Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: THE PHOTOELECTRIC CONVERSION PROGRAM (T-190-12)

To: Mathematics Group, 6673

From: John T. Gilmore, Jr.

Date: June 22, 1951

Abstract: With the introduction of the photoelectric reader as a new medium of transmission to electrostatic storage, it was necessary to rewrite the program which converts Flexowriter standard tape to 5-5-6 binary tape. (See M-1177 and M-1198.) The program's most important revision is a new method of reading in the standard tape (blocks of words) but its greatest asset is its flexibility which is mainly due to the influence exerted by special Flexowriter characters in controlling the program.

At the present time the program is still incomplete due to the limitations of electrostatic storage. However, sometime in the very near future because of the additional 48 registers now available, the program will be blessed with a new subprogram which will facilitate the use of a library of subprograms on standard tape. When this is accomplished, a memo will be written which will describe the complete program in detail and introduce a procedure regarding the general use of subprograms.

This present memo is merely a collection of diagrams which should aid one in understanding the program as it stands now.

Signed John T. Gilmore Jr.
John T. Gilmore, Jr.

Approved R. R. Everett
R. R. Everett

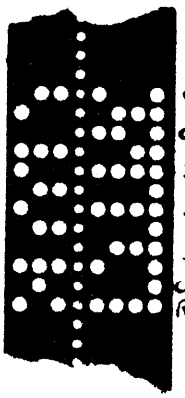
JTG/del
Attached: SA-36800
A-45304
A-45303
A-45305
SA-50049
SB-36801
SB-50044
B-45229-1
SC-36776-1
C-36803-1

The Flexowriter Code as used by the Photoelectric

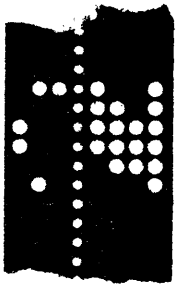
Conversion Program

	Character	Octal value	Decimal value
a	000110	+ 6	+ 6
b	110010	- 15	- 13
c	011100	+ 34	+ 28
d	010010	+ 22	+ 18
e	000010	+ 2	+ 2
f	011010	+ 32	+ 26
g	110100	- 13	- 11
h	101000	- 27	- 23
i	001100	+ 14	+ 12
j	010110	+ 26	+ 22
k	011110	+ 36	+ 30
l	100100	- 33	- 27
m	111000	- 7	- 7
n	011000	+ 30	+ 24
o	110000	- 17	- 15
p	101100	- 23	- 19
q	101110	- 21	- 17
r	010100	+ 24	+ 20
s	001010	+ 12	+ 10
t	100000	- 37	- 31
u	001110	+ 16	+ 14
v	111100	- 3	- 3
w	100110	- 31	- 25
x	111010	- 5	- 5
y	101010	- 25	- 21
z	100010	- 35	- 29
2	100111	- 30	- 24
3	000011	+ 3	+ 3
4	010101	+ 25	+ 21
5	100001	- 36	- 30
6	101011	- 24	- 20
7	001111	+ 17	+ 15
8	001101	+ 15	+ 13
9	110001	- 16	- 14
0	101101	- 22	- 18
-	000111	+ 7	+ 7
÷	011111	+ 37	+ 31
+	100011	- 34	- 28
;	001011	+ 13	+ 11
/	111011	- 4	- 4
.	111001	- 6	- 6
,	011001	+ 31	+ 25
tab	111101	- 2	- 2
back space	000001	+ 1	+ 1
car. return	010000	+ 20	+ 16
shift↓	110111	- 11	- 9
shift↑	111110	- 1	- 1
stop	110011	- 14	- 12
nullify	111111	- 0	- 0
space	001000	+ 10	+ 8

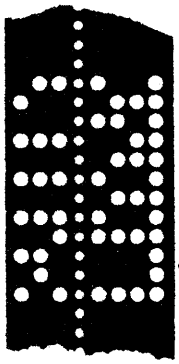
Four different forms of "Standard Flexo Tape"



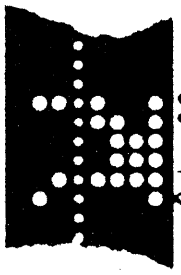
Checked decimal-addressed standard flexo tape



Unchecked decimal-addressed standard flexo tape

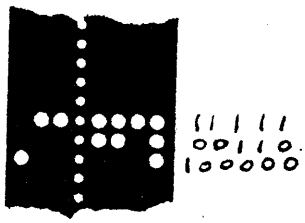


Checked octal-addressed standard flexo tape



Unchecked octal-addressed standard flexo tape

5-5-6 Tape



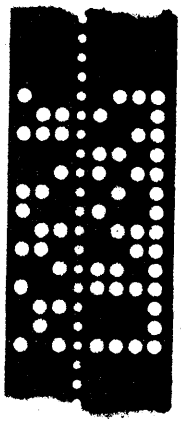
Binary Form

1 0 0 0 0 0 0 0 1 1 0 1 1 1 1 1

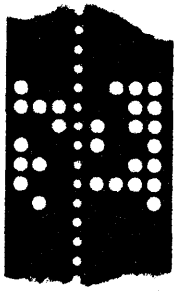
C1 223(d)
337(o)

A-45304

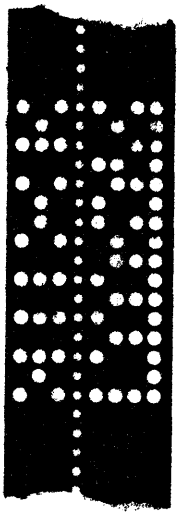
The constant $10^{-4} \times 2^{13}$ may be represented on standard tape as:



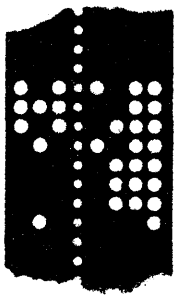
Decimal constant
on checked standard
flexo tape



Decimal constant
on unchecked standard
flexo tape

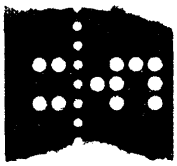


Octal constant
on checked standard
flexo tape



Octal constant
on unchecked standard
flexo tape

5-5-6 Tape



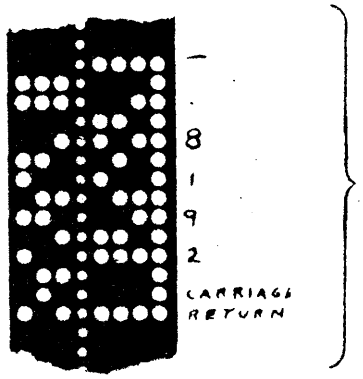
The binary form of $10^{-4} \times 2^{13}$ is:

0 1 1 0 1 0 0 0 1 1 0 1 1 0 1 1

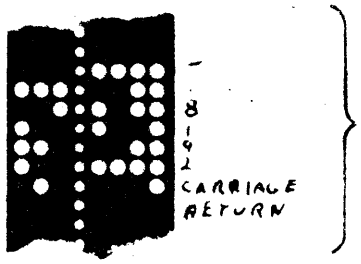
EXAMPLE OF HOW A POSITIVE CONSTANT MAY BE EXPRESSED ON STANDARD TAPE

A-45303

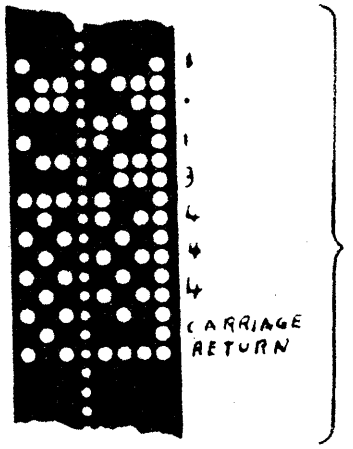
The constant $-10^{-4} \times 2^{13}$ may be represented on standard tape as:



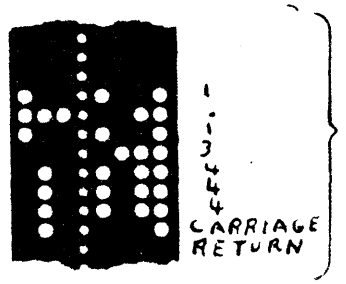
Decimal constant on checked standard flexo tape



Decimal constant on unchecked standard flexo tape

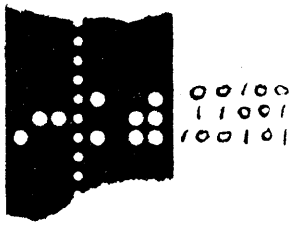


Octal constant on checked standard flexo tape



Octal constant on unchecked standard flexo tape

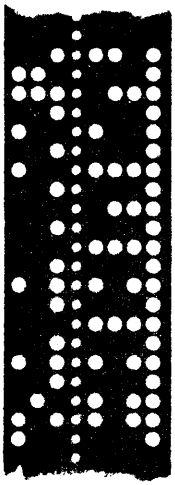
5-5-6 Tape



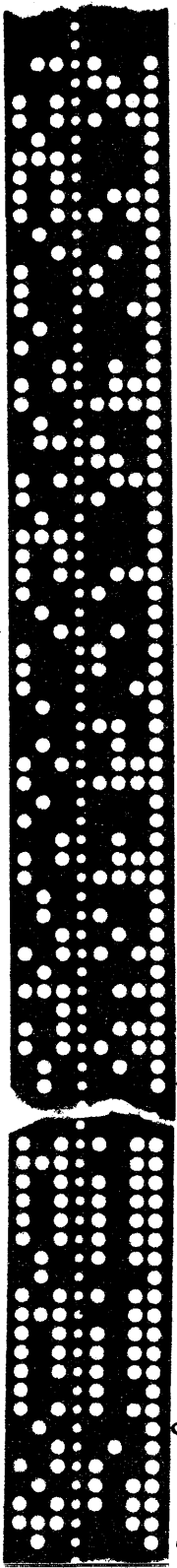
The binary form of $-10^{-4} \times 2^{13}$ is:

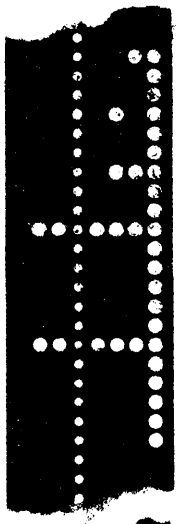
1 0 0 1 0 1 1 1 1 0 0 1 0 0 1 0 0

EXAMPLE OF HOW A NEGATIVE CONSTANT MAY BE EXPRESSE ON STANDARD TAPE



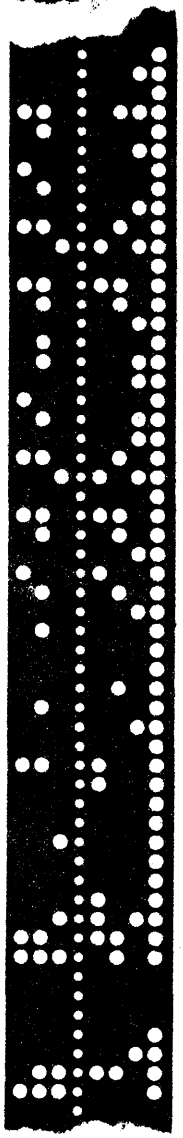
This is a "Flexowriter standard unchecked octal tape which was read in and converted by the conversion program.





ONE
TWENTY
THREE
MODIFICATION
ZERO
PARAMETER
ZERO

3" BLANK TAPE



This is the 5-5-6 tape which was produced by the conversion program and will be read in by the input program.

SA-3004

SL-194 SB-3 6201

TITLE Example PROB.# 0 DIC #6345 ☐ TAPE 623
☒ MOD. 15
AUTHOR P. Fox TYPIST P. F. DATE 4-17-51 ☒ PARAM. 6

uo/→6→2→3→-→1→5→-→6→40t Feed out tape

40	ri10	140		240		340	
41	rs11	141		241		341	
42	rf12	142		242		342	
43	rb13	143		243		343	
44	rd14	144		244		344	
45	rc15	145		245		345	
46	qh16	146		246		346	
47	qd17	147		247		347	
50	ts10	150		250		350	
51	td11	151		251		351	
52	ta12	152		252		352	
53	ck13	153		253		353	
54	qs14	154		254		354	
55	qe15	155		255		355	
56	cp16	156		256		356	
57	sp17	157		257		357	
60	ca20	160	0.12345	260		360	
61	cs21	161	1.23456	261		361	
62	ad22	162	0.34567	262		362	
63	su23	163	1.45670	263		363	
64	cm24	164	0.56701	264		364	
65	sa25	165	1.67012	265		365	
66	ao26	166	0.70123	266		366	
67	qf27	167	1.01234	267		367	
70	mr30	170	/→200d Feed out tape	270		370	
71	mh31	171		271		371	
72	dv32	172		272		372	
73	sl33	173		273		373	
74	sr34	174		274		374	
75	sf35	175		275		375	
76	qr36	176		276		376	
77	qp37b Feed out tape	177		277		377	
100	ca376	200	+.9876	300		400	
101	ad211	201	-.8765	301		401	
102	su4	202	+.7654	302		402	
103	ts101	203	-.6543	303		403	
104	/→160d Feed out tape	204	sp70. Feed out tape	304		404	
105		205		305		405	
106		206		306		406	
107		207		307		407	
110		210		310		410	
111		211		311		411	
112		212		312		412	
113		213		313		413	
114		214		314		414	
115		215		315		415	
116		216		316		416	
117		217		317		417	
120		220		320		420	
121		221		321		421	
122		222		322		422	
123		223		323		423	
124		224		324		424	
125		225		325		425	
126		226		326		426	
127		227		327		427	
130		230		330		430	
131		231		331		431	
132		232		332		432	
133		233		333		433	
134		234		334		434	
135		235		335		435	
136		236		336		436	
137		237		337		437	

The above program is to have an unchecked octal tape. The tape number is 623, modification 15, parameter 6 The first word of the program is in register 40. The words are stored in groups as indicated, and the first order of the program is in register 70.

SL-177

SB-50044

40	0.00163	100	ta 77	140	gr 77	200	rf 77	240	sp — CHAR INPUT SUB PROGRAM	300	ta 316	340	up 171 FEED OUT TAPE	400					
41	ta 122	101	0.00006	141	0.04146	201	ca 77	241	gr 0	301	ta 36	341	up 51 PUNCH ADDRESS	401					
42	ca 331	102	sl 77	142	0.00010	202	su 77	242	ad 10	302	td 113	342	ca 36 SET FF4	402					
43	su 72	103	0.00000	143	sa 77	203	cp 174 FEED OUT SUB PROG	243	ck 155	303	ca 113	343	ta 34 TO 1ST ADDRESS	403					
44	td 154	104	ts 77	144	0.00007	204	sp —	244	ca 367	304	sl 12	344	ca 132 PUNCH SPECIAL	404					
45	ca 63 STORAGE BLOCK OUTPUT SUB PROGRAM	105	0.00125	145	1.03330	205	ca 77	245	up 237	305	sr 12	345	gp 0 CHAR	405					
46	td 331	106	0.04107	146	gf 77	206	up 171 LEADER	246	up 232	306	gp 0	346	up 346 TREAT NEXT WORD	406					
47	td 52	107	0.00011	147	1.02264	207	ca 63 RESET TRANSFER ORDER	247	ad 334	307	ca 113	347	SP 232 READ IN STOP CHAR	407					
50	up 54	110	1.03610	150	up 77	210	ts 331	250	td 252	310	sl 5	350	up 41 PUNCH OUT BLOCK	410					
51	ta 122	111	0.04152	151	0.04173	211	gr 0 IS THE TAPE	251	up 232	311	sr 1452	351	ca 115 PUNCH OUT SUM	411					
52	ca —	112	up 77	152	0.00004	212	ca 10	252	ad —	312	gp 0	352	up 300	412					
53	up 300	113	di TEMPORARY	153	su 77	213	sr 1455 CHECKED OR	253	td 257	313	ca 36	353	ca 214 PUNCH 111010	413					
54	ao 52	114	td 77	154	ca —	214	su 72	254	sr 1453	314	sr 1452	354	gp 37	414					
55	up 120	115	SUM (MODULO ONE)	155	1.76000	215	cp 217 UNCHECKED	255	ad 243	315	gp 0	355	gp 1100 PUNCH = BLANK	415					
56	0.04072	116	ja 77	156	0.20000 2^{-2}	216	gr 0	256	td 326	316	up —	356	gp 1100 SPACES	416					
57	dv 77	117	1.03470	157	0.00163	217	ad 245	257	ca —207	317	0.00036	357	gp 1100	417					
60	mh 77	120	su 154 STORAGE BLOCK OUTPUT SUB PROGRAM	160	su 77	220	ts 236	260	ts 27	320	ts 132	360	up 370	420					
61	0.40165	121	cp 52	161	sr 77	221	up 232 ARE THE ADDRESSES OCTAL OR DECIMAL?	261	td 273	321	sr 1443	361	sa 115	421					
62	0.04104	122	up —	162	su 77	222	sr 4	262	ca 0	322	td 332	362	ts 115 END OF BLOCK	422					
63	ts 376	123	0.04103	163	0.00012	223	ad 107	263	td 27	323	ao 34	363	up 232	423					
64	ao 77	124	0.44046	164	cm 77	224	ts 77	264	ts 35	324	qo 331	364	up 41	424					
65	gh 77	125	ad 77	165	0.64333 $10^{-4}\ 2^{13}$	225	up 246	265	up 232	325	ca 35	365	up 51	425					
66	1.03363	126	ga 77	166	1.13444 $-10^{-4}\ 2^{13}$	226	up 232 END OF LAST BLOCK OF A GROUP	266	ad 105	326	mh — 156	366	up 246	426					
67	0.00005	127	0.04135	167	sf 77	227	up 41	267	td 270	327	sl 2	367	Temp	427					
70	0.00142	130	0.00003	170	sd 77	230	up 341	270	ca —	330	ad 27	370	up 51 PUNCH SP TO FIRST ORDER AND 111000	430					
71	gp 77	131	nb 77	~~171~~	ta 204 TAPE OUT SUB PROGRAM	231	ck 77	271	cp 320	331	ts —	371	ca 132	431					
72	0.00001	132	SPECIAL CHAR IN DIG POS 10-15	172	ca 317	~~232~~	ta 240 CHAR INPUT SUB PROG	272	ga 35	332	sp —	372	gp 0	432					
73	0.04076	133	ms 77	173	ts 10	233	gr 37	273	mh —	333	sa 115 REGULAR WORD OF A BLOCK	373	up 206 TREAT NEXT PROGRAM	433					
74	0.04114	134	0.00031	174	ca 0	234	ad 10	274	sl 17	334	ts 115	374		434					
75	0.00002	135	1.02620	175	gp 1100	235	ts 367	275	ad 35	335	up 246	375		435					
76	1.00142	136	gd 77	176	ao 10	236	up 237/241	276	ts 35	336	ts 115 START SUM	376		436					
77	DECIMAL OR OCTAL CONVERSION FACTOR	137	0.04062	177	up 203	237	sr 1452	277	up 265 NUMBER CONVERSION	337	up 41 PUNCH TAPE #	377		437					

STORAGE BLOCK REGISTERS

ELECTRONIC COMPUTER DIVISION
SERVOMECHANISMS LABORATORY-MIT

OCTAL PROGRAM FORM

TITLE PHOTOELECTRIC CONVERSION

AUTHOR ADAMS - FOX - GILMORE

DIC # 6345 TAPE # T 190

PROBLEM # 10 MODIFICATION # 12

DATE APRIL 1951 PARAMETERS #

SB-50044

Start here for Input Program

Reg. 10
Put the binary form of sr 810 in the AC. (1110001100101010)

Start here for Check Program

Reg. 11
Add the binary form of ck 30 to the AC. (0101100000011110)

Reg. 12

(Check Prog)	(Input Prog)
The result is ck 30. Transfer to register 23.	The result is qd 841. Transfer to register 23.

Reg. 13
Read digits 11-15 of a word into digital positions 1-5 of FF# 3 (sign digital position will contain a zero).

Reg. 14
Put digits 11-15 of the word into digital positions 1-5 of AC. (sign digital pos. - zero)

Reg. 15-16
Move digits 11-15 to digital positions 6-10 of AC and read digits 6-10 into digital pos. 1-5 of FF# 3 and then add them to the AC.

Reg. 17-18
Move digits 6-15 to digital positions 6-15 of AC and read digits 0-5 into digital pos. 0-5 of FF# 3 and then add them to the AC.

Reg. 19-20
Read the next character on tape into digital positions 0-5 of FF# 3. Exchange the contents of FF# 3 and AC.

Reg. 21
If the sign digital position of the AC contains a zero, digital positions 1-5 will contain digits 11-15 of the next word. If the sign digital position contains a one, the AC will contain a special character (110011,111010, 110100, or 111000 in digital positions 0-5) indicating that FF# 3 contains a special word other than a word of the program. Is the AC negative or positive?

Reg. 22
(Positive) Exchange the contents of FF# 3 and AC. The AC now contains the binary form of a word of the program.

Reg. 23

(Check)	(Input)
Check the word with assigned register.	Transfer the word to its assigned register

Reg.
(Special) Add the binary value of the contents of the "sum" register to the binary value of the word and eliminate any special add overflow. Transfer the result to the "sum" register.

Reg. 26-27
Increase the address section of Reg. 23 by 1.

Reg. 5-7
(Negative) Shift the contents of the AC to the right 10 digital positions. Result will be a small negative val. Add the binary value of sp 14. Exchange AC and FF# 3.

Reg. 9
The binary form of the sum which was read from the 5-5-6 tape is in the AC. Check it with the "sum" register 30.

Reg. 2
ri address of first reg. of program is in AC. Transfer the whole word to register 30. This will be the initial value of the sum.

Reg. 3
ri(address to which next word is to be transferred) is in AC. Transfer this address into the address section of reg. 23.

5-5-6 Input or Check Program

```
 0) +0
 1) +1/4
 2) ts 30
 3) td 23
 4) sp 13
 5) sr810
 6) ad 27
 7) qe  8
 8) FF# 3
 9) ck 30
10) ca  5
11) ad  9
12) ts 23
13) qr  0
14) ca  8
15) qr  5
16) ad  8
17) qr  5
18) ad  8
19) qr  0
20) qe  8
21) cp  5
22) qe  8
23) FF# 0
24) sa 30
25) ts 30
26) ae 23
27) sp 14
28) FF# 4
29) FF# 1
30) FF# 2
31) qd2047
```

Reg. 8
sp 3(110100)
sp 2(110011)
sp 9(111010)
sp 7(111000)

Reg. 7
The binary form of sp(address of the register which contains the first order of the program) is in the AC. Exchange the contents of the AC and FF# 3.

Reg. 8
Take the next order from electrostatic storage.