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# A "SPECIAL ECHO-MIXER" FOR A SOUND RECORDING CONTROL CONSOLE

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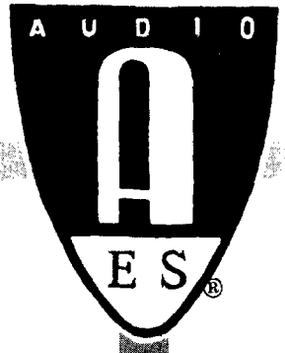


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# A "SPECIAL ECHO-MIXER" FOR A SOUND RECORDING CONTROL CONSOLE

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A mixing console is described which contains, in addition to the usual gain controls, panpots, etc., a "special echo-mixer." The need for this mixer is shown, and the main mixer and the special echo-mixer are described by means of block diagrams.

## 1. INTRODUCTION

Although the "special echo-mixer" has been used in television studio operation for a long time, such a combination of controls and mixing networks is not used in equipment for broadcasting and disc recording, even though in modern sound recording (especially with dance and light music), a variety of equalizers, compressor/limiters, controls for reverberation facilities, delay equipment, etc., is required. The work of the recording personnel would be greatly simplified by grouping these units in a logical manner and combining them into a separate mixer, because complicated setups of patching and switching with each recording, or with each remixing of recorded tapes, may easily lead to the loss of a clear picture of the circuit arrangement, and may even result in time consuming troubles. The designation "special echo-mixer" is appropriate for such special equipment where the treatment of audio signals is handled separately from the normal mixing of the microphone channels; the latter would then be called "main mixer." In the following sections the need for combining switches equalizers, etc., into a special echo-mixer is demonstrated by means of some examples with circuits.

## 2. DESIGN OF THE MAIN MIXER

Conventional control facilities have a greater or lesser number of channels whose grouping into a mixer has been the essential point of the equipment design, up to now. Since, in modern production methods, the treatment of sound signals after the original recording session with the artists is so very important, discussion of the main mixer is of secondary importance for our present purposes. The main consideration here is how to obtain the "echo feed" signal.

The design principles of a single channel in the main mixer may generally be assumed to be uniform, irrespective of whether the construction is still of the tube-type, or whether it is of the transistor-, plug-in or module type.

Figure 1 shows an example of a stereo mixer. A mono microphone or a stereo microphone is followed by a bandpass filter to remove noises that

may be made by bumping the microphone, a pressure-gradient filter or an equalizer for suppressing the self-resonant frequencies of very small rooms. In order to avoid overloading the preamplifier, these filters are placed before the preamplifier or are combined with it, or else with the microphone power supply.

The preamplifier may have a vernier gain control to adjust the channel gain, in order to compensate for sensitivity differences of microphones (especially when M/S microphones are patched). Following the preamplifier, it should be possible to patch in a compressor (in stereo operation both of the agc amplifiers must be electrically coupled) These are followed by the module for directional mixing ("pan-pot") of which numerous types are presently available. The only such units which are of interest here are those that will accept inputs of either M/S or X/Y signals, and will also deliver X and Y outputs, or, better yet, both signal types. Today, built-in boosters must be presumed, i.e., active four-poles, avoiding the need for additional adjustment (at least at this place) when the M/S system is used. Modules are available in symmetrical or unsymmetrical configurations, made by the RFZ (Central Office of Radio and Television Techniques, East Berlin), the Research Institute of Radio and Television, Prague (Czechoslovakian Socialist Republic) and the Wiener Schwachstrom Werke, Vienna. The latter two are not capable of delivering M/S signals. In spite of the known disadvantages of the M/S system[1,2] it should not be abandoned, because it offers operational advantages in certain cases when the system is properly adjusted. (Our present preference for the X/Y system has developed as a result of long operating experience with the M/S system which was initially chosen. We must admit that this opinion is certainly <u>not</u> shared by all European broadcasting organizations!)

Also preceeding the microphone gain controls are the equalizers. They are most important for the sound director and the audio engineer, having special operation ranges where emphasis and/or de-emphasis is effected (e.g., universal equalizers, sharp cutoff filters for radio plays, level filters, presence equalizers, etc.). In this field too, active four-poles are more and more common for ease of patching in.

Next follows the microphone gain control; at this point (either before or after the control) the "echo feed" signal is picked off. Interconnection of the various gain controls takes place in the usual manner by means of mixing amplifiers, decoupling resistances or isolation amplifiers. The most flexible system would interconnect the controls by means of a buss selecting system as shown in Figure 1. The mixing amplifier, or in our case a mixing and boosting amplifier, is followed in the M/S system by a matrix network. A direction-determining module (direction mixer or "panpot") would be more desirable, since it could not only be used as the matrix to the X/Y system but more frequently for the production of special effects. Then follow, as in the microphone channels, equalizers, master gain control controls and line amplifiers. The microphone channels and the main channels are built similarly. For protection against overloading, the channel is often provided with a limiter amplifier at the end.

## 3. ECHO FEED CIRCUITS

In older monophonic equipment, the signal could only be picked up at the input to the gain controls, because of the simple parallel connection of the control outputs. The well-known deficiency of this system is that with artificial reverberation, one often got an "echo chamber sound." This can be eliminated by the isolating interconnection of the controls which is mentioned in Section 2. Therefore, the kind of connection shown in Figure 2a is usually used for all of the points marked with numbers. The attenuation of approximately 10 to 12 dB through the control, necessary for a convenient operating position plus the control's basic attenuation, is compensated by resistance $R_1$.

$R_2$ is used for setting the desired amount of echo feed from that channel. The new studio controls developed in the RFZ (W 744) have an attenuation of 0 dB in the normal operating position; they are more suitable because the level compensation is effected by a built-in transistor amplifier, thereby making $R_1$ superfluous and improving the signal-to-noise ratio in the reverberation channel.

As the mixing equipment is of ever increasing complexity, it will be necessary to consider if the switch which chooses whether to pickup the signal from before or after the control may be eliminated, as there is no doubt that the work of the recording personnel would be simplified by a permanent connection.

With the stereo control in Figure 2b, the connection is limited to the gain control output. For achieving good crosstalk attenuation, a double control with a switch (possibly built directly into the control) could be used in addition to the isolation resistances. It is also common use to employ isolation stages as are shown in Figure 2a following the control; their use is essentially a matter of space and cost, and also depends on the kind of further patching of the signal and on the desired value of crosstalk attenuation.

A buss selection system may also be used for picking up the signal. Figure 2c shows such an alternative. The mixing controls are connected with the required program busses X and Y, and the echo feed signals are connected to two further busses through mixing amplifiers which simultaneously provide the necessary high back attenuation. Two echo busses (I and II) permit either summing the X and Y portions to make M on one of the two busses (since in many cases in stereo recording only M is to be reverberated) or patching X and/or Y to each one of the busses, or patching only M to one of the two channels when M/S is applied to the stereo gain control.

This method of connecting the signals (whose further treatment will be discussed later) obviously permits the most flexible operation, though requiring additional work on the part of the recording personnel. Since the connection of the gain controls is performed by the buss selecting system, it varies according to the number of program busses available. Therefore, combining the signals as shown in Figure 2c will be chosen when the particular production application requires this flexibility.

If the combination of the controls in 3 or 4 groups proves sufficient, permanent connection of the signal to two echo channels will do, the latter being combined to M via group switches or being preserved as independent paths. This will be shown (Figure 6) in the discussion of the bigger "special echo-mixer."

It should be mentioned that in English equipment, as opposed to the system shown in Figure 1, the ratio of direct to reverberated sound is adjusted for each microphone channel by an "echo feed" control after the microphone gain control itself.

In our opinion, certain American equipment is not real stereo equipment, as there the mono-microphones are distributed on 3 busses--left, middle, right--that are then combined into left/right program busses. In this equipment panpots or direction mixers are not usually used, as three directions are considered sufficient. Reverberation mixing is also done according to this monophonic combination technique[3], but with single echo feed controls following the microphone gain controls.

In the next two sections the actual "treatment" of the signal will be explained.

## 4. SIGNAL TREATMENT BY DELAYED ARTIFICIAL REVERBERATION

In the past years, methods of reverberation have been introduced in monophonic recording that are far more complex than the former simple patching to a reverberation room. In modern recording, the effect of the acoustical characteristics of studios is greatly reduced due to the close microphone placement for instrumental groups of dance and entertainment orchestras. For a good effect of spaciousness, and for the representation of imaginary rooms, or of the impression of a certain room volume, it is necessary to add adequately delayed artificial reverberation. By adding single reflections to the delayed reverberation, a considerable improvement of the spatial effect is obtained.[4] The apparent room volume may be varied to a certain extent by proper timing of the direct signal, the "reflection" and the reverberated signal. A special feature of this method is that when properly applied it may also deliver aesthetically satisfactory results with serious music. The signals are delayed by normal tape recorders, or by special delay equipment with endless tapes or rotating magnetic coated discs with a greater number of movable playback heads which can be set for any delay time from 20 to 200 ms.

The corresponding circuit for treating monophonic signals as described is shown in Figure 3.

The channel is shown in a simplified manner, the grouping of the mixing controls and the mixing amplifier being presumed. The delay equipment furnishes signals delayed by $t_1$ and $t_2$.

For stereophonic recording the circuit is similar when, for example, only the M-portion of the stereo signal is to be treated and the delayed and reverberated signal is mixed into the M/S or X/Y channels.

## 5. SYMMETRICAL TREATMENT IN STEREO EQUIPMENT, MD-METHODS, ETC.

There has been an assumption that only the M signal should be reverberated in stereo recording, and that the reverberant signal should be returned to the left and right, or sum and difference channels (depending whether X/Y or M/S mixing is used) in order to emphasize the impression of space; this assumption has not been found valid for many kinds of dance music recording. Now, for example, two reverberation chambers are required, and they are associated with the left and the right channels respectively, i.e., not used simultaneously in both stereo channels, in order to avoid an effect similar to crosstalk.

Thus, the treatment has to be made symmetrically on two channels. If cross-channel feeds are introduced in this method the so-called MD-method (Magic-Dimensions-method) of M. Fouquè and H. Redlich[5] is produced. As is known, this method furnishes a good approximation to an ideal recording room for symphonic music, or a presentation of an imaginary room with dance and effects music. By simultating reflections of first and second order by means of cross-feeds, and of higher order by means of reverberation equipment in a third cross-feed, the radiation of properly mixed and equalized signals may offer to the listener a better picture of the size and kind of the original acoustical setting than is possible by the method used in monophonic recording as described in Section 4. The system of Fouquè and Redlich[5] is shown in Figure 4, and again in the more usual symbols in Figure 5. (It is desirable to employ delay equipment with stereo heads.)

On the other hand, the monophonic and stereophonic-ambiophonic transmission methods of L. Keibs[6,7,8], create the effect of placing the listener into the recording studio by using real room reflections; this method greatly simplifies the equipment required. In this case, the mixing is done directly within the main mixer.

It will be seen that cost of the equipment just for treating the signal has already increased, but this is still not what we would properly call a "special echo-mixer." By the addition of further switching circuits and by the introduction of circuits for repeated echoes, and other features, this equipment appears to have a general application.

## 6. A GENERAL PURPOSE "SPECIAL ECHO-MIXER" FOR A MULTI-CHANNEL CONTROL CONSOLE

A "special echo-mixer" of medium size has been described as a part of the experimental control console of the Radio House at Berlin-Oberschoeneweide[1] (East Berlin). Figure 6 shows the block diagram of a complete "special echo-mixer" which is being used for effects music recording in the field of radio and disc recording.

For interconnecting the signals, two methods have been investigated. First, patching to busses, shown in Figure 2c, which permits both the distribution of the signals on two echo channels as well as simultaneous addition of X and Y to make M, if required. This has been drawn by dotted lines (at the left top). Secondly, when a mixing amplifier system is not available, patching in groups as shown at the input, may be chosen. In

the present equipment, two control groups have been presumed in the main mixer; Group 1 is usually used with microphone channels and Group II with the outputs of magnetic recorders (e.g., stereo and eight-track recording equipment, etc.) This preferred connection also enables the signal to be patched to group switches (SW 1 and SW 2) thus simultaneously selecting the type of echo treatment. By this means, separate patching of each gain control's echo feed (as in Figure 2c) is no longer required. The deficiencies and advantages of either method are apparent and need no further explanation. Three or four control groups are practicable too, but it is desirable to reduce the number of echo channels to two, in order to keep cost within acceptable limits.

Group switches SW 1 and SW 2 have 5 positions each to adapt the type of treatment to the mixing system chosen in the main mixer (M/S or X/Y)--positions 1 - 3 are for X/Y mixing, and positions 4 and 5 are for M/S mixing.

Position 1. "X/Y": symmetrical treatment with two reverberation chambers that are connected respectively to the right and to the left channels. The signals are thus separately fed to the upper and lower echo channels (presuming that all group switches must be set at the same position, X/Y). This technique is frequently used for dance music recordings, and especially for the previously mentioned "M/D" method. Only the addition of the reverberated signals is different (see below).

Position 2. "X/Y-I": In this position of the single group switches, the X and Y signals are added to make M and fed via the upper treating channel (I) to the reverberation room 1.

Position 3. "X/Y-II": Here again X and Y signals are added to make M but are fed via the lower treatment channel (II) to the reverberation room 2.

Position 4. "M/S-I": With the M/S system and this position of the single group switches, only the M signal is picked up for further treatment on channel I (reverberation room 1, etc.).

Position 5. "M/S-II": Similar to position 4 only the M signal is fed via the treatment channel II.

While the symmetrical treatment method (1) is practicable only for all mixing channel groups simultaneously, positions 2 to 5 enable two groups to work independently for X/Y, M/S, or monophonic recording as the subsequent echo channels are arranged identically. Thus, it is possible to set up two different types of echo treatment for comparison.

The combination of the different echo feed signals takes place before the two group controls that set the input level (+ 6 dB) to the delay unit. But as constant observation of this level is hardly possible during a recording session, two limiters have been provided following the group control (these should be coupled appropriately in case of coherent signals).

As may clearly be seen from Figure 6, the delayed and undelayed signals are combined in groups for reverberation, and also used without reverberation. The delay equipment is assumed to have several stereo heads. The delayed signals are fed back via the controls IG 1 - 4 to the input of the delay circuit thus using them for iteration (repeated echo); they can be adjusted to the rhythm of the music piece, or used for special effects, depending to the delay time used. Controls HR 1 and HR 5 feed the signals undelayed to the reverberation rooms. The delayed signals go via the universal equalizers EQ 1 - 8 to the controls ATT 1 - 8, and also (through the reverberation controls HR 2 and 3 for channel I or HR 6 and 7 for channel II) to the two reverberation facilities.

Through the reverberation control HR 4 the signals are fed from the delay channel II/$t_1$ to reverberation channel I or through HR 8 from the delay channel I/$t_1$ to reverberation channel II for cross feeding for certain effects, e.g., to electrically simulate the use of divided reverberation rooms as described by Capitol Records Company[9]. They have found it effective to have the first reverberation after a short musical sound coming from the same side, followed shortly afterwards by a low-level echo coming from the opposite side.

By switch K 1 all reverberation controls may be connected in parallel to the reverberation channel 1, e.g., when only one reverberation room is available, and it must be used as effectively as possible.

The signals are fed through low pass filters to the reverberation equipment 1 and 2 which should be, e.g., stereo reverberation plates, in order to have two incoherent signals at the outputs. These two outputs may be transformed by matrixing networks and may be exchanged by switches K 2 and 3 depending whether emphasis is desired on the impression of spaciousness at the left or right, or the impression of a shifting from the sides to the middle (or vice versa). To correct the frequency response of the reverberation, the signals are fed through equalizers EQ 9 - 12 to the reverberation controls ATT 9 - 12.

The controls ATT 1 - 12 and HR 1 - 8 are opened for providing "echo return" signals. For symmetrical treatment, controls HR 1 and 5, and HR 2 and HR 6, as well as the required controls of the group ATT 1 to 8 and ATT 9 and ATT 12 are opened. (Switch K 4 should be closed). By this means there are several different possibilities available. For the "M/D" system, only the controls HR 3 and HR 7 (or HR 4 and HR 8, if shorter delay times are desired), ATT 2, 3, 5, 8, 10, and 11 are to be opened, and switch K 4 couples the control groups ATT. The circuits may easily be traced out in Figure 6, and seen to correspond to the circuit of Figure 4.

In the MS-I or II, or XY-I or II, positions of the group switches, the delays and reverberation are passed through to one echo channel only. Further possibilities will be worked out as the need arises. Controls ATT 1 to 8 may be designed as double controls and the signals to be applied or to be removed may be switched by relays as required (MD-technique, etc.); thereby setup errors may be reduced. Such a comprehensive "special echo-mixer" of course needs clear appropriate labeling.

Both outputs are permanently connected to the microphone mixing controls of the main mixer. Since these act as the echo-return controls for the special echo-mixer, additional controls are unnecessary. The equalizers EQ 1 to 12 are universal equalizers permitting emphasis and de-emphasis in any range, and also a presence filter characteristic. These permit simulating the frequency response of apparent wall reflections as well as desired modifications to the acoustic properties of the recording hall.

This paper shows that the usual mixing console is inadequate to handle properly the desired echo treatment unless echo treatment is grouped together as a separate interconnecting and mixing system. Such "special echo-mixers" may also be built as independent equipment, and used to complete existing control facilities. They are of special value for re-mixing and treating 4 or 8 track recordings.

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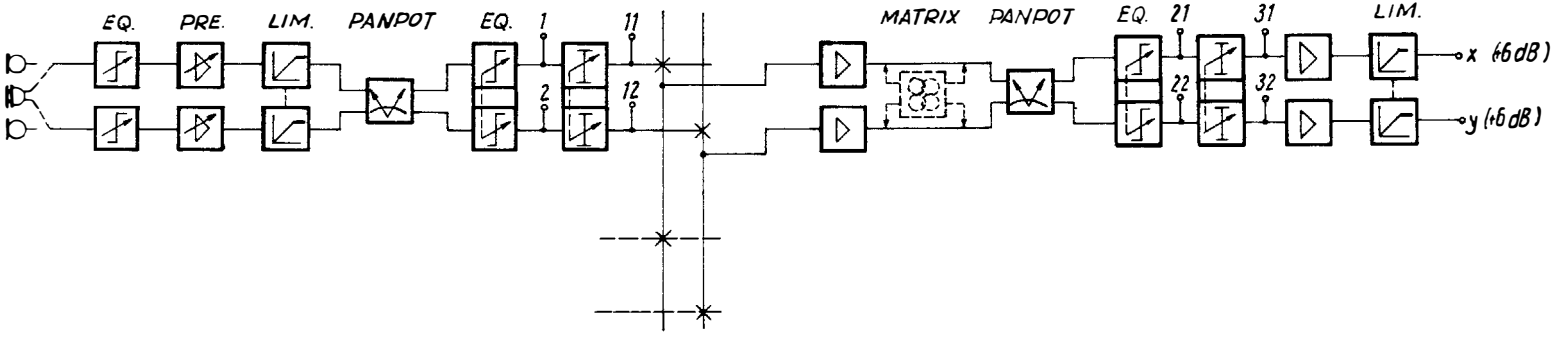
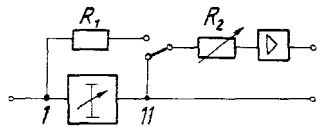
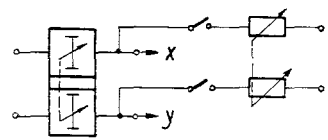


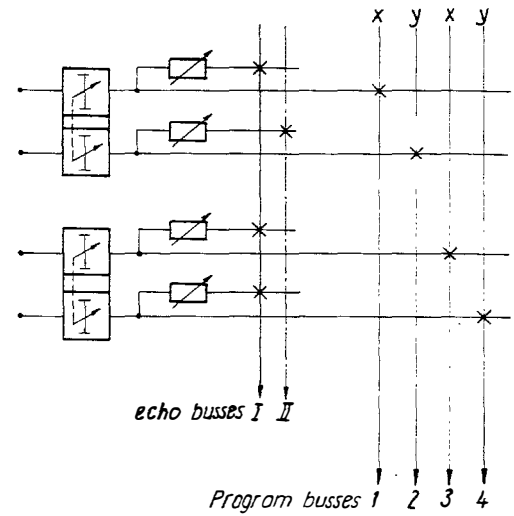

*Fig. 1* Block diagram of a stereo transmission channel




(a)




(b)




(c)

*Fig. 2* Echo-feed systems

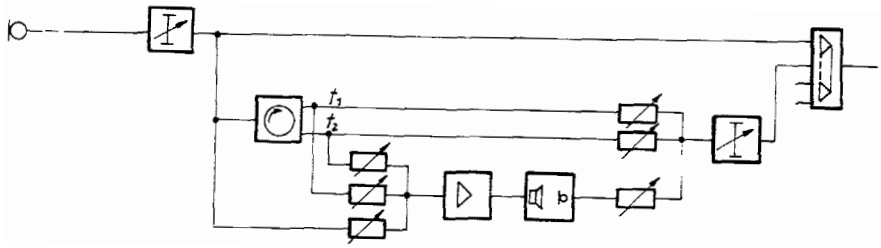


*Fig. 3* Combination of a delayed direct signals, and delayed and reverberated signals

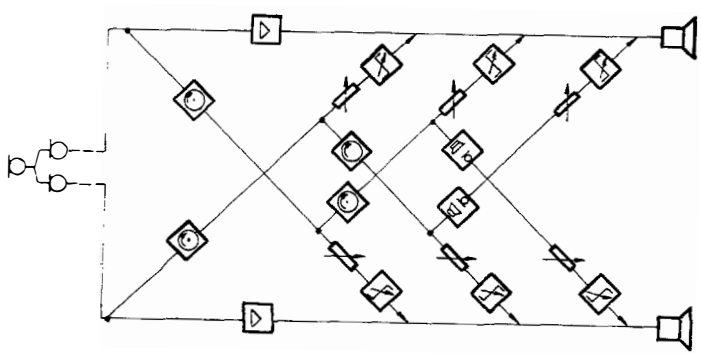


*Fig. 4* The principle of the "Magic Dimensions (MD) Method" (from reference 5)

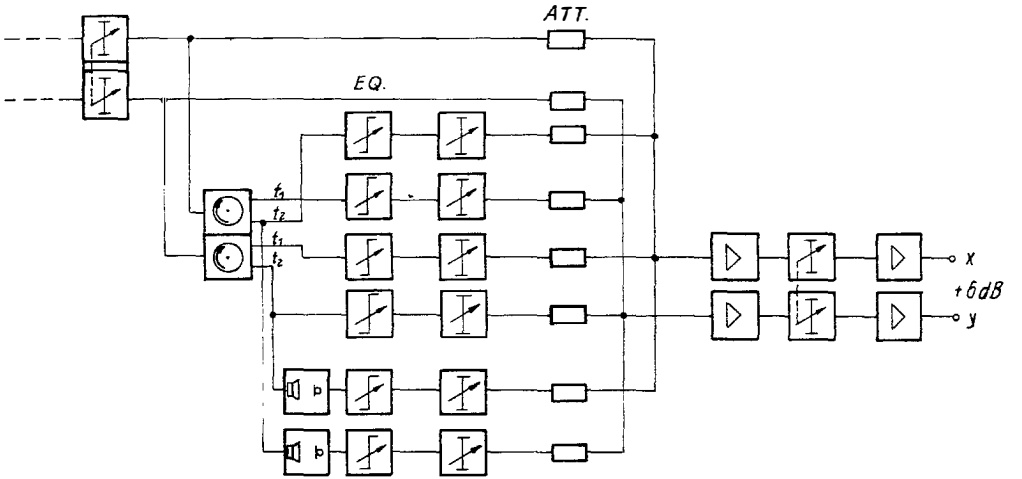



*Fig. 5* Block diagram for the "MD-Method"

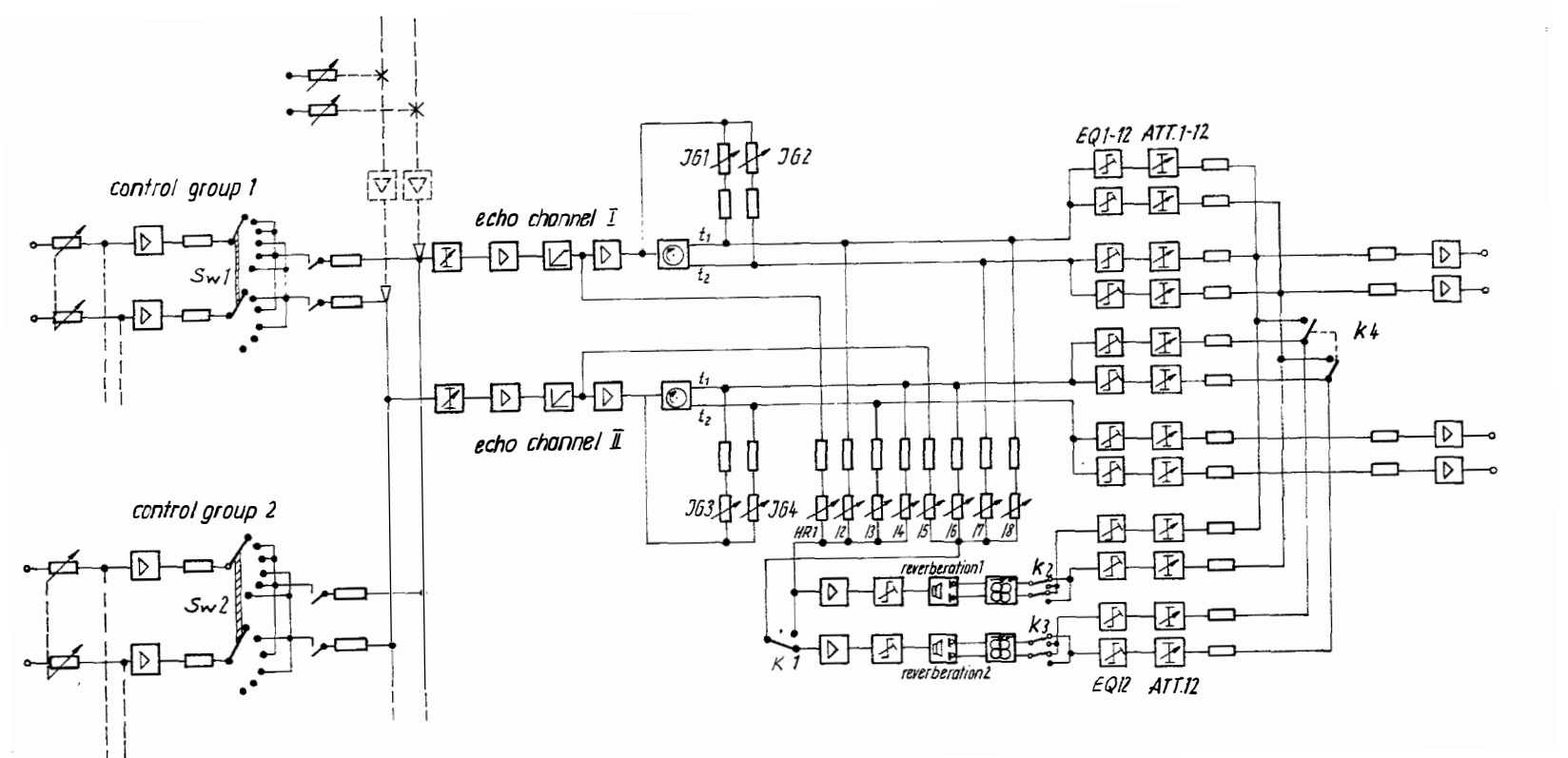



*Fig. 6* General-purpose "special echo-mixer" for a multichannel control console

LEGEND

Amplifier (microphone-, pre-, main-amplifier, program ampl.)

Amplifier with adjustable gain

Linear gain control (microphone control, mixer, not rotary)



Fixed attenuator network

Equipment for artificial reverberation (echo chamber, plate)

Pot. (rotary control)

Control amplifier (compressor, limiter)

Mixing amplifier with several separate inputs

Delay equipment (with adjustable delay times $t_1$, $t_2$ etc.)

Matrix, differential transformer

Effect equalizer, adjustable (with amplifier and therefore without basic attenuation)

Panpot, direction mixer (with effect equalizer and amplifier)