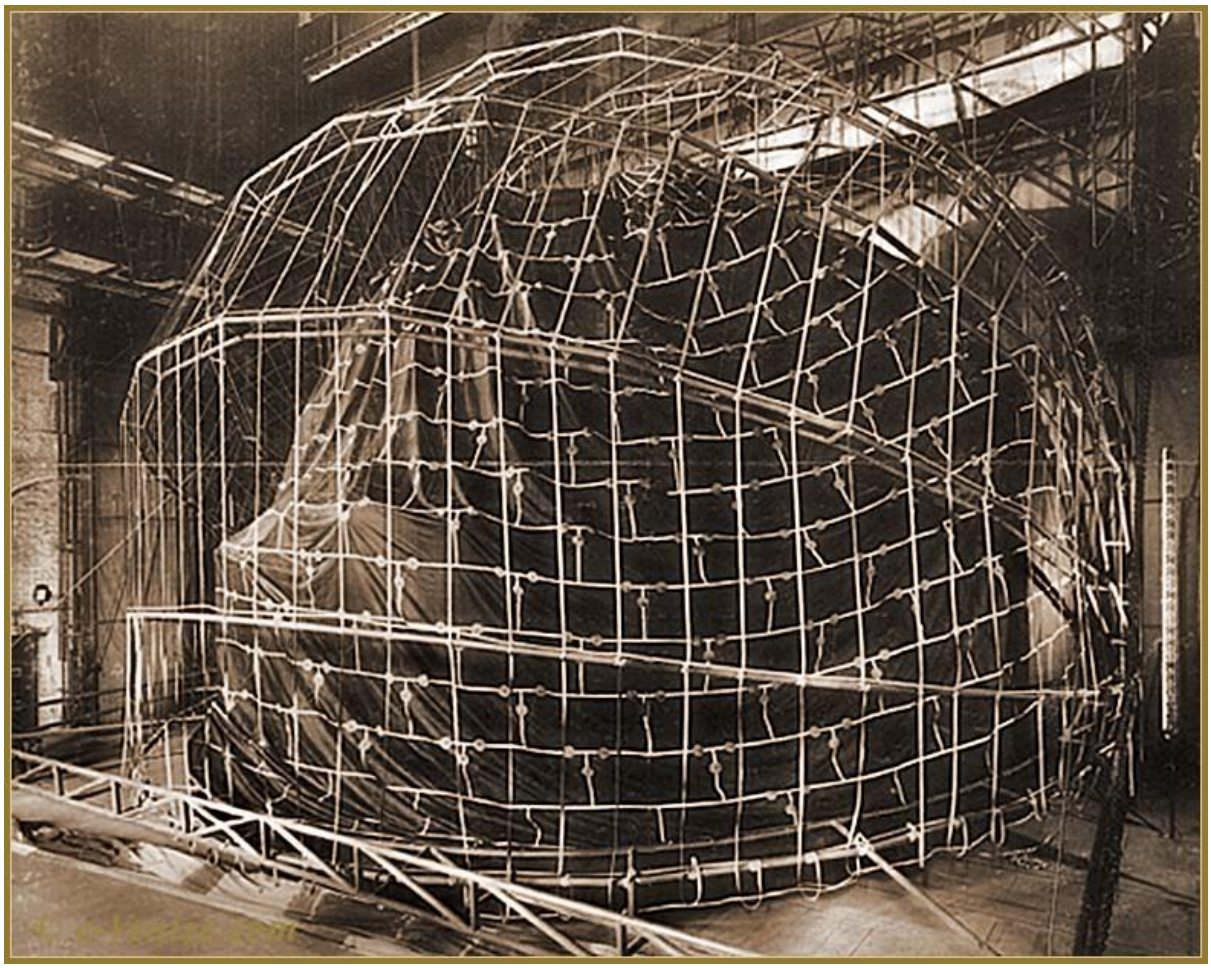


Figure 40. Fortuny folding deflatable dome (Kuppelhorizont) in Kroll Opera, Berlin, 1909–10. (Baumann 1988; "Mariano Fortuny invente la première cabine de régie" 2020)

Initial trials at the Kroll Opera in Berlin were soon followed in 1913 with a lighting installation in the Dresden Royal Opera for its new circular cloth cyclorama (Hasait 1917). These operated with separate arc lamp luminaires (not shown in Figure 41). The scrolling inner and outer silk ribbons allowing transitions between colours and graduation of intensity. Hasait sang its praises in 1917:

> With this system, a lighting system was found that was suitable for the illumination of the circular horizon and with which moods could be created that no stage had previously known. (Hasait 1917)

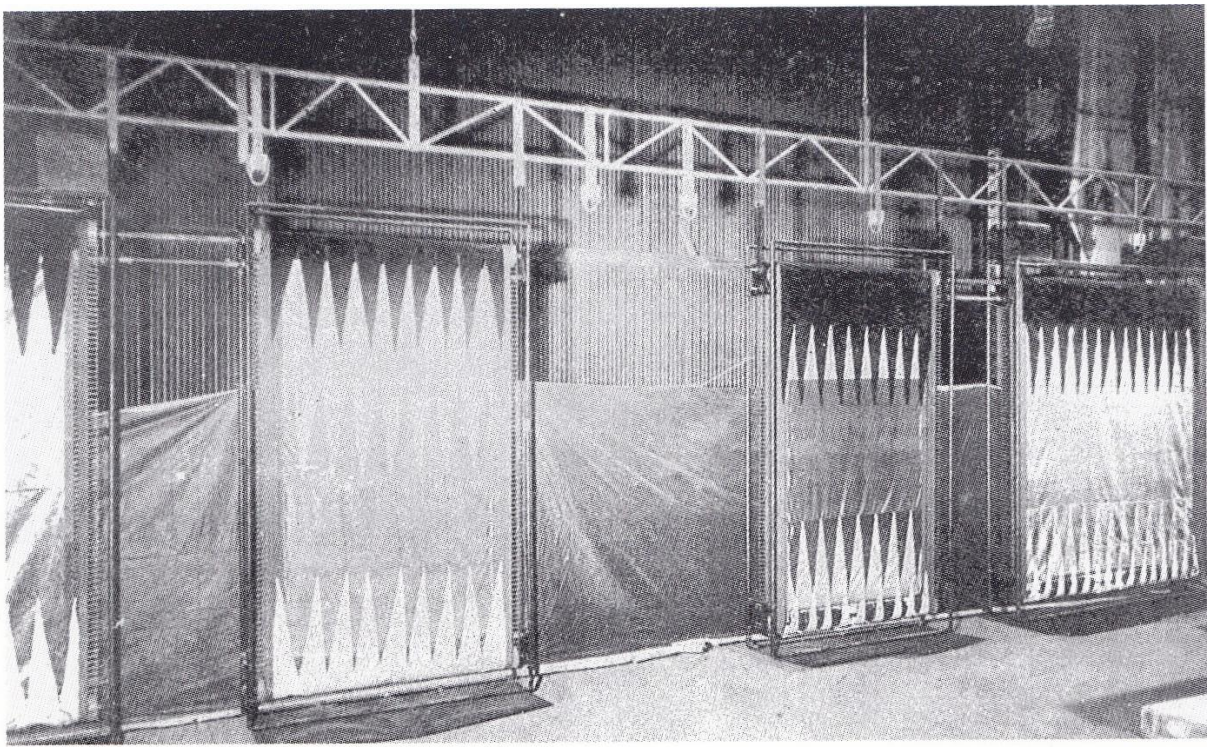


Figure 41. Fortuny-AEG reflectors c.1907. (Paetow 1909)
(Normally suspended high above the stage in front of arc lamps.)

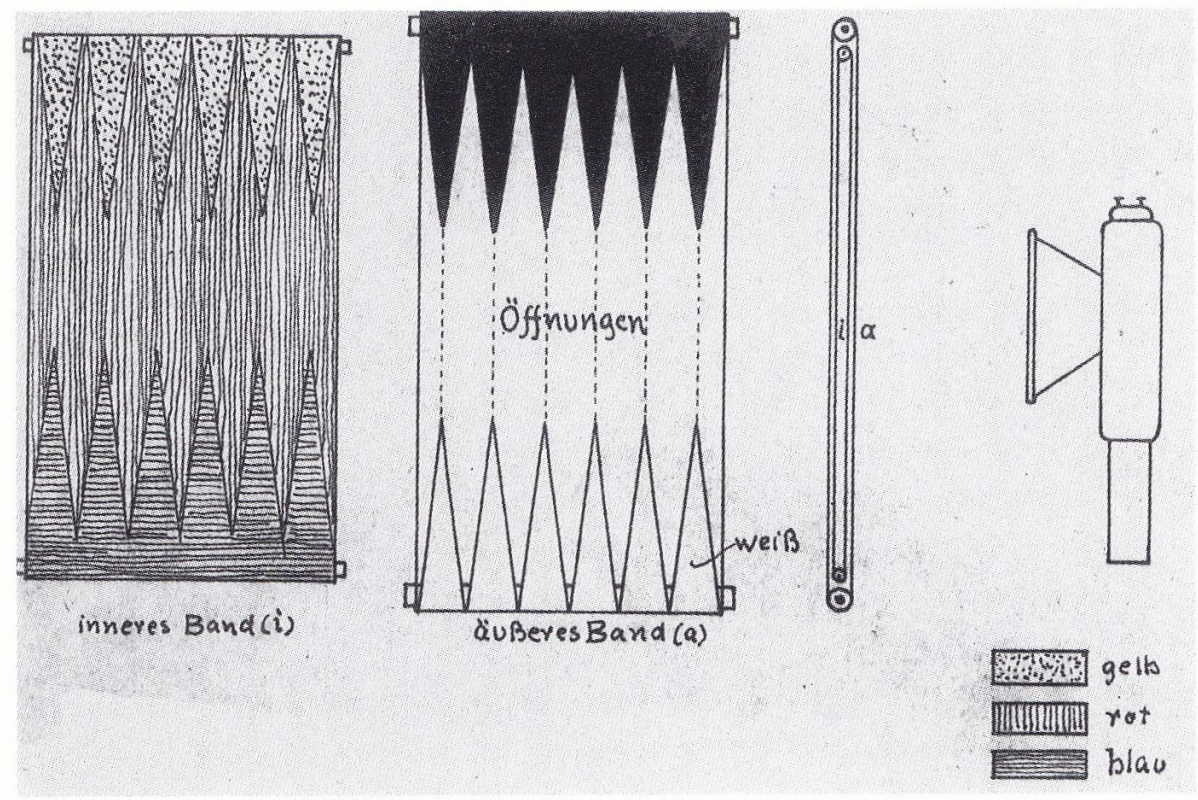


Figure 42. Fortuny-AEG reflector ribbon assembly with two ribbons and notional arc lamp
(Baumann 1988, Abb 82)
(gelb: yellow, rot: red, blau: blue, weiß: white, Öffnungen: opening)

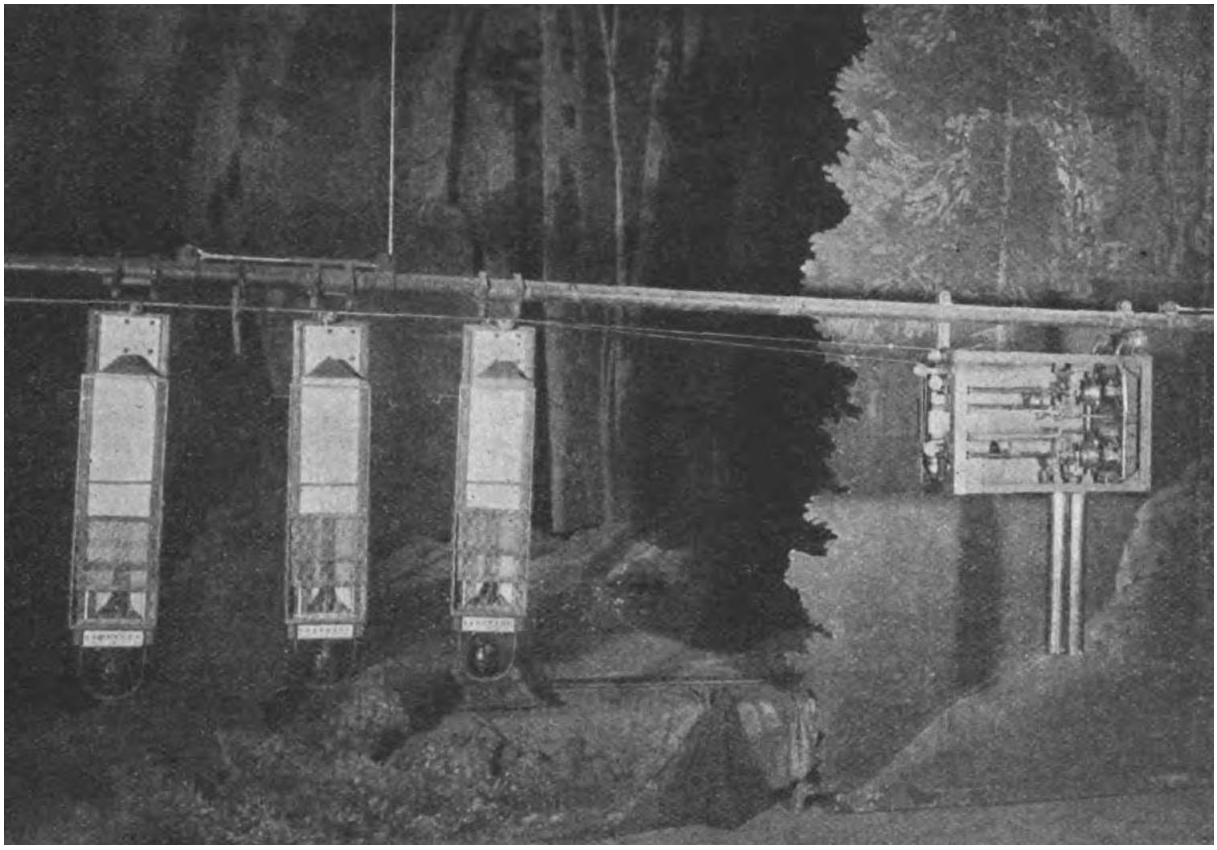


Figure 43. Fortuny-AEG arc lamps with motorised remote control of mechanical dimmers. (Paetow 1909)

The ribbons were doubled, with one inside the other shown in Figure 42. The inner band provided yellow-red-blue transition, the outer band a white-clear-black transition (Baumann 1988). The transitions were saw-toothed to provide a graduated change, thus giving any mix of yellow/red/blue with saturation reduction with the white ribbon or dimming with the black ribbon. The 25 A arc lamp was also equipped with blue glass filter and a mechanical dimmer for a complete blackout (Rouche 1910). The ribbons were controlled by electric motors with the arc lamp filters and dimmers tracker wire operated from a local motor box as shown in Figure 43.

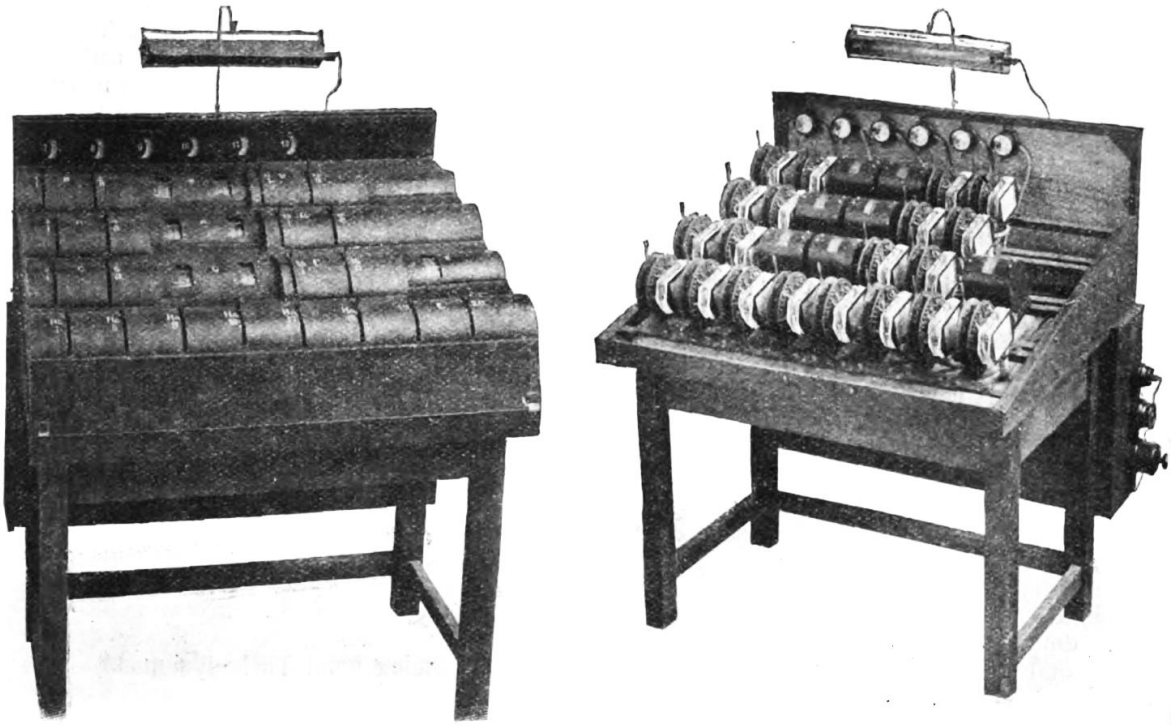


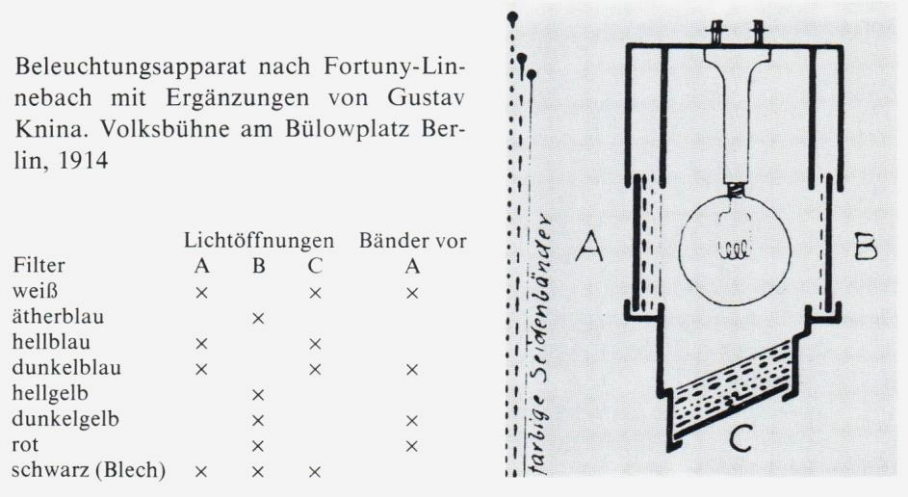
Figure 44. System Fortuny control console (left: with covers, right: without covers). (Paetow 1909)

The whole system was controlled by a small portable console that could be placed in the auditorium, shown in Figure 44. The ribbons and dimmers were controlled by bi-directional, variable speed, control levers. The scrolling ribbons were fitted with feedback potentiometers that drove coloured drums on the console adjacent to each lever controller, enabling the operator to see the actual colour achieved and cease movement when the desired colour was reached. The lamp dimmers similarly had feedback potentiometers indicating their position on meters. There was no electrical servocontrol or presetting facility. However the electrical control systems of the lamps and silk scrolls were complex and proved unreliable. Further in 1913 the Half-watt, gas-filled incandescent lamp was launched, able to compete with arc lamps for output and more controllable, thus permitting a much wider range of competing cyclorama lighting.

While AEG concentrated on perfecting these indirect light sources, Linnebach who was redesigning the Royal Schauspielhaus stage in Dresden which opened in 1913, designed a variation to offset the inefficiency of solely indirect light. The resultant “Fortuny-Linnebach” luminaire used one 5,000 candlepower automatic arc lamp with two outputs, providing direct lighting of the cyclorama and reflected soft light on the acting area simultaneously (Kummer 1913).

A similar design of lamp but retaining arc sources was used by Hasait in the refurbished Dresden State Opera stage, also completed in 1913 (Neumann 1914). The coloration was by six coloured glasses remotely controlled, with mechanical dimmers to each outlet. These consisted of box-shaped housings hung in three rows. They cast their light either backwards directly onto the cyclorama or forwards onto controllable coloured silk surfaces (probably the AEG silk scrolling reflectors) which reflected their colour back to the cyclorama. The two openings where the light exited from the arc lamp housings could also be closed off by differently coloured or dimming covers. In addition to 11 overhead four colour incandescent light battens, 60 of these 25 A automatic arc luminaires were installed (connected in series

pairs) with 34 used on the cyclorama (Neumann 1914). By 1914, the design changed to also use the new gas-filled incandescent lamps (3,000 W) with three light outputs shown in Figure 45 (Baumann 1988).



Beleuchtungsapparat nach Fortuny-Linnebach mit Ergänzungen von Gustav Knina. Volksbühne am Bülowplatz Berlin, 1914

	Lichtöffnungen			Bänder vor
Filter	A	B	C	A
weiß	×		×	×
ätherblau		×		
hellblau	×		×	
dunkelblau	×		×	×
hellgelb		×		
dunkelgelb		×		×
rot		×		×
schwarz (Blech)	×	×	×	

Figure 45. Fortuny-Linnebach luminaire with gas-filled incandescent lamp with three openings and reflectors, 1914. (Baumann 1988, Abb 88)

Though reflected illumination as propounded by Fortuny produced a very soft illumination, it was also very inefficient. The arrival of high power incandescent lamps (esp. half-watt) ended this approach, with vendors such as AEG and Hagendorn soon selling large 3 x 1,000 W tubular lamped luminaires with colour changing filter cassettes. These cassettes were often doubled (i.e. top and bottom) allowing a smooth top-to-bottom colour transition without open white, shown in Figure 51(f). Even so, use of diffusing reflectors remained promoted as shown in AEG's literature in Figure 46 (Krzeszowiak 1986).

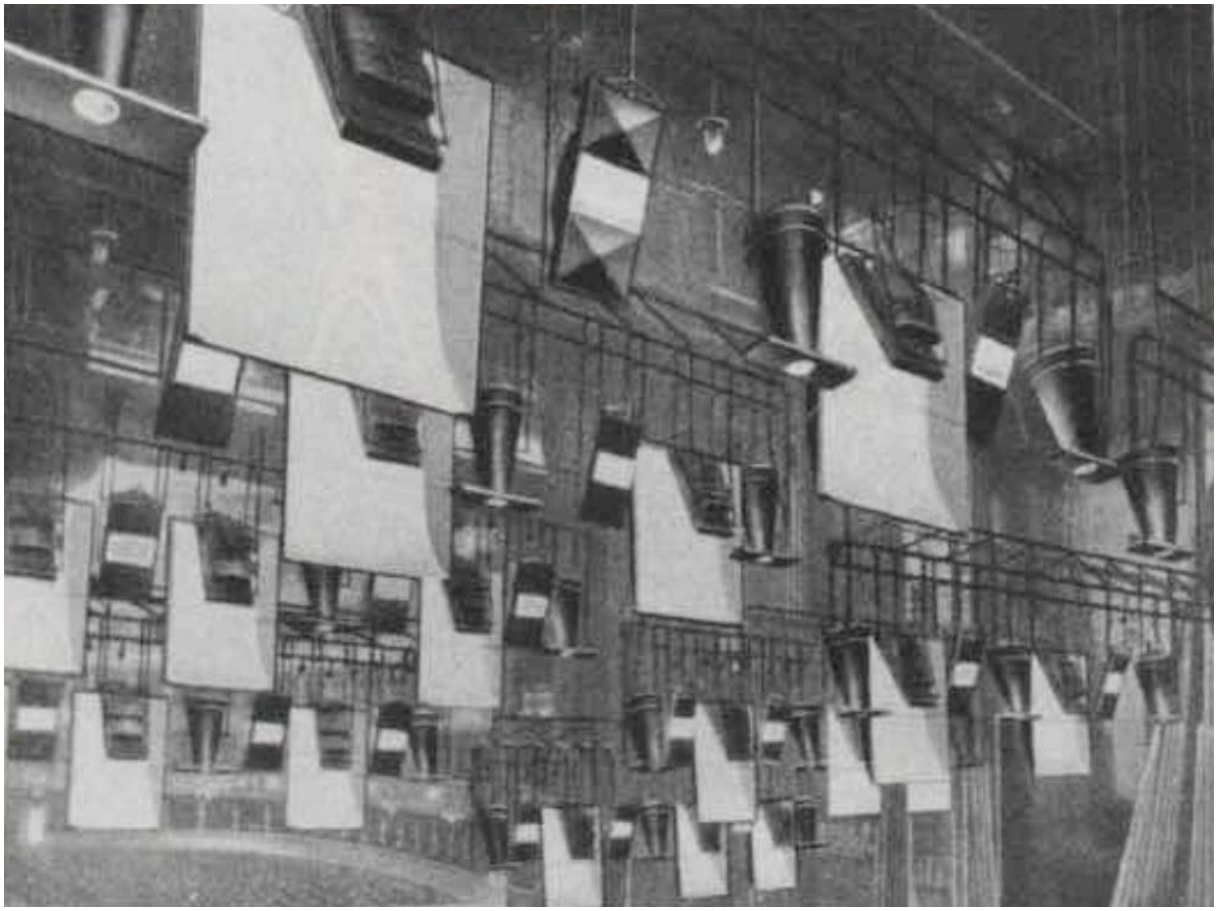


Figure 46. Probably AEG literature displaying both direct and indirect cyclorama lighting, together with acting area lights. (Krzeszowiak 1986)

Several other luminaire types, including from Schwabe, offered integral colour change, either by tracker wire or electric motor. Tracker wire was particularly popular, it being the main stage lighting control methodology. Kranich illustrates in Figure 47 a typical tracker wire controlled lighting frame. The control cables were compensated for changes in their bar height by a differential pulley system illustrated alongside (Kranich 1933). Naturally this became very complex in large installations, and thus fragile and unreliable, encouraging the use of singular lights permanently coloured, needing only electrical dimming.

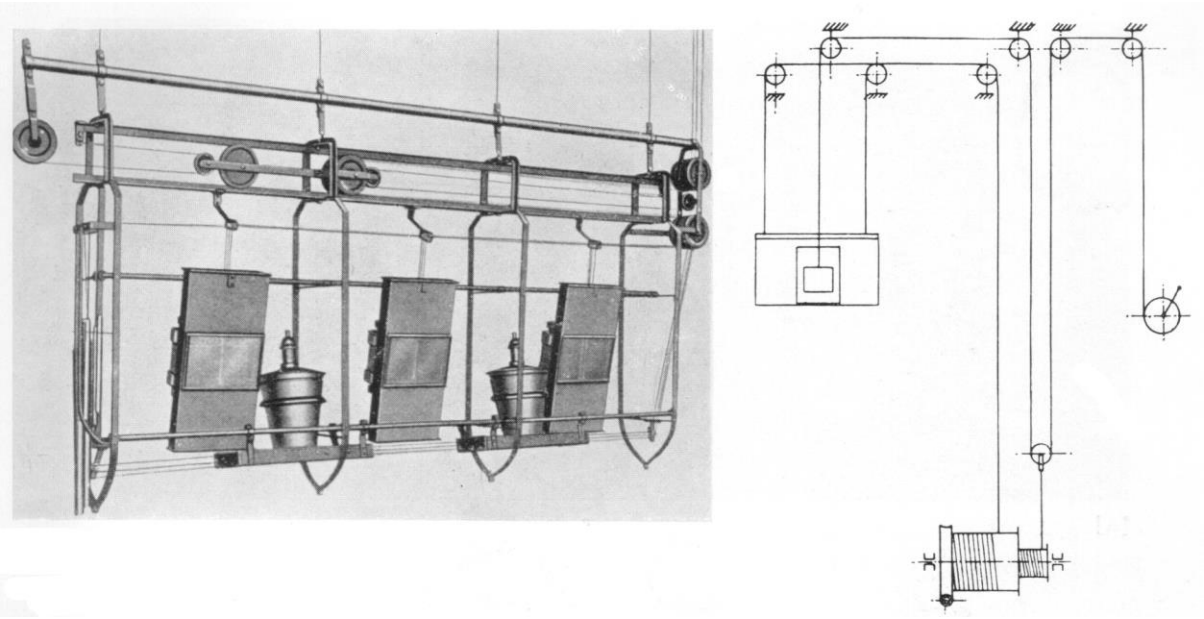


Figure 47. Tracker wire control of cyclorama and acting area luminaire colour changers, showing compensating pulley systems for height change. (Kranich 1933, Abb 17)

Siemens and others developed sophisticated motorised control systems of cable-operated colour changers. Some used simple limit-switched in/out controls, others used servo-motors or selsyn systems to transmit the operator control lever movement to the cable motor. At the Paris Opera in 1937, 34 cyclorama luminaires required 5 colour and dimming controls each (170 total). These were grouped into 2 x 30 groups, requiring 60 selsyn motors to drive the tracker wires locally, necessary since otherwise the cables would have exceeded 150 m. Figure 48 shows the sender motors receiving the cable signal from the lighting control board above. Identical receiver motors were mounted in the lighting bridges and connected to the luminaires by Bowden cables (Mosebach 1937).

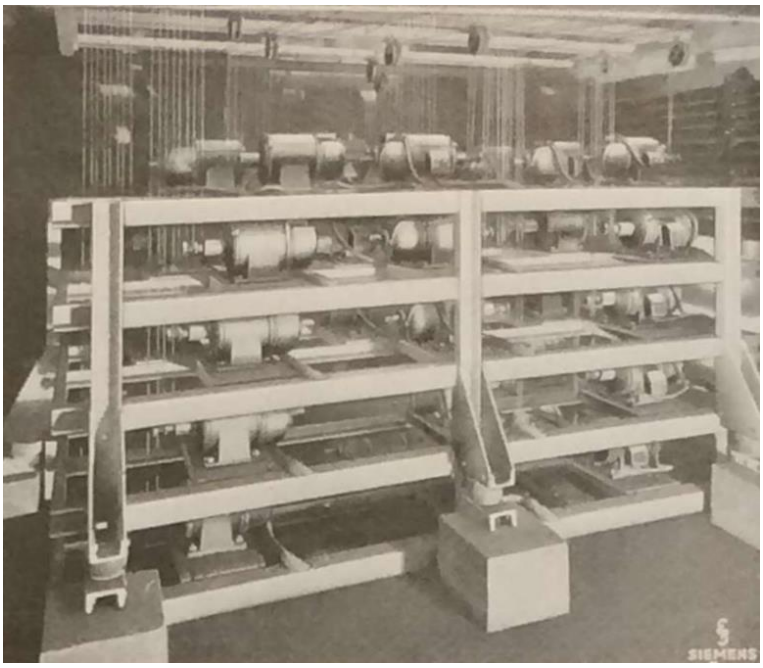


Figure 48. 60 Colour filter and mechanical dimming selsyn sender motors (Gerbermotoren) at Paris Opera, 1937. (Mosebach 1937)

Figure 49. 20 cyclorama arc lights with rotating glass filters by Siemens, Künstler Theater, Berlin, 1913. (Johannsmeyer 1941)

The licensing of the Fortuny system by AEG meant Siemens needed a competitive alternative. They developed a system of separate automatic arc luminaires shown in Figure 49 (Johannsmeyer 1941). The screens were rotatable glass bells providing colour change, with the top left and 4th from left units being shadow cloud projectors (Johannsmeyer 1941). However these too were soon replaced by the arrival of gas-filled high output tungsten lamps (Engel 1926).

The steady replacement of arc based cyclorama lighting by the convenience of tungsten filaments left many users struggling to obtain adequate blue illumination. In 1930, Jahn from Siemens described the benefits of using 30 V, 900 W projector (Kino) bulbs and showed that for blue filtered light a >50% increase in illumination can be achieved (Jahn 1930). Siemens were still promoting this idea in 1941 (Johannsmeyer 1941).

Also in 1930, Hasait again proposed the use of a small quantity of very powerful arc lamps instead of massed tungsten lamps. He quotes the example (described in section 14) of two arc luminaires (rated at 24 kW and probably comparable to Figure 38) greatly outperforming 110 regular 1 kW tungsten luminaires at the Charlottenburg Oper.

A better solution was found in the use of mercury vapour lamps for blue light, such as shown in Figure 50. This used three HgH 5000 lamps, each rated at 1,000 W (~40,000 Lumens) with mechanical dimming. Krzeszowiak reports that Cologne first used them in 1920 (Krzeszowiak 1986). Even though not electrically dimmable, this lamp was easy to adopt

since many of the blue filtered tungsten cyclorama luminaires were already mechanically dimmed to maintain their blue spectrum.

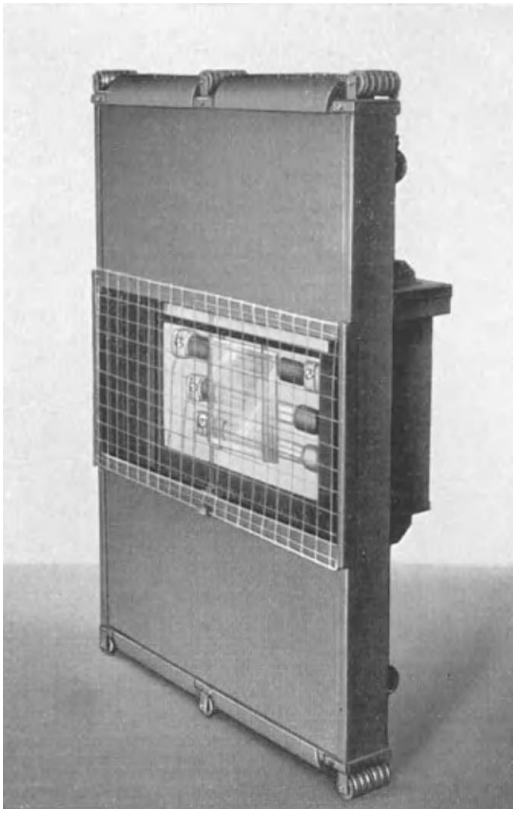


Figure 50. Mercury vapour lamp, cyclorama luminaire with mechanical colour change and dimming, Siemens, c.1920. (Sewig and Richter 1938, Abb 796)

Figure 51. Cyclorama luminaires from AEG (A), Schwabe (Sch), Siemens (S) and Reiche & Vogel (R), 1933. (Kranich 1933, Abb 39)

In the UK, despite Strand Electric's determination to use flat open floodlights for cyclorama lighting, they ultimately found it necessary to offer a compatible "Panorama Flood" with a 1,000 W tubular lamp and 180° spread in 1924 ("Equipment Detail Patt. 34 (1924-1945)" 1924). This was the Patt. 34 illustrated in Figure 52.

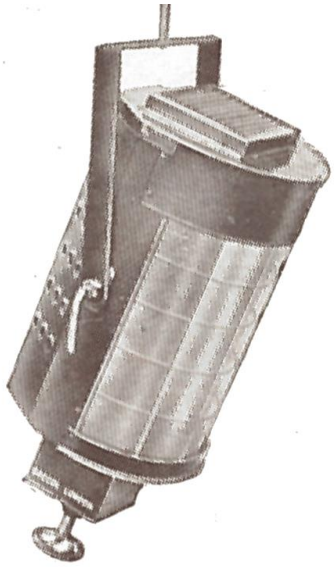


Figure 52. Strand Electric Patt. 34 Panorama Flood. ("Equipment Detail Patt. 34 (1924-1945)" 1924)

By 1935, phosphors had been developed sufficiently to permit the use of fluorescent tube cyclorama lighting such as in Figure 53 (Krzeszowiak 1986). Despite the greater efficiency, their low intensity resulted in limited use on large stages, except as backlights.

Figure 53. Three-tube fluorescent luminaire, with optional rotating colour filters, AEG. ("AEG Bühnenbeleuchting (Catalogue)" 1956)

After WWII the central importance of cyclorama lighting in Germany continued. The original cable operated, colour-changing cyclorama lights were still being offered by AEG in 1956, as shown in Figure 54, with mechanical remote controls ("AEG Bühnenbeleuchting (Catalogue)" 1956). This focus on cyclorama lighting was continued by Siemens during Francis Reid's 1961 visit when exploring suppliers to re-equip Glyndebourne. He reports being shown "a horrible sequence of light cues to music – dusk, night, storm, dawn sequence performed on cut-out scenery against a cyclorama" (Reid 2005, 53).

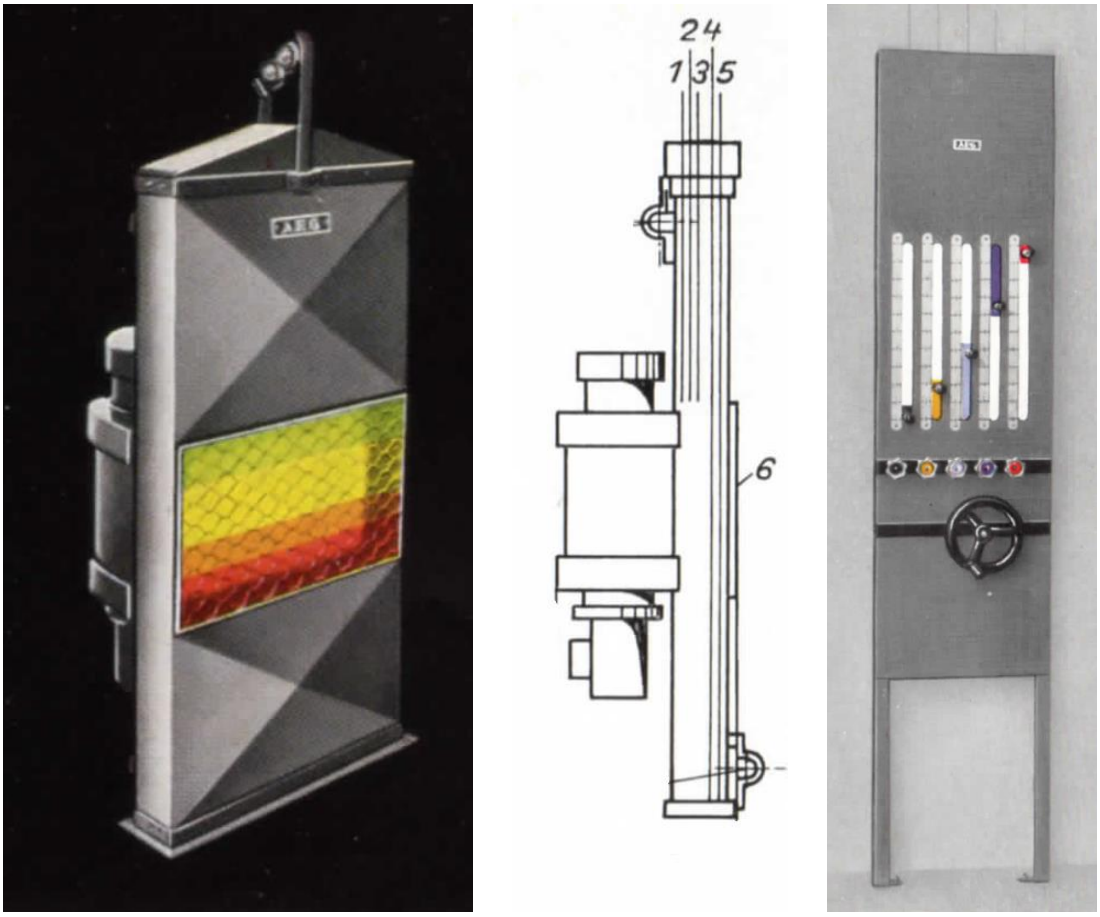


Figure 54. 3 x 1,000 W cyclorama luminaire with four colours and mechanical dimming (left and centre), (Seilzug-Horizontleuchte) plus tracker wire control panel (right), AEG, 1956 (1: dimmer, 2: yellow, 3: light blue, 4: dark blue, 5: red, 6: stray light baffle). ("AEG Bühnenbeleuchting (Catalogue)" 1956)

16. Reiche & Vogel's Development of the Schwabe Systems

By 1931 the business of Schwabe & Co had been taken over by Reiche & Vogel. There is no detailed record of the products they offered in the 1930s, and the company's records were lost in WWII. However given they claimed to be continuing Schwabe's quality, one can assume they continued existing products as well as developing new ones. The wide range of their offering by 1937 can be judged from their advertisement in BTR, shown in Figure 55 ("Reiche und Vogel Leuchtkunst GmbH advertisement" 1937).

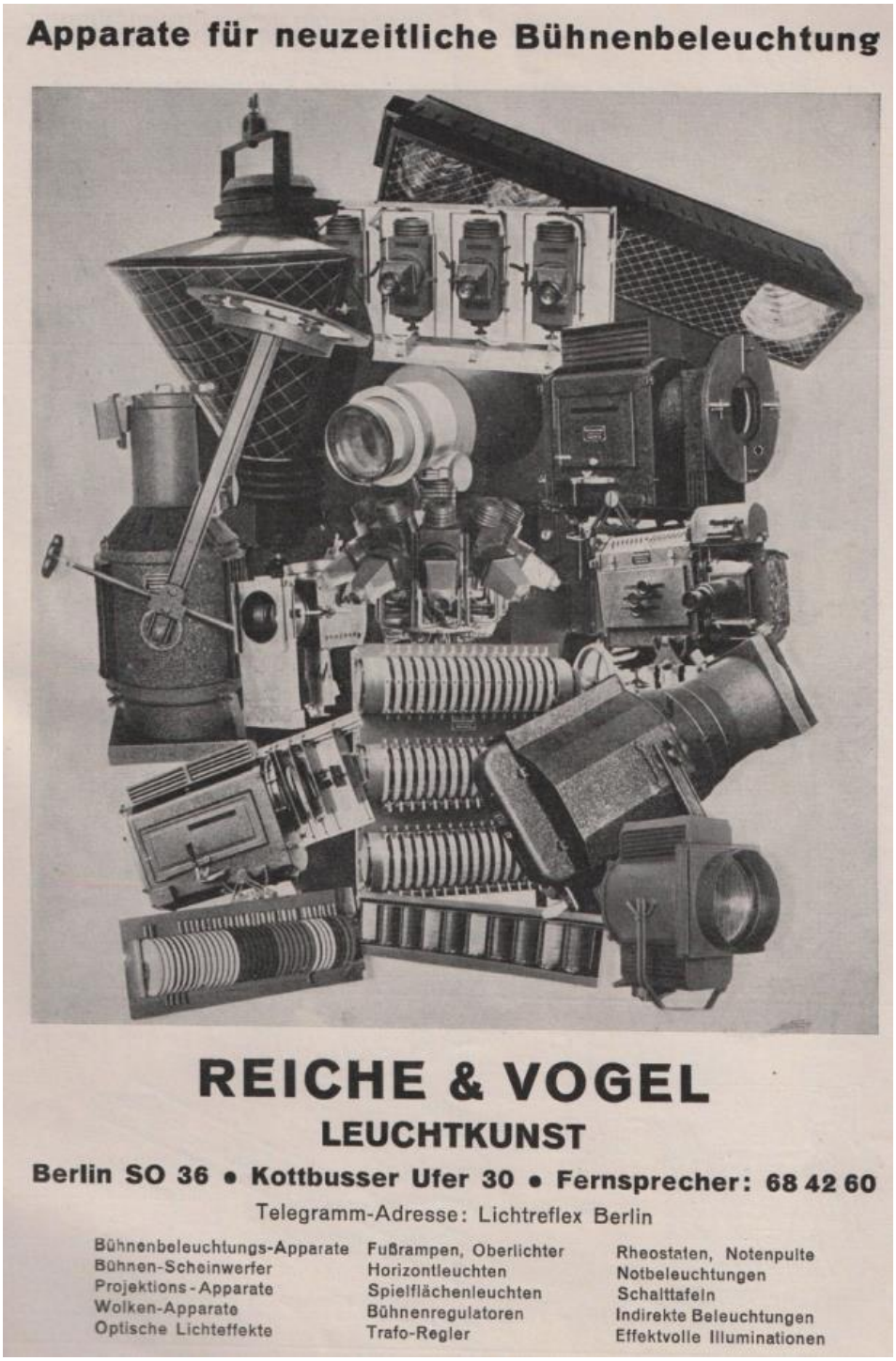
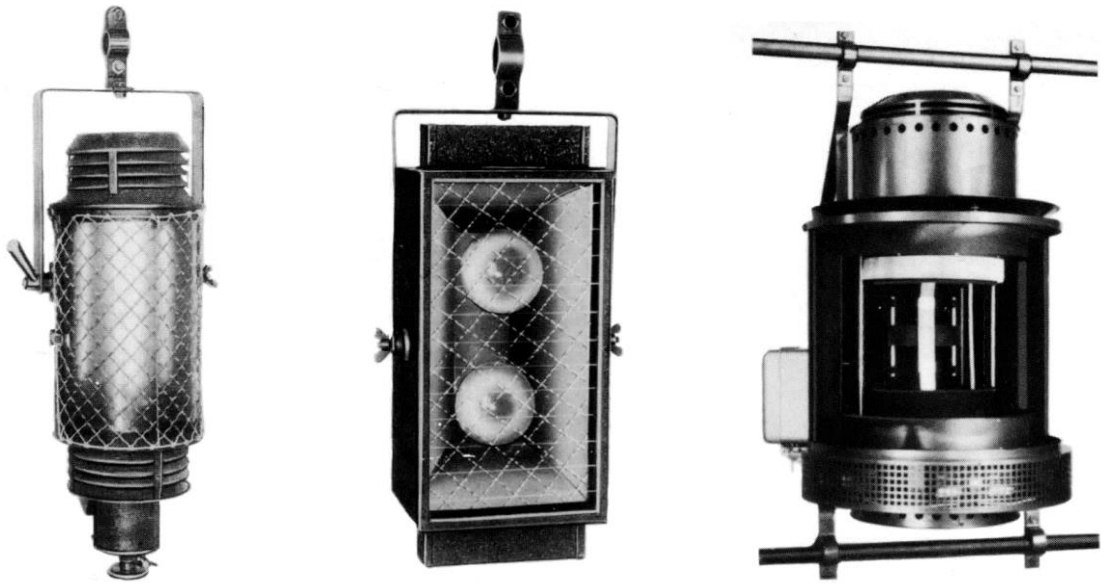


Figure 55. Reiche & Vogel full range advertisement, BTR 1937. ("Reiche und Vogel Leuchtkunst GmbH advertisement" 1937)

The first catalogue accessible is from c.1960,[100] and together with contemporary reference books provides some pre-war guidance (*Bühnenbeleuchtung (Catalogue)* c.1960). The company still offered in Figure 56(a) the classic horizon luminaire now rated up to 1,500 W, and in Figure 56(b) also two and four-way 500 W reflector lamp housings. A new departure in Figure 56(c) was a 2,500 W xenon arc luminaire with motorised colour filters and dimmer, again bringing back the use of an arc lamp to obtain enough blue lumens.



(a) (b) (c)

Figure 56. Reiche & Vogel incandescent and xenon cyclorama luminaires c.1960. (a) 1,000–1,500 W, (b) 1,000 W, (c) 2,500 W (*Bühnenbeleuchtung (Catalogue)* c.1960)

Two further variations appeared, firstly the 2,000 W Cone lantern shown in Figure 57, reportedly new in 1935 (Hasse 1936). This was intended to be used as a corner lantern at the ends of the lighting bridge/bar and has asymmetric reflectors. However it appeared to be popular across the lower ranks of a cyclorama bridge, with 30 installed in the Charlottenburg Opera in Figure 57.

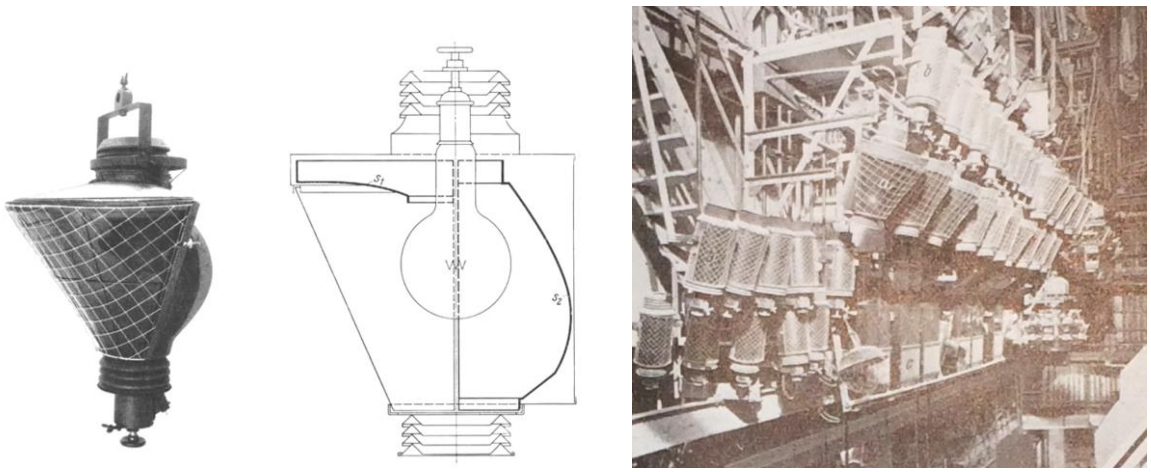


Figure 57. Reiche & Vogel Cone horizon luminaire 2,000 W (right: installed at Charlottenburg Opera, Berlin, 1935). (Hasse 1936; Sewig and Richter 1938, Abb 793-4)

[100] Undated but from address of R&V and lamp types used indicates a date between 1958–68.

The second was the special “Belt lens” luminaire shown in Figure 58, using the 900 W, 30 V “Kino” lamp. It was used to create a long strip of light on the horizon, and appropriately filtered and angled (using the gimbal mount), could be used to project a rainbow.

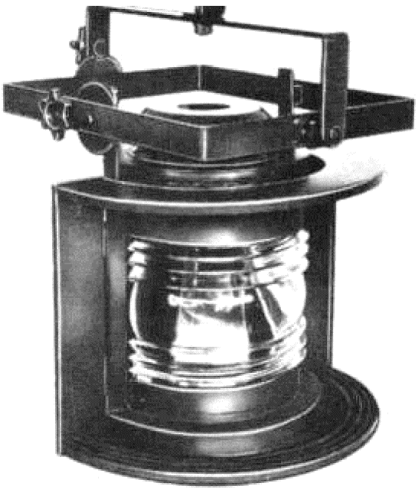


Figure 58. Reiche & Vogel Belt Lens (Gürtellinse) luminaire 900–1,000 W. (*Bühnenbeleuchtung (Catalogue)* c.1960)

Dean made his last contact with Reiche at the end of WWII. He was at the E.N.S.A. post in Berlin in 1945 and heard that Reiche had survived and was working in a cellar in the Russian sector. He writes evocatively of the time:

> It was rather dangerous moving about Berlin in those days. You never knew when you might be held up by a group of Russian soldiers on the prowl. So, escorted by my senior colonel and two sergeants I set out. Eventually we found the cellar. There was Reiche with his son and two or three other technicians, working with his usual enthusiasm, although half-starved and liable to frequent requisitioning by the Russians…We were able to find some extra food for them and, in return, he talked about the work he had been doing on scene projection. (Dean 1975b)

After WWII Reiche & Vogel recovered to continue as an important German stage lighting supplier, particularly known in Britain for their low voltage parabolic spotlights. However the final Directors, Friedrichsen and Wörwag, retired and the company ceased trading at the end of 2012 (Wörwag 2012).

17. The Adjunct to Cyclorama Lighting – Acting Area Lighting

Until the arrival of cycloramas with dedicated lighting, the acting area was usually washed with light from the multiple overhead and side battens, which also illuminated any painted backdrops. Arc-lamped follow spotlights served to pick out detail action but did not provide general illumination. However once the cyclorama was being lit with a dedicated colour for a sky effect, then both the cyclorama colour on the actor or any actor's shadow on the cyclorama was unacceptable. This required dedicated acting area luminaires called Spielflächenleuchten (literally "playing area lights"), which focused a shielded light source down onto the stage surface in front of the cyclorama (Kranich 1933). Dean claimed these were invented in Germany and introduced them into the UK, naming them "acting area floods" (Dean 1960).

Two principal types evolved in ratings from 500–2000 W. Simple designs used a lamp in a rudimentary parabolic reflector (usually split for ventilation) to provide a moderately directed downwards beam but having a large aperture. Schwabe recommended that the units were triple rigged for a three colour installation (*Moderne Bühnenbeleuchtung* c.1913). Many others used an ellipsoidal reflector to generate an internally converging beam, often with a lens, whose much smaller aperture allowed the use of practically sized, colour change mechanisms. This probably achieved a net saving over three separate luminaires and dimmers.

It is not possible to precisely determine the first use of these luminaires. They were not recorded by Weil in 1904 who solely advised battens for overhead light (Weil 1904). In principle Fortuny proposed and used separate arc lamp reflectors for stage lighting, shielded from the cyclorama. The first recorded design in c.1913 is shown by Schwabe in Figure 59, who claim it to be "legally protected" and using the then new half-watt (gas filled) lamp (*Moderne Bühnenbeleuchtung* c.1913). Kranich provides an illustration of the many varieties in use by 1933 in Figure 60 (Kranich 1933).

Figure 59. Schwabe early acting area luminaire, c.1913. (*Moderne Bühnenbeleuchtung* c.1913)

Figure 60. Acting area luminaires (Spielflächenleuchten), (A: AEG, S: Siemens, R: Reiche & Vogel) 1933. (Kranich 1933, Abb 38)

These acting area luminaires were frequently mounted on the same suspension systems as the cyclorama luminaires, taking advantage of their cable operated colour change control systems as shown in Figure 46 and Figure 47. Schwabe similarly illustrates some under early cyclorama luminaires in Figure 36. This is not to say that these acting areas lights were universally employed, the use of lensed spotlights was also a frequent solution to illuminating actors without spilling unwanted light on the cyclorama. Reinhardt was a particular user of

this approach, with the sharp directional lighting adding to the dramatic impact (Bergman 1977).

The use of such downlights and overhead spotlights were however criticised as causing dark faces and invisible eyes. By the 1927 German Theatre Exhibition, auditorium spotlights were being promoted to achieve “an artistic effect” (Wedemeyer 1928).

Britain as usual (at least Strand Electric) lagged well behind. Bentham states that Acting Area lights (as well as the parabolic Pageant projector) were not produced by Strand until his 1936 catalogue (Bentham 1984a).

18. Development of the Schwabe Colour System

Colour and intensity of light are purely human senses, they interact and vary with observer, exposure and the visual environment. Attempts to codify these as scientific rules have been fraught with difficulties, and even by the early 20th century were very uncertain (Bertenshaw 2020).

Newton in 1672 had demonstrated the spectral components of white light, but how these were perceived by the eye and brain remained a mystery (Newton 1671-2). Goethe in 1810 further challenged Newtons purely spectral theories, adding a Black-White dimension (Goethe 1810 (trans 1840, reprinted 1970)). From this a deep schism and controversy developed between the German schools of physiology of Ewald Hering vs that of Herman von Helmholtz, lasting from about 1860–1920 (Turner 1994). Hering (following Goethe) considered the eye's primary colour senses were the pairs Black and White, Blue and Yellow, Green and Red, all acting antagonistically, versus Helmholtz who adopted the hitherto neglected 1801 Young theory of trichromatic colour senses i.e. Red, Green and Blue acting additively (Young 1801 (pub 1802)).

Since the scientific community in the pre-1930 era was struggling with both measuring and standardising light and colour, this led to a variety of empirical colour mixing theories. Most of these came from "colour circles", simply noting the progression of the rainbow. Newton himself was the first to recognise the cyclic nature, declaring that white light is composed of seven constituent colours in the rainbow, a purely subjective division since the days of Aristotle that has stayed with us since (Silvestrini and Fischer 2011). Newton's circle shown in Figure 61(left) assumed that the seven colours aligned with the repeating (Dorian) musical scale. However Goethe appeared to be the first to recognise that there existed colours from mixing red and blue that did not occur in the rainbow, adding magenta to his colour circle[101] shown in Figure 61(right).

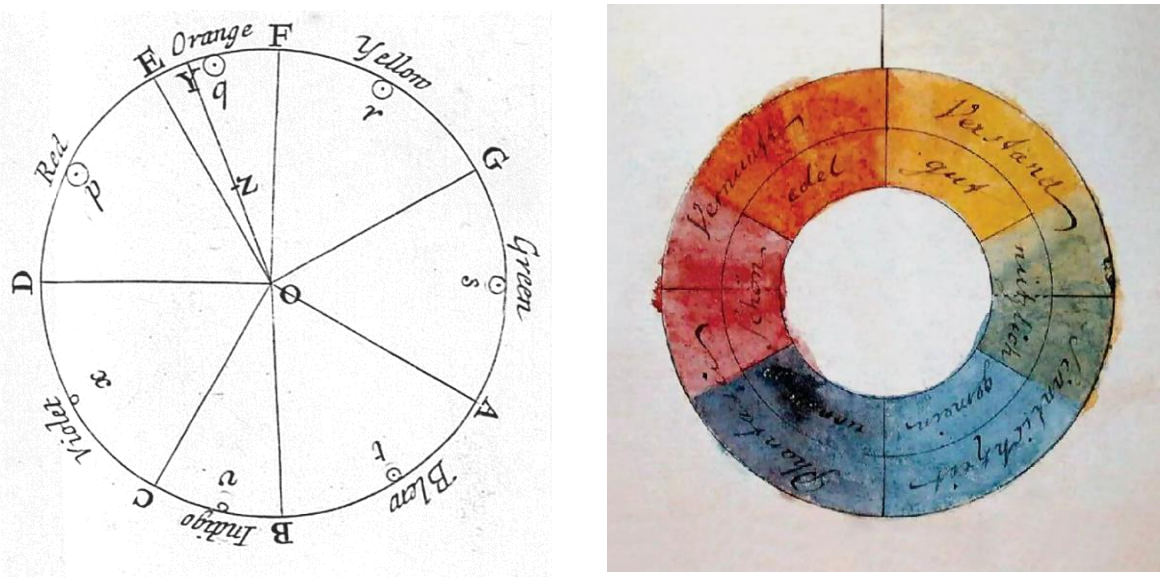


Figure 61. Newton's colour wheel 1704 (left) (Newton 1671-2), Goethe's colour wheel 1809 (right) (Goethe 1809).

[101] This is not immediately obvious from his illustration, but the writings make it clear.

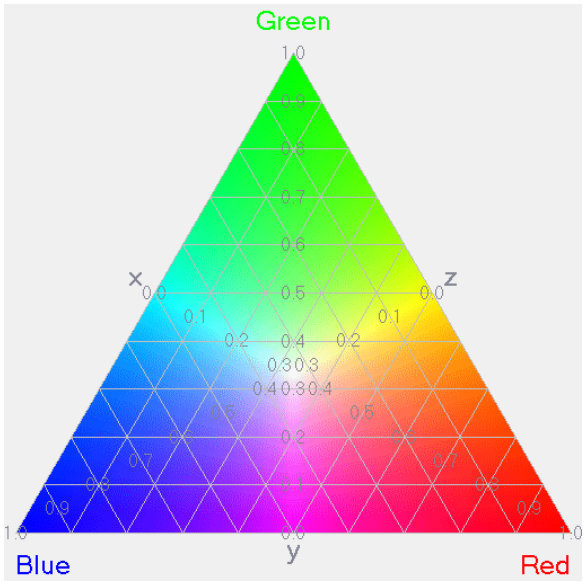


Figure 62. Maxwell's colour triangle, after (Maxwell 1890).

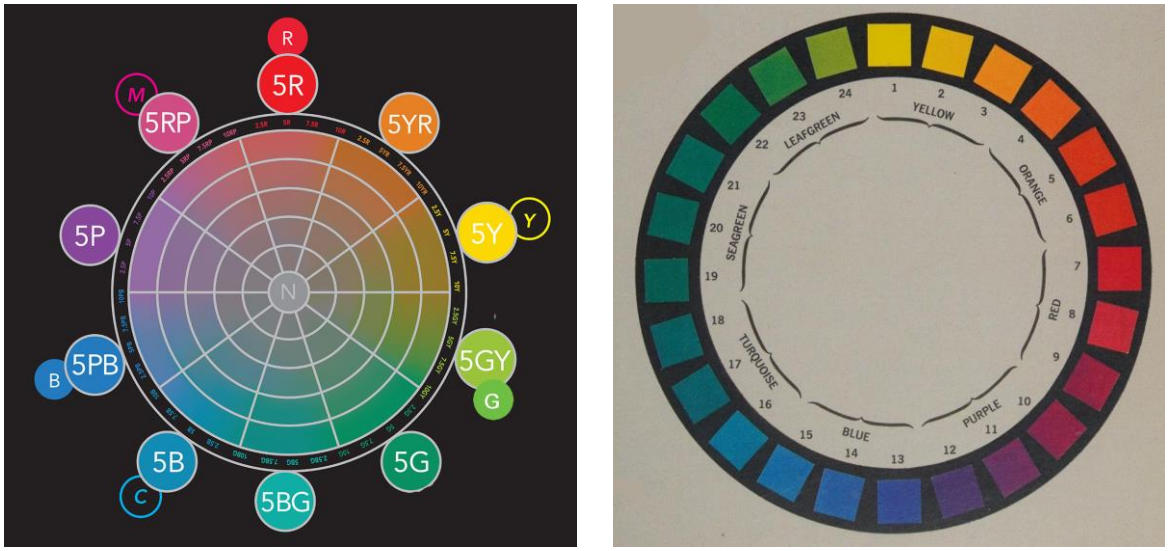


Figure 63. Munsell 5 colour wheel (R/Y/G/B/P) with half divisions, 1905 (left) (Munsell 1905), Ostwald's 4 colour wheel, 1917 (right) (Ostwald 1917 (Translated Faber Birren, 1969), Plate II)

Eventually Munsell in 1905 devised a colour definition scheme based on five fundamental hues, saturation (chroma) and intensity that could be used to rationally describe and replicate colour, and whose system continues in use today (Munsell 1905). In his colour wheel in Figure 63(left) opposing hues always combine to produce white, thus the ocular primary colours (RGB) are at roughly 120° spacing.

Maxwell's 1855 experiments leading to his RGB colour triangle in Figure 62, then Abney's 1886 measurement of the eye's spectral response, plus demonstration of the additive nature of colours, all cast serious doubt on the Hering hypothesis (Abney and Festing 1886). However even by 1915 the RGB trichromatic ocular theory remained unaccepted, with popular authors such as Lovibond supporting three different primaries (Red, Yellow & Blue) and Ostwald (a follower of Hering) four primaries, as shown in the short list of theories in Table 2 (Lovibond 1915).

Theory	Period	Primary Colours
Newton	1672+	Red, Orange, Yellow, Green, Blue, Indigo, Violet
Werner	1814+	Red, Orange, Yellow, Green, Blue, Violet
Hering	1860-1918	Red, Yellow, Green, Blue plus Black/White
Chevieul, Brewster, Hay, Redgrave, Field, Lovibond	18xx-1915	Red, Yellow, Blue
Munsel	1905	Red, Yellow, Green, Blue, Purple
Ostwald	1916	Red, Yellow, Green, Blue
Young, Maxwell & Helmholz, CIE 1931	1801–today	Red, Green, Blue

Table 2. Primary colour theories. (Lovibond 1915)

Colour vision was finally scientifically resolved when Guild and Wright establishing the 1931 CIE[102] standard colorimetric observer with quantified tricolour primaries (Wright 1982; Schanda 2015). By then, from the time of Pythagoras, in total 59 different classification systems of colour had been proposed (Silvestrini and Fischer 2011)!

The Hering theory did not disappear completely. In 1930 Swedish colour researchers resurrected Hering's concept of the six so-called "elementary colours", black, white, red, yellow, green and blue, (NCS Colour ab 2023). Now termed the Natural Colour System (NCS), they used the same four-colour circle as Ostwald with each colour a proportional mixture of the colour wheel tint plus black and white (NCS ab 2022). It is only recognised as a modern colour standard system in Sweden and four other countries.

Inevitably early stage lighting authors supported differing theories. Engel in 1926 described an essentially Newtonian colour circle while also endorsing the Ostwald RYGB colour circle shown in Figure 63(right). Ridge in 1928 and 1930 used the Lovibond RYB primary model to support his colour mixing explanations (Engel 1926; Ridge 1930, 1928). However by1935 Ridge and Alfred had switched to the new CIE RGB orthodoxy (Ridge and Aldred 1935).

In Germany Fuchs in 1929 still proposed a colour circle in which orange rather than yellow was the secondary colour opposing blue (like Newton), but later in the same volume described the standard RGB primary and Yellow/Cyan/Magenta secondary system (Fuchs 1929). However Hansing and Unruh in 1942 (and probably in their first 1930/31 edition) were still promoting a four colour system of Light Blue (LB) – Moon Green (MG) – Yellow – Orange Red (OR) for both stage and cyclorama lighting (Hansing and Unruh 1942). Assuming their moon green was cyan, then it was essentially the Ostwald system. They noted that the use of pairs LB+Y and MG+OR both produce white, thus an all-on state is white, and LB+MG both produce a blue tint, similarly useful in drama.

Regardless of colour theory adopted, practical colouration of light required filters. While gas lighting had used bands of rotating coloured silks to change the overall colour, the arrival of electric lighting with its individual colour dimming allowed much more flexible colour control. Two, three, four, five, six and seven colour systems were used. Weil and Baumann report Fritz Brandt carried out the first electric stage lighting using multiple coloured lamps according to a two colour (red, green, white) system in the Royal Opera House in Berlin in

[102] C.I.E. International Commission on Illumination (Commission Internationale de l´Eclairage) is the body charged with standardising matters relating to light, colour and vision.

1882 (Baumann 1988; Weil 1904). This experiment was only 48 lamps used for some performances. Weil describes the experiment:

> In the three-lamp system, the green lamps must be coated with a mixture of green and blue in order to achieve a moonlight-coloured illumination. If the colour is not bluish, it will have a dirty grey effect on the red make-up of the faces. In order to achieve a subtle transition from white to red and to create a sunny coloured illumination, a number of yellow lamps are often added. (Weil 1904, 94)

Weil further describes how a four colour system (red, yellow, green, blue and white) was used on a cyclorama before 1904:

> On the background cloth which represents the horizon, the peculiar pale yellow stripe of dawn appears, which also in nature, as here, brightens to an ever more intense yellow as the lamps are switched on, which then changes to orange and finally to red. The point on the horizon where the sun is to rise is very carefully illuminated with yellow, red and white lamps when the sun rises on the stage. Yellow, red and white are then strengthened in the overhead and backdrop lamps, blue and green are weakened until the whole stage shines in red and yellow. … Now the white light is suddenly engaged and the sun's disk is raised….At sunset, the reverse is done. (238-9)

Fortuny used in essence three colours (red, yellow, blue and white), though they could not be arbitrarily mixed, in the design engineered by AEG in 1907.

However the massive early Schwabe cyclorama arc luminaires shown in Figure 35 appear to have had colour rails for only three filters (colours undisclosed plus of course open white). The later design shown in Figure 38 carried five colours, red, yellow, “moonlight”, light and dark blue plus white. Kranich reported the single colour cyclorama luminaires shown in Figure 51 are routinely grouped in five to seven colours, typically red, yellow, green, and three shades of blue (Kranich 1933).

Both the Schwabe and AEG colour changing cyclorama luminaries were more limited in range. The devices in Figure 51 (d) and (f) with four slides were three colours plus white and dimming shutter (Engel 1926). Even by 1956, the AEG system shown in Figure 54 offered just red, yellow, light and dark blue plus white and a dimming shutter. Schwabe’s c.1913 acting area lights also had only two colours (yellow, green and white), with their use described:

> These lamps are also best mounted in a three-colour system so that all moods can be achieved. For daylight scenes, yellow and white are used, for evening scenes yellow alone, and for night or moonlight scenes green. (*Moderne Bühnenbeleuchtung* c.1913)

While Schwabe and others were attempting to synthesise coloured stage light from mixed primary sources, the problem of competing primary colour theories was compounded by the difficulty in obtaining a useful range of colours filters that could withstand the heat of luminaires. Schwabe’s first multi-luminaire cyclorama system shown in Figure 36 offered four colours, probably red, yellow, moonlight blue and deeper blue, claiming a “pure blue colour by using suitable azure-blue glasses in rare, natural beauty” (*Moderne Bühnenbeleuchtung* c.1913).

Eventually Schwabe adopted the seven colour approach of the classic system shown in Figure 20 with glass filters in red, yellow, green, daylight blue, light blue, middle blue and dark blue, though the 1921 catalogue permits an alternate six colour system deleting red (*Moderne Bühnenbeleuchtung* 1921; Ridge 1928).The six colour system was supplied to Stockholm Opera, with the missing red colour used in the ground lighting trolleys (Bergman 1977).

Schwabe's 1921 catalogue provided a comprehensive idea of the coloured atmospheric effects that could be achieved:

> The colour filters in front of the lamps have six to seven different shades: white, dark blue, dark blue-green, light blue-green, light yellow, orange and, where deemed necessary, red. This gives the lighting designer a palette with which he can paint any mood on the artificial sky.
>
> If the dark blue group is allowed to shine fully, the spectator sees the sky as a powerful blue mass, as nature produces on beautiful summer days. When darkened, the same lamps give a richly coloured night sky. With dark blue-green radiation, a brighter, very deep daytime air perspective is created. Switching on resistors leads to a greenish-blue moonlight sky. A suitable mixture of the two groups mentioned, which is different on both sides, produces a sky with a colour transition instead of a uniformly coloured sky, as occurs, for example, when the sun is low in the sky. The cheerful spring sky is distinguished by the light blue-green colour group. In the darkened state, it again gives a moonlit sky of special colouring.
>
> The white, which can be used to brighten the overall impression of light, can alone, if muted, represent the uniformly overcast, whitish-grey bad-weather sky. The following occurs as a result. The low glow of the lamp filaments gives rise to red tones that lead over to twilight. The reddening of the sky is emphasised even more when orange tones are mixed in. By adjusting the settings appropriately, blue can gradually be drawn in to violet. The final red of the sinking sun can be given directly by the red colour group, which, mixed with yellow, produces a splendid, very strong orange tone. Over stylised scenes a pale yellow sky is often very suitable, such as does not occur in nature. There are no demands on the illuminator that he cannot meet with some skill on the artificial sky. (*Moderne Bühnenbeleuchtung* 1921)

By 1926 Engel reported that the standard stage glass filters were: "water blue, light blue, medium blue, optical blue, dark blue, violet blue, green blue, green, yellow and red" (Engel 1926, 70). Engel also provided transmission characteristics of three standard glass filter colours that presumably were used in cyclorama lighting, overlaid in Figure 64. It can be seen from this that the very narrow spectral range of the glass filters meant that any attempt to use them in a basic red/green/blue tri-colour system would result in a range of spectral colour tones which could not be resolved. It is thus quite logical and inevitable that a number of different colour glass filters had to be used to achieve a wide gamut of colour. It can also be seen how poor the light transmission was. This, combined with the low blue content of incandescent lamps, clearly demanded a large number of blue filtered lamps.

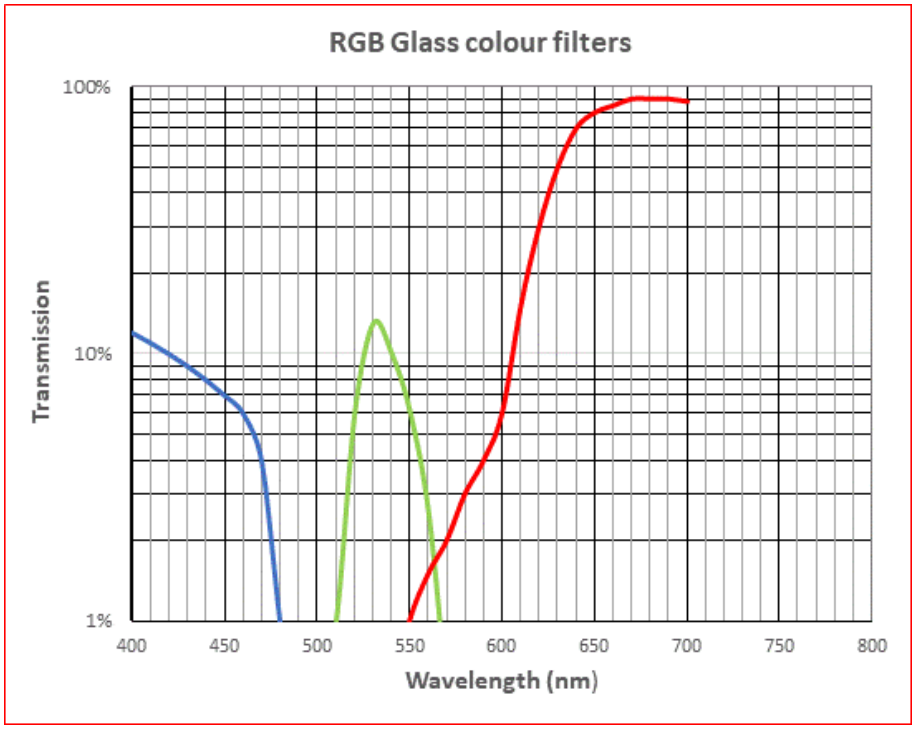


Figure 64. Red, Green and Blue glass filter light transmission. (Engel 1926, Fig 49-51)

The range of colours offered by gelatine filters was much wider, with better transmission values, but their heat intolerance meant they could not be used with gas-filled lamps. By 1926 Siemens had developed a series of acetyl cellulose colour filters[103] called “Cellon” coated with the same tar dyes as gelatine filters, now better able to withstand the heat of gas-filled lamps (Engel 1926; Johannsmeyer 1941). Initially the four standard Siemens colours were termed Sky blue or “Vericolor” (a light blue), Moon green, Sun yellow and Sunset red. The transmission maxima were respectively 482, 500, 590, 620 nm.

This arrival of polymer filters with broader colour transmission, less loss and good heat stability enabled wider adoption of a four-colour (light and dark blue, yellow and red) system. This was implemented in either the AEG style of remote controlled colour filters such as in Figure 54 or the “British” system of individually coloured red, green and blue (sometimes also light and dark blue) floods, causing the eventual demise of the seven colour Schwabe system. By 1935, Ridge and Alfred declared the Schwabe horizon system obsolete, either colour-mixing battens or flood arrays being more effective (Ridge and Aldred 1935).

An interesting observation occurs from the Schwabe seven colour system. Any attempt to portray a colour using three primary colours always fails to provide the full gamut of human discernible colours. This is both due to the need to use primary sources with reasonable efficiency of detection, plus the fact that just three primaries is never actually enough, since the eye performs a non-linear matrix analysis of its tricolour sensors. For example, the sRGB primaries used in modern digital displays are plotted in the CIE 1931 colour space in Figure 65, from which the only displayable colours using these primaries are those within the sRGB triangle.[104]

---

[103] Actually manufactured by Rheinisch-Westfälischen Sprengstoffwerken and later sold by other lighting suppliers (von Sander 1930). In 1930 after a scare due to confusion with the much more flammable celluloid, the Hamburg Fire Dept declared it fire-safe (Sander 1930).

[104] The colours perceived in Figure 65 will also be further restricted due to the colour limitations of printing and computer displays.

Using the colour notes and peak wavelengths of the various glass colours given by Engel and Ridge, the seven Schwabe colours are also plotted in Figure 65 by the X symbols in their estimated positions (Engel 1926; Ridge 1930). From a linear addition of any mixture of these, it can be seen that the colour gamut potentially accessible to Schwabe users was probably in excess of modern computer displays. In practice of course, the low blue light content and red colour shift of dimmed tungsten lamps limited that. This analysis also illustrates the reason modern colour tuneable LED luminaires also need more than three primaries to achieve the full gamut of human detectable colour.

In the era of Schwabe & Co. colour science was still in its infancy and the science behind Figure 65 was unknown. Their development of a system capable of a wide gamut of colour came solely from empirical adding of yet more colours around the colour circle. It was thus not in itself a scientific achievement (Newton had long ago demonstrated that adding all the rainbow colours together reconstituted white), but was certainly the result of technical diligence and best application of knowledge of that time. It also particularly demonstrated the strong and artistic understanding in Schwabe & Co. of the needs of theatre.

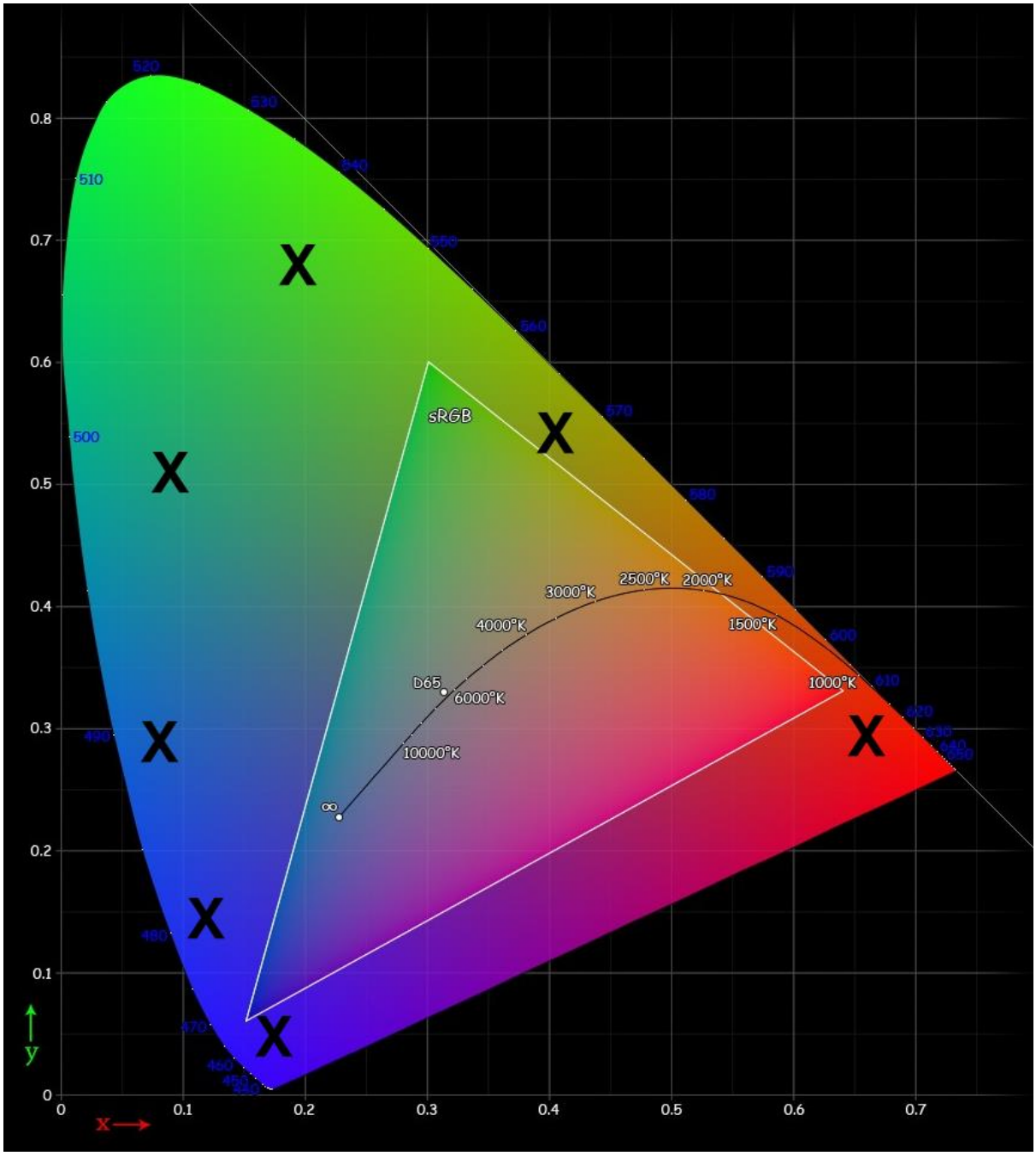


Figure 65. CIE 1931 Colour space, with sRGB primaries and estimated Schwabe seven colour sources (X).

19. Conclusion

The artist Herkomer wrote in 1892: “By means of absolute control of the lights we arrive at mystery, and without mystery the very backbone of scenic-art would be broken” (Herkomer 1892). Despite early work by such as Herkomer and avant-garde dramatist Craig, British dramatic art made little progress during the early 20th century. Meanwhile revolutionary stagecraft and stage lighting was already being forged in Germany. Basil Dean was one of very few British producers who recognised this, noting that many of the spectacular performances relied on large and realistic cyclorama skies. He doubtless hoped that importing the technology, together with coining the Schwabe-Hasait name from two key German technicians, would enhance his productions. However Dean remained still stuck in the British commercial theatre world and failed to instigate major change.

But in Germany, Hasait considered that German stagecraft led the world as a result of reforms after the Vienna Ring Theater fire, benefiting from expert stage technicians such as the Brandt and Mühldorfer families, while foreign theatres had merely “carpenters” (Hasait 1932). This leadership continued well into the 20th century, with further generations of very skilled professionals such as Hasait himself, Linnebach, Kranich (junior and senior) and Unruh who all managed, consulted and taught German stage technology. Further the skilled engineers in the suppliers, responded readily to meet the needs of demanding new producers such as Reinhardt. All this was reinforced by the early formation of a German technical stage association, Deutschen Theatertechnischen Gesellschaft in 1907 with regular journals and meetings to spread best practice. It took another 53 years for comparable organisations to appear in Britain and USA.

The work of Fortuny, Reinhardt, Appia, Craig, Wagner and many others revolutionised acting, scenography and lighting, especially in Germany, with technical developments by Schwabe and Hasait important enablers of the change. By following back along both their paths, it is possible to trace how the evolution of the technology supported dramatic styles, as they changed from naturalism through realism to expressionism.

In addition to a new expression in drama, it can be no surprise that Wagner’s country also strived endlessly to achieve the scenography envisaged in his epic operas. In 1922 Macgowan and Jones wrote:

> If light ... can do no more than signal the downfall of evil or set Valhalla glowing in the heavens, it will take a place in the theater that no other product of inventive ingenuity can reach. Light, at the very least, is machinery spiritualized. (Macgowan and Jones 1922, 80)

A century later modern lighting technology offers us the scenic images that Macgowan and Jones prophesised and Wagner dreamed of, for example as recently interpreted by Schneider-Siemssen in Figure 66.

Figure 66. *Das Rheingold*, designer Günther Schneider-Siemssen, New York Metropolitan Opera, 2009. (Bergman 2009)

Appendix: Basil Herbert Dean MBE, CBE

Basil Dean (1888–1978) was an actor, writer, theatrical and film producer/director. Born in Croydon he was originally intended for diplomatic service. However the family firm's bankruptcy meant university became unaffordable, and after a failed attempt to study analytic chemistry, initially worked in the City (Dean 1925, 1970). Involved in amateur dramatics, he resolved to go on the professional stage himself, first appearing in Cheltenham in 1905. In 1907 Dean joined Annie Horniman's Gaiety Theatre in Manchester, leaving in 1911 to become the first Director of the new Liverpool Repertory Theatre. In 1913 he joined Herbert Beerbohm Tree at His Majesty's Theatre in London, before becoming involved in war entertainment. On the outbreak of WWI Dean joined the Cheshire regiment. By 1917 he had risen to the rank of captain and the directorship of the entertainment branch of the Navy and Army Canteen Board, controlling fifteen theatres and ten touring companies.

After the war's end in partnership with wealthy Liverpool friend Alec Rea, he formed ReandeaN in 1919 as an ensemble company of permanently engaged actors and took a lease on the London St Martin's theatre. The company logo "Histrion" is shown in Figure 67. Plays were also presented in several other London theatres. While Rea (and his wife) was also enthusiastic for the stage the artistic force was Dean, acting as both Producer and Director. In 1923, in addition to introducing his new Schwabe-Hasait system, Dean also launched the "Play-Box" scheme to present new writings and develop fresh actors, through a series of matinee productions on otherwise dark stages. The next year Dean became joint managing Director of Drury Lane Theatre with an ambition to make it Britain's first National Theatre, but which came to nothing. The increasingly estranged Rea brought in a new General Manager in 1926 leaving Dean isolated, thus Dean resigned and ReandeaN was dissolved a year later.

Figure 67. ReandeaN's playbill logo Histrion.

With other financial partners, Dean staged further productions including Priestley's *Johnson over Jordan* with music by Britten in 1939, but the rise of "talkies" had already lured Dean into film production. In partnership with Reginald Baker he founded Associated Talking Pictures Ltd in 1929, which later became Ealing Studios, supporting working class artists such as Gracie Fields and George Formby. At the outbreak of WWII he returned to wartime entertainment, creating E.N.S.A. (Entertainments National Service Association) and become its Director General. Dean was awarded an MBE in 1918 for his WWI entertainment work, and a CBE in 1947 for his E.N.S.A. services. After WWII he returned to the theatre, presenting a few new plays though mostly reviving earlier successes. Ian Bevan described Dean's character:

> A complete man of the theatre - arrogant, opinionated, rude, intolerant, but creative, perceptive, supportive to new writers and, reflecting his original training as an analytical scientist, keen-eyed for detail and relentless in his pursuit of perfection. (Chambers 2003, 198)

He wrote a two volume autobiography, a book on the E.N.S.A. experience and a number of theatrical journal and newspaper articles. He left his extensive personal papers to the University of Toronto, later purchased by the John Rylands Library, Manchester University. However there is no independent biography to put his personal recollections into perspective. He married and divorced three times and had three sons and one daughter (Roose-Evans 2017; Dean 1970, 1973).

Figure 68. Basil Herbert Dean, 1969. (Argent 1969)

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References

"1878: The differential arc lamp." In. 2021. edited by Siemens plc. https://new.siemens.com/global/en/company/about/history/technology/home-appliances-and-lighting-technology/lighting-technology.html (accessed 31/dec/2020).

"Cockaigne". 1923. "A London Letter - Lighting and Basil Dean." In *The Billboard*, 44. New York: The Billboard Publishing Company.

Abney, William De Wiveleslie, and Edward Robert Festing. 1886. "XII. The Bakerian Lecture - Colour photometry." *Philosophical Transactions of the Royal Society of London* 177:423-456. https://doi.org/doi:10.1098/rstl.1886.0013.

"AEG Bühnenbeleuchting (Catalogue)." In. 1956. edited by AEG. Germany.

Ahnert, W., and W. Schmidt. 1980. *Akustik in Kulturbauten*. Vol. 1, *Technische Grundlagen für den Neubau und die Rekonstruktion von Kulturbauten*. Berlin: Institut für Kulturbauten.

anon. 1931. "The Passing Pageant: Ebb and Flow in "Grand Hotel"." In *The Illustrated Sporting and Dramatic News*, 35. London.

Appia, Adolphe, and Marie Louise Bablet-Hahn. 1986. *Adolphe Appia - Œuvres complètes: édition élaborée et commentée par Marie L Bablet-Hahn, Tome 2 (1895-1905)*. 4 vols. Vol. 2 (1895-1905). Lausanne: L'Age d'Homme, .

Applebee, L. G. 1935. "A Cavalcade of Stage Lighting." *The Journal of Good Lighting*:69-82.

———. 1946. "The Evolution of Stage Lighting." *Journal of the Royal Society of Arts* 94 (4723):550-563.

Argent, Godfrey. 1969. "Basil Herbert Dean." In, x13344 © Copyright National Portrait Gallery. London.

Bablet, Marie- L. 2009. "Review: Adolphe Appia, Theatre Artist. By Richard C. Beacham. Cambridge: Cambridge University Press, 1987." *Theatre Research International* 14 (1):96-99. https://doi.org/10.1017/S0307883300005678.

Balme, Christopher. 2003. "Fuchs, Georg." In *The Oxford Encycopedia of Theatre and Performance*. Oxford: Oxford University Press.

Barón-Nusbaum, Brandin 2013. "Forgotten Wizard: The Scenographic Innovations of Mariano Fortuny." In *Theatre, Performance and Analogue Technology- Palgrave Studies in Performance and Technology*, edited by Kara Reilly, 73-93. London: Palgrave Macmillan.

Baugh, Christopher. 2013. *Theatre Performance and Technology - The Development and Transformation of Scenography*. 2 ed, *Theatre and Performance Practices*: Palgrave Macmillan.

Baumann, Carl-Friedrich 1988. *Licht im Theater: von der Argand-Lampe bis zum Glühlampen-Scheinwerfer*. Stuttgart : : F. Steiner, Verlag Wiesbaden, .

Bay, Howard, Clive Barker, and George C Izenour. 2023. *The influence of Appia and Craig*. https://www.britannica.com/art/theater-building/The-influence-of-Appia-and-Craig (accessed 10 August 2023): Encyclopedia Britannica.

Beleuchtung System Fortuny G.m.b.H. c.1911. *Bühnenbeleuchtung System Fortuny*. Berlin: Allgemeine Elektricitätsgesellschaft (AEG).

Bentham, Frederick Percy. 1982. "Famous Strand jobs of the past, or I was there." In *Tabs*, 20-22. London: Rank Strand Electric Ltd.

———. 1984a. "Joe Davis - The Pioneer." *Cue* 30:8-9.

———. 1984b. "Odd Enough or Down in Ringmer Someone Stirred." In *Cue Theatrical Review*, 13-16. Faringdon, Oxfordshire: Tymham Publishing ltd.

———. 1992. *Sixty Years of Light Work*: Strand Lighting.

Bergman, Beth. 2009. "*Das Rheingold*, Guenther Schneider-Siemssen, ." In. http://theoperalenz.blogspot.com/2015/06/guenther-schneider-siemssen.html RHEIN868_0420FB.jpg (accessed 6/jan/2021): © copyright B. Bergman.

Bergman, Gösta Mauritz. 1977. *Lighting in the Theatre*. Stockholm: Almqvist & Wiksell International.

Berlin Address Directories. 1799-1970. https://digital.zlb.de/viewer/cms/141/ (accessed 20-11-2020) ed. Berlin: Zentral- und Landesbibliothek.

Bertenshaw, D. R. 2020. "The standardisation of light and photometry – A historical review." *Lighting Research & Technology* 52 (7):816-848. https://doi.org/10.1177/1477153520904755.

"Besprechungen: "Moderne Bühnenbeleuchtung"." 1921. *Bühnentechnische Rundschau* 1921 (6):5.

Bogusch, George E. 1972. "Norman Bel Geddes and the Art of Modern Theatre Lighting." *Educational Theatre Journal* 24 (4):415-429. https://doi.org/10.2307/3205935.

Booth, Michael R. 1995. *The Oxford Illustrated History of the Theatre: Nineteeth Century Theatre*. Edited by John Russell Brown: Oxford University Press.

Brandt, Fritz. 1912. "A Rigid Arch-like Stage Background." In *GB191214099A*, edited by UK Patent Office. UK.

Bühnenbeleuchtung (Catalogue). c.1960. Berlin: Reiche & Vogel Leuchtkunst KG.

"Bühnentechnische Rundschau Archive." In. 1903-2018. Berlin: http://89.1.94.108:5678/desktop/ (accessed 2/10/2023).

Carnegy, Patrick. 2006. *Wagner and the Art of Theatre*. New Haven, USA: Yale University Press.

Carter, Huntly. 1914. *The Theatre of Max Reinhardt*. New York: Mitchell Kennerley.

Chambers, Colin. 2003. *The Continuum Companion to Twentieth Century Theatre*. London, UNITED KINGDOM: Bloomsbury Publishing Plc.

Cheney, Sheldon. 1928 (reprinted 1966). *Stage Decoration*. New York: B. Blom.

Chisholm, Cecil. 1934. *Repertory: an Outline of the Modern Theatre Movement*. London: Peter Davies Ltd.

Chit Chat. 1923. "At the Queens." In *The Stage*, 12. London.

"Chronik der DTHG." In. 1931. https://chronik.dthg.de/timeline-post/1931/ (accessed 6-nov-2020): Die Geschichte der Deutschen Theatertechnischen Gesellschaft.

Cleugh, James 1921. *Charles Blake Cochran - Lord Bountiful*. London: Pallas Publishing Co Ltd.

"Coat of arms of Germany." In.: https://en.wikipedia.org/wiki/Coat_of_arms_of_Germany (accesed 22-nov-2020).

Commune di Venezia. 1978. *Immagini e Materiali del Laboratorio Fortuny*. Venice: Marsilio Editori.

Cornelia Ernst Architekten. 2020. "dt2_buehnengalerie2." In, https://www.ernst-architekten.de/wp-content/uploads/2018/2009/dt2012_buehnengalerie2012.jpg (accessed 2012-dec-2020). Berlin.

Craig, Mary W. 2015. "Max Reinhardt: the father of theatre direction." https://marywcraig.com/2015/03/01/max-reinhardt-the-father-of-theatre-direction/ (accessed 25/1/2023).

Davis, W. Eugene. 2001. "Oscar Wilde, Salome, and the German Press 1902-1905." *English Literature in Transition, 1880-1920* 44:149-180. https://doi.org/https://muse.jhu.edu/pub/74/article/366646.

de Jonge, Alex. 1978. "Technic Technic über alles." *Tabs* 36 (3):18-19.

Dean, Basil Herbert. 1911. "The Theatre in Germany. Hasty Impressions." In *Liverpool Post and Mercury*, 9. Liverpool.

———. 1922. "'The Actor And His Workshop'. Lecture delivered at the Victoria and Albert Museum during the International Theatre Exhibition. July 1922. ." In. London: Basil Dean Archive at the John Rylands Library, University of Manchester, record 12/1/16.

———. 1924. "*A Midsummer Night's Dream*: Rough Lighting Requirements." In *Basil Dean Archive*, edited by University of Manchester - John Rylands Research Institute and Library, 1-6.

———. 1925. "Who's Who in the Theatre, A Biographical Record Of The Contemporary Stage." In, edited by John Parker, 243-244. Boston: Small, Maynard & Company, Inc.

———. 1926. "Stage Storms." In *Daily Mail*, p8. London.

———. 1960. "Lighting." In *The Stage*, 19.

———. 1962. "Recollections and Reflections." *Tabs* 20 (3):5-23.

———. 1970. *Seven Ages: An autobiography, 1888-1927*. London: Hutchinson & Co.

———. 1973. *Mind's Eye: An autobiography, 1927-1972*. London: Hutchinson & Co.

———. 1974. "Recollections and Reflections - I." *Sightline* 8 (2):38-43.

———. 1975a. "Recollections and Reflections - II." *Sightline* 9 (1):38-42.

———. 1975b. "Recollections and Reflections - III." *Sightline* 9 (2):35-39.

Dean, Basil Herbert, and A. D. Peters. 1924. "Debate: Colour and Light / A Rejoinder." In *The Daily Telegraph*, p13. London.

"Der Wolkenapparat im Vogtlandtheater Plauen." In. 2013. Germany: Vogtlandtheater Plauen.

Desprez, Frank. 1913. "An R. A.'s Ideas on Scenery." In *The ERA*, 1.

Desvaux, Delphine, and Laure Stasi. 2003. "Les innovations scéniques de Mariano Fortuny à l'hôtel de Béhague: une scène idéale?" *Histoire de l'art*:103-112.

Deutsches Institut für Normung. 1952. "Einheitliche Benennungen für theatertechnische Begriffe (Uniform terms for theatre technology) DIN 56920." *Bühnentechnische Rundschau* 1952-03:16.

"Die Köpenicker Straße 116." https://www.köpenicker-strasse.de/Koepenicker116.html (accessed 18/1/2023).

"Die Notbeleuchtung im Theater." 1911. *Lichtbild Bühne* 4 Jahrg, (6):3.

DiLaura, David L. 2006. *A History of Light and Lighting: In Celebration of the Centenary of the Illuminating Engineering Society of North America*: Illuminating Engineering Society of North America.

Downs, Harold. 1951a. *Theatre and Stage : an encyclopædic guide to the performance of all amateur dramatic, operatic, and theatrical work - Vol 1*. Vol. 1.

———. 1951b. *Theatre and Stage : an encyclopædic guide to the performance of all amateur dramatic, operatic, and theatrical work - Vol 2*. Vol. 2.

Dukes, Ashley. 1925. "The Stage of the Day." In *The Illustrated Sporting and Dramatic News*, 34. London.

Eckart, Hubert 2021a. "1918-1920: Wiederaufbau der Theaterlandschaft." *Deutsche Theatertechnische Gesellsschaft* https://podium.dthgev.de/dthg-vor-100-jahren-1918 (accessed 21/1/2023).

———. 2021b. "1920: Die Berufsgruppe der Technischen Angestellten." *Deutsche Theatertechnische Gesellsschaft* https://podium.dthgev.de/dthg-vor-100-jahren-1920 (accessed 21/1/2023).

Eisenman, Harry J. 1967. "Charles F. Brush: Pioneer Innovator in Electrical Technology." Case Western Reserve University (PhD).

Emden, Walter, Baron Friedrich Podmaniezky, and John Leighton. 1888. "Theatres and Fireproof Construction." *The Journal of the Society of Arts* 36 (1836):221-240.

Engel, Alfred von. 1926. *Bühnenbeleuchtung*. Leipzig: Verlag Von Hachmeister & Thal.

"Equipment Detail Patt. 34 (1924-1945)." In. 1924. https://www.theatrecrafts.com/pages/home/archive/equipment/detail/?id=1034 (accessed 25/april/2021): Backstage Heritage Collection.

"ESPACENET." In. 2023. https://worldwide.espacenet.com.

"ESPACENET - Hasait's patents." In. 2023. ESPACENET: https://worldwide.espacenet.com/patent/search?q=ia%20all%20%22hasait%22%20AND%20pd%20within%20%221912-1935%22.

Esslin, Martin. 1995. *The Oxford Illustrated History of the Theatre: Modern Theatre 1890-1920*. Edited by John Russell Brown: Oxford University Press.

Eversmann, Peter G. F. . 2007. "The International Theatre Exhibition of 1922 and the Critics." In *Avant-Garde and Criticism*, edited by Klaus Beekman and Jan de Vries, 67-90. Amsterdam, New York: Brill / Rodopi.

Fagan, James Bernard. 1919. "The Art of Stage Lighting." *The Illuminating Engineer - Transactions of the Illuminating Engineering Society (London)*:117-133.

Fletcher, J. Y, (Director). 1922. The General Electric Co. Ltd respecting Schwabes Stage Lighting System. . Basil Dean Archive in The John Rylands Library, University of Manchester., 5th September.

"Fortuny Dome at Rue St Charles, Paris." In. 1902. https://www.fortuny.shop/blog/mariano-fortuny/the-fortuny-dome-a-revolution-in-the-theatre/ (accessed 9/june/2021): © Fondazione dei Musei Civici di Venezia - Fortuny Museum.

Fortuny Ltd. 2019. "Mariano Fortuny's youth among art and inventions." In, 3. https://www.fortuny.uk/blog/mariano-fortuny-en_in/mariano-fortunys-youth-among-art-and-inventions/ (accessed 11/9/2023): Fondazione Musei Civici di Venezia.

Fortuny, Mariano. 1901. "Improvements in Stage Illumination and the Production of Scenic Effects." In *GB1901-08113A*. UK Patent Office.

———. 1904a. "Système d'éclairage en lumière diffuse." In *FR339140A*, edited by French Patent Office, 3. France.

———. 1904b. "Système de constitution d'une paroi concave au moyen d'une capacité gonflable." In *FR341952A*, edited by French Patent Office, 6. France.

———. 1905. "Système de constitution d'une paroi concave au moyen d'une capacité gonflable." In *FR4676E*, edited by French Patent Office, 6. France.

———. 1906. "Fotografia dello spettacolo inaugurale al Teatro di Béarn, ." In. Venice: https://artsandculture.google.com/exhibit/palazzo-fortuny/ywIitKyiz6dcIw?hl=en

(accessed 14/10/2021) Museo Fortuny © Photo Archive - Fondazione Musei Civici di Venezia.

Frank, Dieter. 2015. *Zur Entwicklung der Bühnenbeleuchtung*. Bonn, Germany: DTHG-Schriftenreihe.

———. 2021a. Schwabe-Hasait-Cyclorama. Personal communication, 20 June.

———. 2021b. To the “Schwabe - Hasait - Tuch” for the panorama. Personal communication, 29 July.

———. 2022. News (regarding Hasait and Kelle & Hildebrandt). Personal communication, 11 october.

Fuchs, Theodore. 1929. *Stage Lighting*. Boston: Little, Brown and Company.

Fuerst, Walter René, and Samuel James Hume. 1928a. *XXth Century Stage Decoration, Vol 1*. Vol. 1. London: Alfred A. Knopf.

———. 1928b. *XXth Century Stage Decoration, Vol 2: The Illustrations*. Vol. 2. London: Alfred A. Knopf.

Fuso, Silvio. 2021. "Piccola chiosa a ‘orizzonte senza paesaggio’." *HoperAperta* (https://www.hoperaperta.com/ha-mag-2-a-proposito (accessed 3/10/2021)).

Fuso, Silvio, and Sandro Mescola. 1978. "Il Laboratorio Fortuny." In *Immagini e materiali del Laboratorio Fortuny*, 11-29. Venice: Marsilio editori.

Gibbons, Stella. 1932. *Cold Comfort Farm*. London: Longmans Green and Co.

Goethe, Johann Wolfgang von. 1809. "Farbenkreis zur Symbolisierung des menschlichen Geistes- und Seelenlebens (Colour circle to symbolize the human spirit and soul)." In. Frankfurt: Frankfurt Goethe Museum.

———. 1810 (trans 1840, reprinted 1970). *Theory of Colours (translated by Charles Lock Eastlake)*: John Murray (London), Reprinted MIT Press (Cambridge Massachusetts).

Grange, William. 2004. "The Theatrical Concession System in Prussia, 1811-1869." *Faculty Publications and Creative Activity, School of Theatre and Film* 7 (https://digitalcommons.unl.edu/theatrefacpub/7/ (accessed 14/8/2021)):28-42.

Grein, Jacob Thomas. 1921. "The World of the Theatre." In *The Illustrated London News*, 274. London.

———. 1923. "The World of the Theatre - The Play-Box at the Sta. Martin's Theatre." In *The Illustrated London News*, 428. London.

———. 1924. "The Fortune Theatre." In *The Illustrated London News*, 824.

Groom, Lester. 1926. "A Discussion on Stage Lighting." *The Illuminating Engineer - Transactions of the Illuminating Engineering Society (London)*:101-119.

Ha. 1922. "Beleuchtung und Heizung - Moderne Bühnenbeleuchtung (Schwabe)." *Elecktrotechnische Zeitschrift* 29:970.

Halliday, Robert. 2020. "classic gear - Schwabe-Hasait seven-colour system." *Lighting and Sound International* (399):76.

Hansing, Friedrich, and Walter Unruh. 1942. *Hilfsbuch der Bühnentechnik*. Berlin: Wilhelm Limpert - Verlag.

Hartmann, Louis. 1930 (repr 1970). *Theatre Lighting - A Manual of the Stage Switchboard*. New York: DBS Publications.

Hasait, Max. 1917. "Die Beleuchtung im Rundhorizont." *Bühnentechnische Rundschau* 1917 (1):1-3.

———. 1921. "Rundhorizontlaufbahn fuer Theater- und Filmbuehnen." In *DE342397*, edited by German Patent Office, 9. Germany.

———. 1922a. " Improvements in means for representing optically scenery and other objects on stages or the like." In *GB178413A*, edited by GB Patent Office, 3. UK.

———. 1922b. "Track Rail for Curved Stages." In *US1,435,390*, edited by US Patent Office, 9. USA: Aktiebolaget ARS.

———. 1930. "Neuere Einrichtungen zur Ausleuchtung des Rundhorizontes." *Bühnentechnische Rundschau* 1930 (5):16-17.

———. 1932. "Die Bühnentechnik im Auslande." *Bühnentechnische Rundschau* 1932 (3):20-24.

Hasse, von H. 1936. "Vorbühnen- und Horizontbeleuchtung des Deutschen Opernhaus." *Elektrotechnische Zeitschrift* 20:555-557.

Herkomer, Hubert von. 1889. "The Pictorial Music-Play: 'An Idyl'." *The Magazine of Art* (1889):316-324.

———. 1892. "Scenic Art I & II." *The Magazine of Art*:259-264, 316-320.

———. 1892,. "Lecture on Scenic Art at The Avenue Theatre, London." In *Sydney Morning Herald, from London Daily Telegraph*, 6.

Herzfeld. 1911. "First Night of Rosenkavalier (Creatives group photograph)." In. Dresden: © Copyright Alamy.

Hopkins, Albert A. 1897. *Magic: Stage Illusions and Scientific Diversions including Trick Photography*. London: Sampson Low, Martson and Company.

Irlam, Geoffrey A. 1989. "Electricity Supply at Cragside." *Industrial Archaeology Review* 11 (2):187-195. https://doi.org/10.1179/iar.1989.11.2.187.

Izenour, George C. 1988. *Theater Technology*. New York: McGraw Hill.

Jahn, Ewald W. 1930. "Die Horizontbeleuchtung." *Bühnentechnische Rundschau* 1930 (5):14-16.

Jansson, Amanda. "Armas Järnefelt i Sverige (Armas Järnefelt in Sweden)." *https://docplayer.se/4893329-Armas-jarnefelt-i-sverige-introduktion.html (accessed 4-dec-2020),*:43-44.

Johannsmeyer, F. 1941. "Die Entwicklung de elektrischen Bühnenbeleuchtung." *Siemens-Zeitschrift* 21 (Jan/Feb):16-25.

Jones, Edward Walter. 1911. "Electric Arc Lamps." University of Illinios, USA.

Kahane, Henry. 1975. "Max Reinhardt's Total Theatre: A Centenary Lecture." *Comparative Literature Studies* 12 (3):323-337.

Kelly, D. 2006. "Covent Garden cyclorama floods." In. http://www.theatrearts.biz/RoyalOperaPhotos.html (Cyclorama.jpg) (accessed 1-june-2021): Illuminati Creative Arts © copyright.

Konstantinakou, Panayiota. 2002. "Proto-Modernistic Scenography; Technology and Aesthetics." Glasgow University (MPhil).

Kranich, Friedrich. 1929. *Bühnentechnik der Gegenwart. Band 1*. 2 vols. Vol. 1. Munich: Verlag von R. Oldenbourg.

———. 1933. *Bühnentechnik der Gegenwart. Band 2*. 2 vols. Vol. 2. Munich: Verlag von R. Oldenbourg.

Kruse, Max. 1902. "Bühnenbild für die Salome von 1902 von Max Kruse. Regie Hans Oberländer und Max Reinhardt." In, edited by G17848. Theaterwissenschaftliche Sammlung (Theatre Studies Collection), University of Cologne.

Krzeszowiak, Tadeusz 1986. "Historische Entwicklung der Bühnenbeleuchtung, Teil 2." *Bühnentechnische Rundschau* (5):19-22.

Kummer, Friedrich 1913. *Das Neue Königliche Schauspielhaus Dresden – Erbaut von William Lossow und Max Hans Kühne*. Darmstadt: Verlags-Anstalt Alexander Koch.

Kunze, Lisa. 2001. *Von Dresden nach Otjiwarongo*. Windhoek, Namibia: Kuiseb Verlag.

Kvam, Wayne. 1988. "The Nazification of Max Reinhardt's Deutsches Theater Berlin." *Theatre Journal* 40 (3):357-374. https://doi.org/10.2307/3208325.

Leonhardt, E. R. 1885. "Das Neue Königliche Opernhaus im Budapest." *Zeitschrift des Österreichischen Ingenieur und Architekten-Vereins* 1:1-10, Tafel I-V.

Leyko, Małgorzata 2014. "Reinhardt reżyseruje Shakespeare'a (Reinhardt Directs Shakespeare)." *Pamiętnik Teatralny* (3):66-85.

"The Little Minister Back Again." In. 1923. *TRUTH*, 833.

Lokker, J. C. 1963/64. "Fifty Years of the Gas-Filled Lamp." *Philips Technical Review* 25 (1):2-15.

"The London Coliseum's Revolve and Lighting Installation on its opening in 1904." 2022. http://www.arthurlloyd.co.uk/LondonColiseumRevolve.htm (accessed 19/5/2022).

"The London Coliseum, St. Martin's Lane, 1904." 2022. http://www.arthurlloyd.co.uk/LondonColiseum.htm (accessed 19/5/2022).

Lovibond, Joseph W. 1915. *Light and Colour Theories, and their Relation to Light and Colour Standardization*. London: W. & F. N. Spon Limited.

Macgowan, Kenneth. 1921. *The Theatre of Tomorrow*. New York: Boni and Liveright.

Macgowan, Kenneth, and Robert Edmond Jones. 1922. *Continental Stagecraft*. New York: Harcourt, Brace and Company.

"Mariano Fortuny invente la première cabine de régie." In. 2020. edited by e-Venise.com. https://www.e-venise.com/art-peintres/mariano-fortuny-invention-premiere-cabine-de-regie-succes-theatral-international-8.html (accessed 6/dec/2020),.

Marshall, Norman. 1947. *The Other Theatre*. London: John Lehmann Ltd.

Marx, Peter W. 2007. "Ein richtiger Wald, ein wirklicher Traum. Max Reinhardts *Sommernachtstraum* 1905." *Forum Modernes Theater* 22/1:17-31.

Matheson, G. A. 1997. "The Basil Dean Archive in the John Rylands University Library." In *Bulletin of the John Rylands Library*, 103-230. University of Manchester - John Rylands Research Institute and Library,.

Maxwell, James Clerk. 1890. "On the Theory of Three Primary Colours (1861)." In *The Scientific Papers of James Clerk Maxwell*,, 662. Cambridge University Press.

Mills, J Saxon. 1923. *Life and Letters of Sir Hubert Herkomer (A study in struggle and success)*. London: Hutchinson & Co.

Modern Stage Lighting. 1923. Edited by General Electric Company (GEC). London: GEC.

Moderne Bühnenbeleuchtung. 1921. Berlin: Schwabe & Co.

Moderne Bühnenbeleuchtung. c.1913. Berlin: Schwabe & Co.

Moderwell, Hiram Kelly. 1914. *The Theatre of To-day*. New York: John Lane Company.

Moncel, Compte Th. du, and Robert Translated from the French by Routledge. 1883. *Electric Lighting*. 2 ed. London: George Routledge and Sons.

Morgan, Nigel. 2005. *Stage Lighting Design in Britain - The Emergence of the Lighting Designer, 1881-1950*. Edited by John Offord. Cambridge: Entertainment Technology Press Ltd.

Morris, J. T. 1916. "Recent Developments in Electric Incandescent Lamps in Relation to Illumination Engineering." *The Illuminating Engineer* IX:6-26.

Morwood, James. 2018. "Richard Strauss's *Salome* and Oscar Wilde's French Text." *The Wildean* (52):63-73.

Mosebach, J. 1937. "Die neue Bühnenbeleutchtunganlage der Grossen Oper in Paris." *Siemens-Zeitschrift* July:384-389.

Munsell, A. H. 1905. *A Color Notation*. Boston: Geo. H. Ellis Co.

NCS ab. 2022. *NCS Teachers Guide*. https://ncscolour.com/product/ncs-teachers-guide/ ed: NCS Colour AB.

NCS Colour ab. 2023. "Our History." *https://ncscolour.com/about/our-history/*.

Neumann, Bauamtmann. 1914. "Der Umbau des Königlichen Opernhauses zu Dresden." *Zeitschrift der Vereines Deutscher Ingenieure* 58 (11+12+13):401-408, 447-454, 494-497.

"New Stage Lighting - The Schwabe-Hasait System." In. 1923. *The Stage*, 24.

Newton, Issac. 1671-2. "A letter of Mr. Isaac Newton … containing his new theory about light and colors." *Philosophical Transactions of the Royal Society* 80:3075-3087.

Nicoll, Allardyce. 1928 (reprinted 1975). *The English Stage, Benn's Sixpenny Library*. London: Ernest Benn.

———. 1966. *The Development of the Theatre*. 5 ed. London: George C. Harrap & Co. Ltd.

Osma, Guillermo de. 2015. *Mario Fortuny, His life and Work*. London: V&A Publishing.

Ostwald, Wilhelm. 1917 (Translated Faber Birren, 1969). *The Color Primer: a basic treatise on the color system of Wilhelm Ostwald*. New York: Van Nostrand Reinhold Company.

Otto, Ulf. 2023. *The Theater of Electricity: Technology and Spectacle in the Late 19th Century*. Stuttgart: Palgrave Macmillan.

Paetow, V. 1909. "Moderne Bühnenbeleuchtung " *Elektrotechnische Zeitschrift* 30+31 (XXX):695-698, 720-724.

Palmer, Scott. 2013. *LIGHT: Readings in Theatre Practice*. Basingstoke, UK: Palgrave Macmillan.

———. 2015. "A 'choréographie' of light and space: Adolphe Appia and the first scenographic turn." *Theatre and Performance Design* 1 (1-2):31-47. https://doi.org/10.1080/23322551.2015.1024975.

Patterson, Michael. 1981. *The Revolution in German Theatre, 1900-1933*. London: Routledge & Kepal Paul Ltd.

———. 2003. "Jessner, Leopold." In *The Oxford Encycopedia of Theatre and Performance*. Oxford: Oxford University Press.

Paysan, Bernhard 2016. "Nachlass der Familie Brandt oder ein flüchtiger Blick in die Geschichte der Theatertechnik." *Die Vierte Wand, Initiative Theatermuseum Berlin, B.V.* 002:4-9.

"People in the Public Eye - Men of Music." In. 1934. *The Sphere*, 149.

Peters, Augustus Dudley. 1923. "Stage Lighting." In *The Daily Telegraph*, p13. London.

———. 1924. "Colour and Light." In *The Daily Telegraph*, p4. London.

Pick, Richard William. 2008. "Herkomer's Legacy to Craig and the New Stagecraft." *The Society for Theatre Research* 62 (3):126-143.

Pilbrow, Richard, Frederick Percy Bentham, Basil Dean, B. Bear, Joe Davis, Bill Loraine, Lew Burroughs, Jack Madre, and Norman Marshall. 1975. "Transcription of a tape recording of a meeting of the Society of British Theatre Lighting Designers discussing the growth of stage lighting in Britain." In, edited by Association of Lighting Designers, 22.

"The Playhouses." In. 1889. *Illustrated London News*, 1, 35. London.

Poetzl, Herbert, and Shelia Weimer. *Finding aid for the Max Reinhardt Archives*. https://archivesspace.binghamton.edu/files/reinhardt-fa.pdf (accessed 2-dec-2020) ed. New York: Special Collections, University Libraries, State Unversity of New York at Binghamton.

Read, Samuel. 1849. "Electra, or the Lost Pleiad." In *Illustrated London News,*, 293. Her Majestys Theatre.

Rees, Terence Albert Ladd. 1978. *Theatre Lighting in the Age of Gas*. London: Society for Theatre Research,.

Reiche, Arthur. 1921. "Projecting Apparatus." In, edited by US Patent Office, 3. USA: Aktienbolaget ARS of Stockholm.

"Reiche und Vogel Leuchtkunst GmbH." 1931. *Bühnentechnische Rundschau* 1931-06:22.

"Reiche und Vogel Leuchtkunst GmbH advertisement." 1937. *Bühnentechnische Rundschau* 1937-03:IX.

Reid, Francis. 2005. *Yesterday's Lights - A revolution reported*: Entertainment Technology Press.

Reinhardt, Max, and Karl Walser. 1905. "Der magische Raum: *A Midsummer Night's Dream*. Stage design model, Neues Theater, Berlin." In, edited by https://www.theatermuseum.at/fileadmin/content/tm/ausstellungen/2017/Der_magische_Raum/12_M_Reinhardt_K_Walser_Sommernachtstraum_W_Shakespeare_c_KHM_Museumsverband.jpg (accessed 26/march/2021). Vienna: KHM-Museumsverband ©

Ridge, Harold C. 1928. *Stage Lighting*: W. Heffer & Sons.

———. 1930. *Stage Lighting*: W. Heffer & Sons.

Ridge, Harold C., and F. S. Aldred. 1935. *Stage Lighting - Principles and Practice*: Sir Isaac Pitman & Sons.

Roose-Evans, James. 2017. "Dean, Basil Herbert (1888–1978), theatre producer." In.: Oxford University Press.

Rorrison, Hugh. 2009. "Designing for Reinhardt: the Work of Ernst Stern." *New Theatre Quarterly* 2 (7):217-232. https://doi.org/10.1017/S0266464X00002189.

Rosenberg, Albert. 1903. *Die Bühneneinrichtung des neuen Cölner Stadttheaters*. Cologne: T. Fuhrman Buch- und Steindruckerei.

Roth, Marc. 2009. "Staging 'The Master's' Works: Wagner, Appia, and Theatrical Abuse." *Theatre Research International* 5 (2):138-157. https://doi.org/10.1017/S0307883300002170.

Rouche, Jacques. 1910. *L'Art théâtral moderne*. Paris: Edouard Cornély & Cie.

Sander. 1930. "Sind Cellonscheiben feuersicher? (Are Cellon discs fire-safe?)." *Bühnentechnische Rundschau* 3:19-20.

"Scene from *A Midsummer Night's Dream*, Her Majesty's Theatre." In. 1900. edited by 2006AH1012.jpg. © Victoria and Albert Museum, London: V&A. https://web.archive.org/web/20160101141229/h.p://www.vam.ac.uk/users/node/8598 (accessed 1-jan-2016).

Schanda, János. 2015. "CIE 1931 and 1964 standard colorimetric observers: history, data, and recent assessments." In *Encyclopedia of Color Science and Technology*, edited by Renzo Shamey, 5. Retrieved 29 December 2019 from: https://link.springer.com/content/pdf/10.1007%2F978-3-642-27851-8_323-1.pdf: Springer Link.

Schenk, Carola. 2015. "Die Bühnenbildentwürfe im Werk von Max Slevogt." Ludwig-Maximilians-Universität.

Schilling, N. H. 1870. "Ueber die Beleuchtung von Theatern I. Das königliche Hof- und National-Theater in München." *Journal für Gasbeleuchtung und verwandte Beleuchtungsarten*:22-33.

Schubin, M. 2016. "The fandom of the opera: how the audience for a centuries-old art form has incubated electrical and electronics technologies [scanning our past]." *Proceedings of the IEEE* 104 (3):673-682. https://doi.org/10.1109/JPROC.2016.2521129.

Schwabe & Co. 1929. "Illumination of the department store KaDeWe in Berlin for the 'Weisse Woche‘' in January , 1929." In *http://www.artnet.com/artists/schwabe-co/illumination-of-the-department-store-kadewe-in-uD6784oJezHIwKrItqEZYQ2 (accessed 23-nov-2020)*.

"Schwabe & Co advertisement." 1930. *Der Kinematograph*:4.

"Schwabe Advertisement." 1930. *Bühnentechnische Rundschau* 1930 (5):27.

Scott, Derek B. 2016. "Silver-Age Operetta: The Power of an Early 20th-Century Transcultural Entertainment Industry." In *Popular Music and Power*, 1-9. Humbolt Universität: Berlin.

Sewig, Rudolf, and M Richter. 1938. *Handbuch der Lichttechnik*. Berlin: Springer-Verlag.

Silvestrini, Narciso, and Ernst Peter Fischer. 2011. "colorsystem - Colour order systems in art and science." In *Colour-Light Centre, Zurich, in collaboration with Urs Baumann.*: https://www.colorsystem.com/?lang=en (accessed 12/march/2021).

Smith, Rupert James Buchanan. 1987. "The Influence and Effect of German Expressionist Drama on Theatrical Practice in Britain and the United States_1910-1940." Royal Holloway and Bedford New College, University of London.

Smith, Wendy Ligon. 2015. "Reviving Fortuny’s Phantasmagorias." University of Manchester PhD.

———. 2017. "Mariano Fortuny and his Wagnerian Designs." *The Wagner Journal* 11 (35-50).

———. 2018. "Electric Designs: The working relationship between Adolphe Appia and Mariano Fortuny." In *WAGNER 1900*. Jesus College, Oxford.

Southern, Richard. 1964. *The Seven Ages of Theatre*. London: Faber and Faber.

"Spectacular Lighting - Modern Stage Lighting at the Carlton." In. 1927. *Kinematograph Weekly*, 77.

"Stage Lighting, Schwabe Equipment in England, G.E.C. Facilities." In. 1928. *Kinematograph Weekly*, 59.

Stern, Ernst. 1951. *My Life, My Stage*. London: Victor Golanz Ltd.

Stern, Ernst Julian, and Heinz Herald. 1919. *Reinhardt und seine Bühne, Bilder von der Arbeit des Deutschen Theaters*. Berlin: Dr Eysler.

Stokes, John. 1972. *Resistable Theatres: Enterprise and experiment in the late nineteeth century*. London: Paul Elek Books Ltd.

"Strand Electric Catalogue." In. 1925. 33. London: Strand Electric and Engineering Company.

Styan, J.L. 1982. *Max Reinhardt, Directors in Perspective*. Cambridge, UK: Cambridge University Press.

Theatrecrafts.com. 2023. "Backstage Heritage Collection – Archive." In.: http://www.theatrecrafts.com/pages/home/archive/.

Thormann, Eric. 1950. "Die Fortuny-Beleuchtung " *Bühnentechnische Rundschau* 1950 (5th October):18, 26.

Tomlinson, Harold, and W. P. Dyson. 1935. "The New A.D.C. Theatre, Cambridge." *The Architect and Building News* 141:134-136.

Turner, R. Steven. 1994. *In the Eye's Mind: vision and the Helmholtz-Hering controversy*. Princeton NJ: Princeton University Press.

Unruh, Walter. 1951. "Max Hasait (1874-1951)." *Bühnentechnische Rundschau* 41 (6):10.

———. 1969. *Theatertechnik*. Berlin: Verlag Klasing & Co.

van Bommel, Wout. 2019. "Carbon Arc Lamp." In *Encyclopedia of Color Science and Technology*, edited by Renzo Shamey, 1-5. Berlin, Heidelberg: Springer Berlin Heidelberg.

"Venreco." In. 2021. Backstage Heritage Collection.

Volbach, Walther Richard. 1968. *Adolphe Appia, prophet of the modern theater; a profile*. Middletown, Conneticut Wesleyan University Press.

von Sander. 1930. "Sind Cellonscheiben feursicher?" *Bühnentechnische Rundschau* (3):19-20.

Wagner, Richard, and Frederick Jameson (translator). 2021. *Das Rheingold, Act 4*. Edited by Dmitry Murashev: http://www.murashev.com/opera/Das_Rheingold_libretto_English_Act_4 (accessed 26/1/2021).

"Walther Karl Gustav Unruh." 2023. https://de.wikipedia.org/wiki/Walther_Unruh (accessed 19/1/2023).

Walton, J. Michael. 1999. *Craig on Theatre*. London: Methuen.

Wamsley, Lewis Ernest. 1998. "The Mermaids Palace." *Picture House* 23 (Summer):22-30.

Wearing, J P. 1984. *The London Stage 1920-1929: A Calendar of Plays and Players*. 3 vols. Vol. 1. Metuchen, New Jersey & London: The Scarecrow Press Inc.

Wedemeyer, A. 1922. *Die moderne Bühne: ihre Entwicklung und der Einfluss der Bühnenbildkunst auf die Entwicklung der Bühnentechnik*. Extract of 1916 Thesis ed. Görlitz: Drud von Hoffmann & Reiber

———. 1928. "Neue Bühnen- und Beleuchtungsanlagen." *Konstruction und Ausführung* 6:88-91.

Weil, T H. 1904. *LXII Band, Die Electrische Bühnen- und Effekt-Beleuchtung.* . Vol. https://archive.org/details/elektrotechnisc13merlgoog/page/n427/mode/2up (accessed 21/mar/2021),, *Elektro-technische Bibliothek*, . Wien and Leipzig: A. Hartleben's Verlag.

Weiss, Lisa. 2009. "Von der Rampenbeleuchtung zur Modernen Theaterbeleuchtung." https://core.ac.uk/download/pdf/11587414.pdf (accessed 11/march/2021) Universität Wien.

Wilkinson, Henry D. 1928. "THEATRE LIGHTING." *Journal of the Royal Society of Arts* 76 (3933):533-557.

Willett, Erwin. 1986. *The Theatre of Erwin Piscator*. 2 ed. London: Methuen.

Williams-Ellis, A , and (Tarn). 1923. "The Schwabe Hasait System of Stage Lighting at the St Martin's Theatre." *The Spectator*:446.

Williams, Simon, and Maik Hamburger. 2011. *A History of German Theatre*. Cambridge: Cambridge University Press.

Winch, G. T. 1956. "Recent developments in photometry and colorimetry." *Transactions of the Illuminating Engineering Society* 21 (5_IEStrans):91-116. https://doi.org/10.1177/147715355602100501.

"Working Dimensions of London Theatre Stages in 1930." In. 1930. http://www.arthurlloyd.co.uk/SeatingPlans1930/Dimensions.htm.

Wörwag, Hans Michael. 2012. "An unsere Kunden und Freunde der Firma REICHE & VOGEL." In. Berlin.

Wright, W. D. 1982. "The golden jubilee of colour in the CIE 1931–1981." *Color Research & Application* 7 (1):12-15. https://doi.org/10.1002/col.5080070103.

Young, Thomas. 1801 (pub 1802). "II. The Bakerian Lecture. On the theory of light and colours." *Philosophical Transactions of the Royal Society of London* 92:12-48. https://doi.org/doi:10.1098/rstl.1802.0004.

Zucker, Paul. 1926. *Theater und Lichtspielhäuser*. Berlin: Verlag Ernst Wasmuth A.G, .