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THE 733 AS A LOW-INPUT-IMPEDANCE PREAMPLIFIER FOR CURRENT-DIVISION USE*

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ABSTRACT

By grounding the usual inputs of a 733 amplifier chip and driving one of the gain-control pins, one obtains a common-base input stage with an input impedance of about 20 ohms. This can be used as an inexpensive current-division preamp and, in large multichannel systems, will probably not limit the performance.

In the current-division method of coordinate measurement one observes the (integrated) current pulses coming from each end of the sense wire of a proportional chamber. The position (along the wire) is proportional to the measured asymmetry of these pulses. Accuracy is limited by electronic noise. The preamp must have an input impedance which is small compared with the sense wire resistance. Considerable effort has gone into the design of low-noise, low-input-impedance preamps, which when combined with optimal filtering give excellent position resolution ($< 10^{-3}$) in small detector systems, such as magnetic spectrometer focal plane detectors. The literature[1] is rather heavily weighted towards such detectors, which usually have a single sense wire, are used to detect particles well above min-i, and permit one to lavish care on the design

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and construction of just a few electronic channels.

In a large multichannel detector (for instance, the "MAC" detector at PEP, having tens of thousands of sense wires), one is operating under entirely different conditions. Here the noise of the "bare" preamp is outweighed by other factors:

1. Sense wires must be ganged for economy so that the effective resistance for current division is low, sometimes less than 100 ohms. This leads to large thermal noise.
2. For the same reason, the sense wires have a large capacitance which causes more noise.
3. It is nearly always necessary to run the wires at high voltage and therefore, to use coupling capacitors. These cannot be made too large or chance discharges will destroy the preamps. Finite capacitances act as additional impedance in the current-division loop and therefore degrade the performance.

In such a situation one is fairly pleased to obtain resolution of a percent or so for min-i particles. In a calorimeter this may already overmatch the multiple scattering of the particles. The "connected" noise will be greater than the "unconnected" noise for even a moderately good preamp. Primary requirements are that the preamp be cheap, rugged and compact enough to mount at the end of the wires. (The ganged wires will have a resistance comparable to the characteristic impedance of cables so it is not desirable to use terminated cables between the detector and the preamp.)

The 733 is a video amplifier chip in wide use. Its input stage is an emitter-coupled pair with access not only to the bases but also to the emitters (the gain may be adjusted by connecting a resistor between the emitters). It turns out that this chip works perfectly well if the bases are grounded and current is injected into one of these "gain control" pins. An input impedance of about 20 ohms is realized. Further, the chip has a balanced output stage which is ideally suited to driving a long twisted pair with signals of a few tenths of a volt. Another 733 can be used as the receiver. The combination will put out a maximum of about 2.5 volts into (say) a sample-and-hold stage.

A practical preamp/receiver combination is shown in Fig. 1. The preamp output leads also carry DC power. This makes for a very simple hookup at the detector and, since power would be decoupled anyway, does not increase the component count. A filter at the input of the receiver integrates the current signal. The preamp puts out a fast signal which could be simultaneously used for a drift-time measurement if a second receiver, without integration, also listened to the signal.

The circuit was tested using cosmic rays passing through four proportional-counter gaps (Fig. 2). The wires were 40 micron stainless steel with a resistance of 1400 ohms (ganged resistance 350 ohms). The "white" noise (as observed on a scope) nearly doubled when the preamp was connected to the wires; this effect would be even greater if more wires were ganged. The gas was 80%/20% Argon/CO_2 and the high voltage, 2100 volts giving a (most probable) charge of 1.5 pcoul per min-i track per gap. The corresponding output from the receiver was 0.5 volt, with a 20% gain spread in the eight channels. The position resolution of each gap, inferred from the scatter about a straight-line fit, was 1% (most probable σ) or 2.4% (mean σ) using data over the entire chamber with no angular cuts. The tests, which included rough studies of the effects of coupling and filter capacitors (best values shown in Fig. 1), are described in detail elsewhere.[2]

We thank Jim Johnson for helping set up these chambers, and Henry Band and Dave Wiser for help with the program.

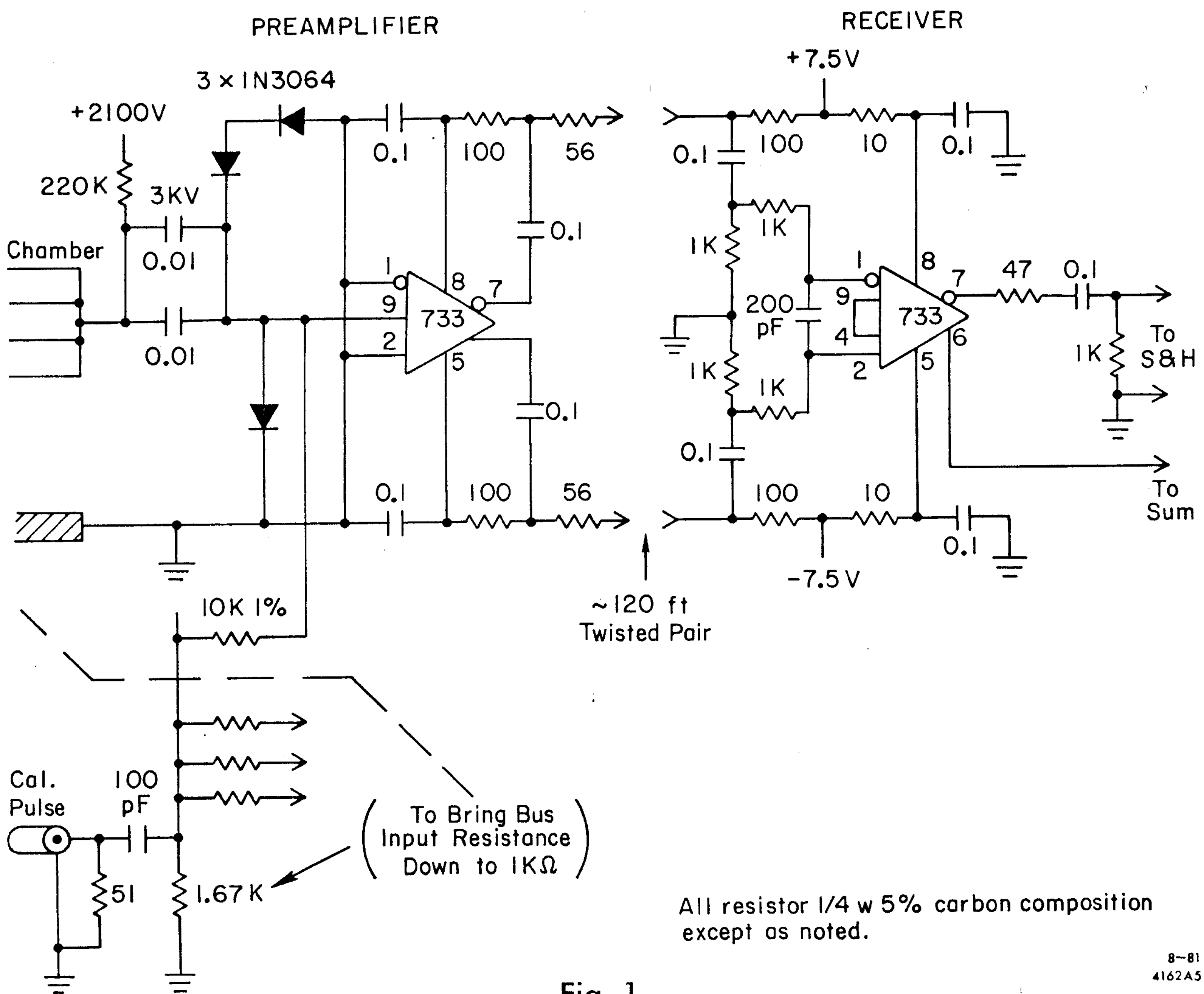
REFERENCES

1. J.C.L. Ford, Nucl. Instr. and Meth. 162 (1979) 277. This review gives comprehensive references to the literature.
2. B. Gottschalk, "Coordinate Measurement by Current Division: A Simple System for Multichannel Detectors," SLAC-TN 81-6, August 1981.

FIGURE CAPTIONS

Fig. 1. Schematic diagram of the preamplifier and receiver.

Fig. 2. Proportional chamber setup used in bench tests.



All resistor 1/4 w 5% carbon composition except as noted.

Fig. 1

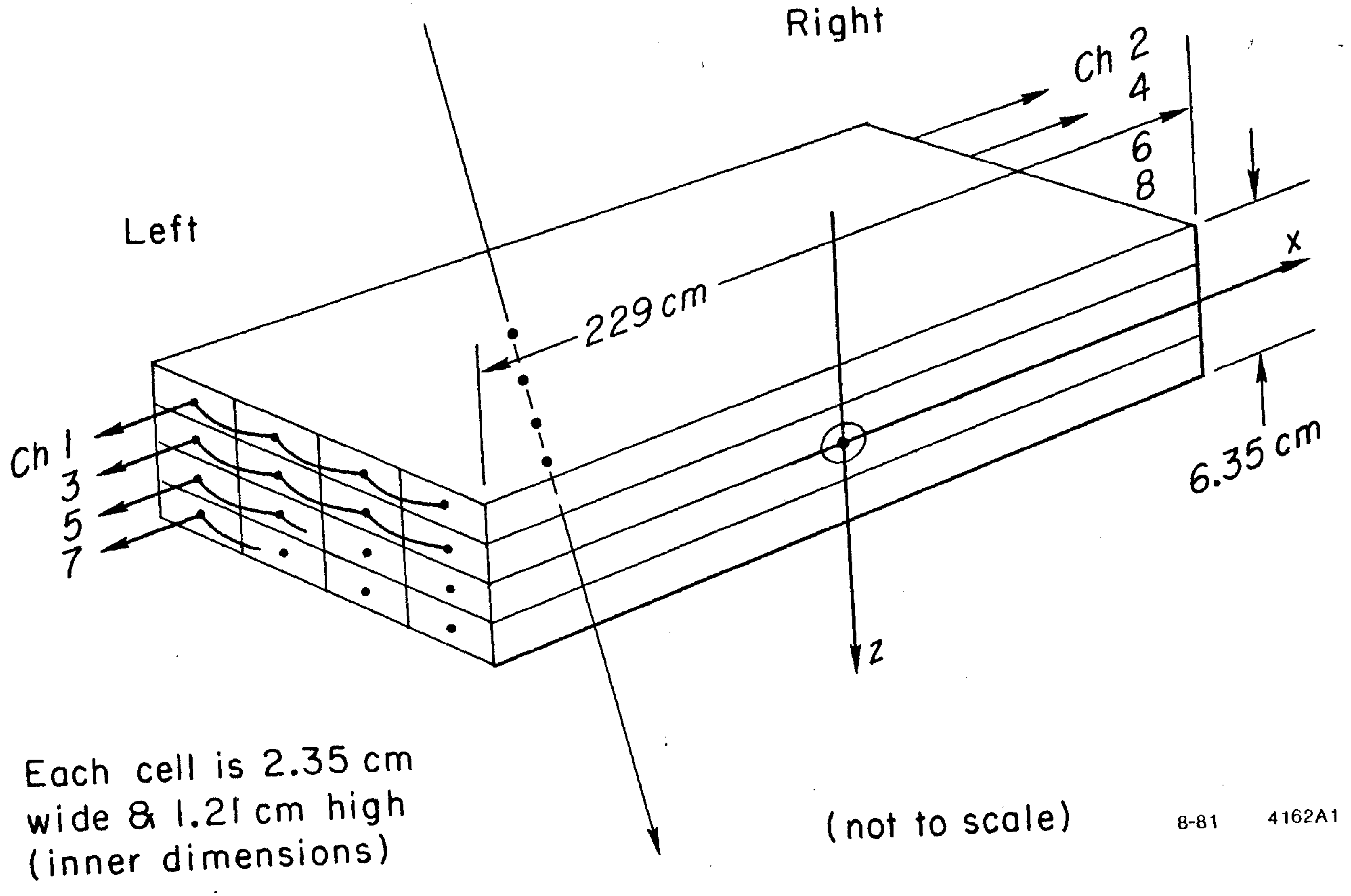

Right
Left
Ch 2
4
6
8
Ch 1
3
5
7
229 cm
6.35 cm
x
z
Each cell is 2.35 cm
wide & 1.21 cm high
(inner dimensions)
(not to scale)
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Fig. 2