Lighting theories and technics in the theatres
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INTRODUCTION

Controllable proprieties of light

To get to know light we can begin with the observation of natural phenomena. On a sunny day the light proceeds from a precise direction, and this can be confirmed by the pattern of shadows on people's faces or by the shadow these people cast on the ground. On a cloudy day, on the contrary, we can observe that the light is much more diffused and indirect; the almost total lack of shadows does not allow us to detect the direction from which the light originates. This is the first general division we can make: a) light with a specific direction; b) general and indirect (diffused) light. Artificially produced light is located between these two extremes and can either come near either one or the other. In any case, any kind of artificial light (such as the one we will use for the lighting of the stage) has characteristics that we can control or modify according to our needs: intensity, distribution, colour and movement.

Intensity

Intensity is given by the quality of light that is present. From the weak light of a candle to the intense light emitted by flood-lights. Luminosity on a stage depends on the number of light sources employed, their power, the distance from the illuminated object and some variables that can be introduced, like the use of coloured filters, the use of devices with a reduced intensity, etc. Luminosity can be determined during the design stage by choosing the number and type of devices as well as their power (on the basis of their distance from the stage too), or it can be modified directly on the stage by means of the dimmers.

Distribution

Distribution means the direction of the light, its form and quality. The source of direction of the light determines the angle with which the ray of light "hits" the actor or an element of the scenography. On such direction also depends the position of the shadow that will be created and its dimensions. The source of direction is usually planned "on paper" and can be modified by positioning the lighting devices in a specific spot of the stage rather than another. The form of the light is given above all by the aperture angle of the ray of light emitted by a device. Most projectors give the possibility of adjusting, with a specific range, the angle of the ray produced. This form can then be modified by means of external finnings or internal thin shaping plates that "cut" the light by modifying the circular shape of the normal ray of light. Quality of light means its concentration or its diffusion and the subsequent fact of having, respectively, very sharp or very faded margins of the ray. These characteristics can be decided by choosing, among the available ones, devices that emit a

type of light instead of another.

Colour

Colour can already be partly determined by choosing the right devices; in particular, lamps that produce a warmer (tending to red) or colder (tending to light blue) light can be used. Then, the colour of the light can be modified by placing coloured filters in front of the devices; it is possible to buy filters of any colour. One thing that must be taken into consideration is that on the stage the general colour is given by the sum of the colours of light that we send with the light reflected by the object present on the stage.
Movement

The above-mentioned characteristics, intensity, distribution and colour, are constantly modified during a show. In practice we "move" from one luminous state to the other and this can happen more or less rapidly, in a time that we have previously established. This means that a completely dark scene can suddenly light up; a back-drop with the sky can go from blue to the red of a sunset in ten minutes, etc. Moreover, there can be a light "that moves" on the scene, such as the light of candle or of a lamp carried by the actors, special effects such as fire or clouds and the follow spot. The combination of these variable and controllable proprieties of artificial light allows us to produce all kinds of possible lighting. These properties thus make up the basis of any project.

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Objectives of lighting

For the lighting of a scenic space there are no scientific rules that always apply and each show creates its own rules and its own style. We could even say that the number of lighting styles equals the number of shows produced. However, if we ask ourselves what light can do for any show or how we can act with light and contribute to theatrical communication ,we can outline a few tasks that are specifically assigned to light. They are: lighting (visibility), the revelation of shapes, selective orientation of vision and the creation of an atmosphere. They are four objectives that the lighting designer must always keep into consideration and that are "transverse", that is they are valid for any kind of show performed on a stage and independently from its style.

Visibility

The first task is, obviously, to supply a lighting that provides a good visibility. This is particularly important for the faces of the actors which are the main instrument of theatrical communication. But how much light is necessary to reach this objective? Light is a scientifically measurable quantity, but photometric measures, which are elsewhere indispensable (in cinema and television, for instance), are not very important on the stage. Here, in fact, we rely on the sensible and perceptive abilities of the human eye, which is much more versatile than a cine-camera and film. For this reason, in theatre it is not so important how luminous is a specific situation, but how much it appears luminous. For instance: a candle on a dark stage will appear more luminous than the ray of a 1000 Watt projector on a flood-lighted stage, just as an identical lighting will seem sufficient if used on a scenography or on costumes with light colours, while it will appear scant on a space created with very dark colours, since the latter absorb light instead of reflecting it like the former. The necessary quantity of light varies also according to the luminousness of the preceding state and this is caused by the adaptation mechanism that is typical of the human eye. This mechanism ensures that a scene appears more luminous than it really is in absolute values if it is preceded by a dark scene (and vice versa). This means that the luminous states of a show shall have to be planned out not singularly but in relation to the

others.

As regards the objects, it must be said that the quantity of light that allows them to be seen clearly depends on a series of factors: the colour, the shape, the material they are made of and its reflecting qualities, its dimensions and the distance from the observer. From all these elements it is possible to derive a simple general rule: on a stage luminousness is a relative rather than absolute value and, as a consequence, the key to obtain the right quantity of light is based on balancing. A final note: when there is too much light or too little light for a long time or when changes that are too rapid and strong, the eye tends to get tired and the observer loses his/her attention.

Revelation of shapes

In a traditional theatre the stage is framed by the proscenium as if it were a painting. This situation tends to emphasize width and height and to hide the third dimension: depth. This tendency to "flatness" increases as the dimensions of the theatre and the distance from the stage increase. Despite the fact that the director and the scenographer can do a lot to give depth to the place of the action, the most important instrument for the right revelation of shapes and to restore the natural tridimensionality of the actors and the space is light. A wrong lighting, such as a totally front one, would be able to flatten any scenography and to make useless all the efforts made by who prepared the show. Tridimensionality is fundamental for the relationship between the actor and the scenography too. An actor illuminated only by a front lighting would look like a picture-card glued to the back-drop. A light that gives depth, such as cutting lighting or backlighting, then, serves also to "detach" the actor form the scene. Depth and shapes can be revealed by choosing the right angle of the light source and this, naturally, must be studied during the design stage. Further on we shall analyze individual angles and the techniques that are used to emphasize tridimensionality.

Selectivity

In cinema or television the director uses the camera to select the parts of the reality that s(he) wants the spectators to see and can decide their width: from a pan shot on the entire landscape to a detail of the actor's face. In theatre, on the contrary, the audience sees everything in a long shot; that is s(he) has the whole area of the action always in his/her filed of vision. One of the tasks of light is that of guiding the attention towards the most relevant area of the stage or the most important actor in a specific moment. The most immediate thing to do would appear to be that of illuminating selectively only the area of interest, leaving all the remaining space in the dark. It is an expedient that some shows adopt but it is an extreme means and it does not work when a certain degree of realism is required. A system that is always valid in guiding the attention is that of balancing the selected area on a level of luminousness that is slightly superior to the rest of the stage. It is a method that is based on a psychological factor: the fact that the eye is always attracted by the most luminous point present in its field of vision, and it is surprising how much a small increase of light helps shift the attention to the desired area without the observer realizing it. In this way, during a realistic show, there can be a high number of changes in the balancing that serve to guide the attention of the unaware spectators towards the areas or the actors as they become important. In musicals and ballet the follow spot is often used It is a very evident and intrusive medium it has the same objective: to act as an arrow that indicates who to look at in a given moment.

Atmosphere

The last of the four objectives is also the most fascinating, it involves succeeding in influencing the emotional state of the public through the creation of an atmosphere. The

atmosphere can act on two levels: at a more superficial level it serves to "tell" the setting, i.e. if it is an autumnal afternoon, or a summer morning or night time; if it rains, snows or it's sunny; at a deeper level the atmosphere should communicate the emotional climate of what we are watching and its evolution during the show, causing in us the consequent state of mind (anxiety, anguish, joy, etc.). There are three main methods used to create an atmosphere and to control it by means of the light. The first is obtained by balancing glimmer and darkness, which are linked respectively to calmness and mystery. The second occurs by mixing warm and cold light. The former gives an immediate sensation of serenity and joy, and is, in fact, the traditional light of comedy; the latter on the contrary creates anxiety and a sense of sadness. Naturally, there is a whole range of intermediate values. The last method is based on controlling the light/shadow relation. Natural and soft shadows induce tranquillity while an image with strong contrasts or which emphasizes the shadows will communicate restlessness and anguish (a typical example is that of horror films).

The above-listed objectives are, naturally, not independent but interact one with one another, creating some conflicts too. For instance: if we want to obtain an atmosphere by lowering the light, we will hinder visibility; the selection of a limited area on which to focus the attention is best obtained by using only one projector, but this can limit tridimensionality; a light studied to create tridimensionality can sometimes lead to a lower visibility of the faces of the actors, etc. In practice, what happens is that the ideal light used to reach an object will often hinder reaching the others. Thus, a project is usually developed in two stages: in the first one it is decided which are the objectives to be favoured on the basis of the type of show (prose, ballet, lyrical work, etc), its style (naturalistic, surreal, abstract, etc) and the interpretative indications of the director. In the second stage it is necessary to carefully balance the means to reach a compromise that more or less satisfies the four objectives. In conclusion, it is important to remember that the lighting of a show is not a fixed datum, but quite the reverse, it can be seen as a fluid that invades the stage and flows from the beginning to the end adjusting to how the show goes. The same objectives (especially selectivity and atmosphere) can then change from moment to moment and must always be pursued.

DEVICES

Motor and projection devices

Theatre illumination requires a much more sophisticated and precise control system compared with other applications of artificial light, such as domestic, architectonic or industrial lighting. The basic system in theatre is involves five elements:

1) A power supply system;
2) A dimmer system;
3) A console
4) Lighting devices (projectors and flood lights);
5) Lamps contained in such devices.

Power supply system

By "power supply" system we mean the power supplied to operating devices. One of the obstacles to be overcome when setting up a stage is the quantity of power available on site, because from this element will depend the quantity of usable devices and the overall luminousness. To calculate the available power we must know the three units of measurement of electricity: volt, ampere and watt. If we define the electric current as a flux of electrons, or movements of charges (electrons, ions) inside a conductor, then we can define the three units as follows: Volt (V): it is the unit of measurement of the electric potential (i.e. the ratio between the potential energy U of a charge in a point and the charge

q situated in the same point. V=U/q). It is more important to know the difference of V potential between two points than the absolute value, because it is this difference (called tension) that makes electric charges displace and travel from one point to another. Ampere (A): it's the unit of measurement of the current intensity (i.e. the quantity of electric charge q which flows in a conductor in the time unit t. I=q/t). In order to keep a constant current intensity it is necessary to maintain a specific difference in potential at the extremes of the conductor, so as to have an electric field that, by acting on the charges, makes them flow in the conductor. In order to do so the two extremes are connected to a device called generator of electromotive power which is used to create and maintain a constant difference in potential. Watt (W): it's the unit of measurement of dissipated power in a circuit (and thus of the available and usable of a circuit). If we consider a circuit supplied by a generator of electromotive power that maintains its extremes at a difference in potential V and is run through by a stationary current of I intensity, then the available power will be: W=iXV.

The three units are related according to a simple formula that makes it possible to obtain a measurement of the other two units:

Volt=watt/amp Watt=volt x amp amp=watt/volt

From an applicative point of view, we differentiate between direct and alternating current, depending on whether the intensity and the direction of the current are constant or variable in time. The tension (difference in potential) varies from country to country; in Italy it is 220V for domestic use and 380V for industrial use (including theatres). The distribution always takes place with a tri-phase system (380V with a cable for each phase plus one for the earth) and only from final transformers it is possible to have branches with the 220V mono-phase domestic system. A connection to the 380V tri-phase network is made in theatres or in other places used for entertainment. From the network the current is brought to the control board of the theatre which distributes it to the single dimmers supplying them.

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The dimmer system

A dimmer is a precision electronic regulator for luminous intensity. The dimmer uses as a variable element a semiconductor, the thyristor or controlled silicon rectifier, to obtain an adjustment based on signals that are sent directly by a console. An illuminating device is connected to each dimmer card. In practice these cards supply and regulate the intensity of the light of each lamp or flood light according to the orders received from the console. The dimmers are usually placed in the back-stage, away from the stage. In theatres, fixed plants are lodged in big closets that can contain 24, 36 or more individual cards, but there are also portable "cases" comprising three or six elements each. Each individual card has one or two sockets for the connection of illuminating devices and contains a 10 or more ampere protection fuse. The basic type supports and regulates devices up to 2/3kW of power but there are also 5 and 10kW cards. The signal that goes from the console to the dimmers can either be analogic or digital. The traditional system is the analogic one, with which a low voltage electric signal (which varies from 0 to + 10 volts) is sent to each dimmer through their individual conductor. This means that a 32-unit closet must be connected to the console with 32 cables (which, given the low voltage they must carry, can be very thin and collected in only one big cable). The new digital system, which has by now almost completely replaced the analogic one, allows to send the signal with a binary code through a cable with two or three conductors and a screening, the one usually used for microphones. Given the complexity and the quantity of information that can be communicated with that code, it becomes possible to control with a single cable a great quantity of dimmers. All consoles are built today as to emit a digital signal (or are even predisposed to have both possibilities) while some dimmers still work only with the analogic signal. There are,

nonetheless, units (called demux or demultiplex) that are able to transform the digital signal that comes from the console into an analogic one. Digital dimmers present some advantages compared to the traditional analogic ones. In general, they answer in a faster way and they offer a more stable and precise adjustment, they can regulate directly even low voltage lamps (12 or 24 volts) and regulate better (even though not perfectly) fluorescent lamps. The DMX512 is the protocol, or language, of the most common signal.

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Console

The console is the unit from which it is possible to control all the lighting devices and thus the luminous state of the stage (i.e. all the devices in use simultaneously and at well defined intensities in a specific scene). The console can be manually operated, computer operated or envisage both modalities of use.
Despite the fact that the computerized console is the most commonly used in any theatre, many small groups or touring companies still use the manually operated one. The advantages of the latter are its manoeuvrability, low cost, simplicity of use and setting. A manual console is made up by two groups (or preset A and B) comprising a line of 12, 24 or more sliders each. Each numbered slider regulates a dimmer (a circuit or channel) and thus every slider switches on and regulates the intensity of a single light. Presets A and B are identical (i.e. A's slider no. 1 controls the same dimmer of B's no. 1), but they do not work simultaneously. While the luminous state seen on the stage is regulated for instance by group A, group B is "switched off" and is thus free to set the succeeding luminous state. At the appropriate moment a general slider (transfert or cross fade) allows to cross the two groups, that is to fade group A and insert simultaneously group B. That slider is associated with another, the timer, that allows to set a cross time; state A and state B, in fact, can be crossed automatically at a speed that is variable and adjustable at one second to some minutes. Moreover, there is also a master slider that regulates the general intensity, that is the luminous state we see on the stage as a whole. In the computerized console the number of the dimmer circuit is keyed in and an intensity of operation is allocated to it and represented by a percentage (from 1% to 100%). Once a luminous state has been programmed, it is memorized by pressing the record button which gives the memory a number, a time for the beginning of a scene and one for the end of it. When all the luminous states have been memorized they can be brought back on the stage one after the other by simply pressing the start button in the predetermined points of the show. The luminous states will come on and off the stage at the times allotted to them. In addition to crossing the two states simultaneously it is possible to fade one at a specific time and bring in the other one with a different timing. The computerized console offers many possibilities: an extreme precision in regulating the single circuits and in creating the luminous states; the possibility of activating and deactivating the effects in different times and also at very low speeds (an impossible thing to do manually); the memorization of a great quantity of complex luminous states and the possibility to summon them one after the other in very short times; the possibility of memorizing the whole programme on a diskette so as to reproduce it with other compatible pieces of equipment, to simply modify it with a personal computer or to print it; the possibility of controlling accessories such as motorized colour changes , smoke machines or machines for the movement of motorized projectors (used especially in musicals, modern ballet and pop-rock concerts). Now, many consoles present the advantages of both systems; the computer in fact is associated with a manual system of sliders that becomes very useful during rehearsals in order to program and quickly modify simple luminous states.

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Lighting devices

A lighting device is basically a container made of tin or aluminium which contains a light source (lamp), a mirror reflector to recover the rays that the lamp sends backwards, and a more or less sophisticated system of lens to control and concentrate the light. A first distinction that we can make is that between sources of "hard" and concentrated light (projectors) and sources of "soft" light, diffused and uniform (floods). The first group comprises projectors with four different optic systems: the profile spots, plano convex lens lights; Fresnel lens spotlight; par cans or beam lights. Each type of device provides a different quantity of light according to parameters such as the width of the emitted ray, its intensity, the consistency of its margins and the uniformity of light. Inside each family there is also the possibility of choosing the angle of the emitted ray and emission power. The devices are mounted with hooks on metal (American) bars that are then lifted, or on stands (frames) set on the ground. Each of them can perform both an horizontal (pan) and vertical (tilt) movement that allows to guide the ray of light in the desired direction. Each device, finally, has in the front a holder for the coloured filters that are previously installed on special frames.

Profile spots These device emit a light beam with very clean-cut and definite margins that forms a perfectly circular figure. In order to do so they adapt a lens that works as a condenser (to condense the light) and one or two additional plano convex lens (zoom). Single lens devices produce a ray with fixed opening while the second lens, by moving independently from the first one, makes it possible to modify the angulation (zoom effect). In the latter devices it is the focus that fixes the dimension of the ray and the sharpness of the margins. The more sophisticated models also adopt a third lens to obtain an even sharper ray and even more clean-cut margins. Nearly all the models have a regulator or "field delimiter" placed under the lamp to obtain either the maximum of luminousness in the centre (peaky), or a diffused luminous on the whole ray (flat).

In the central part of the device, between the condenser and the other lens, there is an opening where four independent gobos that are used to cut the ray of light on four sides are positioned. Inside this opening can be positioned an iris diaphragm used to reduce to the minimum the width of the ray keeping its circular shape. Inside the opening can be placed also some gobos, metal templates that once cut enable the projection of the desired light forms. Pre-shaped ones can be bought with the shape of windows, trees, leaves, buildings, etc. The system makes it possible to shape the light in any way, so that we can obtain very precise and definite geometric figures; substantially it is the device that enables the maximum control of the light ray.

Plano convex lens projectors These devices are much more simple and economical than gobos. They produce a light beam with rather sharp margins, albeit softer and more faded than gobos; in fact, they adopt a single plano convex lens slightly knurled on the flat side in order to soften the margins. The emission angle of the ray of light is adjustable with a rather wide range between spot to flood by moving the lamp respectively away from or closer to the lens. External lens-screen wings can be placed in the front part of the device to cut the ray, even though this happens in a less precise way compared with the gobos. They are widely used for their practicality (reduced dimensions, ease of handling and adjustment) and their inexpensiveness. The most common model is for 1000W lamps but 500W or 2000W models are also frequently used.

Frensel lens projectors They differ from the latter type only because they adopt a particular type of lens that takes its name from its inventor. It is a plano convex lens with a knurled flat side and a convex side that is deeply engraved, so as to present a series of circular steps. These device produce a light beam with very soft margins, and with a luminous centre that fades very softly. Thanks to this characteristic they are mainly used to create sets of light for the stage or to create soft backlights. They too can be adjusted in spot or flood

position and they can be provided with lens-screen wings too.

Par cans/beam lights Introduced in the 1970s, they had a great impact both in theatre and ballet shows, in musicals, in pop-rock concerts. They are very simple devices; their main and original feature is the fact that they adopt a sealed PAR lamp in a container that resembles the beam light of a car, with a lens in front and a reflector on the rear side. The lamp rests in a very simple device that has no other lens or regulator. Since there is no lens it is not possible either to focus or to regulate the dimension of the ray of light. The margins of the emitted beam of light are soft and the centre is very luminous, dense and particularly concentrated. The ray is relatively oval-shaped. The angulation of the aperture of the ray is fixed and depend on the ready-made lamp. It is possible to find models with various predetermined angulations which can be substituted in same device according to the needs of the buyer. The most common unit in theatre is the 1000W one for the par 64 model, available with four different angulations: CP60 (9° x 12°); CP61 (10° x 14°); CP62 (11° x 24°); CP95 (70° x 70°). Pars are devices that are widely used (in pop-rock concerts they are the basic unit) because they are economical, easy to transport, to assemble and above all for the density of the light emitted, perfect to project darker and deeper colours (thus with filters that absorb a lot of light). The beam lights produce a light that I very similar to the pars' but they adopt a common lamp and a double reflector to aim the light. In the front part there is a system of blades placed in concentric rings that prevents the light from spreading once outside the device and thus allows the emission of a light beam with margins that are almost parallel. The beam lights can be used in combined mounting, one next to the other, to create walls of light that have a great dramatic impact. This use was developed by the Czech designer Josef Svoboda who manufactured the devices bearing his name, comprising two lines of alternating beam lights that can be assembled at pleasure.

Floods They simply comprise a lamp and a mirror reflector at the back that can either be symmetric or asymmetric. There is no lens and thus the emission angle cannot be modified. They can only be rotated horizontally and vertically. The light produced is very soft and homogenous and it extends over a wide area even at a close distance. Therefore, they can be used, especially in combined mounting, to illuminate homogeneously back-drops, landscapes or big walls. The asymmetric reflector is particularly useful when the lighting of back-drops comes from above or from the stage level. A very simple and economical diffuser is the "Bell", or gripper. It is a lamp holder with a metal bell reflecting internally which can contain lamps with up to 500W. It is equipped with a gripper that can be used to hang it everywhere very easily.

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Lamps

Inside each device there is a lamp that is the source generating the light. The power of the lamp determines the luminousness of the device. The illumination of the stage is done by adopting lamps that generate lights in the two possible ways and that is incandescent and discharge lamps. These two families moreover differ from one another also in the way that the light is produced, in colour temperature, intensity and the quality of the light emitted and the way in which the lamps are supplied and adjusted. It is important to know the colour temperatures of the lamps being used. When they are mixed together it is necessary to be able to foresee a balanced set and as homogeneous as possible.

Incandescent lamps (or tungsten with halogen) They are most common lamps in theatre. They comprise a glass bulb which contains a filament of tungsten supported at the two extremes and placed in vacuum or in an inert gas. When it is crossed by electricity the filament, by opposing a certain resistance, overheats and by becoming incandescent it emits light. The quantity of emitted light can be controlled by varying the voltage applied, and

this is what happens in theatrical use with dimmers. This kind of lamps produces light with a colour temperature ranging from 2800 K (for class T ones) to 3200 K (for class CP ones). Compared to domestic lamps, which operate in the same way but have a colour temperature that is too low, the ones used in theatre contain, as well as the filling gas, an halogen (generally iodine) that prevents the darkening of the glass bulb due to the vapours produced by the tungsten. The halogen enables a better performance of the high voltage lamp, a longer duration and an acceptable maintenance of the colour temperature (not too low). The advantages of these lamps are represented by their reduced dimensions, immediate start and the possibility of applying a precise adjustment of the intensity through the commonly used dimmers. The advantages are the fact that the colour temperature is quite low compared with white light (especially if the lamps are not used at 100% intensity), the high energy use (only 10% is transformed into light while 90% is dissipated through heat) and they have a relatively shorter life than discharge lamps.

Gas discharge lamps This family includes tubular fluorescent lamps, mercury vapour lamps, high and low-pressure sodium lamps, halide lamps and the so called HMI and MSR lamps. Very few of these lamps are used regularly in theatre while others are used only in exceptional cases. This type of lamps operate thanks to the electricity passing through a gas between two terminals. The initial arc that is created makes the atoms of gas move in such a wide and vorticose way that they emit light. This process is called ionization. This kind of lamps require a high quantity of energy in order to trigger the initial ionization but, once lit up, they have a low energy consumption and they transform almost all the electricity absorbed into light. The fact that they are low consumption lamps explains why they commonly used for industrial and civil use (street lighting, big depots, sports structures, etc.). They are commonly used in theatre because although energy saving they are extremely luminous and strong; moreover they produce a light with a very high colour temperature that even exceeds the limit of "white" light, and thus are ideal to reproduce sunlight on stage. The main disadvantage is represented by the fact that the start of these lamps requires some time (it is not immediate) and that they cannot be adjusted with the conventional analogic dimmers used in theatre. These drawbacks limit their use in theatre. The most commonly used lamps are 2, 5, 4 and 6 kW HMI ones in follow spots, fondografi and in Fresnel projectors, in front of which a is placed a rolling shutter that works as a blind, which by attenuating the emission of light, in some way replaces the regulation operated by dimmers. The mix of halides of rare earths with which they are filled allows to obtain a colour temperature of 6000K, very close to daylight. In order to operate, these lamps, as all discharge lamps, require a starting device and a ballast to stabilize the current once the lamp has been switched on. The starter is usually linked to the body of the projector while the ballast is generally placed externally and connected by a cable to the projector employing this kind of lamps. Devices with discharge lamps are used a lot by cinema or television where they must stay switched on for a long time and the adjustment is much less important.

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Motorized and projection devices

Motorized devices The needs of modern entertainment have led technological progress towards the motorization of devices and the automatization of various functions. The chief innovations are related to the motorization of lights to create spectacular moving light effects and the automatic change of colours. The lights movements can be based on two different systems. The first is the simplest and cheapest one. It is a fork inside which a common theatre (PC, Fresnel or gobo) projector can be placed. The fork is equipped with two internal motors, which are controlled by the console and which make the projector move both on the horizontal (pan) and the vertical (tilt) axis. The advantages of a motorized projector are evident: once it has been positioned it can be completely controlled and aimed

by the console, without the need for a technician to operate it manually, with the consequent saving in terms of time and work; each device can be used in different shows without being dismounted and moved and, moreover, it can even move during the same show and switch on each time in a different position according to the scene, carrying out the work that should be performed by a higher number of projectors, thus saving the number of devices, cables and dimmers. The other system is the one employing SCANNERS, also known as "intelligent projectors", which from a technological point of view are the most state-of-the-art devices (and expensive) devices on the market. These projectors must be installed in a specific position and remain fixed, since the luminous ray is a small motorized mirror, placed at the opening from which the light is emitted. The scanner can produce a great number of effects and figures both fixed and moving, at an extraordinary speed and precision. While the fork is forced to move at a limited speed because of its dimensions and the weight it must move, the mirror is extremely fast, quick and can send light practically in every direction. A whole range of accessories can also be found in the scanner's container. There is a disc which can have from 6 to 24 colours for the emission of already coloured light; there are interchangeable lens to adjust the device to the height at which it will be installed; there are from 3 to 10 gobos to shape the light into different forms (stars, circles, flowers, etc.) and there is a system of filters to make the ray of light, which is usually clean-cut and concentrated, more soft and shaded. All functions are set and controlled by a computerized console. Each of them requires an autonomous digital signal, so that each individual device may need up to 12 channels-signal. These devices are greatly versatile and their potential is exploited to the maximum especially during pop-rock concerts, musicals, in some television shows and in big discos. Another sector of automatization is the one related to the motorized change of colours. If we place a system in front of the projector that can change a jelly that is coloured repeatedly during the show, it is clear that it will be possible to install fewer devices with the consequent saving in terms of time and work. The first system used to change colours automatically is the installation, in the front of the projector, of a wheel with circular holes closed by differently coloured jellies. A small motor makes the wheel turn until it places the beam of light in front of the desired colour. Nowadays the preferred system of motorized colour changers is the SCROLLER. The scroller consists of a frame containing a long strip formed by square sheets of differently coloured jelly linked to each other. The strip is kept rolled up on two rolls contained in the frame and fixed one on the right and one on the left. The rolls are motorized so that the strip can roll in the two directions until it brings the desired colour in the middle, in front of the ray of light. These colour changers are fast, precise and usually contain a system of fan units to cool down the jellies so that they last longer. They too are controlled by the console through the DMX digital signal. The development of increasingly sophisticated devices required, at the same time, the development of computerized consoles. In this way, today there are computers that, beside carrying out the normal function of adjusting the luminous intensity, have specific programmes designed for the setting and the control of a great quantity of scanners and colour changers.

Projections One of the ways to "send" light is by projection, a system which makes it possible to cast figures on the scene realistic or abstract scenes, either fixed or moving. The images can be projected on special screens, on back-drops (panorama/cyclorama), on parts of the scenography, on tulle and any other means that can work as a contrast.. the simplest way to project figures is by inserting gobos inside which shapes have been cut. Pre-cut gobos can be found on the market with any kind of shape, with a focused gobo it is possible to project the shape of windows, flowers, leaves, stars, clouds, walls, legends, trees and any abstract figures. A beam shaper can also be equipped with a small electric motor, on which are installed glass discs that will rotate slowly in front of the ray of light being emitted. The glasses are coloured and with this system it is possible to project more realistic and moving figures, such as waves, flames, clouds, snow, etc. The effects thus obtained are elementary and quite poor. However, acceptable results can be obtained by using more devices

simultaneously or by using them in small spaces. When, on the contrary, we want to project slides with photographed or painted images it is necessary to resort to special projecting devices. Many models can be used: from the small Kodak Carousel for normal 35 mm slides with a 250 W lamp, to the more powerful PANI which adopts a 4000 W HMI discharge lamp for 18 x 18 slides. Apart from the small Carousel, projectors have a series of optics (lens) that are interchangeable with the aim of projecting images that are more or less enlarged in order to adapt to the distance at which they are placed in relation to the screen. Projections give better results when they are made by using special screens, which are usually placed as a back-drop. Screens can be white, black or in various shades of grey, and they can either be for front or rear projections. The use of projections in plays presents a few problems and is quite a difficult technical operation. Back-projection gives the best results in terms of luminousness and definition, but it can only be employment in a few cases; in fact, it is rare that behind a scenography there is enough room to place the projector at a distance that allows to project big images (even by adopting a wide-angle lens). It is usually the case that front-projection must be employed, which in its turn presents another problem. If behind a scene it is possible to place the projector in the middle of the screen and perpendicular to it, it is not possible to do the same in the front, that is to place a projector in the middle of the scene. The projector must necessarily be placed on a high place and it must be aimed downwards or on the side (behind the scenes or behind the proscenium arch) and aimed towards the centre. In any case, it will result in a distortion of the image. The correction of this alteration must be made when the object to be projected is photographed, resorting to complex geometric calculations or by photographing the object exactly from the same point of view from which it will be reproduced. Another aspect that must be taken care of is the balancing of the relationship between the screen and the stage. If the stage is very luminous the projected image will result faded and little present, but the image, at the same time, cannot be predominant so as to make difficult the vision of the actors. It is also necessary to take care that the light of the stage never touches directly the screen, but this drawback can be reduced by studying the position and the aiming of the lights; instead of a front light, which is reflected by the floor onto the screen, a lateral light that is reflected on the opposite side without touching the screen can be adopted. Even the colour of the screen is determinant. A white screen will make the image a little more luminous but it will be extremely sensitive to any small reflection and will be an obtrusive element of the scene; vice versa a black screen will be a little less luminous but also less sensitive to reflections and, once the projection is over, it will be practically non-existent. Beside all these difficulties, if everything is calculated with precision and if the equipment is suited to the aim, it is possible to obtain highly spectacular and efficient effects. Some designers, such as Josef Svoboda, have based their work (and success) on the use of complex combinations of any kind of projection.

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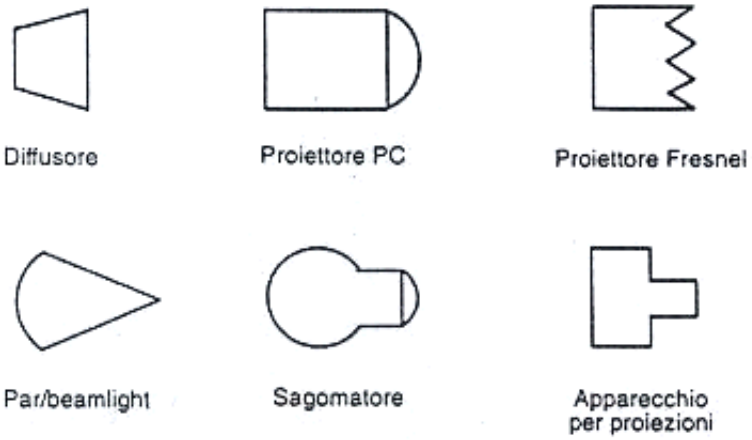
PLANNING PRINCIPLES

From a practical point of view, to elaborate a light project means to choose what kind of equipment to use, decide their position and their direction, choose the colours and fixing everything by transferring it on a plan of the stage where the encumbrance of the scenography has already been marked out.



The choice of the position and, consequently, of the aiming of the single devices is fundamental; the nature of the image we will obtain will depend on it. Let us try to think of an actor in the middle of the stage and let's analyse the images we would obtain by illuminating him with a projector moved in all positions and aimed with all possible angulations, concentrating above all on three variables: the effect on the actor, stage area that will be illuminated and the shadows that will be created.

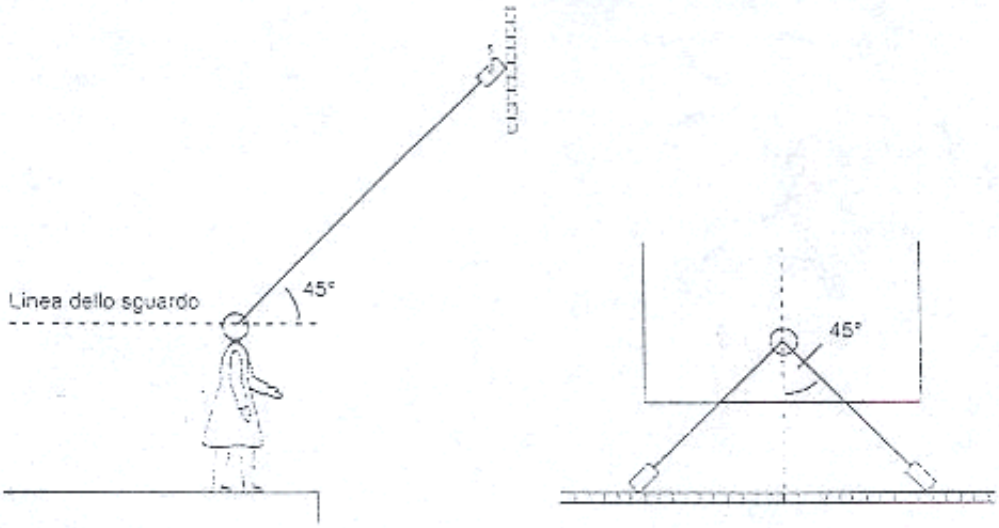
Front light Let's start with a light coming from above, with a luminous ray that falls vertically on the head of the actor. The eyes will be in the dark and the nose very illuminated but which shadows the mouth. The shadow cast by the body will be very little and the illuminated stage area extremely limited. These characteristics are typical of a very selective light, that hits the body and the face in a very dramatic way but that creates a very limited visibility, especially because the eyes and the mouth are shadowed. Now let's place the projector facing the actor and at a certain height. The eyes and the mouth will become more visible but the illuminated area behind the actor's body becomes notably bigger. Even the shadow on the floor becomes longer and more present. If we lower the projector further towards the front down to the actor's eye level, we see that the face is completely illuminated even though a little flattened. In this case, moreover, the light illuminates the stage very deeply, the shadow is very long and, possibly, it is projected also on part of the scenography. Generally speaking about the front light we can say that to the lowest position of the projector corresponds the maximum flattening of the image but also the maximum visibility and the minimum possibility of selecting space through light.

Lateral light If we position the projector on the actor's side we see that his face and his body are very sculptured and tridimensional. This depends on the fact that, when watching from the audience's point of view, only one side of the actor is illuminated. The more we lower the projector, the more the visibility and the modelling of the face increases. Naturally, both the stage area and the dimensions of the shadow gradually increase. If we use two projectors, on each side, to illuminate the actor, we would have shadowed area in the middle of the face anyway, with the added drawback that we have created two shadows on the floor. By lowering the two projectors until they reach an horizontal position at the actor's eye level, we would obtain a passage of light that crosses the whole stage. In general, we can say that by lowering the light source laterally, the visibility and tridimensionality of the actor increase, but his shadow lengthens and most possibilities of selecting the space are lost.

Backlighting A light coming from above and from behind the actor does not allow us to see his face, but greatly helps to give depth to the whole room and, thanks to the very luminous profile that is created around his head and shoulders, it allows to clearly detach the actor from the scenography highlighting him.

Light from below A front light from below creates a very big and incumbent shadow of the

actor. Naturally, if it is used on its own it produces a very dramatic and unnatural image. Used at low intensity to complete the light from above, it can be useful to lighten the shadows under the nose and in the eyes and to soften the contrasts. The analysis of the possible positions and angulations tells us that there is no ideal position that satisfies simultaneously all our needs. Front positions are quite all right for visibility, but they tend to flatten the image; lateral positions yield the exact contrary (tridimensionality but little visibility). High angulations give less visibility but allow to tighten the illuminated stage area and produce small shadows, unlike low angulations, and so on. It is a question, then, of finding compromise positions and angulations basing our choice on the theatrical needs and the objective we want to privilege. If we take as a point of reference the kind of illumination we can see in nature, we can reproduce it quite faithfully by following a simple method. We need to use two projectors placed in front of the actor, at a height that allows to create a 45° angle between the ray of light and the horizontal line of the eyes, and positioned so as to form, each on every side, a 45° angle between the ray of light and the vertical plan that crosses longitudinally the body of the actor. The two projectors, thus, will form, between themselves, a 90° angle.

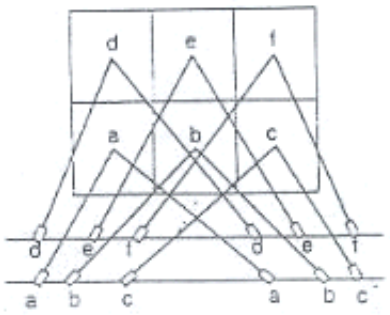


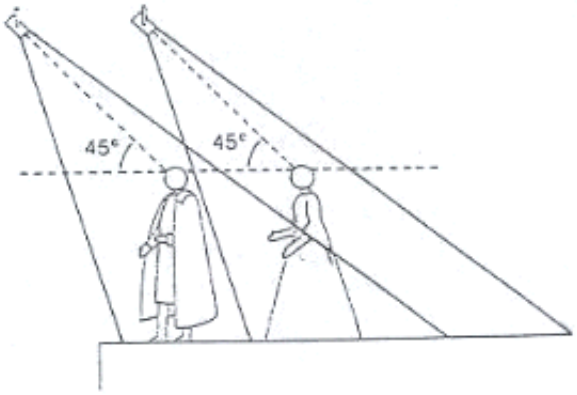
line of the eyes

It is a method derived empirically by the fact that this combination of angulations is the best compromise between visibility and tridimensionality that can be given to an actor on stage. The ideal thing would then be that of adding a third projector in a backlighting position, to give more depth and tridimensionality to the actor and to detach him from the surrounding scenography. In nature too, as a matter of fact, light illuminates every object from all directions, coming both from the main source (e.g. the sun) and the whole surrounding environment thanks to the reflection phenomenon.

Methods and theories A show is illuminated by a sequence of luminous states linked to each other. In simple terms, we can say that a source text is divided into smaller units (single scenes), each of which shall have its own particular light. The most immediate thing to do would seem that of positioning and aiming the specific devices for each individual scene. Obviously, this is very dispersive and, above all, it would require a great quantity of devices which often are not available. It is thus necessary to seek some compromises in order to obtain the maximum result with the available means, by studying for instance if a single device can perform more than one function and thus be useful in more than one scene. By following this logic, as well as direct experience on the stage, a method has been developed based on what had already been theorized in 1932 by the American professor Stanley McCandless. This method provides some basic formulas for the setting-up of the lighting of

a show. Obviously, there are no strict rules in this sector and the method itself seem to have been devised to be transgressed or at least to be applied in a very flexible way. Its strict application would lead to an illumination that is quite anonymous and boring, without considering the fact that each show must have its own specific visual character. At the time of their formulation Prof. McCandless' simple rules, which today might seem obvious, were innovative and soon became the method followed by all light designers. The first suggestion is that of keeping the lighting of the stage area separate from the one for the scenography. It is clear that a total division is impossible to obtain, since the light is reflected by all the surfaces it hits, however, the more these two areas are controlled separately, the more will be the advantages.





The stage area We have seen that the most natural way to illuminate the actor is the one employing two projectors placed at a 45° vertical angle and a 45°horizontal angle on each side. Two projectors thus placed make it possible to illuminate approximately a 2- or 3-metre area both in width and depth. The classic method advices to divide the whole stage in which the actors will move, in a series of squares that are 2-3 metres wide. At this point we only need to repeat the basic module of the two projectors for each of the single squares and to add a few elements for the backlighting (e.g. a projector for each square or a powerful one with a more suffused light that covers more zones). In reality, naturally, it is difficult to always have an angle that measures exactly 45°, especially in the most lateral areas of the stage. Even if the angle were slightly wider or narrower, the important thing is that the two rays of light that illuminate an area are partially superimposed on those of the surrounding areas so that no shadow areas are left when passing from one to the other.
Such a system is very versatile; it makes it possible to control individually small areas of the stage and to balance them with each other so as to follow, for instance, the movements of the actors. With slight changes in the balancing of the areas, which the audience usually does not perceive, it is possible to shift the attention to the areas of the stage that from time to time we wish to highlight, thus giving them an increased relative luminousness. When necessary , the division into small areas can be use to obtain a more faithful reproduction of reality. For instance it is possible to increase the intensity of light on the stage area where there is a lamp switched on or a candle lit up, or in front of a fireplace, at a window, etc., by lowering the intensity in the areas that are gradually more distant. To improve the effect of the tridimensionality and the modelling of the faces it is possible to differentiate the group of all the projectors that illuminate from the right side from the group of projectors on the left side, by adjusting them at different intensities or by colouring them in a slightly different way (e.g. by placing a jelly that cools down the light on all the projectors that illuminate from the right side and none on those that illuminate from the left). The division between the right and the left group is useful even when we want to highlight a light source. If in a scene outdoors the light source is a sunbeam that comes from the right, we can highlight the effect by placing the projectors that illuminate the areas from the right at their maximum intensity and leaving those on the left at a lower intensity.

The scenography If the illumination of the stage area is done meticulously then probably part of the scenography will have already been illuminated by reflection. However, big walls, landscapes or cycloramas (which reproduces for instance the sky) require a specific illumination. This is usually done with diffusers that, apart from illuminating, also give a general tone of colour to the scene and thus an atmosphere. The diffusers are used in combined mounting alternating eventually two or three different colours. The line of devices installed on an americana luci is positioned 1, 5-2 metres in front of the wall or the back-drop to be illuminated, and as high as possible as to be hidden from the audience's eyes. Some materials for landscapes (PVC and specific screens) can also be illuminated from behind, with a very evocative depth effect. The illumination from behind can be done even from below, by resting the devices on the stage, and can be either direct or indirect. In the former case, the low and high diffusers are directly aimed towards the back-drop; in the latter case, it is necessary to install a white screen, as big at least as the backdrop, at a distance of approximately 1, 5-2 metres. In this case, the diffusers are installed immediately behind the back-drop and aimed backwards against the white screen. Once operating, the white will reflect the light sending it on the back-drop. This system is decidedly the best because it gives the most soft and homogeneous illumination without ever seeing the light source. On the other hand, however, it is also the method that requires the highest number of devices or a higher power, because not all the light is reflected by the white screen and thus part of it is lost. Whatever the method employed, the most important thing is that of being able of controlling autonomously the illumination of the scenes and the back-drops, because this allows to balance in the best possible way the relationship with the stage area.

The alternatives If the applications derived from the McCandless method are the most diffused, there are however some alternatives. The main one is based on the binomial key light - filling light. It is a method that even precedes McCandless' since it has been used, though in its "primitive" form, since already the era of the gas light. The system reaches the peak of its success during the 1930s, before being gradually supplanted, but it is still quite used today (perhaps unaware) by amateur theatres. This kind of illumination consists of the interaction between two kinds of light that are very different from each other; first of all the stage is illuminated by a diffused filling light, which with its colour gives the scene a general tone. This light is obtained with a few diffusers, installed behind the proscenium arch or in the high part of the stage, which slowly illuminate the whole area below. The diffusers can be numerous and have differently coloured jellies, for instance jellies with the three primary colours, so as to obtain many different tones by simply working on the intensities of the single devices. To this basis is added the key light, a more intense light, obtained with few projectors, which illuminates selectively the more restricted area of the action and defines precisely a source direction. It is a particularly interesting system for small theatres, because it allows to obtain good results with few means, even if it is much less versatile than the "area" method. Of course, nothing stops from applying simultaneously the two methods according to any combination, so as to unite some of the advantages of on method to those of the other. The last method that can be mentioned is the one that comprises the division of the stage into horizontal strips. Each area is approximately 2 metres deep and as wide as the whole width of the stage; it is illuminated "diagonally", from each side, with a few projectors or gobos installed at various heights on frames positioned behind the scenes. The subdivision into areas makes it possible to illuminate, according to the cases, the whole depth of the stage or only the areas in which the action takes place. Then a few devices for backlighting, the autonomous lighting of the scenes and the back-drop and eventually some of the front filling light can be added to this basis. This is a method that tends to exalt the tridimensionality of the bodies, and this represents a drawback in terms of visibility. It is exactly because of these characteristics that it is a method appreciated and used especially in ballet dancing.