TM-675
2628

Fermilab

AN ANALOG SIGNAL TRANSMISSION AND DISTRIBUTION METHOD

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Summary

A simple and inexpensive transmission system was designed to make the analog signal of proton-beam intensity in the Main Accelerator readily available in the experimental areas, where it is needed. The 15' Bubble Chamber, for instance, needs the signal to gate off the piston expansion cycle when the beam is below a preset value at a predetermined Time. The purpose is to prevent the undue wear of the piston when there is not enough or no particles delivered for the experiment. Originally available only in the accelerator main control room, the signal is now broadcast over the audio section of the CATV system. The designed transmission system is accurate and speedy enough for the 15' Bubble Chamber application. Although the system's performances can be improved by using better components and 100 KHz audio range instead of 10 KHz, **but this method is not recommended.**

INTRODUCTION

The fiberglass piston is one of the essential components in the 15' Bubble Chamber. It is about 6 feet in diameter and subject to a maximum of 140 psia pressure and 165 "g" inertial loading. Just about 50 ms before the Main Acceleraotr proton-beam spill, the chamber expands. At then the beam intensity information is needed to decide wheather or not to start the expansion cycle. There were two signals that existed previously, the audio tone signal on CATV channel 13 and the contact closure of the "Watch Command" from CAMAC (computer automated measurement and control) data link. Both of them are too slow for hadron beam experiments and non-dedicated type, which can not be used solely for one application without interfereing with others. An obvious but costly solution is to use tranmission cable, about a mile and a half long, for transmitting a signal to one experimental area. Since the CATV audio portion is available to us, the simple and inexpensive approach is to broadcast the beam intensity information over CATV channel 10. This transmission system has been installed at the 15' Bubble Chamber since April, 1976, and it is working satisfactorily. An overall accuracy of 0.1% and a step response of 2 ms can be achieved.

SYSTEM DESIGN

1. Overall Design:

In order to transmit the proton-beam intensity analog signal over a CATV system, the signal has to be converted linearly to an audio-frequency signal. This audio signal is then carried through a TV modulator, trunk amplifier, distrubution net work and finally the receiver in the experimental area. A reconstructed beam intensity signal can be obtained by converting this audio signal back into voltage information. This reconstructed beam signal is then used for various control purposes. A block diagram of the overall system is shown in Fig.1.

2. Transmitter:

The transmitter consists of an analog signal source, a buffer stage, a voltage-to-frequency (v/F) converter and a modulator (Fig. 2). An analog voltage of 0 ~ + 10 v, equivalent to 0 ~ 2×10^{13} protons, generated form a toroid beam sensor with an internal impedance of approximately 2000 ohm, is available in the accelerator control room. This signal is fed to a buffer stage, two 741 operational amplifiers. The input is scaled by a factor of 0.91 and biased by + 0.6v. This voltage output (0.6 ~ 9.7v) is then converted into a frequency output (600 ~ 9700 Hz) by a v/F converter (AD456J). After modulation, this audio signal is broadcast over the CATV system in a conventional manner.

3. Reciever:

The receiver consists of a standard TV receiver, a signal conditioner, a frequency-to-voltage (F/v) converter and an amplifier (Fig. 3). The audio output of the receiver is conditioned by a 741 op. amp. circuit with hysteresis and variable threshold control. It is then converted to voltage information by a F/v converter (AD451J). The amplifier circuit of the 741 op amp has a gain of 1.09 and a - 0.6v bias. The op amp restores the voltage signal to its original analog value. The reconstructed beam intensity signal can then be used for various control purposes.

4. Control Circuit:

The control circuit can be tailored to fit in the different needs. For 15' Bubble Chamber application, it is designed to cut down the unnecessary expansion and keep the chamber in a ready mode. The control circuit consists of a gate generator (Fig. 3) and a gating circuit (Fig. 4). By comparing the reconstructed beam intensity signal with the setting value through the comparator,LM311, a GO/NO GO level signal is generated. Two kinds of signals are derived from this output; a 50 ms stretched output (NE555 and SN74128) for expansion cycle gating and a pulse output, generated about 4~5 seconds after the accelerator clock T1, for the computer data used. In the gate circuit, the gating signal is used to gate expansion, hadrons and neutrino camera systems with a "fail-safe" design ("No go" at open circuit state). A re-triggerable timer circuit (NE555) is built to control the gating function on expansion trigger allowing a maximum time interval for a continuous "gate off" (20 to 65 seconds in a step of 5 seconds). After the predetermined elapsed time, the expansion trigger is no longer gated by the gating signal, until the next trigger pulse. It expands the system, starts the timer and enables the expansion gating function. This will prevent the piston from settling and the mixture in the chamber from separating. (LNe & LH_2)

DISCUSSION

The concept to use CATV as a transmission media is practical only when there is a CATV system available. Up to 21 analog signals can be transmitted simultaneously in a typical VHF-CATV system without any modifications required. So the system has the capability for many more users and many different applications. The limiting factor on speed is mostly in the filtering circuit of the F/V converter. This can be improved by using higher audio frequency (100 KHz), which can easily be carried over on the sub-carrier band width. The audio sub-carrier has to maintain 10 db below the video carrier in order to avoid the cross modulation. Based on the audio frequency response curve (Fig.5) of a typical 5" Sony black and white TV receiver, a 600 ~ 9700 Hz frequency range was chosen to optimize the operation. For the application requires better accuracy and higher speed, this method is not recommended.

ACKNOWLEDGEMENT

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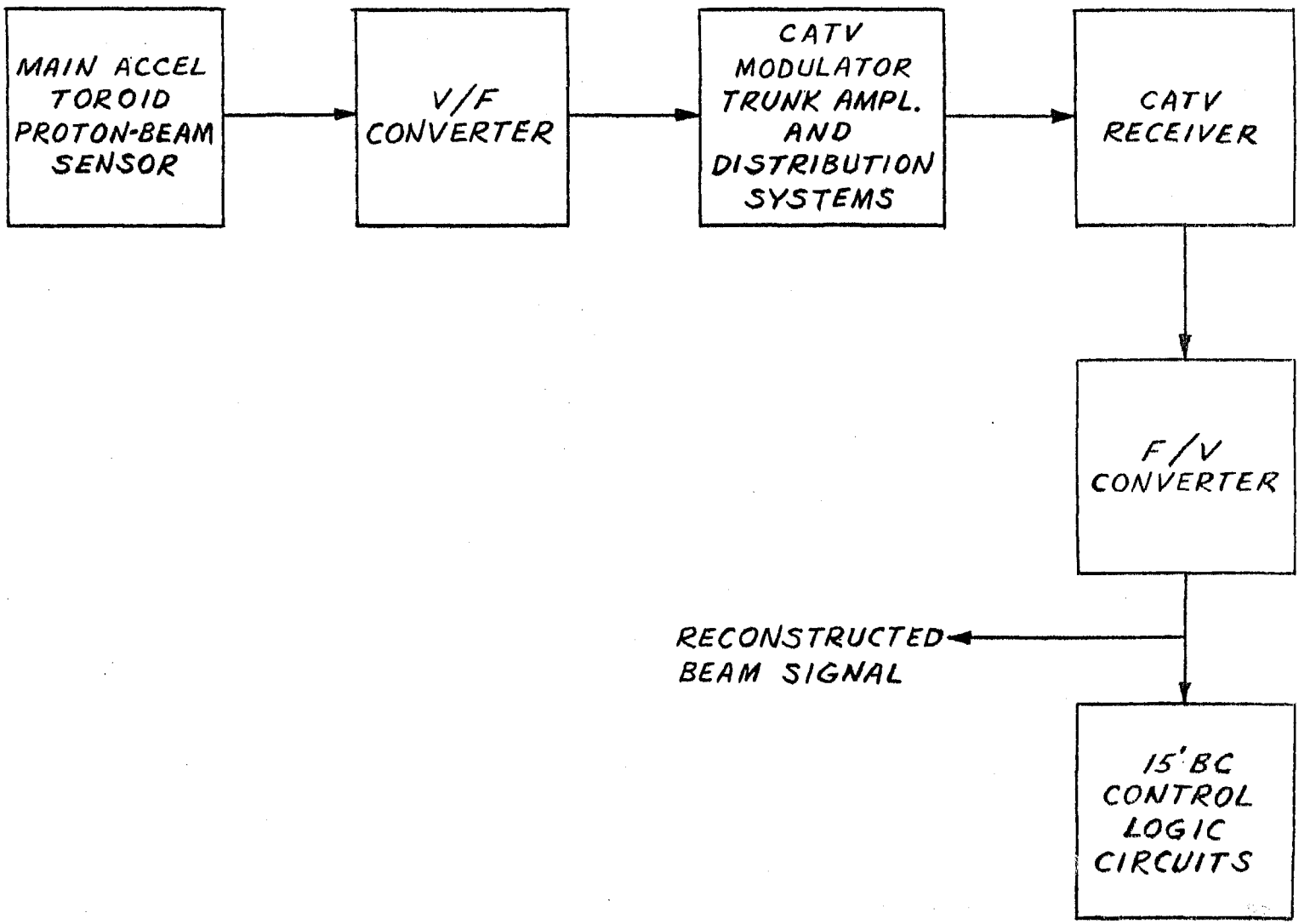
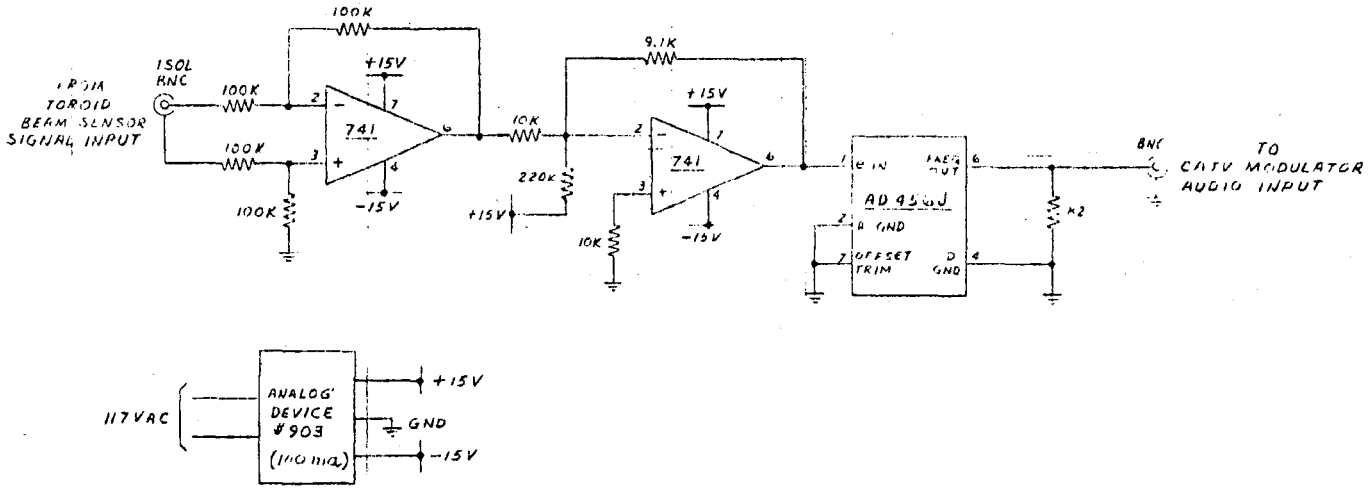


FIG. 1 BLOCK DIAGRAM – ANALOG SIGNAL TRANSMISSION AND DISTRIBUTION SYSTEM.

REV.	DESCRIPTION	DRAWN	DATE
		APPD.	DATE



REFERENCE DRWGS

2628. EE-86086	BEAM STATUS-EXP/CAM-TIMING SYSTEM-BLOCK DIAGRAM.
2628. ED-86134	TIMING SYST-FRONT & REAR VIEWS OF MODULES-LAYOUT.
2628. ED-86178	ACCELERATOR BEAM GATE GENERATOR-SCHEMATIC DIAGRAM.

Fig. 2

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
PARTS LIST			

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	H. FENN	7-9 76
FRACTIONS	DECIMALS	ANGLES	DRAWN	H. STAPAY	7-8-76
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX.			APPROVED		
2. DO NOT SCALE DWG.			USED ON		
3. DIMENSIONING IN ACCORD WITH ANSI Y14.5 STD's.			MATERIAL-		
√ MAX. ALL MACHINED SURFACES					

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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

30K LITER HYDROGEN B.C.
ACCELERATOR BEAM GATE-TRANSMITTER
SCHEMATIC DIAGRAM

SCALE	FILMED	DRAWING NUMBER	REV.
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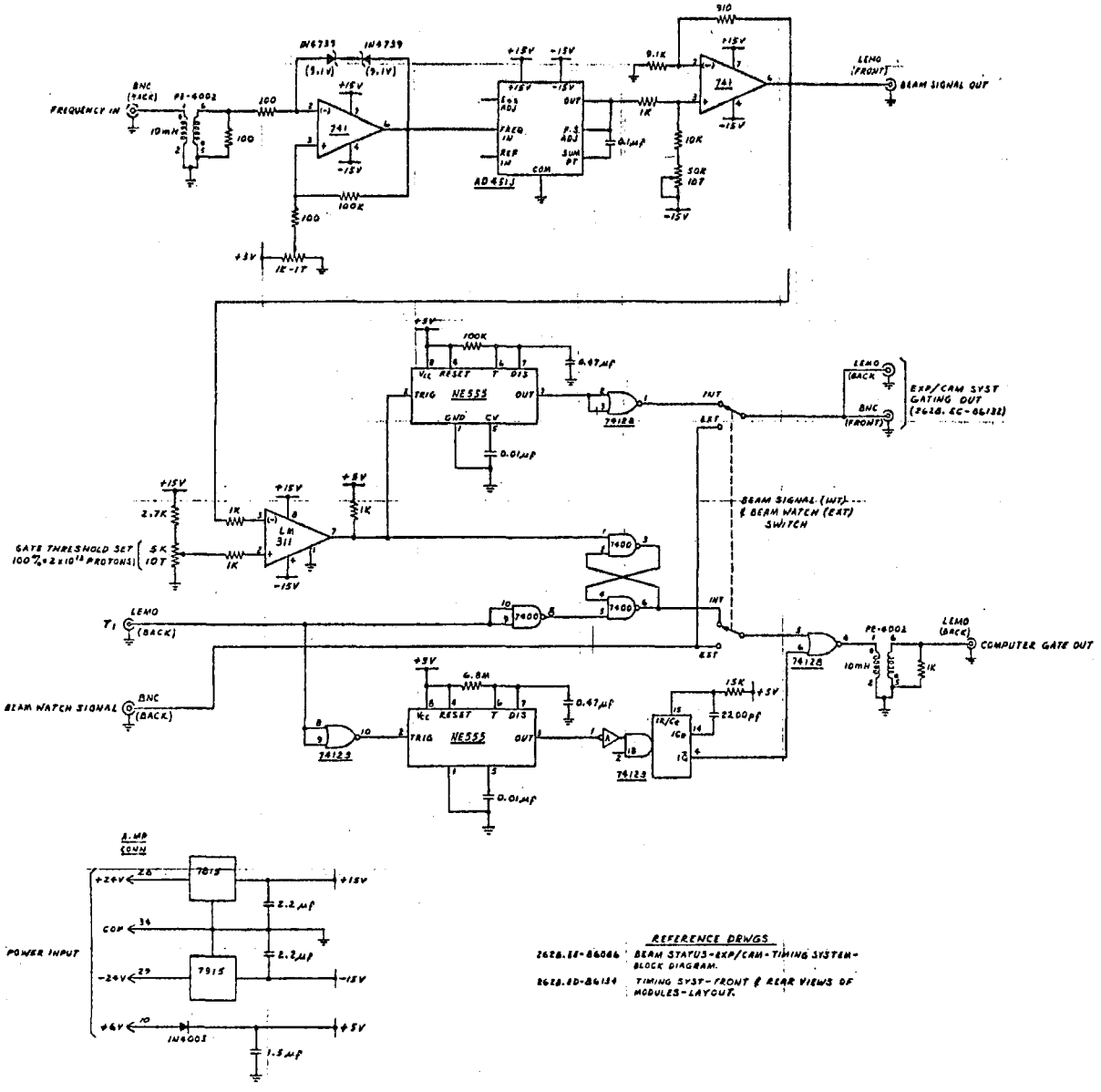

REFERENCE DRWGS

2628.EE-86066 BEAM STATUS-EXP/CAM-TIMING SYSTEM-BLOCK DIAGRAM.

2628.ED-86134 TIMING SYST-FRONT & REAR VIEWS OF MODULES-LAYOUT.

Fig. 3

REVISIONS			
SYM	DESCRIPTION	DRAWN / APPD.	DATE
A	GENERAL REVISION	H.S.	3-12-76

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TM-675

ITEM NO.	PART NO.	DESCRIPTION	QTY. REQ.
		PARTS LIST	

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2. DO NOT SCALE DWG.			APPROVED	
3. DIMENSIONING IN ACCORD WITH USAS Y14.5 STD'S.			USED ON	
√ MAX. ALL MACHINED SURFACES			MATERIAL	

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30K LITER HYDROGEN B.C.
ACCELERATOR BEAM GATE GENERATOR
SCHEMATIC DIAGRAM

SCALE	PLMED	DRAWING NUMBER	REV.
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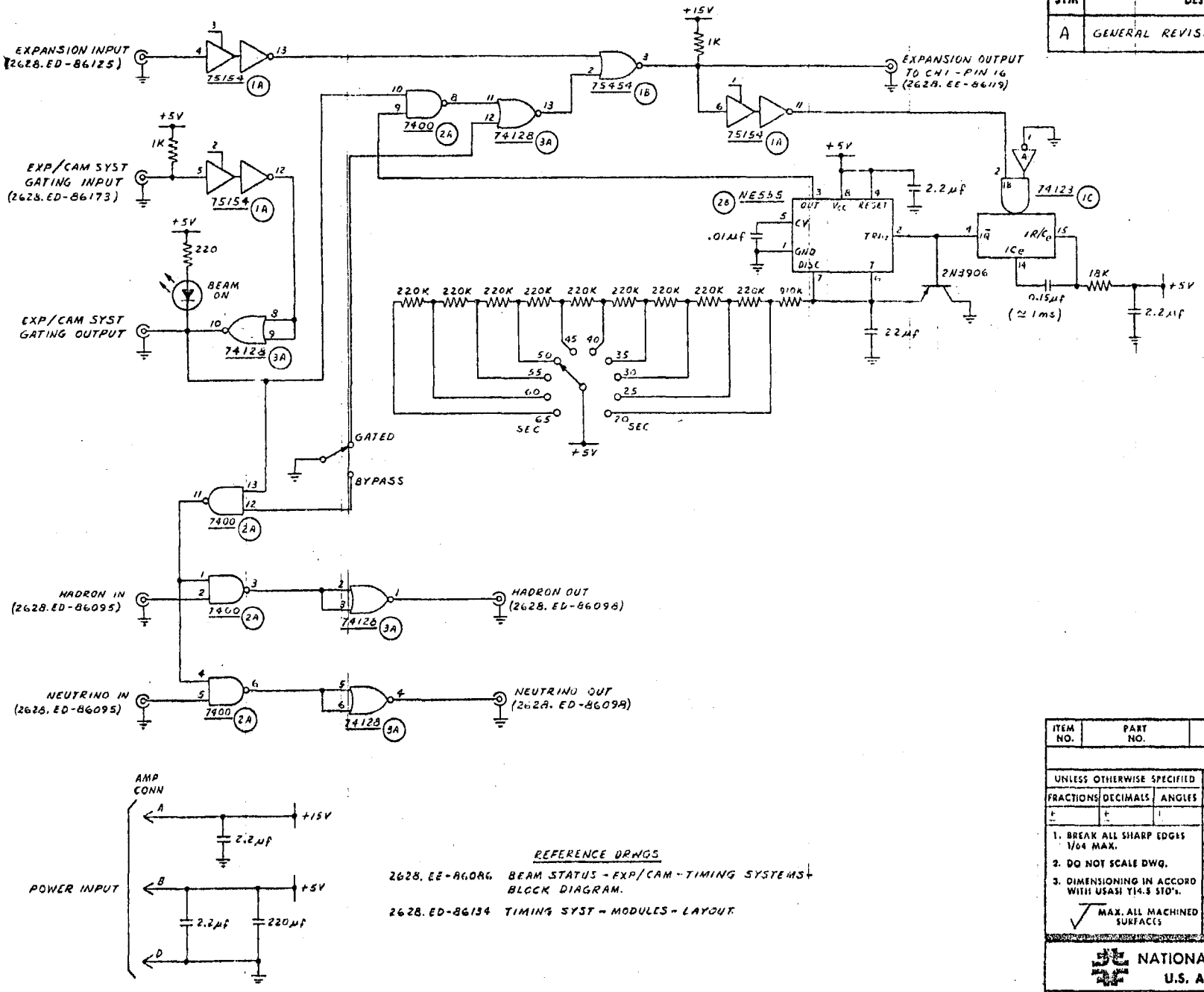

REFERENCE DRWGS

2628. EE-86086 BEAM STATUS - EXP/CAM - TIMING SYSTEMS BLOCK DIAGRAM.

2628. ED-86134 TIMING SYST - MODULES - LAYOUT

Fig. 4

REVISIONS			
SYM	DESCRIPTION	DRAWN / APPD.	DATE / DATE
A	GENERAL REVISION	[illegible]	1-12-76

ITEM NO.	PART NO.	DESCRIPTION	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	[illegible]
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2. DO NOT SCALE DWG.			APPROVED	
3. DIMENSIONING IN ACCORD WITH USASI Y14.5 STD's.			USED ON	
√ MAX. ALL MACHINED SURFACES			MATERIAL -	

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30K LITER HYDROGEN B.C.
ACCLERATOR BEAM GATE MODULE
SCHEMATIC DIAGRAM

SCALE	FILMED	DRAWING NUMBER	REV.
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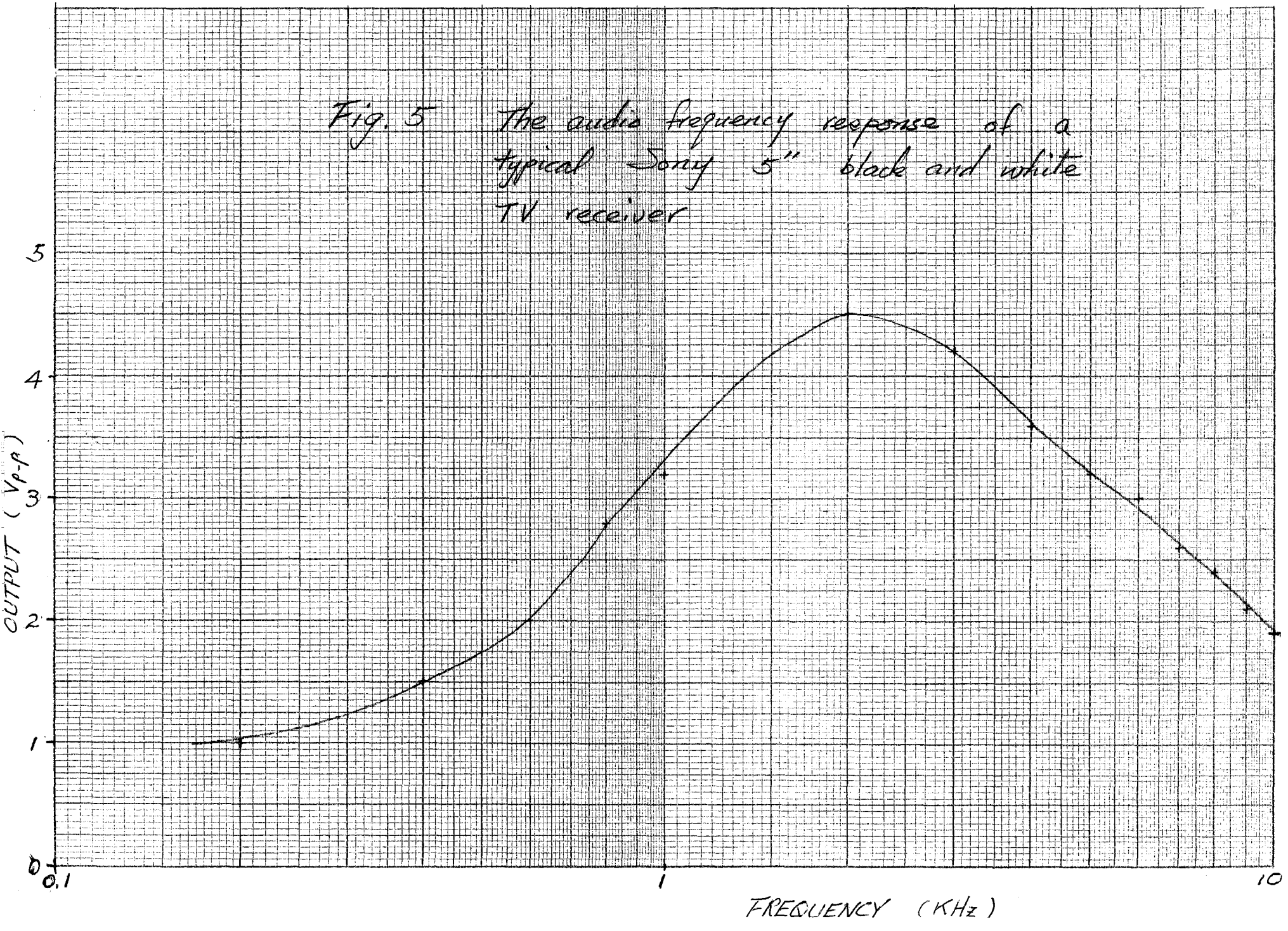

Fig. 5 The audio frequency response of a typical Sony 5" black and white TV receiver