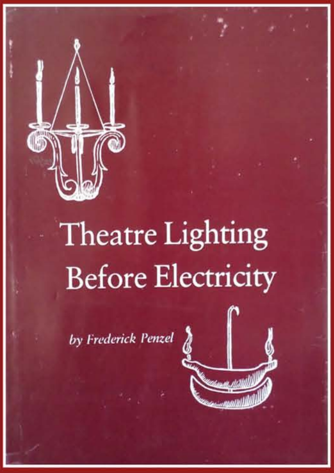
WESLEYAN OPEN BOOKS IN DANCE AND THEATER

THEATRE LIGHTING BEFORE ELECTRICITY

FREDERICK PENZEL

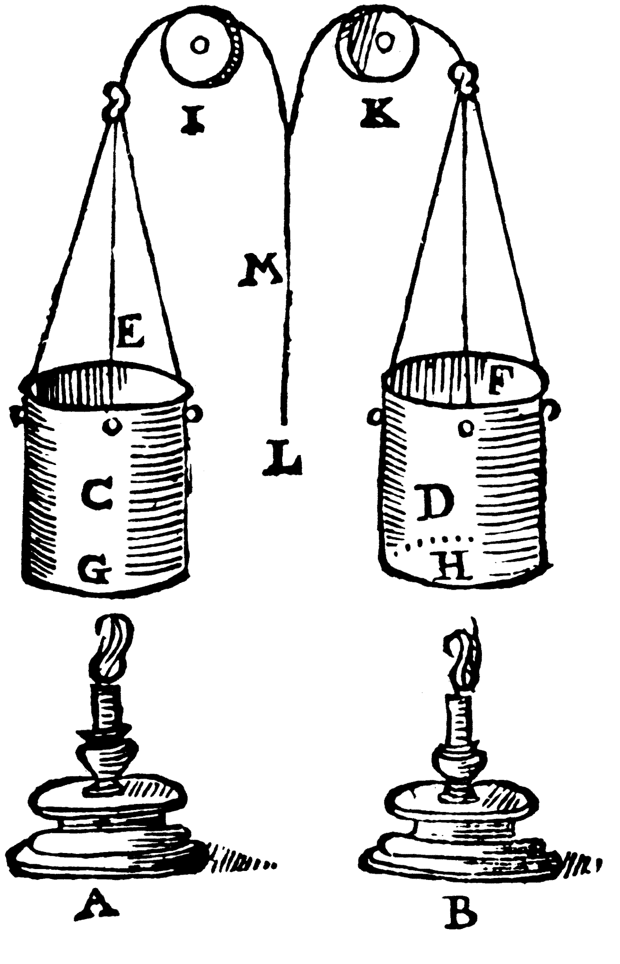


FUNDED BY THE HUMANITIES OPEN BOOK PROGRAM, A JOINT INITIATIVE OF THE NATIONAL ENDOWMENT FOR THE HUMANITIES AND THE ANDREW W. MELLON FOUNDATION

Theatre Lighting Before Electricity

Frederick Penzel

THEATRE LIGHTING BEFORE ELECTRICITY



Wesleyan University Press
Middletown, Connecticut

The publishers gratefully acknowledge support toward the publication of this book by the Friends of the Wesleyan University Press Publication Fund.

Library of Congress Cataloging in Publication Data

Penzel, Frederick, 1948–
Theatre lighting before electricity.

Bibliography: p.
Includes index.
1. Stage lighting—History. I. Title.
PN2091.E4P44 792'.025 77-14840
ISBN 0-8195-5021-3

Design and Typography by Howard I. Gralla

Publication of this title is funded by the Humanities Open Book program, a joint initiative of The National Endowment for the Humanities and The Andrew W. Mellon Foundation.

For my wife, Lynda Salsbury

Contents

List of Illustrations and Tables
Preface

One:	From the Beginnings to 1660	3
Two:	From the Restoration to 1800	15
Three:	The Early Uses of Gas	27
Four:	Gas Takes the Stage	35
Five:	Gaslighting on the American Stage	47
Six:	The Impact of Gas on the Theatre	53
Seven:	Gas—The Final Phase	69
Appendix I:	The Production & Delivery of Gas	77
Appendix II:	Gaslighting Instruments	95
Illustrations		111
Notes		153
Bibliography		165
Illustration and Table Sources		173
Index		177

List of Illustrations and Tables

ILLUSTRATIONS:

1. The torch, as used on the Elizabethan stage
2. One of the *bozze* used at the Teatro Olimpico, Vicenza
3. Sabbatini's oil lamp
4. Sabbatini's chandelier
5. Sabbatini's dimming mechanism
6. Covent Garden Theatre in 1763
7. Red Bull Theatre (1672)
8. Footlights in a trough (1749)
9. Schouwburg Theatre, Amsterdam, in 1772 (as rebuilt in 1664)
10. Wing lights on the German stage (1794)
11. Production of *Hamlet* in 1709, showing practical wall sconce
12. Drury Lane, a typically lit theatre in 1813
13. Gas table of the Metropolitan Opera, October 1888
14. *The Corsican Brothers* (1851): *above,* Corsican Palace; *below,* Paris duel, as seen behind a scrim
15. Footlight system used at the Paris Opéra
16. G. W. Lloyd's patented footlight
17. Offstage left view of a gaslit stage
18. Light board at the Paris Opéra
19. A gas table
20. Clemançon gas table
21. Gas table, Théâtre Montansier, Versailles
22. Gas table, Théâtre Montansier, Versailles
23. Gas table, Théâtre Montsanier, Versailles
24. Flat flame burners
25. Gas Argand burner
26. Glass-shielded footlight
27. Split service footlights

28. Wood-framed gas batten
29. Metal-framed gas batten
30. Typical French theatre rigged for gas
31. *Rampe de terrain*
32. Vertical batten
33. Vertical batten, detail
34. Vertical batten with wire guards
35. Gas orchestra pit lights and a bunch light
36. A bunch light
37. *Boîte conique*
38. *Boîte conique*
39. Limelight
40. Improved limelight burner
41. Improved limelight burner
42. Limelight stereopticon shown with typical oxygen and hydrogen bag feed apparatus
43. Stereopticon limelight burner, lime block, and dissolve tap
44. Sun burner
45. Typical backstage fixture with wire protection
46. "Perpetual gas lighter"
47. Nassau gas lighter
48. Gas burner igniter
49. Full ignition system spark gap
50. Full ignition system schematic

TABLES:

1. Comparative Candlepower of Fuels
2. Comparative Statement of the Illuminating Power and Expenses per Annum of Gas, Candles, and Spermaceti Oil (1841)
3. Comparison of Fuels

Preface

There exists a common notion that stage lighting is the youngest of the stage arts, having suddenly come into bloom with the advent of electricity. This could not be more false. Electricity was the final link in a chain of development stretching back to the Renaissance.

The reason for the prevalence of such false information is the lack of collected source material on stage lighting. While countless books have been written about scenic, costume, and even lighting design, there has never been a factual work devoted to the history of stage lighting. Certainly, there have been paragraphs and even chapters in lighting design texts which give brief accounts of the subject, but nothing of any depth or detail.

Stage lighting has come a long way from the flaming torch of the Elizabethan stage and the Italian oil lamp. Along with many other technical arts, it began in the Renaissance with equipment dating back to the Greeks, and grew up with the Industrial Revolution, virtually seething like a gas out of the English coalpits. With modern chauvinistic attitudes common to the postindustrial age, many of us assume that there was little or no lighting before Edison. But much of the equipment and most of the techniques used in modern stage lighting had well-developed forerunners in the preceding three centuries. Colored light, the spotlight, translucencies, follow-spotting, and dimming were already known before the incandescent lamp, and were only waiting for a powerful light source to reach advanced development. It was the pre-electric development that needed tracing.

In this book I have attempted to pull together a small mountain of collected and previously uncollected material. There have been few guidelines along the way, and no extended treatment of the subject to which I could refer. Perhaps this book will encourage others to continue exploring the field. What I have done represents little more than a beginning, but a beginning that badly needed to be made. I wish success to those who pursue it; this has been the easy part.

I should like here to express my especial gratitude to William B. Warfel for the generous help and encouragement which he gave me throughout the writing of this book.

Theatre Lighting Before Electricity

One

From the Beginnings to 1660

At the beginning of deliberate theatrical activity, light played an important role. The light used in the earliest productions was natural light. The open Greek theatres were built to use directional sunlight and had no need of artificial sources. The Greeks organized their plays to run a course through the day, in order to use the different types of light available at different times.

Although the Romans may have used torches in their theatres, the important idea of light being manipulated as an aesthetic variable to achieve a theatrical statement had not yet been discovered. Until the Renaissance, the main purpose of theatre lighting was simply to permit the spectators to see. Most ancient and medieval drama was performed outdoors; indoor performances no doubt made use of the normal household oil lamps, torches, or candles.

By the beginning of the Renaissance, these three types of light source were about all that was available to produce artificial light. The oil lamp, with animal or vegetable fat in a metal or clay container and a floating wick, had been used since prehistoric times, as had the torch, perhaps the oldest of the three. The candle developed somewhat later, though there is no way to be exact as to the date. Candles were generally made of tallow and were hand-dipped; the molded candle was not introduced until the eighteenth century.[1]

In Elizabethan and Jacobean theatres, most performances took place in outdoor playhouses, which had no need of artificial light. These theatres had unlocalized settings, and through the use of verbal conventions and selected properties playwrights could appeal to the visual imaginations of the spectators. Lanterns and torches carried on stage could suggest night (see Fig. 1), as could the use of off-stage sound effects like owls, bells, or roosters crowing.[2] The English Shakespearean critic Sir Walter Raleigh, analyzing the conspiracy scene in *Julius Caesar,* describes such suggestiveness:

> The whole scene is heavy with the sense of night and the darkness of conspiracy, yet the effect is produced by nothing but the spoken words and the gestures of the players.[3]

In winter, when the days were shorter, light seems to have been used in the latter parts of performances. For this purpose, the cresset was used. It was a variety of torch, fitted on the end with an open iron cage to hold burning material.[4]

In private theatres of this same period — some of them the first indoor theatres — daylight was again largely relied upon, being admitted through large windows. Apparently there were occasions when some other form of lighting was desired, as can be seen in a line from Thomas Dekker's *Seven Deadly Sins of London* (1606): a shuttered city is described as appearing "like a private playhouse, when the windows are clapt down, as if some Nocturnal or dismal Tragedy were presently to be acted."[5] At performances of this nature, only the regular general illumination was employed. In the early seventeenth century, this consisted of branched chandeliers which held candles, or candle-sconces.[6] One modern scholar believes that the shutters were probably closed only for protracted dark scenes, since the closing would have taken too long for momentary effects.[7]

Despite this activity in Britain, Renaissance Italy can probably be referred to as the birthplace of lighting devised specifically for stage productions, as opposed to general-purpose lighting. It was only natural that the Italians, being the innovators of scenic illusion, should also have been the first to manipulate light. Lighting theory was being expounded by artists and architects like Sebastiano Serlio (1475–1554),[8] Leone di Somi (1527–1592),[9] Angelo Ingegnieri (c. 1550–c. 1613),[10] Niccolo Sabbatini (c. 1574–1654),[11] and Josef Furtenbach (1591–1667), a German who had studied in Italy.[12]

The production of the Renaissance spectacle was generally in the hands of the theatre architect, who was responsible for scenery and lighting. Sebastiano Serlio was a noted architect who worked in this manner in the theatre. In his *Second Book of Architecture* (1545), Serlio wrote about theatre construction and the uses of scenery and lighting.[13] In a section of his treatise entitled "Of the Artificial Lights for the Scene," he discusses lighting instruments, coloring stage lights, and the mounting of lights. Although he used the basic chandeliers that were standard equipment in every theatre or large hall, he also wrote what is apparently the earliest description of devices that became inseparable from artificial lighting displays of the period. These were known as "*bozze*" and according to Serlio were "made of glass, of special shapes with flat and rounded side to hold the water" (see Fig. 2).[14] Besides holding colored water for effects, these *bozze,* when filled with oil, could be used as lamps. The addition of a small metal holder containing a wick completed this conversion. These instruments can still be seen at the Teatro Olimpico.[15] Serlio goes on to describe their use:

> There is a special way of placing these containers for the translucent colors. At the back of the painted houses

> where the lamps are to go is fastened a thin board pierced to hold the lamps separate, and below it is another board to hold the glass containers. Then each of those *bozze* is placed with the curved part to the opening and made fast lest it be shaken down by the dancing. Behind every one is placed a lamp that the lights may all be even. The sides of the *bozze* toward the lamps should be flat or convex the better to receive and send out the light. In the same manner such lamps are to be put in the openings on the perspective faces. When you need a specially strong light you put a torch behind a glass and behind the torch a barber's basin well burnished.[16]

It is interesting to note the similarity between the basin, glass, and torch combination and the modern spotlight. Serlio also mentions what may be very early footlights. He says that for the actual illumination of the scene "a large number of candles are placed leaning at the front of the scene."[17]

To color the light, the water in the *bozze* was treated with translucent colors. For blue, Serlio recommended a sal ammoniac and salt mixture, and to turn this to a green, saffron could be added. Wine produced red tints, and water was filtered through felt for "diamond."[18]

In addition to lighting his flats from behind and from a low angle in front, Serlio made a further contribution to lighting design. Although shadows were painted on the set as if they were coming from a single side source, "nevertheless it is better to illuminate the scene from the middle because of the greater power of a light hanging at the center."[19] This, of course, was the ever-present chandelier. More effective overhead lighting would not be developed for several centuries.

Leone di Somi, another stage artist (and a noted physician) also published a work on the subject of staging entertainments. Written around 1565 in Mantua, his *Dialogues on Stage Affairs* gives us valuable insight into period practices. Written in dialogue form, this paper presents different characters who discuss aspects of production. In the course of the discussion several important ideas are expressed, which for their time were rather novel. These ideas include lighting to create a specific mood, as in a tragedy; indirect lighting by mirror reflectors; and keeping the auditorium darkened during the performance.[20]

At one point in the dialogue, a character named Veridico, a theatre designer, is questioned by another man, named Santino, about why he placed so many more lights on the roofs of the houses in his set than were actually needed for illumination. Veridico answers:

> Now it has been a custom, both in ancient and modern times, to light bonfires and torches in the streets, on the housetops, and on towers as a sign of joy; and hence arises this theatrical convention — the imitating of such festive occasions. The lights are put there for no other purpose but to imitate, in the very first scene, this mood of gaiety.[21]

They go on to discuss tragedy as well, and Veridico reminisces that at a particularly tragic moment, "most of the stage lights not used for the perspective were darkened or extinguished. This created a profound impression of horror among the spectators and won universal praise."[22] Di Somi obviously had used *bozze* too, as another member of this dialogue named Massimiano asked:

> Will you now please tell us why most of your lights have in front of them transparent or coloured glasses?
>
> *Veridico:* This was invented by some men who realized a little-appreciated fact — that a brilliant light striking directly upon the eye for any length of time becomes exceedingly irritating. . . . The shading of the lights was devised to minimize the annoyance.[23]

Veridico goes on to say that those who believed that the color was only to produce an attractive effect were only partly right. Apparently the lamps would produce too much glare without them. The harshness of available light sources was also remedied by indirect side lighting. Di Somi has something to say on this subject as well.

> I should like to point out also that the small mirrors which some managers set at appropriate places in the perspective settings and the far sides of the wings are very effective. They reflect those concealed lights which the architects cleverly place behind columns and in the openings between the wings, thus serving to make the set more gay and bright. Not only can these reflections give no annoyance to the eyes; they have the further advantage that we here have light without smoke — a great consideration. I may take this occasion to remark that the producer who does not take care to have a number of holes made behind the scenes so that the smoke from the lamps may have a means of escape will land himself in serious difficulties.[24]

One further advance in lighting which di Somi seems to have been the first to champion was the darkened auditorium.

> *Santino:* I see, Veridico, that on your stage there are many lamps both behind the scenes and in front of them; yet in the auditorium here you have made arrangements for but twelve standing candelabra. The reason I can't imagine; for I have often counted as many as 250 torches in this large hall.
>
> *Veridico:* It is a natural fact — as no doubt you are aware — that a man who stands in the shade sees much more distinctly an object illuminated from afar; the reason being that sight proceeds more directly and without any distraction towards this object. . . .
>
> *Santino:* By introducing only a few lights in the auditorium, then, you obviate the trouble of smoke fumes and to a certain extent you render the seeing clearer.
>
> *Massimiano:* There is yet another advantage: he saves the Duke fifty ducats in respect to the torches usually set in the hall.[25]

In 1598, Angelo Ingegnieri, another stage designer, published his views in a work entitled *Dra-*

matic Poetry and How to Produce Plays. He calls lighting "one matter of supreme theatrical importance."[26] It could be most effective and artistic only when the sources were so concealed as to be indiscernible by the audience. The lighting of the actors' faces was especially important. For this purpose, he proposes the use of what may be the first flying light batten position.

> The method, which I now wish to demonstrate so that it may be of general service in all future productions, consists in hanging up a valance between the stage heavens and the roof of the auditorium, without, of course, bringing it so low as to cut off too much of the set. On the inner side facing the stage it is to be fitted with many lighted lamps, having tinsel reflectors to direct the beams upon the actors. These lamps ought to be firmly fixed at the top and lit before being drawn up to the positions they are to occupy.[27]

Ingegnieri was also an advocate of the darkened house during performances. Unlike di Somi, he recommended the removal of all house lights once the audience had been shown to their seats, to achieve complete darkening.[28]

To add to a growing body of information on stage practices, Niccolo Sabbatini published his *Manual for Constructing Theatrical Scenes and Machines* (1638).[29] Though not a collection of his own innovations, Sabbatini's book was an important compendium of the details of theatre architecture and scene design, as already employed in many theatres.[30] The passages of interest describe the placement and qualities of lights in the auditorium and on the stage as well as a method for quickly darkening the stage.

Concerning house lighting, Sabbatini discusses the relative merits of wax candles as opposed to oil lamps. He says that while candles give a richer appearance and have less odor than oil, they are apt to drip on the audience. Oil lamps seem to have dripped too, for he advocates constructing them out of tin, with another lamp hung below to catch overflowing oil. According to his own illustration (Fig. 3), the oil lamps were fitted with hooks and hung from chandeliers. The candles were also placed in chandeliers, but these were of wood and wire, and held three candles each (Fig. 4). Sabbatini advocates placing these chandeliers largely in the front of the house, to help illuminate the scenery, and more to the sides, so as to not obstruct the stage.[31]

As to the lighting of the stage, Sabbatini, like Ingegnieri, advocates concealing numerous oil lamps behind the overhead scenery. He also mentions the use of sidelight and footlights. He describes a groundrow (his word for "groundrow" may also be translated "parapet") at the edge of the apron, behind which are fixed oil lanterns.[32] This parapet was to be made of boards and at least half a foot higher than the stage.[33] He does not recommend footlights, however: they cast shadows on the scenery, make the actors' faces look pale, and send fumes into the audience.[34] This last problem was to persist until footlights were powered by electricity, despite various imaginative solutions.

Sabbatini's method for quickly darkening the stage was rather crude and mechanical, although it was a new concept in lighting. In his own concise description, he states that

> as many cylinders of soldered tin are made as there are lamps to be darkened. These are at least one-half a foot high, a little less in diameter, and at the top they are open. This done, you adjust each cylinder over its lamp . . . in such a manner that by one motion at the side of the stage, the cords with the cylinders descend over the lamps and so darken them. When the cords are again raised to their places, the stage is illuminated [see Fig. 5].[35]

Not unlike Sabbatini, Josef Furtenbach, in his *Civil Architecture* (1628), *Recreational Architecture* (1640), and *The Noble Mirror of Art* (1663), recorded in extensive detail the facts and figures related to theatre buildings and scenery.[36] His works pretty well sum up the achievements of the Renaissance, in so far as stage lighting is concerned. In *Recreational Architecture* he outlines the various positions available to the artist. Oil lamps could be placed "within the scene, above between the clouds, at both sides, and in the front and rear pits, all of course completely concealed."[37] This backlighting and groundrow lighting position at the rear of the stage had seldom been mentioned before. In *The Noble Mirror of Art* he goes into great detail about lighting positions:

> At the front of the stage oil lamps are set three feet apart on the floor behind the ¾-foot board. . . . From this hidden position they send light only over the scene. Behind the side walls of the proscenium next to the scene opening oil lamps are placed in iron rings one above the other two feet apart up to the heavens. Behind these lamps are placed glittering pieces of gold tinsel. Other lamps are placed behind the clouds, so that one cloud lights the next, sending down a glow like day. Also in the rear pit 50 oil lamps should be placed, each filled with 1/4 pound of olive oil.[38]

He goes into more detail about the front and rear pit lights. In the front pit,

> round holes are cut into the floor to hold the pointed underpart of the lamps. . . . Behind the lamps a piece of beaten brass or golden tinsel covered with a piece of mica will reflect glimmering rays.[39]

We find out that the rear pit was seven feet deep and was also used for ships, waves, etc., when trap doors uncovered it. Near the top of the pit, iron rings were set to hold the *bozze*.[40] These iron rings were also used up behind the six cloud borders to hold rows of lights with six-inch square gold reflectors behind them.[41] In agreement with earlier writers, Furtenbach felt the house should be completely darkened during the production as a means of focusing audience attention.[42]

Furtenbach gives us the most detailed descriptions of the lighting instruments of his time. He mentions three types: the "glass oil lamp," the "leaning light," and the "standing light box." The first is, of course, a member of the *bozze* family. He describes his as measuring five inches high, and four inches wide at the mouth, tapering to one inch at the bottom. It was filled with water to within one and a half inches of the top, and the rest of the way with a quarter pound of heavy olive oil, which burned up to twelve hours. The wick, made of rush fibers, was three inches long. A reflector could be placed behind the lamp. It was a five-inch by eight-inch piece of "gold tinsel" (foil), etched with a diamond grid pattern (probably for better diffusion of light). Sometimes, a thin, flat piece of mica could be used. The lamp sat in an iron ring with a four-inch screw attached to it. According to Furtenbach, up to fifty could be used around the stage. The "leaning light" sat on a wedge-shaped base, with a vertical gold and mica reflector behind it. It was used as a footlight, a wall fixture, or a backstage light. The third type, the "standing light box" (also called a perspective lantern), was a close relative of the modern floodlight. It was a trapezoidal tin box with no top or front, and the inside was an etched gold reflector. The box was eight inches wide at the front and nine inches high, and it was used in the rear pit.[43]

While the Italians were presenting their grand spectacles, their methods were also being used by Inigo Jones to light lavish masques at the British court. Jones, according to fragmentary existing evidence, used *bozze* both as hidden sources and for star effects. There are records of his having purchased them as early as 1609, and in the *Entertainment at Theobalds* there "were placed Diaphanall glasses fill'd with severall waters that shew'd like so many stones of orient and transparent hiewes."[44] He used these in great profusion, both openly and indirectly from behind other scenic pieces, in the Italian manner. In the *Masque of Flowers* (1614) "certaine lights" were "shadowed" by "great pottes of Illiflowers" making "a resplendent and admirable lustre," and further "lustre" was provided by "secret lights" placed behind "great tufts of severall kindes of Flowers."[45]

Jones was evidently among the pioneers in the use of translucencies. Scenic pieces like clouds, pillars, and special flats were covered with either calico or oiled lantern paper. Lights were shone through these pieces to give the effect of stars, or to make them translucent. These effects seem to have been used quite frequently.[46]

Despite Jones's importation of Italian stage lighting methods, his house lighting still consisted of torches and flambeaux. Performances at the large Banqueting House at Whitehall (finished in 1622) were discontinued when it was discovered that smoke was soiling the ceiling paintings by Rubens. As a result, a temporary masquing house had to be constructed.[47]

Precedents for most of the major lighting conventions in positioning, coloring, dimming, floodlighting, translucencies, and auditorium darkening were established by the early seventeenth century. The inspiration and creativity of the Renaissance stage artists is indisputable: the basics of stage lighting were created with only the most rudimentary means. The technology would be two centuries in coming, but the Renaissance genius for viewing in terms of light and perspective would provide the guiding principles.

Two

From the Restoration to 1800

During the interval of Puritan rule in Britain, all the formerly vigorous stage production was suspended. While Charles II and his court resided in France during these years, they were exposed to Italian methods of staging, which consisted of a proscenium stage fitted with sliding wings and backdrops. Richard Flecknoe, author of *A Discourse of the English Stage* (1660), knew that much could be learned from the theatres of the Continent, where important developments had been made while the English theatres stood idle. In the concluding paragraphs of his work, Flecknoe sums up the state of the art:

> For Scenes and Machines they are no new invention, our Masks and some of our Playes in former times (though not so ordinary) having had as good or rather better than any we have now.
>
> They are excellent helps of imagination, most grateful deceptions of the sight, and graceful Ornaments of the Stage, transporting you easily without lassitude from one place to another; or rather whilst you sit still, does bring the place to you. Of this curious Art the Italians (this latter age) are the greatest masters, the French good proficients, and we in England only Schollars and Learners yet, having proceeded no further than to bare painting, and not arriv'd to the stupendious wonders of your great Ingeniers, especially not knowing yet how to place our Lights, for the more advantage and illuminating of the Scenes.[1]

It is no wonder, then, that after 1660, with the return of the monarchy, these Continental methods were brought back as well.[2] With the full resumption of theatrical activity, new theatres were built, and old ones were renovated on a large scale. This work included newer and more extensive lighting for many of the houses.

We find the main source of light in Restoration theatres to be chandeliers concentrated toward the front of the house, and especially over the forestage. It might be wise to differentiate, at this point, between lighting Restoration commercial theatres and Restoration court theatres. The commercial theatres were more conservative in their lighting, for economic reasons, while the court was able to use most of the Continental innovations in its own productions. The commercial houses were the ones that resorted primarily to the candle-burning chandeliers. Little material exists about lighting at the end of the seventeenth century in England. Some later evidence is available, though, which depicts theatre lighting that probably had changed little by the mid-eighteenth century. By the time of David Garrick, the second Drury Lane Theatre (built 1674), according to Tate Wilkinson's memoirs, was lit by a large central chandelier and six stage chandeliers of twelve candles each. The Lincoln's Inn Fields Theatre owned six chandeliers constructed of iron rings suspended by chain. Covent Garden Theatre was probably lighted by a central chandelier of six candles over the stage, 4 sixteen-candle iron rings hung at a level just over the top of the proscenium arch on the auditorium side, and 2 hung upstage of the large chandelier. These theatres also used candle sconces hung around the fronts of their balconies.[3] The chandeliers proved to be a sight-line obstruction to the people seated in the second circles of these theatres (see Fig. 6); however, this was not to be reformed until David Garrick's time.[4] Obviously these chandeliers were something of a nuisance, since they had to do for indoor and outdoor scenes alike. Furthermore, they dripped hot grease on both audience and actors.[5]

Meanwhile, in the two court theatres, the Cockpit (renovated and opened in 1660) and the Hall Theatre (built 1665), other developments were taking place, especially at the Hall.[6] The Cockpit was newly fitted out with five pairs of sconces and two brass chandeliers; the chandeliers were most likely for use over the stage. The Hall Theatre was a source of more interesting happenings. In the building accounts, there is an entry for "black and white plates, wires, lines, Muscovy glass and pulleys."[7] (Muscovy glass was another name for mica.) Eleanore Boswell, in her *Restoration Court Stage,* believes that these were intended for the construction of lanterns. The white plates were for the reflector in back, the black ones for the top and bottom, and the glass to face the remaining three sides. Further, she believes that these were meant to be hung on wires from the pulleys, mounted in rows behind the proscenium, and in the wings.[8] Whatever their use, the lanterns were soon supplanted in 1666 by candlesticks with tin reflectors. A bill of sale tells us that 130 plates and 120 "socketts and panns" were ordered for a masque in early 1670, as well as what may have been another type of candleholder with a scallop-shaped reflector. For the next masque produced at the Hall, 96 tin sconces with reflectors were added to the stock. These were used rather extensively behind the scenery:

> Making degrees behind ye backe clouds for ye setting of lights there boarding with slitt deales behind ye upper sceanes for ye putting up of sconces & Candlesticks . . . lineing ye backes of ye shutters for ye putting up of lights, & nayleing ye sconces & Candlesticks to ye backes of ye clouds, makeing a frame with degrees for lights behind ye glory.[9]

Footlights were used in Hall productions as early as February 1670. This would seem to refute the widely held opinion that David Garrick brought footlights over from France almost a century later. In the plans for the previously mentioned masque (the one for which the scallop reflectors were ordered) is the entry: "making a trough at ye foote of the stage for lights to stand in."[10] In June 1675 footlights are mentioned again, in connection with an overhaul of the theatre. The entry calls for "two ledges of boards in ye throughs [sic] where the lamps were sett."[11] Clearly, footlights were part of the Hall Theatre's standard equipment, and there are many other references to footlights between 1670 and 1689. During this period footlights used either lamps or candles.[12] The frontispiece to Kirkman's *The Wits* (1672) shows a row of footlights in what is commonly (but conjecturally) identified as the Red Bull Theatre, as well as chandeliers lighting the stage (see Fig. 7).[13] The footlights are candles or, possibly, oil lamps. Oil lamps usually had two or more wicks in individual containers, and their use certainly predates this print.

Additional information on the use of footlights before 1765 (Garrick's return from France) may be seen in Aaron Hill's *Prompter* for November 7, 1735. Criticizing certain acting conventions, he mentions footlights in passing:

> Suppose, for Example, we are present at the Representation of some Scene, wherein an Actor comes forward to the Line of Lamps, on the Edge of the Stage, and, after sending his eyes, like his Gentleman Ushers, into the Pit, or the Boxes, begins to tell the Spectators, in the Words of the Soliliquy, "I am ALONE!"[14]

Another depiction of the "Line of Lamps" can be found in a political cartoon dated 1749, which clearly shows a row of footlights set in a trough on a stage floor (Fig. 8).

On the Continent during these years, stage lighting was settling into fairly conventional patterns. French and English stages were fairly similar by the end of the seventeenth century. In an illustration of the Hotel Bourgogne from 1688, six chandeliers are shown hung over the apron in front of the proscenium, and six more are hung in two perspective rows running upstage — one per wing opening. At Versailles, five chandeliers were hung in line before the proscenium, lighting the forestage and leaving the upstage rather dim. The stage of the Comédie Français is shown in a painting from around 1670 as being lighted by six chandeliers and a bank of thirty-four footlights. Actually, footlights were used in most of the French theatres, and they were, in the main, oil lamps.[15]

A good example of Continental lighting of the period can be seen in the depiction of the Schouwburg Theatre of Amsterdam as it was rebuilt in 1664 (Fig. 9). Although the illustration dates from 1772, the lighting is typical of the 1660 to 1800 period, with five chandeliers downstage of the proscenium and a row of oil footlights.[16]

One Renaissance development, the darkened house, never became widespread; however, one does find it in isolated cases. In 1667, the Teatro San Giovanni Crisostomo, in Venice, installed chandeliers that could be lowered or raised into a ceiling well to dim the house.[17]

In the eighteenth century, we find few significant changes. Spermaceti candles seem to have come into more common use in the early years of the century, and to have taken their place with wax candles as one of the main illuminants on the English stage.[18] It should also be noted that all candles at this time were dipped. It was not until 1720 that molded candles were introduced for the first time, and then, in French theatres.[19]

The candle snuffer was a characteristic figure of these times. Candlewicks needed frequent trimming, regardless of what was taking place on the stage.

> When the stagelights began to flare or flicker out the gods commonly set up a cry of "Snuffers! Snuffers!" for-

> seeing a happy opportunity of indulging in some facetiousness at that worthy's expense — badinage, however, which, as he went deftly about his work, was generally received by him with the utmost aplomb.[20]

The candle snuffer's office arose in the Elizabethan private playhouse (in England, of course — the Continent saw its own development), and continued on until the early nineteenth century. An early reference, in an introduction to the play *The Careless Shepherdess* (1638), mentions such a person. In discussing the surplus of playwrights, a character says:

> . . . now their trade
> Must needs go down, when so many set up.
> I do not think but I shall shortly see
> One poet sue to keep the door, another
> To be prompter, a third to snuff the candles.[21]

Candle snuffers were hard at work on the Continent as well. When the poet Ragueneau went on tour with Molière's company, he was expected to make himself useful by trimming the lights. A work of 1674, written about Paris theatres by Chappuzeau, says that the job was assigned to the scene painter. He was allowed to keep the wax stubs left at the end of the show. Apparently, in England and abroad, it became common for a theatre to have two snuffers, one for the stage, and one for the house.[22]

In this period, we have a further reference to wing lights. As previously mentioned in relation to the Hall Theatre, candles had been fixed behind the shutters (sliding flat wings) as early as 1670. The Covent Garden inventory of properties of January 1744 mentions "12 pairs of scene ladders fixt with ropes, with 24 scene blinds and 192 tin candlesticks for the same."[23] These scene blinds were curved tin shields that could be drawn across the sidelights for darkening the stage.[24] This was not too unlike Sabbatini's tin cans on pulleys. The fact that there are two scene blinds for each scene ladder may mean that while one acted as a shield, the other functioned as a reflector, or else the shields were split. We have a German illustration dated 1794 to give us a good idea of how eighteenth-century wing lights (unshielded) were mounted (Fig. 10).

Scenery-mounted practical instruments may have come in around this time, if not earlier. An illustration from 1709 of a production of *Hamlet* shows two lighted sconces mounted on a wall of the set (Fig. 11).

Perhaps the most significant lighting of the eighteenth century was practiced at the Drury Lane Theatre, under the management of David Garrick. On his return from the Continent in 1765, Garrick began to institute his so-called reforms at the theatre. While in Paris, he was particularly impressed by the staging and lighting at the Opéra and the Opéra-Comique. Jean Monnet, director of the latter theatre, proved especially helpful as a contact for importing French stage techniques and lighting equipment.[25] Few of the changes Garrick effected could be considered revolutionary, but he did make more efficient use of what he had at his disposal, and he may even have imported some new instruments as well.

Garrick's genuine innovation was the removal of the chandeliers. As mentioned previously, these obstructed the view for those in the upper galleries, and they were simply inefficient as light sources for the stage. This change must have proved beneficial to the theatre, because Covent Garden soon followed suit and removed its chandelier. The emphasis on lighting was now shifted to sources located behind the proscenium and across the apron. We know that in Britain, sidelight units had been in use for quite a few years previous to this, and that footlights had been in use since at least 1670. While the notion that Garrick brought the footlight over from France is clearly false, he did introduce the "float," a long metal trough filled with oil, in which a number of metal rectangular saucers, each containing two wicks, could float. The trough itself was lowered into the stage floor by means of ropes and pulleys operated by the prompter. In this way, a crude sort of dimming could be achieved.[26] A similar lowering device had been used at Drury Lane as early as 1758.[27]

According to a letter from Jean Monnet, Garrick must have sent to Paris for samples of reflectors and footlights. Monnet writes:

> I have carried out your two commissions and with M. Bouquet's designs I will send you a reflector and two different samples of the lamp you want for the footlights at your theatre. There are two kinds of reflectors: those that are placed in a niche in the wall, and which have one wick; and those which are hung up like a chandelier, and which have five; the first, which are, I fancy, the more suitable for the illumination of your hall, cost twelve shillings and sixpence, and the others from thirty shillings up to three pounds, according to the size and the ornaments applied to them. . . . As to the lamps for lighting your stage, they are of two kinds: some are of earthenware, and in biscuit form; they have six or eight wicks, and you put oil in them; the others are of tin, in the shape of a candle, with a spring, and you put candles in them. But for them not to smell, you must use the best oil and keep the lamps very clean.[28]

Although it is not known whether Garrick actually went any further with these samples than examining them, we do know that he was studying general improvements in his stage lighting along French lines. While perhaps not the innovator some have called him, Garrick did much to modernize British stage lighting and bring it up to Continental levels.

A significant addition whom Garrick made to the staff at Drury Lane in 1771 was a scene painter and designer named Philippe Jacques de Loutherbourg (1740–1812). Hired by Garrick at a salary of £500 a year, he introduced many startling effects on the stage, through the use of lights and color media. In 1781 de Loutherbourg struck out on his own to produce an elaborately painted and lighted moving panorama called the Eidophusikon.[29] He had formerly been a landscape painter, and he put his knowledge to work creating vistas of London, storms at sea, and various conflagrations. The first exhibition was held on February 26, 1781, at a large house on Lisle Street, off Leicester Square in London. The scenes presented were:

1. AURORA; or the Effects of the Dawn, with a view of London from Greenwich park.
2. NOON; the Port of Tangier in Africa, with the distant view of the Rock of Gibraltar and Europa Point.
3. SUNSET; a View near Naples.
4. MOONLIGHT; a View in the Mediterranean, the Rising of the Moon contrasted with the Effect of Fire.
5. The Conclusive Scene, a STORM at Sea, and Shipwreck.[30]

All these scenes were shown in diorama form, on a stage eight feet deep by six feet wide.[31] A contemporary description of the first show indicates how advanced de Loutherbourg's techniques with light sources and color effects were. The description is of the first scene in the above bill.

> The clouds in every scene had a natural motion, and they were painted in semi-transparent colours, so that they not only received light in front, but by a greater intensity of the Argand lamps employed, were susceptible to being illuminated from behind. The linen on which they were painted was stretched on frames of twenty-times the surface of the stage, which rose diagonally by a winding machine. De Loutherbourg excelled in representing the phenomena of clouds. The lamps were above the scene and hidden from the audience, — a far better plan than the "foot-lights" of a theatre. Before the line of brilliant lamps on the stage of the Eidophusikon were slips of stained glass — yellow, red, green, purple, and blue; thereby representing different times of day, and giving a hue of cheerfulness, sublimity, or gloom, to the various scenes.[32]

Not only were the lighting effects used in the Eidophusikon a preview of what was to happen in the century ahead, the equipment, too, was somewhat ahead of its time. As mentioned in the account above, de Loutherbourg used the Argand lamp, an instrument which was later to come into wide use with illuminating gas.

The Argand burner was invented in 1780 by a Swiss chemist named Amie Argand, who had gone to Montpellier to install a distillation system, and who was dissatisfied with the light sources at his disposal.[33] He later traveled to England, where he patented his burner in 1784, under Patent No. 1425. It reads:

> A lamp so constructed as to produce neither smoak [sic] nor smell and to give considerably more light than any lamp hitherto known, by converting the smoak into flame, by causing a current of air to pass through the inside of air on the outside of the wick by means of a chimney.[34]

The lamp truly did give off less smoke, and its hollow, cylindrical flame used less oil than previous types. This seems to have been the first advance in lamp technology in thousands of years, and it started a great rush of activity in lighting that was to take place during the nineteenth century.

Eighteenth-century stage lighting was far from satisfactory, and many criticisms were leveled at it in its time. One critic, George Saunders, had some rather practical suggestions to make as to the improvement of stage lighting. In his *Treatise on Theatres,* he recommended frontal lighting that could not really be implemented until the advent of the electric light:

> Monsieur Patte has proposed a method to light the avant-scene without that tormenting line of lamps at the front of the stage, which wrongs every thing it illuminates. He would have reverberators placed at the extremity of the boxes, on each side of the stage; and this

> has been practiced in small theatres with success, particularly at Blenheim, and it is worth the trying in larger ones.[35]

By "reverberators," Saunders meant reflectors, but the balcony-front lighting position would not come into use until the twentieth century. Earlier in the treatise, he also expressed dissatisfaction with house lighting, and specifically the annoyance of chandeliers as sightline obstructions. He called instead for indirect house lighting through the use of reflectors — another advance that would be a long time in coming.

By the beginning of the nineteenth century, stage lighting had reached a plateau. Stage artists had exploited Renaissance innovations as far as the limits of technology permitted. All of the possibilities for positioning instruments had been tried. The coloring of light was being explored, as was the concept of using it to create mood. With the invention of the Argand burner, the oil lamp had reached the peak of its efficiency. Unfortunately, the peak efficiency of oil lamps and candles was not very great. Further development in stage lighting would require a more powerful light source. This source would soon be available with the introduction of illuminating gas.

Three
The Early Uses of Gas

Although the potentials of flammable gas were not fully realized until the dawn of the nineteenth century, the substance itself and its sources had been known for several centuries. The Chinese are rumored to have used it before anyone else, but as this study is concerned with Western developments, we begin with a Flemish alchemist named Jan Baptista van Helmont.

Van Helmont was born in 1577 in Brussels, and it is to him that we are indebted for the formal recognition of gas as a state of matter, and for its name. While searching for the Philosopher's Stone, he was heating materials in his crucible when it "did belch forth a wild spirit or breath. This spirit, up to the present time unknown, but not susceptible to being confined in vessels, nor capable of being reduced to visible body, I call by the new name of gas."[1] Perhaps he was heating coal. If so, the gas would have burnt had he lit it, and the porous substance left behind would have been what was later known as coke — pure carbon.[2]

This isolated event had little impact. But many persons not engaged in the sciences were also well aware of the existence of gas. Miners were closely acquainted with it, and in many coal-bearing lands, it would occasionally break through to the surface, quickly making its presence known. This gas is different from manufactured gas, but it was the earliest type with which anyone had contact. Miners called it "choke damp" for its suffocating qualities and "fire damp" for its combustible nature when in contact with the open flames of their lamps.[3] The earliest account we have comes from the Royal Society's *Philosophical Transactions* for the year 1667, and is entitled "A description of a Well and Earth in Lancashire taking fire by a Candle approached to it. Imparted by Thomas Shirley, esq. an Eye Witness."[4] The event took place in 1659, when Shirley and several friends went to examine a spring whose waters were reputed to be burning like oil. Upon close examination, it was noticed that the water seemed flammable at only one particular spot in its course. Said Shirley: "The boyling [bubbling of the gas at the burning point] I conceived to proceed from the irruption of some bituminous or sulphurous fumes, considering this place was not above 30 or 40 yards distant from the mouth of a coal pit there." He confirmed this correct observation by diverting the spring away from the spot and lighting the still issuing gas with a candle as before, at which "the fumes took fire and burnt very bright and vigorous."[5]

In 1733, Sir James Lowther described a similar phenomenon in the *Transactions*. While digging a pit to drain water from one of his mines at Whitehaven, his workmen struck a pocket of gas that "bubbled through a quantity of water spread over a part of the pit, and made a great hissing noise. . . ."[6] Lowther lit the gas with a candle and found that it would burn. Not content with this, he went a step further and collected some gas. Afterwards, he made the following notes: "The said air being put into a bladder . . . and tied close, may be carried away, and kept some days, and being afterwards pressed gently through a small pipe into the flame of a candle, will take fire, and burn at the end of the pipe as long as the bladder is gently pressed to feed the flame, and when taken from the candle after it is so lighted, it will continue burning till there is no more air left in the bladder to supply the flame."[7] Lowther had managed to discover, in its simplest form, the principle of gaslighting.

One other experimenter, the Reverend Dr. John Clayton, Dean of Kildare, went a step further. His work with gas took place sometime before 1691, but his manuscript was not printed in the *Transactions* until 1739.[8] Living in the vicinity of Thomas Shirley in the same coal area, Clayton heated coal in a closed container and observed that the "spirit which issued out caught fire at the flame of a candle."[9] Unfortunately, Dean Clayton, like his predecessors, put his discovery to no more use than to amuse himself. It was not until more than a century after Clayton's production of gas that the substance was recognized for its practical value. A certain Englishman observed that "the gas obtained by distillation from coal, peat, wood and other inflammable substances burnt with great brilliancy upon being set fire to" and that "by conducting it through tubes, it might be employed as an economical substitute for lamps and candles."[10] The man's name was William Murdoch.

As the famous James Watt's chief assistant, Murdoch worked in a stimulating environment of engineering inventiveness. Although somewhat overshadowed by his master, Murdoch has to his credit such inventions as a pneumatic lift, the oscillating engine, and a locomotive engine, to name a few. However, on his own time, Murdoch conducted experiments with coal gas; he felt it had a great potential.[11]

Like others before him, he began by simply heating a small quantity of coal and burning the gas given off. Having done this, however, he took the next obvious step and began conducting large-scale investigations. His first invention was a glass lantern fitted with a gas-filled bladder attached to a small jet, with which he saw his way home across the moors at night (he lived at Redruth in Cornwall, where he was supervising the erection of mining engines).[12] This having been successful, he went on to light his house by conducting gas "through seventy feet of tinned iron and copper tubes."[13]

Murdoch went on to light his next home at Old Cunnock in Ayrshire, in 1797, and then one of Boulton and Watt's workshops at Soho, near Birmingham.[14] This work was of a large scale, and he next experimented to find better ways of producing, purifying, and burning the gas. On the occasion of the signing of the Peace of Amiens in March 1802, Murdoch decided to present a public gas lighting display at the Soho works. According to William Matthews, an eyewitness,

> the illumination of Soho works on this occasion was one of extraordinary splendour. The whole front of that extensive range of buildings was ornamented with a great variety of devices, that admirably displayed many of the varied forms of which gas-light was susceptible. This luminous spectacle was as novel as it was astonishing; and Birmingham poured forth its numerous population to gaze at and to admire this wonderful display of the combined effects of science and art.[15]

Samuel Clegg, Murdoch's jealous assistant, left a somewhat different account. According to him, the display of gas was merely a forty-foot rod with a burner on each end:

> The operation was simply effected by fixing a retort in the fireplace of the house below, and then conducting the gas issuing from thence into a copper vase. This was the only gas used on that occasion, and not with the gas as has been erroneously stated [*sic*][16]

Clegg's statement may be rather biased, however, as he and Murdoch later went on to become bitter rivals. When Murdoch went on to light the cotton mills of Phillips and Lee of Manchester with a thousand-burner installation in 1805, Clegg raced to complete a similar installation first, at the cotton mill of a Mr. Lodge in Halifax. Clegg won by a few nights. In any case, whether Clegg truly disliked Murdoch and whether his downgrading of Murdoch's exhibition may be slanderous, the fact remains that gaslighting was now coming to public attention and was beginning to find practical application. The relative costs were rather appealing, too: the Phillips and Lee factory spent £2,000 a year for candles as opposed to £600 a year for gas. Even the insurance companies approved of it.[17]

While Murdoch was content to carry his experiments with gas no further, others were hard at work. In particular, Philippe Lebon, a French chemist, obtained a patent for making gas by processing wood or coal, in September 1799. This is only of passing interest, however, as Murdoch had made moves to obtain patents in 1798, but was discouraged by Watt.[18] The significance of Lebon's work is that another person destined to promote gaslight derived a strong impetus from it. The man was a German by the name of Frederick Albert Winsor. Although he failed at first to discover Lebon's technique, he finally was able to demonstrate light produced from wood gas at Brunswick in 1802.[19] Apparently Winsor had very little theoretical knowledge of chemistry or engineering, but he did have high ambitions for gaslight, along with great perseverance.

In 1803 Winsor arrived in London, and, supported by several well-to-do patrons, began experimenting with an apparatus similar to that of Lebon. After further work, he obtained a patent on May 18, 1804, for:

> An improved oven, stove, or apparatus, for the purpose of extracting inflammable air, oil, pitch, tar, and acids from and reducing into coke and charcoal all kinds of fuel, which is also applicable to various other useful purposes (and by which) the inflammable gas or air, being purified from that carbon so pernicious to respiration and dwellings, may be led and conducted in a cold stage through tubes of silk, paper, earth, wood, or metal

> to any distance in houses, rooms, gardens, places, parks and streets to produce light and heat.[20]

In the same month, Winsor held his first public demonstration at the Lyceum Theatre. The July 2, 1804, issue of the *Times* states that:

> Sir Joseph Banks, ever indefatigable in examining and promoting useful discoveries, went last Thurs. evening . . . to the Lyceum, to witness the incredible effects of smoke; the whole Theatre was lighted with the same, in a novel and pleasing manner; the arch of lights above the stage had a very striking effect, and from the English grate on the stage (which may be fixed in every room) issued a very brilliant and fanciful light.[21]

Another description of some of the apparatus used there mentions "a chandelier in the form of a long flexible tube suspended from the ceiling, communicating at the end with a burner designed with much taste, being a Cupid grasping a torch with one hand and holding the tube with the other."[22] Winsor himself, in a patent dated February 7, 1809, makes reference to his demonstrations (at the Lyceum in 1804, his Green Street workshop in 1805, and Pall Mall in 1806) while promoting gaslight, saying that "the gas may be used in ornamental, movable, and flexible branches, issuing from the condensing pedestals, such as has been shown in a great variety."[23] Apparently the audience was quite pleased with the light shown at these lectures, but according to one source, they found the smell rather unpleasant.[24]

Winsor's aim, in devising all these lecture-demonstrations, was to promote his project for the National Light and Heat Company, subscriptions to which were sold beginning in 1805.[25] The demonstration began in 1806 in Pall Mall, with the laying of leaden gas mains — seventeen hundred feet (the first ever laid publicly). Both sides of the street were lighted by June of 1807. It was estimated that the new street lamps had eighteen times the light output of the ones they replaced. Unfortunately for Winsor, public support for his venture was insufficient, causing his foundling organization to come to an end. Undaunted, Winsor went on to found the London and Westminster Gas Light and Coke Co., which, over the opposition of Murdoch and Watt, was incorporated in 1809. In April 1812, success was assured with a royal charter, and public gaslighting in London soon became a reality.[26] With employees of the inventive caliber of Samuel Clegg, the gas meter was soon invented (1815), and by 1817 the first cylindrical gasometer (gasholder) was constructed.[27]

Four

Gas Takes the Stage

By 1817, the development of gas production, storage, and metering was virtually complete. It is not surprising, then, that by this time gas had begun to be put to general use in theatres. The public's first contact with gaslight was in the Lyceum Theatre in 1804.

Gas was perhaps first regularly used in a London theatre at Covent Garden. A playbill for September 11, 1815 — the start of the 1815–16 season — claims that the "Exterior, with the Grand Hall and Staircase will be lighted with Gas."[1] According to the *Times* review of September 11, the house had "a brilliant and imposing aspect, much more profusely magnificent than the rival theatre."[2]

Possibly the first theatre to light its house with gas was the Olympic. Its playbill for October 30, 1815, reads: "The Exterior, the Saloon, and part of the Interior will be lighted with Gas."[3]

Another early installation, about which little information has been preserved, was the East London Theatre at Wellclose Square. It is known that it opened in August 1816 and that it produced mostly melodramas and other less reputable works.[4] Its advertisement in the *London Times* of August 6, 1816, states:

> GAS LIGHTS — The Public are respectfully informed, that this THEATRE IS OPEN every Night for the Season; the whole of the interior and exterior totally illuminated with Gas.[5]

Unfortunately, the *Times* never condescended to review any of the East London's shows, and we seem to have no other record than its advertisements, in which "gas" and its effects were highly praised. It is difficult to tell from the advertisements just how extensive the installation was. The following season another *Times* advertisement of September 4, 1817, reveals that the East London had a bit of trouble with its installation. More important, the notice seems to imply that the stage might have been gaslit:

> In the course of last season some slight degree of inconvenience was occasionally felt from a partial escape of gas, to remedy this, during the recess the works have been entirely rebuilt, at a vast expense, and the Managers have now the honour to announce, that they have succeeded far beyond their most sanguine expectations in removing the evil complained of; and for brilliancy of effect in Melo-dramatic pieces this Theatre must stand unrivalled.[6]

If the gas was used to light the stage, the theatre was, as the management claimed, "unrivalled." On the other hand, the gas may have been used merely for effects, such as "a smuggler's vessel in flames which blows up with a terriffic explosion,"[7] a scenic wonder advertised on September 5. Until further information is uncovered, it will remain in doubt whether the East London was the first totally gaslit theatre.

By the opening of the 1817–18 season, the houses of the Lyceum, Drury Lane, and Covent Garden were all gaslit. Covent Garden's house, according to a contemporary description, was "brilliantly illuminated with a grand central chandelier which has been rendered still more effective, and the three auxiliary lamps which were complained of as impeding the sight and the contour of the theatre have been removed, and Grecian lamps substituted, which range round the back of the Dress Circle, and shed a soft medium light, without obstructing the view of the stage."[8] Another account mentions that:

> At Covent Garden the improvement in lighting the interior is considerable. The lights which formerly hung round the house are removed and a magnificent chandelier of gaslights is now suspended from the centre. The effect is beautiful and novel.[9]

In its bills, the theatre advertised its new house lighting in the following manner:

> *The Proprietors respectfully inform the Publick that a new Method of*
> LIGHTING:
> and likewise a new Principle of VENTILATING the Theatre has been adopted. The First has been effected by a MAGNIFICENT CHANDELIER, which from the Centre of the Ceiling diffuses a soft and brilliant Light around, without obstructing the View of a single Spectator. In its effect, the Body of Light is equal to 300 ARGAND LAMPS; and the Heat is directly carried off through a Tube communicating with the open Air. The SECOND is upon the Principle of a forced VENTILATION, by which the Theatre can be either Cooled or Warmed, and the Atmosphere of the different Parts of the House can be kept to one pleasant Temperature throughout the different Seasons of the Year.[10]

The *Times* for September 8 contains the most detailed description of Covent Garden's lighting. This is essentially a description of a preliminary demonstration held on September 6, as Covent Garden's season did not open until September 8.[11]

> We derived considerable satisfaction from viewing the alterations which have taken place in the mode of lighting the interior of Covent-garden Theatre. It was already sufficiently provided with handsome lustres and branches, and wax candles: but a great change is now made by the introduction of the gas-lights. A select company was assembled to witness, before the opening of the season, the experiment of the first exhibition of this mode of illuminating a vast theatre. All the former chandeliers are removed, and a great central light de-

scends from the centre of the ceiling, but not so far as to intercept the view of the stage even from the one shilling gallery. It is of a rotund form, and spreads itself into a large circular canopy of a dark and subdued tint, under which is a constellation of lights which illumines and irradiates the house. Descending in the shape of an inverted cupola, under the canopy it contains about six circles of gas lamps with the clearness of diamonds, yet chastened with such a mild radiance as not to glare or to dazzle the eye by their brilliancy. They are covered by clusters of glass ornaments; and above and around them is a very deep fringe of small glass pendants hanging from the canopy which crowns this most beautiful lustre. It is but justice to say, that we have seen no specimens of the united attractions of glass and light that rivals it in the diffusion of its light, and the simplicity of its elegance. We do not perceive any particular inconvenience likely to arise from the shades it might be likely to cast into the boxes, in consequence of their projections. This is provided against by the other gas lights which are intended for the illumination of the dress circle and the pit. Of these there are five magnificent branches: one on each side of the stage with five arms or brackets, holding up five lights, fully ornamented. Three more are placed, one in the centre, and the other two intermediately between that and the side stage light branches or girandoles. The gas lamps have also been fixed upon the edges of the first wings on each side of the stage. Semi-circular mirrors are put up at the ends of the stage dress boxes. Considerable skill has been exercised to prevent any disagreeable smell from the gas, by placing the lesser lights in lamps, over which tubes with funnel mouths open to take off the unpleasant air. The great light under the ceiling, which is the presiding luminary, has a very large tube for this purpose. It is not improbable that the whole illumination may prove too brilliant: but that redundancy may easily be removed, either by diminishing the number of lamps, or by the partial application of gauze screens. The scenery, which was shown off in succession, testified the advantages of the new lighting.[12]

In the eyewitness account, we see several significant developments. The gas lamps fitted to "the edges of the first wings" are the beginnings of gas stage lighting. The mirrors on the boxes near the stage were obviously intended to reflect light on the forestage, an idea put forth in 1790 by George Saunders (see Chapter 3) as an alternative to the use of footlights and the unnatural shadows they cast. Also, the first crude attempts were made at ventilation.

Apparently Covent Garden's auditorium lighting was the most elaborate. According to another account, its rival, Drury Lane, though it could not compete for size, still did not wish to be outdone:

> Since our last [review] the interior of this elegant theatre has been lighted with gas round the boxes; the lights are enclosed and festooned with cut glass from one to the other, and if the tout ensemble does not vie with the more brilliant display at Covent Garden, it has an air of neatness and lightness which is as pleasing to the eye as it is tasteful and elegant.[13]

Leigh Hunt, editor and critic of the *Examiner,* made his own observations of the Drury Lane's equipment in his review of September 7, 1817.

> Drury Lane Theatre was to open last night, and Covent-Garden opens tomorrow. The improvements or alterations which the former has been making, we saw on Friday evening, and can promise our Readers much satisfaction with the gas-lights, which are introduced not only in front of the stage, but at various compartments on each side: Their effect, as they appear suddenly from the gloom, is like the striking of daylight. . . . It is as mild as it is splendid — white, regular, and pervading. . . . The Theatre has not the advantage of this part of the beauty as the lights are enclosed in glasses and blinded from the audience by side scenes and reflectors. . . . If the front light could be thrown, as day-light is, from above instead of below (and we should like to hear the reasons why it cannot) the effect would be perfect.[14]

It is interesting to note how aware Hunt was of the possibilities for naturalistic lighting. He had just seen one of the first gaslit stages, and was already yearning for overhead frontal lighting, as others did toward the middle part of the century (see Chapter 6).

Drury Lane obviously bent its efforts to match its rival. A review dated March 23, 1818, notes a large new chandelier that was obviously meant to be compared with Covent Garden's. This review also contains a rather good description of the large gas chandeliers that were coming into increasing popularity.[15] (These will be described in greater detail below.)

As for lighting the stage itself, the Lyceum (see Appendix II), Drury Lane, and Covent Garden, respectively, led the way. In its bill for August 6, 1817, the Lyceum stated that "the Gas Lights will this Evening be introduced over the whole Stage."[16] About a month later, its bill for September 8 announced:

> The complete Success which after a Trial of several Weeks, has attended the Experiment of Lighting the stage by Gas, has induced the proprietors of this Theatre still further to consult the Improvement of the Public Accommodation; and this evening a new and brilliant Mode of illuminating the Audience Part of the Theatre by means of Gas Lights will be submitted to the Observation, and it is respectfully hoped, to the Approbation of the Visitors of the English Opera House.[17]

The *Times* review of September 9 mentions the house lighting:

> The Audience part of the theatre was illuminated for the first time with gas-lights, upon a very simple and convenient plan. The lamps were suspended, at equal distances, from two rows of glass drops, formed into festoons and diffused an excellent light.[18]

Although the Lyceum was completely gaslit by September 8, 1817, and had the first gaslit stage, Drury Lane was the first total gas installation. When its season opened on September 6, it was lit both on stage and in the house, putting it just two days ahead of the Lyceum and Covent Garden.

Drury Lane's house installation has already been described; the *Times* for September 6 has a good description of the stage:

> A very considerable improvement, we think, will be found in the introduction of "gas-lights" on the sides of the stage, on which there are 12 perpindicular lines of lamps, each containing 18, and before the proscenium a row of 80. The advantage anticipated from these lights consists mainly in the facility with which they can be instantly arranged so as produce more or less of illumination, according to the particular description of the scene.[19]

As already mentioned, Covent Garden's stage was also gaslit by this time. The first wings had gaslights attached to the edges (probably the upstage edges to cast light on the next row of wings upstage); to dim the lights, either the gas could be lowered, or gauze screens could be placed in front of them. These screens may also have served the functions of coloring the light, as well as diffusing it more evenly.

In its review of Covent Garden's opening night of September 8, 1817, the *Times* complains about the footlight arrangement, and mentions that their prominent chandelier's advantage,

> that of throwing the light on the countenances of the actors from above instead from below (which last method inverts the natural shadows of the face and distorts the expression) is defeated by the gas lights which are still retained between the stage and the orchestra. Nor do we know how these can well be dispensed with, as it is by raising or withdrawing them that the stage is enlightened or darkened as the occasion requires it.[20]

Footlighting had always provided the greater part of early stage illumination, but now that its power had increased, its garish effects became more apparent. From the review, it sounds as if Covent Garden's footlights were mounted on some sort of pulley to increase or decrease their effects.

The sudden introduction of the new illuminant brought other problems as well. A rumor was spread that Drury Lane was manufacturing gas on its premises, and could explode without warning. (The theatre had to issue disclaimers.) But real difficulties did confront the patrons of London theatres. The *Times* commented that "after having sat through a whole evening in the theatre, playgoers felt a burning and prickling sensation in their eyes, a soreness in the throat, and a headache which lasted for several days afterward."[21] This was a direct result of the gas combustion, which both depleted the air in the hall, and produced other potentially toxic by-products like carbonic acid. The development of improved ventilation systems was necessary to offset this problem, which was in some measure relieved later in the century. As mentioned in a bill earlier (see note 10 in this chapter) some attempts were made at ventilation. The *Theatrical Inquisitor and Monthly Mirror* of September 1817 took notice of the ventilation. Covent Garden's chandelier was "suspended under an immense reflector, of a conical form, which by means of a tube carries off the heat arising from the immense body of flame."[22]

The system which Covent Garden advertised in 1817 was again mentioned in the *Times* four years later. The occasion was the apparent upgrading of the equipment.

> The attractions of this place of amusements have been considerably increased within the last few nights, in consequence of the excellent manner in which it has been ventilated. The theatre is perfectly free from that unpleasant and close smell experienced on entering other crowded assemblies, and it is surprisingly cool, considering the state of the weather and the numbers who frequent it. . . . The temperature of the House of Lords has been frequently up to 90 deg., and the House of Commons has baffled every attempt hitherto made to ventilate it. . . . Covent-garden theatre has now a constant current of air passing through every part, and its

> temperature is, even on the most crowded nights, not higher than summer heat.[23]

By today's standards this seems rather crude, but for a theatre to be no hotter than summer heat was something to be appreciated in 1821. More will be mentioned about ventilation later.

Now that the largest London theatres had established the use of gas, it was only natural that lesser local establishments, as well as the larger provincial houses, should follow suit. The King's Theatre was one of the first of this series. A review of January 10, 1818, states:

> A superb chandelier, lighted with gas, is now suspended from the ceiling, and illuminates the Theatre, in lieu of the lustres and wax candles. Its form is beautiful, and the dispositions of thousands of brilliant cut beads produces the finest possible effect.[24]

Next came Astley's Amphitheatre, which opened in March 1818 for the purpose of presenting equestrian shows. In one description, it was said that "the ceiling represents a dome supported by pilasters of trelliswork, in the centre of which the new and superb chandelier, illuminated by gas, descends."[25] Another addition was the Adelphi Theatre, which, when opened following reconstruction on October 18, 1819, proudly informed the public that "the brilliant effect of the gas chandelier suspended from the dome is the subject of universal admiration."[26] In the outlying cities of Liverpool, Edinburgh, and Manchester, gas was adopted in May 1818, December 2, 1818, and December 1819, respectively.[27]

The one notable holdout in the midst of all this conversion activity was the Haymarket Theatre. A contemporary observer, speaking about its seasonal opening on July 7, 1819, noted that "the stagelights were so badly conducted, that the glasses frequently broke during the performances: it is to be hoped that the gas lights will be adopted, which can be diminished at pleasure, when a dark scene is required, without the noise of a bell for the descent of the lights, as contrived at the Theatre Royal, Drury-lane."[28] But the Haymarket kept its oil patent lamps and spermaceti candles even after it was rebuilt in 1820. The reason for this was that under the terms of the theatre's lease, only oil lamps could be used on the premises.[29] It was not, in fact, until 1843 that Benjamin Webster, the manager, introduced gas. A bill for April 17, 1843, announced that "among the most important improvements is the introduction of GAS as the medium of light."[30] The Royal Coburg (today the Old Vic) was another holdout, though not for as long as the Haymarket. It opened on May 11, 1818, with oil lamps.[31] Its stage was subsequently gaslit by 1832, or earlier. A bill dated August 15, 1836, declares that "a set of new and splendid chandeliers has been added to the dress-circle, lighted with gas."[32]

There were some regressions. The Olympic, which led the way in the gaslighting of the stage, returned to candles in 1822, when gas was removed from the interior.[33] Covent Garden also experienced a temporary setback following the explosion of a gasometer during some repair work on November 18, 1828,[34] and also because of a generally offensive odor. In a review dated November 6, the *Times* complained of the odor, and described a resulting incident.

> The nuisance arising from the gas, which escapes in such quantities as to make the theatre perfectly unendurable, increased last night to such a pitch as will probably have the effect of putting an end to it altogether. Besides the stench, the greater part of the row of chandeliers in front of the dress boxes were suddenly seized with intermittent fits of dimness and blaze. . . . At the falling of the drop, Mr. Fawcett, being loudly called for, came forward to apologize, and to express a hope that the audience would not suffer the displeasure at this accident to influence their judgement on the play. He said there was

> no doubt that it had been occasioned by the villany of somebody, and that it had never happened before. A gentleman in the boxes reminded him that it was nearly as bad on the preceding night. Mr. Fawcett admitted that something had been wrong then, and said the whole day had been passed endeavoring to detect the persons by whom it had been occasioned. He requested the audience to permit the dress circle chandeliers to remain unlighted for the evening, and promised that they should never be lighted again until the fault should be wholly remedied. This satisfied the house, and the audience sat very quietly during the remainder of the play darklingly, and regaling themselves with the scent of gas which escaped from the unlighted chandeliers.[35]

At this point, the management issued a bill announcing a one-week closing because "the introduction in the audience part of the Theatre, produced an offensive odour, and the Public having suffered inconvenience and disappointment in their amusements, by the mischievous agency of some malignant and interested Persons; the Proprietors have determined to remove the Gas, not only from the Box Circles, but from all internal avenues leading to them, as well as to the Pit and Galleries."[36] To reassure the public upon reopening, the following bills were issued. The first, dated December 3, 1828, was signed by the manager of the gas company.

> In reply to a statement in the Morning Journal yesterday I certify that no gasometer, chamber or receptacle of gas is now placed within the theatre and those parts of the theatre at present lighted with gas are supplied from the mains of The Chartered Gas Company. I beg leave to add that The King's Theatre, The Adelphi and The English Opera House are also supplied from the mains of the above company.[37]

The other bill stated:

> The public attention is respectfully solicited to the following facts: The Gasometers and apparatus for making gas are destroyed and no more gas will be manufactured within the walls of the theatre. The circles of Boxes will

> be illuminated with wax; the lights in front of the stage and every interval avenue to box, pit and galleries will be produced by the agency of purest oil.[38]

Despite such setbacks, however, the gradual spread of the new gaslighting was inevitable. The French quickly took notice. Some streets were lighted in early 1819, and Louis XVIII dispatched his household minister to London the same year (some sources say 1818) to study theatre lighting. King Louis had the Paris Opéra in mind as the recipient of this new technology; it was a publicly subsidized institution and would certainly reflect well upon the state by being up-to-date.[39] His minister, M. de la Ferté, returned with favorable information, and work proceeded soon after.[40]

The job was turned over to two engineers, Darcet and Cagniard de la Tour, who proceeded to erect a large gas works in Montmartre on the Rue de Latour-d'Auvergne. Apparently, after the other outside installation work was complete, the actual works inside the theatre took only eight days to install, after which it reopened with a grand ballet spectacle entitled *Filets du Vulcain.*[41] This took place in August 1821, with the first completely gas-lit production actually taking place on February 6, 1822.[42] The next large theatre installation of note was made in 1832 at the Comédie Française, when it was remodeled.[43] The Comédie, however, did retain oil for use in its border lights as late as 1885, because it was believed that gas overhead would be too fatiguing for the eyes of the actors.[44]

For all its early trials and tribulations, gas was now well established in the theatre as an illuminant. With a brilliance and directionality never before available, stage lighting was being revolutionized. The possibilities were only beginning to be realized. There would be many problems to solve and much technology to develop, but the use of gas would spread: no modern stage could afford to be without it.

Five

Gaslighting on the American Stage

Important developments in lighting were happening in America while the aforementioned activity was taking place in Britain and France. Experimentation with gas took a rather different form in America, largely because American coal was anthracite, a poor source of gas. It was not until 1812 that this particular coal could even be made to burn. Consequently, early experimenters turned their efforts to extracting gas from wood and animal fats. One of the foremost in the field was Benjamin Henfrey, a man with a mining background who had emigrated from England in 1791. In March 1802 Henfrey held an exhibit in Baltimore, at which he burned gas produced from wood and coal.[1] In the following year, he appeared in Richmond, where he lit the main street with a large lamp set atop a forty-foot tower. Henfrey referred to his gas as "Inflammable Air."[2]

There is an interesting connection between Henfrey's Baltimore exhibit and the first American gaslit theatre. In mid-April of 1802 William Warren, later to be one of the managers of the Chestnut Street Theatre of Philadelphia, and at that time an actor with that company, apparently was in Baltimore. He probably could not have helped either seeing the demonstration (still reported to be in progress on April 6) or at least hearing of it. In addition, Warren was acquainted with Dr. James Mease, who in the winter of 1802 had exhibited gaslight produced by extracting essences from red cedar. Warren, who would also have been in Philadelphia at this time, was thus very likely to have been familiar with gaslight.

Furthermore, at this time, there was in Philadelphia a Dr. Charles Kugler, another gas researcher. Kugler, realizing the relative scarcity of high quality coal, turned his attention to producing gas from pitch. He got an opportunity to put his experiments into practical use at Peale's Museum in Baltimore, in 1816. Rembrandt Peale, the owner, contracted Kugler to build a small gas plant on the premises, and in early June the exhibit was opened to the public.[3] On June 13, 1816, a Baltimore paper announced the exhibition of " 'Gas Light without Oil, Tallow, Wick or Smoke' to be Given in the Museum and Gallery of the Fine Arts in Holliday Street, established by Rembrandt Peale in 1813."[4] The exhibition was apparently successful; on June 17, an ordinance was passed allowing Peale and others to produce gas, lay piping, and to make contracts for public lighting with the city. This became the first American gas company and was incorporated on February 5, 1817, as the Gaslight Company of Baltimore.[5]

William Warren probably saw Kugler's work and was impressed by it. We have a diary kept by Warren from September 10, 1796, to December 6, 1831, in which references are made to the project of lighting the Chestnut Street Theatre in Philadelphia.[6] For July 11, 1816, the entry states that Warren "saw Archy McCall [a builder] abt. lighting the Theatre next season with Gas."[7] Finally, on October 26 he says that he has signed bonds with Kugler, "relative to the Gas Lights."[8] It is not known exactly how much of the theatre was lit, but the gas was first used on November 25, 1816, for a performance of *She Stoops to Conquer.*[9] According to an advertisement in the *Aurora,* dated November 21, "The managers were happy to be the first to introduce the use of gas in lighting theatres in America," and they "flatter themselves that its superior safety, brilliancy and neatness will be satisfactorily experienced by the audience."[10] The theatre subsequently burned down on April 2, 1820, one of the first casualties of the new system.[11]

The next American theatre to be gas illuminated was the Belvidere Theatre in Baltimore in the year 1817. It was conveniently located across the street from the city's new gasworks (the first American gas company, mentioned earlier), and had the honor of being the first building in Baltimore to be lit by gas.[12] The *Federal Gazette* of May 5, 1817, anticipated the first production given there.

> From the Managerial advertisements we may expect much novelty and look with some impatience for the production of the Melodrama of "Alladin or the Wonderful Lamp," taken from the beautiful romance of that title in the Arabian nights Entertainment. The introduction of the Gas Lights, to the theatre, is an improvement which must instantly attract, by their transparent brilliancy the observation of the beholder, and are wonderfully calculated, by their easy management, in graduating light, to aid in the scenery requiring the necessary alterations in that respect. Their safety is also another strong recommendation and will serve to do away with those fears which sometimes interrupt the pleasures of the more timid part of the audience. . . . We understand their disposition in our theatre is an improvement upon that of Philadelphia. . . . We will however take the liberty to hint, that a row of drops pending from the hoops of the lustre surrounding the first and second tier of boxes would add richness to the general effect; much however has been done, and we entertain no doubt that every necessary addition will be made which either liberality or good taste may in the future dictate.[13]

A gas company was founded in Boston in 1822; however, no theatres were lit there at the time.[14] Gas had been exhibited there in November 1815 at the Boylston Museum. According to the *Boston Evening Gazette* of November 30, 1815,

> The Gas-lights which are to be exhibited at the Boylston Museum this evening will be an interesting curiosity to those who are unacquainted with chemistry, as the lights will be burnt upwards of one hundred feet from the reservoir which contains the gas, without the aid of tallow, oil or wick. We understand that the streets of the city of London are lighted with this gas in various directions for upwards of fifteen miles.[15]

The next American theatre to use gas illumination was in New Orleans. James H. Caldwell decided to build a theatre there modeled on a local architect's knowledge of the Chestnut Street Theatre (though it was not an exact duplicate). For this purpose, Caldwell purchased land on March 21, 1822, and began construction of a theatre and a gas plant. The gas apparatus was imported from Britain and was run by an engineer named Simonds, apparently a lighting pioneer in that section of the country. The Camp Street Theatre, the first building to be illuminated with gas in New Orleans,[16] opened on January 1, 1824.[17]

New York soon followed the New Orleans stage in the growing movement toward technological improvement. Although there are many conflicting claims, it would appear that the Chatham Garden Theatre was the first New York theatre to possess gas equipment. The *Mirror* of May 12, 1825, reported that the whole theatre was lit with gas, which shed "a clear, soft light over audience and stage."[18] Soon after the Chatham Garden, Scudder's Spectaculum, a large museum and exhibition hall, opened on June 30, 1825, also lit with gas.[19]

The competition for audiences inevitably led to an increased number of gas installations among the New York theatres. The third public entertainment facility to get a gas system was the Lafayette Theatre, in the following year of 1826. For a show which opened on July 31, it was announced that "the whole will be for the first time thrown open, and brilliantly lighted with gas, displaying an extent of stage and capabilities for the production of Equestrian Melodramas wholly unrivalled in this country."[20] The implication of the "extent of stage" claim was that due to the arrangement of the new instruments, a good deal of wing space was freed for use. Previous to this, standing wing lights had impeded much offstage-onstage movement of the sliding wings (standard scenery at that time), because they would have been exposed. With gas borders rigged overhead, the stands were removed, allowing the acting space to be altered, and in addition, lighting the actors' faces from above — surely a more naturalistic direction.[21] In the same year the Bowery Theatre opened on October 23 with a gas system. The Bowery is credited by several sources as the first gaslit theatre in New York. This error may have arisen from articles like one in the *American* of October 24, 1826, which says: "The new mode of lighting is extremely grateful to the eyes — sit where you will, you can never be annoyed by an offensive glare of light."[22] This "new mode" has been taken by some to mean that the system had introduced gas to the New York stage. The real novelty of the system was that the lights were placed within ground glass shields, not common open burners, which were very glaring.[23]

The last of the major theatres to get in on the initial switch to gas was the Park Theatre. According to an advertisement in the *Post* on November 23, 1827, "To give greater effect to the scenery . . . the stage has been fitted up for 'Lighting by Gas' which will be introduced for the first time this evening."[24]

As in England, where the new development in lighting moved outward into the larger provincial houses, gaslighting followed the development of theatre in American cities. Gas reached Washington, D.C., in 1831. An experiment was attempted there in using portable lamps; however, it was un-successful, the instruments failing on opening night. Consequently, the audience had to be dismissed and other lights subsequently provided.[25] Chicago was next. With the formation of the Chicago Gas Light and Coke Company in October 1849, gaslit theatres soon appeared.[26] The next year, Rice's Randolph Street Theatre opened to gaslight on September 4.[27] In cities that had no gas works, individual theatres had to fend for themselves, as in the Chestnut Street establishment. In 1846 there was reference to a theatre in Cincinnati lit by gas produced from lard (a not unheard-of method).[28] This particular installation, however, must have predated the installation of city gasworks, which were installed in 1841.[29] With the lighting of theatres in California, the geographical spread was almost complete. The city of San Francisco was gaslit on February 11, 1854, and within a few weeks, a theatre by name of the Metropolitan was using gas too. In November 1855, Maguire's Opera House was completely gaslit and possessed a large chandelier, comparable to those back East.[30] Gas reached Denver in 1872, and when the Denver Theatre was remodeled in April of that year, it was advertised in the *News* that the house would be "lighted with gas entirely."[31]

Six

The Impact of Gas on the Theatre

Although the Renaissance pioneers had dreamt of real control of lighting, their efforts were doomed to fail. Despite their ingenuity, they lacked a workable technology. Gas brought with it two important technical advantages. The amount of light on the stage was greatly increased due to the brighter combustion, and it was easier to raise or lower light levels selectively. For financially pressed theatre operations, a further advantage was that gas was considerably cheaper than oil or candles.

Gas was now a commonly accepted fact of life, not a novelty. Old conventions had been adapted to meet its rise, and new ones sprang up. Candle-lit chandeliers, which most theatres used to light their houses, were no longer as great an inconvenience as they had been. Previously, at the opening of a performance, the chandelier was withdrawn into a recess in the roof of the theater, thereby darkening the house somewhat and acting as a formal signal to the audience. Now the chandelier could be dimmed, although not totally darkened, due to the pilot lights, which had to remain lit. Another problem now eliminated was the threat of dripping oil or wax striking the heads of the patrons. Gone were the candle snuffers and the attentions which had had to be paid to the older and cruder lighting instruments.[1]

As far as actual productions on the stage were concerned, many changes were also quite noticeable. True, the gas instruments at first were not used much differently from their predecessors, but this was just a lag in thinking. The first and most noticeable change concerned the actors. By the time John Philip Kemble died in 1823, gaslight was widely used throughout the London theatres. The new mode of illumination made it rather difficult for old-line declamatory actors like Kemble to practice the tricks of their trade. All of a sudden, gestures seemed overbroad, and facial expressions seemed greatly exaggerated. What had apparently worked before murky candlelights was no longer effective before the gaslights. Even the makeup appeared garish. Things only half-seen before were now totally revealed, and all had to be toned down.[2]

It is interesting to observe that the reaction to the electric light, sixty years later, closely paralleled that to the gaslight. *The Electrician* of October 21, 1882, reported:

> The Opera House, at Pittsburgh, U.S.A., was lighted by the Electric light September 27. It is stated by the local papers that the lighting was successful, except that the members of the theatrical company did not like the electric light very well. It showed all their imperfections too plainly; the powder and paint were very visible.[3]

"Gaslight" could easily be substituted for "Electric light": audiences and actors had to adjust to the gaslight just as they would to the electric light.

Another change for the actors was that the stage area was suddenly opened up for them. Formerly, they had competed for that lighted portion at the center of the apron before the footlights and also in the range of the house chandeliers. With the house darkened, the direction and intensity of their principle light source was now changed, and the actors had to withdraw behind the proscenium. This also helped focus audience attention more upon the stage and less upon the other distractions out in the house, because the house was much darker than before. Theatre managements and patrons became less tolerant of the distractions prevalent in the old playhouses.[4]

All these factors were helping to create a new dramatic atmosphere and a new set of visual possibilities. There was a distance now, with the entire show behind the proscenium, and each member of the audience was somewhat more isolated from the others than previously. Much was lost in the way of direct participation. The actors, too, lost something: unlike the audience, they were forced to participate even more, in a sense, in the onstage action. The scenery being much more visible than before, the actors could not now ignore what had been a murky area upstage. They were further back from the apron and in more of a scenic environment, into which they blended somewhat, or in some cases, with which they had to compete.[5]

With the new hardware came more possibilities for stage illusion, especially by selective illumination or darkening. In the Renaissance, stage illusion had been aided by poor visibility. Forced perspective vistas and painted shadows and highlights would not have borne inspection under bright lights as well as they did by candlelight. Unlike the individual tapers, gas instruments could all have their lines run back to a single control point, usually referred to as a gas table (*jeu d'orgue*) and run by a single operator (see Fig. 13).

One effect pioneered before gas and made much more effective by it was the use of scrim. De Loutherbourg used transparencies with some success in his exhibition. In a production of Planché's *Telemachus* at the London Olympic in 1834, we have a stage direction which says that Calypso "waves her sceptre — Music — A gauze to imitate smoke covers the stage . . . music — Gauze rises and discovers the figure of ULYSSES leaning on a pedestal."[6] In the description of a pantomime done in Covent Garden around 1832, we have another description of a "thick mist" covering the stage "and gradually rolling off . . . managed by means of fine gauze."[7]

Brighter lighting also allowed for alternatives to the standard flat-wing background for dimensional scenery. In a description of a production of *Le Corsaire* done at Her Majesty's Theatre in 1856, it is stated that "the complete withdrawal of what are technically called the wings, and the substitution of a broad expanse of panoramic atmosphere, extending over the whole area of the stage is a new, bold, and successful idea."[8] This was an early use of a cyclorama — taken for granted today, but an innovation made possible by the new technology.

One offshoot of the basic gas burner, and a great contribution to stage lighting effects of the nineteenth century, was the limelight. This interesting piece of equipment originated in the 1820s and was also called the calcium light, the oxy-hydrogen light, and the Drummond light. Thomas Drummond (1797–1840), a Scot with a mathematical and engineering background, was appointed in 1820 to serve on the trigonometrical survey of Great Britain. While on the survey, he spent his winters in London, where he attended lectures by William Brande and Michael Faraday at the Royal Institution. At one of these lectures, the subject was the intense luminosity of lime in an incandescent state. Apparently Drummond saw in this a practical application for surveying, in that it could replace the Argand lamps then in use for making stations visible at great distances. His first limelight instrument was completed in 1825 and put to a practical test in 1826 in Ireland.[9] An 1826 publication of the minutes of the Royal Society mentions Drummond's invention.

> Friday, May 12. The subject of this evening was the improvements made by Lieutenant Drummond in geodesical and other similar operations, by the introduction of an object to be seen at one station from another with a

facility and at distances much greater than had been heretofore attained.[10]

A note in a later issue of the same publication is more specific.

> Surveying Signals. — As a signal to be employed by night in geodesical and other similar operations, a ball of lime intensely ignited and placed in the focus of a parabolic mirror (the ingenious invention of Lieutenant Drummond), will supersede every other.[11]

The basic principle of the limelight was the heating of a block of compressed quicklime by a flame of combined oxygen and hydrogen. Apparently, coal gas was sometimes substituted for the hydrogen, and it was then called the oxy-coal-gas light.[12] Sometime between 1826 and 1837 the limelight made the transition between surveying and the stage; however, not much is known of its whereabouts until the latter year. Apparently, at that time, one type of limelight was the exclusive property of a Frederick Gye, later known as an Italian opera impresario. Gye rented limelights to William C. Macready, then the manager of Covent Garden, for a show put on there during the 1837–38 season. The show was a pantomime entitled *Peeping Tom of Coventry,* and the lights were used to give extra effect to a diorama of Continental views by a designer named Stanfield; they were also used within the show. They were apparently successful when used for moonlight effects, but Macready felt that the expense (thirty shillings a night — though it is not mentioned whether this charge was per instrument or for the entire package) was not justified, and he removed them after one week.[13] Their next mentioned use, was in 1847 by a Mrs. Warner who managed the Marylebone Theatre.[14] The production was *Hamlet.* The *Times* for October 13, 1847, has a description of some of the effects, which could only have been produced by limelight.

> Her [Mrs. Warner's] endeavour has been to give the Ghost more than usual of a supernatural character. He is placed on an eminence which elevates him above the other personages; when Hamlet follows him a change of scene slowly takes place, the use of gauze media produces a melting, dreamy effect; and when the change is accomplished and the Ghost in the bright moonlight is again in the presence of the audience, an entirely new sensation is awakened.[15]

It would seem that the season of 1851–52 was some sort of milestone for limelight. An "improved" version of the instrument was used in a production of *Azael* at Drury Lane. (The improvement may have been in the gas regulator system; the rest of the mechanism was rather simple and remained relatively unchanged in years to come.)[16]

As mentioned earlier, brighter lighting encouraged the use of translucencies, and limelight, as it became more widely accepted, certainly helped to increase their use. From later in the century, we have a description of an effect used in a production of *The Corsican Brothers* (see Fig. 14):

> In the first act the back of the scene in the Corsican palace is of this material [painted gauze] through which the tableau of the Paris duel is shown, a fierce light being cast upon it. In the original representation half of the wall descended, the other portion ascending, and revealed the scene.[17]

The limelight seems to have taken a while to catch on widely, however. According to one account, it was still a rare sight in 1878, and its wider use was encouraged by such theatre managers as Sir Henry Irving. The well-equipped theatre had several varieties of limelights for various uses. Now rather than just being used for general illumination, stage lighting instruments were becoming more specialized. Open limelights were used for bright washes, and lime spotlights were used for more concentrated beams and follow-spotting.[18] Although there is no certain information on how many of these instruments may have been used by the average theatre, one account from 1881 mentions that "a scene in St. James Park, which seemed lit up in the average way, had been set off by no less than three limelights."[19]

At first limelights seem to have been used primarily for moonlight effects, probably owing to their greenish color. Later, color media (probably glass) helped to offset the greenish cast and enabled the limelight to be more versatile in its application. With the addition of lenses, the first spotlights were created. Formerly, no instrument had been bright enough to make effective use of lenses, and the early spots and their operating adjustments left something to be desired. According to one observer,

> When the dancer is performing and the burlesque queen singing her song, we can see the fierce strong bar of lime projected from the corner — often, too, the lamp and the man that holds it. Nay, before the drop-scene ascends, he has taken his place aloft, and the rays, not to be restrained, stream out fiercely across the curtain. It performs fitful and irregular motions as the operator changes his glasses to a new color. There is something grotesque and primitive in the position in which the dancer pirouettes and gambols over the expanse of the large stage; the operator strives to pursue and overtake her with this lamp, always succeeding in displaying his illuminative ring upon the boards.[20]

Color mixing was also being added to the range of things that lighting could do. It is mentioned that "there is a great art even in the management of the limelights, and by crossing the rays of different lamps and of different tints, strange twilight and soft moonlight effects may be produced."[21] Although de Loutherbourg had been experimenting with color media of cloth and glass almost a hundred years earlier, he was able to work only on a small scale due to the low candlepower of his lights. Now new lights with higher intensity made de Loutherbourg's ideas exploitable.

Sir Henry Irving was perhaps one of the first to begin re-exploring the uses of color and design on the stage. When he took over management of the Lyceum Theatre in 1878, there had been very little done previously with color in light.[22] Many had been content with the green glare of the lime, and "the sallow effect of the yellow gas-light,"[23] but the extensive possibilities of the control and effect of color had yet to be investigated. There had been some attempt to use red, blue, or green media of glass or paper in the footlights, but nothing had been done in the way of color gradation or mixing. According to Bram Stoker, who worked with Irving as a lighting assistant before Irving became manager:

> The only appliances used were what were called "mediums" which were woven films of cotton or wool or silk drawn between the lights and the stage or scenery which they lit. The finest stuff we then used was "scrim" a thin silk which gave certain colour without destroying or suppresing an undue amount of the illuminative quality. This stuff, dyed only in a few rudimentary colours, could be used to go beneath the battens and encompass the standards, wire guards being affixed everywhere.... But it was impracticable to produce colour effects, except generally. The stage could be fairly well reduced to one dominating colour, but that was all.[24]

Although much of Irving's color work was done after the introduction of electric lighting, his pioneering in color work was done primarily with limelight. One of his main methods was the use of transparent lacquers on the glasses of the limelight boxes, by which he obtained many subtle gradations. Limelights, as mentioned earlier, had been colored with changeable glass media, but these were undoubtedly only the basic colors, and without subtlety. Irving later transferred his coloration directly to electrical lamps. He also broke up his row of footlights into different color groups, which could be individually controlled. Now, with his greater control of color and intensities, Irving truly began to design, and was able to light different portions of the stage space selectively, whereas others had been content to wash the entire stage with a single color. According to Stoker, "it became an easy matter to throw any special part of the stage into greater prominence — in fact to 'vignette' that part of the stage picture which at the moment was of the larger importance."[25]

All these advances were met to a degree with resistance on the part of the critics. Speaking particularly about Irving's work, one critic complains of "the frequent sacrifice of truth and fitness to mere scenic effect."[26] "A flagrant instance," he claims,

> was the blaze of light with which Juliet's bedchamber was filled, even when the moon's light was waning, in order that the fierce, ghastly livor of the lime-light might fall upon the parting caresses of Romeo and Juliet.[27]

Although we have no visual record of this performance and cannot judge whether Irving was heavy-handed or the critic merely conservative, we can see that experiments were being conducted. The idea of lighting portions of the stage picture was a new one, and it took people a while to adjust their perceptions. The same critic elsewhere condemns as "contrary to sound taste"

> our modern practice of concentrating the glare of a limelight upon the hero or heroine of a drama, and while bringing them into unnatural prominence, throwing all the other actors of the scene into shade.[28]

Irving was a true innovator, despite these criticisms. It is said that at the Lyceum he reintroduced the idea of darkening the house during performances and put all gas controls in the prompter's hands — a revolutionary concept by itself. In any case, he was the first to treat light as a creative and expressive medium, not just as a means to gimmicky effects.[29] On one occasion he is quoted as having said, "Stage lighting and groupings are of more consequence than the scenery."[30] He was perhaps the first modern lighting artist.

Another movement in lighting design that began to gather impetus around mid-century was a challenge to footlights as an accepted lighting position. This was rather important in that it foreshadowed changes that were to come in with electric lighting, and not necessarily because it caused widespread changes in gas techniques. Theatregoers showed considerable dissatisfaction with the effects of the footlights. One reason was simply that footlights lighted things from below and were therefore unnatural. Other complaints centered on the heat and gases they produced and their obstruction to the first several rows' sight lines. Many people put their objections in print, but few were able to offer practical alternatives. One of the more articulate spokesmen was J. E. Dove. In an article in *The Builder* in 1847 Dove not only objected to footlights but described some experiments in finding an acceptable alternative to them:

> I have frequently been annoyed and disgusted with the effect of the unnatural glare of light from the foot lights, particularly on the faces of those on the stage. The false and unnatural effect thus produced, everyone must have remarked.[31]

Frontal overhead lighting, Dove explained, was usually more agreeable:

> I had often been struck with the classical or picturesque expression thrown over the features of even a very plain and inelegant countenance by the elevation of the artificial light, when alone reflected on it, from a point *exclusively above its level*. . . . Of course, I do not mean that the light be elevated directly above the head, but immediately in front of it, at an angle, probably of forty-five degrees, *so that the expression of no feature be lost.*[32]

Dove had had the opportunity to test his ideas in the Edinburgh Theatre. His changes had included:

> the entire removal of the footlights, and the bold substitution of a central congeries of lights in the very body of the house (a small one certainly) and almost in the place usually occupied by the chandelier, with a reflector sufficiently large and powerful to turn the whole flood of light upon the stage, at about an angle of forty-five degrees. A second congeries was found necessary, however, at a like elevation, but within the proscenium, or above and behind the general range of the actors' heads, to aid in the proper and uninterrupted display of the scenery on the like principle, the complete design for which display comprehended the systematic use of scenery so illuminated also from behind as to give the dioramic effect, as far as possible.[33]

The dioramic effect, as we know, had earlier origins with de Loutherbourg, and his then-startling three-dimensional creations. Dove's work, however, was on a much larger scale. In his experimentation, Dove hit upon two of the positions most commonly used today for area lighting. Because the intensity of gaslight was low as compared with electric light, this method of lighting could be used only in small houses (see Table 1). Perhaps for this reason it never caught on. Large-scale interest in the 45-degree angle of lighting was not to be realized until the advent of electricity. In any case, *The Builder* championed the idea, and fortunately made a point of reporting innovations of this type. In 1851, a few years after Dove's experiment, a new theatre in Paris was lighted very much along Dove's lines: "There are no footlights, and the whole space is illuminated from above by an ingenious combination of reflectors."[34] An American installation in 1872 combined the more powerful limelight with the frontal position:

> Mr. Fechter's theatre in New York is to be lighted by means of a limelight fixed in the ceiling of the auditorium, with reflectors, so as to illuminate the stage, not in the preposterously unnatural manner which cus-

> tom has made less than intolerable, and the effect of which is the reverse of truth.[35]

(This was either the old Globe Theater, built in 1862 and renovated by Fechter,[36] or the old Théâtre Français, which he attempted to renovate in the summer and autumn of 1871.[37]) One other example of these techniques in use was in a production of *The Passion Play* done by David Belasco in March 1879 at the Grand Opera in San Francisco. In it, Belasco removed the footlights and lit the stage from out front using locomotive bull's eye lanterns.[38]

While some were busy rejecting footlights, others were finding new uses for them. Some designers were discovering new uses for floor-mounted units. Although usually lined up downstage to light actors' faces, the units could also be used in perspective flat sets. "Floatlights being placed behind these parts, impart brilliant effects that no colouring can attain to, resembling the sunny spots of a landscape."[39]

Back in the days when footlights burned oil, they were still rather inoffensive. Now that they burned gas, they were larger, hotter, gave off more post-combustion vapors, and posed a danger to whose who came too close. It was not until just after mid-century that any practical attempt was made to correct these faults. This first new-style installation was part of the old Paris Opéra (not the large one erected later) and was installed in July of 1861. The work was done by the firm of Melon and Lecoq of the Rue St.-Denis, normally responsible for the maintenance of the Opéra's lighting system.[40] Formerly the footlights were merely rows of open gas jets, sometimes shielded, but always sitting full height on the extreme forestage. The changes were described in an article in *The Builder:*

> The gas-burners in a row, are placed eighty centimetres below the stage, where they are completely enclosed.

> The luminous rays are gathered by opposed reflectors of curved form in section, and projected to the scene through a conveniently inclined slat or opening in that part of the contrivance which is necessarily above the stage, extending the length of the "ramp" as of the row of lights below, and which opening is glazed with ground glass. The eyes of the actors are not dazzled; and sitting in the pit, we can say there is a very decided gain for the spectators. . . . The elevation of the metal-case, so to call it, as above the stage is less than that of "the float," by so much as 15 centimetres; so that from this circumstance, the view for the audience is improved. . . . It remains to be explained that the products of combustion being passed by the several chimneys of the burners into the long horizontally-placed light-reflecting recipient, pass from that by transverse ducts (of terra-cotta) into a pipe or channel placed parallel to the former, and connected at each end, that is each side of the house, with a pipe placed perpendicularly and ending above the roof. There may be a question as to the quantity of light, as at present arranged; but in the diffusion of light, as well as those respects which are obvious, the system is a great improvement on the old one [see Fig. 15].[41]

This system was repeated in the new Paris Opéra, built several years later. Other systems apparently worked along similar lines. By 1862, G. W. Lloyd of Detroit had patented a footlight that, although it lacked a ventilation system, was also sunk below floor level. It was faced with a wire mesh, had a movable reflector, and accepted color media (see Fig. 16).[42]

In Britain, the French footlight system was received with enthusiasm and widely accepted. The Lyceum Theatre's use of it is mentioned in an October 1863 issue of Charles Dickens's *All the Year Round.* The Lyceum's footlights were sunk very low into the stage floor, and the angle at which the light hit the actors' faces was thereby improved. The theatre also had an improved color-changing mechanism:

> Some remarkable and patented improvements con-

> nected with the action of the float itself have also been introduced by means of which the red or green lights can be turned on in place of what is called the ordinary daylight, or these, in turn, can be substituted for by the others, the change being effected by the most delicate gradations, or in a flash at will. Nor is it a small thing that in case of the breaking of a glass, or of its being necessary to substitute glasses of one colour for those of another, as the whole float can be sunk at a moment's notice into the regions below.[43]

Further improvements in the system soon followed. The Prince of Wales Theatre in Liverpool was fitted with the next innovation in 1866 by J. Defries & Son. In this installation, the gas jets were enclosed

> within a box formed of a series of compartments (cast in about 2 ft. lengths) joined together, and the back forming a tube, with openings at its upper part, within the box. The top of each compartment is double-cased in order that the float may always remain perfectly cool. From the main gas-pipe beneath the stage, branch pipes rise into the several compartments, there being six to each compartment — their arrangement being very novel and simple. That face of the tube or back of the box which is towards the stage slopes backward at an angle of about 45 degrees, the branch pipes following this angle, each alternate pipe rising higher than the preceding; thus, when the gas is lighted, there are two rows of jets, one higher than the other, the lower one being at an angle to the stage, which will throw its light almost horizontally; and the other at an angle which will throw it almost vertically, so that the performers can stand over the float without any fear of accident. The top of the float does not rise more than 3 in. above the rake of the stage, the sheets of glass in each compartment completely enclosing the flame on the face towards the stage; the tube at the back carries off all the heated air from the flame: the oxygen necessary for proper combustion arrives at the open bottom and a slight space is left between the top of each sheet of glass and the top metal plate. The glass mediums by which colored light is thrown over the stage are raised in a frame raised and

lowered like a window in grooved supports worked from the prompter's box, enabling him to give different mediums in each scene, if required.[44]

Many ingenious attempts were made to overcome the basic problems of the footlight. The unnatural angle, the sight-line obstruction, and even the color were dealt with in a variety of ways, but it was still not a good way to light a stage. When the more powerful electric light sources became available, the frontal ceiling position would eventually supersede the footlight.

The power of gas illumination, the limelight, and a growing body of technology were combining in mid-century to refine the aesthetics of stage lighting and to pave the way for twentieth-century advances.

Seven

Gas — The Final Phase

By mid-century, practically every theatre of any importance had a gas installation. It was now a theatrical commonplace, and the obvious trend was a turn toward larger and more elaborate displays of light and equipment (see Fig. 17).

The new Paris Opéra was unique in many respects, and served as a model to many theatres that came after it. The construction was supervised by the architect Charles Garnier. The building, begun in 1861, finally opened on January 5, 1875.[1] The Opéra was one of the largest theatres in the world. Its lighting system contained more than twenty-eight miles of gas piping, and its gas table had no fewer than eighty-eight stopcocks, which controlled nine hundred and sixty gas jets.[2]

Perhaps the record holder, as far as size went, was Astley's Equestrian Amphitheatre in London. According to the *Illustrated London News,*

> everywhere white and gold meets the eye, and about 200,000 gas jets add to the glittering effect of the auditorium. . . . Such a blaze of light and splendour has scarcely ever been witnessed, even in dreams.[3]

Another interesting large installation of this period was the Théâtre de Chatelet, built in 1862. Apparently in order to avoid the problems of heat and vitiation that most auditorium illumination systems produced, the builders of the Chatelet installed a huge tinted glass ceiling over the entire house. According to one observer, "The whole theatre is thus filled with a subdued light like that of the setting sun."[4] Some criticisms leveled at this structure were its effects upon acoustics, its disproportional cost in relation to its actual contribution, and the fact that it intercepted a third of the light that passed through it.[5] A similar apparatus on a smaller scale was said to have been used at the French Vaudeville. It was a glass hemisphere lit from within.[6]

For these larger buildings, larger staffs had to be hired to maintain more elaborate equipment and run the shows themselves. At the Vienna Court Opera House a staff of eighteen men was employed, with a lighting inspector, a chief mechanic and his assistant, thirteen mechanics, and three laborers.[7] In Great Britain a production of *The Corsican Brothers* at the Lyceum Theatre, admittedly a lavish production, employed thirty gasmen.[8] No doubt the average commercial theatre did not employ this many men, although there are no available figures on this.

The time was now approaching, however, when the lavish installations and ingenious effects would no longer be enough, because electricity was fast catching the imagination of theatre people and the public.

Electricity can be seen exerting its influence at a fairly early date. Electric arc lights had been in use for many effects well before there was a serious threat to gas lighting. The ever-innovative Paris Opéra had use them to produce the disk of the rising sun in 1846, and again in 1860 in spots and floods in a production of Rossini's *Mose in Egitto.* The arc never posed a challenge, however, being noisy and requiring as much effort to run as the limelight.[9] In 1875, the Euclid Avenue Opera House in Cleveland was using an electric system to ignite its gas lights.[10] (See Appendix II.) Many other theatres were also using electricity to create effects and do other odd jobs.

A parallel can be seen between the introduction of gas and that of electricity. Both sources of light were first used to illuminate exteriors, hallways, foyers, and staircases before they were allowed onto the stage or into the house.[11] The Gaiety Theatre in London, under the management of John Hollingshead, had electric lights installed on its exterior in August 1878.[12] Just as gas was cheaper than the candles it replaced, so was electricity cheaper than gas. Paul Jablochkov, one of the pioneers of electric lighting, wrote in 1878 that "at the Theatre du Chatelet the proprietor has dispensed with 30 francs' worth of gas every evening, and uses instead my system of electric light, which costs him only 14."[13] Jablochkov also lit the Paris Hippodrome in 1878 with arc lights. His system used the Jablochkov candle, which consisted of two carbons set next to one another and insulated with kaolin. Twenty of these were used, set in globes along the edge where the audience met the arena, together with another sixteen set in reflector units; all reinforced by 3 twenty-burner gas lamps. These were apparently not as bright as everyone would have wished.[14]

One other early installation is noted at the Teatro Paynet in Havana. A play entitled *El Fruto de la Deshonra,* by Miguel Ulloa, which opened there on September 23, 1880, mentions in its stage directions for one scene: "On opening the windows there streams forth a ray of electric light that crosses the scene in imitation of sunlight."[15] This undoubtedly refers to an electric arc lamp.

Electricity became less and less expensive, and its other advantages — cleanliness and lower heat output — made it even more attractive to theatre managers. It was only a matter of time until one of them took the new advance all the way and replaced his gas lights, as Richard D'Oyly Carte did at the Savoy Theatre in London in October 1881. According to the *Times* of October 3, 1881:

> It is worthy of notice that an attempt will be made here for the first time in London to light a theatre entirely by electricity. The system used is that of the "incandescent lamp" invented by Mr. J. W. Swan, and worked by an engine of Mssrs. Siemens Bros., & Co. About 1200 lights are used, and the power to generate a sufficient current for these is obtained from large steam engines, giving about 120 horse power, placed on some open land near the theatre. The new light is not only used in the audience part of the theatre, but on the stage for footlights, side and top lights, etc. . . . What is being done is an experiment, and may succeed or fail.[16]

The theatre was scheduled to reopen on October 6, following the installation, but due to technical delays, the day was pushed up to October 11.[17] On this day, the theatre opened with its auditorium electrically lit. Finally, on December 28, the theatre was totally lit by electric incandescent lamps.[18] The inaugural statement by D'Oyly Carte, the manager, contains some interesting comments:

> It is not possible, until the application of the accumulator or secondary battery — the reserve store of electric power — becomes practicable, to guarantee absolutely against any breakdown of the electric light. To provide against such a contingency, gas is laid on through the building and the "pilot" light of the central sunburner will always be kept alight, so that in case of accident the theatre can be flooded with gas light in a few seconds. The greatest drawbacks to the enjoyment of the theatrical performances are, undoubtedly, the foul air and heat which pervade all theatres. As everyone knows, each gas burner consumes as much oxygen as many people, and causes heat, besides. The incandescent lamps consume no oxygen, and cause no perceptible heat. If the experiment of electric lighting succeeds, there can be no question of the enormous advantages to be gained in purity of air and coolness.[19]

The Savoy installation represented a transitional phase. Like the earliest gaslit theatres, the Savoy had to manufacture its own illuminant, there being no public services. It also had to maintain a dual system for contingencies. This was "the first time that any theatre or public building will have been illuminated in every part by electricity alone," according to the *Times*.[20] More than just the value of this immediate gain was realized, however. Unlike the unsuspecting public and theatre artists of almost seventy years before, everyone was rapidly becoming aware of the future possibilities of electricity. Change and development were now becoming more frequent in people's lives. On January 7, 1882, after the Savoy's debut, *The Builder* published an unusually perceptive article, and many of its comments could well have been applied to the days of the introduction of gas.

> The change promises, in the first place, to be greater even than that from the reeking tallow-candles of the past, or from the next step, the Argand oil-lamp, to the introduction of gas. The conditions under which theatrical effects have so far been obtained, both on the stage and in the house, find themselves, it is clear, entirely altered; a new departure has to be made, it cannot fail to be evident to any observant eye. . . . The electric light seems to show up all the poverty of ill-executed, and to try even the best executed distemper-work, to an extent that must be positively distressing to the worker in that old and justly esteemed mode of decoration. . . . The management of the electric light on the stage so as to please the experienced artistic eye is a very difficult matter, and probably it will not be until a school of artists with this aim in view has been established that we shall be able to see the gorgeous effects that our stage may bring before us. One thing is certain at present, the effect of electric light on stage scenery is very far from satisfactory; in fact, so far as it is from being so, all our old admiration and recollections of the splendid scenery of Stanfield, Grieve, and Telbin, and abroad of Allegri and others, is terribly disturbed. . . . That progress is the law of existence in matters theatrical as in all things human is a truism. . . . It is evident that the next step must be taken in the direction of a greater consideration of artis-

> tic effect, that is, such as it is understood by the painter, and not the theatrical manager; the acknowledgement of the value of gradation, the value of contrast, the value of shadow, the value of proper grouping, the value of relative tones, of consideration of proper relief in backgrounds, of concentrated light, with many other pictoral secrets, the existence of which, though amply acknowledged and appreciated by the theatrical scene-painter, costumier, and manager, seem by them, for what reason we know not, to be entirely thrown to the winds. . . . We see, in fact, that most important of all laws of pictoral effect violated — the law of contrast. It remains, therefore, for us to hope that the next move may be in the direction of a more thoroughly artistic and pictoral improvement of our theatrical effect.[21]

The spread of electric lighting was extremely rapid, much more so than that of gas. The advantages of electricity — comfort and safety — far outweighed the new set of visual problems to be solved. In 1883, at the Alliser Theatre in Havana, 193 Edison lamps replaced 342 gas burners and lowered the temperature of the house by 14 degrees Fahrenheit.[22] By 1887 most of the important American and Continental theatres were electrically lit.[23] In many places it became mandatory to have electrically lit theatres, and this dealt the finishing blow to gaslight. According to German theatre regulations published in 1897, gas and oil lights were prohibited in theatres;[24] and at some time after November 1887, the Spanish government made electric theatre lighting compulsory.[25]

Electric lighting skills and improvements would advance in a way gas never had, through the employment of scientific principles and research. Pre-electric lighting was a haphazard, hit-or-miss affair. It was pragmatic at best, with little basis in theory. Modern technology had finally enabled theatre artists to catch up with the visions of the Renaissance pioneers. It is no wonder that electricity replaced gas so quickly, and that there are practically no examples of gaslighting equipment to be found anywhere. The sixty years that preceded electricity, however, should not be passed off lightly, as many of the techniques hammered out pragmatically then anticipated our lighting practices of today.

Appendix I
The Production & Delivery of Gas

We have seen previously how flammable gas was discovered, both in its natural state in the earth and in the laboratory, where it was produced by heating combustible materials. The most common gases used in theatres were coal gas and gas distilled from wood or resin.

Coal gas, as mentioned earlier, was produced by heating varieties of softer coal, bituminous particularly, in some sort of closed container, called a retort or oven, at such a temperature that it decomposed. The bituminous coal, moreover, had to contain no less than one-third combustible material (which would become the actual gas), a low ash content, and also less than 1 percent sulphur (sulphur would be troublesome to remove later).[1]

The process of manufacturing coal gas consisted of three main steps, the distillation, condensation, and purification of coal gas. When William Murdoch first began distilling coal gas, he used rather simple and crude retorts, not unlike the glass ones used in laboratories. He then tried heating his coal in cast-iron cylinders, which he stood on end within small furnaces. This method was good for processing about fifteen pounds of coal at a time. The end product, after gas extraction, was also a salable product for industry — coke, highly combustible and somewhat purified carbon. Murdoch's later retorts were built with the easier removal of the coke in mind. In 1802, he began setting his retort horizontally, and beginning in 1804, he constructed retorts with doors at each end, for putting coal in and removing the coke. This was not really satisfactory either, so when he lit the Phillips and Lee factory in Manchester he built a large, bucket-shaped container with a cover and an iron cage inside to hold the coal. By this method, the coke could be more easily removed. This was a large apparatus, holding fifteen hundred pounds of coal. Later retorts were somewhat smaller and elliptical in shape, as these were found to be more efficient.[2] More modern retorts varied in design, but all worked on the same principle.

In the next stage of the process, the gas was drawn from the retort through a hydraulic main and into a condenser, where it was cooled and collected.[3] During this same process, the heavier tar and water settled out, simultaneously beginning the third process of purification.[4] The gas next moved through further condensation, where carbonic acid and some ammonia were removed. As it moved on to the washers, more ammonia was taken away. Finally, in the purifiers, the gas moved through wood shavings mixed with iron oxide, and then lime, where carbonic acid, sulphurated hydrogen, and other gaseous sulphur compounds left it.[5] The purified gas finally had the following composition:[6]

	Percent
Hydrogen	50.2
Methane	29.8
Carbonic oxide	7.9
Heavy hydrocarbon	4.3
Nitrogen	7.8

Obviously these figures differed to some extent according to the type of coal used. Some impurities remained, but they were necessary for safety, so that escaping gas would retain a detectable odor.[7]

Once coal gas was produced and purified, it was stored in tanks called gasometers. These tanks were collapsible, and their lowest levels were filled with water. Additionally, where the rims of the collapsible sections overlapped, there were water-filled joints to keep them tight.[8] The top level was counterweighted in order to keep the outgoing gas pressure constant as the remaining volume decreased.[9]

The earliest gases produced in America were made from wood and other organic substances, owing to the difficulty of burning anthracite. Benjamin Henfrey, in his demonstrations, used both wood and coal in his retorts.[10]

Dr. Charles Kugler, who lit Peale's Museum in Baltimore and the Chestnut Street Theatre in Philadelphia, made his gas from pitch. Kugler's process is described in an article by Rembrandt Peale, dated June 7, 1816, concerning his museum's apparatus:

> Instead, therefore, of pursuing his experiments on coal, an article always dear in our cities, and sometimes not to be had, he more judiciously directed his attentions to less offensive substances which can be everywhere procured; and has finally completed a discovery of the greatest consequence, in a country abounding in pitch, from which, by a simple apparatus, easily managed, without anything offensive in the operation, he prepares a gas at once cheaper and more brilliant, than that prepared from coal.
>
> In his apparatus, the oil condensed in the receiver, immersed in water for the purpose, is afterwards employed to dissolve the pitch, which, thus dissolved, descends in a liquid through an aperture, regulated by a stop-cock, down to the hottest part of the red-hot retort, and is there decomposed, and ascends into the Gas-holder, after escaping from the condensing receiver. . . . The gas requires no washing in Lime-water, no noxious vapor is produced, and the objections made are avoided.[11]

The oil was oil of turpentine, which caused the solid pitch to become tarry, thus aiding its vaporization. The residue left after the gas was produced was a thick soup of nearly pure carbon.[12]

The Chestnut Street Theatre had its own selfcontained gas unit, as well as its own gasometer. Judging from the candle needs of theatres of comparable size, the theatre could have been lit sufficiently by a single eight-hundred-cubic-foot capacity gasometer. The system would probably have cost the theatre over $4,000.[13]

However, coal gas was the most common illuminant, and once it was collected, the next step was its distribution. Large cast-iron or steel mains laid underground conducted gas to smaller diameter pipes called "services," which ran directly to the burners. The first gas pipes are thought to have been made in England from gun barrels screwed together or sometimes from wood.[14] Later, cast-iron pipes became standard, especially the socket type. This type had one plain end, and the other had a cup-shaped socket. The pipes were joined as follows:

> The workman, having introduced the spigot end of one pipe into the socket of the pipe adjoining, passes gasket or spun yarn around it till the socket is filled therewith (when well set up by means of a proper caulking tool and mallet) to within from an inch and a half to three inches of its entire depth, the smaller depth left vacant being sufficient for the lead which forms the joints in all pipes up to four inches in diameter, the depth for the lead gradually increasing from one inch and a half to three inches, as the diameters of the pipes increase from four to fourteen inches. This being done, he makes a roll of clay, of a sufficient length to go quite round the pipe, and passing it underneath the pipe, he forces the clay close up to the edge of the socket, quite round, and joins it at the top, where he forms an opening or lip for receiving the melted lead which he has ready for use. Things being thus arranged, he takes a sufficient quantity of lead in his ladle, and pours it into the socket through the opening just mentioned, till the socket is entirely full, which is known by the lead rising to the top of the clay. So soon as the lead is set, the clay is removed, and he proceeds to make the next joint in a similar manner. After making two or three joints, and allowing the lead to become quite cold, the lead is driven up (or, as it is

> generally termed, set up) by means of a caulking tool and mallet, and thus joints perfectly gas-tight are formed.[15]

A second method of joining gas pipes was through the use of a filler compound called Roman cement, which expanded as it dried and made rather strong joints. Other types of pipe included "turned and bored pipes" (having one slightly conical end and one socketed, conically bored end, both coated with white or red lead and pounded together for long straight runs), and flanged pipes (flanged on both ends and bolted together with cement and gaskets.)[16]

From the mains buried in the streets, gas was next conducted into the building via service pipes. These pipes were generally made of cast or wrought iron, and were screw-jointed for smaller buildings; in larger buildings, the joints were lead caulked. For smaller services, pipes up to and including three inches in diameter were used, and in larger installations like public buildings, pipes four inches and upward were usual. These pipes ran as far as the building's gas meter or meters, and were the property of the gas company, its responsibility not extending past them. Just before the service pipe entered the building, there was usually a shut-off in the line that could be opened or closed by a long key inserted into a box set into the sidewalk close to the curb. These were generally required by law for safety, so that the gas could be shut off from outside the building in case of fire.[17]

Gas meters were installed at the ends of each service pipe inside the buildings by the gas company, in order to measure the incoming amounts of gas for billing. The gas meter, though invented around late 1815 or early 1816 by Samuel Clegg, did not come into immediate use. Early gas users were charged on the basis of the number of burners they used. Theatres may have had different arrangements by special contract, but this information is not presently obtainable. At some time around 1840, the Chartered Gas Light Company of England decided to make the gas meter standard equipment everywhere. The French legalized the meter as a standard measuring device in 1846, and within a few years it was in use throughout Europe.[18]

Two types of meters were in common use— the "wet meter," and the "dry meter." The wet meter, as mentioned above, was invented by Samuel Clegg, who began manufacturing it in 1816 as part of the firm of Clegg and Crosley. In 1817, the dry meter was pioneered by John Malam. Clegg and Crosley stole Malam's design the following year, and not without some legal wrangling did the inventor manage to obtain the patent in 1820.[19]

> The wet gas-meter may be described as simply consisting of four peculiarly formed gas-holders, each of which represents the fourth part of a cylinder; these are all attached to a shaft, with which they revolve. These gas-holders, with their shaft, are placed in a closed tank or outer case, supplied to a certain height with water, and as they revolve each of them is filled with gas in rotation, which gas is expelled by the action of the holder or chamber succeeding it; or, in other terms, each chamber on being filled with gas, causes the preceding chamber to be immersed in the water, and the gas to be expelled therefrom to the burners.[20]

The wet meter had several disadvantages. The water level had to be maintained, or the gas would shut off. If there was too much water, it had the same effect. If the meter were exposed, the water could freeze in the winter. Salt could be added to prevent this, but if the interior was tin plated, it could corrode.[21] The dry meter was a less vulnerable device.

> The principle of the dry meter will be best understood by referring to the action of the common bellows. When the upper leaf of this well-known domestic appliance is

> raised, an exhausting power is produced in the interior of the bellows, which raises the valve in the lower flap, and the air enters. But on the upper flap being depressed, the valve is immediately closed, and the air is expelled through the nozzle of the bellows. If we now conceive the upper flap to be attached to clock-work, so as to register the number of times in succession the bellows has been filled and emptied, it is evident that if its capacity at each stroke were known, then we could obtain the means of measuring the air which has passed in, and out of the bellows.[22]

The dry meter demanded no attention, as there was no liquid level to be maintained. This precluded any chance of the lights suddenly going out. These would clearly be the better choice for a theatre.

National building codes are excellent sources of information about gas installations and equipment, especially codes pertaining to theatres and public buildings. One of the more detailed legal codes concerning theatre gas installations was that of Lower Austria. In *Modern Opera Houses and Theatres* (1897) we find several paragraphs pertaining to as much of the typical theatre gas installation as we have so far discussed.

> 42. Every theatre shall have two separate and distinct gas services; the one for the auditorium, including the chandelier, front of tiers, etc., the other for the stage and its adjuncts. The junctions of these two services with the main in the street must be at least 20 yards distant from each other. All the regulations for gas services, etc., must be most strictly observed.
>
> 43. Both services must have stop-cocks fixed below the level of the street.
>
> 44. The gas pipes shall be of iron, and only where this is impossible may protected tubing be used. Common gutta-percha tubing is prohibited.
>
> 45. Each main service is to be provided with two gas meters connected with each other. Those for the service of the stage must not be near the others, but must be

> fixed in another apartment. Floats in the meters should be avoided.[23]

In the "Theatre Regulations" for Brussels we have further regulations concerning gas meters:

> 54. The gas meters shall be placed in strongly-vaulted chambers, properly ventilated and separated from the stage. These chambers should be lighted by a safety lamp, or by other means to be approved. The meters should be dry meters.[24]

Apparently, dry meters were widely stipulated because they were safer, more reliable, and needed no servicing.

A unique description of a dry gas meter used in a theatre comes from the *London Times* of July 27, 1848.

> A gas meter of immense size has just been cast and completed at the iron works of Mssrs. Glover in Charles-Street, Drury-lane, which is about to be erected in Covent-garden theatre for the measurement of the gas supplied to that establishment by the Chartered Gas Company. It is what is called a dry gas meter, no water being employed in the process as in the common meters, and is the invention of Mr. Defries of the Hampstead-road, by whom it has been patented. This species of meter is exceedingly accurate in its measurements, and is likely to become universal. The specimen now to be seen at Mssrs. Glover's contains two chambers: the lower is divided into six compartments by three movable diaphragms, which act upon the indicating machinery by means of a very simple and ingenious contrivance, which registers the consumption of gas with unerring accuracy, on a plate of six dials and indices from units to millions. The meter is capable of measuring 6,000 cubic feet of gas per hour; and is to measure the supply of 1,500 burners. It weighs two tons, is 16 feet in circumference, and eight feet in height. The shape is a hexagon, with gothic devices and ornaments; the name of the inventor, the gas company, and the Royal arms are introduced in the castings. As a piece of iron casting it is amongst the very best things produced by the London forges.[25]

According to British regulations, there had to be three distinct services — to the auditorium, to the stage, and to the staircases, corridors, and exits. Meters also had to be placed in fireproof chambers.[26]

In *Theatre Construction and Maintenance* (1888) James G. Buckle, who apparently had more contact with the practical end of things, drew up his own recommended set of suggestions and regulations:

> The failure of gas-lighting may arise from several causes, but chiefly in consequence of the insufficiency of the meters, which are frequently overtaxed. On special occasions extra lights are required, the gas for which is drawn from existing supplies without any regard to the capacity of the meters. It would appear desirable to have a reserve meter for use, in conjunction with those supplying the normal number of lights, during pantomime and other seasons when the consumption of gas is largely increased.
>
> To provide for the failure of one or more meters, arrangements should be made whereby the gas may be diverted from one section of pipes to another. A "switch" should also be fitted whereby the gas may be diverted direct from the main into the supply pipes.[27]

According to Charles Garnier, the Paris Opéra of 1875 possessed ten gas meters, fed by six service pipes, of which six meters fed into a thousand burners each, and four into eight hundred. These meters had control valves at both their entrances and exits to give maximum control over gas flow. Apparently, too, these meters could be ganged in different combinations through the use of movable tubing.[28]

After leaving the meters, the gas had to be regulated before it reached the actual instruments. This was done at the gas table — in France the *jeu d'orgue,* and in Britain the "gas plate." The gas table was fitted with a series of taps that usually supplied gas to the stage lights, the house chandelier, the prop rooms, and the dressing rooms.[29] Perhaps the dressing room lights were also controlled from here as a cueing device. According to British regulations, every tap had to be distinctly labeled with the area it governed.[30] The rest of the lighting, including the auditorium, the foyers, rest rooms, corridors, staircases, and entrances, was usually controlled from another position in the theatre. Buckle said this position should be enclosed and called a "watch-room." He further stated that stopcocks to close the theatre off from its main should be located here as well.[31] The gas table was generally located in the wings, against the proscenium wall. At the Paris Opéra, the *jeu d'orgue* could not be placed in the normal prompt position due to its size (over ten meters long) and was located in front of and below the apron (see Fig. 18). Apparently this central location had some advantage, since the light man could see the effect of each cue clearly.[32] The gas table itself was fed by permanent iron or brass tubing, and from its stopcocks (each labeled to indicate the position it controlled) further metal tubing ran out to permanent outlets on the stage, backstage, and at the chandelier position.

The gas table shown in Figure 19 is a smaller one, made of iron tubing and controlling

1. the main gas line
2. the footlights
3. the house chandelier
4. the portable, scenery-mounted units
5. the overhead striplights

There are two portable unit feed pipes, probably one going to stage right and one to stage left. Also, there were four rows of strips over the stage. As an added safety measure, additional bypass tubes were built into the network, which always maintained a premeasured flow of gas to the pilot burners on all the instruments controlled by the table.

Figure 20 shows a gas table of 1880, no doubt one of the last and most advanced. This one would appear to have mastering valves for dimming or raising groups of units. The large wheel at the bottom undoubtedly controlled the main gas line.

Figures 21–23 are photographs of the remains of a rare surviving gas table uncovered recently at the Théâtre Montansier at Versailles in the course of renovation. It appears to be of iron or steel pipe with brass fittings. Fig. 21 shows the pipes that controlled the orchestra lights (perhaps like those in Fig. 35), as well as one labeled "Girandolles" ("branched candlesticks" — probably house sconces).

All the lighting instruments drew their gas from the permanent outlets on stage. These instruments can be divided into two general categories: fixed units, which include the footlights and the house chandelier, and movable units, which include the overhead striplights, the groundrow units, the portable vertical strips, standards, and a type of burner unit fitted with a reflector cone, which may or may not have been movable and could have been strapped to the vertical booms.

The fixed units were fed by permanent metal pipe installations (no movement was required), but the movable units were fed by flexible hoses. These hoses, according to most regulations that make specific mention of them (those of Austria, Belgium, London, Paris, Germany, and New York) had to be sturdily constructed, and many countries went so far as to forbid the use of rubber, which they deemed unsafe. Belgium specified the use of leather with metal fittings at connections, and this was generally used for these hoses at most installations.[33] The Parisians went even further, and specified according to their rules ("Lighting of the Stage," paragraph 46), that "The 'ground lines' [as opposed to flexible tubes, which fed hanging instruments] shall be furnished with a basketlike covering formed of wire of close mesh."[34] Germany called for "screw unions" on its hoses ("Lighting, Warming, and Ventilation," paragraph 41),[35] and London called for a tap on the tube itself, as well as one on the stage outlet feeding the tube.[36] The tubes had to be protected from collapsing when trod upon, so that the gas flow could not be impeded. One solution was fitting the inside of the leather tube with a spiral spring. According to one French source, this was used in England, as opposed to exterior metal protection, as was used in France.[37] The wings generally had these hoses running across the floor to the "wing ladders," as the vertical strips hung on the upstage sides of the wings were called. Lines also hung down from the striplights. To prevent movable wings from hitting these lines, some codes, and particularly the Paris code ("Lighting of the Stage," paragraph 44), specified that the pipes had to be fixed at a height greater than that of the wings.[38]

James Buckle mentions one further measure for safety, a new type of hose connection:

> The manipulation of the movable lights is a constant source of risk. . . . To remedy some of the defects of the present systems, Messrs. Vaughn and Brown, gas engineers of Farrington Road, London, have recently patented an ingenious and novel automatic water-joint, by the use of which the possibility of accidents is reduced to a minimum, as the insertion or withdrawal of the "dip" suffices to turn the gas on or off, as required. This water-joint is fitted at the Adelphi and Terry's Theatre, London.[39]

The gas burner was both the final delivery point and the heart of the gas lighting instrument:

> A gas burner may be defined as the point at which illuminating gas issues from the service pipe to be ignited for the purpose of giving light. . . . A gas burner generally consists of a metal, lava, or steatite tip attached to the gas fixture, which by its size or opening regulates to some extent the size of the flame and the amount of the

> gas consumed. The common gas burners for lighting are generally composed of two parts, the body and the tip of the burner.[40]

Additionally, as regards the chemical reaction taking place at the burner,

> The process does not vary in principle whether the illuminant burned be solid (like tallow, wax, parrafine, or other candles), or liquid (such as colza oil and kerosene burnt in lamps), or gaseous (coal or water gas). All gas contains hydrogen and carbon. In all illuminants the heat of the flame eliminates carbon; the hydrogen combines with the oxygen of the air, creating a very high temperature, which causes the carbon particles to become incandescent. The carbon is finally consumed in the flame, and carbon dioxide, some carbon monoxide, and watery vapor are formed.
>
> While in candle and oil-lamp illumination the gas is only generated during combustion, it is in the case of gas illumination, already prepared at the gas works and therefore issues at the burner ready to be lit.
>
> Every luminous flame has three distinct parts or zones, namely: an inner zone, where there is no combustion; a middle or intermediate zone, in which partial combustion takes place, and which is the luminous or light-giving zone, as it contains the carbon particles raised to incandescence; and finally an outer zone where complete combustion takes place, and which is luminous.[41]

Six types of burners are of interest to us:

1. Single-jet burners
2. Flat-flame burners
   a. Batswing
   b. Fishtail
3. Argand, or round-flame burners
4. Multiple flat-flame burners
5. Regenerative burners
6. Incandescent burners (see Table 2)[42]

The single-jet burner was the first type of burner used with gas. This simple and crude burner was merely a body and tip with a small round hole in the end, which produced a rather small flame. It was used in some of the earliest experiments and the first lamps.[43]

Flat- and round-flame burners were the most widely distributed of all the varieties, and were the most commonly found burners in theatres and theatre instruments.

> The bat's-wing burner has a hemispherical tip, with a narrow vertical slit, from which the gas issues in a thin, broad sheet, whereas the union-jet (also known as the fish-tail burner), originally invented by James Milne of Edinburgh consists of a flat and sometimes of a slightly depressed or concave tip, with two small holes drilled under a certain angle to each other, from which two jets of equal size issue, and by impinging upon one another produce a flat flame [see Fig. 24].[44]

In the union or fishtail burner, the holes were drilled toward each other at a 90-degree angle.[45] Bram Stoker mentions that the striplights at the Lyceum Theatre were equipped with fishtail burners, and that during the lighting-up "the spreading flame of one burner caught the escaping gas from the next orifice, and in a few seconds the whole line would be alight."[46] The main difference between the two burners was that the batswing gave a low, wide flame, whereas the fishtail produced a narrower and taller flame.[47] Although the first gaslit theatres used open flames and probably had batswing jets in their instruments, the trend most likely went to fishtails when glass covers for the jets were introduced. This assumption is based on the following passage:

> On account of its great width, the flame of an ordinary bat's wing burner is easily affected by even slight currents of air, which cause the flame to smoke, and the protection which a glass globe affords to the flame cannot be so readily applied to the common bat's wing burner, because the slightest lateral deviation of the broad flame often causes the cracking of a glass globe.

> This is one reason why ordinary union-jet burners were so commonly used on gas fixtures with glass globes.[48]

Improvements in the burner came gradually, the first coming about in terms of the actual composition of the burner head itself. The very first tips were iron — unacceptable because the orifice was likely to become clogged by corrosion. In addition, the head tended to draw heat away from the flame, and loss of illumination resulted. Thus, it was found that burner tips had to be nonmetallic, noncorrosive, and nonconducting. To meet these specifications, tips of porcelain, steatite (a kiln-hardened soapstone), and adamas (a mineral compound) were employed.[49]

Later development in both types of flat-flame burners also evolved. The aims of all the developments were to ensure an even distribution of gas to the burner tip and to keep pressure to the lowest possible level without loss of illumination. Eventually, as a result of these developments, both varieties of burner produced flames that were indistinguishable.

The round-flame burner, better known as the Argand burner, was based on the principle of the Argand lamp (see Chapter 2), which had been in use since 1780.

> Argand, or round-flame burners consist essentially of a hollow ring, connected with the gas tube and perforated on its upper surface with a series of fine holes from which the gas issues, forming an annular, hollow, round flame. The Argand burner derives its name from its similarity with the Argand oil lamp, and like the latter always requires a glass chimney, properly proportioned in diameter and height, to induce a perfect combustion by increasing the air supply to the flame, and also to lessen its susceptibility to side drafts [see Fig. 25].[50]

As compared to flat-flame burners, the Argand produced more light per unit of gas, but also a good deal more heat. Early Argand burners tended to smoke somewhat, but this was later corrected by devices which regulated both the air and the pressure of the gas reaching the burner.[51] The only specific mention of Argand burners for use in lighting instruments is in connection with the California Theatre, which opened in 1869 in San Francisco and had eighty-one Argand burners in glass chimneys in the footlights (three color groups of twenty-seven). Argands were also used in the side lights, and seven borders twenty-four feet long mounting twenty-five burners each were used as well.[52]

One attempt at a more powerful light source was the multiple gas burner. Like the head of the fishtail burner, these combined two or more batswing or fishtail burners to obtain a single brighter flame. Concentric rings of round burners were also used for this purpose. These types of burners did not come into wide use, however.

A later development was the regenerative gas burner.

> In all burners of this type the high temperature due to the combustion of the gas flame is directly utilized to raise the temperature of the gas before ignition, or of the air supply before combustion, or of both, the result being an intensified and more perfect combustion, and a vastly increased illuminating power.[53]

These lamps gave a powerful, steady light, and were economical.

> In its original form, this burner is a round-flame burner, in which the flame burns around a central porcelain cylinder, over the top edge of which it turns. From this point the products of combustion pass downward through a central flue, and in their passage they heat a chamber through which the air passes upward, becoming highly heated by contact with the burning body. The products of combustion are then carried to the escape pipe by means of one or two side tubes.[54]

These burners were invented rather late, one of the first regenerative burners being produced in 1879 by Friedrich Siemens. The early models were rather clumsy, but found use in lighting large halls, which means that they could have been used in theatre auditoriums.[55]

The last big development was the incandescent burner, also known as the Welsbach burner. It was the gas industry's final hope in its competition with electricity and was dependent upon the Bunsen burner, which had been introduced in 1855 by Robert Wilhelm Bunsen. The Bunsen burner was a more economical device, burning a much leaner gas mixture at a rather high temperature. In 1885, a student of Bunsen's, an Austrian named Carl Auer, discovered, while working in his teacher's laboratory, that certain rare earths became incandescent when heated in a gas flame.[56] He proceeded to impregnate a cotton mesh with cerium and thorium oxides. When heated, the cotton burned away, leaving a fragile web which burned brightly in conjunction with a Bunsen flame. This apparatus became known as the gas mantle. Earlier attempts had been made at gas mantles, but none was as successful as Auer's.[57] For his discovery, which increased the candle power of coal gas by more than three times, he was created a baron with the title "von Welsbach."[58]

For theatres that lacked electricity, the Welsbach burner was a way of keeping pace, and was widely adopted. A few criticisms of the Welsbach burner were that it lost intensity with age, and that the expensive mantle portion was rather fragile.[59]

Appendix II

Gaslighting Instruments

In an age when the lens had not realized its potential in lighting, the burner was *the* lighting instrument. Its ability to use gas efficiently determined how much light would be projected on given scenes. These instruments, as we may observe, were a long time in developing; by the gas era they had achieved quite a diversity, both in form and in function. Many instruments developed at this time exist now and differ from their gas prototypes only in being modified for electricity. Gas lighting instruments may be broken down into the following classifications:

1. Footlights (floats, *rampe au gaz*)
2. Border lights (gas battens, *herses*)
3. Groundrows (*rampes de terraine*)
4. Lengths (*portants*)
5. Bunch lights (standards)
6. Conical reflector floods (*boîtes coniques à reflets*)
7. Limelight spots

In the field of stage lighting during the nineteenth century no instrument went through as much evolution as the footlight. At first just a row of open individual burners along the apron, footlights were dangerous and rather unsatisfactory. No efforts were initially taken to shield them, and they sat full height on the stage, blocking the view of the spectators in the pit, and presenting a fire hazard to actors who were unlucky enough to get too close to them. Stories of actors set afire by them are innumerable. Other unpleasant products of footlights were noxious vapors and heat, which bothered both the spectators and the actors. The only advantage the audience had was that its eyes were shielded by the backs of the reflectors. (The reflectors were generally made of tin.) From an aesthetic viewpoint, footlights were also unsatisfactory, as they cast their light at a rather unnatural angle, and the early models had no provisions for color. Obviously, these defects could not be tolerated indefinitely.[1]

The first attempts at assuring the safety of the actors included fireproofing their costumes and placing wire screens in front of the footlights. The screens became standard and were eventually required by most theatre codes. The next step forward came in 1861 at the Paris Opéra (see Chapter 6). The footlight gradually was made a more efficient and safe apparatus by being recessed into the stage floor, provided with glass guards (see Fig. 26), and made to light the stage in some cases by indirect reflection. Also, the dangerous vapors were being drawn off by forced air current (see Fig. 15). This last development is mentioned as having come to the Haymarket Theatre, among several others, at the end of the 1860s.

> The footlights as in some other recent theatres, instead of burning up, burn down into iron flues, under an artificial pressure of air, which also does duty in carrying off the smoke.[2]

Mention is made of another installation of this type almost a year later (April 1870) in the Vaudeville Theatre, in London.[3]

Considerable progress was made in coloration as well. Some footlight units were fitted with alternate sets of gas controls, in some cases as many as three, to enable them to project several colors (see Chapter 6). This provided an alternative to the old manual color-changing system, and could be worked remotely. We have a good description of the older system in *The World Behind the Scenes,* by Percy Fitzgerald:

> These lamps are furnished with "chimneys" of white and green glass, which by an ingenious system of levers commanded by the prompter, ascend or descend as required, and produce moonlight or other optical effects. In some theatres, notably one at Birmingham, a series of coloured glass screens can be shifted in front, but with a loud clatter.[4]

Although we possess little in the way of specifications on footlights, we have a few figures concerning those used at the Paris Opéra and other French houses. According to one source, the burners were placed an average of fifteen centimeters apart. The same source illustrates how one system (it is not clear where it was used) divided the footlights into two sections at the center line, and fed them from the center outwards, with a Y-shaped gas line. The footlights at the new Paris Opéra (1875) appear to have been fed by halves as well; one illustration (Fig. 27) shows a valve at either end of the line feeding the burner (or possibly controlling the color).

Another lighting instrument with a history perhaps predating the introduction of gas was the border light. As we have seen, this instrument may have been used in Garrick's time. Like the footlight, the border light (or striplight) was simply a row of burners mounted on a feed line. The primary difference, however, was that this instrument was hung in the flies and fed by a flexible tube. To support the line of jets, a sturdy framework had to be constructed, and this appears to have come in two varieties. The first type (Fig. 28) seems to have been basically a wooden framework with metal bracing and fittings. The second type (Fig. 29) appears to have had a cast-iron frame.[5]

Most theatre codes were specific as to the rigging of these instruments, since they had closer contact with the flammable hanging pieces in the flies and thus were more likely to set things afire. According to the London regulations:

> All "battens" shall be hung by at least three wire ropes, and be protected at the back by a solid metal guard and wire fixed to a stiff iron frame at such a distance from the gas jets that no part of the scenery or decoration can become heated.[6]

Such rules as this may explain the different varieties of chassis for the border lights; the wooden frame being perhaps an older and less safe model, predating regulatory codes. Border lights were hung on wire ropes: the city of Brussels required at least four,[7] but New York City required wire ropes for only the first ten feet above the instrument.[8]

In most theatres, there was a border light for each wing and border section facing upstage.[9] According to Charles Garnier, the Paris Opéra (1875) was equipped with eleven border units, one unit for every section. These units apparently took up a large portion of the fly space and were equipped with special drums by which they were lowered (see Fig. 30).[10]

Probably due to their design and the difficulty of manipulating them, little was done to color batten lights. Of course, cloth was usually drawn around and under them in some places, but this only served to suppress a good deal of their illuminating power. Cotton, wool, and silk were all used for this purpose, and were dyed basic colors.[11]

Another frequently employed instrument was the groundrow. This was simply a floor-mounted batten unit (used with electric striplights today) used to illuminate low shrubbery rows or waves. The only code rule specifically pertaining to them was in Paris, where the need for a wire guard was specified (see Fig. 31).[12]

Another instrument, for which no true modern equivalent exists (although it had Renaissance forerunners) is the "length" (the British term), a sort of vertical striplight. These were not of a standard size, but were probably adapted as needed. According to one French source, they ranged in the number of burners mounted from four to twenty.[13] Their most common use was as an indirect light source mounted on the rear of the onstage edges of the sliding wings, and illuminating the face of the next flat upstage (see Fig. 32).[14] They were made of rectangular wooden strips, with the individual burners and their hoses attached by means of removable clamps (see Fig. 33).[15] These wooden battens were also fitted with hooks on top for easy attachment to the flats.[16] According to the Paris regulations:

> 47. The lights in the "wings" shall be protected to the height of 6 feet by a net-work of close mesh, and they shall be equipped with suitable smoke consumers.[17]

It is not clear whether "smoke consumers" were smokeless burners or ventilating tubes. Most codes, however, did insist on the wire protection (see Fig. 34). Many codes also specified the minimum height above the stage floor that these instruments had to be hung; in Saint Petersburg it was four feet eight inches, and in Copenhagen and London it was four feet.[18]

Along with the lengths in the wings were the bunch lights. These were portable clusters of powerful burners set on top of a vertical pipe mounted on a heavy base to which a gas line was attached.[19] The burners were protected, again, by a wire cage, and the height regulations no doubt included these instruments as well (see Figs. 35 and 36). These instruments apparently stood in the wings and threw general lighting onto the stage from either side.

A rather unusual instrument mentioned in French sources only is the "*boîte conique à reflets*" — a conical reflector box with a burner at the narrow end (see Figs. 37 and 38). Perhaps a throwback to Furtenbach's "standing light box," this box had plated inner surfaces to concentrate its light. As an added feature, the sides of the box were movable as the present-day "barndoor" fittings for modern Fresnels.[20] They appear to be forerunners of the beam projector, and can be seen mounted high in the wing areas in Figure 30.

The limelight, that powerful source of light invaluable in the early days of spotting, was the first instrument to mount a lens. Fed by two separate lines, the limelight burned oxygen and hydrogen against a block of lime heated to incandescence. These gases were kept in separate tanks and piped through rubber tubing to the tube leading to the burner nozzle. In front of the nozzle was a block of lime in a holder, whose height could be adjusted by means of a screw device (see Fig. 39). In lighting these, the hydrogen was turned on and lit first, and then the oxygen was gradually bled in to produce the desired flame. Too much oxygen too soon would make the flame "pop out."[21]

Although the limelight was introduced well after the gas era had begun (see Chapter 6), it had time to undergo some development. As mentioned before, some limelights were fitted with lenses around the 1870s, thereby becoming the first "modern" spotlighting instruments.[22] Some advances in lime burner technology were made as well. It seems that in many limelights, the two gases (in some theatres, illuminating gas was used in place of pure hydrogen) were mixed in a tube and burned at the nozzle tip. This was dangerous, for the flame could back up and cause an explosion. In an improved burner shown in *Scientific American* on February 24, 1883, this danger seems to have been eliminated. The burner (see Fig. 40) was thus described:

> The central or oxygen tube has a conical end with a central orifice 0.03 inch in diameter. The hydrogen tube is

provided with an adjustable cap, having a central orifice 0.1 inch in diameter. The cap is conical internally and externally, and when properly adjusted, as shown in the sectional view, the space between the internal surface of the cap and the conical end of the oxygen tube forms a passage for the hydrogen which directs it across the path of the jet of oxygen. By this simple device the gases are intimately mixed at the moment of ignition.[23]

This particular limelight also had a special spring that both adjusted the height of the lime block and turned it; the spring was worked from the rear of the instrument, not from beneath it.

Another improvement in limelight technology is shown in Figure 41. Although probably not very widely used (it is mentioned only in the *Scientific American* of March 25, 1881), this unit had the economic advantage of burning any shape lime block, not just the expensive cylinder. Another feature of this invention was a sort of master gas adjustment for both gases at once, after the two individual taps between it and the burner had been proportionally adjusted.

For some reason, the limelight is not usually mentioned in safety regulations. There is no apparent reason for this, and it may be that special permission had to be obtained in order to use it. One suggestion for the proper handling of the limelight tanks was made by James Buckle:

The tanks containing the gases for the oxy-hydrogen light should not be placed within the building, but fitted up in an open area or room specially constructed, and the gases forced by water pressure through metal pipes into the theatre. On no account should "lime-light bags" be manipulated on the stage or in the "fly galleries."[24]

Limelights were also used in the scene shop. According to an article dated 1877 and entitled, "A New Way of Outlining Theatre Scenery,"

In the London theatres, scenic artists are now availing themselves of photography and the magic lantern in the

> production of scenery. The artist, instead of drawing on his imagination for a group of medieval houses to represent the market-place at Rouen, for example, procures a large photograph of the actual locality. This, by means of the oxy-hydrogen light, he throws upon the canvas, the image being suitably enlarged in size. Then he follows the outline and has an accurate picture.[25]

Although not used for stage lighting in the nineteenth century, the chandelier was an important gas instrument. It was the mainstay of house lighting for over three centuries prior to the introduction of gas and was important right through the introduction of electricity. When chandeliers used candles, the trend was — for practical reasons — to use numerous units to provide enough light for the house and forestage. The first London theatre to use gas for house lighting was probably the Olympic (see Chapter 4). It is not known to what extent it was used there; however, we do know that by late 1818 the house was lighted by one large glass chandelier and twelve smaller ones.[26] This arrangement of several chandeliers represents the first phase of gas house-lighting.

This phase was not to last long; larger and more powerful chandeliers were soon built, and new places were found in the house to install smaller lights as well. Numerous chandeliers were a great expense and were inconvenient to service. Covent Garden was probably the first to break away from the old trend. Its house was lit by gas in 1817, and in that same year, it was described as

> brilliantly illuminated with a grand central chandelier which has been rendered still more effective, and the three auxiliary lamps which were complained of as impeding the sight and contour of the theatre have been removed, and Grecian lamps substituted which range round back of the Dress Circle and shed a soft medium light, without obstructing the view of the stage.[27]

The installation of enormous chandeliers in houses whose ceilings had been designed only high enough to accommodate dimmer and smaller candle fixtures presented sight-line problems for these pioneer ventures. Drury Lane was somewhat more practical in its installation, perhaps learning from Covent Garden's errors. We have a good description, dating from 1818 and published in the *European Magazine.*

> This evening the activity of the Managers, during the recent short recess, was manifested conspicuously, in the display of a new and magnificent lustre of cut glass, suspended from the centre of the ceiling over the pit, and communicating, by innumerable gas flames most beautifully disposed, a profusion of light to all parts of the house before the curtain. The splendid apparatus is not in compass so large as that of Covent Garden, but the light which issues from it is scarcely less. There are two large circles, the upper regular and emitting an uninterrupted blaze, the lower proceeding from a disposition of the glass materials, which gives it the appearance of easy drapery, and shining out in six distinct and equidistant spaces. Above those is a smaller circle, lighted up with equal brilliancy while the glass work ascends towards the roof in a pyramidical shape, varied and ornamented in a very tasteful manner. The whole is dependent on a large but almost hidden central bar, and six enclosing lines, or tubes of polished brass, by which the gas appears to be supplied. The elevation of this superb lustre is higher than that at Covent Garden Theatre. To the pit and the dress circle, the illumination and heat are rather too powerful. The design and execution, however, are highly creditable to the genius of Mr. Collins, the inventor and artist.[28]

The heat and fumes from the large chandeliers, not to mention the other gas lights, were to remain problems throughout the gas era. This problem certainly was not eased when chandeliers got even larger — apparently the trend. By 1846 a bronze unit weighing over 10,800 pounds was installed in the Hamburg Theatre. As this monster was being hauled into place, the rope broke, and it fell. The chandelier was demolished, and the two English-men who had come to supervise the job were killed.[29] Much later in the century, in 1881, in a description of Wallack's New Theatre in New York (which was soon to open), the *New York Times* mentions that:

> A magnificent chandelier of copper and brass, with a spread of 14 feet and 200 burners descends from the dome, and smaller gas-fixtures spring from the painted panels on the walls and other points.[30]

Needless to say, all this made for considerable vitiation of the air and an abundance of fumes. One solution was the "sun burner." This was a very large metal multiple burner built into the theatre ceiling with a direct ventilation duct leading to the roof (see Fig. 44). Its somewhat flatter construction partly solved the sight-line problems caused by lower-hanging crystal fixtures. A description of what may be one of the first sun burners is to be found in the *London Times* of November 23, 1825. Referred to as a Continental system of lighting, it contained some rather interesting technical developments.

> The following admirable method has lately been adopted in Paris, and we strongly recommend it to the attention of our theatres in England. A large opening is formed in the centre of the ceiling, and hung round thickly with lamps, each lamp is furnished with a parabolic reflector, and each reflector is united to its neighbour all round the circle. By these means the light would be thrown down into the theatre, was it not checked by the presence of a system of large magnifying glasses (un systeme de verre lenticulaire) — that is a number of glasses of a foot diameter each, all united and forming one solid mass, and fixed beneath the lamps, and covering the opening. On looking at it from the pit it appears like an immense burning globe.[31]

This early combination of a lens and a reflector is unusual in a theatre, and doubly so in house lighting.

In his book on theatres published in 1881, Percy Fitzgerald objected to the sun burner and also had some criticism of other methods of house lighting:

> One of the most difficult questions is how is the salle . . . to be effectively lighted? Mr. Garnier has worked the true principle out in a very interesting way. As may be conceived, there can be but two methods — either by a great light in the centre or by a number of small lights all around. To both modes there are objections. To light a hall of vast dimensions with a central lamp, the chandelier must be of corresponding power and size, must be low, and will therefore intercept the view. The same objections, with some others of a minor kind, may be taken to a series of smaller lights hung round or attached to the panels of the boxes. The glow or heated mist from the flames rises up into the faces of those above, and the light and heat interfere with the view and comfort. If they are hung out too far, the branches themselves shut out the stage.
>
> This difficulty has set the ingenuity of our architects to work, who have to contrive a lamp of such a kind that it does not interfere with the view, and yet is brilliant enough to light the whole salle. This, in short, is the ever-to-be-abhorred "sunlight" . . . which is so much in vogue in our theatres. This invention is repugnant to all notions of stage effect; it really suggests the coarse flame of a coal-fire, and illumines with a hot glare the texture and very blemishes of all that it plays on. . . . In its own immediate range there is excessive glow and glare, but its beams play but languidly on the rest of the house, while it casts coarse shadows on all that it does not reach. As it is fixed to the ceiling, all the roofs and backs of the boxes are thrown into the blackest shade.[32]

Obviously the problems of successful house lighting were not to be solved before the advent of electricity. Some other solutions (mentioned in Chapter 7) at the Théâtre de Chatelet and the French Vaudeville, with their glassed-in ceilings, never caught on and were too expensive.

Most safety codes were rather specific about house lighting and ventilation, and tell us much.

According to the Austrian code:

> 34. The chandelier in the auditorium shall be fixed to iron brackets, and hung with counter weights and wire ropes, any one of which alone must be capable of bearing the entire strain.[33]
>
> 58. All parts of the auditorium, dressing and other rooms off the stages if lighted either by gas or electricity, must be provided with oil lamps.[34]

In Copenhagen:

> 7. All gas jets in the auditorium, passages and staircases shall have a direct supply service quite independent from any other part of the building.[35]

In London:

> 24. b. All gas brackets shall be fixed without joints; and all burners within reach of the audience shall be fitted with secret taps, and be efficiently protected by glass or wire globes.[36]

In Paris:

> 12. The chandelier must be supported by an iron girder and raised and lowered by means of a winch. . . .
> A wire gauze must be provided to protect the spectators in the case of the fall of any glass globes or prisms.[37]
>
> 48. The dressing-rooms and green-rooms lighted with gas shall have fixed jets without elbow joints; the jets shall be enclosed by a glass globe or by wire gauze. Portable standards are not allowed in this part of the theatre (see Fig. 45).[38]

James Buckle recommends:

> 8. In the auditorium section the dual systems of gas service shall supply alternate lights.
>
> 14. The auditorium shall be lighted by a central sun-burner, having an iron flue to carry off the products of combustion. This flue shall be constructed within an outer ventilating shaft not less than 7 feet by 7 feet, and fitted above the external roof with louvre framing or an approved extraction cowl.
>
> 15. Where sun-burners are not used, openings shall be

formed in the auditorium ceiling to carry off the smoke in the event of fire.

28. All gas jets shall be turned on and off by a special key without taps.[39]

The Austrian code mentions the emergency use of oil lamps, and Buckle further recommends rules governing their use:

3. Only colza oil shall be used for trimming the lamps.

4. A lamp shall be attached to every third gas or electric light bracket throughout the building before the public are admitted and shall be kept burning until the audience has left the theatre.[40]

A daily ritual in every gaslit theatre was "lighting up." This was a potentially dangerous process which took place before the house opened and during which, in the early days, the instruments were all lit (later on, only the pilot burners). Probably the former was done with an open flame at first, a technique which may have continued in more careless establishments. For this method, usually a burning ball of waste or an alcohol lamp was mounted on the end of a pole.[41] One such procedure is described in Otis Skinner's memoirs:

> Electrical lighting had not been invented; when the gas man had lighted the "borders" at seven-thirty P.M. with torch and long pole, and his "foots" in front of the curtain, and turned them "down to the blue," all illumination was ready, except for the calcium lights of blended gas from the red and black cylinders.[42]

Obviously, in a space filled with wood, canvas, and other flammable materials, an open flame was an invitation to disaster. Percy Fitzgerald outlines a later and safer development.

> The lighting even of these jets, which is done from below with a light rod of enormous length, is a matter of danger, as a mere contact with the canvas might set all in a blaze, for the lighter has to carry his rod along every jet. A system lately introduced at the Lyceum happily

> guards against these dangers. A second row of jets, "needle points," which almost touch each other, runs along close beside the more scattered jets; a single light being applied, the flame flies along from jet to jet, until all, in both lines, are lighted. The first row having thus discharged its duty, is extinguished, and the other remains lighted.[43]

It is not clear exactly when pilot lights were introduced on either continent. The only date we know is May 25, 1857, when the Broadway Theatre (New York City) advertised that the following day it would

> exhibit the newly discovered and truly useful arrangement by which the innumerable burners, chandeliers, &c. will as if by magic at once be ignited. By this most dazzling and startling process, economy and safety in all public buildings will at once be secured.[44]

Later in the century, electric spark lighters were introduced, which were much safer and became the obvious choice of the safety codes. Several designs for these are extant (see Figs. 46, 47, 48); however, there is no way to determine to what extent they were used in theatres. Something like them was no doubt used. The first (Fig. 44) is merely a small "static induction machine," which activated a small battery in the bottom, and produced a spark.[45] The second (Fig. 47) was a bit more compact, containing a spark coil and two batteries in the handle.[46] The third (Fig. 48) attached directly to the burner, though it could no doubt be applied to a pilot burner as well. It was operated by a series of ratchet wheels and two electromagnets.[47]

The only available documented device (it was patented in 1875) was one used at the Euclid Avenue Opera House in Cleveland. As differentiated from the smaller hand units, this one involved a whole remote system with the capability of lighting any portion of the house or stage. The system produced a direct current generated by six voltaic chemical cells kept in jars backstage. The total output was just under 12 volts, but this was stepped up by means of an induction coil, allowing a spark to jump across a spark gap (see Fig. 49) at the instrument. When this system was used with the gas table, one gasman could light up the entire theatre. He had a knob mounted on a marble panel, which, when he turned it to the desired contact for a given instrument, completed the circuit and lit the gas which had just been turned on as well (Fig. 50). This apparatus was the invention of Samuel Gardiner, Jr., who held several patents in the field of electric gas lighting.[48]

The safety codes were explicit about lighting up — a dangerous procedure, and often a time when new gas leaks were discovered. Some rules were: in Austria,

> 54. The lighting of gas battens must be effected by first lowering the battens. All jets upon and over and under the stage are to be lighted by portable electric lighters, except the jets in the battens, where a "central lighter" may be used. The lighting of the burners in the dressing rooms and in the auditorium must be effected with protected lighters.
>
> 56. The use of Lucifer matches and naked wax taper for lighting purposes is most strictly prohibited.[49]

And in Copenhagen,

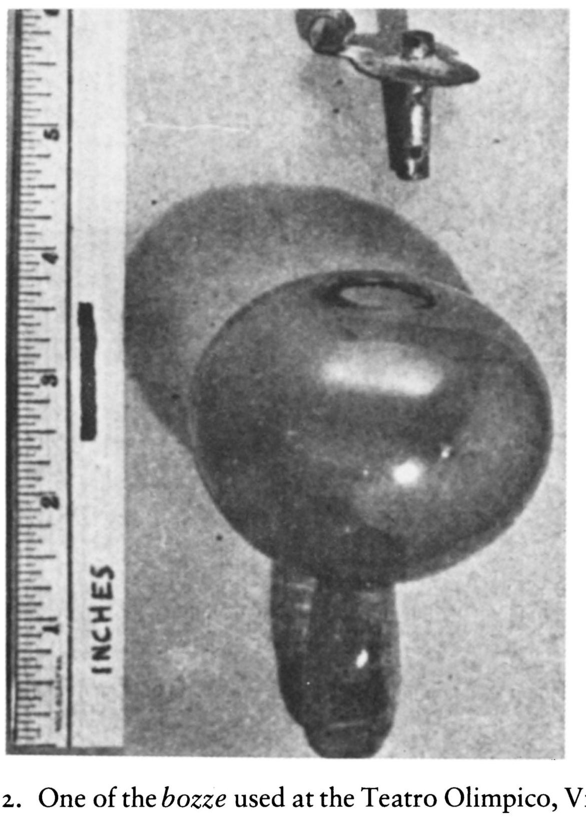
> 6. The gas battens shall be lowered to at least 5 feet from the top scenery before they are lit.[50]

James Buckle also had several suggestions, among them,

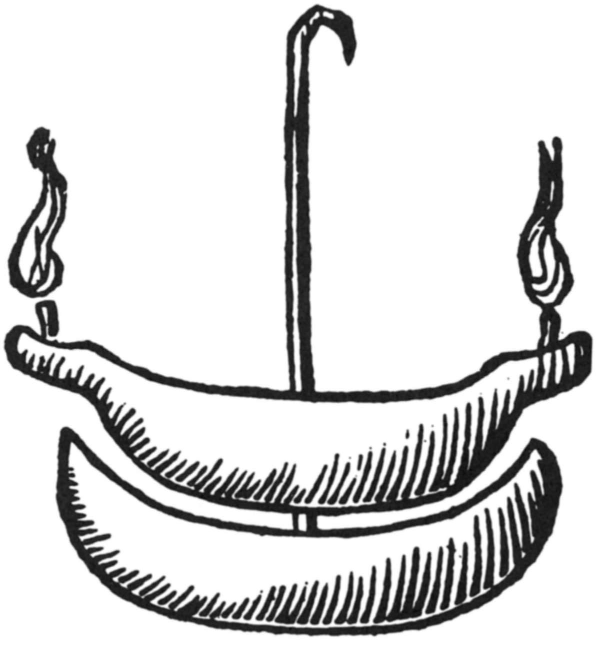
> 19. All gas burners within the auditorium and its adjuncts shall be lighted 30 minutes . . . before admission of the public.
>
> 20. No lights shall be extinguished within the auditorium and its adjuncts for at least 15 minutes after the close of the performance.[51]

One instrument whose lighting-up procedure was slightly different was the draft-ventilated footlight. Before it could be lit, "the interior burners in the vertical upcast tube are lighted to induce a draught sufficiently strong to draw the flames downwards."[52]

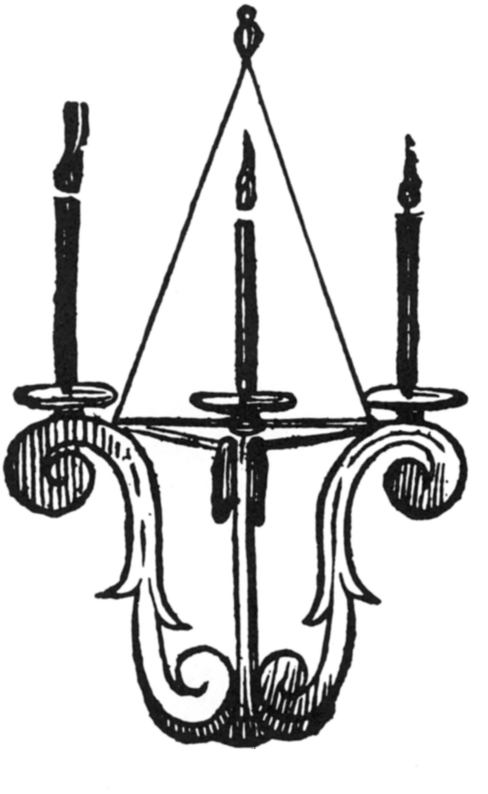
1. The torch, as used on the Elizabethan stage



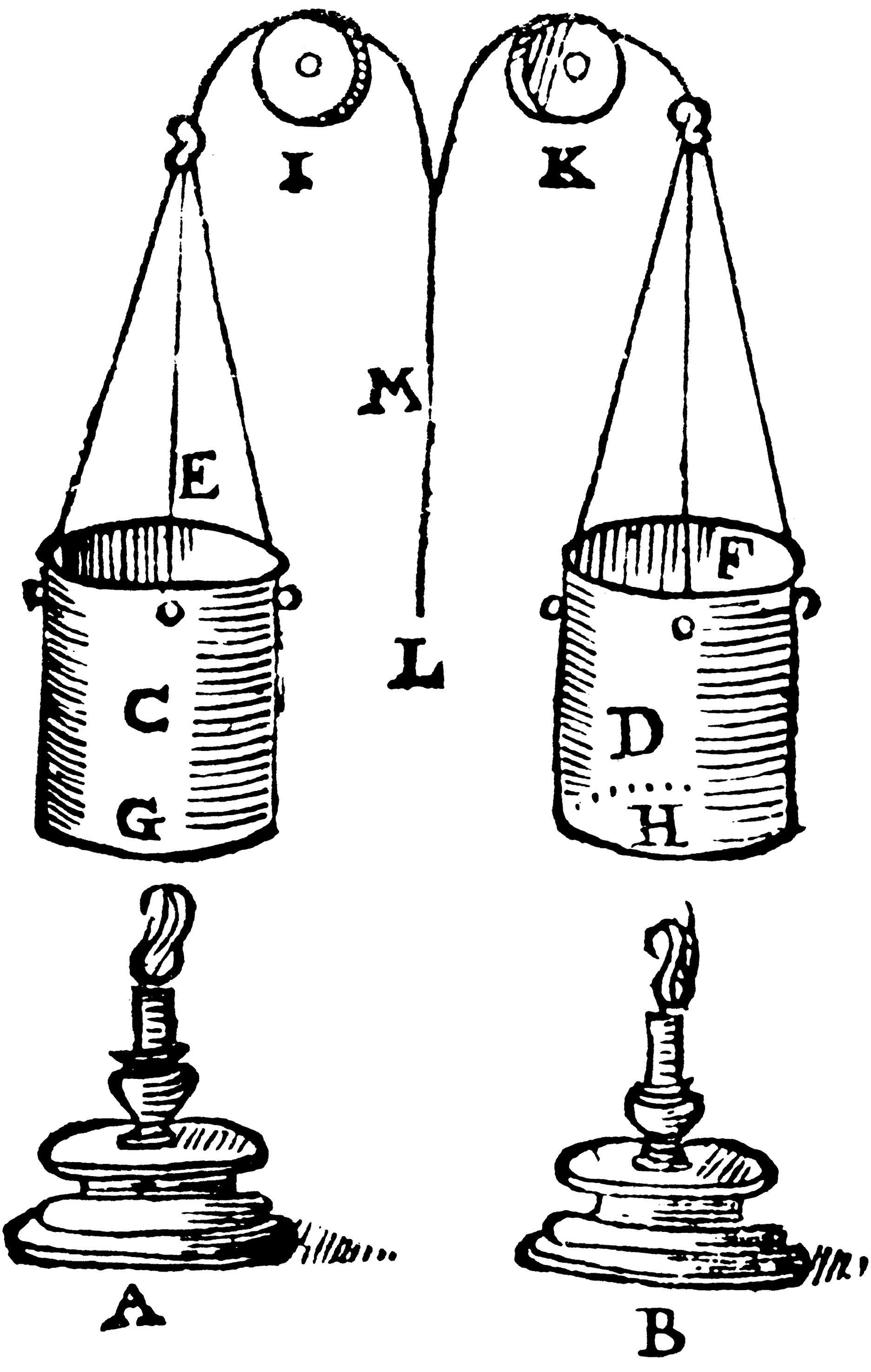
2. One of the *bozze* used at the Teatro Olimpico, Vicenza



3. Sabbatini's oil lamp



4. Sabbatini's chandelier

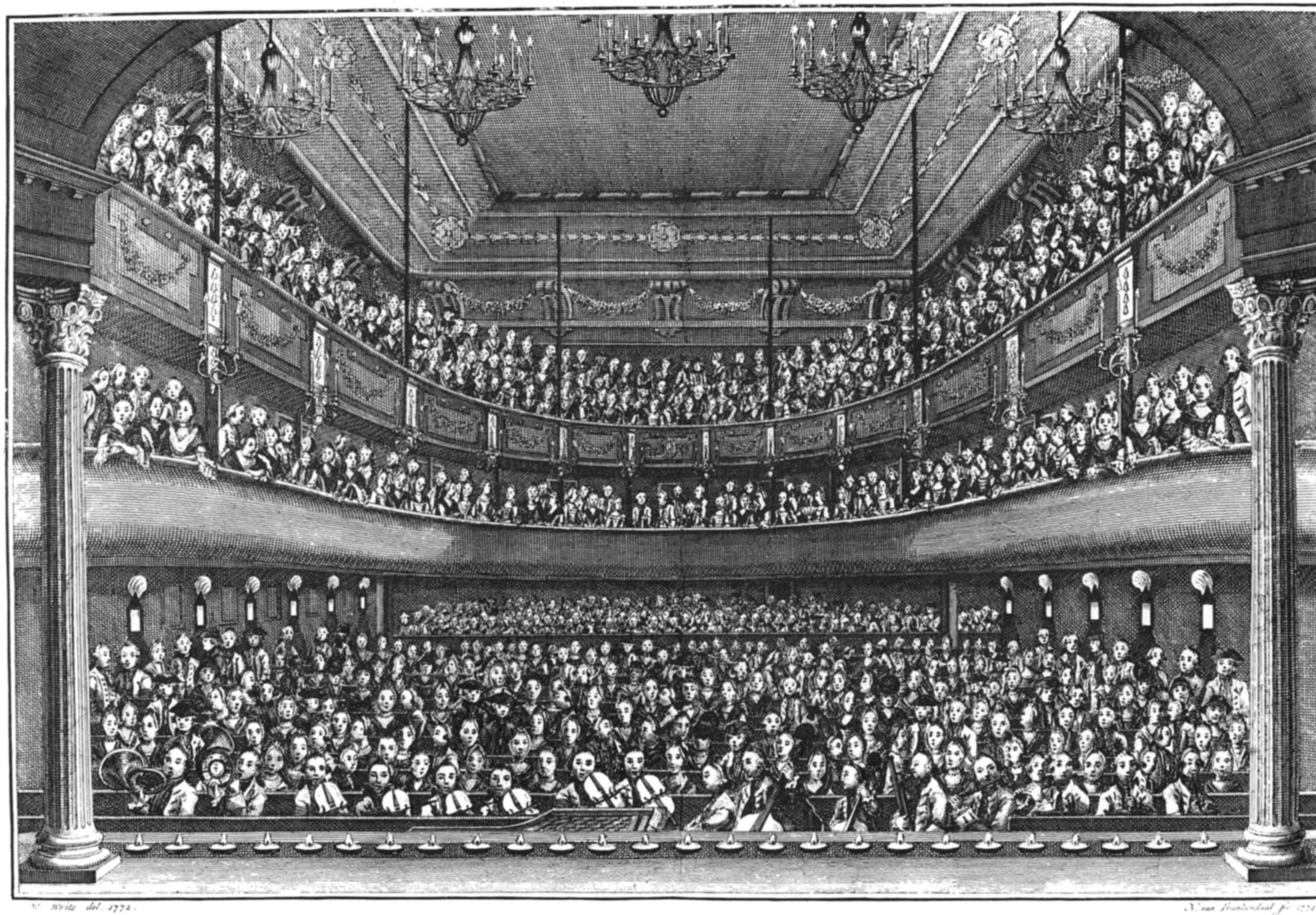


5. Sabbatini's dimming mechanism

6. Covent Garden Theatre in 1763

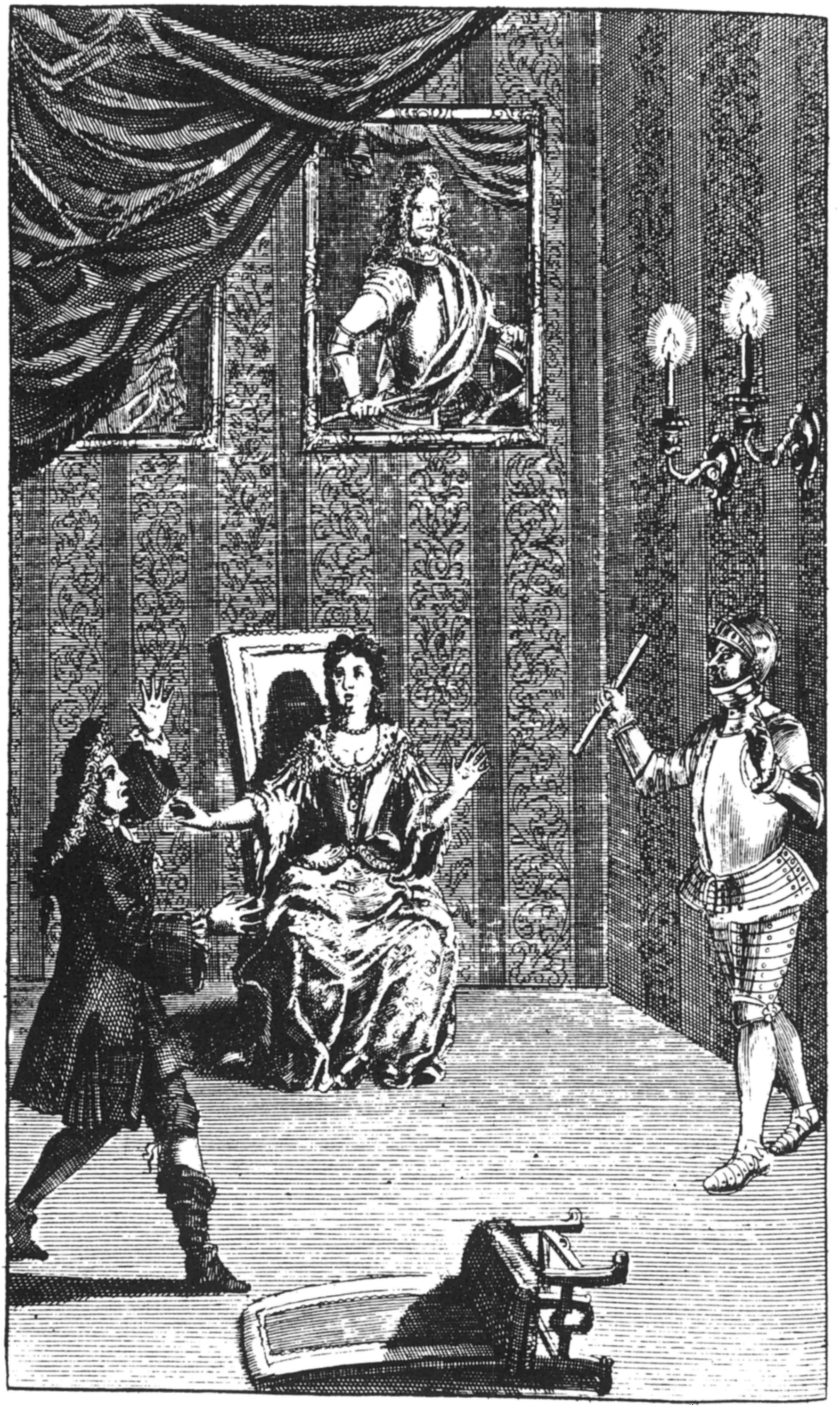
7. Red Bull Theatre (1672)

8. Footlights in a trough (1749)

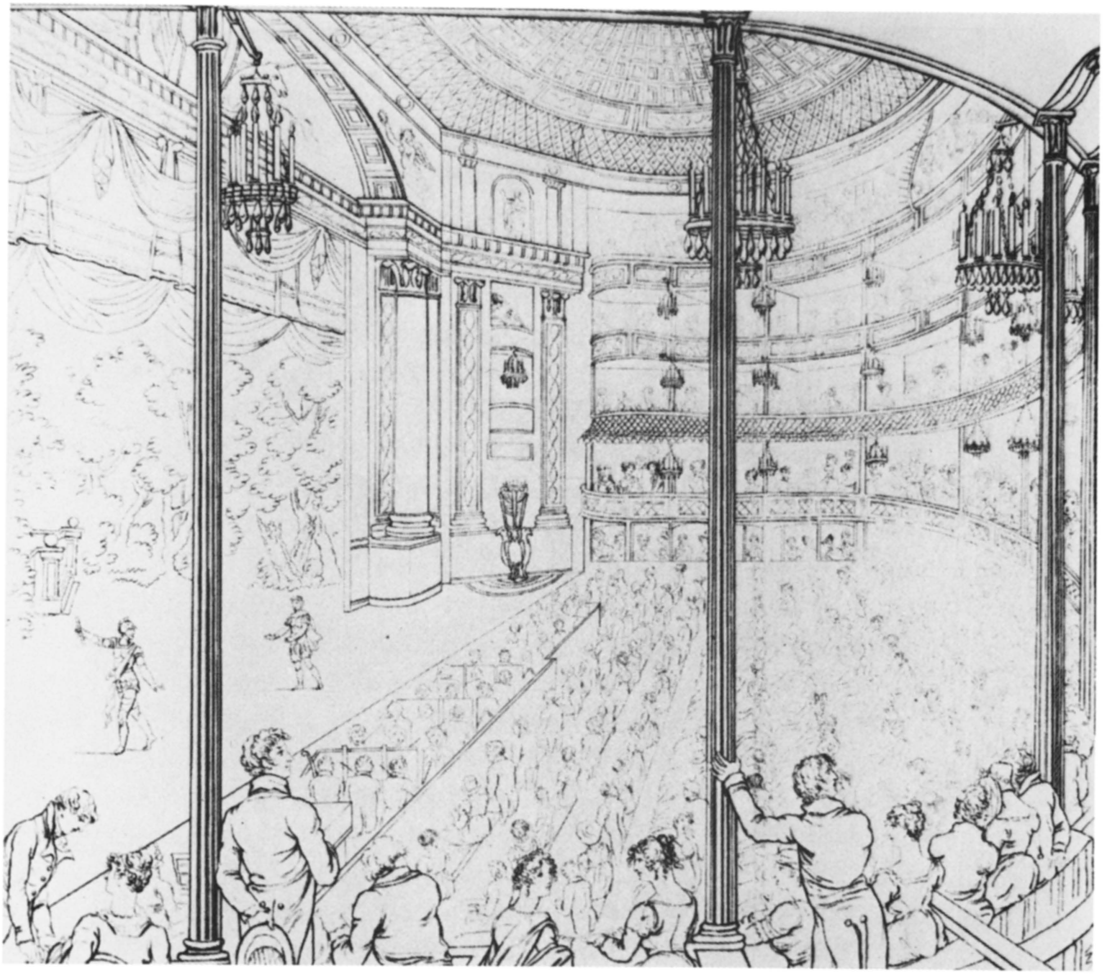


9. Schouwburg Theatre, Amsterdam, in 1772 (as rebuilt in 1664)

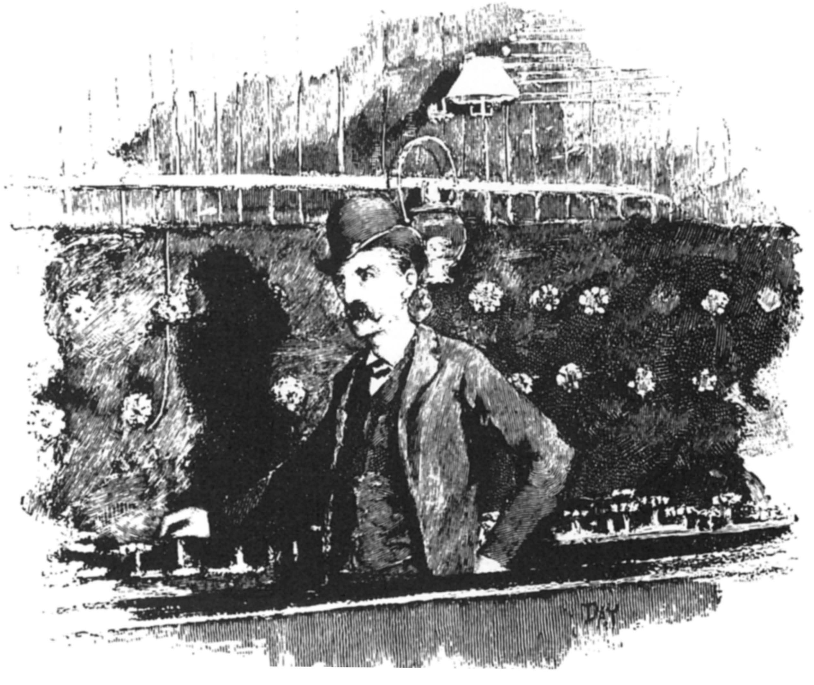
10. Wing lights on the German stage (1794)



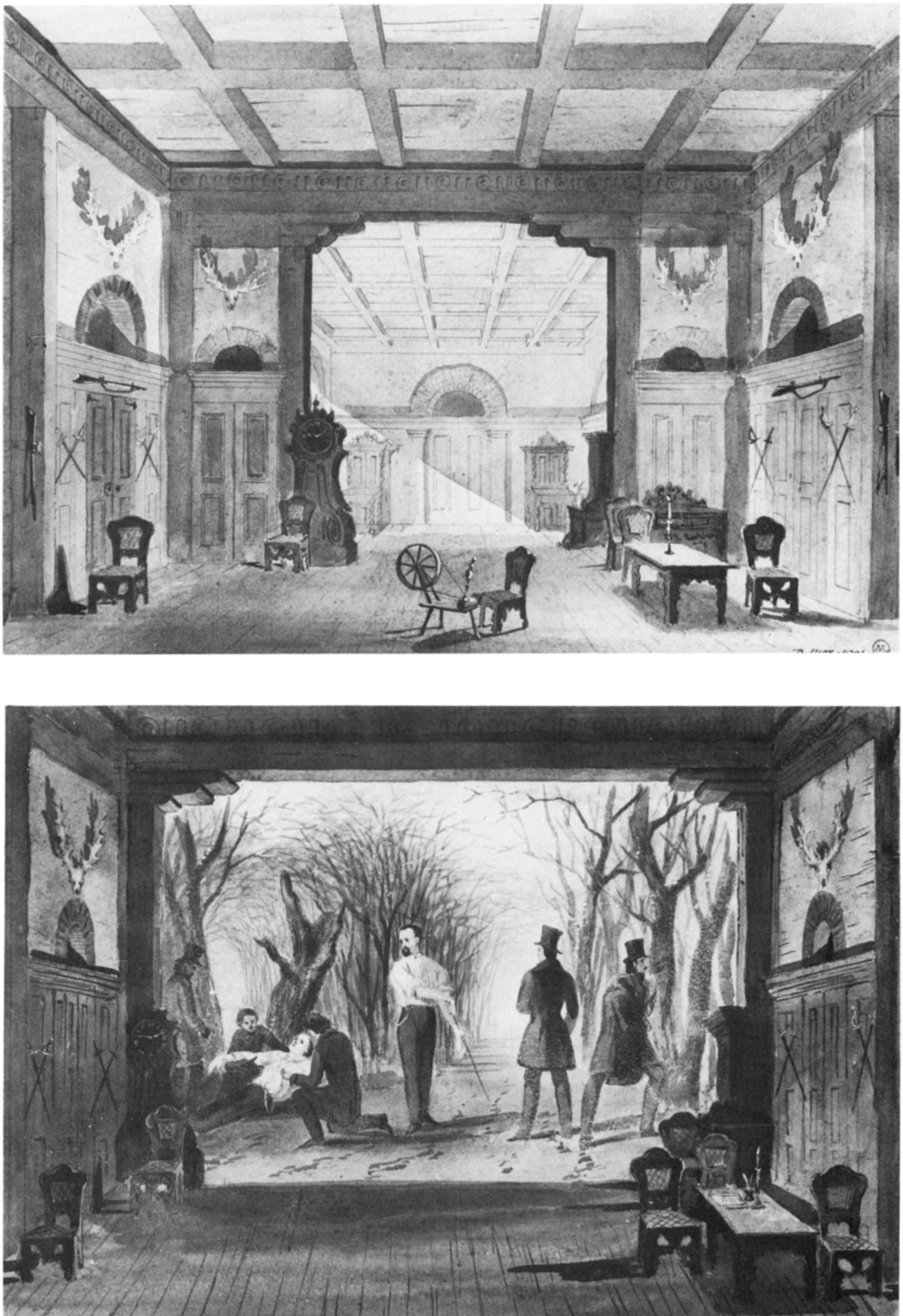
11. Production of *Hamlet* in 1709, showing practical wall sconce



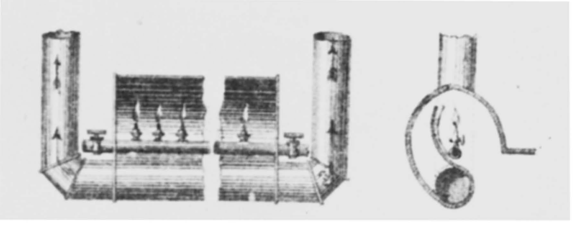
12. Drury Lane, a typically lit theatre in 1813



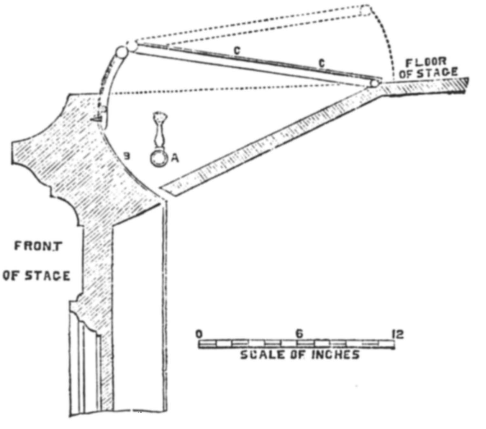
13. Gas table of the Metropolitan Opera, October 1888



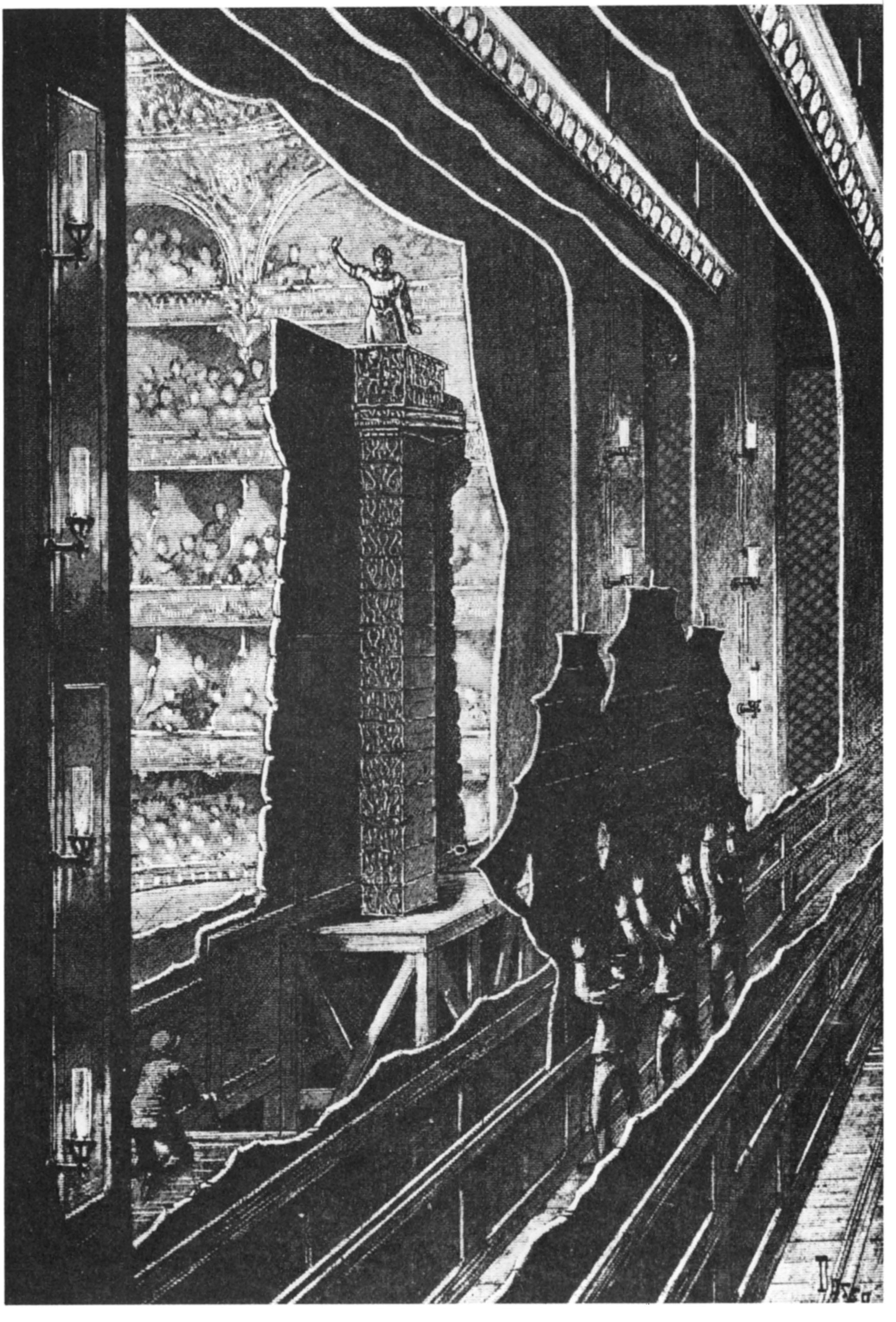
14. *The Corsican Brothers* (1851): *above,* Corsican Palace; *below,* Paris duel, as seen behind a scrim



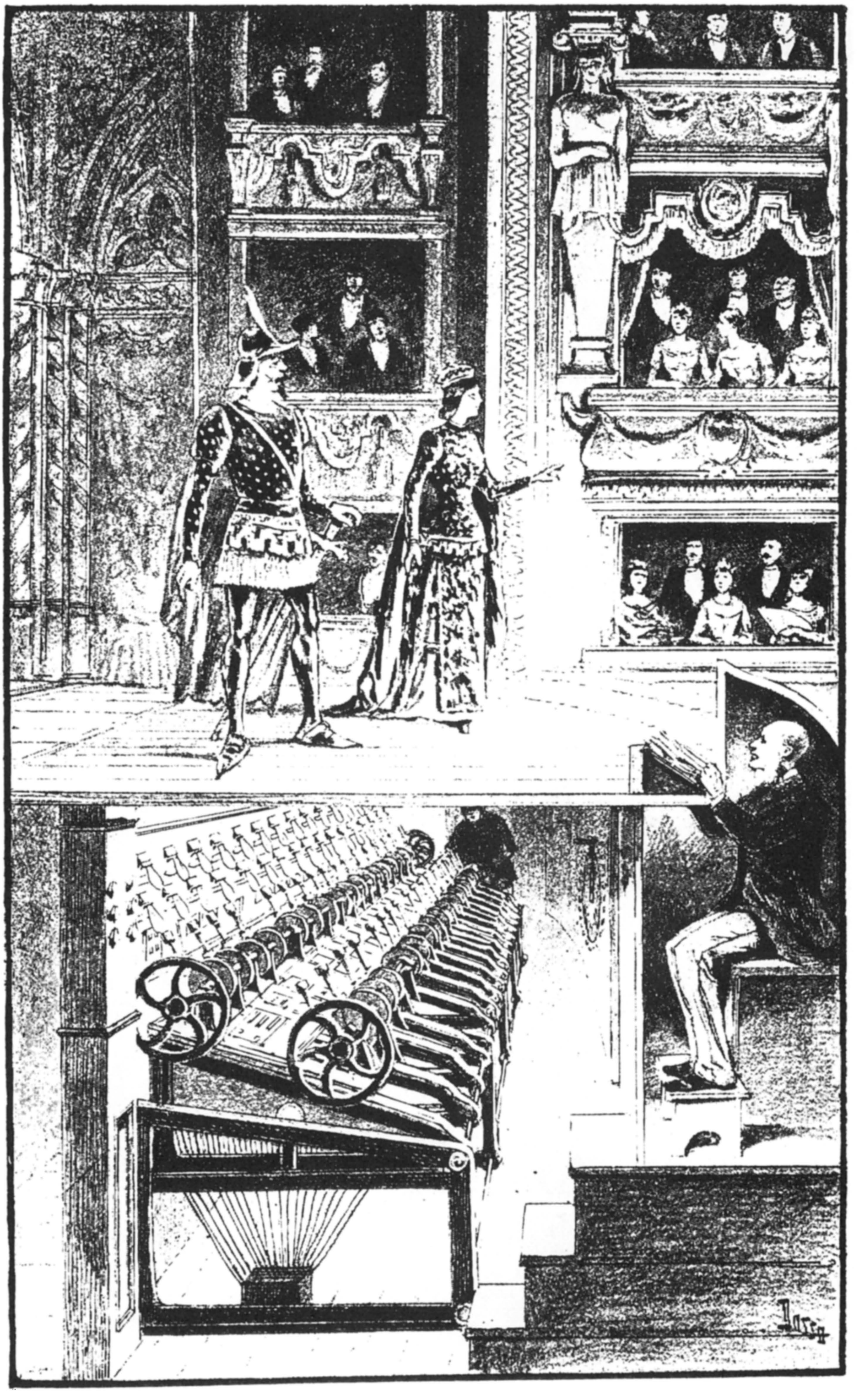
15. Footlight system used at the Paris Opéra



16. G. W. Lloyd's patented footlight

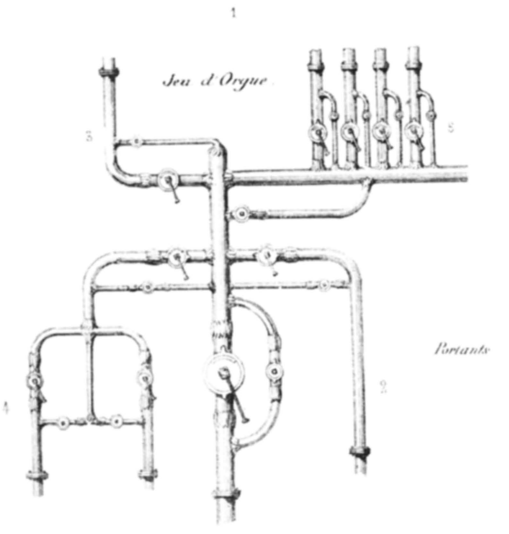


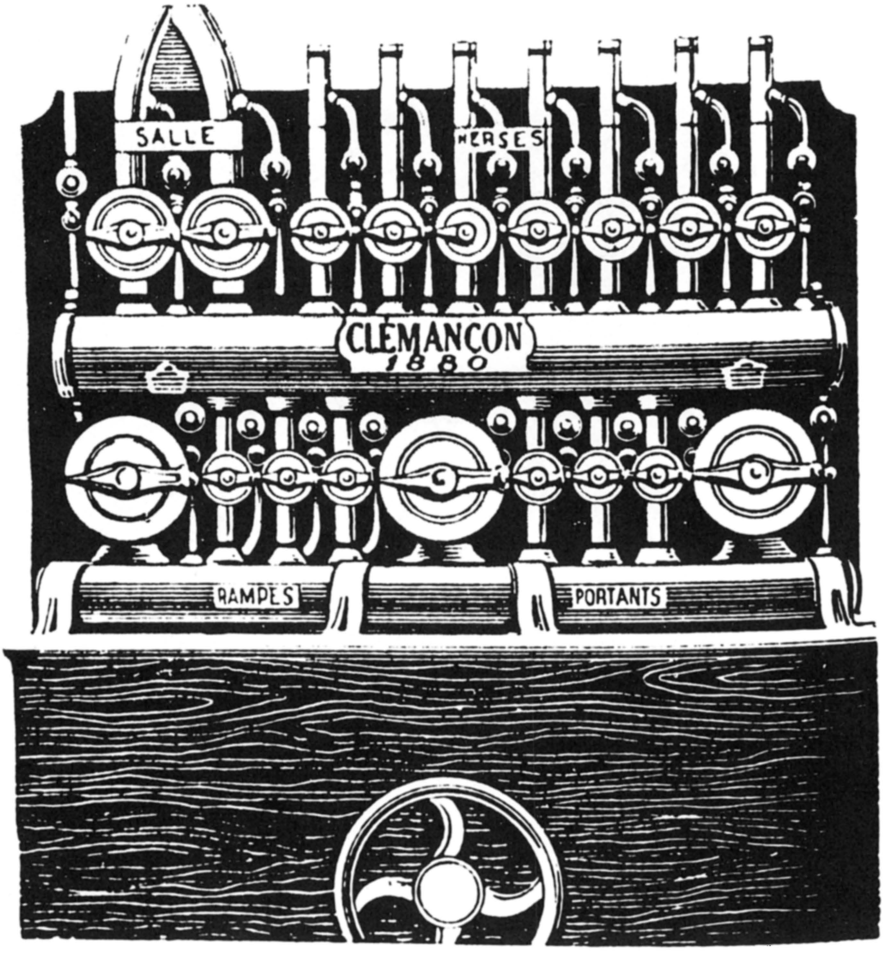
17. Offstage left view of a gaslit stage



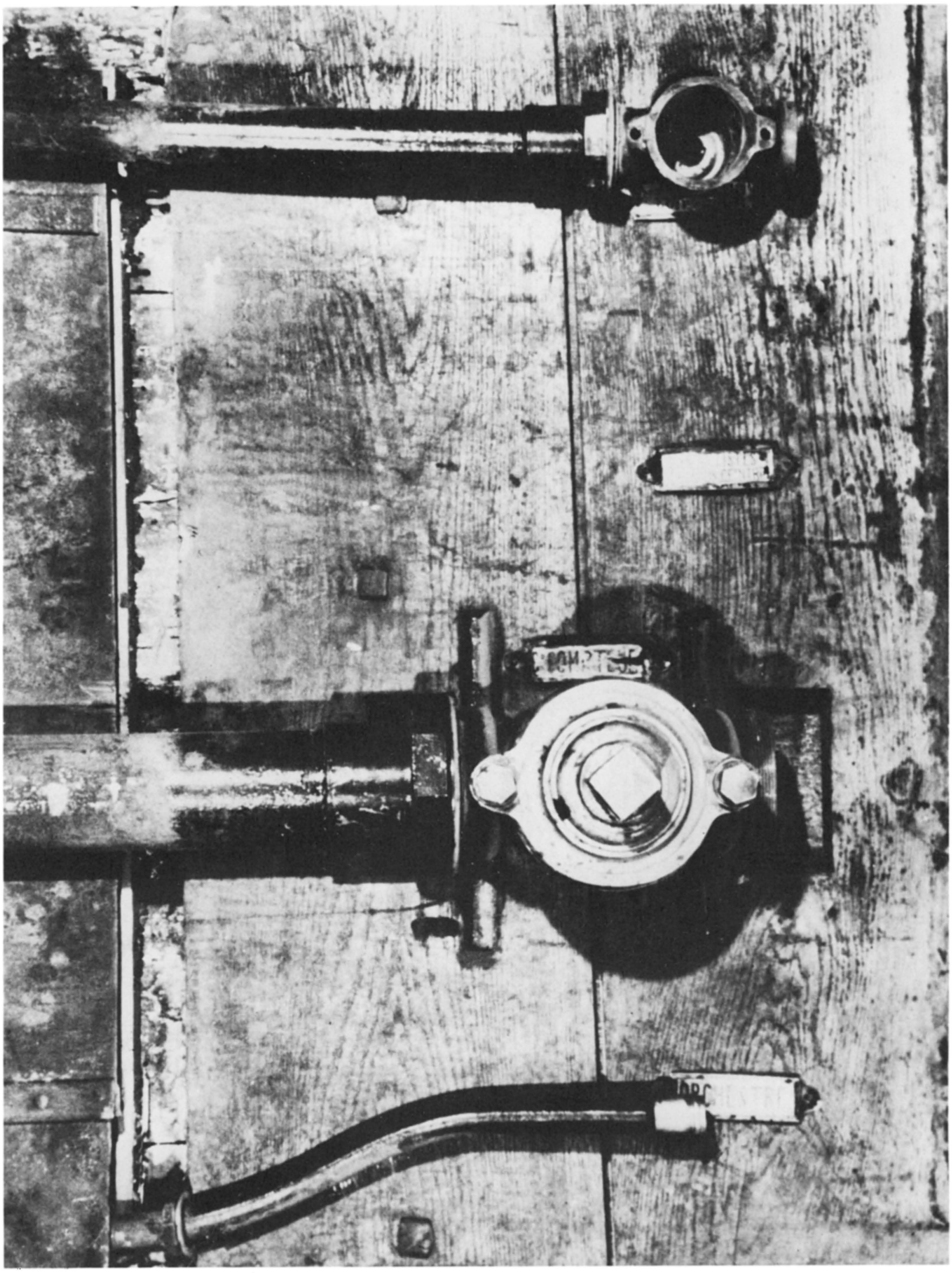
18. Light board at the Paris Opéra

19. A gas table

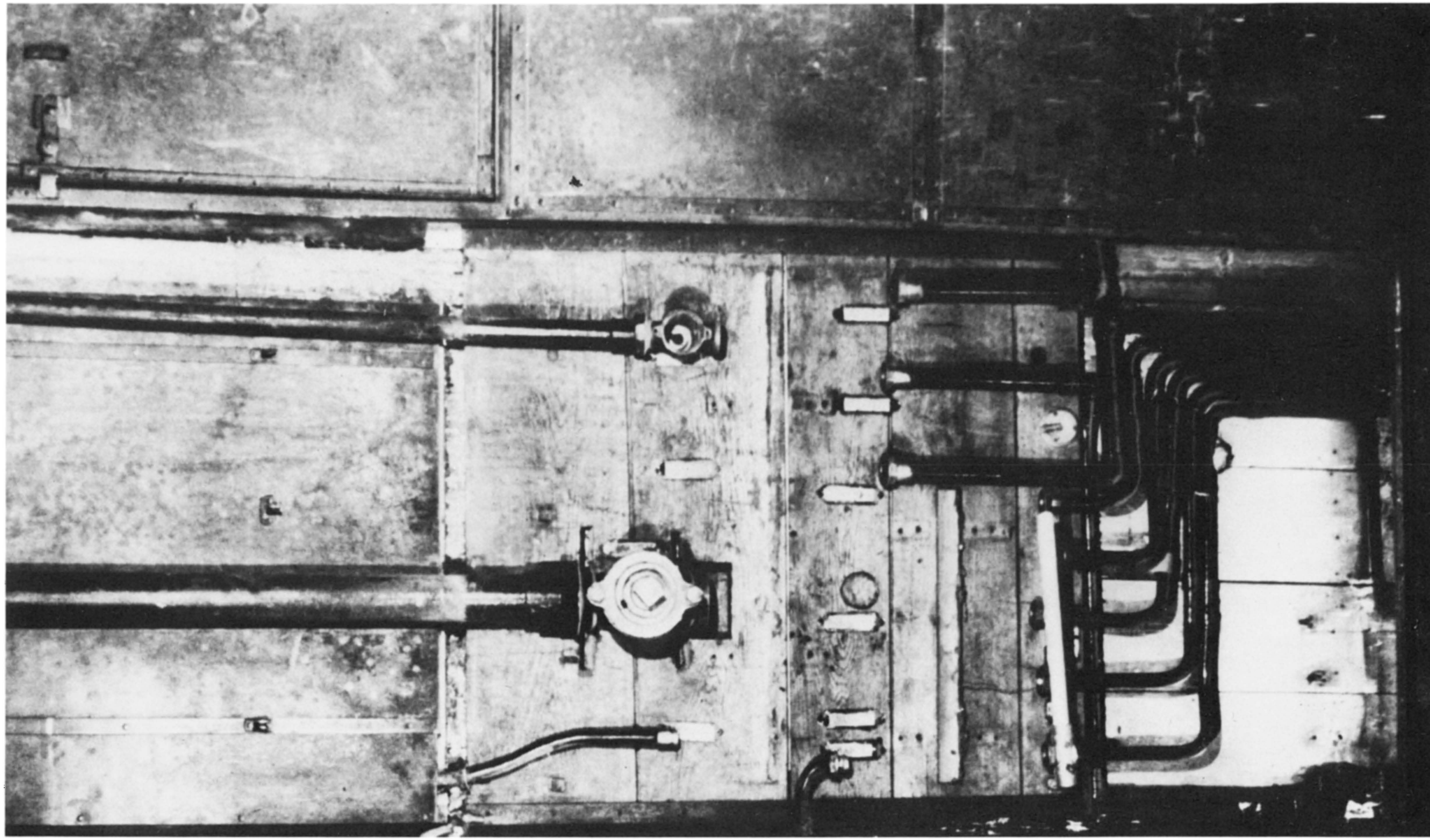




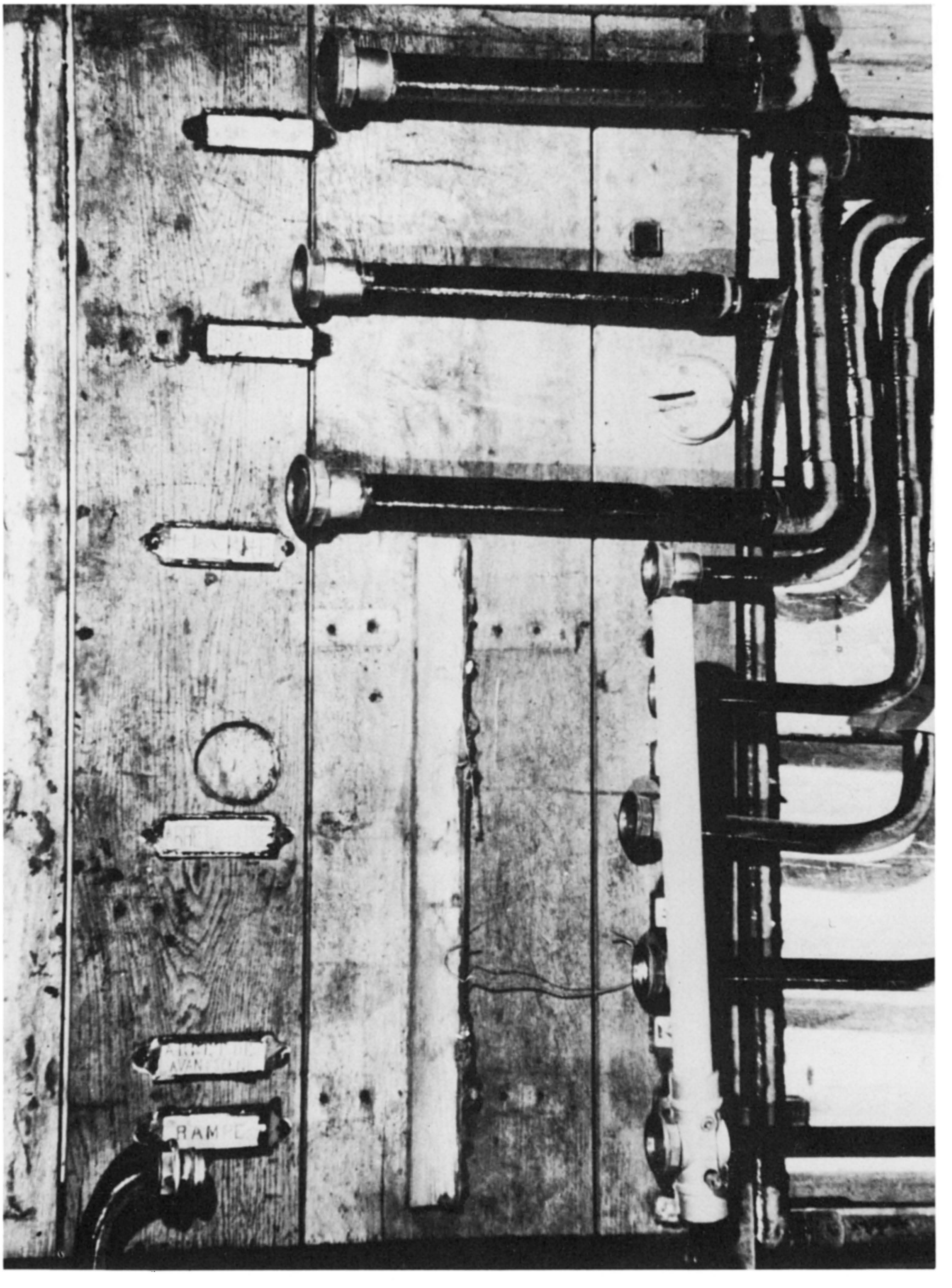
20. Clemançon gas table



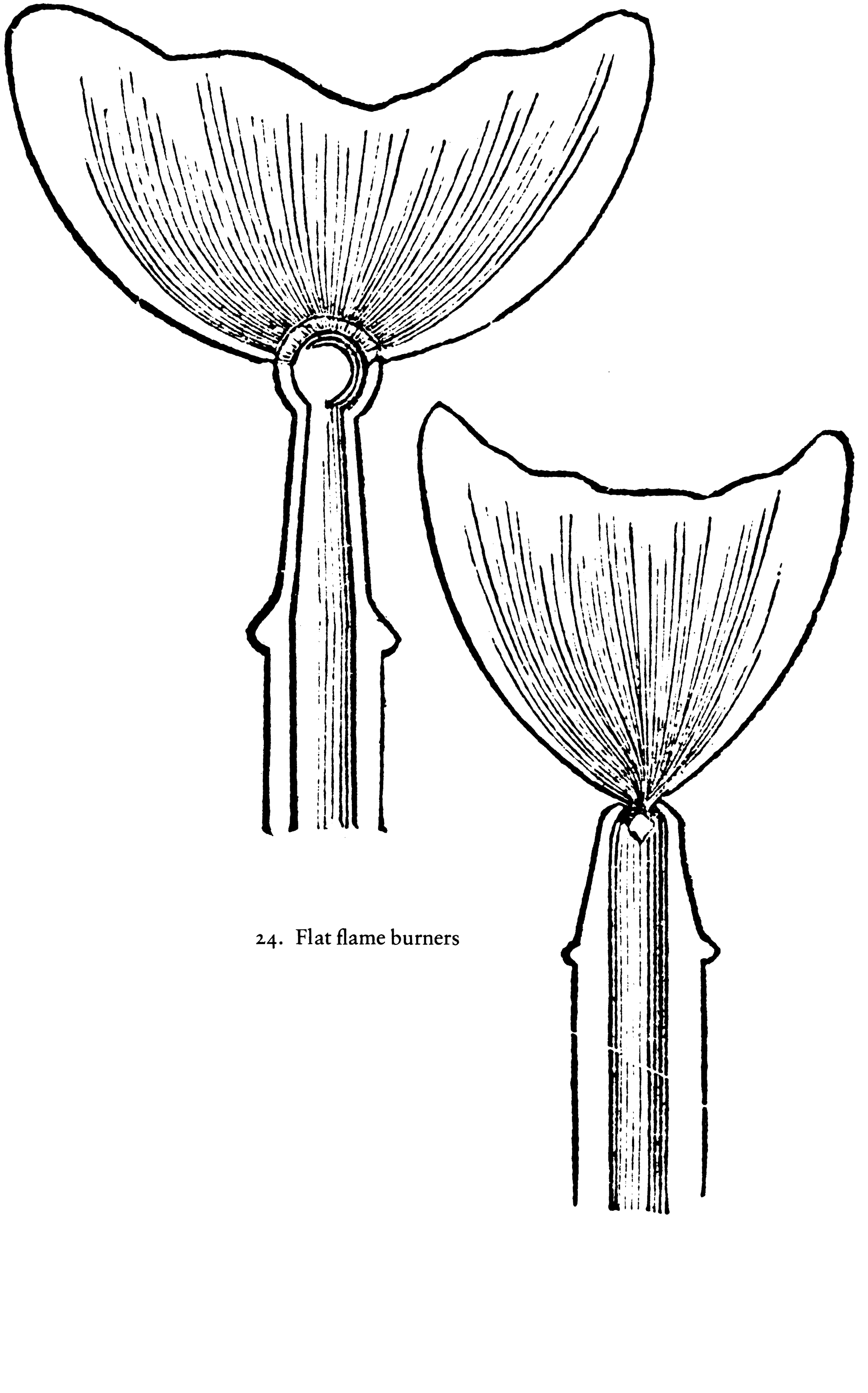
21. Gas table, Théâtre Montansier, Versailles



22. Gas table, Théâtre Montansier, Versailles

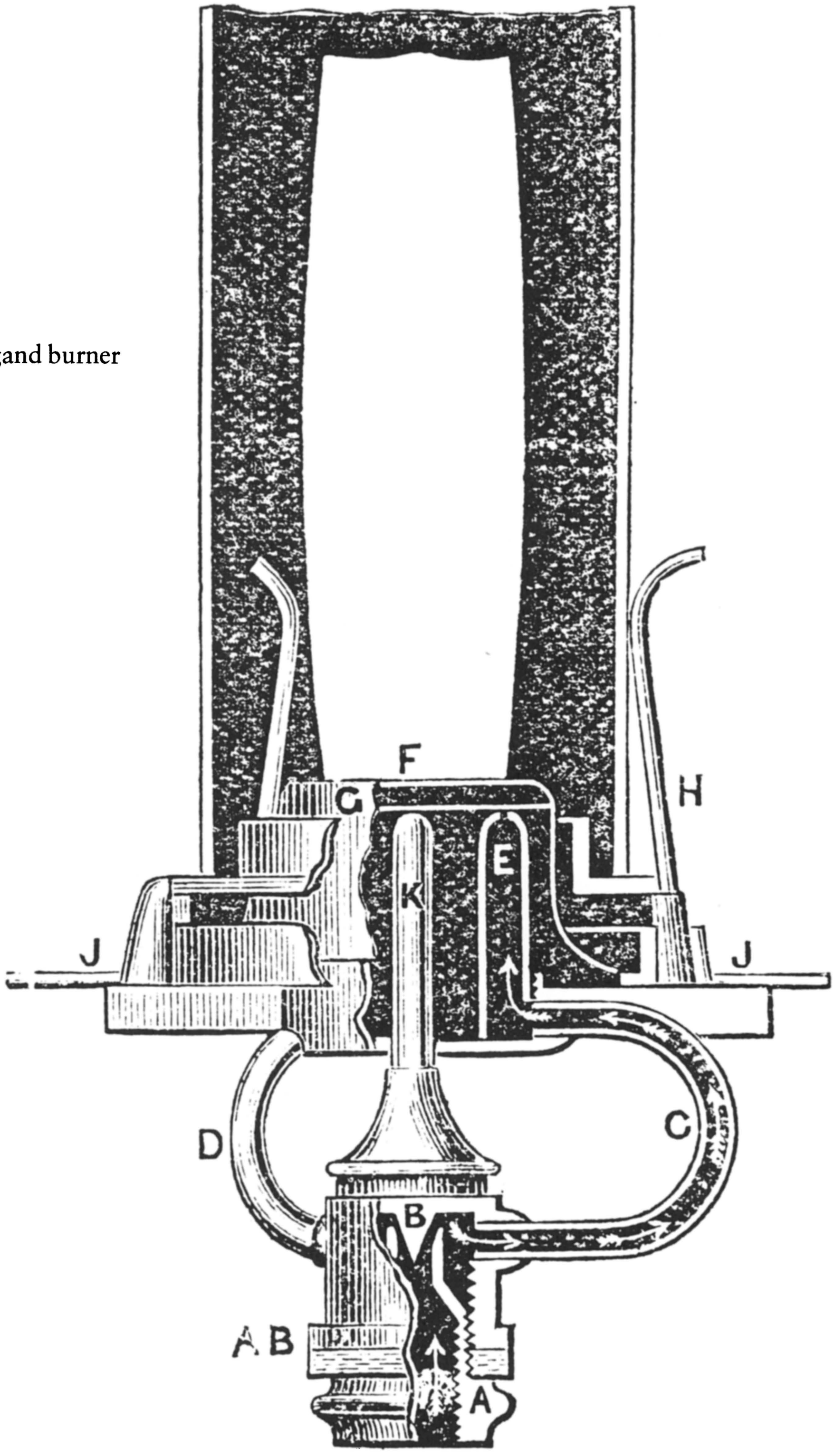


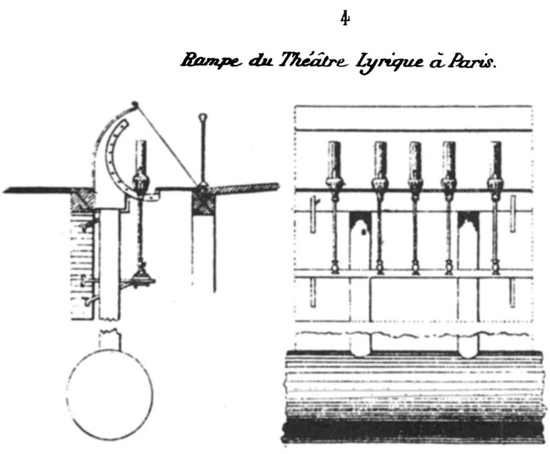
23. Gas table, Théâtre Montsanier, Versailles



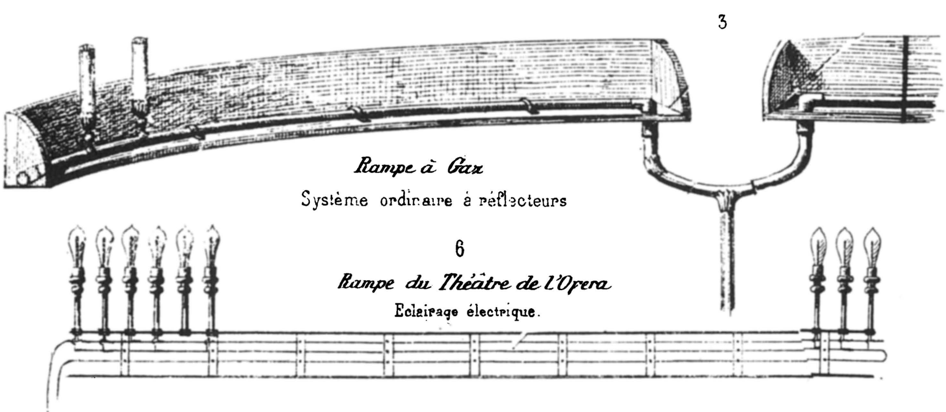
24. Flat flame burners

25. Gas Argand burner

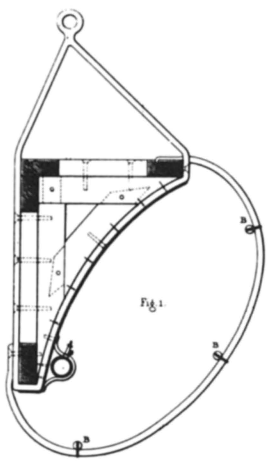


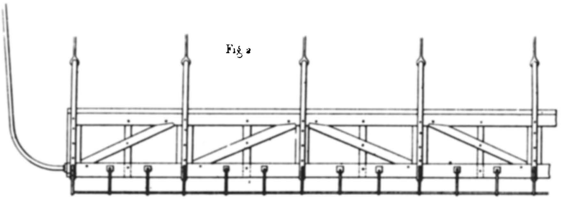


26. Glass-shielded footlight



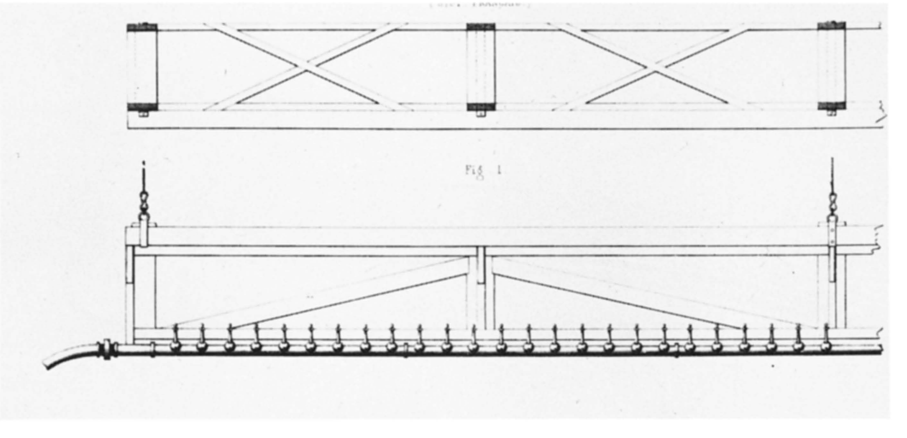
27. Split service footlights

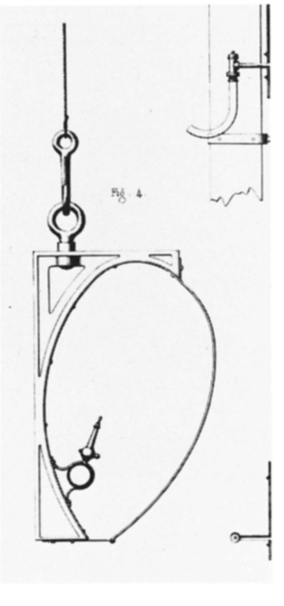


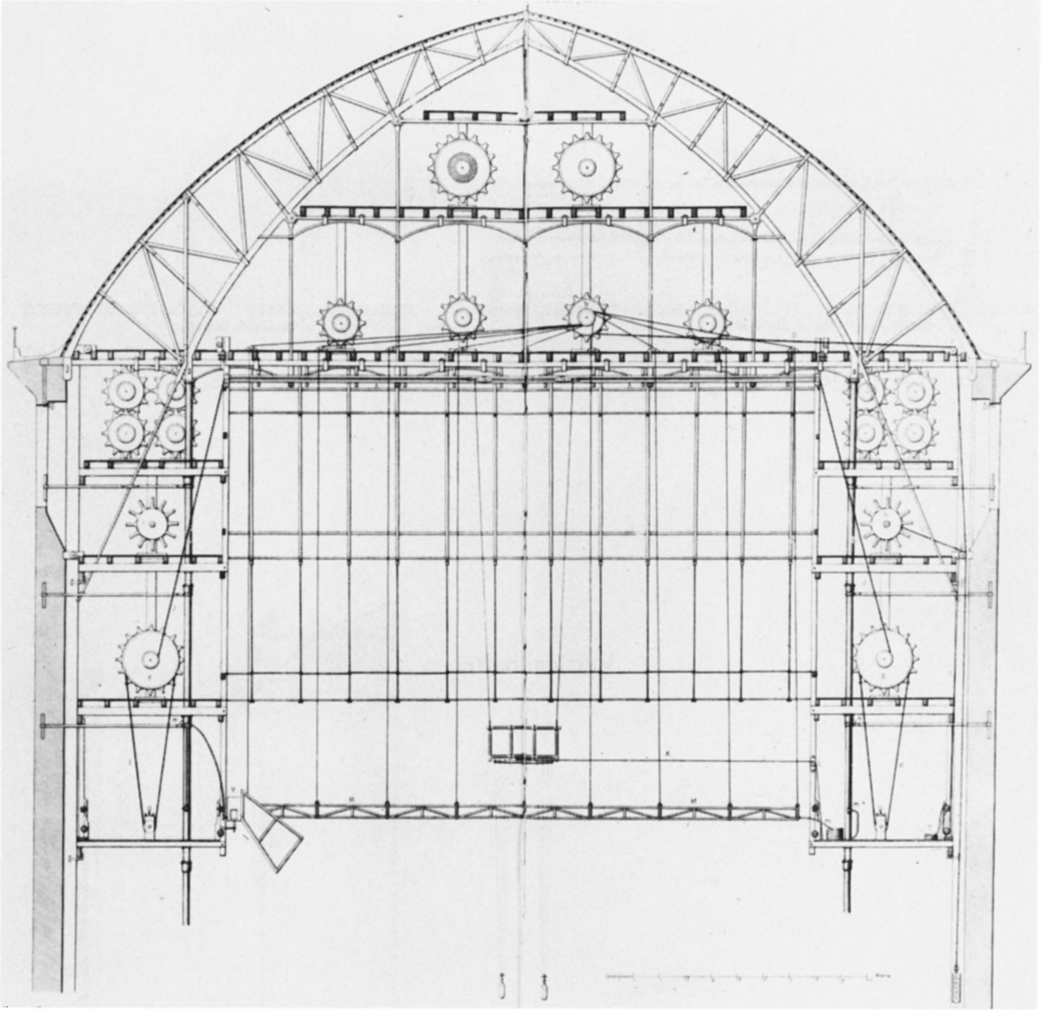


28. Wood-framed gas batten

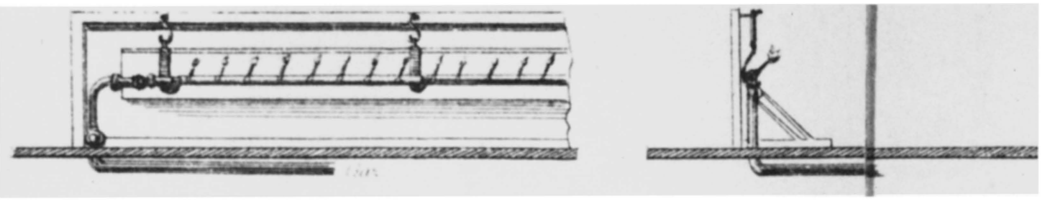
29. Metal-framed gas batten





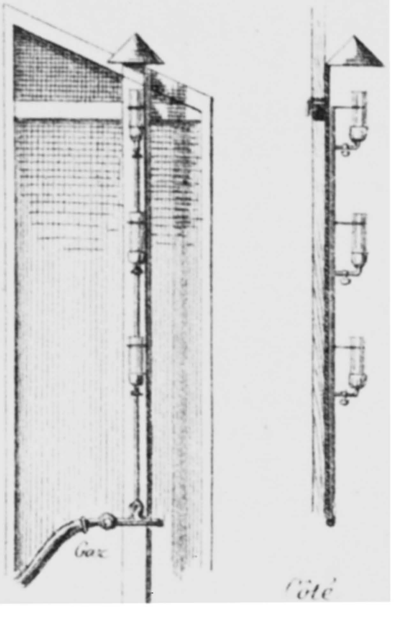


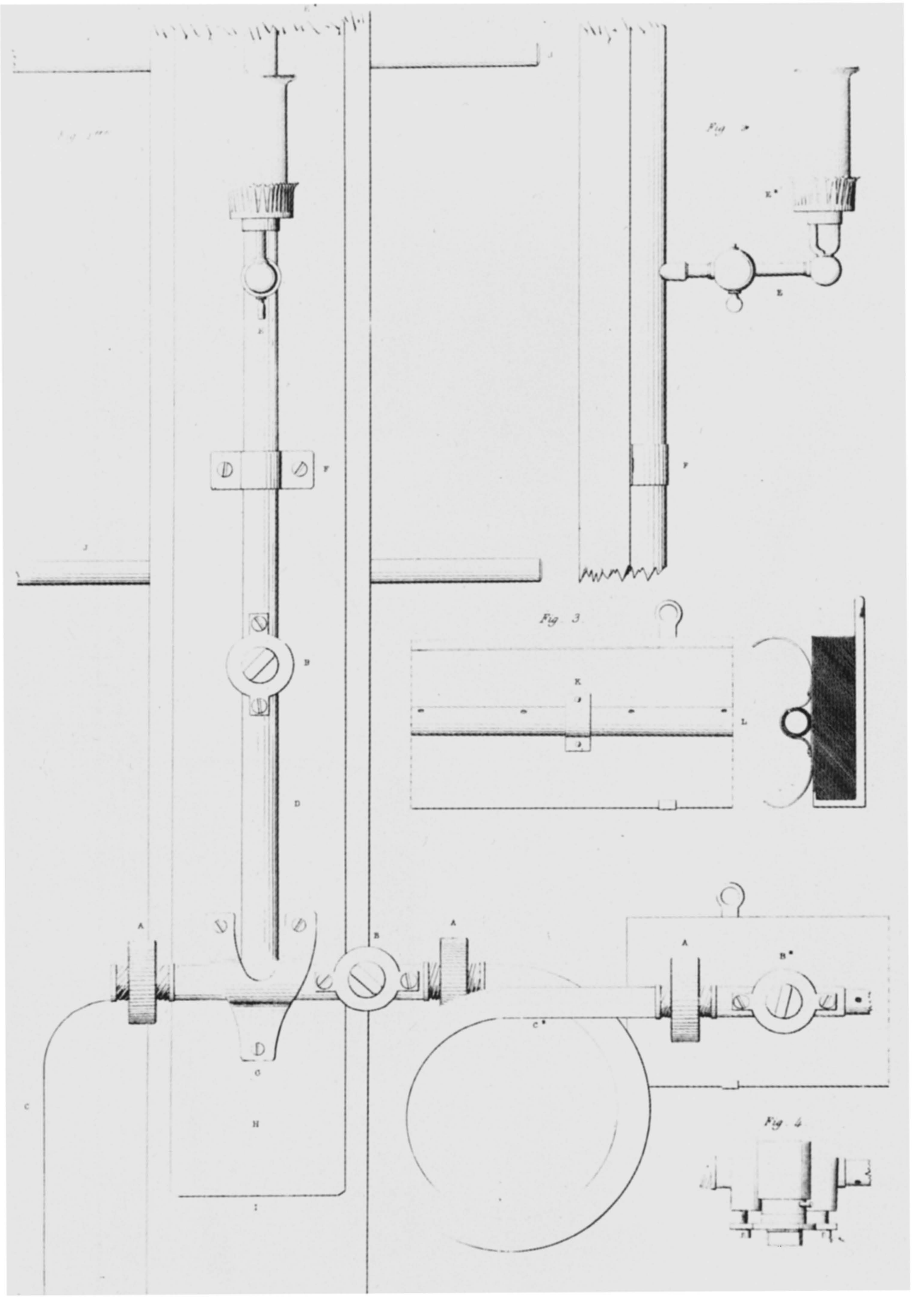
30. Typical French theatre rigged for gas



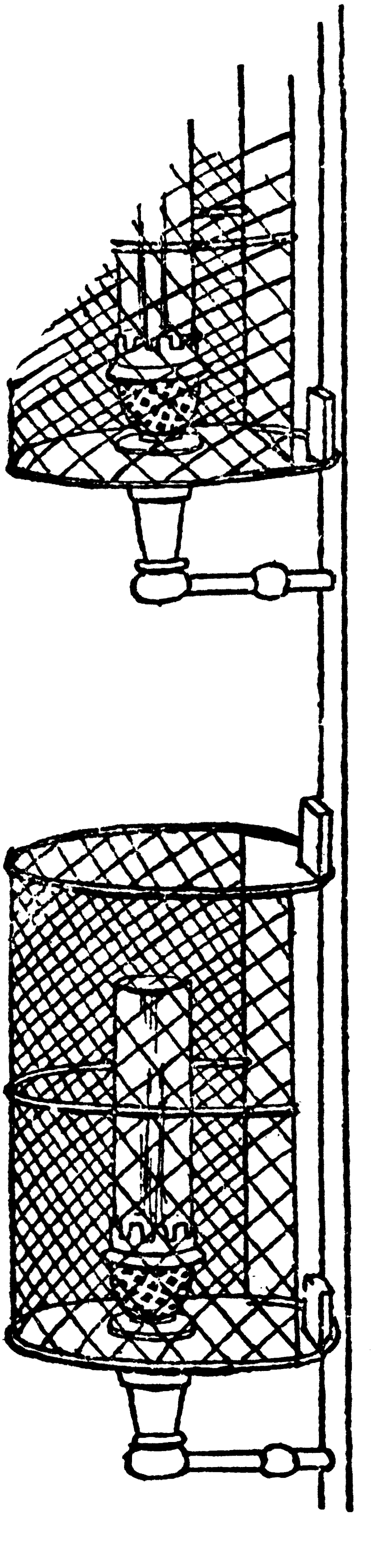
31. *Rampe de terrain*

32. Vertical batten

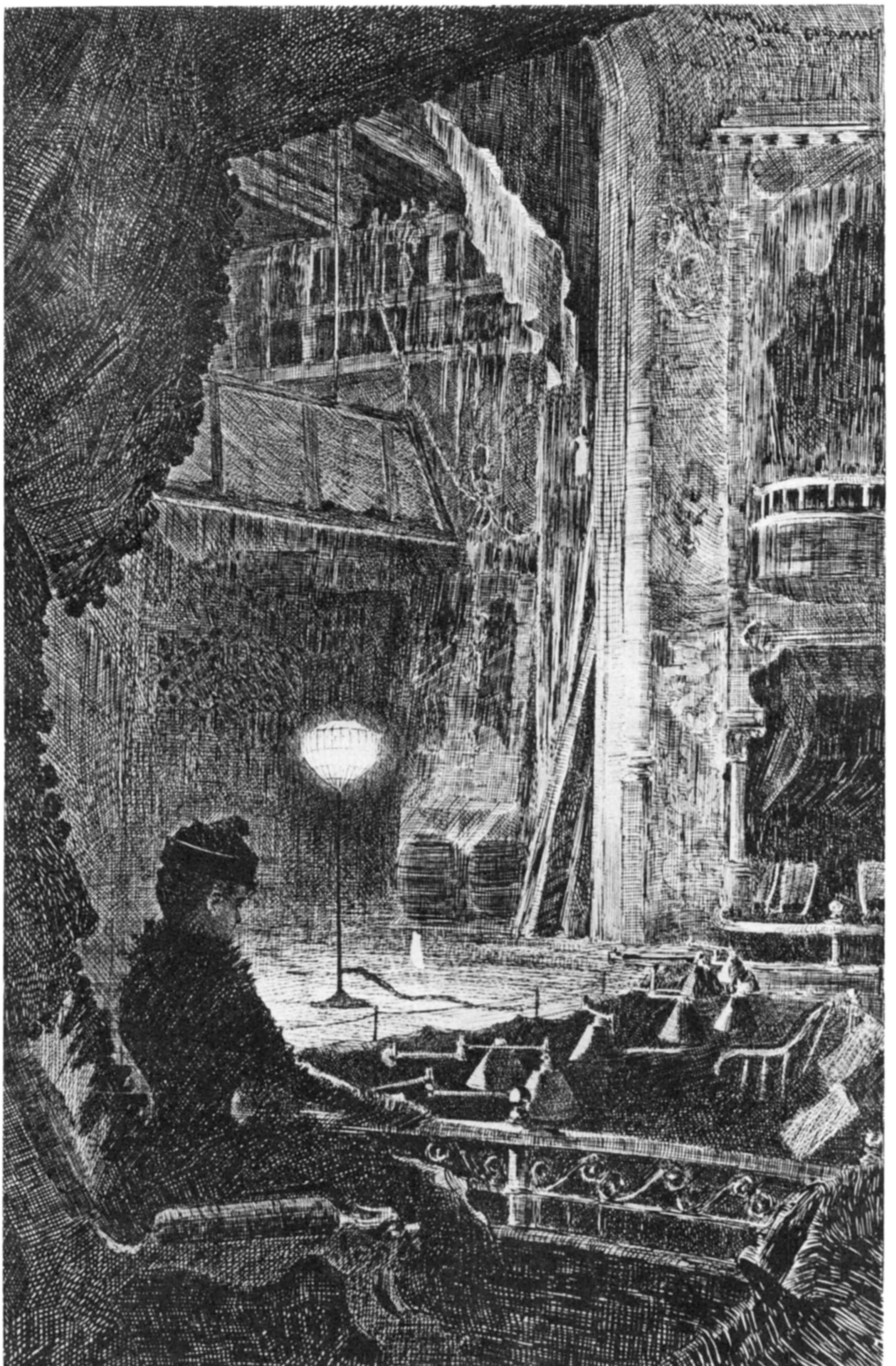




33. Vertical batten, detail

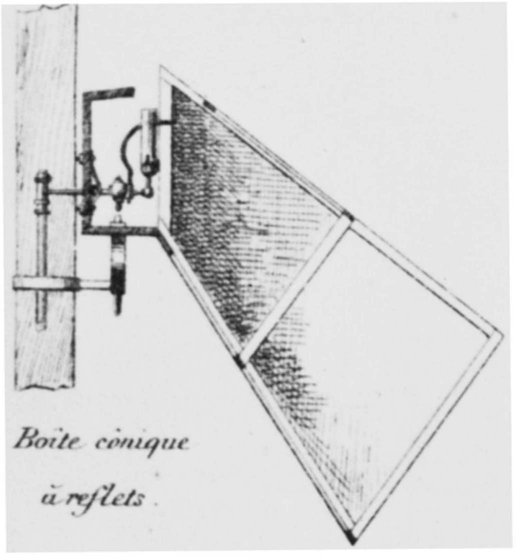


34. Vertical batten with wire guards

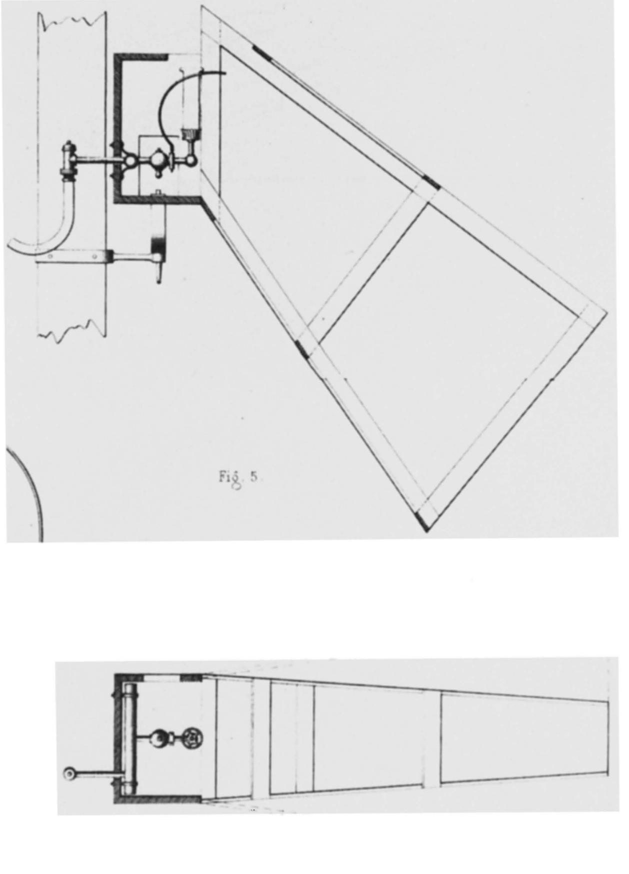


35. Gas orchestra pit lights and a bunch light

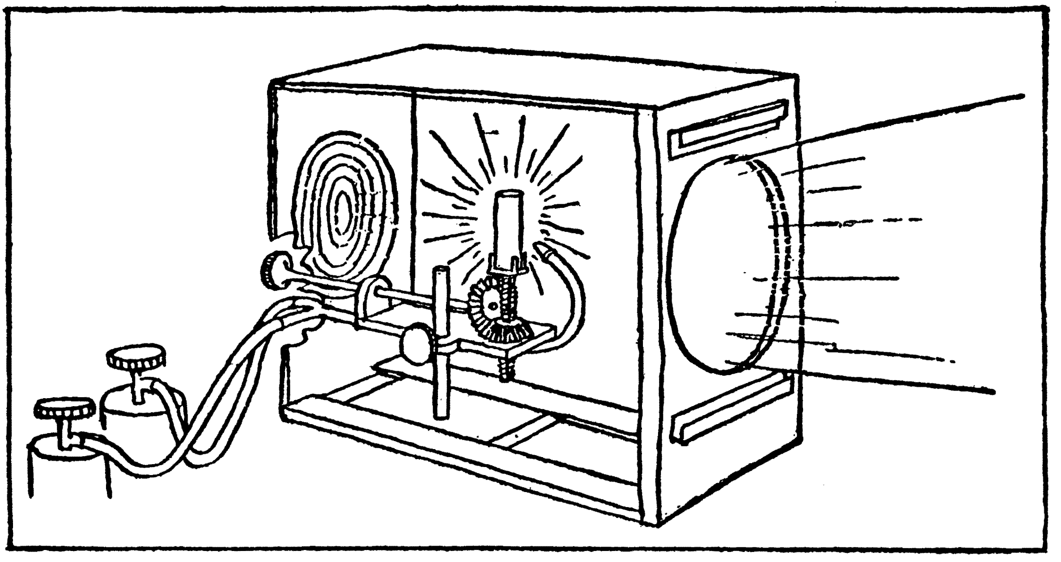
36. A bunch light



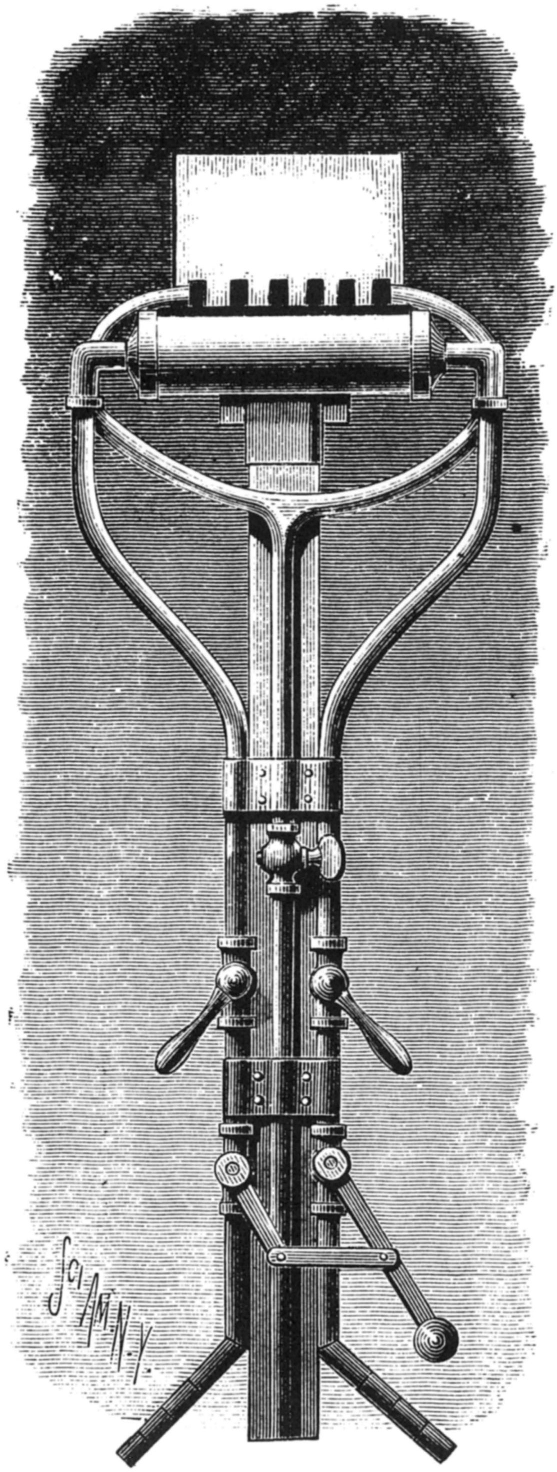
37. *Boîte conique*



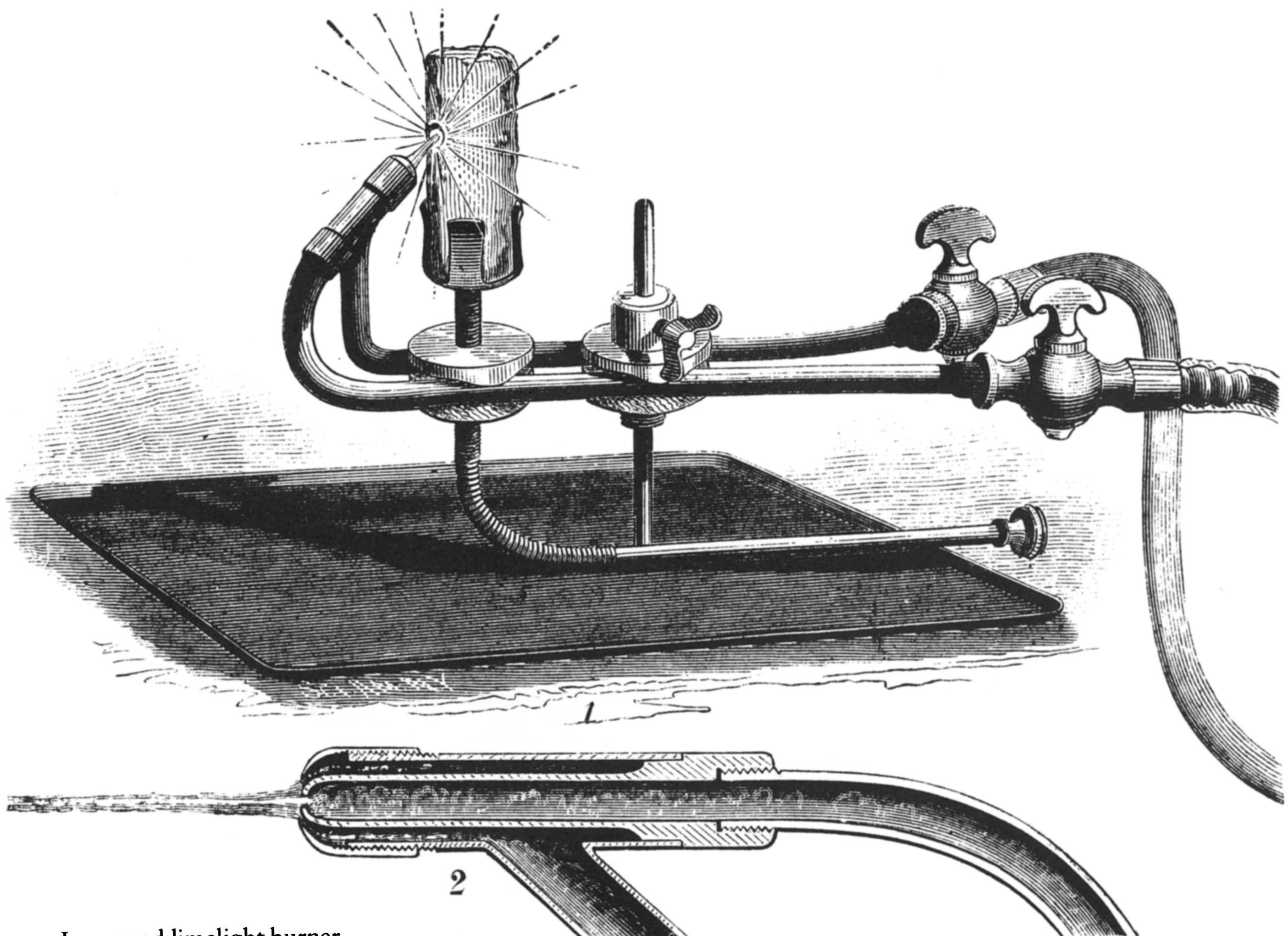
38. *Boîte conique*



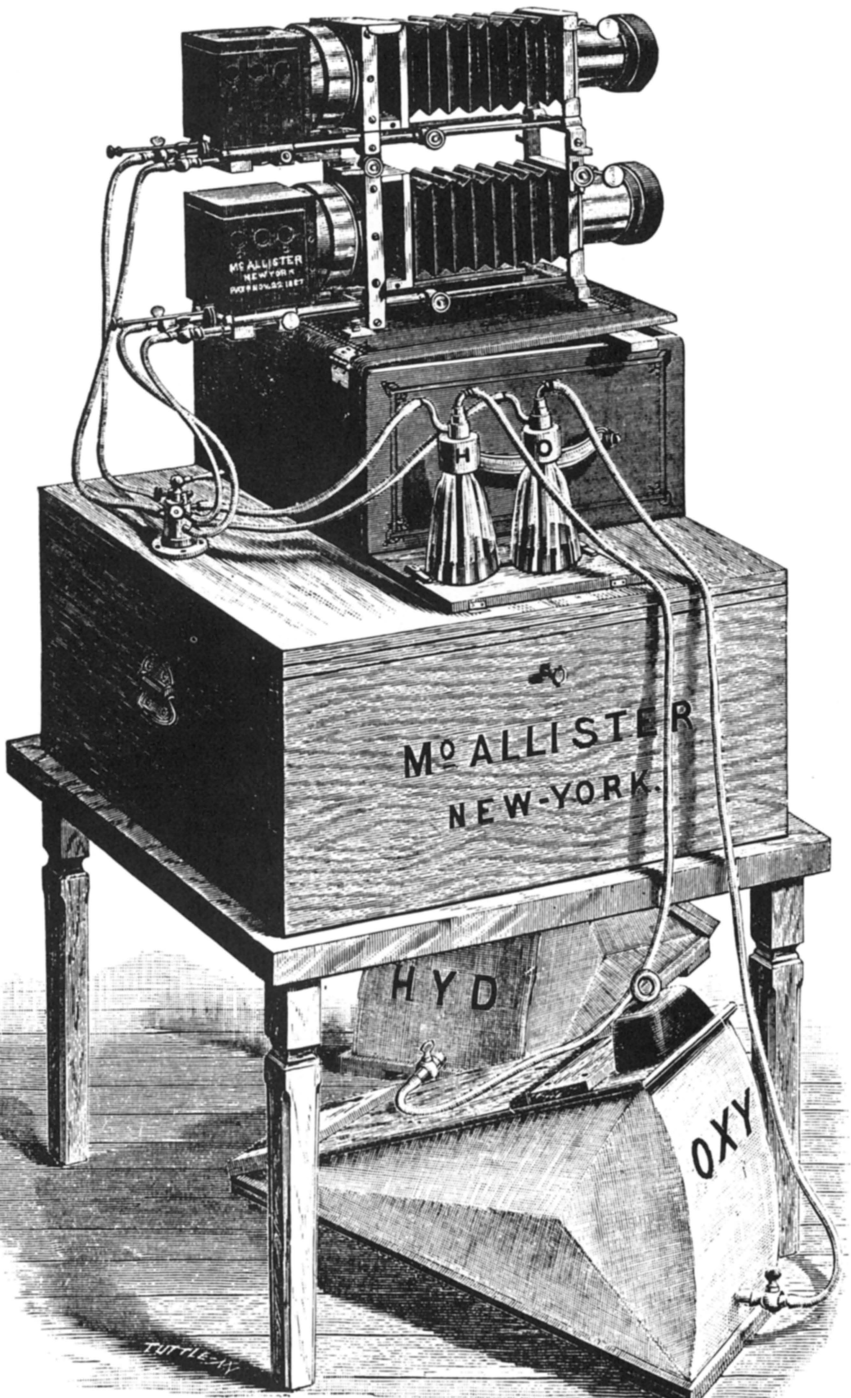
39. Limelight



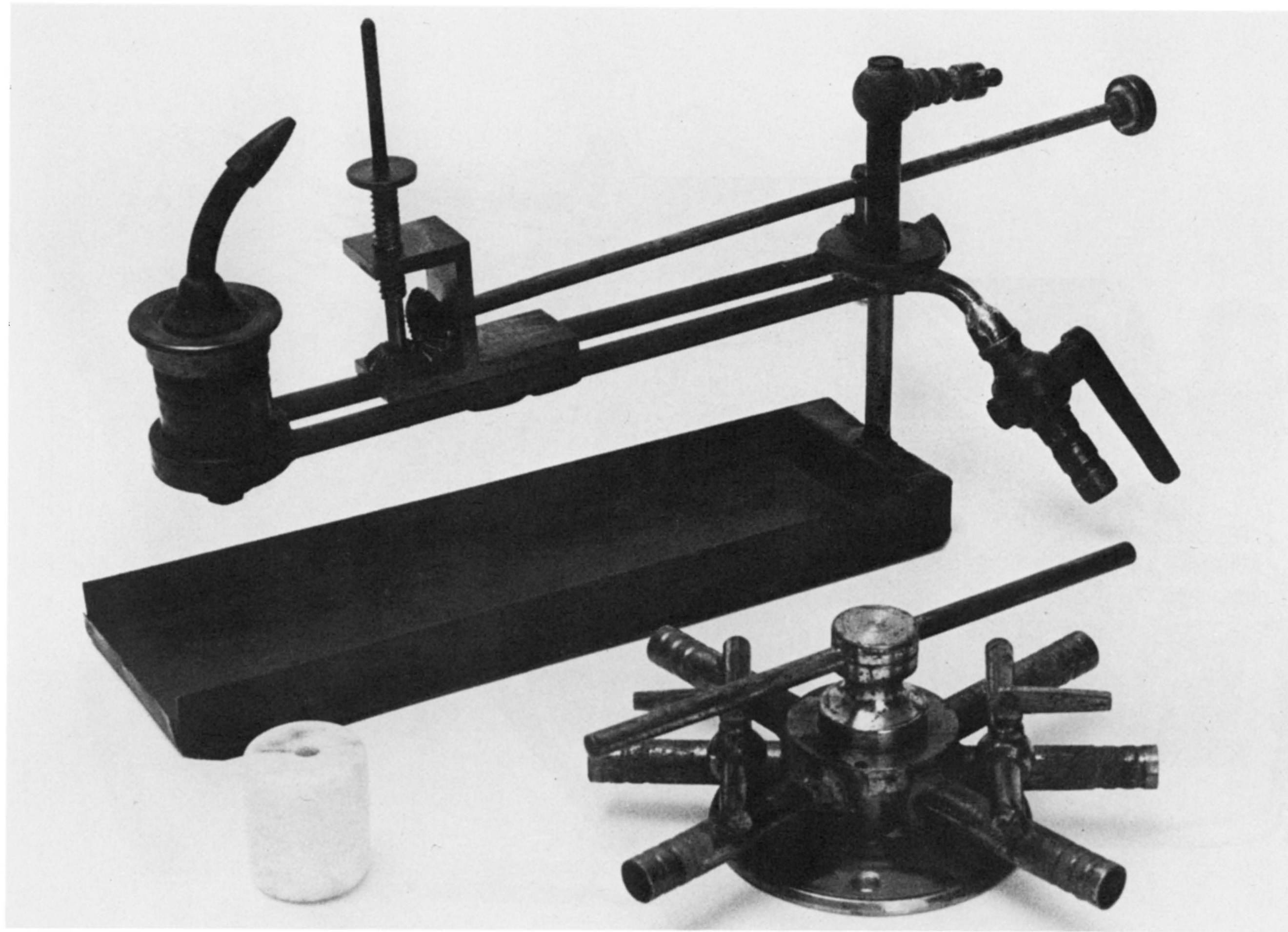
40. Improved limelight burner



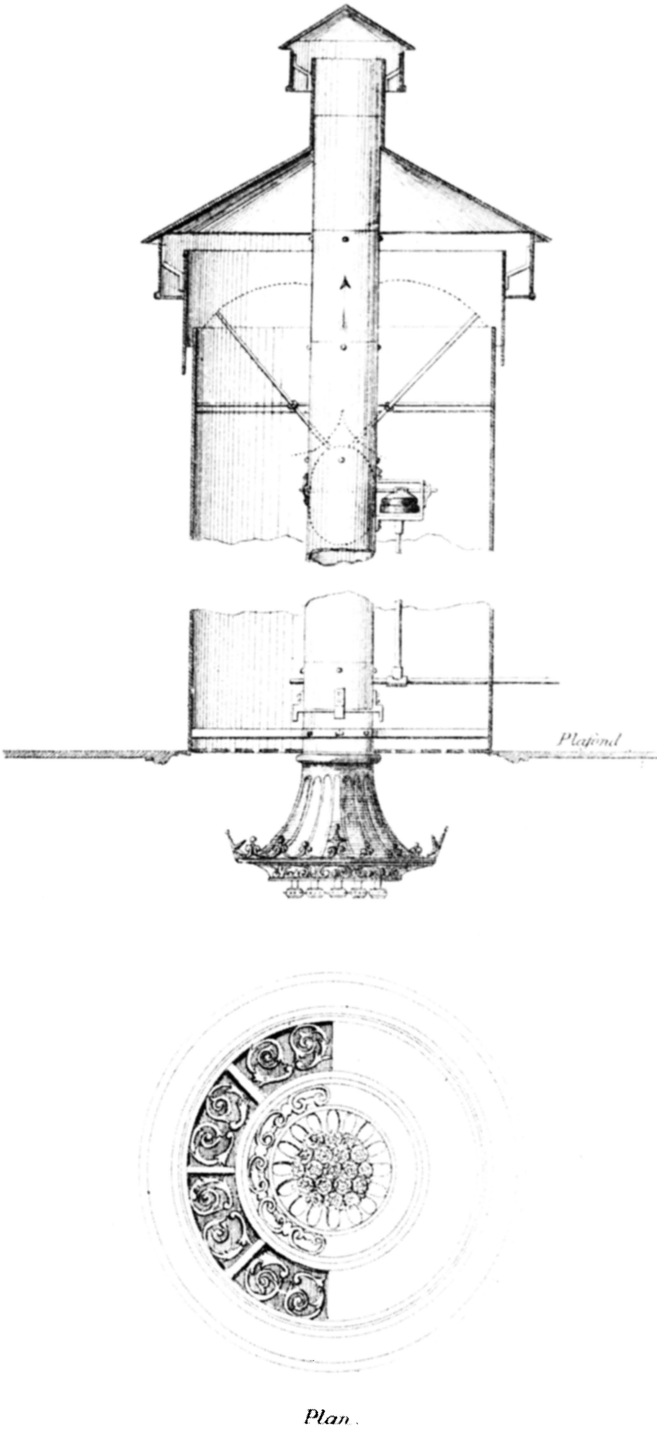
41. Improved limelight burner



42. Limelight stereopticon shown with typical oxygen and hydrogen bag feed apparatus

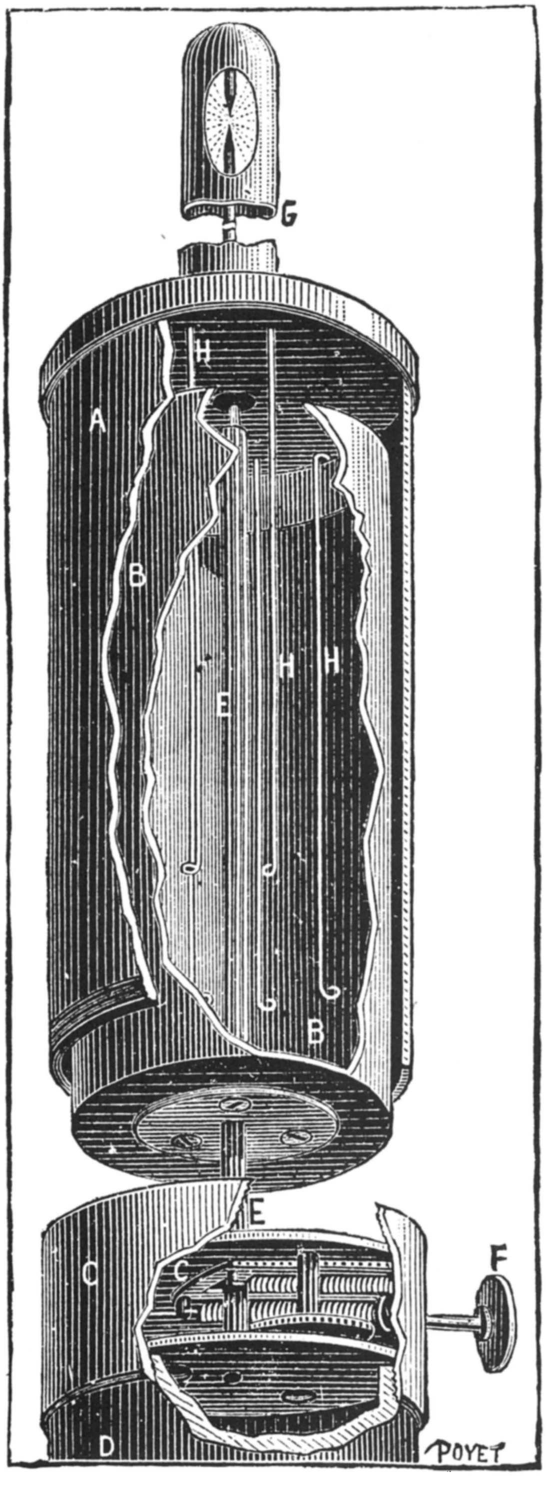


43. Stereopticon limelight burner, lime block, and dissolve tap

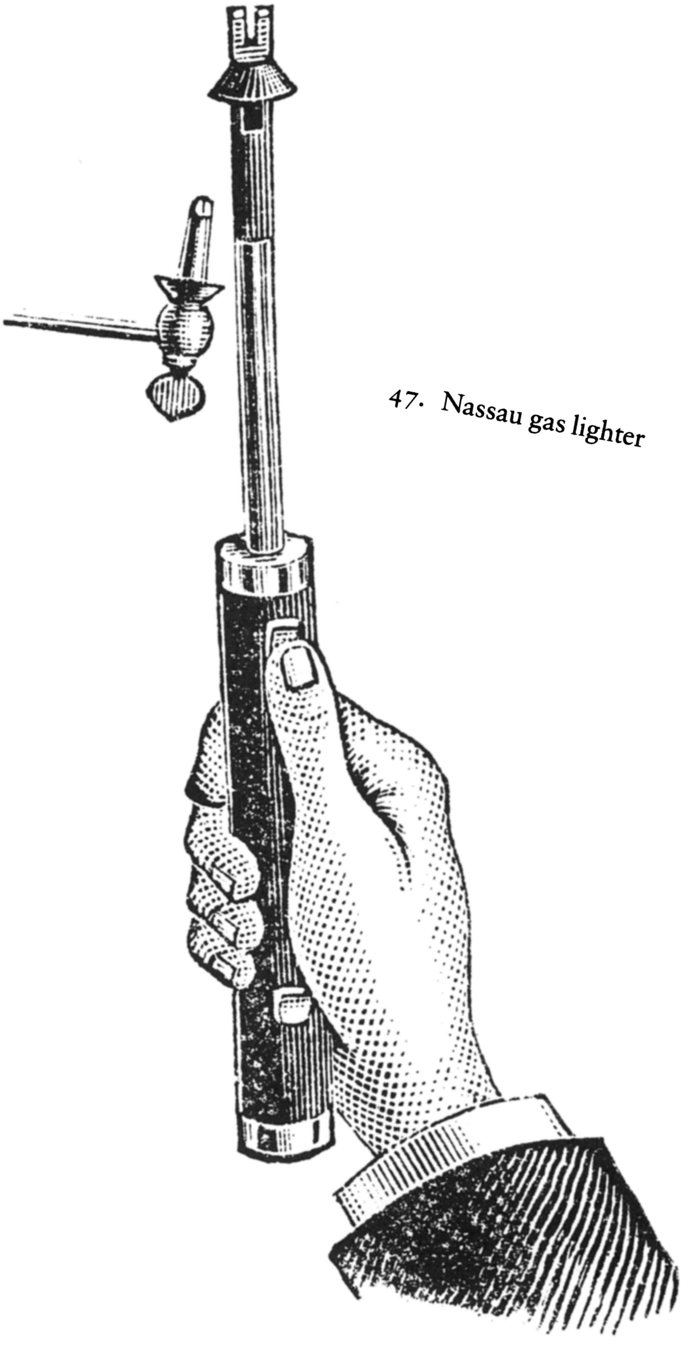


44. Sun burner

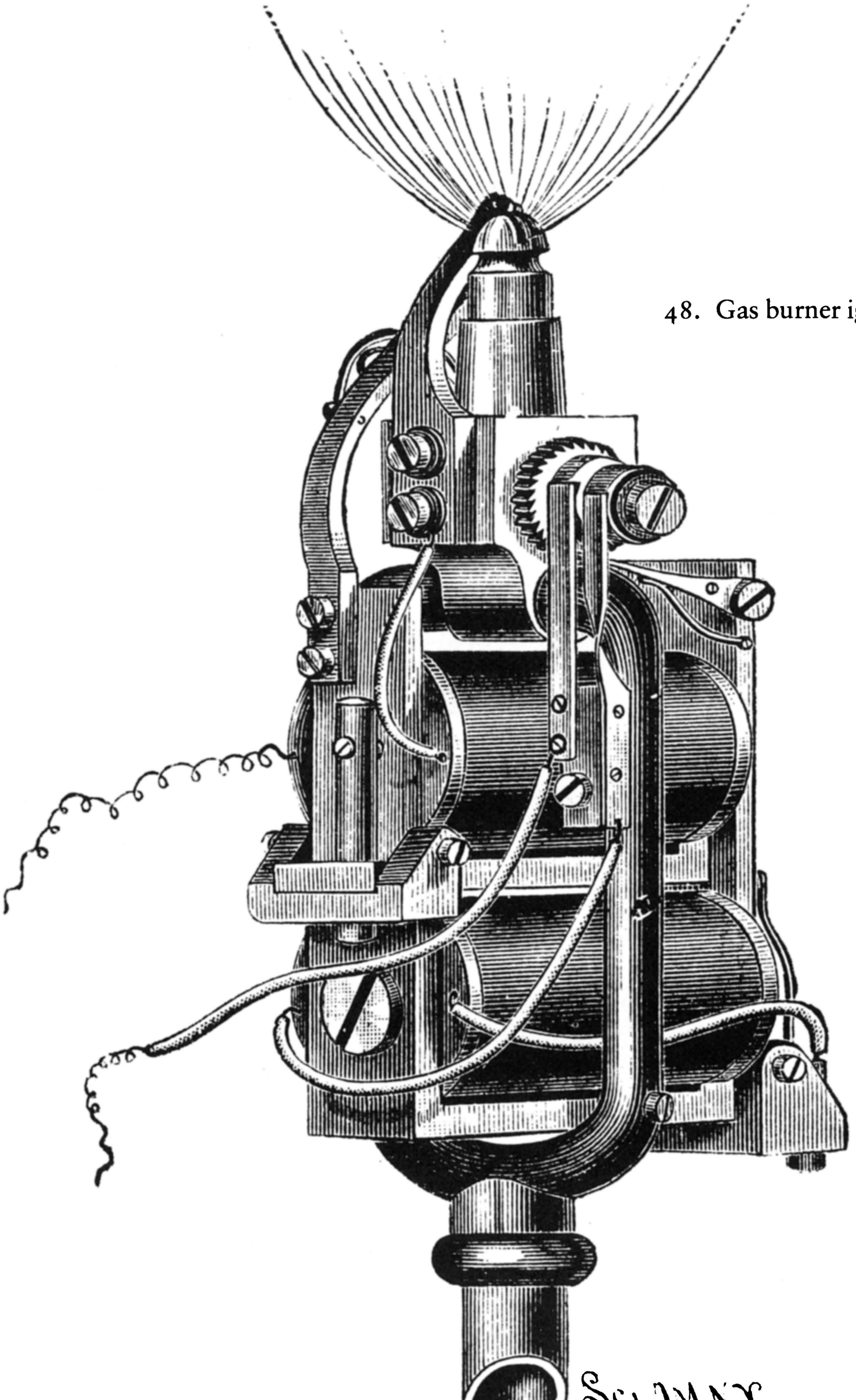
45. Typical backstage fixture with wire protection



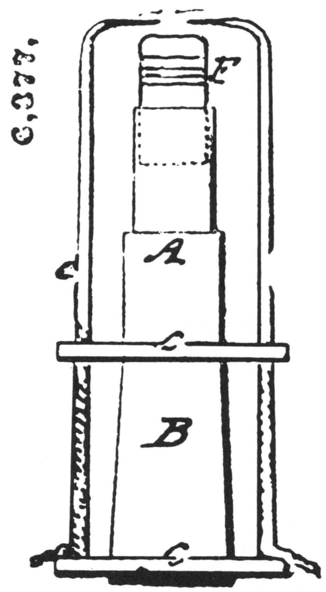
46. "Perpetual gas lighter"



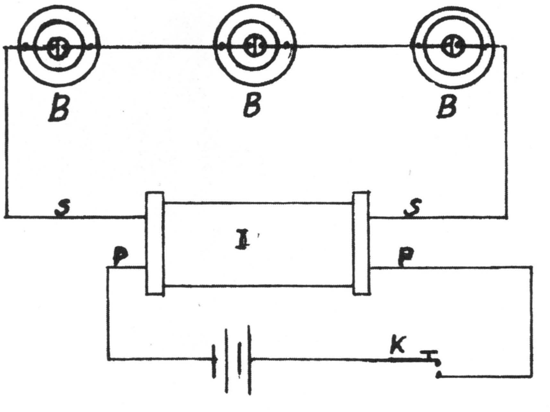
47. Nassau gas lighter



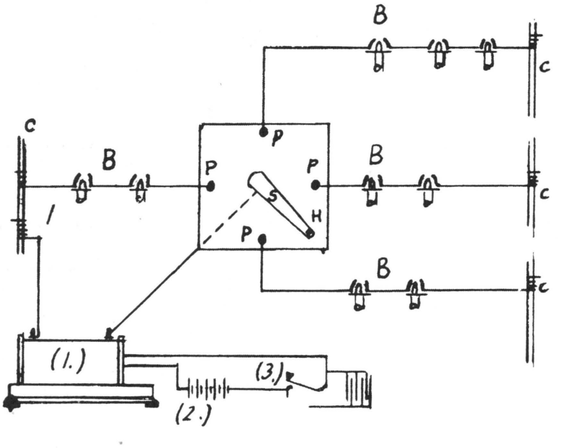
48. Gas burner igniter



49. Full ignition system spark gap



50. Full ignition system schematic



	Candlepower-hours
Wax candle	33
Stearine candle	77
Incandescent electric lamp	440
Coal gas in slit burner	625
Acetylene and air slit burner	716
Oil gas	1660
Water gas and benzine	1666
Large petroleum lamp	2250
Welsbach burner with coal gas	2300
Electric arc light	2322
Welsbach burner with water gas	4350

Tables

1. Comparative Candlepower of Fuels

COMPARATIVE STATEMENT of the Illuminating Power, and Expense per Annum, of Gas, Candles, and Spermaceti Oil.

Description of Burners.	Gas Light.		Equal to		Consumption for One Year, from Sunset till Eleven o'Clock.				Annual Expense of Light from Sunset till Eleven o'Clock.			
	Height of Flame.	Consumption per hour.	Tallow or Wax Candles 6 to the lb.	Argand Oil Lamps.	Gas.	Tallow Candles.	Wax Candles.	Sperm Oil.	Gas, at 9*s*. per 1000.	Tallow Candles, at 8*d*. per lb.	Wax Candles, at 2*s*. 6*d*. per lb.	Sperm Oil at 9*s*. per gallon.
	In.	Feet.	No.	No.	Feet.	lbs.	lbs.	Gals.	£. *s*. *d*.	£. *s*. *d*.	£. *s*. *d*.	£. *s*. *d*.
Single jet	2	½	1	..	920	40	29	..	0 8 3½	1 6 8	3 12 6	..
Ditto	4	8/10	2	..	1,640	80	58	..	0 14 9	2 13 4	7 5 0	..
Two jets, flames conjoining.	5	2	4	1	3,650	160	116	17½	1 12 10	5 6 8	14 10 0	7 17 6
Three jets	4	3	4	1	5,480	160	116	17½	2 9 4	5 6 8	14 10 0	7 17 6
Twelve-hole argand. . .	3	3½	5	1¼	5,940	200	145	30½	2 13 6¼	6 13 4	18 2 6	13 14 6
Ditto	3½	3½	7	1½	6,400	280	203	31½	2 17 7	9 6 8	25 5 6	14 3 6
Fifteen-hole argand. . .	3	5	12	2	9,130	480	348	35	4 2 2	16 0 0	43 10 0	15 15 0

The above Table is calculated on the supposition that the Gas, the Candles, &c., are burnt in exactly similar circumstances; where the positions are varied, the expense will in like manner differ from what is here given, much of the economy of Gas light depending on a judicious arrangement of the burners, and the proper height of the flame.

The consumption being given in the above Table for one year (of 365 days) of Gas per burners, as therein specified, also of Tallow Candles, Wax Candles, and Sperm Oil; the comparison can be carried out at any other cost of the materials named.

2. Comparative Statement of the Illuminating Power and Expenses per Annum of Gas, Candles, and Spermaceti Oil (1841)

	Quantity consumed per hour	The candle power	O removed cubit feet	Or produced cubit feet	Moisture produced cubit feet	Heat produced calories	Vitiation equal to adult persons
Tallow candles . .	2200 grains	16.	10.7	7.3	8.2	1400	12.0
Sperm candles. . .	1740 "	16.	9.6	6.5	6.5	1137	11.0
Paraffin oil. . . .	992 "	16.	6.2	4.5	3.5	1030	7.5
Kerosene oil . . .	909 "	16.	5.9	4.1	3.3	1030	7.0
Coal gas (argand). .	4.8 cubit ft.	16.	5.8	2.6	6.4	1240	4.3
Coal gas (Welsbach).	3.5 " "	50.	4.1	1.8	4.7	763	3.0

3. Comparison of Fuels

Notes

Full bibliographical citations can be found in the bibliography.

CHAPTER 1

From the Beginnings to 1660

1. *Encyclopaedia Britannica,* 9th ed., 23:226.
2. Styan, *Shakespeare's Stagecraft,* pp. 42–43.
3. Lawrence, *Pre-Restoration Stage Studies,* p. 129.
4. *Oxford Companion,* "Lighting, Stage," p. 559.
5. Ibid.
6. Ibid., p. 560.
7. Lawrence, *Pre-Restoration Stage Studies,* p. 132.
8. Hewitt, *Renaissance Stage,* p. 18.
9. Nicoll, *Development of the Theatre,* p. 231.
10. *Oxford Companion,* "Ingegneri, Angelo," p. 470.
11. Hewitt, *Renaissance Stage,* p. 37.
12. Ibid., p. 178.
13. Ibid., pp. 18–19.
14. Ibid., p. 34.
15. Nicoll, *Stuart Masques,* p. 129.
16. Hewitt, *Renaissance Stage,* p. 34.
17. Ibid.
18. Ibid., pp. 33–34.
19. Ibid., pp. 28–29.
20. Nicoll, *Development of the Theatre,* p. 231.
21. Ibid., p. 252.
22. Ibid.
23. Ibid., p. 253.
24. Ibid.
25. Ibid.

26. Nicoll, *Stuart Masques,* p. 133.
27. Ibid., p. 134.
28. Ibid.
29. Hewitt, *Renaissance Stage,* p. 37.
30. Ibid., pp. 41–42.
31. Ibid., pp. 94–95.
32. Ibid., pp. 95–96.
33. Ibid., p. 45.
34. Ibid.
35. Ibid., pp. 111–12.
36. Ibid., p. 182.
37. Ibid., p. 192.
38. Ibid., pp. 211–12.
39. Ibid., p. 215.
40. Ibid.
41. Ibid., p. 216.
42. Ibid., p. 206.
43. Ibid., pp. 234–38.
44. Nicoll, *Stuart Masques,* p. 135.
45. Ibid., p. 136.
46. Ibid., pp. 136–37.
47. Mullin, *Development of the Playhouse,* pp. 39–40.

CHAPTER 2
From the Restoration to 1800

1. Hazlitt, *English Drama and Stage,* p. 281.
2. Joseph, *Playhouse in England,* p. 78.
3. Oxford Companion, p. 561.
4. Ibid.
5. Odell, *Shakespeare,* 1:280–81.
6. Avery and Scouten, *London Stage,* p. xxxvi.
7. Boswell, *Restoration Court Stage,* p. 159.
8. Ibid.
9. Ibid., pp. 159–61.
10. Ibid.
11. Ibid., p. 61.
12. Ibid., pp. 161–62.
13. Odell, *Shakespeare,* 1:139.
14. Ibid., p. 281.
15. *Oxford Companion,* p. 562.

16. Mullin, *Development of the Playhouse,* pp. 29–30.
17. Ibid., p. 100.
18. Stone, *London Stage,* p. xxxviii.
19. *Encyclopaedia Britannica,* 9th ed., 23:226.
20. Lawrence, *Old Theatre Days and Ways,* p. 130.
21. Ibid., p. 131.
22. Ibid., p. 135.
23. *Oxford Companion,* p. 561.
24. Hogan, *London Stage,* p. lxv.
25. Hedgcock, *Garrick,* p. 390.
26. Hogan, *London Stage,* pp. lxv–lxvi.
27. *Oxford Companion,* p. 561.
28. Hedgcock, *Garrick,* p. 391.
29. *Encyclopaedia Britannica,* 14th ed., 14:364.
30. Dobson, *Prior Park,* p. 278.
31. Ibid., p. 112.
32. Britton, Autobiography, 1:97–101.
33. Thwing, *Flickering Flames,* p. 71.
34. Ibid., p. 73.
35. Saunders, *Treatise on Theatres,* pp. 38–39.

CHAPTER 3
The Early Uses of Gas

1. Norman, *Gas Industry,* p. 12.
2. Ibid.
3. Ibid.
4. *The Builder,* 37 (April 5, 1879): 359.
5. Ibid.
6. Ibid.
7. William Matthews, *Gas Lighting,* p. 12.
8. *The Builder,* 37 (April 5, 1879): 359.
9. Norman, *Gas Industry,* p. 22.
10. Ibid.
11. *Engineering Magazine,* 6:1 (October, 1893): 223–26.
12. Ibid.
13. Norman, *Gas Industry,* p. 22.
14. Ibid., p. 23.
15. William Matthews, *Gas Lighting,* p. 23.
16. *The Builder,* 37 (April 5, 1879): 359.
17. Ibid., pp. 359–60.

18. Ibid.
19. Norman, *Gas Industry,* p. 30.
20. *The Builder,* 37 (April 5, 1879): 360.
21. *London Times,* July 2, 1804, p. 2.
22. Ibid., p. 10.
23. *The Builder,* 37 (April 5, 1879): 360.
24. Ibid.
25. Ibid.
26. Ibid.
27. Norman, *Gas Industry,* p. 33.

CHAPTER 4
Gas Takes the Stage

1. *Oxford Companion,* p. 564.
2. *London Times,* September 11, 1815, p. 3.
3. *Oxford Companion,* p. 564.
4. Nicoll, *Early Nineteenth Century Drama,* 1:220.
5. *London Times,* August 6, 1816, p. 2.
6. Ibid., September 4, 1817, p. 2.
7. Ibid., September 5, 1817, p. 2.
8. Mander and Mitchenson, *Lost Theatres,* p. 55.
9. *European Magazine and London Review,* 72 (September, 1817): 257.
10. Odell, *Shakespeare,* 2:157.
11. *European Magazine,* 72 (September, 1817): 259.
12. *London Times,* September 8, 1817, p. 2.
13. *European Magazine,* 72 (September, 1817): 260.
14. *The Examiner,* no. 506 (September 7, 1817): 570.
15. *European Magazine,* 73 (March, 1818): 252.
16. *Oxford Companion,* pp. 563–64.
17. Ibid.
18. *London Times,* September 9, 1817, p. 2.
19. *Oxford Companion,* pp. 563–64.
20. Ibid.
21. Maqueen-Pope, *Drury Lane,* p. 251.
22. *Theatrical Inquisitor,* January, 1818, p. 47.
23. *London Times,* August 1, 1821, p. 2.
24. *Theatrical Inquisitor,* January, 1818, p. 47.
25. *European Magazine,* 73 (March, 1818): 256.
26. Mander and Mitchenson, *Lost Theatres,* p. 16.

27. *Oxford Companion,* p. 564.
28. Coulton, *Theatres of London,* p. 227.
29. *The Builder,* 37 (April 5, 1879): 361.
30. *Oxford Companion,* p. 564.
31. Mander and Mitchenson, *Lost Theatres,* p. 239.
32. *Oxford Companion,* p. 564.
33. Ibid.
34. *London Times,* November 19, 1828, p. 2.
35. Ibid., November 6, 1828, p. 2.
36. Scott, *Drama of Yesterday and Today,* p. 90.
37. Mander and Mitchenson, *Lost Theatres,* p. 56.
38. Scott, *Drama of Yesterday and Today,* p. 90.
39. D'Allemagne, *Histoire du luminaire,* p. 582.
40. Pougin, *Dictionnaire du théâtre,* p. 319.
41. D'Allemagne, *Histoire du luminaire,* p. 582.
42. Moynet, *Trucs et décors,* p. 190.
43. *Theatre Survey,* vol. 13, no. 1 (May, 1972): 21.
44. Pougin, *Dictionnaire du théâtre,* p. 319.

CHAPTER 5
Gaslighting on the American Stage

1. *Theatre Research,* 12:1 (1972): 81.
2. Norman, *Gas Industry,* p. 42.
3. *Theatre Research,* 12:1 (1972): 81.
4. Norman, *Gas Industry,* p. 44.
5. Ibid.
6. James, *Old Drury,* p. viii.
7. *Theatre Research,* 12:1 (1972):84.
8. James, *Old Drury,* p. 26.
9. Ibid., p. 27.
10. Ibid.
11. *Theatre Design and Technology,* no. 17 (May, 1969): 4.
12. Stotz, *Gas Industry,* p. 16.
13. Brown, *Gaslight Company of Baltimore,* pp. 22–23.
14. Norman, *Gas Industry,* p. 47.
15. Clapp, *Boston Stage,* p. 145.
16. Kendall, *New Orleans Theatre,* p. 30.
17. *Theatre Design and Technology,* no. 17 (May, 1969): 4.
18. Odell, *Annals,* 3:256.
19. Ibid., p. 167.

20. Ibid., p. 218.
21. Mullin, *Development of the Playhouse,* p. 125.
22. Odell, *Annals,* 3:256.
23. Ibid., p. 257.
24. Ibid., p. 307.
25. *Theatre Design and Technology,* no. 17 (May, 1969): 4.
26. Norman, *Gas Industry,* pp. 50–51.
27. McVicker, *Early Days in Chicago,* p. 69.
28. *Theatrical Times,* no. 28 (December 8, 1846): 24.
29. Gerhard, *Gas Piping and Gas Lighting,* p. 265.
30. *Theatre Design and Technology,* no. 17 (May, 1969): 4.
31. Schoberlin, *Candles to Footlights,* p. 224–25.

CHAPTER 6
The Impact of Gas on the Theatre

1. Mullin, *Development of the Playhouse,* p. 134.
2. "The Use of Gas in Theatres," *The Mask,* 10 (1924): 163–65.
3. *The Electrician,* 9 (October 21, 1882): 529.
4. Mullin, *Development of the Playhouse,* p. 134.
5. Joseph, *Playhouse in England,* p. 98.
6. Nicoll, *History of English Drama,* 4:35.
7. Ibid.
8. *Illustrated London News,* 29 (July 19, 1856): 67.
9. *Encyclopaedia Britannica,* 9th ed., 7:480.
10. *New Monthly Magazine,* August 1, 1826, p. 329.
11. Ibid., October 1, 1826, p. 424.
12. Rodwell, *Dictionary of Science,* p. 333.
13. *Notes and Queries,* 7th series, vol. 8 (September 21, 1889): 226.
14. Ibid.
15. *London Times,* October 13, 1847, p. 3.
16. *Notes and Queries,* 7th series, vol. 8 (September 21, 1889): 226.
17. Fitzgerald, *World behind the Scenes,* p. 48.
18. Stoker, *"Irving and Stage Lighting,"* p. 903.
19. Fitzgerald, *World behind the Scenes,* p. 15.
20. Ibid., p. 16.
21. Ibid., p. 18.

22. Stoker, *"Irving and Stage Lighting,"* p. 903.
23. *American Architect and Building News,* 6:191 (August 23, 1879): 59.
24. Stoker, *"Irving and Stage Lighting,"* pp. 910–11.
25. Ibid., p. 911.
26. *Quarterly Review,* 155 (April, 1883): 382.
27. Ibid.
28. Ibid.
29. *Oxford Companion,* p. 566.
30. Tweedie, *Footlights,* p. 223.
31. *The Builder,* 5:227 (June 12, 1847): 281.
32. Ibid.
33. Ibid.
34. *The Builder,* 9:438 (June 28, 1851): 406.
35. Ibid., May 4, 1872, p. 342.
36. *Oxford Companion,* p. 312.
37. Odell, *Annals,* 9:282.
38. *Oxford Companion,* p. 567.
39. *The Builder,* 5:222 (May 8, 1847): 216.
40. Ibid., August 3, 1861.
41. Ibid.
42. Ibid., October 18, 1862, p. 745.
43. *All the Year Round,* 10:235 (October, 1863): 232.
44. *The Builder,* 24:1238 (October 27, 1866): 800.

CHAPTER 7
Gas — The Final Phase

1. Pougin, *Dictionnaire du théâtre,* p. 558.
2. Fitzgerald, *World behind the Scenes,* p. 18.
3. *Illustrated London News,* October 28, 1871, p. 407.
4. Fitzgerald, *World behind the Scenes,* p. 22.
5. *Illustrated London News,* October 28, 1871, p. 407.
6. Ibid.
7. Sachs, *Opera Houses and Theatres,* 3:5–6.
8. Fitzgerald, *World behind the Scenes,* p. 49.
9. *Oxford Companion,* p. 567.
10. *Theatre Design and Technology,* no. 27 (December, 1971): 25.
11. *Oxford Companion,* p. 567.

12. *Notes and Queries,* 9th series, vol. 8 (October 5, 1901): 294.
13. *Scientific American Supplement,* 6:154 (December 14, 1878): 2452.
14. *Oxford Companion,* p. 567.
15. *Notes and Queries,* 8th series, vol. 8 (October 5, 1901): 288.
16. *Oxford Companion,* p. 567.
17. Ibid.
18. *The Electrician,* 8 (December 31, 1881): 98.
19. Mander and Mitchenson, *Lost Theatres,* p. 176.
20. *Oxford Companion,* p. 567.
21. *The Builder,* 42 (January 7, 1882): 10.
22. *Scientific American Supplement,* 15:389 (June 16, 1883): 6207.
23. *Oxford Companion,* p. 567.
24. Sachs, *Opera Houses and Theatres,* 3:157.
25. *The Electrician,* 20 (January 13, 1888): 228.

APPENDIX I
The Production & Delivery of Gas

1. Norman, *Gas Industry,* p. 66.
2. William Matthews, *Gas Lighting,* p. 24.
3. Ibid., p. 75.
4. Gerhard, *Gas Piping and Gas Lighting,* p. 240.
5. Ibid.
6. Ibid.
7. Norman, *Gas Industry,* p. 79.
8. Ibid.
9. *Theatre Research,* 12:1 (1972): 78.
10. Ibid., p. 81.
11. Ibid., p. 82.
12. Ibid., pp. 83–84.
13. Ibid., pp. 85–86.
14. Norman, *Gas Industry,* p. 81.
15. Peckston, *Gas Lighting,* pp. 336–37.
16. Ibid., pp. 338–39.
17. Gerhard, *Gas Piping and Gas Lighting,* p. 24.
18. Norman, *Gas Industry,* pp. 82–83.

19. Hughes and O'Connor, *Gas and Gasworks,* pp. 318–32.
20. Ibid., p. 321.
21. Ibid., p. 331.
22. Ibid., pp. 332–33.
23. Sachs, *Opera Houses and Theatres,* 3:144.
24. Ibid., 3:147.
25. *London Times,* July 27, 1848, p. 5.
26. Sachs, *Opera Houses and Theatres,* 3:148.
27. Buckle, *Theatre Construction and Maintenance,* p. 73.
28. Garnier, *Nouvel Opéra,* 2:134.
29. Buckle, *Theatre Construction and Maintenance,* p. 118.
30. *American Architect and Building News,* 37:867 (August 6, 1892), p. 86.
31. Ibid., p. 118.
32. Garnier, *Nouvel Opéra,* p. 141.
33. Sachs, *Opera Houses and Theatres,* 3:147.
34. Ibid., 3:154.
35. Ibid., 3:158.
36. Ibid., 3:148.
37. Contant and Filippi, *Théâtres modernes,* p. 150.
38. Sachs, *Opera Houses and Theatres,* 3:154.
39. Buckle, *Theatre Construction and Maintenance,* p. 77.
40. Gerhard, *Gas Piping and Gas Lighting,* p. 111.
41. Ibid.
42. Ibid., p. 113.
43. Ibid.
44. Ibid.
45. *Encyclopaedia Britannica,* 9th ed., 10:99.
46. Stoker, "*Irving and Stage Lighting,*" p. 905.
47. Gerhard, *Gas Piping and Gas Lighting,* p. 114.
48. Ibid.
49. Ibid., pp. 114–15.
50. Ibid., p. 118.
51. Ibid., pp. 118–19.
52. Gagey, *San Francisco Stage,* p. 105.
53. Gerhard, *Gas Piping and Gas Lighting,* p. 120.
54. Ibid., p. 121.
55. Ibid.
56. Norman, *Gas Industry,* p. 171.
57. Ibid., p. 54.
58. Pond, *Calcium Carbide and Acetylene,* p. 10.
59. Gerhard, *Gas Piping and Gas Lighting,* p. 123.

APPENDIX II
Gaslighting Instruments

1. Gosset, *Construction des théâtres,* p. 94.
2. *The Builder,* 27:1377 (June 26, 1869): 509.
3. Ibid., 28:1420 (April 23, 1870): 319.
4. Fitzgerald, *World behind the Scenes,* p. 18.
5. Contant and Filippi, *Théâtres modernes,* plate 15.
6. Sachs, *Opera Houses and Theatres,* 3:148.
7. Ibid., p. 147.
8. Birkmire, *Planning and Construction,* p. 116.
9. Stoker, *"Irving and Stage Lighting,"* p. 905.
10. Garnier, *Nouvel Opéra,* p. 139.
11. Stoker, *"Irving and Stage Lighting,"* p. 909.
12. Sachs, *Opera Houses and Theatres,* 3:154.
13. Gosset, *Construction des Théâtres,* p. 96.
14. Ibid.
15. Contant and Filippi, *Théâtres modernes,* plate 16.
16. Stoker, *"Irving and Stage Lighting,"* p. 905.
17. Sachs, *Opera Houses and Theatres,* 3:154.
18. Ibid., 3:144–61.
19. Stoker, *"Irving and Stage Lighting,"* p. 905.
20. Contant and Filippi, *Théâtres modernes,* plate 15.
21. Hartman, *Theatre Lighting,* pp. 8–9.
22. Stoker, *"Irving and Stage Lighting,"* p. 906.
23. *Scientific American,* 48:8 (February 24, 1883), p. 118.
24. Buckle, *Theatre Construction and Maintenance,* p. 38.
25. *American Architect and Building News,* 2:62 (March 3, 1877): 72.
26. Mander and Mitchenson, *Lost Theatres,* p. 263.
27. Ibid., p. 55.
28. *European Magazine and London Review,* 73 (March, 1818): 252.
29. *Theatrical Times,* no. 15 (September 19, 1846): 120.
30. *New York Times,* December 4, 1881, p. 9.
31. *London Times,* November 23, 1825, p. 2.
32. Fitzgerald, *World behind the Scenes,* pp. 21–22.
33. Sachs, *Opera Houses and Theatres,* 3:144.
34. Ibid.
35. Ibid., 3:147.
36. Ibid., 3:148.
37. Ibid., 3:153.
38. Ibid., 3:15.

39. Buckle, *Theatre Construction and Maintenance,* pp. 118–19.
40. Ibid., p. 121.
41. *Theatre Design and Technology,* May, 1969, p. 4.
42. Skinner, *Footlights and Spotlights,* p. 59.
43. Fitzgerald, *World behind the Scenes,* p. 34.
44. Odell, *Annals,* 6:518–19.
45. *Scientific American Supplement,* 18:467 (December 13, 1884): 7452.
46. *Scientific American,* 49 (July 30, 1892): 78.
47. Ibid., 45:26 (July 16, 1881): 206.
48. *Theatre Design and Technology,* December, 1971, pp. 24–27.
49. Sachs, *Opera Houses and Theatres,* 3:144.
50. Ibid., 3:147.
51. Buckle, *Theatre Construction and Maintenance,* p. 119.
52. Ibid., p. 74.

Bibliography

All the Year Round, 10:235 (October 31, 1863), p. 232.

American Architect and Building News, 2:62 (March 3, 1877), p. 72; 6:191 (August 23, 1879), p. 59, 75, 77; 22:617 (October 22, 1887), pp. 194–96; 37:867 (August 6, 1892), pp. 86–88.

Antoine, André (H. D. Albright, ed.). *Memories of the Théâtre Libre.* Miami, Fla.: University of Miami Press, 1964; p. 152.

Avery, Emmett L., and Scouten, Arthur H. *The London Stage 1660–1700: A Critical Introduction.* Carbondale and Edwardsville: Southern Illinois University Press, 1968.

Bailey, Lydia R. *Philadelphia Councils Committee on Lighting the City with Gas.* Philadelphia: 1833; pp. 36, 38–39.

Baker, H. Barton. *A History of the London Stage.* London: Routledge & Sons, Ltd., 1904; p. 276.

Birkmire, William Harvey. *The Planning and Construction of American Theatres.* New York: John Wiley & Sons, 1901.

Boswell, Eleanore. *The Restoration Court Stage.* New York: Barnes & Noble, 1966; pp. 14–15, 42–43, 46–47, 94–95, 154–55, 158–63, 208–9, 212–15.

Britton, John. *The Autobiography of John Britton.* 2 vols. London: Printed for the Author as presents to subscribers to "The Britton Testimonial," 1850; 1:97–101.

Brown, George T. *The Gaslight Company of Baltimore.* Baltimore: The Johns Hopkins Press, 1936; pp. 22–23.

Buckle, James George. *Theatre Construction and Maintenance.* London: The Stage Office, 1888.

Builder, The, 5:222 (May 8, 1847), pp. 216–17; 5:227 (June 12, 1847), p. 281; 9:438 (June 28, 1851), p. 406; 19:965 (August 3, 1861), pp. 521–22; 20:1028 (October 18, 1862), p. 745; 20:1036 (December 13, 1862), pp. 888–89; 24:1238 (October 27, 1866), p. 800;

27:1377 (June 26, 1869), p. 509; 28:1420 (April 23, 1870), p. 319; 30:1526 (May 4, 1872), p. 342; 37:1887 (April 5, 1879), pp. 359–61; 42:2031 (January 7, 1882), p. 10.

Cavos, Albert. *Traité de la construction des théâtres.* Paris: L. Mathias, 1847; pp. 72–75.

Chamber's Encyclopedia, USA. J. B. Lippincott Co., 1892. "Limelight," 6:635–36; "Theatre," 10:156–57.

Chicago Tribune, December 28, 1850, p. 3.

Clapp, William W. *A Record of the Boston Stage.* Boston and Cambridge: James Munroe & Co., 1853; p. 145.

Clunes, Alec. *The British Theatre.* New York: A. S. Barnes & Co., 1964; p. 78.

Contant, Clement, and De Filippi, Joseph. *Paralèlle des principaux théâtres modernes de l'Europe.* New York: Benjamin Blom, Inc., 1968 (first published 1860); plates 11, 15, 16, 37; text, pp. 144–45, 150.

Coulton, W. C. *A History of the Theatres of London.* London: 1817; pp. 227–29.

Cyclopedia of Painters & Painting (John Champlin, Jr., ed.). New York: Charles Scribner's Sons, 1887; "Loutherbourg, Philippe Jacques," p. 106.

D'Allemagne, Henri Réné. *Histoire du luminaire.* Paris: Alphonse-Picard, 1891; pp. 522–23, 582.

Dimmick, Ruth Crosby. *Our Theatres — Today and Yesterday.* New York: H. K. Fly & Co., 1913; pp. 22–23, 27–28.

Dobbs, Brian. *Drury Lane.* London: Cassell & Co., 1972; p. 136.

Dobson, Austin. *At Prior Park and Other Papers.* London: Chatto & Windus, 1912; pp. 112, 278.

Electrical World, July 30, 1892, p. 78.

Electrician, The, 8 (December 31, 1881): 98; 9 (October 21, 1882): 529; 20 (January 13, 1888): 228.

Encyclopaedia Britannica. New York: Encyclopaedia Britannica, Inc., 9th ed., 4:802–4; 7:480; 10:98–99; 23:226; 14th ed., 14:364.

Encyclopedia Americana. New York: 1947, 5:161.

Engineering Magazine, 6:1 (October, 1893), pp. 223–28.

European Magazine and London Review, The, 72 (August, 1817): 155;72 (September, 1817): 257, 260, 262; 73 (March, 1818): 252, 256.

Examiner, The, no. 506, September 7, 1817, p. 570.

Fitzgerald, Percy. *A New History of the English Stage.* Lon-

don: Tinsley Brothers, 1882; pp. 234, 386, 424.
———. *The World behind the Scenes.* London: Chatto & Windus, 1881; pp. 12–23, 30–35, 40–41, 48–49, 78.
Freedly, George, and Reeves, John A. *A History of the Theatre.* New York: Crown Publishers, 1968; not paginated.
Gagey, Edmond M. *The San Francisco Stage.* New York: Columbia University Press, 1950; pp. 37–39, 148–49, 105, 109.
Gamble, William Burt, ed. *The Development of Scenic Art and Stage Machinery* (list of references in the New York Public Library). New York: The New York Public Library, 1928.
Garnier, M. Charles. *Le Nouvel Opéra de Paris.* Paris: Ducher et Cie., 1881; vol. 2.
Gerhard, William Paul. *The American Practice of Gas Piping and Gas Lighting in Buildings.* New York: McGraw Publishing Co., 1908.
———. *The Safety of Theatre Audiences and Stage Personnel.* New York: W. P. Gerhard, 1899.
Gosset, Alphonse. *Traité de la construction des théâtres.* Paris: Baudry et Cie., 1886; pp. 92–97.
Harper's Weekly, 34:1737 (April 15, 1890), pp. 269–72; 33:1693 (June 1, 1889), pp. 430–31.
Hartman, Louis. *Theatre Lighting.* New York: D. Appleton & Co., 1930; pp. 7–9.
Hazlitt, W. C., ed. *The English Drama and Stage.* London: The Roxburghe Library, 1869; p. 281.
Hedgcock, Frank A. *David Garrick and His French Friends.* London: Stanley Paul & Co., 1912; pp. 390–91.
Hewitt, Barnard. *The Renaissance Stage.* Miami, Fla.: University of Miami Press, 1958.
Hogan, Charles Beecher. *The London Stage, 1776–1800: A Critical Introduction.* Carbondale and Edwardsville: Southern Illinois University Press, 1968.
Hughes, Samuel, and O'Connor, Henry. *Gas and Gasworks.* London: Crosby Lockwood & Sons, 1904; pp. 318–33.
Illustrated London News, 29 (July 19, 1856), p. 67; 43 (November 7, 1863), p. 475; 59 (October 28, 1871), p. 408.
James, Reese D. *Old Drury of Philadelphia: A History of the Philadelphia Stage, 1800–1835.* Philadelphia: University of Pennsylvania Press; 1932, pp. 25–27, 209.

Joseph, Stephen. *The Story of the Playhouse in England.* London: Barne & Rockliff, 1963; pp. 78–79, 96–99, 110–13.
Kendall, John S. *The Golden Age of the New Orleans Theatre.* Baton Rouge: Louisiana State University Press, 1952; p. 30.
Lawrence, W. J. *Old Theatre Days and Ways.* London: George G. Harrap & Co., 1935; pp. 130–36.
———. *Pre-Restoration Stage Studies.* London: Oxford University Press, 1927; pp. 129, 132.
Living Age, 318 (1923), pp. 520–21.
London Times, July 2, 1804, p. 2; September 2, 1815, p. 3; September 11, 1815, p. 3; August 6, 1816, p. 2; September 4, 1817, p. 2; September 5, 1817, p. 2; September 8, 1817, p. 2; September 9, 1817, p. 2; August 1, 1821, p. 2; November 23, 1825, p. 2; November 6, 1828, p. 2; November 19, 1828, p. 2; October 13, 1847, p. 3; July 27, 1848, p. 5.
Ludlow, Noah Miller. *Dramatic Life as I Found It.* Saint Louis: 1880; pp. 249–50.
Mackaye, Percy. *Epoch: The Life of Steele Mackaye.* New York: Boni & Liveright, 1927; pp. 232–33.
McMinn, George R. *The Theatre of the Golden Era in California.* Caldwell, Idaho: Caxton Printers, 1941, p. 54.
McVicker, J. H. *The Theatre: Its Early Days in Chicago.* Chicago: Knight and Leonard Printers, 1884.
Mander, Raymond, and Mitchenson, Joe. *The Lost Theatres of London.* New York: Taplinger Publishing Co., 1968.
———. *The Theatres of London.* London: Rupert Hart-Davis, 1961.
Maqueen-Pope, W. *Haymarket: Theatre of Perfection.* London: W. H. Allen, 1948; pp. 232–33.
———. *Theatre Royal Drury Lane.* London: W. H. Allen, 1945; p. 251.
Matthews, J. Brander. *The Theatres of Paris.* London: Law, Marston, Searle & Rivington, 1880; p. 46.
Matthews, William. *A Historical Sketch of the Origin, Progress & Present State of Gas Lighting.* London: Rowland Hunter, 1827.
Moussinac, Leon. *Le Théâtre: Des origins à nos jours.* Paris: Amiot-Dumont, 1957; pp. 133, 261.
Moynet, Georges. *Trucs et décors.* Paris: La Librairie Illustrée, 1893; pp. 137, 190, 237–41.

Moynet, M. J. *L'Envers du théâtre.* Paris: Librairie Hachette et Cie., 1874; pp. 103–11.
Mullin, Donald C. *The Development of the Playhouse.* Berkeley and Los Angeles: University of California Press, 1970; pp. 29–30, 39–40, 100, 125, 134.
La Nature, 37, no. 1879 (May 29, 1909), pp. 411–14.
New Monthly Magazine, August 1, 1826, p. 329.
New York Times, May 19, 1872, p. 4; December 4, 1881, p. 9; March 16, 1889, p. 8; December 5, 1890, p. 3.
Nicholson, William. *The British Encyclopedia,* vol. 4, "The Lamp."
Nicoll, Allardyce. *The Development of the Theatre.* New York: Harcourt, Brace, & Co., 1937; pp. 231, 251–52.
———. *A History of Early Nineteenth Century Drama, 1800–1850.* Cambridge (England): The University Press, 1930; 1:220.
———. *A History of English Drama, 1660–1900,* Cambridge: Cambridge University Press, 1955, 4:34–37.
———. *Stuart Masques and the Renaissance Stage.* New York: George G. Harrap & Co., 1937; pp. 129, 137.
Norman, O. E. *The Romance of the Gas Industry.* Chicago: A. C. McClung, & Co., 1922.
Notes and Queries, 7th series, vol. 8 (September 21, 1889), p. 226; 8th series, vol. 8 (October 12, 1895), p. 288; 9th series, vol. 8 (October 5, 1901), p. 294; 11th series, vol. 7 (June 14, 1913), p. 469, (July 5, 1913), pp. 10–11, (August 2, 1913), p. 96, (August 23, 1913), pp. 153–54.
Odell, George C. D. *Annals of the New York Stage.* New York: Columbia University Press, 1928; 3:4–5, 161, 167, 256, 257; 6:518–19; 9:282.
———. *Shakespeare from Betterton to Irving.* New York: Scribners, 1920, 1:139, 280–81; 2:156–57, 233.
Oxford Companion to the Theatre (Phyllis Hartnoll, ed.). 3rd edition. London: Oxford University Press, 1967; "Lighting, Stage."
Peckston, Thomas S. *A Practical Treatise on Gas Lighting.* London: Cheapside, Herbert, 1841; pp. 34–37, 334–39, plate 18.
Pilkington, Matthew. *A General Dictionary of Painters.* London: William Tegg & Co., 1897.
Pond, George Gilbert. "Calcium Carbide and Acetylene." *Pennsylvania State College Bulletin,* Department of Chemistry, pp. 8–13, 30–31.

Pougin, Arthur. *Dictionnaire du théâtre.* Paris: Firmin-Didot et Cie., 1885; pp. 318–21, 602–3.
Quarterly Review, 155 (April, 1883), pp. 374, 382.
Rodwell, G. F., ed. *A Dictionary of Science.* London: E. Moxon, Son, & Co., 1871; p. 333.
Rosenthal, Jean, and Wertenbaker, Lael. *The Magic of Light.* Boston: Little, Brown, & Co., 1972; pp. 43–56.
Sachs, Edwin O. *Modern Opera Houses and Theatres.* New York: Benjamin Blom, Inc.; reissued 1968.
Saunders, George. *A Treatise on Theatres.* London: privately printed for the author, 1790.
Schoberlin, Melvin. *From Candles to Footlights.* Denver: Old West Publishing Company, 1941; pp. 24, 225.
Scientific American, 5:1 (July 6, 1861), p. 101; 15:19 (November 3, 1866), p. 297; 44:13 (March 25, 1881), p. 199; 45:226 (July 16, 1881), p. 206; 48:8 (February 24, 1883), p. 118.
Scientific American Supplement, 6:154 (December 14, 1878), p. 2452; 15:389 (June 16, 1883), p. 6207; 18:467 (December 13, 1884), p. 7452.
Scott, Clement. *The Drama of Yesterday and Today.* London: Macmillan & Co., 1899, 1:90–91.
Scribner's Magazine, vols. 3–4 (October, 1888), pp. 450–51.
Skinner, Otis. *Footlights and Spotlights.* Indianapolis: The Bobbs Merrill Co., 1924; p. 59.
Southern, Richard. *The Victorian Theatre: A Pictorial Survey.* Devon: David & Charles, 1970.
Stoker, Bram. *"Irving and Stage Lighting." Nineteenth Century and After,* 69:411 (May, 1911): 903–12.
Stone, George Winchester, Jr. *The London Stage, 1747–1776: A Critical Introduction.* Carbondale and Edwardsville: Southern Illinois University Press, 1968.
Stotz, Louis. *History of the Gas Industry.* New York: Stettiner Bros., 1938; pp. 16, 31.
Styan, J. L. *Shakespeare's Stagecraft.* Cambridge: Cambridge University Press, 1967.
Theatre (July, 1918): 36.
Theatre Design and Technology, no. 17 (May, 1969), pp. 4–7; no. 27 (December, 1971), pp. 24–27.
Theatre Research, 12:1 (1972), pp. 74–87.
Theatre Survey, 13:1 (May, 1972).
Theatrical Inquisitor and Monthly Mirror (September, 1817), p. 224; (January, 1818), p. 47.

Theatrical Times, no. 15 (September 19, 1846): 120; no. 28 (December 9, 1846): 24.
Thwing, Leroy. *Flickering Flames.* Rutland, Vermont: Charles E. Tuttle Co., 1958.
Trélat, Emile. *Le Théâtre et l'architecte.* Paris: A. Morel et Cie., 1860; pp. 72–77.
Tweedie, Mrs. Alec. *Behind the Footlights.* New York: Dodd Mead & Co., 1904; p. 223.
"Use of Gas in Theatres," *The Mask,* 10 (1924), pp. 163–65.

Illustration and Table Sources

ILLUSTRATION SOURCES:

1. Title page, Thomas Kyd, *The Spanish Tragedy,* London, 1623. Courtesy of The Chapin Library, Williams College.
2. Allardyce Nicoll, *Stuart Masques and the Renaissance Stage* (New York: George G. Harrap & Co., 1937), p. 134.
3. Nicola Sabbattini, *Manual for Constructing Theatrical Scenes and Machines,* Book One, Ravenna, 1638. Barnard Hewitt, ed., *The Renaissance Stage* (Miami, Fla.: University of Miami Press, 1958), p. 94.
4. Sabbattini, *Manual,* Book One. Hewitt, p. 94.
5. Sabbattini, *Manual,* Book Two. Hewitt, p. 112.
6. The Harvard Theatre Collection.
7. Francis Kirkman, *The Wits; or Sport Upon Sport,* 1672. Courtesy of The British Library.
8. Frank A. Hedgcock, *David Garrick and His French Friends* (London: Stanley Paul & Co., 1912), p. 119. Courtesy of Hutchinson Publishing Group Limited.
9. The Harvard Theatre Collection.
10. Heinrich A. O. Reichard, *Theater-kalender Gotha,* 1794. Leon Moussinac, *Le Théâtre: Des origines à nos jours* (Paris: Amiot-Dumont, 1957), p. 261.
11. Nicholas Rowe, *The Works of Mr. William Shakespeare; in Six Volumes,* London, 1709. Courtesy of The Beinecke Rare Book and Manuscript Library, Yale University.
12. Archives Department, Westminster City Libraries, London.
13. *Scribner's Magazine,* vols. 3–4 (October, 1888), p. 451.
14. Watercolor drawings by F. Lloyds, Department of Prints

and Drawings, Charles Kean Collection, Victoria and Albert Museum, London.

15. Alphonse Gosset, *Traité de la construction des théâtres* (Paris: Baudry et Cie., 1886), plate 29–30.
16. *The Builder,* 20:1028 (October 18, 1862): 745.
17. Georges Moynet, *Trucs et decors* (Paris: La Librairie Illustrée, 1893), plate 18.
18. Moynet, *Trucs et decors,* p. 245.
19. Gosset, *Traité,* plate 29–30.
20. Clemançon Catalogue (1930–40) "Appareillage électrique spécial pour théâtres." Courtesy of the French International Theatre Institute.
21. Courtesy of the French International Theatre Institute.
22. Courtesy of the French International Theatre Institute.
23. Courtesy of the French International Theatre Institute.
24. *Encyclopaedia Britannica* (9th ed.), 10:99.
25. *Encyclopaedia Britannica* (9th ed.), 10:98.
26. Gosset, *Traité,* plate 29–30.
27. Gosset, *Traité,* plate 29–30.
28. Clement Contant and Joseph De Filippi, *Parallèle des principaux théâtres modernes de l'Europe* (1860; reprinted, New York: Benjamin Blom, Inc., 1968), plate 37.
29. Contant and De Filippi, *Parallèle,* plate 15.
30. Contant and De Filippi, *Parallèle,* plate 11.
31. Gosset, *Traité,* plate 29–30.
32. Gosset, *Traité,* plate 29–30.
33. Contant and De Filippi, *Parallèle,* plate 16.
34. Louis Hartmann, *Theatre Lighting* (New York: D. Appleton & Co., 1930), p. 8. Courtesy of Drama Book Specialists (Publishers), New York.
35. *Harper's Weekly,* 34:1737 (April 5, 1890): 271.
36. *Harper's Weekly,* 34:1737 (April 5, 1890): 269.
37. Gosset, *Traité,* plate 29–30.
38. Contant and De Filippi, *Parallèle,* plate 15.
39. Hartmann, *Theatre Lighting,* p. 9.
40. *Scientific American,* 48:8 (February 24, 1883): 118.
41. *Scientific American,* 44:13 (March 25, 1881): 199.
42. Courtesy of Mr. David Brooke.
43. Courtesy of Mr. David Brooke.
44. Gosset, *Traité,* plate 29–30.
45. *Harper's Weekly,* 34:1737 (April 5, 1890): 271.

46. *Scientific American Supplement,* 18:467 (December 13, 1884): 7452.
47. *Electrical World,* 20:5 (July 30, 1892): 78.
48. *Scientific American,* 45:226 (July 16, 1881): 38.
49. *Theatre Design and Technology,* no. 27 (December, 1971): 24. Courtesy of *Theatre Design and Technology.*
50. *Theatre Design and Technology,* no. 27 (December, 1971): 26.

TABLE SOURCES:

1. William Paul Gerhard, *The American Practice of Gas Piping and Gas Lighting in Buildings* (New York: McGraw Publishing Co., 1908), p. 191.
2. Thomas S. Peckston, *A Practical Treatise on Gas Lighting* (London: Cheapside, Herbert, 1841), p. 37.
3. "Use of Gas in Theatres," *The Mask,* 10 (1924): 164.

The author gratefully acknowledges the courtesy of the Yale University Library in providing copy prints of most of the illustrations reproduced in this volume.

Index

A

Actors, 54, 96
Adelphi Theatre, London, 43, 45
Alliser Theatre, Havanna, 74
American theatres, 47–52, 63–64, 74
Amsterdam, 19
Ancient drama, 3
Arc lights, 70
Argand, Amie, 24
Argand burners, 91–92
Argand lamps, 23, 24, 25, 91
Astley's Equestrian Amphitheatre, 43, 69
Auer, Carl, 93
Austria, 83–84, 87, 106, 107, 109

B

Backlighting, 11
Baltimore, 47–49
Belasco, David, 64
Belgium, 87
Belvidere Theatre, Baltimore, 49
Boîte conique à reflets, 99–100
Border lights, 97–98
Boswell, Eleanore, 17
Boston, 49–50
Bowery Theatre, New York, 51
Boylston Museum, Boston, 49–50
Bozze, 5–6, 7, 11, 12
Brande, William, 56
Broadway Theatre, New York, 108
Brussels, 84, 98
Buckle, James G., 85, 88, 101, 106, 109
Bunch lights, 99
Bunsen, Robert Wilhelm, 93
Burners, 89–93

C

Caldwell, James H., 50
California, 52
California Theatre, San Francisco, 92
Camp Street Theatre, New Orleans, 50
Candles, 3, 6, 9–10, 17, 18, 19, 25, 44, 53
Candle snuffers, 19–20, 53
Chandeliers, 25, 32, 40, 53; in Covent Garden, 36, 37–38, 41, 102; Garrick's removal of, 21; installation of, 102–104; Restoration, 16–17, 19
Chappuzeau, 20
Charles II, King of England, 15
Chartered Gas Light Company, 82
Chatham Garden Theatre, New York, 50
Chestnut Street Theatre, Philadelphia, 47, 48–49, 50, 52, 79–80
Chicago, 52
China, 27
Cincinnati, 52
Clayton, John, 29
Clegg, Samuel, 30–31, 33, 81, 82
Coal gas, 27–29, 77–78, 80
Cockpit Theatre, London, 17
Codes and regulations, 74, 83–84, 87–88, 97–101, 105–109
Coloration, 23, 25, 65–66, 96–97; Irving's work with, 59–61; in Restoration theatres, 5, 6, 13
Comédie Française, 19, 46
Conical reflector boxes, 99–100
Copenhagen, 106, 109
Covent Garden, London, 20, 40, 55, 57, 103; chandeliers in, 16, 21, 36–39, 41, 102; first regular gas use in, 35; problems with gas in, 44–46; ventilation in, 42–43
Cycloramas, 56

D

Darcet (engineer), 46

Dekker, Thomas, 4
De la Ferté, M., 46
De la Tour, Cagniard, 46
De Loutherbourg, Philippe Jacques, 22–23, 55, 59, 63
Denver, 52
Dimming, 13
Dioramas, 23
Di Somi, Leone, 5, 6–8, 9
Dove, J. E., 62–63
D'Oyly Carte, Richard, 71–72
Drummond, Thomas, 56–57
Drury Lane Theatre, London, 16, 36, 42, 58, 103; competition with Covent Garden by, 39–41; Garrick's lighting in, 21–22

E

Edinburgh Theatre, 63
Eidophusikon, 23–24
Electric lighting, 54, 70–75
Electric spark lighters, 108
Elizabethan theatres, 3–4, 20
Euclid Avenue Opera House, Cleveland, 70, 108–109

F

Faraday, Michael, 56
Fechter, Mr., 63, 64
Fitzgerald, Percy, 97, 107–108
Flambeaux, 13
Flecknoe, Richard, 15
Floats, 22
Floodlighting, 13
Flying light batten position, 9
Footlights, 41, 60, 92, 110; changes in, 62–67, 95–97; early use of, 6, 10; Garrick's introduction of, 17, 21; in Hall Theatre, 17–18
France, 18–19, 21, 22, 46, 65, 82, 85, 88, 97
French Vaudeville Theatre, 105
Furtenbach, Josef, 5, 10–12, 100

G

Gaiety Theatre, London, 71
Gardiner, Samuel, Jr., 109
Garnier, Charles, 85, 98
Garrick, David, 16, 17, 21–22, 97
Gaslight Company of Baltimore, 48, 49
Gas mantle, 93
Gas meters, 81–85
Gasometers, 78–79
Gas tables, 85–87
Germany, 74, 87, 88
Globe Theatre, 64
Grand Opera Theatre, San Francisco, 64
Greek theatres, 3
Groundrow, 10, 11, 98
Gye, Frederick, 57

H

Hall Theatre, London, 17–18, 20
Hamburg Theatre, 103–104
Haymarket Theatre, London, 43–44, 96
Henfrey, Benjamin, 47, 79
Her Majesty's Theatre, 56
Hill, Aaron, 18
Hippodrome Theatre, Paris, 71
Hollingshead, John, 71
Hotel Bourgogne, Paris, 19
House lights, 7, 8, 9, 11–12, 13, 25, 61, 102
Hunt, Leigh, 39–40

I

Incandescent burners, 93
Ingegnieri, Angelo, 5, 8–9, 10
Irving, Sir Henry, 58, 60–62
Italy, 5–12, 13, 15

J

J. Defries & Son, 66–67
Jablochkov, Paul, 71
Jacobean theatres, 3–4
Jones, Inigo, 12–13

K

Kemble, John Philip, 54
King's Theatre, London, 43, 45
Kugler, Dr. Charles, 48, 79

L

Lafayette Theatre, New York, 50–51
Lanterns, 17
Lebon, Philippe, 31
Length, 99
Lenses, 59
Limelights, 56–59, 60, 70, 100–102
Lincoln's Inn Fields Theatre, London, 16
Lloyd, G. W., 65

London, 87, 88, 98, 101–102, 106
London and Westminster Gas Light and Coke Co., 33
Louis XVIII, King of France, 46
Lowther, Sir James, 28–29
Lyceum Theatre, London, 32, 65–66, 70, 90, 107–108; introduction of gas at, 35, 36, 40; Irving's work at, 60, 61

M
Macready, William C., 57
Malam, John, 82
Masques, 12
Matthews, William, 30
Mease, Dr. James, 47
Medieval drama, 3
Meters, 81–85
Milne, James, 90
Molière, 20
Monnet, Jean, 21, 22
Murdoch, William, 29–31, 33, 77–78

N
National Light and Heat Company, 32
New Orleans, 50
New York City, 50, 87, 98

O
Oil lamps, 3, 9–10, 11, 12, 18, 25, 44, 53, 74
Olympic Theatre, London, 35, 44, 102
Opéra, Paris, 21, 46, 70; footlights at, 64–65, 96, 97; new building for, 69, 85, 86, 98
Opéra-Comique, Paris, 21

P
Paris, 63, 87, 88, 99, 106
Park Theatre, New York, 51
Peale, Rembrandt, 48, 79
Perspective, 13
Philadelphia, 48
Pilot lights, 53, 108
Pipes, 80–81
Pit lights, 11
Prince of Whales Theatre, Liverpool, 66
Prompters, 61
Puritans, 15

R
Ragueneau, 20
Raleigh, Sir Walter, 4
Reflectors, 24–25
Renaissance theatres, 5–13, 19, 55
Restoration drama, 15–18, 19
Roman theatres, 3
Royal Coburg Theatre, London, 44

S
Sabbatini, Niccolo, 5, 9–10
Safety codes and regulations, 74, 83–84, 87–88, 97–101, 105–109
San Francisco, 52
Saunders, George, 24–25, 39
Savoy Theatre, London, 71–73
Schouwburg Theatre, Amsterdam, 19
Scrims, 55–56
Scudder's Spectaculum, 50
Serlio, Sebastiano, 5–6
Shirley, Thomas, 28
Side lighting, 8, 10, 21
Siemans, Friedrich, 93
Skinner, Otis, 107
Spain, 74
Spotlights, 59
Stanfield (designer), 57
Stoker, Bram, 60, 61, 90
Striplights, 90
Sun burners, 104–105

T
Teatro Olimpico, 5
Teatro Paynet, Havana, 71
Teatro San Giovanni Crisostomo, Venice, 19
Théâtre de Chatelet, Paris, 69–70, 71, 105
Théâtre Français, 64
Théâtre Montansier, Versailles, 87
Torches, 3, 13
Translucencies, 13, 58
Transparencies, 55

U
Ulloa, Miguel, 71
U.S. theatres, 47–52, 63–64, 74

V
Van Helmont, Jan Baptista, 27
Vaudeville Theatre, London, 96
Venice, 19

Ventilation, 39, 42, 96
Versailles, 19, 87
Vienna Court Opera House, 70

W

Wallack's New Theatre, New York, 104
Warren, William, 47–48
Washington, D.C., 51–52
Watt, James, 29, 31, 33
Webster, Benjamin, 44
Welsbach burner, 93
Wilkinson, Tate, 16
Wing lights, 20–21, 51
Winsor, Frederick Albert, 31–33