LIGHT MUSIC IN THE SOVIET UNION

by Roberta Reeder and Claas Cordes

Light music is the term that is applied in the former Soviet Union to performances based on a sequence of light projections, usually accompanied by music and often by acting and movement. It can take many forms, such as designs produced on a screen controlled by a live artist, works created for video and film, and "Sound and Light Shows" at the site of famous architectural monuments.

In the 1960s and 1970s light music became popular art and often appeared in the form of simple machines programmed to produce various lights and patterns as an accompaniment to popular music. However, through the possibilities created by modern technology, B.M. Galeev, S.M. Zorin and R.F. Saifullin and F. Yurev and other light-artists in the Soviet Union saw the potential for creating new works of art and developing an aesthetic that analyzed the role of this art form in the context of the other arts. These artists have written two of the most important sources on light music, *Light-Music Instruments* by Galeev, Zorin and Saifullin and *Light-Music* by Yurev.

An early Russian predecessor of light music in this century was W. Kandinsky. In his work *Concerning the Spiritual in Art*, he turned to Goethe, who said that man becomes the lord of nature when he uses her not for commonplace ends, but to communicate the spiritual through works of art. In his aesthetics, Kandinsky employs a communication model in which the message is not about the external world, but about feelings and thoughts that originate within the artist. The work of art serves as a medium which acts on the consciousness of the perceiver to evoke similar ideas and emotions. The medium may be representations from the real world, but they can also be non-objects composed of pure color and form arranged in a particular way, as sounds are in music, thereby providing the artist with possibilities to express himself as freely as a composer does in his medium.

Galeev has pointed out a similar relationship for the field of light music. In addition, the tradition of light music in the Soviet Union can also be traced back to Alexander Scriabin who already composed scores for light-music at the beginning of the twentieth century.

One of the most original inventors of the early period of this new art which could only have been born in the age of electricity was L. Termin. He created his instrument while working on an alarm system to protect the Diamond Collection at the Kremlin. When a human hand moves near the antenna of his instrument, it produces a sound signal. Termin then applied this concept to a machine known as a "Terminbox." He later experimented with combining music with light and dance, and even fragrances. At the same time G.I. Gidoni designed a model of a light monument to the Revolution in the form of a semi-transparent globe which was a hall holding several thousand spectators, and the light projection could be seen from outside.

In the post-war years light music became very popular. A center for research and new ideas in this art was the Scriabin Museum in Moscow. There S.I. Vavilov worked on a light instrument using static stencils and in the 1950s V.P. Borisenko performed light concerts there on a small light-music instrument. The museum also made plans for the first light-music halls.

Another artist, the engineer K. Leontev began experimenting with automated light instruments. In 1953 at his institute he demonstrated a simple automatic machine whose brightness and color changed in relation to the loudness and pitch of the music. For this concept Leontev developed an allegedly universal algorithm of the translation of

sound data into light data which he believed was based on "objective laws" of perception.

THE 1960S AND 1970S

The 1960s and 1970s witnessed an outburst of activity in the Soviet Union in the field of light-music which is still going on today. There were important works written analyzing the art and describing the light-music instruments, many performances were presented all over the country, and theoretical and practical concerns were discussed at symposiums and festivals. Sometimes works were limited to visual designs, but more frequently they were the result of an interrelationship of the arts, combining visual and auditory media, and sometimes including live actors and dancers as well.

In 1969 in the Ukraine, Y. Pravdiuk organized a kinetic music art studio in Kharkov. An engineer by profession, Pravdiuk built a light instrument in 1955 and began to create compositions synthesized with music. In the early stages he worked on the principle of synchrony, but later in 1970 when he performed Scriabin's "Prometheus," he used audio-visual polyphony, where the interrelationships between the auditory and visual components were more subtle and complex.

For all instruments Pravdiuk built in the following years he used shadow projectors, combining static and revolving stencils with colored light filters. A different set of stencils and sometimes even a new instrument was required for each musical work. Since 1970 various modifications of the Kharkov instrument have been used in the Moscow Studio of Electronic Music and in many other parts of the country.

Zorin, one of Pravdiuk's students trained in electronics, organized the "Laboratory of Light Dynamic Instruments" in Poltava, Ukraine, where he worked with shadow projectors. More recently Zorin has been working at Moscow University trying to create an artificial light-sound environment which would make it possible to control the participant by changing the environment. This may lead to new methods for curing the sick, developments in psychotherapy, and new teaching methods.

In the early 1960s Galeev began to work at the Kazan Aviation Institute with a group interested in producing light-music works, the Student Construction Bureau (SCB) "Prometheus". The team included radio technicians and musicians. Beginning in the 1960s they created the light music instruments "Prometheus 1-3" and a small one called "Crystal" which is in the form of an octahedron of transparent glass. The color of each facet is controlled by a panel of forty keys, and the brightness can be controlled automatically or by foot pedals. Films and light music instruments made by this group have been exhibited not only in the former Eastern World but also in Western countries: in 1984 their work was seen at the exhibition "Electricity and Electronics in the Art of the 20th Century" (Museum of Contemporary Art, Paris).

In 1967 the first festival of light music took place in Kazan with representatives from the entire Soviet Union. At the beginning it was small but it has grown over the years. When it took place at the end of September 1986 with many performances, exhibits and symposiums it was the first time a festival of light music had been organized on such a large scale in the country. The relationship of light music to film and television was discussed in a special seminar which again occured in Kazan in 1988.

Today all over the former Soviet Union light-music concerts are given. Elements of light music have also been used in various theatrical productions, and even a record company, Melodia, has started sponsoring light music experiments in its Moscow Experimental Studio of Electronic Music (ESEM). There have also been experiments done with film, video and with the oscilloscope.

LIGHT MUSIC INSTRUMENTS

In their book, *Light Music Instruments*, Galeev, Zorin and Saifullin set up a model of audio-visual communication. They first point out that the possibilities of any light instrument are not infinite, but limited by the possibilities which have been inserted in it by the constructor.

Objects existing in nature as well as those artificially created by man can be used as a potential source of an enormous variety of colors and forms in movement to produce light music compositions.

In traditional music the interaction between a person and the Acoustic Output Instrument occurs through an intermediary control. An analogous situation exists in the visual arts. An artist creates a visual object (a sculpture, a picture) with specific materials (stone, paints) and tools (a chisel, a brush)

also made of natural materials: in doing so he controls the final output of his piece of art: the exhibit. In both cases the artists uses his mechanical energy to carry out his work.

In the field of visual arts the problem occurs that the source of light itself cannot be employed as a "bearer of information" as long as its intensity, color, form and movement cannot be controlled. Natural visual objects are self-illuminating like fireworks, light-reflecting like pictures, or light-translucent like stained glass.

In the pre-electronic period, art employed mainly light-reflecting objects, since their source of light is external, while the art object itself is stationary and controllable. Actors and dancers are the only moving visual objects which can be controlled.

The situation changed dramatically with the appearance of electricity and other artificial sources of light. It now became possible to create self-illuminating visual objects whose structure and movements could be manipulated (neon advertisements). However, the basic technique was light projection. Here the visual object is no longer a concrete image, but a screen with a varied image resulting from a combination of the source of light and the "bearer of information" placed on the path of light. Similar types of projection are also found in nature (the shadow of trees on the ground), but outside of nature lens optics is used for this purpose, and slide projection is the most popular form of this technique.

The simplest method of producing a shadow projection is sending the ray of light through a lens onto a screen. More complicated methods are sending the reflection of artificial light through a lens or sending artificial light through a "bearer of information" (e.g., a slide or filter) and a lens. Adding a condensor to the third setup will provide a means of concentrating the light as it is needed for slide projection.

Light music instruments are divided into a sound and light channel whose general construction is quite similar.

When the instrument is operated the light channel includes the operator, a control panel making contact possible between the artist and the instrument, a control unit forming electronic signals for controlling the light features, a power control unit and the optical output on whose screen light images are produced. For the interaction between the operator and the optical output the control panel and the block of controls serve as an interface where manual information is transformed into electronic information.

Correspondingly the sound channel consists of the sound operator, a control panel, a sound-producing instrument, a sound frequency amplifier and the acoustic output instrument. Here the control panel and the sound-producing instrument serve as an interface between the artist and the actual acoustic output. Interactions between the light and sound channel are possible. Of course the control panel and the operator can be replaced by programming or recording if the show is given several times.

A light music instrument can consist of more than one light channel which can be controlled by one panel (which may have the shape of a keyboard). The single light channel is much more complex than has been described. The chain of components in the channel which will transport the light information to the lamps has to be provided for each single optical output instrument and for each single aspect of light such as brightness, form and color.

Therefore for each optical output instrument, three chains acting in parallel are needed: one for the control of brightness, another for the form-shaping and a third one for color. Each of these chains is composed of the components control panel, control unit, power control and optical output instrument.

The optical output of the light instrument as a whole, therefore, must be a combination of the optical output instruments of the single control chains in the light channel: it must contain the source of light, the form-shaping media and the color filters. These three elements can, of course, be placed in several different orders, and sometimes two or even three elements may be combined in one control chain.

For example, in cinema the control chains of color and form are combined. The manipulations performed by the operator on the presentation of a movie are reduced to a minimum: switching the apparatus on and off. A long period of preparatory work has created the patterns which appear in the film, and these patterns are mainly taken from nature. In contrast a performance of light music is a live event showing images originating in the imagination of the artist. In spite of that the techniques of live performance and of cinema do not exclude each other. Specific light music works have

been created using cinematic techniques.

With these technical possibilities the performer can change the speed and nature of the movements of the images, their color and brightness, and combination. If the light score is complex, the piece can be controlled by several operators or a programmed instrument which will reproduce parts of the light score when necessary.

In opposition to cinema a standardization of the technical equipment is undesirable in the field of light music or electronic music. Here the functions of the technology are much more than merely recording, reproduction and translation. Timbres exist in electronic music which are different from the timbres of sounds in nature and in traditional music. For this reason the composer of electronic art must work closely with the constructor of the unique instrument. The artist, who as in any art, must work "within the materials", here must not only think in light images but must also know, down to the smallest detail, by what means he can achieve the desired effects. The very first act in the creation of a light-music composition with a specific artistic conception is the creation of the light instrument.

THE OPTICAL OUTPUT INSTRUMENT

The optical output instrument is the simplest instrumental unit in light music. It is this node which is the most important for the constructor. The construction of the optical output instrument largely determines the functional model of the electronic nodes of the control unit and the power control unit. The material which the artist uses is colored light organized into specific forms of different textures which change over time. The simplest element of the optical output instrument are light filters which are applied when the source is white light. Monochromatic sources of light such as lasers can also be used.

Light can be distinguished by color value which is given in two parameters - the color tone and the saturation. The color tone is defined by the length of the wave of the light radiation measured in nanometers. The saturation is characterized by the degree that the color is diluted by white light. The basic colors in nature are represented as a spectrum resulting from the decomposition of the white (sun) light by a prism or diffraction grating.

Light filters must have different values of the coefficient of translucence in different zones of the spectrum. Absorbing filters are the most popular for light music instruments, i.e., they depend on their chemical composition to absorb the radiation of one color and allow the other colors through. The coefficient changes in relation to different colors.

There are two main types of filters: glass and film. Film filters can sustain less temperature than glass and fade over a long period of use. If glass or film filters are lacking, one can use liquid - a water solution of analine dyes in a flat cuvette, or cellophane filters. Soaked and heated gelatin is colored with a water solution of analine dyes, poured on the glass, and after drying, is removed in the form of thin, flexible film.

One should not be limited to colored lamps of different colored laquers since they have very reduced color features and a small variety of tones. They should only be used in the simplest automatic light music instruments. In preparing light music instruments, lacquer should be used only in specific situations such as preparing colored slides by hand.

The mixing of dyes, color lacquers, and the composition of multi-layered film filters produces a decrease in the intensity of the light passing through them. Because this colored light is a result of the subtraction from white light, this method of color mixing is called subtraction. But there is another method of mixing colors - additive, directly on the screen, when different colored light beams hit it. The brightness of the screen increases, and the resulting effect depends on the color features of the various beams of light.

One of the most widespread errors in light music is the attempt to obtain a variety of colors on the screen by the sum of the three primary colors in different proportions. This is theoretically possible, but only with a maximum saturation of color. Normal light filters are not very good for this purpose, and adding colors together results in a whitish color mixture. Therefore, constructors choose as many different colored filters as possible and, if they have to change the color while a specific light image is being projected, they apply complex light filters, for example, in the form of a disc composed of narrow sections of different colors. If the disc revolves slowly in front of the lens of the projector, the borders between the sections will not be apparent, and on the screen there will be a smooth change of colors arranged according to the spectrum.

Though the color will somehow also influence the brightness of the light the main means of manipulating this aspect are, of course, the lamps themselves.

Incandescent lamps are the most popular source of light in light music performances. They vary in voltage, size, the gas inside of them, the form of the socket and the thread of incandescence. They can work in almost any position.

Luminescent lamps have a larger light output than incandescent lamps, and have good color features. Still they are not suitable for light music instruments because of their large size and the difficulty in controlling their brightness. Xenon lamps have the latter features; they are small lamps which are very bright. Constructors use them in powerful light music instruments with an optical mechanical regulator of brightness.

For special effects, impulse gas output lamps or strobe lights are used. Lasers have also recently become popular: its monochromatic nature and the possiblity of concentrating light into a narrow beam is important. However, they still do not produce three-dimensional images. Lasers can be used for interesting effects, for example, when they shine into a space filled with dust or smoke. If a beam is put between mirrors arranged around a hall, the entire space will be filled with a web of streaming lines. If the laser beam is static, it shines on the screen as a bright dot, but when it is moved quickly it produces a thin line. An interesting effect is obtained by modulating the brightness of the ray with a high frequency signal, and the line decomposes into a linear drawing.

The technique of holography, especially for multicolored moving images, has still not been extensively developed. There is an interesting direction that is taking place - synthesizing holograms and shooting them with animation intruments which produce figures and movements which do not occur in nature.

In order to understand the way form-shapers work, one must recall the different types of projection. The most typical method in light music instruments is based on the idea of the camera obscura: if an opaque object is set between the source of light and the screen, then a shadow image of the given object appears upside down on the screen. Shadow, or transparent projection as it is still called is based on this principle (in contrast to diaprojection or epiprojection using lens optics).

In transparent projection the size of the shadow depends on the space between the lamp and stencil. With a small distance between the light source and the stencil the image will be larger and vice-versa. The vagueness of the edges of the shadow depends on the distance between the stencil and the screen.

If the incandescent thread in the lamp is complex and large, very interesting semi-shadow effects can be produced on the screen, which change when the lamp is revolved or shaken. It is difficult to control this process of form-shaping, since the way the form changes is dependent on the construction of the lamp. However, with a set of lamps with different threads, the constructor can select what he needs, knowing which light effect can be achieved with each. Figured threads (threads forming different shapes) can also be used in the lamps.

The construction of shadow projection stencils may be very different. They are all based on the general principle of shadows. Cylindrical (or conic) drums with slits are made of firm opaque sheets of material (aluminum foil, paper, electro-cardboard, etc.) or of transparent plastic and glass with a drawing.

The sources of light are placed either inside or outside of the drum; in the latter case, the light passes through the stencil twice, which makes it possible for shadows to move in opposite directions when the drums revolve. Shadows from the zone close to the lamp will be vague. The revolving axles can be horizontal or vertical, depending on the desired direction the shadows should move. A stationary stencil is called a stator, a moving one a rotor. In combination with each other, stators and rotors may form interesting images. Another way of combining effects is using different light sources (of different colors) with one stencil. Using two revolving discs will also produce different shadows, the discs usually revolving in opposite directions while the frequency of the revolution of the disc stencils must be very small.

The various shaped cut-outs in the stencils are drilled or sawed from a pattern, and in cardboard or paper stencils they are burned out or cut out. In preparing flat stencils, it is best to cover the glass with an opaque color, which is then removed based on the contours of the image. If one wishes to paint something on the glass with watercolors or touche, the surface is covered with an absorbing layer, for example gelatin or transparent cellulose laquer. Photoplastic developed in fixer is also good for this

purpose.

Slide projectors can be used as the optical output instrument of a light music instrument as well. The principle of slide projection is a combination of lens and shadow projection.

In light music instruments, a moving stencil rather than a stationary slide is put in the film channel of the projector. In contrast to stencils in shadow projection, not only graphic and linear stencils can be used but also many transitional types. There are unlimited opportunities in setting the stencils, lenses and lamps.

Glass stencils with photomontage images create interesting effects in slide projection. Photos of minerals, liquid crystal, a starry sky, fragments of reproductions of abstract pictures, etc. which have been rearranged into a unified composition are glued onto a sheet of cardboard. This collage is reshot on film, for which a stencil is cut. Relief stencils prepared from transparent materials with an uneven surface also produce usable effects.

In some light music instruments a set of flat cuvettes with transparent liquid put on an overhead projector is used. Color is sprinkled into the liquid producing the effect of explosions on the screen. A special effect is created by the interaction of colored liquids that cannot mix. As in all the preceding cases, the image on the screen is reproduced in reverse to the image on the slide. In working with liquids, it is best to transform the projector into a periscope so that the cuvette is in a horizontal position.

Engineers have discovered an original way to obtain a "living" slide which changes within broad limits. This slide is prepared from objects which change their optical features under the action of an electronic or ultraviolet ray. The slide is normally placed across the axis of the optical system. At a small angle to the axis, electric projectors (as in kinescope) or an ultraviolet laser beam is directed onto it. The dot on the slide onto which the beam falls no longer allows light through, but if the beam is removed, the dot becomes transparent again.

Another technique for form-shaping is the use of moving mirrors (flat, concave, convex), lenses and other types of elements deforming the image which are put on the path of the beam. By turning light mirrors placed on the path of the beam, one can move the image along the screen with a stationary projector. By mixing these techniques with the possibilities offered by transparent and slide projection, the artist can produce a feeling of the movement of light into depth as well as a change in the texture of the image. Without the use of curved mirrors and moving lenses, it is difficult to obtain a rapid change of light shadows and a smooth "interflow" of one moving form into another.

Any constructor can add to this list of techniques. The lighting devices used in theater can also be used. There are important attachments which are applied to standard theater slide projectors. Besides standard stencils may also be attached to them. Form-shaping elements can be moved by different devices, e.g. by electric motors.

There are two types of screens used in a light music peformance - direct (frontal) and reverse (rear) projection. In frontal projection an opaque screen is illuminated, as in normal cinema, from the hall. In rear projection the image is projected onto a semi-transparent screen from behind. Here one must take the brightness of the screen into account from the angle it is being observed.

Depending on particular problems of a given performance (size of hall, etc), one can use screens with different kinds of reflection. Screens with a white matte surface which makes diffuse reflection possible sometimes may not be economical. However, the screen will be equally bright for the viewer sitting in the hall as well as in the balcony. An interesting effect is created by so-called pearl screens whose surface is covered by a layer of tiny glass beads. Projection on white velvet has also created interesting results.

In order to prevent the disturbances which may occur because of light reflected from the ceiling and walls bouncing back to the screen, the interior of the hall must be constructed in a special way and all objects with shining surfaces removed.

The selection of material for the screen - glass, cigarette paper, tracing paper, treated silk (for example, glycerin with talc) and plastic cellulose treated with sandpaper, changing the thickness of these materials, combining them in different ways - makes it possible to achieve different effects.

Rear projection is frequently used in light-music peformances, so the sources of light or beams are not visible. In this case, the audience also will not disturb the demonstration in any way. Another reason why rear projection is good with live performers is that it does not interfere with them in any way. The problem with rear projection is the need for a certain amount of space behind the screen - large

enough to be able to use slide projectors successfully. Its length can be shortened with the aid of revolving mirrors.

A frequent, specific case of rear projection is a light music instrument using a three-dimensional screen lit from inside which is in the form of a sphere, crystal, a network of glass tubes or rods, etc. which usually produces light images in accompaniment to music. The best conditions for this are in special halls in which the screen is spherical, enveloping the viewer on all sides, as Scriabin once dreamt of and Gidoni proposed building. The "Prometheus" group worked on such a project twenty years ago, trying to produce light music in a planetarium. Recently experimental light concerts have been performed in the Moscow planetarium.

The constructor must remember that simple transparent projectors remain the basic element of light-music compositions. Slide projections, however, are often considered too ordinary, while shadow projection in combination with moving lenses, prisms, and mirrors make it possible to obtain unusual and fantastic images. One assumes that now, with the appearance of powerful low voltage lamps, lasers, spherical xenon lamps and halogen sources, the techniques of the transparent projection will be developed further.

THE POWER CONTROL UNIT

The power control unit is an important element in all chains of light instrumentation.

The sources of light and electric machines can be controlled in two ways: in the electric channel and directly in the output of the instrument. The simplest mechanical means is switching off the light beam by a round, or other type of, diaphragm. Another similar technique is changing the coefficient of penetration of the filter's brightness. This is either a wedge put across the beam, and most often two wedges moving in opposite directions or a pair of polarizers revolving in a certain relation to each other. In the photochrome method this is achieved by a selection of material reacting to a specific form of radiation. Under the action of electric energy, several features of the material of the filter change. The optic system in light channels are constructed so that these changes are visualized and represented as changes of the optical surface of the filter.

All these methods of regulation are attractive because they do not influence the spectral characteristics of the light beam, and mechanical methods are accessible and simple. If remote control is necessary, one can use different types of electrical machines with little power, since their function is to change the levers of the diaphragm, revolve the sheets of foil on the path of the beam, turn the polarizers, etc., and do not require great energy.

Power is also regulated in the electric channel. The simplest method is using transformer regulators of voltage which make it possible to control power up to several kilowatts. Electric amplifiers make it possible to control significant power in chains with very weak signals.

There are two basic methods of regulating electric power. The amplifying regulation is a change in the amplitude of voltage or current in a load. Impulse regulators work with the help of thyratrons, thyristors, electron lamps, transistors and magnetic amplifiers. They make it possible to most effectively use the possibilities of electronic devices because of the reduction of the power dispersed in it; however, it may be more complicated than in amplitude regulation.

Regulating the power of incandescent lamps can be done by the amplitude and impulse methods. Both methods of regulation are also used to change the brightness of luminescent lamps. In xenon lamps, both with amplitude and impulse control the instantaneous value of the current must not drop lower than a specified value - when the current is extinguished. Therefore one must decrease the light beam to zero with a diaphragm. With impulse lamps working with strobes one can control the average power of radiation by increasing the frequency of flashes. Control of the intensity of a laser is done with the aid of special photoelectric modulators allowing one to change the intensity of the beam according to any frequency of the controlling sign.

CONTROL PANEL OF LIGHT

The control panel of light in the light music instrument sometimes works like a regular piano keyboard. In this case the constructor must introduce supplementary regulators performed as foot and knee pedals. The specific features of light material make it necessary to construct special control panels for light music instruments which make it possible to achieve a very flexible control of

brightness, color, saturation, choice of forms and their movement on the screen.

The control panel "Chromon" used for a "Light and Sound" spectacle is like this. On the panel is a colored graphic in the form of a curved triangle. The operator moves the handle of the control along this triangle. The handle is connected with three chains for regulating light sources with three basic colors. By putting the handle in the center of the triangle, the sources of all three colors are set into operation, and their sum produces white light. By moving the handle to the top of the triangle there is an increase in the corresponding color, while the others are smoothly extinguished. Each point of the triangle, therefore, corresponds to a color of the light beam. On the basis of this technique, G.L. Kurdiumov made a clever device, controlling the regulators with threads, as in marionette theater.

In normal theater light regulators, a channel is selected and changes in brightness are produced by a moving lever connected with a non-contact inductive data unit or moving resistor of control giving the level of the signal to the input of the power control unit. Regulators are also provided with programs, making it possible to establish the order of action of all chains of regulation in each consecutive scene in advance. But they should not be applied to light music instruments, since they are good only when the lighting of a scene remains the same. In the light music instrument it is better to use another method of programming with an operative commutation of light projectors on the output of each channel of the power control unit.

The control panels of the light music instrument resemble organ consoles in complexity and even in external appearance. If the control panel is combined with the optical output instrument, it can be normal mechanical levers, steel ropes, etc., connecting the organs of the control of the panel with diaphragms, light filters, and stencils in the output optical instrument.

There are non-contact control boards with photo data units controlled by light. They are best applied in network light music instruments when the control board is also a network field of data units. The action of the photo-data unit can be tuned to the opening or closing of photo cells when light falls on them. By covering the light falling on the control board by a hand, filtered stencils or film, the movement of corresponding light or dark images of a given configuration will be produced on a large screen. This method can be also used in transistor light music instruments.

The light composition is reproduced on the control panel according to a light score which is not based on a standard notational transcription. However, for each actual light music instrument, a conventional transcription is possible. Only the movements of the handles on the control board can be transcribed by notes or other signs; the actual basis of the composition is embodied in stencils of the optical output instrument. In order to record the entire composition in its entirety, one must turn either to film and video or to special programmed intruments which can combine with the light music instrument if the electric variant of the power control unit is used.

Thus, in working with a normal optical-mechanical light music instrument, there is the problem of the memorization of the signals on the input of the light music instrument according to a required sequence of turning on the corresponding power control unit and controlling the signals according to a specific programme. Frequently one can borrow from the experience acquired in working with multi-programmed regulators of light in the theater. Their controlling signals are transcribed in the form of systems of holes on perphocards or perphotapes. These holes are a double code of values for brightness established during rehearsals. In reproduction the transformer "code-voltage" forms a signal which is introduced into a bridge instrument of comparison, where this signal acts on electro-magnetic boxes of control levers.

The controlling impulse can be trancribed directly on magnetic tape. This can be done by certain models of switching instruments synchronizing the tape recorder and an automatic slide projector.

For the transcription and reproduction of the sound programme and control signals onto one magnetic tape, special multichannel tape recorders or normal stereo tape recorders are used; however it is important to make sure that when necessary it is possible to erase, transcribe and reproduce the necessary signals on each track separately.

In comparison with the analysed analogic system, there is a digital system of transcription which recently has become very popular and with which one can use ordinary tape recorders. It is very precise, and the control signals transcribed on the tape can be transmitted simultaneously on several light music instruments at great distances.

Light music compositions can be performed accompanied by a live orchestra or by a phonogram reproduced by an electric acoustic intrument.

THE SOUND CHANNEL

The sound reproduction must be of high quality. The sound channel is composed of elements analogous to those of the light channel. It is very important to exclude the interference of the light channel's electronic power control unit on the acoustic track. This influence is in the form of foils on the chain of supply or of electron-magnetic foils (basically high frequency). Besides separating the sound and light channels along the power supply chain, using preventive filters and the screening of the input chains of the amplifier, it is necessary to separate the blocks of these channels in space.

The sources of sound must be put as close as possible to the output optical instrument, otherwise the effect of the unity of light and sound is lost. If the screen of the optical output instrument is large, it is necessary to make it (with frontal projection) out of acoustically penetrable material, and the loudspeakers must be put behind it. With rear projection the loudspeakers must be placed at the base or along the edges of the screen. Because the height of the sound is psychologically associated with rising, high-frequency speakers are usually placed above the lower frequency ones, above the screen.

In large halls sound reflectors are used for increasing the acoustic features of the space. In special spherical halls where one must struggle with an undesirable focusing of sound, reflectors are placed not in the hall itself but behind the screen (when the screen is acoustically transparent, the sources of sound are also placed behind the screen).

While working together with the light music instrument, the sound control panel must be independent and worked by a special operator. Besides the traditional functions of controlling the loudness and quality of the sound, the sound operator must work with the light operator to form a unified artistic audio-visual composition, particularly when using special electro-acoustic effects of spatial sound, when the light operator can control the movement of sound in a hall or on the flat space of the screen and mix the simultaneous movement of light and sound images in space.

The technique of spatial distribution and movement of different voices, melodies, and instruments is rarely used by itself. Usually it is used in combination with light. Therefore the movement of sound must also be transcribed by conventional signs in the score. The sound need not constantly "chase" the light. Although there can be a unified synthesis of the two, they can purposely be divided and contrasted polyphonically with each other.

The process of controlling the light and sound combination during a concert is difficult and requires the action of an entire group of light music operators directed by a conductor, who is not like a musical conductor. He must direct a light orchestra in the dark. This is best done by spoken commands into a microphone from a sound-isolated space behind glass. Signals go to the headphones of the operators. One can transcribe the spoken commands on a multichannel tape recorder during rehearsals. However, the ideal is to transcribe coded electric signals for controlling all the projectors and trajectories of sound movement onto a tape, along with the music.

THE LIGHT MUSIC INSTRUMENT "KHARKOV"

One of the light music instruments working with transparent projection has been developed over the last twenty years, the light music instrument "Kharkov" which was created by Yu. A. Pravdiuk. It combines simplicity, elegance of construction and broad possibilities for producing images. Transistor projection with cylindrical rotors are used in the optical output instrument. The power control unit is made up of six autotransformers.

The sources of light in the control channels are incandescent lamps whose brightness is regulated by a change of voltage from 0 to 170 V. The handles of the control panel are set up so that the performer can manipulate three handles simultaneously with one hand, while it is possible to depict from one to six stationary or moving forms separately or in groups on the screen. Practice in light music has shown that this number of images projected simultaneously is sufficient and has been confirmed by psychology: the human mind can simultaneously recognize no more than six to seven independent objects in a field of vision.

The control board of "Kharkov" contains the corpus, a commutation panel, a keyboard panel

with four switches, contol levers, autotransformers with a mechanical rod and counterbalance, a stand, switches for the remote control of the light in the hall, a magnetaphone, motors of projection cells and pedals for switching on instantaneous flashes. The panel is in front of a flat screen of the size 4 x 3 m. Over the control board at a height of 3.5 m is a cassette with dozens of square light projection cells. The distance from the projectors to the screen is 5 - 7 m.

The projection cell's corpus is made of steel 0.5 - 0.8 mm. thick. A permanent magnet is fastened on the butt end of the socket of the lamp, allowing it to be fixed in any position at any point in the cell behind the revolving drum. The possibility of moving the lamp is very important, since the position of the incandescent thread of the lamp in relation to the slits on the drum determines the nature of the design of the light projection on the screen. The drum is revolved by an intermediary moving gear consisting of two multi-staged pulleys and a reducer with a small belt run by a motor working by a constant current. The back part of the corpus has been cut out in advance near the reducer, and the entry axle onto which the pulley is placed, has been opened. On the discharge axle of the reducer inside the corpus there is a loop for fastening the drum, and above and below the drum are hooks. This suspension of the drum broadens the possibilities of dynamic light projection. On the outlet of the projector is a light filter and a stationary stencil.

Since the walls of the drum move in opposite directions, the beams of light from the lamp pass through the crack formed by two oppositely moving slits. The crack continously changes configuration. The movement of forms on the screen is rhythmic. This double modulation of the beam of light makes it possible to obtain light projections which are distinct from the design of the slits on the drum itself.

The stationary stencil (stator) plays a double role; it either limits the area of development of a given form on the screen, enclosing it in a contour, or transforms its original form even more (if it contains tiny holes). A light filter is attached close to the stator.

The form-shaping rotors and stators are made of thick Watman paper. The slits are either cut out by a scalpel or burned out, and the slits can be straight or curved lines. Burning out is better, since it makes it possible to produce large slits as well as tiny lacelike slits. Prepared drums with lids pasted in on both sides should be painted black for increasing the contrast of the image on the screen and should be saturated with a special component preventing flare-up.

Besides round form-shapers, one can use conical, prismatic, elliptical, and other forms. The bare drum can be filled with strips of colored transparent film (rods, wires, etc.), which make it possible to change the texture of the light image.

The "palette" of the light artist is enriched by three-dimensional form-shapers, which are spatial constuctions inscribed in the contours of the drum. These can also be suspended thin rods oscillating when revolving, and then depending on the diameter, number and frequency of revolutions, there is a flickering of the image, whose contours depend on the design of the slits in the stationary stencil. It is impossible to replace this flickering with an electric modulation of the light source itself, since such a form-shaper, besides producing a flickering effect, creates a basic change in the structure of the light-dynamic image itself.

THE LIGHT MUSIC INSTRUMENT "POLTAVA"

Great possibilities were discovered in using the optical output instrument based on shadow projection with disc rotors. Since 1963, Zorin has been experimenting with them, putting them at the basis of several light music instruments "Poltava" of different power and size. Generally speaking the instrument consists of a corpus with four rotating lamps and a form-shaping disc.

Four lamps are set on the disc of the lamp holder. They can be put at different intervals from the center of the disc. When two diametrically opposite lamps are burning, and when the form-shaper revolves, there are two light images on the screen moving in opposite directions. They are distinct in form from the slits on the form-shaper, since the thread of the lamp has a specific length and configuration. A stationary form-shaper as well as a light filter are in a special cassette, set close to the turning form-shaper.

The lamp holder is fixed by a screw to the plug in any position. The distance between the lamps and the form-shaper which determines the size of the forms on the screen as well as the sharpness of the

image can be changed. The lamps can be turned on individually or in groups. When two diametrically opposed lamps are burning and the form-shapers are revolving, the light images move in opposite directions.

As a result of many years of experimentation, Zorin could produce a construction of a projection cell with double drums. In a cylindrical corpus with a light projection window, two form-producing drums are set with a very slight gap between the cylinders. Both drums revolve in opposite directions around a common shaft. The drums can easily be extracted from the bottoms and turned 180 degrees.

The construction of the cell with a "double drum" makes it possible to control the scale of imagery with a moving lamp relative to the wall inside the drum. The vertical movement of the lamp holder is also possible, which is used both with adjustment of all light projection cells and with a reduction of the image on one screen, as well for a mixture of light images. The manipulation of the source of light with a prepared optical output instrumentcan are done by hand, but during the concert it is best to do it by remote.

The constructor also tried using an independent drive for the external and internal drums. This allowed him to turn the drums not only in opposite directions but also in the same direction, while the speed of turning each one could be varied. A unique effect of "running" light forms was the result.

The form shaper is made of metal foil on which a drawing was produced by photo-processing and then etched. For increasing the hardness along the circumference of the cylinder above and below, steel wire with a diameter of 1.5 - 2 mm was soldered on. The drums can also be made of colored film, and glass cylinders can be used.

LIGHT MUSIC INSTRUMENTS ON THE BASIS OF STANDARD SLIDE PROJECTORS

Slide projection in light music is achieved by the application of complex models and constructions. However, much simpler means can be used - with the aid of two ordinary slide projectors directed onto one screen. One must work with slide cassettes and special double channel regulators of brightness working in a "flow" regime.

If pure color filters are put in the slide frames instead of slides and the slide projectors are turned on in alternation, and the brightness in each is changed smoothly from minimum to maximum and back again, one can obtain practically any dynamics of color on the screen.

The change of slides in each projector should take place when the projection lamp is turned off. The sequence of changes of color is established in advance by selecting the order of light filters in the cassettes.

This light music instrument is easy to use because the color slides can easily be changed and their place in the cassettes can be shifted, correcting the color score of the piece. The number of slides in the cassette is usually 36 or 50, so that their number is doubled when using two projectors. The light filters can be film transparencies or gelatin.

The possibilities of the light music instrument based on slide projection is limited, and if one works with formless colored slides, then the picture on the screen is somewhat more effective when using several projectors with a dispersal and overlay of fields of projection. By changing the brightness of each of the projectors, one can obtain interesting combinations of colors in overlapping zones.

The slide projector light music instrument is best used for reproduction of more complex light compositions with the "flow" regime, but the element of form must be introduced, a drawing (for light music this drawing is usually abstract). Abstract slides can be made by a flowmaster, colored lacquer (transparent celluloid lacquer, or other kinds) on film with wash or fixed emulsion later without developer. The drawing may be made "by hand" or produced by different chemical, mechanical and optical means. Slides of frost patterns, for example, can be made from a solution of hyposulphate or urea, put on the film (or on thin glass). Mosaic application of small pieces of light filters pressed between two thin pieces of glass provides an interesting effect.

One can also make slides using photography. Not only an abstract picture, patterns or ornaments can serve as an object for this purpose, but also objects from nature photographed in an unusual way: a close-up of tree bark, granite, sand, a microsection of plants, the microstructure of metal, liquid crystals, etc. It is possible to use different special photo attachments such as filters, prisms, and "smear" movement while shooting, shooting out of focus, etc. Developing the film and printing it pro-

vide possibilities such as solarization, double exposure in copying, negative copying, etc

An interesting effect is obtained with "Lantern Magic" - slide combinations with images of actors who performed "live." One can also print a black and white slide from a colored slide and put them in mixed cassettes - and the black and white photo of a rose slowly turns into a colored rose. This image then is transformed into pure color and is extinguished (in the cassettes corrspondingly there is a light filter, and behind it - an opaque slide of black paper). The combination of realistic and abstract slides produces another interesting effect.

One variant of a light music instrument based on slide projection was constructed by Zorin and B. Nesterenko. A universal holder of the lens must first be produced, with a standard thread of 42 mm. This makes it possible to use any lenses with the required focus in each particular case. The upper lid is from the projector "Svitiaz-M," since there is a window in it for an attachment allowing slide films to be shown. Instead of this standard attachment, another one has been developed, making it possible to transform the apparatus into a light-effective projector. Inside the attachment, a ring, which may be out of negative black and white film with a drawing imposed on it by the contact method, revolves at different frequencies and in different directions by means of an additional motor. In the frame window, opposite sides of this ring are pressed toward each other and move in opposite directions at a distance of about 1.5 mm. The lens focuses on a point between the layers in order to slightly wash out (blur) the image of each layer, otherwise it will be too sharp in contour. The supplementary unit makes it possible to control the change of the shape's color remotely. When the disc of light filters revolves, signals from the control panel arrive from six different sectors blocking the beams coming out of the lens. The disc of light filters moves in different directions at different frequencies with energy from an independent motor. Units controlling the brightness of the lamp and the rotation of the rotors of both motors are set on printed chips and are mounted inside the projector. If a rotor is made so that its transluscent zone is placed close to the focal surface of the film channel, then the stators can be placed in the slide frames and delivered into the film channel automatically, with a signal from the control panel. Both the stator and rotor are made of contrast film, black paper in which the required drawing has been cut out or burned out, or of thin copper foil. The stator with its light filter is put into the slide frame. Thus one modernized slide projector can replace 36 (or 56) regular sequentially operated large light cells of a shadow projector. This type of projector must work in a "flow regime" with several other similar projectors having rotors with other drawings. One can also reverse the rotors and change the speed.

LIGHT MUSIC INSTRUMENTS ON THE BASIS OF LENS PROJECTION

A good example of light music instrument on the basis of lens projection is "Prometheus-3" (Galeev, Saifullin, V.P. Bukatin). It is in the Kazan studio of light music and works with a flat rear projection screen of the size 5 x 2.5 m. It has a 12-channel control board with the same control levers as "Kharkov." In the control board, nodes of the standard theater light regulator "Sputnik 12" are used. At the output of each of the 12 power control units which form the light regulator is the 6-channel commutational instrument, making it possible during a light music concert to connect any of six light projectors that go with it, and in any combination. Thus the general number of projection instruments in the light music instrument is equal to 72. The artist controls the performing mechanisms of the commutational instrument with the control panel directly during the performance. He also directs the performance mechanisms in the optical output instrument from the control panel. All signals of the control can be transcribed in a memory instrument.

The optical output instrument contains projectors based on different principles of action - some are based on lens projection. The projectors are combined with standard nozzles containing two cassette frames with a wavy wire network, moved backward in the film channel, with a shift of the phase of one relative to the other. In theater the attachment is used for projecting images of water. The texture changes if to this network one adds drops of transparent resin on a wavy wire fastened on it which has tiny pieces of film, light filters, thin wire, threads, etc.

The picture becomes different when the square cassette is turned 90 degrees. Any variety of flat

optical material can be placed into these cassettes (different textured relief glass, heat resistent film with a dotted or liner network, tin foil with tiny holes cut out in various shapes). The movement of the cassettes creates unexpected light patterns - twinkling stars, light waves, etc. When tiny capron or metallic nets are put in them, the screen turns into a "canvas" on which it is possible to "paint" with other projectors.

The nozzle works with one condensor, but with two lenses next to each other. The stencils - discs turning co-axially - usually are made of thin aluminum or painted glass. Any structural transluscent materials are applicable here. There is also a supplementary effect; the combination of clear projection with one lens and out of focus projection in the other. Sometimes discs of multcolored filters are placed in front of the lenses. In all these projectors, light filters and stationary stencils can be fastened which are applied to reproduce contour images projected on a plain or textured background. The structure of the static image participates in the formation of the projected image.

There is also a kaleidoscope nozzle (with 3-, 4-, 5- and n-faceted mirror prisms). The base of the prism is attached directly to the revolving stencil. The length of the prism must be equal to 0,95 of the length of the focus of the lens. Besides lenses making it possible to project the most complex changing kaleidoscope pictures of various degrees of symmetry on the screen, there are also special deforming lenses which can be attached. For this purpose, cylinders of smooth or embossed mirrored film are put inside the tube, then any projected image is surrounded by wavy amorphous aureoles.

With another machine, bright and contrasting projections can be produced if large round holes on two disc rotors are covered with lenses. The lenses and holes project moving and deformed images of shining threads of a lamp on the screen. The deformation is quite complex, since the lenses and holes "chase" each other in different combinations, and the projection is unrecognizably transformed. On a close screen the image will be different than on an external distant one. In "Prometheus 3" a complex of several optical output instruments of this instrument was used. By having a set of different filters, different lenses and shadow stencils, choosing lamps with different shaped threads, and putting the threads at different angles, one obtains very interesting visual effects.

SPATIAL MUSIC

Spatial music is a term applied to the possibility of free and smooth movement of the sound of specific instruments according to any trajectories on a flat or three-dimensional screen according to laws of musical dramaturgy (with repetition, an emphasized melodic curve, visual thematic development with which the instrumentation is closely connected). Usually "spatial music" is always combined with light music, amplifying the effect.

The signals from a sound producing instrument are distributed according to corresponding independent control panels. Each control panel contains receivers of light and the radiator of light placed over them. Under the action of light, on output, the receivers form shifted signals being fed at the input of the amplifiers. After amplification, the sound signals are produced through corresponding loudspeakers - the acoustic output instruments distributed around the hall. Depending on what sequence the controls will reproduce on the data units in the control panels, the sound will move corresondingly from one loudspeaker to another. The loudspeakers in the hall are placed on walls, in the floor and ceiling in such a way that in the passage of sound from one loudspeaker to the next there is a smooth change in loudness. Control panels of light are placed in the same order as the loudspeakers in the hall.

On the control panel of another instrument there are photoresistors included in a chain of controls by regulated amplifiers of the sound signal. The operator has a flashlight which forms a spot of light with brightness decreasing toward the edges. Depending on the level of illumination of the photoresistor, the loudness of sound changes in the loudspeakers of the corresponding channel. The size of the spot of light and the distribution of the photo-resistors on the control panel are selected so that at one time not more than two photo resistors can be illuminated.

LIGHT MUSIC INSTRUMENTS FOR FILM AND TELEVISION

In 1965 the first light film, "Prometheus," (music by Alexander Scriabin) was shot in the USSR. It might appear that the simplest method of making a light music film would be to shoot a prepared light composition from the screen of a light music instru-

ment synchronically with the recording of the music. However, this composition looks quite different on the screen - the nuances of color dynamics is lost, the brightness of the screen is limited, and most important, the effect of audience presence which usually accompanies a performance at light music concerts is lost. The light conception of Scriabin's "Prometheus" was realized on film differently than on the screen of a light music instrument. The technique of film makes it possible to obtain a very complex image if the light music film is shot in episodes, using special methods in shooting, processing the film and printing it. The fragments are then mounted into a single film tape and combined with music.

For shooting a light music film one uses a a rear screen on which the instrument from one side projects the show while the camera on the other side is filming it. The light effects are produced to the accompaniment of music based on a scenario and plan of a regisseur. One may also use an oscillograph as the screen of the shooting model, on whose inputs signals from the controlling generators fall.

The deforming optics - slowly oscillating lenses, numerous prisms, diffusion filters - make it possible to transform the light images. For example, simple glass covered with a thin layer of vaseline and put in front of the camera forces a brightly lit spot to emit sparks.

Another possibility for making the light images more complex is during the printing process - the mixture of several negatives, corrections for brightness and color, the use of solarization during the development process, etc. Complex graphic drawings are created by animation.

In the most recent films of the "Prometheus" group - "Cosmic Sonata" and "Light Music" to the music of G. Sviridov's "Small Triptych" - the following elements were used: optical mechanical projectors with disc stencils and three-dimensional stencils, lamps with shaped threads shining through a lens; horizontal and vertical cuvettes with different liquids, through which air was blown; a layer of iron filings controlled by a magnet; a set of crystals; an oscillagraph.

The basis of the technique is the individual optical output instrument of the light music instruments discussed earlier. By using small objects, it was possible to use effective techniques of "electronic graphics" formed on the screen of a two-beam oscillagraph with the aid of a special electronic block controlled by operator contructor V.V. Golovkov. Each of the beams is controlled autonomously for brightness, thickness of line, degree of focus, the type of drawing, and speed with which the Lissage image is revolved on the screen. A normal oscillagraph is not colored, but it is possible to shoot the image through colored filters, in this way coloring the "electronic graphic" on the film itself in any required color. Also, if one believes, that the movement of lines is the most important in light music, corresponding to the melody in music, black and white light music films can also be shot. The instrument of the "electric graphic" can also be used in combination with a laser oscillagraphic scan, so that the possiblities of this instrument can be used in light music very widely.

The resulting interrelationships between light music and television is quite unique. Light music can be translated through video and programmed light music instruments can be used for producing video programs. But the specific possibilities of contemporary video technique make it possible to use light music in unexpected variants. The video camera, like the film camera, can perceive light music images produced with small optical output instruments. Another camera can work, for example, with the orchestra and singer and through a special mixer "imprint" their image into a light music image (method of "electronic incrustation") analogous to the method of a "wandering mask" in film, but in video this "imprinting" can be realized instantaneously. The neutral background on which a singer is standing, for example, is blue and can be replaced by another image.

In any telecenter there are so-called control panels (generators) for special effects. It is possible to transform these control panels into video light music instruments by "modulating" their standard signals by an external signal, including a musical one. It is also possible to create and connect special intruments related to light music to a video track. Thus in programs of the Kazan TV, a synthesizer of light music images developed by the "Prometheus" group, called the "Electronic Artist" (constructed by Bukatin and Saifullin) was applied, which can be linked by the TV viewer to his own color television. The basic element of the synthesizer is a set of generators divided into two groups - basic and supplementary. The basic group forms the image of the given configuration on the screen. The supplementary makes the received image more complex by

reading their signals from the signals of the basic. The signals of each can be controlled within broad parameters.

OTHER ASPECTS OF LIGHT MUSIC

Another important author who has written on light music in the Soviet Union is F. Yurev, who published his book, *Light Music in Kiev,* in the Ukraine in 1971. He discusses the possibility of using different light instruments - a tube, a pyramid, a disc emitting color - forming a light music orchestra. Each instrument could light up at different times or in combination with each other. He also discusses "isoliterature," where letters of a poem, for example, may appear on the screen in color. The background can be colored, or a phrase, individual syllables, or letters may appear in color. Different styles of script can be used, each with its own psychological and cultural associations. The duration - how long - each of these components remains on the screen is another factor in the effect produced. This event resembles a visual recitation of the poem - instead of intonation and stress, each letter or word may scream, sing, or flow with tenderness based on its visual realization. In this way the light artist interprets the emotional content of the poem.

Yurev also discusses the problems of how a color range can be tempered in the way that the Western musical scale is. Man can perceive more than 10,000 nuances of color, but only some will be selected to be used in a light music composition. Yurev suggests different ways of producing scales and chords based on various color combinations. The colors also have to be measured in a standard way so any light artist anywhere will be using the same set of colors for a particular light composition.

Transcription is another problem that Yurev tries to solve. One way is to use musical notation, for example, a color is noted down by a letter (R = red, etc.) and the exposition of the letters on the staff indicates the specific nuance of color, while Roman numerals indicate intensity. Yurev's own interpretation of Scriabin's "Prometheus" is transcribed in bars of color which are transcriptions of "light chords" synchronized with different passages of the music.

V. Briusov, a famous Russian poet at the turn of the century, said: "A new art may arise. I dream about such an art for the eyes, like sound for hearing, about changing combinations of outlines, colors and fire." Today we are seeing the realization of this dream.

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