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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

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Abstract

Constructional details are given of a new electronic picker unit for the concentration of coarse low-grade uranium ore using a scintillation detector. Typical results obtained with low-grade ore from two mines in the Beaverlodge area are presented as examples of the concentration achieved with the higher sensitivity of such a detector. Comparative tests with a Geiger detector are also reported.

ELECTRONIC CONCENTRATION OF LOW-GRADE ORES WITH THE LAPOINTE PICKER

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Introduction

The Lapointe Picker method of concentrating uranium ore by the electronic selection of radioactive pieces passing under the detector on a conveyor belt was first developed in 1947 and applied to certain pitchblende ores of relatively high grade. Attempts to employ it on lower grade material were not successful because of the low sensitivity of the Geiger tubes then available and the fact that they had to be mounted some distance above the belt to permit easy passage of the ore pieces.

During 1954, it became desirable to attempt the concentration of a rather disseminated low-grade uranium ore and it was decided to try a modified Lapointe Picker. To achieve the required sensitivity a scintillation detector with a 1 1/2-inch sodium iodide crystal was chosen and placed under the conveyor belt. This means that a gamma-ray detector was employed in this case and that the bulk of each piece of ore was relatively close to the detector.

A series of tests was performed on two ores from the Beaverlodge area, Saskatchewan. The material from one mine (Ore A) was tested in Ottawa, and that from the other mine (Ore B) at Eldorado, Saskatchewan. The purpose of these tests was to establish the applicability of the Lapointe Picker to low-grade ores and to find an optimum setting of the unit for maximum beneficiation, i.e. maximum percent weight rejected at minimum loss of U_3O_8.

A summary of the results indicates that for +1 1/2-inch mine ore the following can be expected:

Calculated heads	0.045-0.08% U_3O_8
Recovery	75-80%
Weight rejected	70-75%
Grade of concentrate	0.15-0.22% U_3O_8
Grade of rejects	0.01-0.02% U_3O_8

Tests on Ore A in Ottawa proved that, for + 1 1/2-inch ore, the scintillation unit was more sensitive and gave better overall results than the Geiger units, so only the scintillation unit was used on Ore B at Eldorado.

Description of the Picker Unit

A new unit was constructed for these tests. It is capable of handling material up to 12 inches, and can be operated either with one or more Geiger tubes located over the belt or with a scintillation head located under it. Figs. 1 and 2 show views of the complete assembly as set up in Ottawa. The ore was hand-fed to the far end of the belt, passed over the detector shown under the heavy lead shield and was directed into the concentrate or reject bin depending on the position of the gate plate. The belt was run at a speed of 22 ft/min.

The scintillation unit is more or less conventional. It consists of a cylindrical sodium iodide crystal, thallium activated, 1 1/2-inch in diameter and 1 1/2-inch in length. The crystal is optically coupled to a DuMont photomultiplier tube type 6292 through a Lucite plate and a film of silicone oil. The contact between the crystal and the Lucite window is assured by means of a spring mounted in the magnesium casing. The socket of the photomultiplier tube is also spring-mounted, to ensure contact between the Lucite window and the cathode of the tube. Mechanical details of the scintillation head are shown in Figs. 3 and 4.

The scintillation head is mounted under the conveyor belt, in a lead shield of 3-inch average thickness. A preamplifier, capable of amplifying the pulse signal up to a level detectable by the main picker unit, is mounted directly to the socket of the tube (Fig. 3). The circuit of the preamplifier has been described previously and is shown in Fig. 5.

The main picker circuit follows closely one described earlier and is shown in Fig. 6. The picker framework was made of angle iron and the method of mounting the drive motor and gate system can be seen in Figs. 1 and 2. The Appendix lists some of the major components used in the system. A detailed set of mechanical drawings are available for future applications.

For greater stability a Sola stabilizing transformer was employed on the main A.C. line. Because of the vibrations caused by the movement of the picker gate the scintillation head was supported by sponge rubber. The gate was operated from a compressed air line of 45 p.s.i. reduced to about 10 p.s.i. in the pressure reducer shown in Fig. 1.

Test Results

Ore A

About 12 1/2 tons of the material were screened on 3-inch and 1 1/2-inch screens and the coarser fractions were treated separately on the belt. These tests were carried out in collaboration with Mr. W.R. Bull. The results of this treatment are summarized in Table 1. All assays are gamma equivalents obtained on the bag assay unit, handling 50 pounds of sample per reading. The weight and grade distributions of the original ore were as follows:

Screen Analysis of Original Ore

	Wt. lb	%Wt.	$\%U_3O_8$	$\% U_3O_8$ Dist.
+3"	5740	23.2	0.045	20.4
-3" + 1 1/2"	6071	24.6	0.053	25.4
-1 1/2" (untreated)	12895	52.2	0.053	54.2
Totals	24706	100.0	0.051	100.0

Two scintillation crystals were used as detectors, No. 1 of 1 1/2-inch diameter and 1-inch length, and No. 2 of 1 1/2-inch diameter and 1 1/2-inch length. The Geiger counter consisted of two Anton type 108 tubes connected in parallel and mounted 4 inches above the belt. Different runs differ mainly in the choice of discriminator setting ("Trigger control"). The tests reported in Table 1 showed that the scintillation head worked efficiently and is capable of producing lower grade rejects.

Table 1

Picker Tests on Ore A

							Overall	
Run	Detector	Fraction treated	Product	%Wt.	Grade $\%U_3O_8$	$\%U_3O_8$ Distr.	%Wt.	$\%U_3O_8$ Distr.
11	Scintillation I	+3"	Conc.	21.9	0.167	77.8	5.1	15.9
			Tails	78.1	0.013	22.2	18.1	4.5
			Total	100.0	0.047	100.0	23.2	20.4
12	Scintillation I	+3"	Conc.	8.7	0.259	51.2	2.0	10.4
			Tails	91.3	0.024	48.8	21.2	10.0
			Total	100.0	0.044	100.0	23.2	20.4
13	Geiger	-3"+1 1/2"	Conc.	14.0	0.161	39.3	3.4	10.0
			Tails	86.0	0.041	60.7	21.2	15.4
			Total	100.0	0.057	100.0	24.6	25.4
14	Geiger	-3"+1 1/2"	Conc.	16.7	0.123	44.8	4.1	11.4
			Tails	83.3	0.030	55.2	20.5	14.0
			Total	100.0	0.045	100.0	24.6	25.4
15	Geiger	-3"+1 1/2"	Conc.	26.3	0.142	67.9	6.5	17.2
			Tails	73.7	0.024	32.1	18.1	8.2
			Total	100.0	0.055	100.0	24.6	25.4
16	Geiger	-3"+1 1/2"	Conc.	25.2	0.128	59.7	6.2	15.2
			Tails	74.8	0.029	40.3	18.4	10.2
			Total	100.0	0.054	100.0	24.6	25.4
17	Geiger	-3"+1 1/2"	Conc.	28.9	0.133	68.7	7.1	17.4
			Tails	71.1	0.025	31.3	17.5	8.0
			Total	100.0	0.056	100.0	24.6	25.4
18	Scintillation II	-3"+1 1/2"	Conc.	14.8	0.194	58.8	3.6	14.9
			Tails	85.2	0.024	41.2	21.0	10.5
			Total	100.0	0.049	100.0	24.6	25.4

The -1 1/2-inch fraction of the screened ore was not treated and was considered part of the combined product in which picker-belt concentrates would be included. Two examples of combined product are shown in Table 2, the first combining the untreated -1 1/2-inch fraction with the products of the two belt runs giving the highest recovery of U_3O_8 in the concentrates, and the second combining the untreated -1 1/2-inch fraction with the picker concentrates of highest U_3O_8 grade.

Table 2

Examples of Combined Product

(a) Combination of all -1 1/2'' fractions and highest recovery picker concentrates.

	Overall		
	%Wt.	$\%U_3O_8$	$\%U_3O_8$ Distr.
-1 1/2''	52.2	0.053	54.2
Run 11 Conc. (+3'')	5.1	0.167	15.9
Run 17 Conc. (-3'' +1 1/2'')	7.1	0.133	17.4
	64.4	0.069	87.5

(b) Combination of all -1 1/2'' fractions and highest grade picker concentrates.

	Overall		
	%Wt.	$\%U_3O_8$	$\%U_3O_8$ Distr.
-1 1/2''	52.2	0.053	54.2
Run 12 Conc. (+3'')	2.0	0.259	10.4
Run 18 Conc. (-3 +1 1/2'')	3.6	0.194	14.9
	57.8	0.070	79.5

The above results were encouraging but should not be considered the best which this method of treatment can produce, as such a high proportion of the run-of-mine feed was in the -1 1/2-inch fraction and remained untreated. Obviously the overall results depend greatly on the primary crushing of the ore.

Ore B

The picker assembly was transported to Eldorado and set up using the scintillation head only. It was used initially to treat a 10-ton sample of Ore B taken from the mine dump. Background fluctuations inside the mill building caused some difficulties and later batch tests were carried out with the equipment outside the building. The cold weather, often below freezing temperatures, affected the sensitivity of the bag assay unit, but did not appear to influence the operation of the picker. High humidity also did not have any effect on the picker operation.

Table 3 lists the results obtained on the different tests run at different trigger settings. In all cases the ore was hand-fed and the location of the unit is indicated. In runs 8 to 13 the trigger was set to a position chosen as the best for that particular size by means of brief preliminary trials. Runs 1 to 10 refer to the first 10-ton sample.

Table 3

Picker Tests on Ore B

Run*	Size fraction	Trigger setting	Recovery %	Conc. %Wt.	Conc. $\%U_3O_8$	Tails $\%U_3O_8$	Calc. head %
1	-3 3/4" + 1 7/8"	33	77.9	28.7	0.168	0.019	0.061
2	"	33	63.2	25.0	0.14	0.027	0.055
3	"	38	64.0	20.0	0.20	0.027	0.061
4	"	34	62.0	28.0	0.104	0.024	0.045
5	+3 3/4"	50	80.0	45.0	0.072	0.015	0.041
6	"	55	80.0	41.5	0.094	0.016	0.045
7	"	60	73.2	33.0	0.115	0.020	0.052
8	-3 3/4" + 1 7/8"	Set for optimum results	70.0	27.0	0.227	0.012	0.083
9	"	Set for optimum results	77.0	26.0	0.14	0.01	0.048
10	"	Set for optimum results	77.0	25.0	0.22	0.022	0.095
11	-12" + 3 3/4"	Set for optimum results	81.5	37.0	0.15	0.023	0.07
12	+6"	Set for optimum results	91.2	24.8	0.071	0.002	0.019
13	-6" + 3"	Set for optimum results	96.2	25.0	0.141	0.002	0.037

*Runs 1 to 7 in mill; 8 to 13 outside mill.

A second batch sample of Ore B, weighing about 14 tons, was also treated, but in a different way. The material was screened so as to give three fractions, namely +6", -6" +3", and -3". Only the +3" fractions were treated on the picker unit, in runs 11 to 13.

The results of the screening were as follows:

Fraction	% Weight	$\%U_3O_8$	% Distribution
+6"	19.4	0.019	11.5
+3"	15.1	0.037	17.4
-3"	65.5	0.035	71.1
	100.0	0.032	100.0

The assays for the +6-inch and +3-inch fractions were calculated from the results of the picker test work. The -3-inch assay was the average of six 50-pound grab samples.

The +6-inch and +3-inch fractions were treated on the picker belt. The results of these tests constitute Runs 11 to 13 in Table 3. Both fractional and overall recoveries have been calculated and combined. Combining the two picker-belt concentrates of the last two runs with all the untreated -3-inch material, one obtains the following recovery:

	% Weight	% U_3O_8	% Distrib.
+6" Conc.	4.8	0.071	10.5
+3" Conc.	3.8	0.141	16.7
-3" Total	65.5	0.035	71.1
	74.1	0.042	98.3

It is felt that the ore contained more -3-inch material than would be encountered with run-of-mine ore and overall results should improve with, say, 50% of the weight in the +3-inch sizes. Considering the +3-inch and +6-inch sizes alone the following results were calculated:

	% Weight	% U_3O_8	% Distrib.
+6"	56.2	0.019	39.8
+3"	43.8	0.037	60.2
Calc. head	100.0	0.027	100.0
+6" Conc.	13.9	0.071	36.3
+3" Conc.	10.9	0.141	57.9
Total coarser conc.	24.8	0.103	94.2

These test results can be summarized as follows:

94.2% of the U_3O_8 in the +3" fractions of the mill ore could be recovered in 24.8% of the weight at a grade of 0.103% U_3O_8.

75-80% of the U_3O_8 in all the +1 1/2" fractions could be recovered by the Lapointe Picker in 25-30% of the weight at a grade of 0.15 - 0.22% U_3O_8.

Conclusions

The results obtained in these tests are encouraging, considering the fact that it has not been possible to make a satisfactory preconcentrate of these low-grade ores by gravity means.

Screening of the ore is most important. It was found indeed that, for an optimum recovery at a minimum loss, the sensitivity setting was critical enough to warrant closer screening.

It is to be noted that the ore was fed by hand to the conveyor, as no adequate feeder has yet been designed for all the size ranges.

Finally, washing the ore prior to treatment does not alter the results, unless a Geiger tube is used on the -2" +1" fraction.

Appendix

Special Components Used in the Picker Belt

Detectors

1 sodium iodide crystal, thallium activated, cylindrical, 1 1/2" diameter, 1 1/2" long; from Harshaw Chemical Co., Cleveland, Ohio.

1 photomultiplier tube, DuMont type 6292.

2 Geiger tubes, Anton type 108; from Anton Electronic Laboratories, Brooklyn, N.Y.

Gate operation

1 relay, Kurman type B 201-35; from Kurman Electric Co., Long Island City, N.Y.

1 valve, solenoid operated, 4-way spring return, 1/4 NPT, Cowan Goodridge type S-254-S;

1 air cylinder, double-acting, 5" stroke, 1 1/2" bore, Cowan Goodridge type A-205; both from Canadian Aviation Electronics Ltd., Montreal, Que.

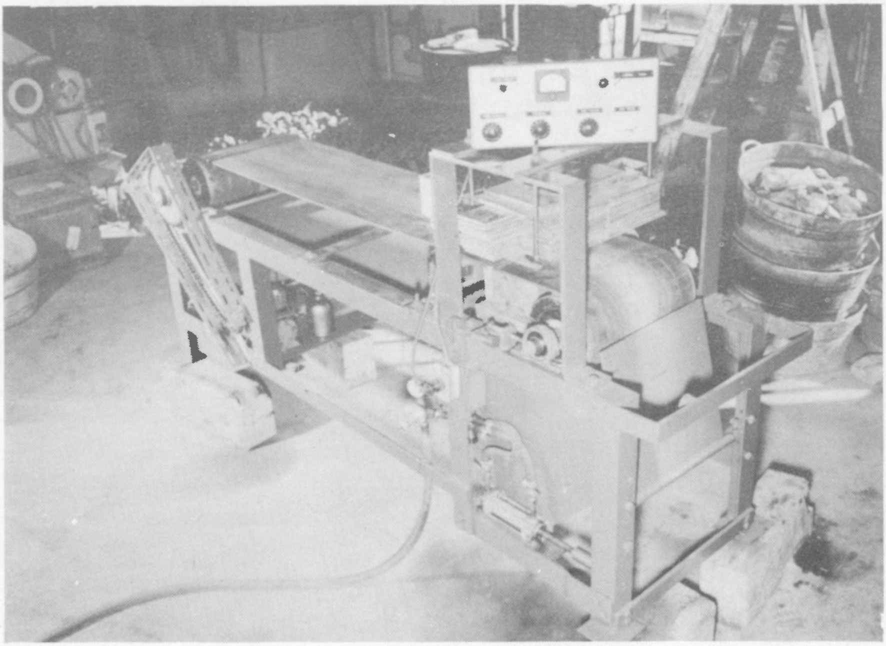

Fig. 1 - View of picker unit.

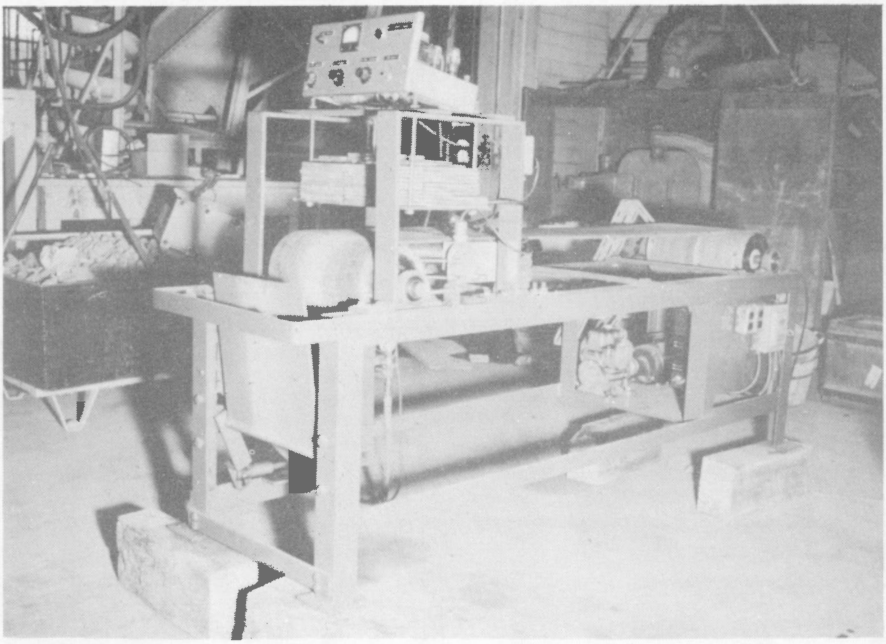

Fig. 2 - View of picker unit.

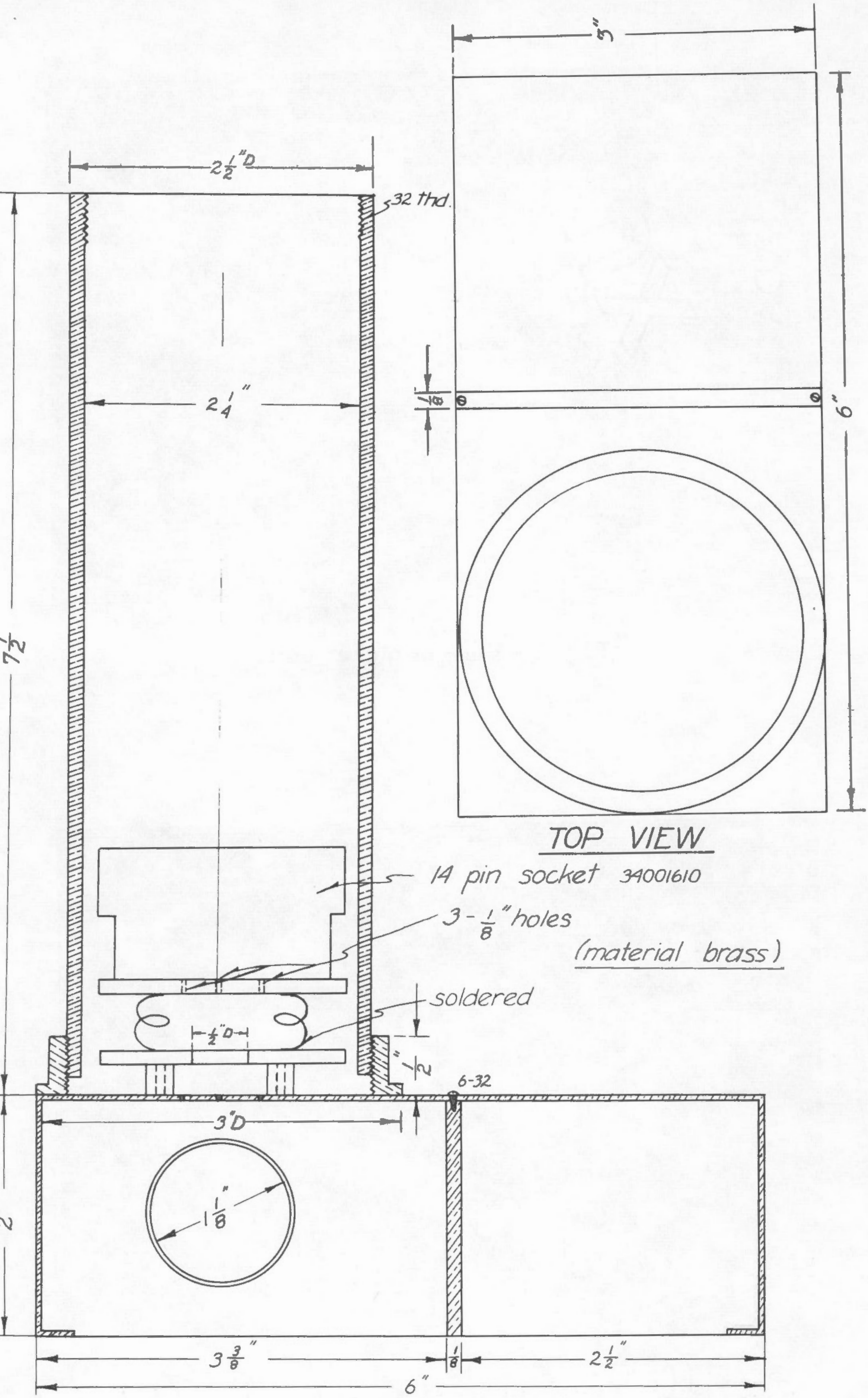

Fig. 3 - Scintillation head.

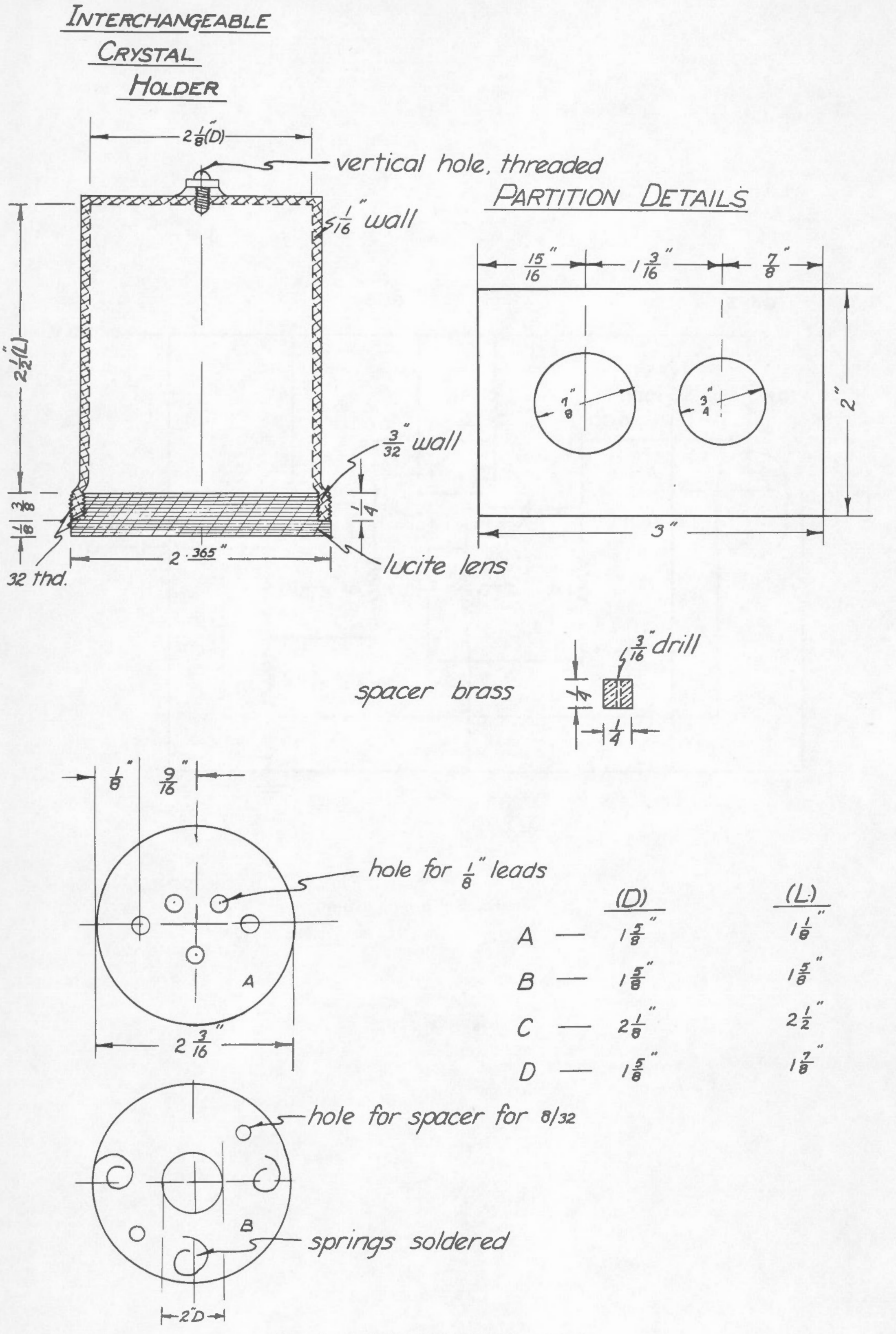

Fig. 4 - Details of scintillation head.

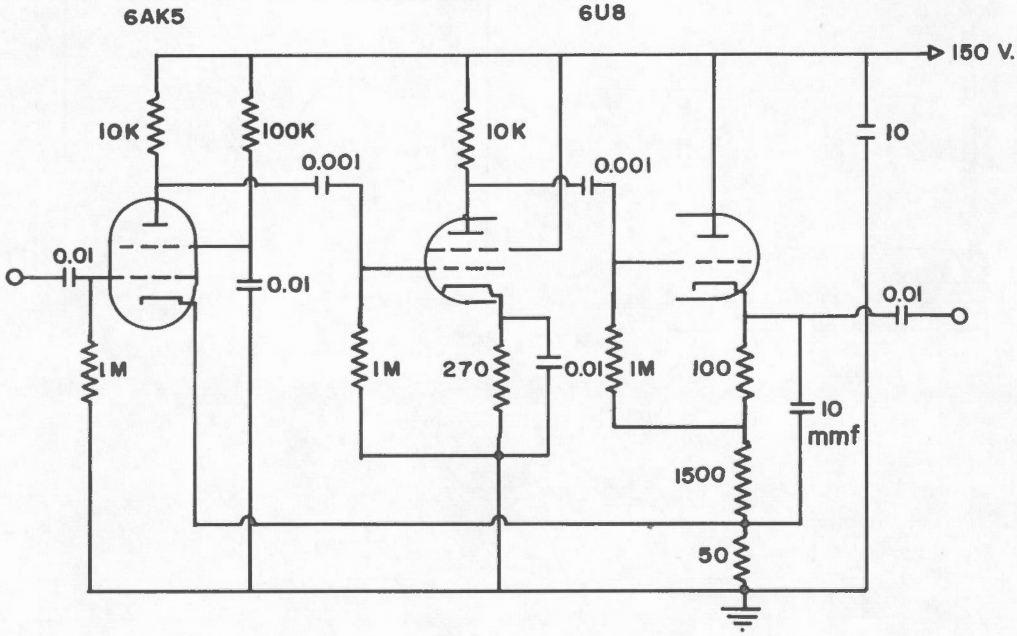

Fig. 5 - Circuit of preamplifier.

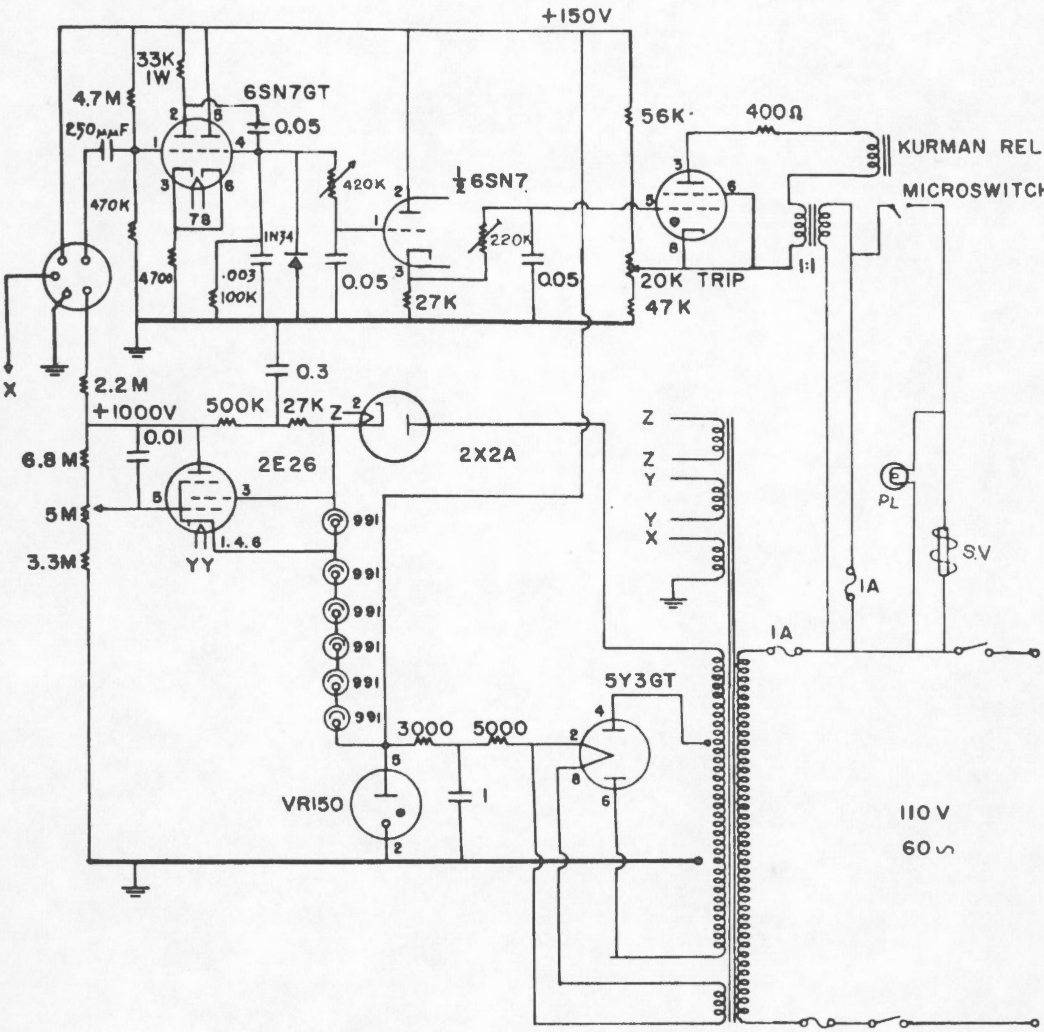

Fig. 6 - Circuit of picker unit.

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