FLEXICADE - AN EVOLUTIONARY CABLE SYSTEM

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INTRODUCTION

When the total telecommunications requirements of a cable system for the top 100 markets is considered, it becomes evident that the conventional frequency division multiplexed cable system lacks certain important features that will be needed for the metropolitan areas.

Two of the more obvious shortcomings are:

- 1) It cannot transport high quality television signals over the distances encountered in the metropolitan areas.
- 2) It does not work well in the high ambient signal levels found in most large cities.

To overcome these shortcomings, Ameco is introducing a system concept called FLEXICADE.

The name FLEXICADE has been coined by Ameco to describe a total concept in signal handling and distribution equipment that was designed specifically to provide a cable system capable of meeting the multi-faceted industrial and community requirements that exist in these metropolitan markets today. At the same time, however, FLEXICADE offers alternate capabilities that can help the small system owner who needs an economical system to handle long signal transportation runs through sparsely populated areas.

A partial list of the salient features of FLEXICADE include:

- TV pictures can be made available to the customer without influence of local high ambient signal levels.
- Two way capability is provided without group delay distortion.
- Reverse channel capacity is not limited by the system.
- Forward and Reverse trunk capability may be interchanged to meet changing requirements.

- Low frequency trunk system holds signal degradation to a minimum by minimizing the amplifier cascade.

- Systems are available with 12, 20, 24, 26, 32, 40 channels as standard equipment.

The FLEXICADE concept, in spite of the impressive features, does not represent a revolutionary concept in cable television. Instead it is a concept that has evolved from Ameco's DISCADE[1]/ system design experience. The hardware that has been designed to implement the concept is new, and designed with the latest components, but the principles are merely an extrapolation of existing techniques that have been proven through years of experience. Hence, it can be said that FLEXICADE is an evolutionary system.

II. GENERAL SYSTEM DESCRIPTION

The FLEXICADE system combines the virtues of space division and frequency division multiplexing along with sub-band signal transportation to provide a variety of possible system configurations to meet many different requirements. To understand the various system configurations available, let us first examine the basic constituent elements that are used to make up the systems.

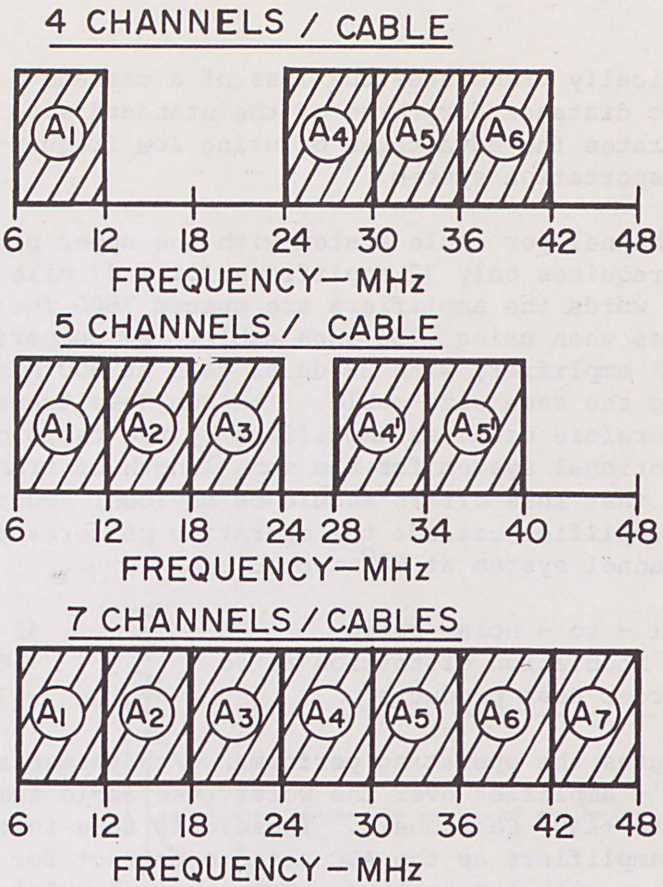
TRANSPORTATION SYSTEM

The FLEXICADE transportation system uses the frequency spectrum between 6 and 48 MHz for sub-band signal transmission on conventional coaxial cable. The picture and sound carrier assignments for each of the channels A1 through A7, listed in Figure 1, are uniformly spaced at 6 MHz. This allows a maximum of 7 television channels to be handled in the 42 MHz bandwidth available.

There are two versions of the transportation system available, a 4 channel per cable system that uses Channels A1, A4 and A5 and A6, and a 7 channel per cable system that uses the entire bandwidth of the transportation system to handle channels A1 thru A7.

When the FM radio band is being transported it occupies the 20 MHz band between 15 and 35 MHz on the cable.

The amplifiers that were designed for this application are Ameco's new SUBNOVA line of R.F. amplifiers. These are high quality trunk line amplifiers that use the latest hybrid push-pull circuits to provide the signal amplification. A dual pilot carrier AGC system is used to provide absolute control of output level and slope over a temperature range of -40 to +140 degrees Fahrenheit. The basic amplifiers are designed to provide 30 dB of flat gain over the frequency range of 2-110 MHz in this application. Plug-in equalizers provide gain equalization for the coax cable over the frequency range from 6 MHz to the upper picture carrier at 37.25 MHz or 43.25 MHz depending on the number of channels carried on the cable.



CHANNEL	BAND—MHz	CARRIER FREQUENCY—MHz VISUAL	AURAL
A_1	6–12	7.25	11.75
A_2	12–18	13.25	17.75
A_3	18–24	19.25	23.75
A_4	24–30	25.25	29.75
$A_{4'}$	28–34	29.25	33.75
A_5	30–36	31.25	35.75
$A_{5'}$	34–40	35.25	39.75
A_6	36–42	37.25	41.75
A_7	42–48	43.25	47.75

FIGURE 1 – TRANSPORTATION SYSTEM-SPECTRUM UTILIZATION

Figure 2 graphically translates the loss of a cascade of 32 Sub Nova amplifiers into distance for three of the standard size coax and clearly illustrates the advantages of using low frequency for the FLEXICADE transportation system.

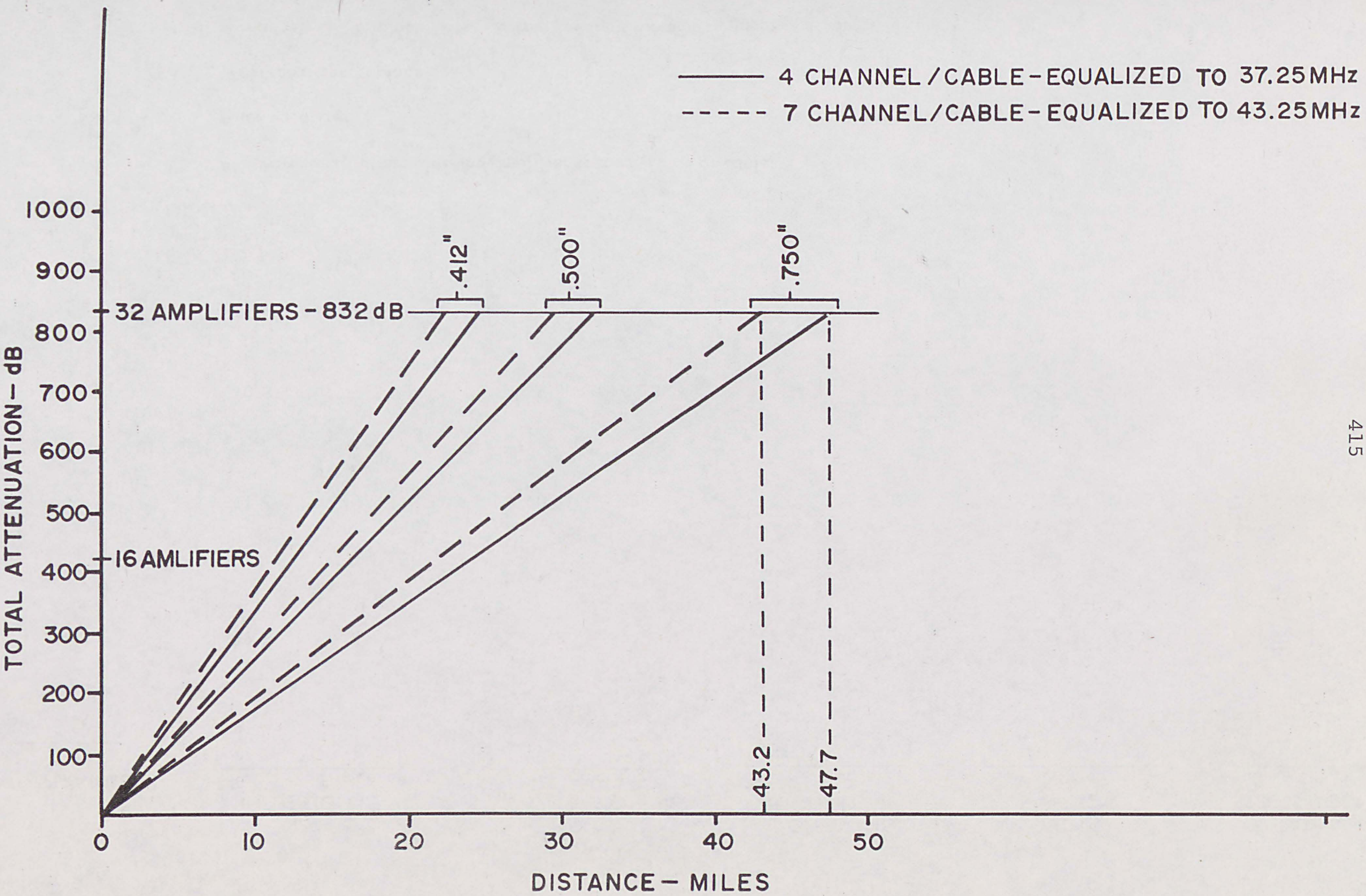
Here, a four channel per cable system with the upper picture carrier at 37.25 MHz, requires only 32 amplifiers for a 47 mile transportation run. In other words the amplifiers are spaced 7880 feet apart or nearly 1.5 miles when using .750 inch cable. By comparison the conventional trunk amplifier, with 22 dB of gain at 300 MHz is spaced 2000 feet using the same size cable. The Sub Nova transportation system will therefore use less amplifiers by the ratio of 3.94 to one over the conventional system for the same length of transportation run. The advantages that this offers should be obvious. Further, at the end of the 32 amplifier cascade the operating performance characteristics of a 4-channel system at 68°: would be:

Signal - to - noise ratio	$\geq$	45 dB
Cross Modulation distortion ratio	$\leq$	-60 dB
2nd Order Beat products	$\leq$	-61 dB

Figure 3 tabulates the operating performance characteristics of an individual AGC'd amplifier over the worst case cable temperature extremes of -40 to +140° Fahrenheit. These data take into account the action of the amplifiers as the AGC acts to correct for the changes in cable attenuation with temperature. From these tabulated characteristics it can be noted that while the output Cross Modulation distortion changes very little with temperature, the Noise Figure changes by a relatively large amount going from 6.9 dB at +140°F to 9.6 db at -40°F. Contrary to first reactions this is not a bad situation since this occurs at the same time that the input signal level has increased from 7.3 dBmV to 12.8 dBmV. The net result is that at this "worst case" Noise Figure of 9.6 dB the output signal to noise ratio, the parameter of real concern, only degraded by 0.4 dB below the value at 68°F. This trend prevails in all cases with the result that the change in input signal to noise ratio caused by cable changes with temperature tends to be offset by the amplifier Noise Figure changes, thereby holding the output signal to noise ratio relatively constant.

In general the Sub Nova amplifier has been carefully designed to optimize its performance characteristics within the framework provided by the state of the art components. This means that long amplifier cascades can be used with minimum effect on the signals being carried.

Each Sub Nova amplifier is symmetrically packaged so the direction of amplification can be reversed by physically plugging the amplifier into its housing in a reversed sense. Thus forward and reverse lines may be readily interchanged as the system needs change. Detailed electrical and mechanical specifications are tabulated in Appendix "A".



4 CHANNEL / CABLE - EQUALIZED TO 37.25MHz
7 CHANNEL/CABLE - EQUALIZED TO 43.25MHz
TOTAL ATTENUATION - dB
1000
900
800
700
600
500
400
300
200
100
32 AMPLIFIERS - 832 dB
16 AMLIFIERS
.412"
.500"
.750"
43.2
47.7
0
10
20
30
40
50
DISTANCE - MILES

FIGURE 2 – CASCADE DIAGRAM – SUB NOVA AMPLIFIER

TEMPERATURE °F	2/ INPUT SIGNAL dBmV @ Frequency f1	f2	2/ INPUT S/N RATIO dB @ Frequency f1	f2	3/ OPERATING NOISE FIGURE dB @ Frequency f1	f2	OUTPUT S/N RATIO dB @ Frequency f1	f2	4/ OPERATING CROSS MOD- dB
-40	12.8	12.9	71.8	71.9	9.6	8.5	62.2	63.4	90 5/
+68	11.6	9.5	70.6	68.5	8.0	7.3	62.6	61.2	92
+140°	10.8	7.3	69.8	66.3	7.3	6.9 5/	62.5	59.4	92

f1 = 7.25 MHz , f2 = 43.25 MHz

NOTES:

1/ All characteristics are with the amplifier spaced 26 dB of cable

2/ After equalizer

3/ With equalizer in place

4/ 4 channel, 5 dB Block Tilt - output level = +36 dBmV, input = 10 dBmV @ 68° F

5/ Amplifier Specifications (See Appendix A)
NOISE FIGURE - 7.5 dB @ Min. full gain, f= 43.25 MHz W/O Equalizer
CROSS MODULATION DISTORTION - (-) 90 dB @ +36 dBmV

FREQUENCY TRANSLATION EQUIPMENT

Since the signals in a FLEXICADE system are transported at sub-band (6-48 MHz), frequency translation equipment is required at both the Head End and at some other point in the system to make the frequency transition from the standard VHF channels to sub-band and back again.

HEAD END

At the Head End frequency translation is accomplished by a heterodyne signal processor with the output directly on the sub-band channel desired. The signal processor that is used is Ameco's new MARK II CHANNELEER.

This new MARK II CHANNELEER features:

- An FET front end for better S/N ratio and over load capability
- Improved filtering for better adjacent channel selectivity
- Improved temperature stability

These improved features assure that the signal to noise ratio will be a minimum of 59 dB, as long as the input signal is above +6 dBmV, and that all other undesired signals will be at least 60 dB below the desired signal level under normal operating conditions.

UNIVERTOR

Four models of strand mounted Hub Converters called Univertors are available to convert the sub-band spectrum back to VHF at the end of the transportation run. The choice of which Univertor to use depends entirely upon the services that will be provided to the customer and the choice of set-top converter, if any, that will be used.

MODEL I UNIVERTOR

The frequency translation scheme of the Model I Univertor is depicted in Figure 4. This particular conversion scheme is also compatible with the TYPE II FLEXICADE system to be explained later. Three input cables with four television channels per cable plus one cable with FM radio are provided at the input to this converter. Conversion is accomplished with six converters. Three single channel converters accept the 6-12 MHz band at the input and provide an output on Channels 5, 6 and 13. Three block converters accept an input of 24-42 MHz and provide at the output Channels 2, 3 & 4, Channels 7, 8 and 9 and Channels 10, 11 and 12.

The FM radio band is carried on the trunk between 15 and 35 MHz and is block converted from this spectrum back to the standard 88 to 108 MHz FM radio band. After conversion the FM is multiplexed onto the output cable along with the twelve television channels.

The output amplifier of the converter is a push-pull hybrid amplifier that drives two output ports at a nominal output level of +36 dBmV or one output port to a level of +40 dBmV.

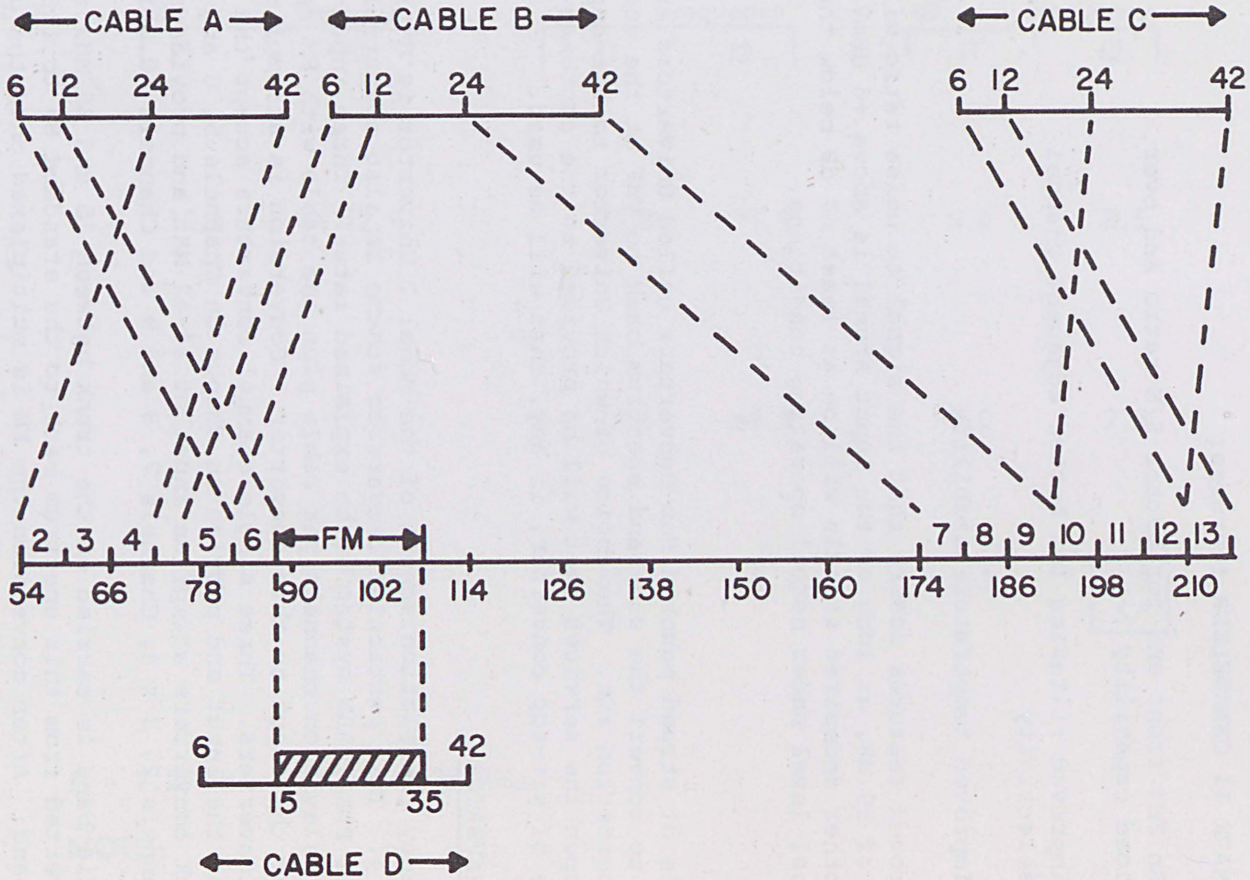


FIGURE 4- FREQUENCY TRANSLATION - UNIVERTOR, MODEL I

In this manner the output is high enough so it can drive a feeder line directly. This drive level may be reduced from +40 dBmV to +32 dBmV to make the output level suitable to drive a trunk line for a more extensive distribution system.

When it is necessary selected VHF channels at the output of the Model I Univertor may be phase locked to an off-the-air TV channel to minimize the visible affects of local TV channel interference. Since these problems are different for each locale, the phase lock feature is customized to meet the requirements of each installation.

MODEL II UNIVERTOR

The frequency translation scheme of the MODEL II UNIVERTOR is depicted in Figure 5. Here two input cables with television channels and one with FM are provided at the input to the converter. Conversion is accomplished with three Block Converters. Cable No. 1 has five television channels on it with a 4 MHz spacing between the 3rd and 4th channel. When properly block converted this input spectrum translates to the Low VHF Band Television Channels 2 through 6. Cable No. 2 has seven television channels on it in a contiguous spectrum between 6 and 48 MHz. When properly block converted this input spectrum translates to the High VHF Band television Channels 7 through 13. Cable No. 3 carries the FM radio band between 15 and 35 MHz and, as in Model 1, is block converted to the 88-108 MHz band. The output multiplexing is similar to the Model I Univertor and provides twelve standard VHF television channels plus FM radio at the same output drive capability as the Model I Univertor.

The MODEL II UNIVERTOR output is compatible with the standard television set and no set-top converters are required by the customer. Two MODEL I or MODEL II UNIVERTORS are required for dual 12 channel capability.

MODEL III UNIVERTOR

The frequency translation scheme of the Model III Univertor is depicted in Figure 6. Here four input cables with television channels and one with FM radio are provided at the input to the converter. Conversion is accomplished with five block converters. The Low VHF Band is handled in the same manner as the Model II Univertor. The next three cables with seven TV channels per cable are block converted to provide the Mid-Band, High-Band and Super-Band television channels A through N and 7 through 13.

Again FM radio is block converted as described in the Model I Univertor. The output multiplexing is also similar to the Model I Univertor and provides 26 channels of TV plus FM at the same drive capability as this Univertor.

The Model III Univertor is compatible with most existing 26 channel step tuned set-top converters.

MODEL IV UNIVERTOR

The Model IV Univertor frequency translation scheme, depicted in Figure 7, is identical to the Model III Univertor except that the converters for the Mid-Band and Super-Band channels are arranged so as to invert these channels. In this manner the output of this Univertor provides 26 channels of television that is compatible with the tunerless style of set-top convert

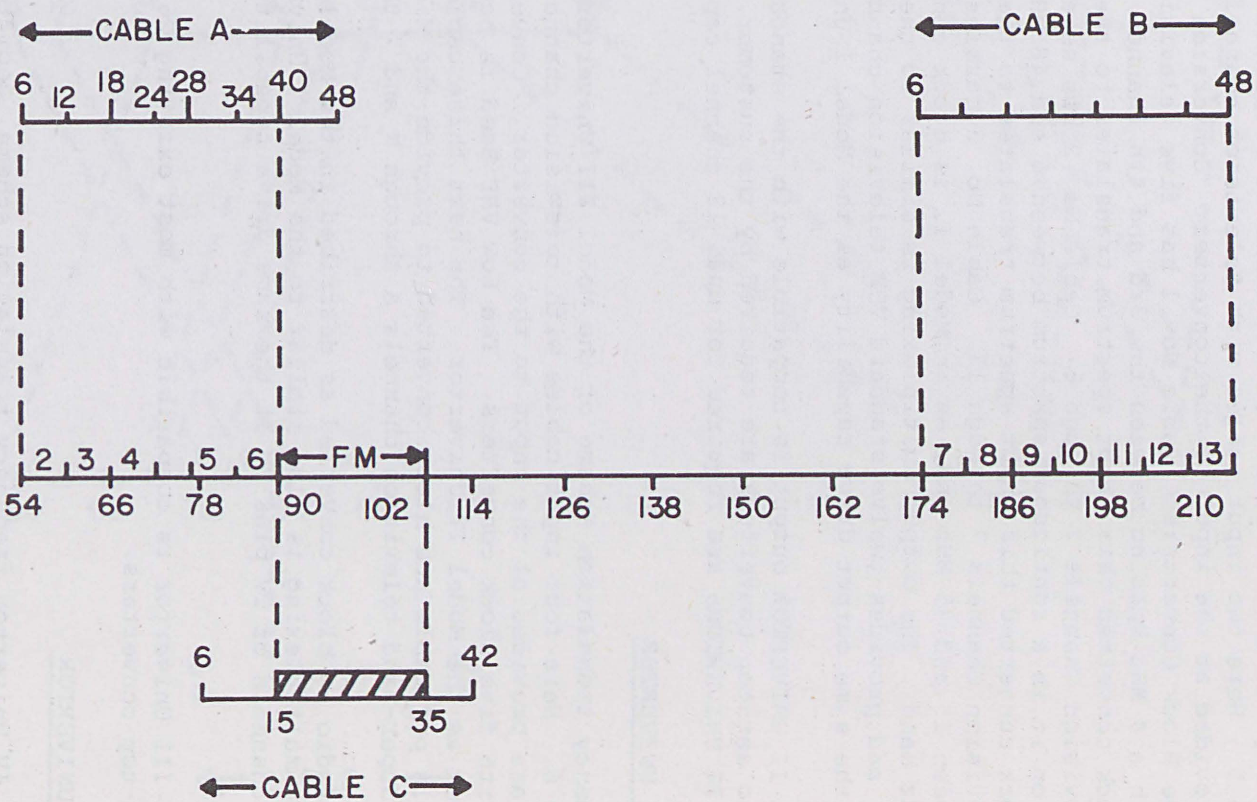
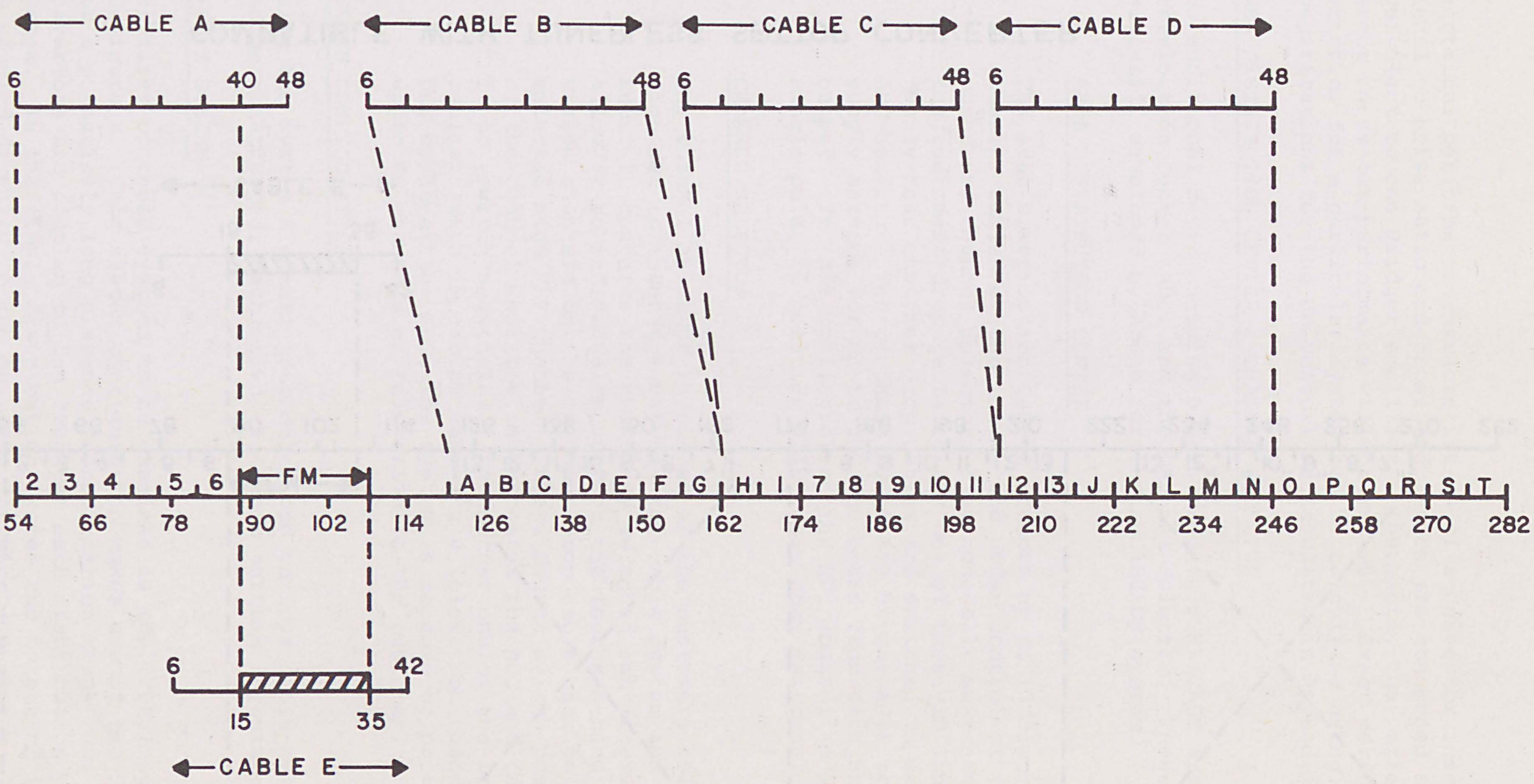
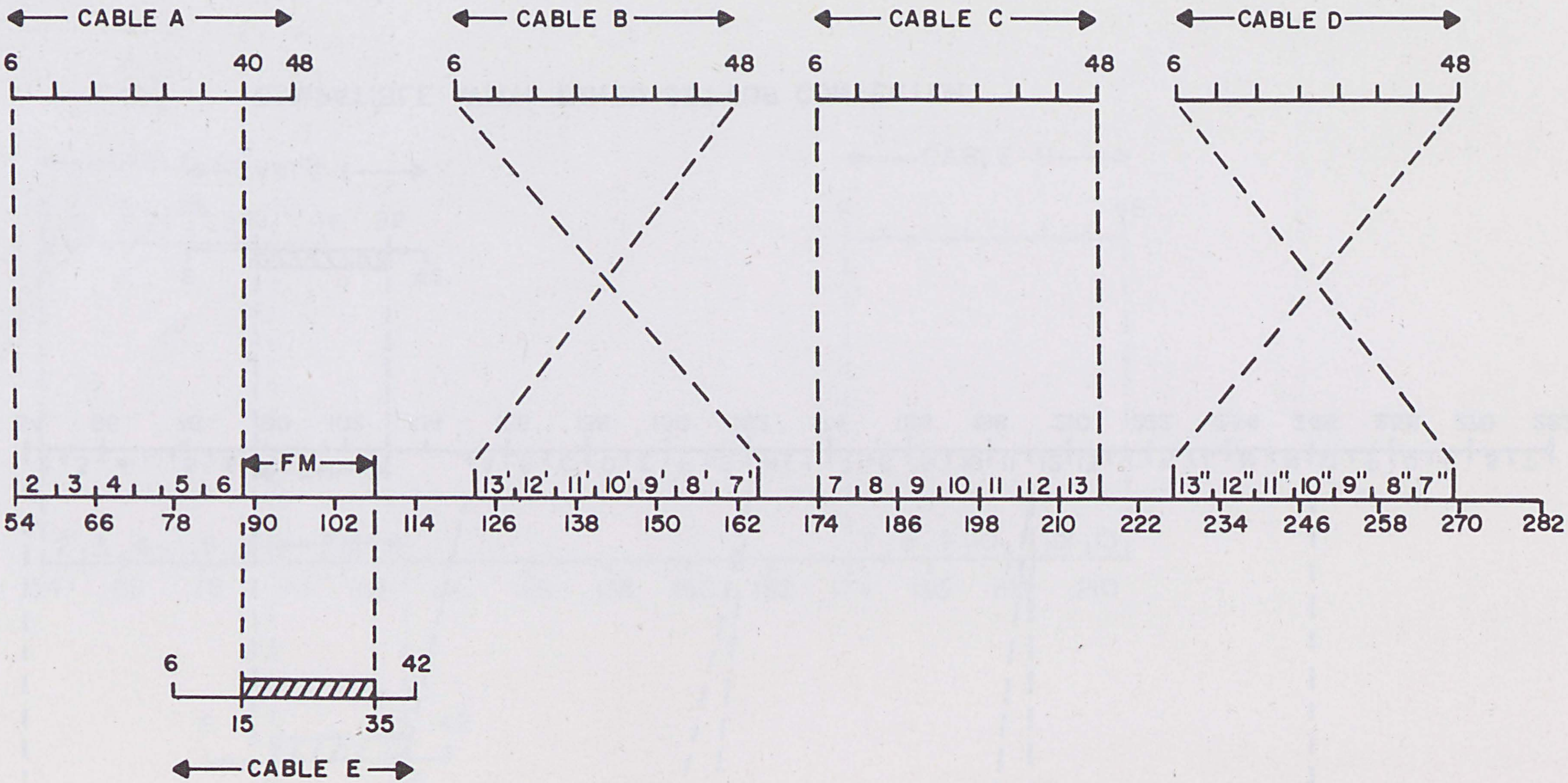


FIGURE 5 — FREQUENCY TRANSLATION — UNIVERTOR, MODEL II



COMPATIBLE WITH TUNED SETTOP CONVERTER

FIGURE 6 – FREQUENCY TRANSLATION – UNIVERTOR, MODEL III



COMPATIBLE WITH TUNERLESS SETTOP CONVERTER

FIGURE 7 — FREQUENCY TRANSLATION-UNIVERTOR, MODEL IV

Electrical performance characteristics of a Univertor insofar as overall signal to noise ratio and cross modulation are concerned are approximately equivalent to one Bridger amplifier. Therefore, the affect of the Univertor on system performance will be minimal. Exact performance characteristics for a particular system may be calculated using the detailed specifications for the Univertors as tabulated in Appendix "A"

AREA DISTRIBUTION CENTER & CHANNEL SELECTOR

Two additional basic building blocks used in FLEXICADE are the Area Distribution Center (ADC) and the Channel Selector. These units were originally developed by Ameco for their DISCADE system.

AREA DISTRIBUTION CENTER

The Area Distribution Center accepts up to 10 discrete coaxial cables at the input, and under control of the customers channel selector, electronically switches the customers drop cable to any one of these 10 lines; twenty-four customer drop cables are switched in each ADC housing. Ten of these ADC's may be cascaded to supply service for up to 240 customers from each bridger output. In this configuration the ADC looks like 240, single pole, 10 position electronic coax switches.

CHANNEL SELECTOR

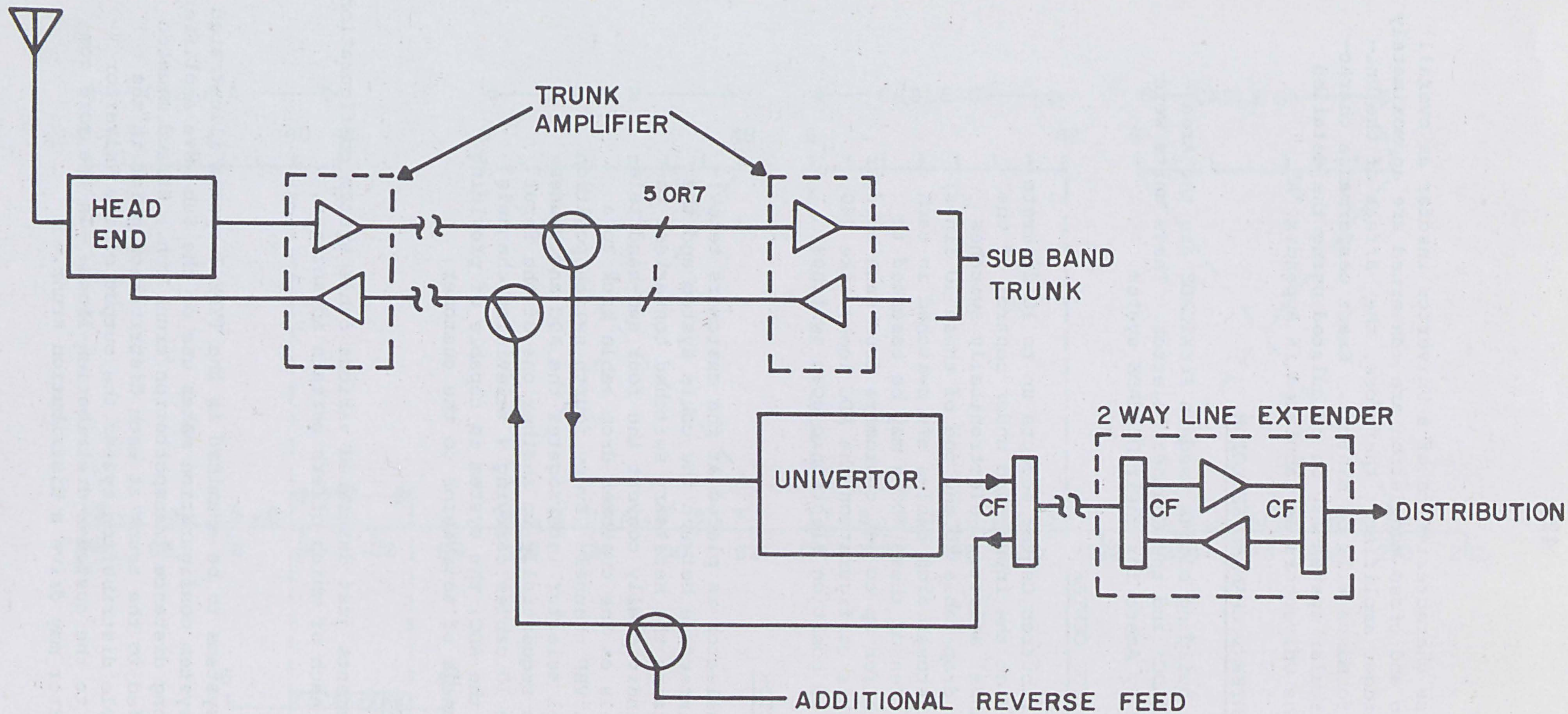
The channel selector is placed at the customers television set to interface between the cable system and the set. It contains the necessary switched converters to allow it to individually convert the four sub-band television channels on the customer drop cable back to a selected high VHF channel. Every fourth switch position of the channel selector interrogates the ADC and causes it to switch sequentially to another one of the input cables. With 10 cables carrying 4 television channels per cable at the ADC, the system is capable of providing up to 40 channels of television to the customer.

SYSTEM CONFIGURATIONS

Using the system elements just described various cable system configurations can be constructed, each of which offers certain advantages.

TYPE I SYSTEM

The first of these systems to be examined is the TYPE I system illustrated in Figure 8. This system configuration makes use of the Sub Nova amplifiers for a potentially long distance transportation trunk run. Strand mounted Univertors are coupled to the trunk at each distribution point in the system. In the simple distribution system the output of the Univertor is coupled directly to the customer distribution lines. In the more complex case the Univertor may drive a distribution trunk.



OUTPUT—DUAL 12 CHANNELS OR 26 CHANNEL TV PLUS FM

FIGURE 8—TYPE I SYSTEM CONFIGURATION—UNIVERTOR MODEL I, II, III, OR IV
CONVENTIONAL ENTERTAINMENT WITH REVERSE FEED

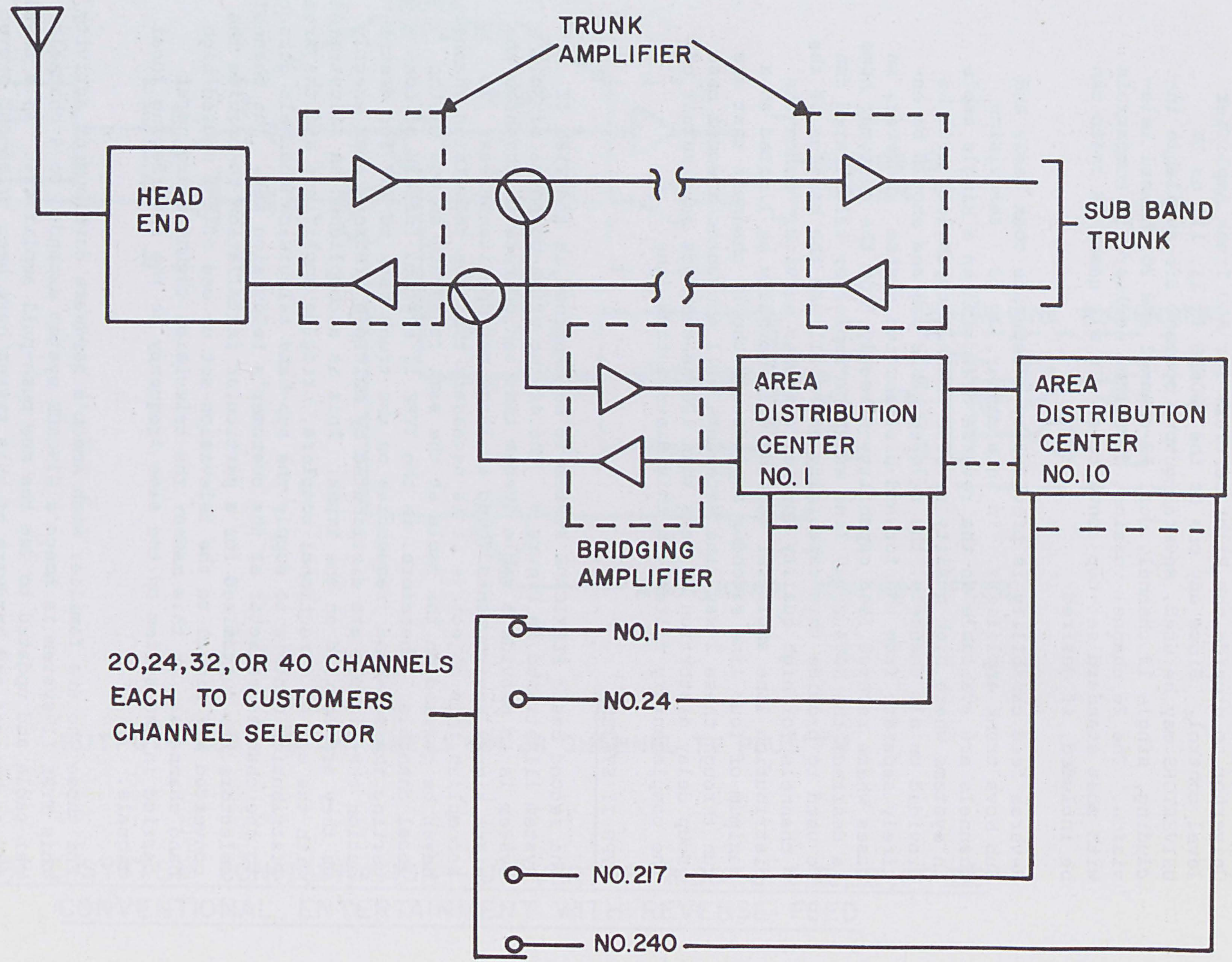
In this latter case Pilot Carrier generators are included in the Univertor to provide the Pilot Carriers for AGC Trunk Amplifier level control. Since any one of the MODELS I, II, III or IV UNIVERTORS may be used, several output options are available including, single 12 channel, dual 12 channel and 26 channel television. The 26 channel version, described earlier, is compatible with most standard set-top converters. In all cases FM radio can be included, if desired.

Reverse feed capability is provided by a separate coax cable and Sub Nova trunk amplifiers. In this manner, up to 7 television channels are available in the reverse direction on a single cable. In systems where high quality reverse channel capability will be provided on all channels, the reverse cable can and should be entirely separate from the forward distribution system. However, in cases where reverse feed capability directly from the customer home is desired, the NOVA 2-way line extender amplifier illustrated can be used to provide this capability and still use the balance of the 7 channels for high quality special customer service. Since the distribution line amplifier cascade will normally be limited to a maximum of four line extender amplifiers, the TV channels that are run through these 2-way line extenders will encounter a worst case group delay distortion of less than 120 nanoseconds as a result of the complementary filters in this distribution line.

TYPE II SYSTEM

The second basic FLEXICADE system to be examined is the TYPE II system illustrated in Figure 9. One of the prime purposes of this system is to provide a cable system that can operate in the high ambient signal environments found in large metropolitan areas. To accomplish this objective it is necessary that the television channel never be carried on the cable at the same frequency as one of the local channels. Therefore, in the TYPE II system, instead of converting the sub-band frequencies on the trunk back to VHF for distribution the signals are distributed by multiple discrete coax exactly as they are carried on the trunk. This is accomplished as illustrated with the use of directional couplers, bridging amplifiers and the Area Distribution Centers to supply the sub-band television channels directly to the channel selector at the customer's television set. The channel selectors are customized for a particular installation to provide the converted VHF signal to the television set on one of the unused high band channels. In this manner the television channels are never carried in the system on the same frequency as the interfering local signals.

For those who are familiar with Ameco's hardware development activity this TYPE II system is Ameco's DISCADE system expanded to 4 channels per cable and updated to use the new push-pull amplifiers. As a result, the techniques and hardware of this system have been tried and proved in actual service.


TRUNK
AMPLIFIER
HEAD
END
SUB BAND
TRUNK
AREA
DISTRIBUTION
CENTER
NO. 1
AREA
DISTRIBUTION
CENTER
NO. 10
BRIDGING
AMPLIFIER
20,24,32, OR 40 CHANNELS
EACH TO CUSTOMERS
CHANNEL SELECTOR
NO. 1
NO. 24
NO. 217
NO. 240

COMBINED SYSTEMS

In most large metropolitan areas the cable system requirements will vary from area to area within the city. In one locale the prime problem may be high density housing with attendant strong interfering signal levels.

In another, more suburban area, these problems may not exist at all. A system designed to meet the criteria in one area may be completely unsuitable for application in another area served by the same operator.

FLEXICADE system components can be combined in various ways to provide acceptable solutions to all of these requirements. Figure 10 illustrates a very simplified combination of a TYPE I and TYPE II system that is designed to serve a high density industrial/commercial complex as well as a more remote suburban area. In this illustration, a local control hub serves to provide a switching center, remote from the Head End, which will allow the operator to adapt the system capabilities to meet the variable services that will be demanded by a dynamic commercial market.

The system illustrated provides the very flexible two-way services of the TYPE II system for the commercial services where high ambient local signals would be expected. On the other hand for the regular home entertainment services the TYPE I system with dual 12 channel output capability provides a very acceptable grade of service. In this manner set-top converters are not required for the large population of customers in the homes. Channel selectors would be required by those served by the TYPE II system, but this would only be for the relatively few commercial customer served.

A system with the basic principles of the one described above is presently in the first phases of construction by AMECO.

APPLICATION OF FLEXICADE

The most comprehensive application of the FLEXICADE system to date has been a cable system proposed to LVO, in Tulsa, Oklahoma, to meet the franchise requirements for that city. The capabilities of the system design reflects some of the potential that can be achieved using FLEXICADE system components in combination with conventional equipment.

SYSTEM DESCRIPTION

In laying out the FLEXICADE system design the city is divided into four major geographical regions with a neighborhood programming and distribution hub placed central to each area, see Figure 11. A fifth Neighborhood Hub is located adjacent to a Main Central Distribution Center. Each neighborhood is a self contained cable television system with its own receiving antennas for local television stations and provisions for receiving up to four distant microwave signals. Each Neighborhood Hub can originate one channel of television for distribution within its neighborhood or to other neighborhoods.

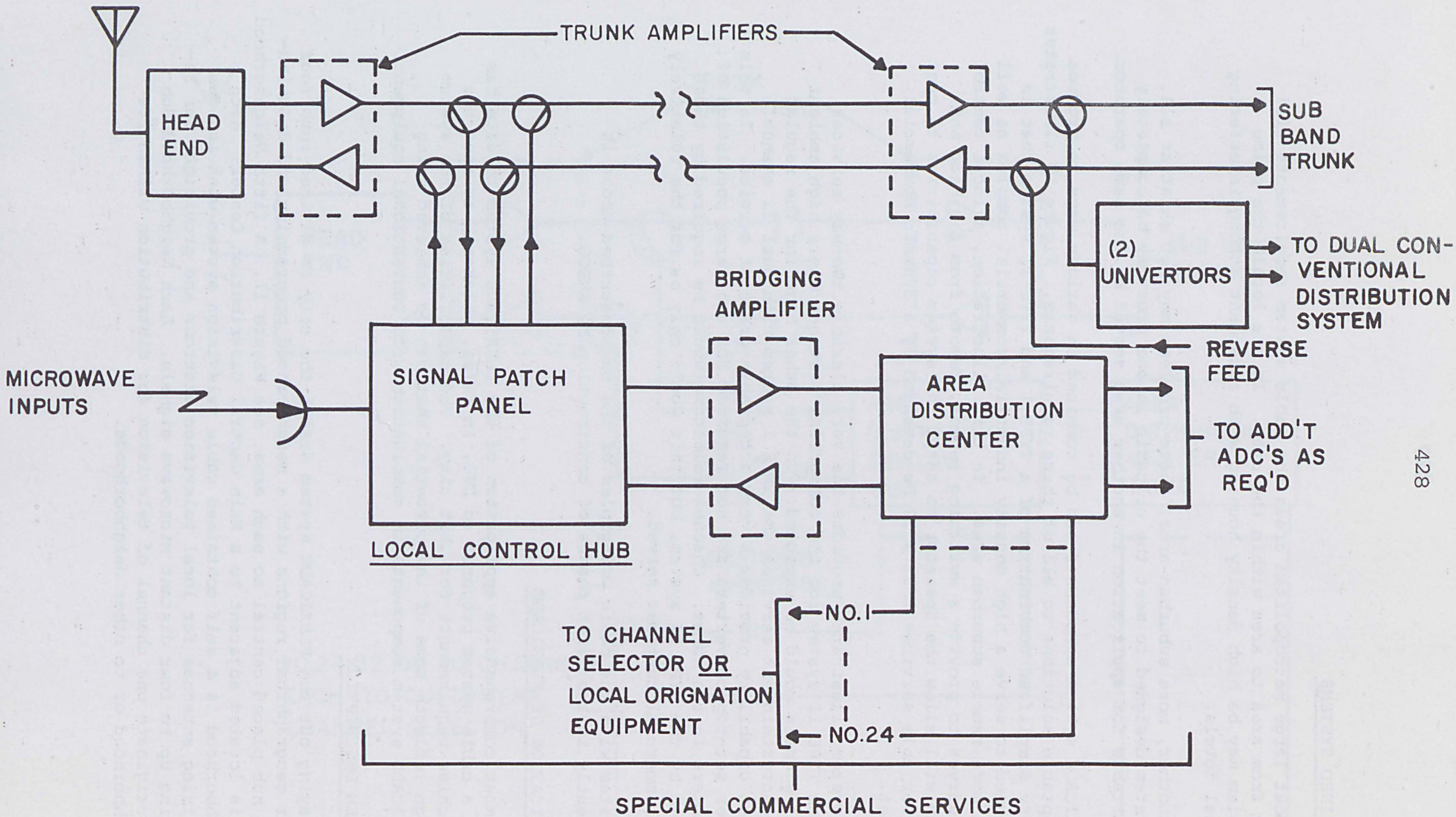


FIGURE 10 – COMBINATION, TYPE I & TYPE II SYSTEM – FLEXICADE WITH INDUSTRIAL/COMMERCIAL CONTROL CENTER

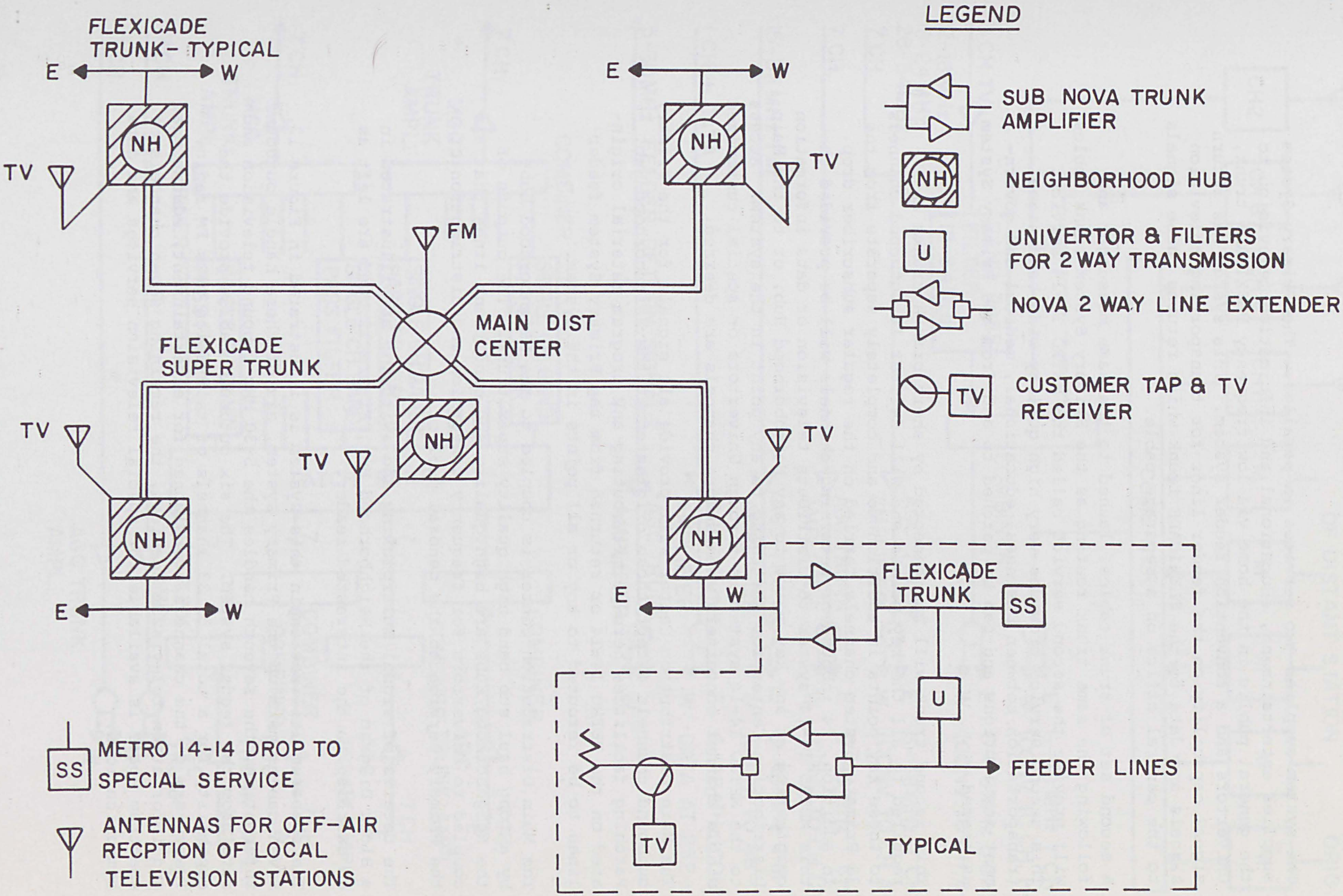


FIGURE 11— OVERALL SYSTEM CONCEPT

The system supplies two services in parallel. The Primary System supplies entertainment, educational and information television to the general public in the home via low frequency FLEXICADE trunk, Univertors and a convention feeder system. This system has return signal capability on the feeder lines for transporting television signals and data to the FLEXICADE trunk which returns these signals to the central office on a separate cable.

A second set of trunk cables, lashed to the same messenger and following the same trunk routing as the Primary System trunk cables will provide the second service called the METRO 14-14 service. This second service provides very high quality wide-band signal transportation between business, educational, medical and government institutions and can be patched to and from the Primary System as needed.

This second trunk will be connected by short branch trunks as required to all the key points and will deliver 14 outbound channels to these key points in addition to and completely separate from the 33 Primary System channels carried on the regular subscriber drop. In addition, 14 inbound or returning channels will be provided on this METRO 14-14 system to distribute television or data information originating at any key point to any Neighborhood Hub, or to the Main Distribution Center for switching to any point in the system. Access to the METRO 14-14 system is through Univertors or special customized single channel converters when secure channels are desired.

The Main Distribution Center will provide all signals for the Primary outbound channels except those originated at the Neighborhood Hub. Patching facilities here permit routing any program material originated on the METRO 14-14 or returned from the Primary System feeder lines to be rerouted to any or all points in the system.

The Main Distribution Center is coupled to the Neighborhood Hubs by a long haul sub band high quality super trunk. The outputs of the Neighborhood Hubs are high quality sub band trunk lines that are coupled to Univertors for frequency conversion and distribution of the Primary service to the general public.

The details of signal multiplexing and switching are illustrated in a Block Diagram of the Neighborhood Hub, Figure 12, and are left as an exercise to the interested reader.

The spectrum utilization in this system is illustrated in Figure 13. Seven cables make up the Primary system, six of these handle outbound information, the seventh handles the 5-30 MHz inbound television and data from the feeder system. The six outbound cables provide the capability for a total of 33 channels of television plus FM radio. Twenty-six of the channels are planned for entertainment, educational and information television services, the remaining seven channels of spectrum space is available for special television services and data communications.

PRIMARY SYSTEM

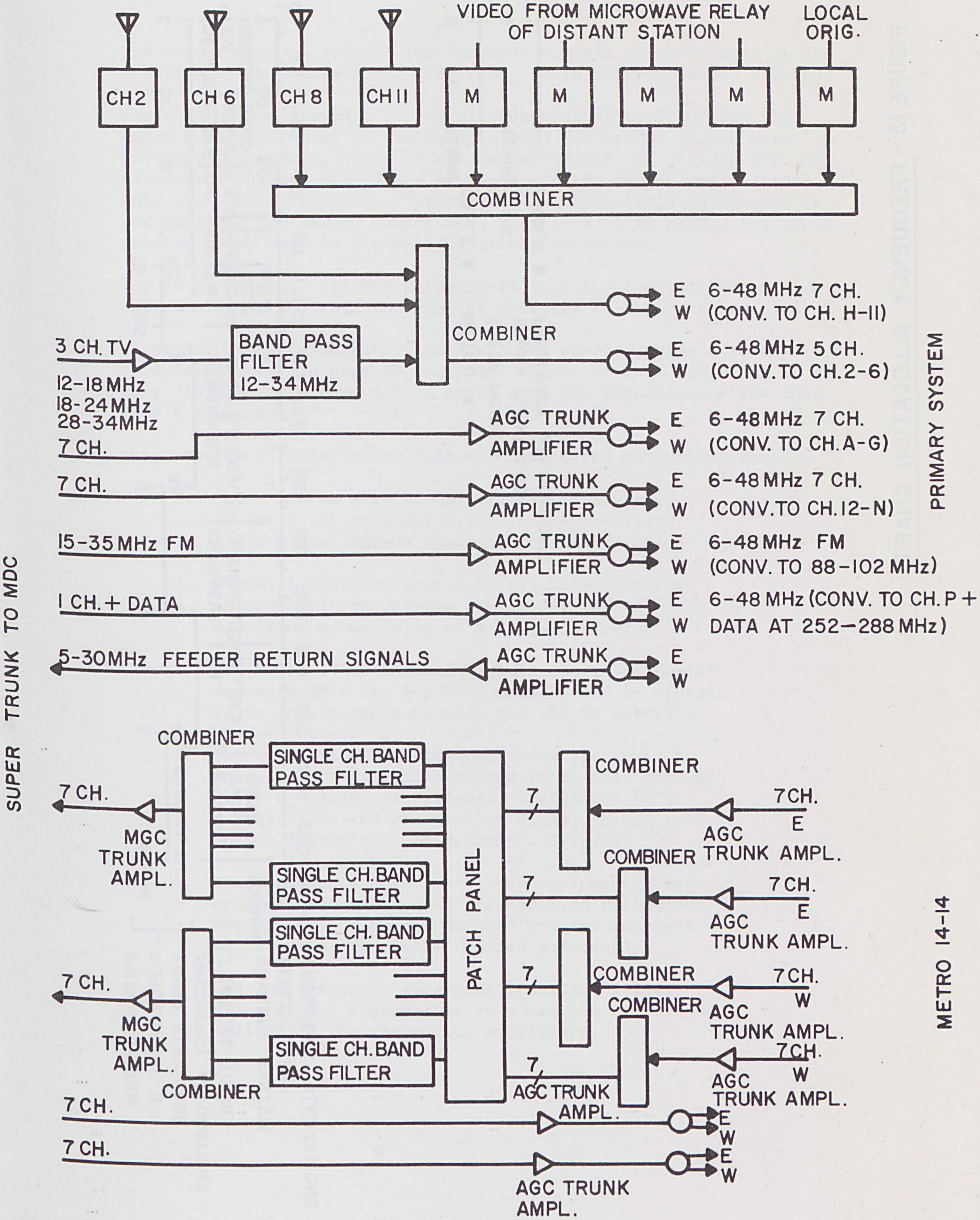


FIGURE 12—NEIGHBORHOOD HUB

METRO 14-14

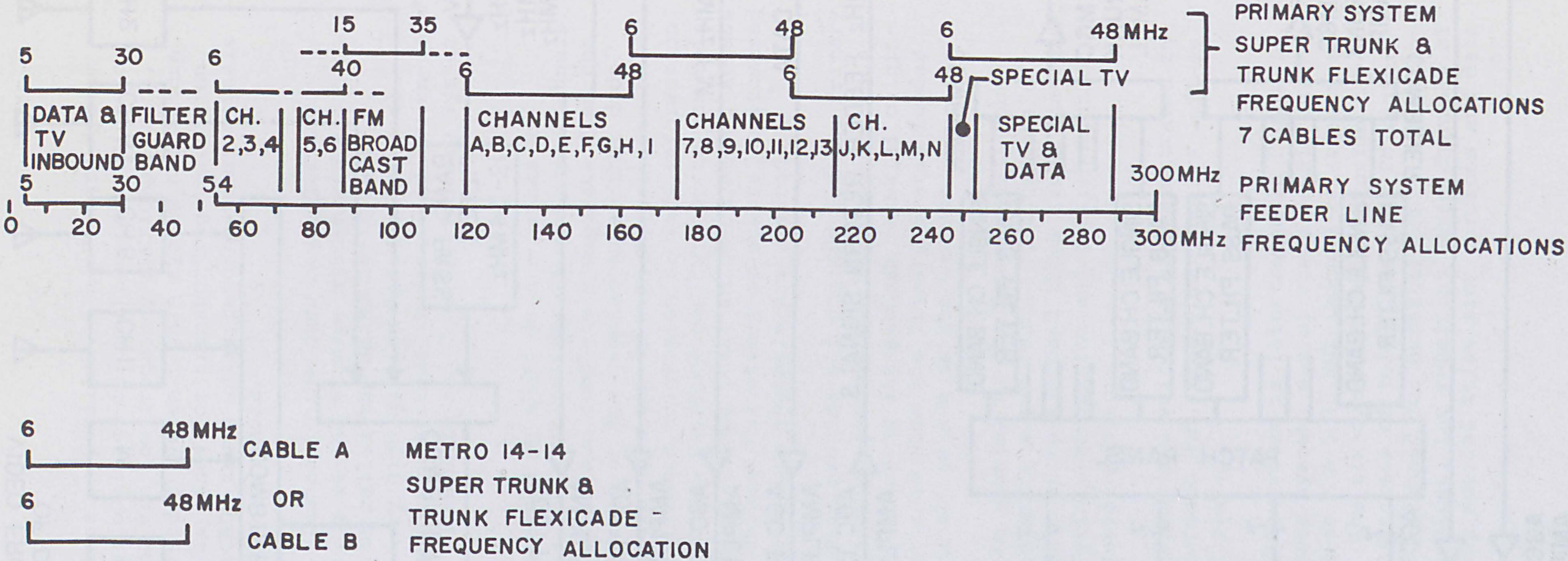


FIGURE 13 — FREQUENCY ALLOCATION CHART

The Univertor Hubs convert the sub band signals on each cable to the spectrum space allocated on the feeder cable between 54 and 300 MHz.

The return line provides 25 MHz of system capacity from each and every subscriber drop to the Neighborhood Hub and on to the Main Distribution Center. This 25 MHz bandwidth will be divided into one television channel and 19 MHz of bandwidth for data communications. This spectrum is strictly "party line". The television channel is not intended for use by subscribers, but as a quick method for remote program relay back to the Main Distribution Center.

The 28 TV channels for the Metro 14-14 facility are carried on four coax cables on sub band frequencies directly to the customer.

In summary the FLEXICADE system for Tulsa would provide a total of 58 television channels plus FM radio and 19 MHz of data bandwidth in a very flexible arrangement that would meet the requirements for this city's franchise.

The features of this system that are considered noteworthy are:

1. There are no directional filters in any part of any trunk or super trunk, hence no filter guard bands need be allocated on the trunks.

2. Normal outbound channels to all subscribers go through filters only on the feeder cables which maintains group delay at a very low level.

3. The METRO 14-14 inbound signals return on cables separate from the 5-30 MHz data/remote TV signals so no interference between the two is possible.

4. The complete cable communications system is an enclosed non-radiating system which does not require a transmitter license; therefore, FCC restrictions are minimized. Signal format is not as restrictive as Microwave Systems.

5. Standard cable television test equipment, test methods, and techniques are employed throughout the system. There is no need for special test equipment or specially trained personnel.

6. The low frequency long haul FLEXICADE system holds signal degradation to a minimum by minimizing the cascade of amplifiers.

CONCLUSION

The FLEXICADE hardware and system concepts that have been described here do not provide solutions to all of the myriad of problems that the systems designer faces. However, they do add a substantial new dimension to his "bag of tools" that will help him to meet the new demands that will be placed on him by the expanded market place.

REFERENCE:

1/ Hickman, J.E. and Kleykamp, G.C. "Multi-Cable Solutions to Communications Systems Problems", presented to the IEEE CONVENTION, March, 1971, New York, N.Y.

APPENDIX "A"

DETAILED ELECTRICAL AND MECHANICAL SPECIFICATIONS

I SPECIFICATIONS - SUBNOVA TRUNK AMPLIFIER

FREQUENCY RESPONSE (W/O Equalizer)	2-48 MHz
RESPONSE FLATNESS 2-48 MHz	± .25 dB
6-48 MHz	± .15 dB
MINIMUM FULL GAIN (W/O Equalizer)	30 dB
OPERATING GAIN (W/ Equalizer)	26 dB
*NOISE FIGURE @MIN. FULL GAIN (W/O Equalizer, f=43.25 MHz)	7.5 dB MAX
RETURN LOSS, IN/OUT 2-48 MHz	18 dB
6-48 MHz	20 dB
CROSS MODULATION 4 Ch, 5 dB Block Tilt	-90 dB @+36 dBmV
7 Ch, Tapered Tilt	-85 dB @+36 dBmV
SECOND ORDER BEAT	-76 @+36 dBmV
HUM MODULATION	-65 dB
AGC RESPONSE (±3 dB of Cable)	± .25 dB
SLOPE RANGE, MANUAL	± 3 dB Cable
GAIN RANGE, MANUAL	0-9 dB
RECOMMENDED OPERATING CHARACTERISTICS:	
INPUT @HIGHEST VISUAL CARRIER	+10 dBmV
OUTPUT @HIGHEST VISUAL CARRIER	+36 dBmV
AMPLIFIER SPACING (W/ APPROPRIATE EQUALIZER)	17-26 dB
POWER REQUIREMENTS	21V @ 450 MA
PILOT CARRIER FREQUENCIES	7.25 & 37.25 MHz
OPERATING TEMPERATURE RANGE	$-40^{O}F$ to $+140^{O}F$
CABLE EQUALIZATION RANGE (W/ plug-in Equalizers)	8-26 dB
FLAT GAIN	9-0 dB
SIZE - Individual Amplifier	2"(W) x5"(H) x10 1/4"(L)
Housing with (8) amplifiers & power supply (Exclusive of mating connectors and mounting hardware)	7 1/2"(W) x12 1/2"(H)x22 3/4"(L)

*Noise Figure @Operating Gain, w/ equalizer (f=43.25 MHz, Cable = $68^{O}F$) 8.5 dB

II SPECIFICATIONS - MARK II CHANNELEER

ELECTRICAL

Recommended input (picture carrier):	0 to +10 dBmV
Recommended output: Visual carrier	+54 dBmV
Aural carrier	+38 dBmV
Maximum input range (picture carrier):	-14 dBmV +30 dBmV
Minimum input (sound carrier):	-24 dBmV
AGC control:	±0.5 dB output change for an input change from -14 dBmV to +30 dBmV
Output level control:	12 dB range (video-to-audio ratio constant)
Signal to noise Ratio:	59 dB Min. @+6 dBmV input
Return loss input/output:	16 dB (75 ohms)
Image rejection:	60 dB minimum
Adjacent channel carrier rejection:	50 dB minimum
Local oscillators:	Crystal controlled
Video IF response:	41.57 MHz to 46.50 MHz, ±0.25 dB
Carrier substitution oscillator:	45.75 MHz, crystal controlled carrier
Spurious signals:	60 dB below desired output from 6 to 300 MHz
Power requirements:	95 to 130 VAC, 60 Hz, 30 Watts

MECHANICAL

Physical dimensions:	19 x 17 x 5 - 1/4 inches
Weight:	19 pounds

III SPECIFICATIONS - UNIVERTOR

ELECTRICAL

Input - (See Channel frequency assignments in Figure 1)

MODEL I:	3 Cables with Channels A1, A4, A5 and A6
MODEL II:	2 Cables - one with Channels, A1, A2, A3, A4', A5' one with Channels A1, A2, A3, A4, A5, A6, A7
MODEL III & IV:	4 Cables - one with Channels A1, A2, A3, A4', A5' three with Channels A1, A2,A3,A4,A5, A6, A7
ALL MODELS:	1 Cable (optional) with FM from 15 to 35 MHz and Pilot Carriers at 7.25 MHz and 37.25 MHz Reference Pilot Carriers as may be required for specific Channel phase locking.
LEVEL:	+ 10 dBmV ± 3 dB
RETURN LOSS:	16 dB Minimum (75 ohms)
NOISE FIGURE:	13 dB Nominal

Output

MODEL I:	12 Channels of TV, CH. 2-13 plus FM Radio at 88-108 MHz (if FM option specified)
MODEL II:	Same as Model I
MODEL III:	26 Channels of TV, CH. 2-13 and Channel A thru N - compatible with tuned set-top converter, plus FM at 88-108 MHz (if FM option specified).
MODEL IV:	26 Channels of TV, CH. 2-13 and Channels 7M thru 13M (Mid Band channels,); Channels 7S thru 13S (Super Band channels) - compatible with tunerless set-top converter, plus FM at 88-108 MHz (if FM option specified). -Pilot Carrier Generator (optional) - supplied as part of FM converter.

LEVEL:	+32 dBmV with Block Tilt 5 dB - 12 channels +32 dBmV with Block Tilt 32/30/28/25 - 26 channels +40 dBmV output optional available with reduced C.M. characteristics.
CROSS MODULATION:	(-) 72 dB @+32 dBmV output - 12 channels (-) 70 dB @+40 dBmV output - 12 channels (-) 70 dB @+32 dBmV output - 26 channels (-) 66 dB @+40 dBmV output - 26 channels
RETURN LOSS:	- 16 dB minimum (75 ohms)

MECHANICAL

HOUSING:	7 1/2" (W) x 12 1/2 " (H) x 22 3/4 " (L) Exclusive of mating connectors and mounting hardware
OPERATING TEMPERATURE RANGE:	-40°F to +140°F

PHASE LOCKING CAPABILITY

PURPOSE:	To provide a method for phase-locking an output VHF channel to an off-the-air channel to minimize effects of Co-channel interference.
METHOD:	A pilot carrier, phase locked to the off-the-air channel is supplied to the Univertor for phase-lock reference.
AVAILABILITY:	On special order: most channels can be accommodated.
ADDITIONAL EQUIPMENT REQUIREMENTS:	One special unit is required at the head end to derive the pilot carrier reference for each off-the-air channel, regardless of the number of Univertors in the system.