This article, provided by John Schmul, was published in the August, 1941 issue of the Journal of the Society of Motion Picture Engineers. You have to get mad at people like Hitler and Tojo for starting WWII, because stereophonic sound would very likely have become commonplace five to ten years before it finally appeared on any scale. The article is extremely technical and there are no pictures of Mickey Mouse. You have been warned. MBH

FANTASOUND

WM. E. GARITY AND J. N. A. HAWKINS

***Summary.*–This paper discusses the multiple-speaker system known as "Fantasound," currently used with Walt Disney's "Fantasia."**

First are discussed some of the deficiencies of conventional sound-picture reproduction, and then a very complete history of the Fantasound development. In addition, are described in considerable detail the various important elements of the system.

The art of sound-picture reproduction is about 15 years old. While an engineer familiar with the complications of sound reproduction may be amazed at the tens of thousands of

trouble-free performances given daily, the public takes our efforts for granted and sees nothing remarkable about it.

Therefore, we must take large steps forward, rather than small ones, if we are to inveigle the public away from softball games, bowling alleys, nightspots, or rapidly improving rad reproduction.

The public has to hear the difference and then be thrilled by it, if our efforts toward th improvement of sound-picture quality are to be reflected at the box-office. Improvement perceptible only through direct A–B comparisons have little box-office value.

While dialog is intelligible and music is satisfactory, no one can claim that we have even approached perfect simulation of concert hall or live entertainment. It might be emphasized that perfect simulation of live entertainment is not our objective. Motion picture entertainment can evolve far beyond the inherent limitations of live entertainment.

Before discussing the operation of the Fantasound equipment, some deficiencies of conventional sound-picture reproduction may be summarized:

(a) Limited Volume Range. **– The limited volume range of conventional recordings is reasonably satisfactory for the reproduction of ordinary dialog and incidental music, under average theater conditions. However, symphonic music and dramatic effects are noticeably impaired by excessive ground-noise and amplitude distortion.**

(b) Point-Source of Sound. **– A point-source of sound has certain advantages for mon-aural dialog reproduction with action confined to the center of the screen, but music and effects suffer from a form of acoustic phase distortion that is absent when the sound comes from a broad source.**

(c) Fixed Localization of the Sound-Source at Screen Center. **– The limitations of single-channel dialog have forced the development of a camera and cutting technic built around action at the center of the screen, or more strictly, the center of the conventic high-frequency horn. A three-channel system, allowing localization away from screen center, removes this single-channel limitation, and this increases the flexibility of the sound medium.**

(d) Fixed Source of Sound. **– In live entertainment practically all sound-sources are fixed in space. Any movements that do occur, occur slowly. It has been found that by artificially causing the source of sound to move rapidly in space the result can be highly dramatic and desirable.**

It is felt that Fantasound provides a desirable alternative to the four major deficiencies ju described.

There have been other attempts to provide increased volume range and a broad sound-source. It appears that three separate program channels are an essential part of any solution to these sound problems. The matter of maximum usable loudness in the theater is closely related to the number of separate program channels used.

Three channels sound louder than one channel of three times the power-handling capacity. In addition, three channels allow more loudness to be used before the sound becomes offensive, because the multiple source and multiple standing-wave pattern prevents sharp peaks of loudness of long duration.

Three tracks and program channels have other advantages over a single-channel : Cross-modulation between different sounds can be greatly minimized. Dialog, music, and effects could conceivably be placed upon separate tracks. It should be pointed out t single-frequency steady-state measurements of amplitude distortion do not necessarily give an indication of the amount of cross-modulation that may be present in a single channel. It has been found that low-frequency transients, caused by even-order overtones, can cau objectionable cross-modulation at levels somewhat below the nominal peak overload point of the amplifier.

For economic reasons, it is almost impossible to eliminate this source of cross-modulation from single-channel reproducing systems. It is a simple matter to isolate conflicting program material on a three-channel system.

The use of three program channels allows phase differentiation to supplement amplit differentiation in obtaining directional perspective. The phase differentiation also minimizes trouble with acoustic interference in the theater, which often accompanies attempts to us multiplicity of horns on a single program channel.

THE DIFFERENTIAL JUNCTION NETWORK

The first step toward Fantasound occurred when we were asked to make a sound move back and forth across the screen. It was found that by fading between two speakers, located about 20 feet apart, we could simulate a moving sound-source, provided that the total level in the room remained constant. It became obvious at once that simple mechanical ganging of the volume controls feeding the two loud speaker circuits was not capable of producing the desired effect.

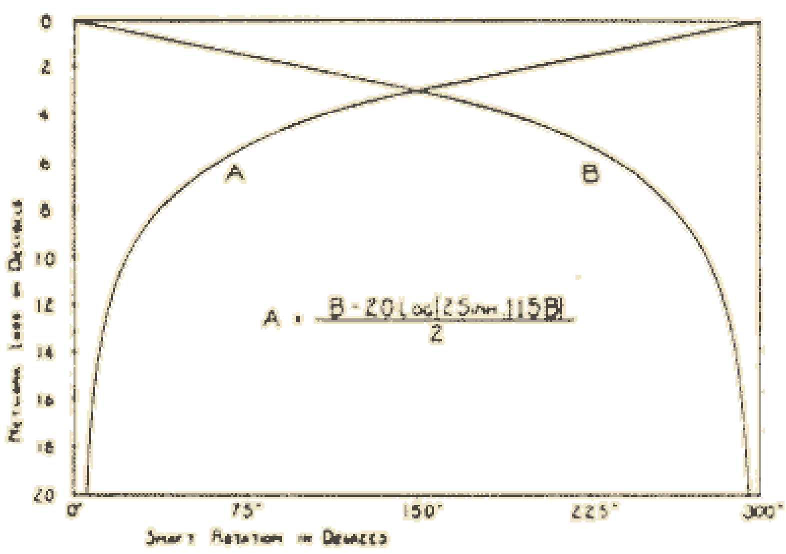

Fig. 1. Curves showing loss *vs.* shaft rotation of a typical two-circuit differential junction network. The cross-over point for the two losses is at −3 db.

A special two-gang volume-control was then designed with complementary attenuations in the two circuits such that the sum of the attenuations, *expressed as power ratios*, equaled a constant. The formula for the relationship between the two attenuations is:

$$A = \frac{B - 20 \log (2 \sinh 0.115B)}{2}$$

where A and B represent the two attenuations, expressed in decibels. Typical attenuation curves are shown in Fig. 1.

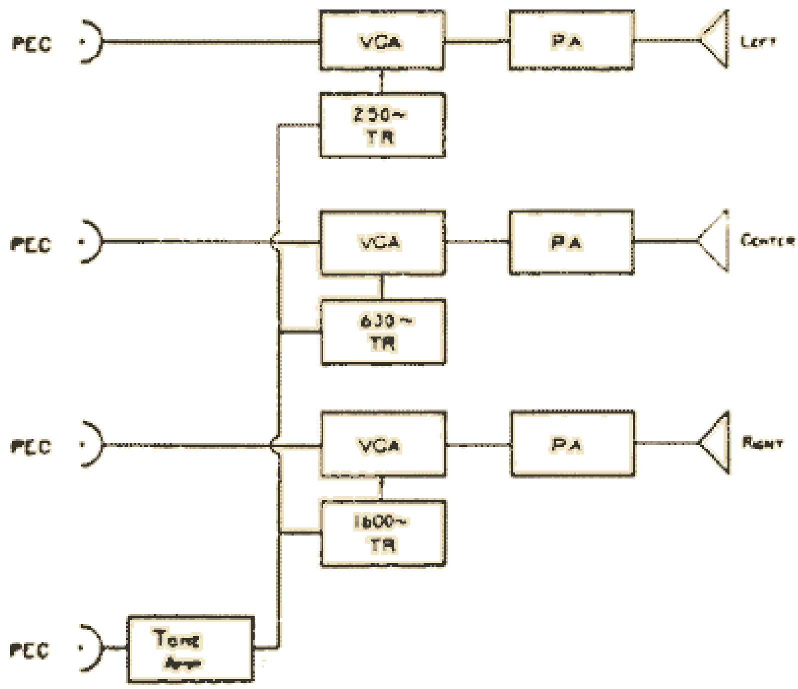

FIG. 2. Simplified block diagram of the Fantasound reproducing equipment.

Many uses have been found for this type of network. It is extensively used in our Fantasound re-recording system to make constant output fades possible. A special 3-circuit differential junction network, nicknamed "The Panpot," is used to dub one original track onto one, any two, or all three of our Fantasound program tracks with smooth transitions and any desired level difference. Thus we simulate a moving sound-source by starting on either side-track and progressively moving the program material through the center-track to the other side-track. This move through three tracks, and thus three horns, is made smoothly by maintaining constant the total output of the three trac* and horns, regardless of the distribution among the three program circuits.

The simple 2-circuit differential junction network has been used to make smooth, constant-level fades between two sound-sources. It also has been used to vary the ratio of close to reverberant microphone pick-up without affecting the output level. It was found to be a convenient means of controlling reverberation.

FANTASOUND REPRODUCING EQUIPMENT

A simplified block diagram of the reproducing equipment is shown in Fig. 2. On the left are shown the four photocells which scan three program tracks and a pilot control-track. Each program photocell feeds a variable-gain amplifier, then, through power amplifiers, the three-stage horns.

Associated with each variable-gain amplifier is a tone rectifier, which selects one of the three pilot tones on the control-track, rectifies it, and applies the resulting d-c control bias to the grids of the variable-gain stage. Thus the output from each loud speaker varies with the amplitude of its associated control tone.

TOGAD

The heart, or perhaps we should call it the brain, of the Fantasound reproducing equipment is the tone-operated gain-adjusting device, abbreviated, *Togad*.

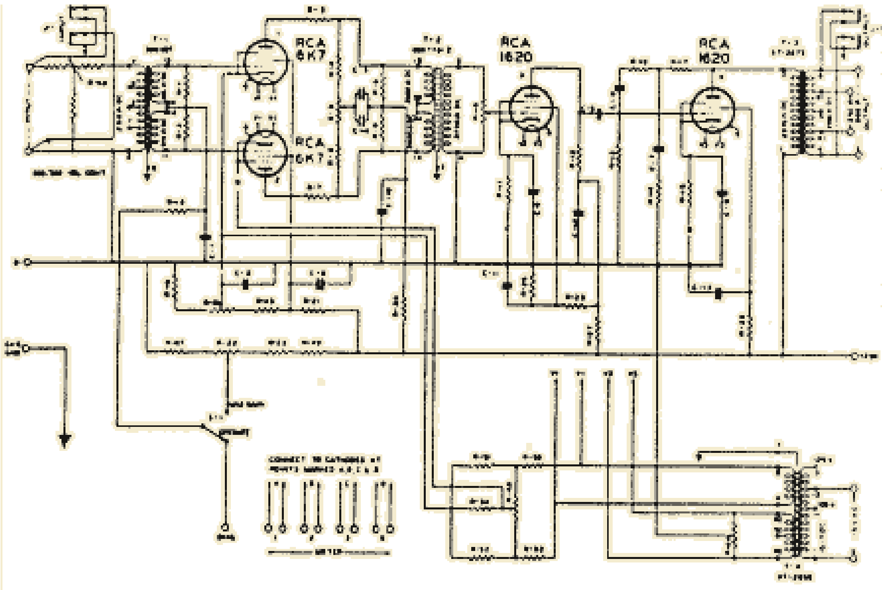

FIG. 3. Circuit diagram of the variable-gain amplifier.

The *Togad* equipment is composed of two units-the variable-gain amplifier and the tone rectifier. A sine-wave control-tone is applied to the input of the tone rectifier, where it is transformed into a d-c bias voltage. This d-c bias voltage is then applied to the variable-gain amplifier to vary its transmission. The equipment is arranged so that a 1-db change in tone level causes a 1-db change in program transmission through the variable-gain amplifier.

***Variable-Gain Amplifier.*–The variable-gain amplifier, abbreviated, *VGA*, is a single stage of transformer-coupled push-pull pentode voltage amplification (Fig. 3). Its transmission is a function of the d-c bias applied to its grid circuit. A variation of 50 db in the transmission through the VGA can be effected by changing the bias.**

A two-stage, single-ended voltage amplifier follows the variable gain stage and the three-stage unit has a maximum gain of 58 db and maximum power output of +6 db above milliwatts.

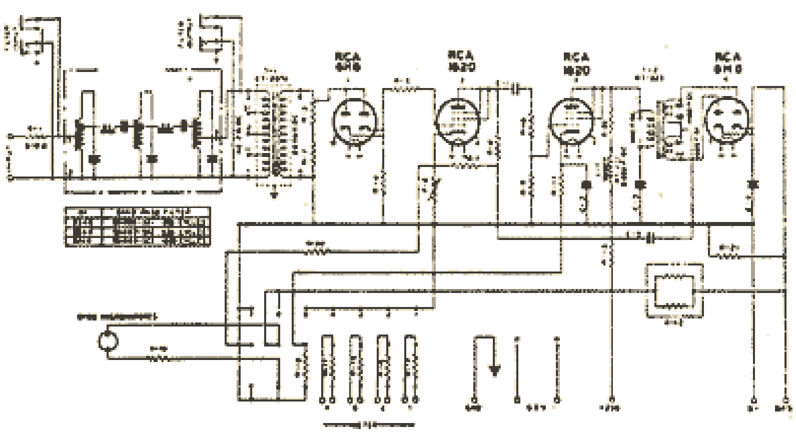

FIG. 4. Circuit diagram of the tone rectifier.

The circuit features of the variable-gain stage include a balancing potentiometer in the plate circuit to balance out tone cross-talk; a loaded cathode resistor to provide high initial bias

and low transmission in the absence of tone; and switches and bias potentiometers to test and adjust the bias-gain characteristic of the 6K7 variable gain stage.

Normally, the maximum level applied to the *VGA* input terminals is about -45/0.006w, although up to about -30/0,006w the distortion is not excessive. Hum and tone cross-talk at this point are well below tube hiss.

The change in transmission, with bias, is the result of two effects occurring simultaneously. Raising the bias lowers the mu of the tubes, thus reducing the ability of the tubes to amplify. Raising the bias also raises the internal plate resistance, which increases the ratio of mismatch between the plate circuits of the tubes and the relatively low load resistance into which the tubes look. The combination of these two effects makes the transmission a complex inverse function of the bias.

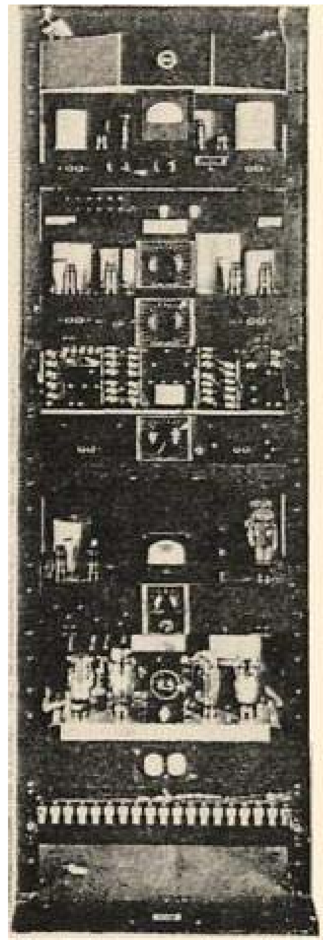

FIG. 5. Program rack with front cover removed.

It might be noted that screen and bias regulation have a marked effect upon the bias-transmission characteristic. The external control bias, obtained from the tone rectifier, is used to "buck out" a semi-fixed bias obtained from a cathode tap on the plate supply bleeder.

***The Tone Rectifier.*–The tone rectifier (Fig. 4) contains four important elements:**

(a)

A band-pass filter in the input circuit designed to select the proper control tone and reject noise and the unwanted tones.

(b)

A compressing amplifier, using a 6H6 and a 1620 tube. The output of this amplifier v approximately as the logarithm of the logarithm of its input. The 6H6 half-wave rectifier cuts off the negative half-cycles of tone and the remaining positive half-cycles are applied to the grid of a 1620 triode functioning as a grid current compressor. Contact potential and gas current in both 6H6 and 1620 tubes are balanced out by the variable cathode-bias resistor in the 1620. This particular log-log amplifier was devised by Kurt Singer.

***(c)* A 1620 triode amplifier, transformer coupled.**

***(d)* A 6H6 full-wave rectifier, whose d-c bias output is fed to the variable gain amplifier.**

There are many time-constants in the *VGA* and tone rectifier which contribute to the total "operate" and "restore" time-constants of the combination. However, all but the time-constants associated with the 6H6 rectifier ripple filter are so small, relatively, that they may be neglected. The *RC* products of both charge and discharge circuits are approximately equal and the "operate" and "restore" times are about 15 milliseconds.

Fig. 5 shows most of the equipment used in one program channel. The topmost panel contains a pilot light. Below that is shown the tone rectifier unit. Next below is the variable-gain amplifier, which has two volume-control knobs in the center. Immediately below the *VGA* is an equalizer panel. Below that is a volume-control panel, and next below is a 20-v power-amplifier. The lowest shelf contains a regulated plate supply.

In addition to the equipment shown in this rack, a program channel normally includes a single stage of preamplification ahead of the *VGA* and a 60-watt power-amplifier following the 20-watt amplifier. The front cover, normally used on this rack, is not shown in Fig. 5.

MULTIPLE-TRACK FILM-PHONOGRAPH

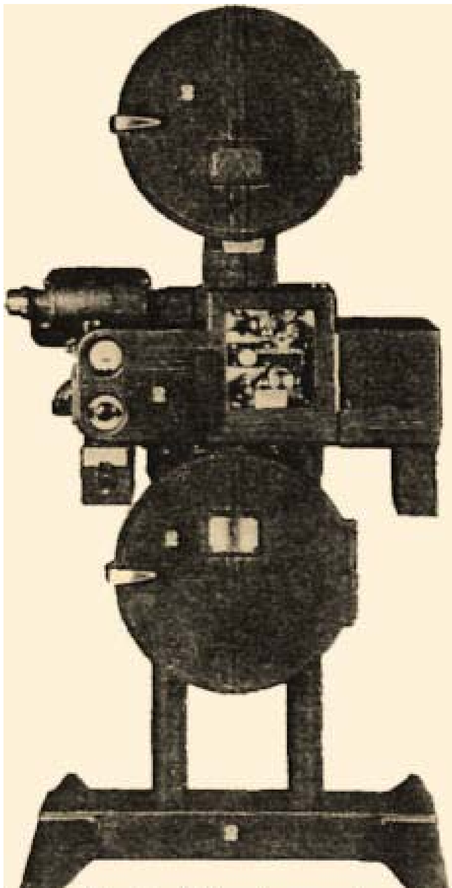

Fig. 6. Film-phonograph

This film-phonograph, shown in Fig. 6, scans four 200-mil push-pull sound tracks simultaneously on one 35-mm. print. It is driven in synchronism with a picture projector by means of a selsyn interlock system. The lamp and film compartments are shown in Fig. 7.

Film Drive.–The sound-tracks are scanned on a curved film-gate. Constancy of film movement is obtained by the use of a magnetically driven drum which draws the film down over the gate. Flutter measurements indicate that this is a highly satisfactory driving and scanning arrangement.

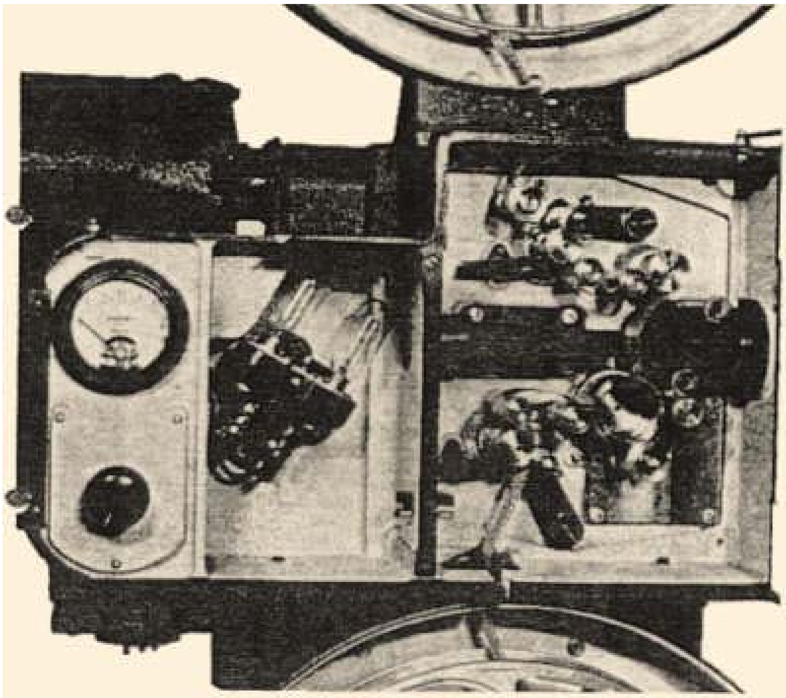

FIG. 7. Lamp and film compartments of film-phonograph.

***Optical System.*–A single 10-volt, 5-ampere exciter lamp mounted in a double holder in the left compartment of the sound-head provides the illumination. All four sound-tracks are scanned simultaneously by a single optical system of the slitless type. The optical train consists of a light-collecting optical system which images the lamp filament as a long beam of light 1 1/4 mils high across the four soundtracks. The illuminated image of the sound-tracks is then projected by a camera and cylindrical lens system onto four multiple beamsplitter lenses which, in turn, focus each half of the push-pull soundtracks upon the respective cathodes of four push-pull phototubes (Fig. 8).**

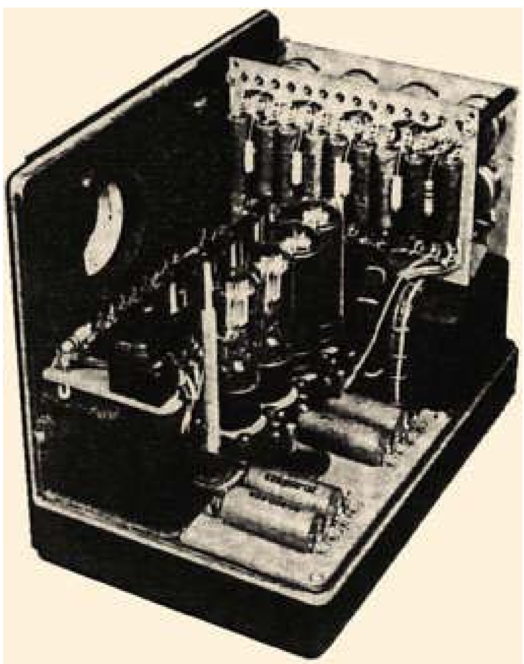

FIG. 8. Phototube compartment of film-phonograph.

OPTICAL PRINTER

The Fantasound optical printer is designed to print four double width sound-tracks side by

side across the useful area of a 35-mm film, from negatives having a standard width sound-track in the standard location. The way in which this is accomplished may most easily be explained with reference to Fig. 9, which shows the printer threaded for operation in or direction. The negative passes around under the upper drum and is illuminated by an illuminating system enclosed in the lamp-house. Below the upper drum is the optical system which projects an image of the sound negative upon the positive raw-stock running over the lower drum. Each scanning drum is driven by a magnetic drive. The optical system projects an image of the sound negative upon the positive film travelling on the lower drum. This image is enlarged in the lateral plane but not enlarged in the longitudinal plane of the film.

***Traversing Mechanism.*– On the left of the upper mechanism (Fig. 9) is the traversing lever which controls the position of the image on the positive raw-stock. By raising this lever and moving it forward and backward, the entire upper mechanism and optical system are moved forward or backward across the film to be printed. The traversing mechanism provides four locking positions for the upper mechanism spaced 0.200 inch apart so that the resulting sound-tracks are spaced 0.200 inch apart on the print.**

***Reversing Mechanism.*–The printer is designed to print negatives either forward or backward; *i. e.*, either "heads" or "tails" out, at 90 feet per minute. It incorporates simplified threading in that regardless of the direction of printing, the threading is always done in one standard manner with tight film loops. Then by operating one lever, the correct film paths and loops are formed for either direction of film travel.**

Fig. 10 shows the threading position. In this view, the arrow shaped lever is shown in a vertical position. With the reversing lever in this position, the four loop-forming roller guide-rollers, and pressure-rollers assume the positions shown. The negative and raw-stock are threaded as shown, over the sprockets, loop-forming rollers, and drums. It will be noted that the film loops are fairly tight when the sprocket pad-rollers are closed. Also, on each side of each drum, the film lies between the flanges of a guide-roller.

***Automatic Blooping.*–Automatic blooping of splices is provided on the printer. Two blooping switches are shown in Fig. 9. These switches are designed to close when a double thickness of negative at a splice passes the switch rollers. When printing to the left, the right-hand blooper switch operates; whereas, when printing to the right, the left-hand switch operates. In either direction, when the portion of the printing stock on which the image of the splice will fall, passes the end of the blooper tube (Fig. 9), the light in the blooper tube lights and blacks out the image of the splice. A time-delay mechanism synchronizes the bloop and the splice. In series with the blooper lamp is the blooper indicator lamp, also shown on Fig. 9.**

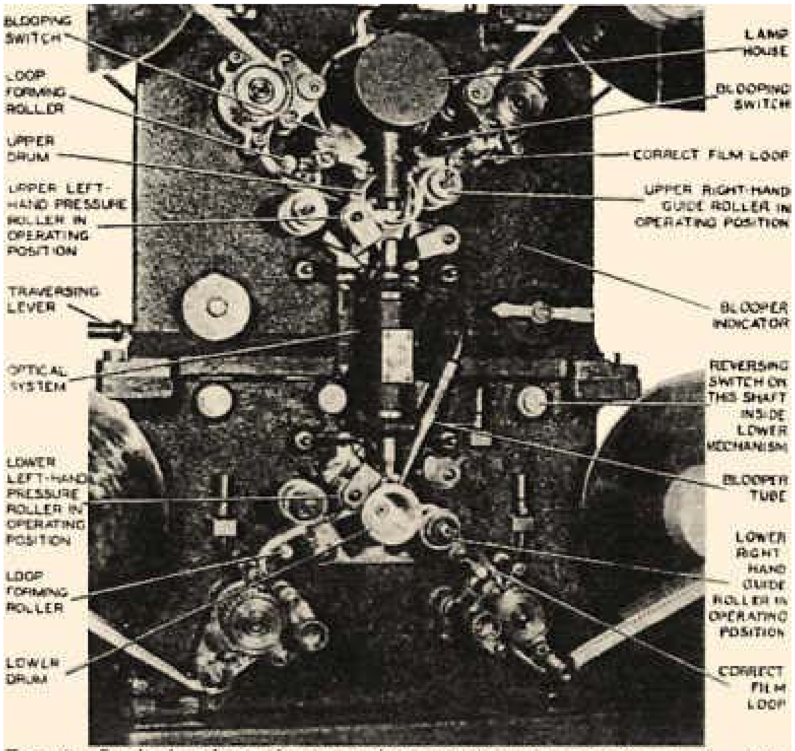

FIG. 9. Optical printer in operating position for printing to the left.

***Direction Indicator.*–On the lower right-hand sprocket is mounted a small lamp-house for exposing an arrow-shaped image on the guiding edge of the print. An arrow-shaped detent is ground on the outer edge of the sprocket and is so arranged that an arrow will appear on the print every 32 sprocket-holes, pointing toward the start, or in the direction of travel of the print when being reproduced.**

***Lamp-House and Optical System.*–The lamp used is the standard 10-volt, 7.5-ampere curved-filament exposure lamp, and is housed in the light-proof lamp-house above the upper drum.**

The functions of the various lenses will be explained, starting at the lamp end of the optical train. The first is a plain window which a prism keeps dust out of the illuminating system. Next is a reversing prism which rotates the image of the filament 90 degrees in a horizontal plane.

The next item in the optical train is the ultraviolet filter, followed by a plano-cylindrical lens which focuses the image of the filament in one plane only upon the negative.

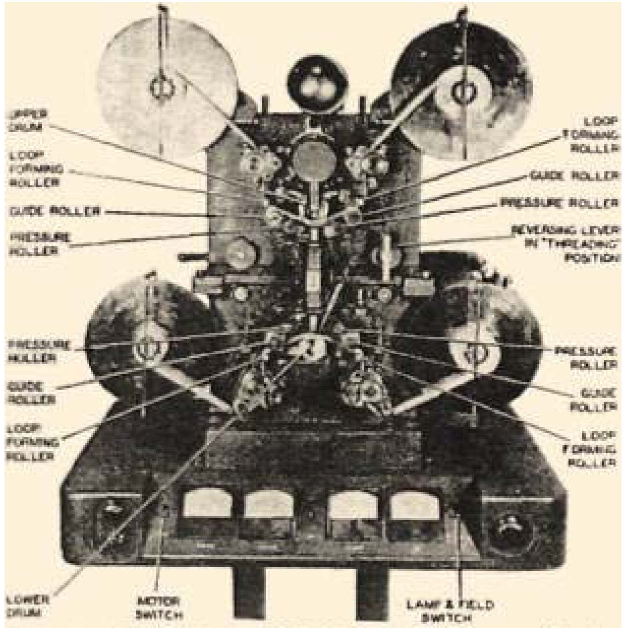

FIG. 10. Front view of MI-3817 optical printer showing threading position

Below the negative is the optical system for projecting the image of the negative upon the printing stock. The top lens system is used to project an enlarged (5 to 1) image of the negative on a plane approximately in the center of the optical system. At the center of the optical system is a condenser lens followed by an aperture. This aperture limits the illumination in both planes and is 0.471 inch long by 0.050 inch wide. The lower lens system images this enlarged image at the center of the optical system upon the printing stock and has a reduction ratio of 5 to 1 in the direction of travel of the film and a little less than 2.5 to I across the film. Thus the image of the negative on the printing stock has a ratio of I to 1 in the direction of motion of the film and a ratio of one to slightly over two across the film.

This printer has proved to be very free from flutter. The 9000 cycle loss from negative to print (corrected for 1000-cycle loss) averages less than one decibel.

HISTORY OF THE FANTASOUND DEVELOPMENT

Fantasound reproduction differs markedly in both results and equipment from standard theater reproduction. It may be of interest to follow the history of the development step by step.

A great many equipment combinations were explored on paper, probably several hundred. Of these, ten different systems have been built up and tried out, up to the time this paper was written, Even though Fantasia has been released, development has not stopped.

The *Mark I* system used three widely separated horns across the stage and horns in each rear corner of the house. Two tracks were used, one feeding the screen horn, or center-stage horn, while the other fed the remaining four horns selectively by means of a four-circuit differential junction network. By manipulating a manual control, the sound could be moved smoothly around the theater. Experiments with this system brought out the advantages of a broad sound-source.

The *Mark II* system was a simple expansion of the *Mark I* system, adding three horns; one on each side-wall about halfway back from the stage, and one in the ceiling at about the center of the house.

These were in addition to the screen horn and four corner horns used in the *Mark I* system. This system used three tracks and a 6-circuit, manually controlled differential junction network. In addition to creating the effect of moving the sound around the theater, the controls allowed side to side movements in any plane between the screen and rear wall of the house. Simultaneous fore and aft control was also available.

Up to this time it was felt that the Fantasia roadshow equipment could be manually operated by a mixer who would go along with each show. He would provide manual volume range expansion as well as control the perspective effects. However, two objections to manual operation appeared. The five controls became rather complex for one man operation and the studio felt that it would be difficult to keep all shows alike, due to the large human element involved.

The use of a pilot tone-control arrangement was suggested to avoid these difficulties, and the *Mark III* system came into existence to study the advantages and difficulties of a pilot tone-control track.

This *Mark III* system was a single-channel *Togad* expander, controlled by either an oscillator or a tone track. Problems of crosstalk balance, tone-program amplitude characterist time-constants, distortion and noise compromise, and amount of range expansion desirable, etc., were attacked.

The *Mark IV* system was identical with the 8-horn, 3-track *Mark II* system, except that Togad control replaced manual control. This system used 8 control-tones on the control track logarithmically spaced from 250 to 6300 cycles, using a preferred number series. This *Mark IV* system was installed in our Hyperion studios in the summer of 1939 and was used for sound and music department research until we moved to Burbank in 1940.

The equipment racks and sound-heads for this system required a floor space about 35 feet long by 4 feet wide. It used nearly 400 vacuum-tubes. All equipment appeared on jacks and almost any conceivable combination could be patched up in a few minutes.

The *Mark V* system, first installed at Burbank, was similar to the *Mark IV* system in that 8 horns, 3 program tracks, and an 8-tone control-track were used. However, by using 8 hybrid coils in the program circuits we obtained a still more flexible system. This system was in operation only one day. The equipment operated satisfactorily and no technical difficulties were encountered. The system failed only because the musical director, the music cutter, and the "enhancing mixer," could no longer remember from one rehearsal to the next, "What should come out where?"

From this extreme of complication, the pendulum swung to the *Mark VI* system, which used 3 stage horns, 3 program tracks, and a 3-tone control-track.

Our first serious dubbing of Fantasia was attempted on this system. Our original Fantasound dubbing set-up required 10 program mixers, each with 3 pots, designated "Left, Center, and Right" positional controls. In addition, 3 mixers with one pot each were used to handle the left, center, and right pilot tones. We soon found that the tremendous number positional mixing cues made it nearly impossible for a mixer to handle 3 positional controls in such a way as to avoid undesirable discontinuities during moves. We then designed differentially ganged 3-circuit pots, based on the differential junction network principle, which greatly simplified the mixing problem. This change allowed 6 mixers to satisfactorily

control '24 program circuits.

The *Mark VII* system was the first of the RCA-manufactured systems. Functionally, this system closely resembled the *Mark VI* system. The only important difference lay in the use of a linear tone rectifier in place of the log-log rectifier used in our earlier systems. This changed the tone-program amplitud characteristic.

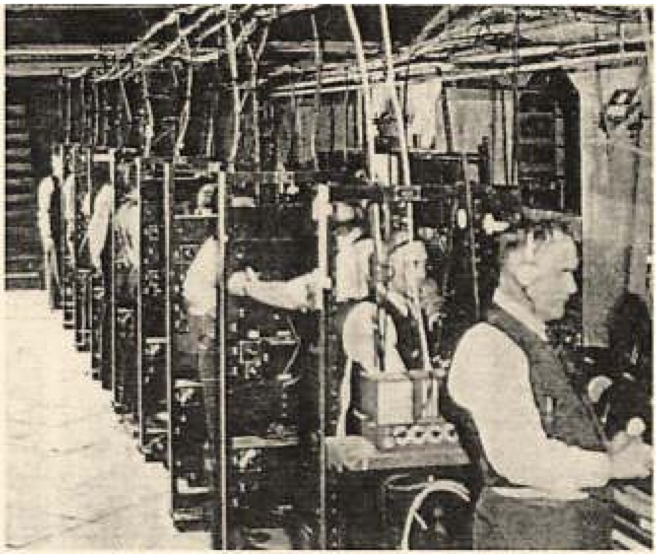

Fig. 11. View of eight recording channels at the Philadelphia Academy of Music.

The *Mark VIII* system consisted of the *Mark VII* equipment rearranged physically. An ingenious log-log tone rectifier, designed by RCA, replaced the linear tone rectifier used in the *Mark VII* set-up. The second dubbing of Fantasia was done through this system. After adding a stand-by channel, this equipment was installed in the Broadway Theater in New York for Fantasia's World Premiere.

The *Mark IX* equipment closely resembled the *Mark VIII* system. The physical layout was again modified, a few minor changes were made, and two sets of rear-house horns were manually switched in to supplement or replace the left and right screen horns at several points in the picture. This system is operating in eight of the roadshows.

The *Mark X* system is identical with the *Mark IX* equipment, except that the switching and level changes in the rear horn circuits are done automatically instead of manually. The control arrangement uses a thyratron and mechanical relay system operated by means of notches on the edge of the film. This ingenious arrangement was developed by Messrs. Hisserich and Tickner of our engineering department, The *Mark X* system is installed at the Carthay Circle Theater in Los Angeles.

SCORING AND DUBBING

***Scoring*.–All the numbers, except The Sorcerer's Apprentice and the vocal portions of Ave Maria, were scored at the Philadelphia Academy of Music. Eight push-pull variable-area recording channels were used (Fig. 11).**

Separate channels recorded close pick-ups of violins, cellos and basses, violas, brass, woodwinds, and tympani. The seventh channel recorded a mixture of the first six channels

and the eighth channel recorded a distant pick-up of the entire orchestra. The mixer handling the distant pick-up used horn monitoring, while the other mixers used headph monitoring. Cathode-ray oscilloscopes were used as level indicators (Fig. 12). ,

FIG. 12. View of some of the mixer positions at the Philadelphia Academy of Music.

The Sorcerer's Apprentice **number was done in Hollywood on a somewhat similar multi-channel system. The *Ave Maria* vocal numbers were recorded on three channels: two close channels, separating male and female voices, with a distant overall channel for added reverberation.**

Fig, 13 shows the mixer arrangement used in recording the 3-channel vocal numbers. Three-channel horn monitoring was provided in our theater and the level-indicating oscilloscopes again proved valuable in avoiding overloads.

FIG. 13. View of the 3-channel mixing position used in scoring the *Fantasia* vocal numbers at Burbank. (Messrs. Hawkins, Hisserich, and Marr.)

The necessity for checking the range compression on all channels during scoring and dubbing caused the development of a means whereby one man could visually monitor oscilloscopes. By using color differentiation at the overload and underload points, eye fatigue was minimized. This was accomplished by masks on the face of the cathode-ray tube. An opaque mask eliminated everything below about 3 per cent modulation, including the complete negative, or downward, half-cycles. A translucent red mask covered the range from

3 to 100 per cent modulation on the positive half-cycles. Above 100 per cent modulation, the trace on the tube was not masked, and so was highly visible. Program material below 3 percent modulation (100 per cent - 30 db) produced no visible indication. Material between 3 and 100 per cent modulation appeared as a white series of half-cycles, and modulation in excess of 100 percent appeared as a brilliant green series of peaks. The recording, re-recording, and monitoring systems were poled so that the compression wave, referred to the original microphone, gave positive peaks on both oscilloscopes and galvanometers. Tl adaptation of the oscilloscope was devised by C. 0. Slyfield. Over half a million feet of sounc negative was exposed on our scoring channels on this picture.

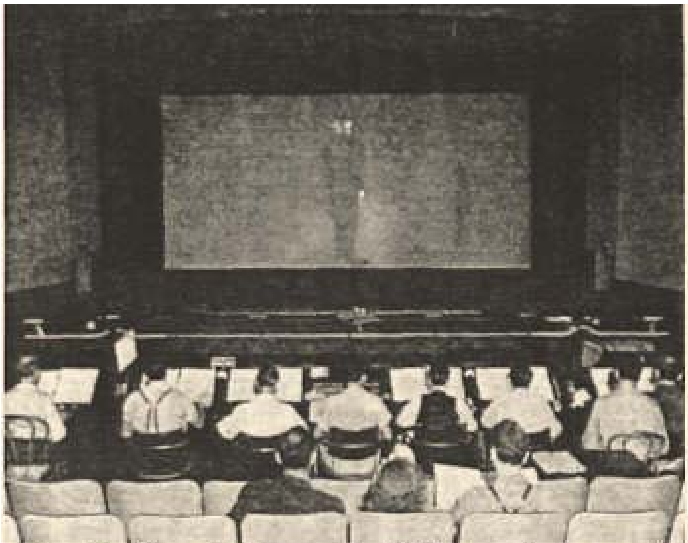

FIG. 14. View of the program dubbing console in operation. (Tone console not shown.) (Left to right, at console, Messrs. Blinn, Steck, Marr, Perry, Moss, Hawkins, Slyfield, and Hisserich. At rear, Ed Plumb, *Musical Director;* Luisa Fiels, *Asst. Music Cutter,* and Stephen Csillag, *Music Cutter.*)

Curator's Note:

Buried in the tons of historical materials written about *Fantasia* is an infrequent mention that Walt Disney planned to show the film in a wide screen format. Figure 14 may give us evidence that those statements were true. The aspect ratio of the projection screen illustrated here is 2.14:1. In the early 1950s, Disney released the film in a Superscope version with four channel magnetic sound. The critics panned the cropping of the film, which may have been a sloppy job, pretty atypical of anything that Mr. Disney was associated with.

***Dubbing.*–Our re-recording process used 8 to 10 tracks, depending upon the sequence. Fig. 14 shows the re-recording console in operation. The output of the mixing panels fed three recorders, one for each horn channel, left, center, and right. Another channel recorded the tone track. These four re-recorded negatives were then printed on the composite quad print. The *Mark VIII* Fantasound reproducer was used for dubbing monitoring (Fig. 15). Including everything but release prints, about five million feet of film was used for this picture.**

FIG. 15. View of part of the dubbing monitoring equipment. (Messrs. Hawkins and Garity.)

This history of Fantasound is far from complete. Another year and we shall know a great deal more about theater operating and maintenance problems on this type of equipment. To date, our operating and maintenance experience has been quite satisfactory.

We should like to acknowledge the suggestions and assistance of C. 0. Slyfield, W. C. Lamb, Jr., C. A. Hisserich, H. M. Tremaine, P. J. Holmes, Melville Poche, H. J. Steck, and E. A. Freitas in the development of this system. We wish to express our appreciation to Walt Disney, whose vision and willingness to encourage technical development made this system possible.

RETURN

HOME

The second of three FANTASOUND articles provided by John Schmul is an optimistic appraisal of what can be done with directional sound reproduction in the future. It was presented at the 1942 Spring meeting of the Society of Motion Picture Engineers and this article was published in the July, 1942 issue of their Journal.

THE FUTURE OF FANTASOUND

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Summary.–A non-technical discussion of Fantasound from the musician's point of view. The use of Fantasound is reviewed as a basis for discussing ways in which it can be used in the future.

Fantasound has been demonstrated to the public only in Walt Disney's *Fantasia*, but to accept or reject Fantasound on the basis of its use in that picture would be unjust. *Fantasia* is a remarkable showcase for an experiment in sound engineering because it uses music as a vital function of the picture. However, the dramatic effectiveness of Fantasound was limited by three conditions peculiar to this production.

(1) During its actual picture footage *Fantasia* uses only music on the sound-track. This eliminates the possibility of placing and moving dialog or sound-effects in the multiple speaker system that Fantasound includes. Dialog and sound-effects are the "real" sounds of the movies with which the audience is thoroughly familiar. Because of this familiarity it is quite possible that the location of these sounds in the theater could be more easily registered than the placement of musical sounds.

(2) The music that *Fantasia* interprets was conceived long before sound-film was available for use. The compositions were designed for concert performance and were so well designed for that medium that any orchestral changes made to improve reproduction greatly affected their basic character:

(3) The original recording of the entire orchestral performance of *Fantasia* had been completed before it was known what dimensional effects would be available in the theater. It was thus impossible to guess what method of recording would be most efficient for reproduction in Fantasound.

This is in no sense to be interpreted as an apology for *Fantasia* or the methods used in it. It is merely a description of certain obstacles that would not be confronted in the usual feature.

The future of Fantasound depends upon the efficiency with which the original sound material can be transferred to film and upon the dramatic effectiveness

of the total result. These related factors dictate the future of Fantasound because they represent, respectively, the expenditure necessary and the expenditure warranted by box office returns.

Before suggesting a method of recording an orchestra that might be practicable for future productions in Fantasound it seems advisable to describe briefly the method employed in *Fantasia*. During the original performance, each of six sound cameras recorded the close pick-up of a particular section of the orchestra. A seventh camera recorded a blend of these six close pick-ups, and an eighth recorded a distant pick-up of the entire orchestra.

In preparing the final re-recorded track from this original material several weaknesses became apparent. Because of acoustical pick-up the separation between the six sections of the orchestra was merely relative. In the material on the woodwind channel, for instance, the woodwinds usually predominated, but material from other sections of the orchestra was definitely present. Many times, because of differences in performance level, the material from adjacent sections would be as loud as, or louder than, the woodwinds directly picked up. This lack of complete separation was not an insurmountable obstacle in creating an artistic balance for ordinary reproduction, but it greatly limited the dramatic use of orchestral colors in Fantasound. If we wished, for dramatic reasons, to have a horn call emanate from a point to the right of the screen, our purpose would be confused by hearing the same call, at a lower volume, on every other speaker in the theater. Greater separation in the original recording could have been achieved only by greater segregation of the sections or by moving the microphones closer to the individual instruments. To go any further than we had gone toward segregation of sections or close pick-up would have impaired quality of performance in one case and recorded tone quality in the other. On the point of efficiency of the *Fantasia* recordings we must observe that only one-third of the material recorded on chosen performances was used in the final dubbing. The unused film contained sound that was too repetitious of, other channels, too poor in quality, or, during long sections, too unimportant in the design of the composition to help the total result.

Since the completion of *Fantasia* we have recorded orchestral performances of five compositions for possible use in Fantasound. It is not likely that these can appear as productions for a long while, but the method that was used may provide a possible approach to future Fantasound projects. The recordings were much less expensive and, there is every reason to believe, can be much more effective dramatically than the *Fantasia* recordings. We concentrated upon the achievement of two qualities of Fantasound that seem to us to be important-the illusion of "size," possible to attain by proper use of a multiple-speaker system, and recognizable placement of orchestral colors important to the dramatic presentation of the picture.

For the illusion of "size" or "spread," we used a three-channel recording set-up. Channel A was fed by a directional microphone far enough from the instrumentalists to cover the entire left half of the orchestra. Channel B recorded the right half of the orchestra. Channel C recorded a distant pick-up of the entire orchestra. This three-channel system recorded the "basic" tracks of the composition. It is important to note that in planning the material for

these "basic" tracks any orchestral color or passage for which we might have special dramatic use was omitted from the performance. The recording of this special material will be described later.

In reproduction over the Fantasound system this method of recording the basic tracks has great flexibility. To regain the natural spread of the orchestra, the A channel (left half of the orchestra) appears on the left stage speaker, the B channel (right half of the orchestra) appears on the right stage speaker, and the C channel (distant pick-up) appears-on the center speaker. The distant pickup appearing in the center adds an illusion of depth which is beneficial and also provides a more practical "cushion" for the solo instruments or other special material that would normally appear in the center. The "panpot" (described by Garity and Hawkins in the August, 1941, JOURNAL) can execute practically any variation of this reproduction plan that could be demanded. Each track can appear on any one stage speaker, any two stage speakers in whatever balance desired, or on all three stage speakers in any balance. The house speakers can be added to the left and right stage speakers in whatever set balances desired, or they can replace the left and right stage speakers so that-sound comes only from left and right house and center stage (as in "Ave Maria" in *Fantasia*).

In the recording of what I have termed special material-material whose location it is important to register-we employed the only method that assures absolute separation. The section of the basic track with which the special material is to synchronize is used as a playback on earphones available to conductor and instrumentalists. The physical difficulties of this method can be minimized by careful planning of the orchestration. It is usually possible to avoid the occurrence of the same melodic passage or rhythmic pattern in both the special and basic material. This makes synchronization less critical and also allows more freedom in performance of the special material. As advantages, the playback method offers complete control of the volume relationship between special and basic material; complete freedom in locating or moving the special material; and freedom to choose the pick-up, in recording the special material, that produces the finest quality in reproduction.

As an example of the use of the playback method, in *The Swan of Tuanela*, by Sibelius, there is an English horn solo that is vitally important in the design of the composition. We knew that this English horn should be a principal actor in dramatizing the score. We had recorded the composition played by the complete string orchestra omitting, among other instruments, the English horn. We then recorded the English horn alone, using the performance by the strings for the playback. A relatively distant pick-up was used, which gave the tone of the English horn brilliance, but also lent a feeling of mystery in character with the subject. Because of the complete separation achieved it is possible to submerge the solo in the rest of the orchestra or to make the solo stand out in a clear relief physically impossible to attain in concert performance. The solo can locate as its source one of the three stage speakers or, by balancing its volume between two speakers, can seem to locate a definite point between them. The solo can come from the left or right unit of house speakers without the stage speakers or, if power or diffusion are desired, can come from every speaker in the theater. The solo can move in such a way that it seems to follow the pattern

of a pictorial effect; it can change from offstage to onstage; or it can change its source, by a smooth, irregular movement of the panpot dial, so that it seems to float through the theater. I have mentioned a single composition and only a few of the effects possible. However, it is clear that the restrictions offered by this tentative method are infinitely less than those offered by the method used for *Fantasia*. (The *Fantasia* score contained only one example of complete separation-the solo voice and chorus of "Ave Maria" were recorded by the playback method to an orchestral accompaniment recorded a year and a half before. The vocal performance of "Ave Maria" was the last material to be recorded for *Fantasia*, and we were able to use everything Fantasound had to offer. It is interesting to note that for many of those in the audiences-at least in New York and Los Angeles-Fantasound was "turned on" only for "Ave Maria.")

The advantages of volume range are probably more obvious than the advantages of other features of Fantasound. To be able to use the upper volume range without distortion and the lower range without submerging the tone in ground-noise has been the dream of every dramatically minded sound-director since the advent of sound reproduction. Experience shows us, however, that this greatly extended volume range still has important natural limits. If sound is reproduced so low that it is unintelligible or so high that it causes physical discomfort, there must be adequate dramatic reason. Either extreme is likely to irritate.

Dialog and sound-effects, as material for use in Fantasound, have one decided advantage over music. They do not have to be recorded differently from the customary recording of ordinary sound. Their placement, movement, and extended volume range are all accomplished after they are normally put on the film.

Dialog is the only sound medium in whose reception the audience has been well rehearsed. The average member of the audience has heard the sounds that the screen sound-effects imitate, but he does not ordinarily analyze their character or location with any great care. He has listened to music but, perhaps wisely, he does not bother himself with the details of its complex pattern. In the reception of speech, however, he has trained himself to register, in great detail, character, pitch, volume, and location. Location of sound source is an unconscious function of his daily group conversation, group work, and group play. It is reasonable to expect, then, that when dialog placement has dramatic meaning it will be efficiently received by the audience-at least, more efficiently received than the placement of sound-effects or music. Because of the visual limitations of the screen, dialog, in Fantasound as in ordinary reproduction, comes normally from the center of the stage. For this purpose the center stage speaker is adequate. Because the ear is critical of voice placement, however, it is not far-fetched to attempt the location of characters by changing the speaker source. If an actor appears in the area at the extreme left of the projected frame, or if the implied location is slightly to the left of the projected frame, placement of the voice on the left stage speaker supports the illusion. Such use of the three stage speakers creates the possibility of dialog between extreme left and extreme right or between center and either side without greater sacrifice of intelligibility than would exist in dramatic productions on the stage. Obviously

the device could be over-used to the point of annoyance, and should be limited to dramatic situations that are definitely improved by the illusion. In the treatment of off-stage voices the house speakers could be used to advantage. When a voice, or a group of voices, comes from the left or right unit of house speakers, an effect of reverberation is added to the original recording. The loss in intelligibility and in point source definition could have dramatic value because they imitate these same losses in the reception of real sounds from a distance.

Fantasound is able to make its greatest contribution in combining dialog, music, and sound-effects. In ordinary reproduction one of these three mediums must, with rare exceptions, be dominant while the other two are sacrificed. In Fantasound it is possible to follow the continuity of the dialog clearly and still receive the full emotional impact of the music, or the dramatic realism of atmospheric sound-effects. As a possible use in the theater, consider that the center stage speaker would be saved exclusively for on-stage sound-dialog, music performed on the screen, or realistic sound-effects. The house speakers and, at a lower level, the side stage speakers would project music or general sound-effects at a level natural for them. As long as the music or effects are pertinent to the story being portrayed they will not distract and would not cause the dialog to become unintelligible. This physical separation of sound-tracks also reduces to a minimum the unpleasant phenomenon produced when a well-modulated track is "pinched."

If these comments seem to wander it may be because Fantasound is at the wandering stage of its development. We have the tools and we have not decided what we intend to build with them. These tools may not be available in the theater "for the duration," but this might be an excellent period during which to develop a practicable, effective plan for using them. It is within the power of Fantasound, as an idea, to revitalize the industry. This power, however, can not be fully developed until script, direction, music, and recording are planned with Fantasound as an organic function.

RETURN

This is the third of three articles provided by John Schmul covering Disney's FANTASOUND semi-stereophonic optical sound system. As the title indicates, it deals with the particulars of installation and setup of the enormous amount of equipment required to play *Fantasia* in select theatres across the country in 1940-41. The article, based on a paper presented at the 1942 spring meeting of the SMPE on May 1, 1942, was published in the Journal of the Society of Motion Picture Engineers in its July, 1942 issue.

EXPERIENCES IN ROAD-SHOWING WALT DISNEY'S "FANTASIA"

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Summary.*–*A discussion of the various problems encountered in the road-showing of "Fantasia" with the multiple-track Fantasound equipment. The experiences and conditions encountered are presented as a guide for the further development of this very important field. It is expected that this system will add greatly to the dramatic presentation of pictures and will, in some form, replace our sound-reproduction systems.

Fantasia **was the result of an idea that grew over a period of three years from a "standard" one-reel "short" to a multi-million dollar road show that required the largest outlay of sound equipment that has been used commercially in the theater to date. Many new methods and procedures were found necessary to achieve the results that were desired for the final product. These new methods and procedures applied not only to the sound technic but the pictorial aspect as well. In order to appreciate fully the amount of artistic and engineering work that was expended on *Fantasia* it is interesting to review some of the highlights of our experience over a period of about three years prior to the premiere of the picture in New York on November 13, 1940.**

During the latter part of the year 1937 Walt Disney conceived the idea of making a cartoon "short" using as a basis some well known musical selection that lent itself to cartoon animation. A serious effort was made to interpret the composer's musical ideas pictorially as well as to record music that would blend into the picture and provide a combined, indivisible form entertainment. *The Sorcerer's Apprentice* was chosen for the original, and was recorded in January, 1938, by 100 musicians conducted by Leopold Stokowski.

The Sorcerer's Apprentice **was recorded at the Pathé Studio, Culver City, Calif., on a production stage that was altered acoustically for the occasion. Our theory was to make a multiple-channel recording that would have satisfactory separation between channels so that suitable material would be available from**

which to obtain any desired dynamic balance in re-recording the original material. In the effort to obtain satisfactory separation between channels, a semicircular orchestra shell was constructed in the stage. The shell was then divided into five sections by means of double plywood partitions. Two difficulties were encountered with such a set-up; one was poor low-frequency separation; the other was the inability of the musicians at the rear of the sections to hear the music from the other sections, to such an extent the tempo was impaired. This condition was improved, at a sacrifice in separation, by having the musicians move nearer the front of the shell sections. As work progressed on the animation and re-recording of the material, Walt Disney decided to add other musical selections and to present a full-length presentation that would be outstanding in its scope. It was at this time that discussions first took place regarding special equipment for the showing of the picture. The goal that we hoped to reach was the reproduction in the theater of a full symphony orchestra with its normal volume range and acoustic output as well as the illusion that would ordinarily be obtained with a real orchestra. Many ideas were investigated, equipment was designed, and tests made of vario combinations of equipment that would give the ultimate in a sound and picture entertainment. For a further description of these investigations the reader is referred to a paper on "Fantasound" by Garity and Hawkins in the August, 1941, JOURNAL.

The best combination of music and recording conditions was desired for the additional selections, and it was decided therefore to abandon the Sorcerers set-up and to record the Philadelphia Orchestra in the Academy of Music in Philadelphia. This decision had two points in its favor; one being the fact that the acoustic properties of the Academy are excellent, and the second being that this orchestral group has been organized for many years and their musical talent is rated as one of the highest. At the time of the decision to do the recording at Philadelphia it was not known exactly what the music requirements would be in order to achieve the dynamic and musical balance necessary to the picture story being told. So that this requirement might be fulfilled in the re-recording of the original material, a multiple-channel recording was made and it was, of course, necessary to install nine studio-type recording channels in the Academy.

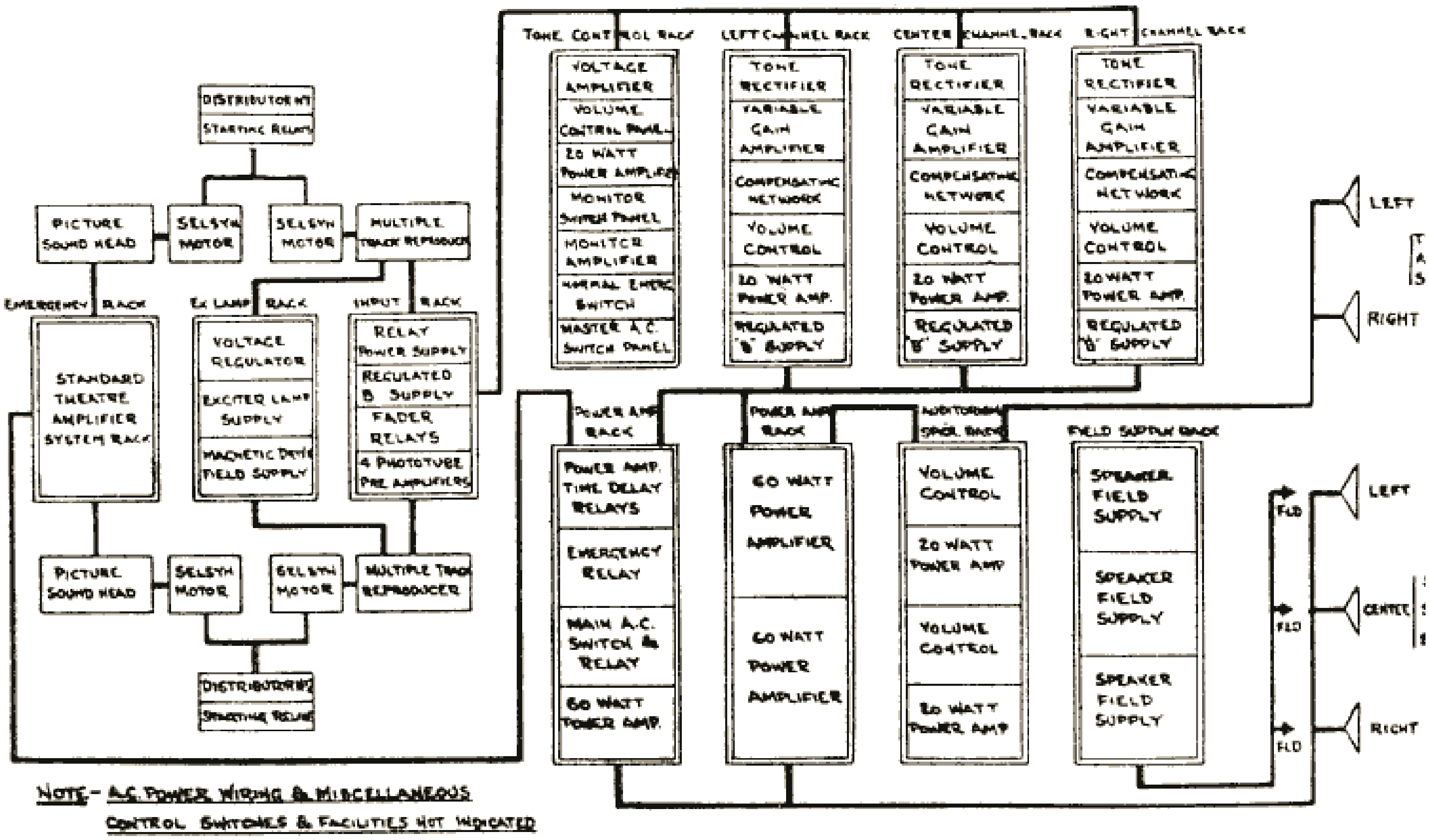

FIG. 1. Block diagram of Fantasound road-show unit.

The recording machines were located in the Academy basement, and since the inside of the building is constructed of wood, many safety measures had to be taken. No more than eighteen rolls of raw stock were allowed in the Academy at one time, and in order to insure a sufficient quantity of film for each recording session, a film-delivery truck was converted into a suitable loading room and was parked outside the building during recording sessions. All loading and unloading was done in this truck. The work of installation and recording was supervised by the authors, who spent the entire spring of 1939 in the Academy basement.

EQUIPMENT PROBLEMS

To appreciate fully some of the problems encountered in the design of the road-show units it is necessary first to see what constitutes a complete unit. Each Fantasound road-show equipment consisted of sound reproducers, amplifiers, and loud speakers so arranged as to reproduce sounds from a multiple sound-track film run in synchronism with the picture film. The level and distribution of sound to the various stage and auditorium loud speakers was automatically varied in a predetermined manner by means of the control-tone and program sound-tracks on the multiple sound-track film. Fig. 1 is a block diagram of the Fantasound equipment as used for the reproduction of Fantasia. This system consisted of three separate program amplifier and loud speaker channels, and a control-tone channel; two selsyn-operated multiple sound-tra reproducers; two selsyn operated sound-heads; two selsyn distributors; three two-way stage loud speaker systems; auxiliary theater auditorium loud speakers; and amplifiers and necessary operating facilities. Fig. 2 shows the equipment as installed in the Carthay Circle Theater, Hollywood.

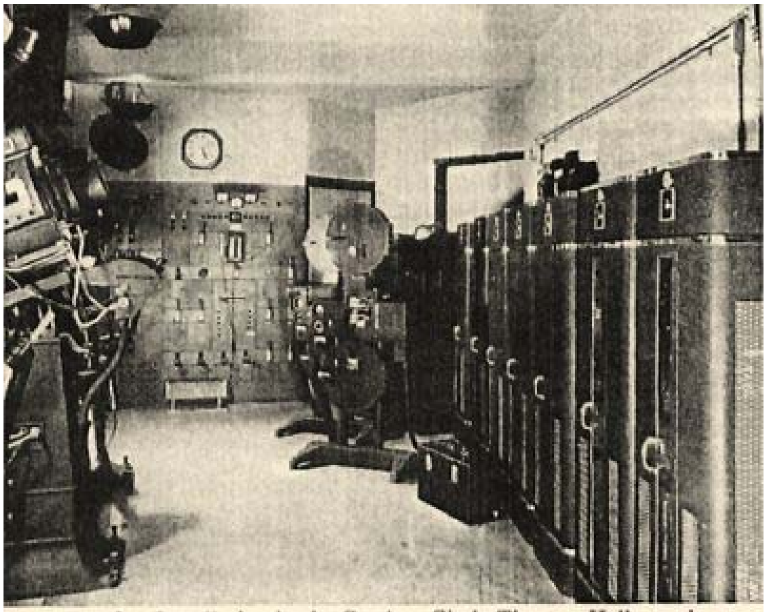

FIG. 2. Installation in the Carthay Circle Theater, Hollywood.

***Power Supply*.–All equipment was furnished for 60-cycle power. The amplifiers and power-supply units required 110-125-volt single phase current; the selsyn distributor 220 v three-phase. Where power fulfilling these requirements was not available, the necessary rota equipment or transformers were supplied for the particular job. In order that the line-voltage variations would have the least effect upon the sound output level, the a-e input voltage to exciter-lamp, supply was regulated, and regulated supplies were employed to furnish plate power for the variable-gain amplifiers and tone rectifiers, and polarizing voltage for the phototubes.**

***Stage and Projection Room Space*.–Due to the fact that each road show unit consisted of eleven 62-inch racks of amplifiers and power supply units, in addition to the other items indicated in Fig. 1, there existed quite a problem in finding space in the average theater for the various items. The wiring and operating facilities of the equipment were so arranged that it was necessary to install a minimum of six racks in the projection room in addition to the two multiple sound reproducers. This was further complicated by the fact that many theaters available and suitable for road-show attractions generally did not have much of a projection room, if any. Power switching facilities were contained in one of the racks installed in the projection room so that the additional five racks could be mounted outside the projection room if space was not available therein. The two selsyn distributors on which were mounted the necessary starting and remote-control devices were located outside the projection room where conditions permitted. The speaker-field supply rack was so arranged that it could be mounted on the stage proper, near the loud speakers, in order to conserve wire runs; however, in some theaters this was not advisable due to the differences in local rulings as to whose duty it was to turn on and off the power to the rack. Space behind the picture screen was generally available for the loud speaker systems. The screen had to be moved up or down stage in many theaters in order to get the l distribution of sound. The three loud speaker systems required an average width of 44 ft, and it was always necessary to change the masking draperies on either side of the screen in order to obtain satisfactory sound transmission from the side loud speakers.**

***Inter-Apparatus Connections*.–The model road-show unit that was first manufactured made use of Cannon-type plugs and fittings for all inter-apparatus connections. Due to the large number of cable connections necessary, it was impossible to have a different type of plug for each circuit, and there was always the possibility and hazard of plugging a cable into the wrong position, with resulting damage to equipment. After a nation-wide survey of city inspectors concerning the use of rubber-covered cables and plugs on equipment located in projection rooms in a theater on**

road-show basis, we found there existed many rulings, some definite and others rather vague. Some city inspectors would agree to the use of rubber-covered cables provided the show did not run longer than thirty days or so. Others would not agree to rubber-covered cables in the projection room on any condition. In one installation no exposed conduit was permitted, due, no doubt, to a safety measure as well as a "projection room beautification program." For the foregoing reasons all cables and plugs were eliminated and Greenfield or rigid conduit was used for all installation wiring.

***Emergency Features*.–Since this was a major project so far as the amount of sound equipment to be used was concerned, and it was to be a "two-a-day" show with road-show prices, some emergency feature was desired in case of failure of the Fantasound system. In case of failure of the control-tone variable-gain part of the system, switching facilities were provided whereby control-tone section could be by-passed and the three program channels could operate with the volume range that existed on the program tracks themselves. This still involved the use of a large percentage of the equipment, and further simplification of the emergency feature was thought desirable. The sound-track on the picture film was a standard variable-area, composite of the sound material that was located on the three program tracks of the multiple-track film. By means of one switch which actuated a relay system, the sound was transferred from the Fantasound set-up to the emergency channel, making use of the standard sound-track on the picture film, the emergency amplifier, and the center-stage loud speaker. Theater experience proved that the equipment was very reliable, and even though the number of component parts in the road-show unit was many times that of a standard theater set-up, the number of sound outages were no more than is experienced in a standard theater. The sound outages that did occur were caused in the majority of instances by operating failure rather than equipment failure. Such successful performance with the large quantity of equipment involved indicates the high degree of perfection that has been reached in present-day engineering and manufacture of theater sound equipment.**

***Audio Power Requirements*.–The success of any high volume range reproduction depends greatly upon having equipment with sufficient undistorted power-handling capacity. The Fantasound equipment has three 60-watt amplifiers for the stage speakers. This proved satisfactory for the majority of installations; the New York unit used additional power. The full capacity of the system was usually reached on peak levels during the performance.**

***Equipment Testing and Program Level Adjustments*.–The experimental work on the multiple-channel reproducing system indicated that slight differences in level between channels would give the effect of motion of the sound from one loud speaker to another. For this reason we found it necessary to provide facilities for readily checking the levels of the channels in order that the sound-perspective at the time of reproduction would be the same as intended during re-recording of the picture. A portable-type bridging input amplified volume-indicator having a range of -50 to +40 db (6-mw reference level) was provided for making all measurements. Multiple-track test-films and film-loops were used for making such measurements as level balance, gain-change characteristics, push-pull balance of the sound-track, and frequency response. Bridging jacks only were used at points in the circuits where routine measurements were to be made. Switches were so connected that resistance loads could be substituted for purpose of measurement. Vacuum-tubes having any bearing on the characteristics of the control-tone variable-gain section of the system were aged, balanced, and matched. This simplified the work for the field personnel in the routine maintenance of the equipment.**

***Operating Features*.–The routine show-operating details were kept as near to standard theater practice as possible; however, due to the use of a selsyn motor system and separate film reproducers, there did exist some difference in operating technic. There were three stations for the operating of the sound-control and motor systems, The motor controls for the selsyn system were operated by a sequence switching arrangement that was quite foolproof. Suitable pilot-light**

indicating devices were employed for all control stations, and changeovers could be made from any station at any time. It was general operating practice to allow the selsyn motor on the picture machine and the multiple-track reproducer to remain "in lock" during the entire show, and because of this very little trouble was experienced from "out-of-sync" conditions. The power circuits were so designed that the entire system could be turned on by one switch, and during normal operating times such was the practice.

Manual switching was provided for monitoring the tone or program channels individually. This was fairly satisfactory with the exception that the volume range of the recording was too great for projection-room monitoring. With any reasonable adjustment for satisfactory high-level sounds it was impossible to hear the low-level sounds over the machine noise. Future equipment should be designed with a volume-compressor stage in the monitor amplifier and possible means for monitoring the combined channels.

***Shipping Facilities*.–All equipment was shipped from the factory in caravan packing units. Such packing facilities would no doubt have been satisfactory for the transfer of the equipment between installations. The weight of a complete Fantasound equipment was approximately 15,000 lbs.; it was packed in forty-five cases and required one-half of a standard freight car space.**

The following information was obtained from eight Fantasound installations, and indicates the general conditions that were encountered. Six of the installations required that a new or a large capacity three-phase service be run to the projection room. The majority of the six were new services, as no old services were available. In some theaters adequate single-phase power was not available in the projection room. Such additional power-line runs to the projection rooms were always costly and time-consuming. In three of the

theaters it was necessary to enlarge the projection room, as sufficient space was not available for all the equipment nor was there space nearby that could be used. This item made a large increase also in the installation cost. As a general rule the projection rooms encountered were poorly arranged and too small for a first-class installation of the entire equipment. It must remembered, however, that these theaters were not usually first-run motion picture houses, but were theaters that could be engaged for such a road-show project.

In some of the earlier installations the right and left stage speakers were placed as far out to either side as conditions would permit. Preliminary tests indicated that this was undesirable, as there was an objectionable sudden movement of the sound when shifted from one loud speaker to another. The condition was corrected by moving the side speakers nearer the center by such an amount that a smooth transition occurred when the sound was shifted from one speaker to another. The correct separation of the theater stage speakers for obtaining a sound illusion similar to that obtained at the time of re-recording depends to a certain extent upon the general acoustic properties of the re-recording monitoring room and the location and spacing between, the monitor speakers. Due to the fact that the Disney re-recording monitoring room is a 600-seat theater of average theater acoustic properties, it was more or less an easy matter to anticipate the final results.

The normal undistorted audio-power output of the equipment was 220 watts, which proved satisfactory for most theaters. In the Broadway Theater (New York) the power was increased to 400 watts and three additional loud speaker systems were added to the stage complement to handle the additional power.

The music and the control-tone tracks for *Fantasia* were re-recorded with the idea that a certain volume-range could be used in the theater showing the picture. This volume-range as chosen, which consisted of a 40-db control-tone range and a 30-db range on the music tracks, was found

to be greater than could be tolerated in the theater. It was general practice to use the high-level section of the music as the point at which the gain-controls were set for the correct level. If the low-level portions of the music were below the theater noise-level, the volume-range was reduced by changing the ratio of the control-tone-level to the variable-gain amplifier output, The music was re-recorded with a one-to-one ratio; however, in some theaters it was necessary to use a ratio of eight to five. This means of controlling the volume-range of sounds that have already been recorded was found to be very useful and necessary for the successful presentation of the picture. The best audience reaction to the high level musical passages occurred when the level was at a certain value, which varied from theater to theater and was determined by trial and error. A decrease of 2 db in this level resulted in a decided "letdown" of audience reaction as the "thrill," or "punch" was lacking.

***Conclusions*.–The outstanding success of *Fantasia* in its limited number of runs with Fantasound has demonstrated the value of this means of increasing the dramatic value of a picture.**

There were three primary reasons for the discontinuance of the use of Fantasound:

***(1)* The amount of equipment required and the time necessary to make the installation.**

(2)
Because of the time element attractive theaters were not available to us, as the first-class houses in the various communities had established policies and the installation of the equipment would generally require darkening the house for a few days.

(3)
The advent of wartime conditions precluded the possibility of developing mobile units that would have lessened installation time and costs.

(4)
The variation in the regulations throughout the country, both as to operating personnel and local ordinances, materially affected the operating and installation costs.

***(5)* Space factors of the projection room in particular were problems of major importance.**

We are convinced that, with greater simplification of equipment in keeping with the available space in the theater, the elimination of the separate selsyn sound-track reproducer, and the combining of the multiple-track on the composite print, future sound reproduction will e multiple-track reproduction with automatic volume control, and, something that was not used in Fantasound, the automatic change of frequency-response with volume. We can only express our own opinions and the opinions of those who worked with this equipment; viz., having used multiple-track system, no matter in what form, the ordinary sound-track reproduction is flat and dull by comparison. We can not say what the problems of original recording would be for the live-action producer. We can assume they will be many and various, but we are sure that with study and ingenuity they can be overcome, and the final results will be worth while.

RETURN