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A Study of the Statistics of Letters in English Words

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Data which had previously been published by several authors (Ohlman, 1958; Pratt, 1942; Ohaver, 1933; Smith, 1943; Cox, 1947; Griffith, 1949; Gaines, 1956; Luhn, 1958) to describe the statistical characteristics of English words was examined to show the extent of their agreement. In addition, a detailed empirical study was made of two special types of English word: subject words and proper names. The data for the subject words and proper names was compared with previously reported data on subject words, proper names, and continuous text material. The statistical parameters which were measured and compared are: the distribution of initial letters, the distribution of terminal letters, the composite or total distribution of letters, the distribution of characters for each letter position, the distribution of bigrams, and the distribution of word lengths.

I. INTRODUCTION

Frequency distributions and bigram distributions of English words were required by the authors as supporting information for a study of methods for systematically abbreviating written English words.[1] Previously published frequency distributions were derived primarily from studies of continuous text material and were not representative of the data which was to be used as subject material for the abbreviation study. In addition, no information was available to describe the letter distributions for each position within a word. An empirical study of a relatively large collection of words was subsequently initiated, and the

[1] Some work in this area has already been done by Barrett, 1960; Bemer, 1960; Frishberg, 1960; Newcombe, 1959; Taunton, 1960; Remington Rand (undated), and Bloomer, 1874. Additional work in the study and processing of natural languages has been done by Blair, 1960; Burton, 1955; Chapanis, 1954; Frumkina, 1959; Korolev, 1958; Mandelbrot, 1954; Evans, 1960; Miller, 1957 and 1958; Newman, 1951, 1952, 1960; Oettinger, 1954, 1957; Shannon, 1951; West, 1953; Yngve, 1956; Zipf, 1935, 1949.

results of that study are reported in this paper. Character distributions for each letter position within a word were derived in order to show how the character usage changed with the letter position within the word. These distributions by letter position were obtained both for a sample of subject words and for a sample of proper names. A total distribution of letter usage was also obtained for both types of data. In addition, the frequency of occurrence of bigrams (adjacent letter pairs) was obtained for both types of data. Generally, this study determined the statistical nature of two special populations of English words (proper names and subject words) and compared these statistics with results which had been collected by other workers for more general samples of English words (continuous text and telegraphic text). However, with the exception of some work by Ohlman, no corresponding literature could be found for subject words and proper names to describe the frequency distributions by letter position, and the distributions of word lengths. The derived data and the comparisons are described in more detail in subsequent sections.

II. DESCRIPTION OF THE DATA BASE

The one source of English words for this study was a list of 2082 different single-word descriptors (e.g., "magnetic," "optical") which were used to index a collection of technical documents at Stanford Research Institute. This sample did not represent the entire descriptor dictionary, since multiple-word descriptors (e.g., "aerodynamic heating" or "black body") were not considered for this analysis. In all cases, the analysis started with the full and correct spelling of the words. That is, no truncated words or abbreviations were included in the material for analysis.

The second source of material for this study was a list which represented the entire 1959 student registration of Stanford University. Each of the names was initially restricted to a total of 25 characters, including spaces, and consisted of at least the last name, as well as some combination of the first and middle (or more) names, and their prefixes (in that order). The names were basically more awkward to work with than the subject words, and a simplification was made by editing each name to remove all spaces and special characters (e.g., hyphens) and compressing it to form a single long word of 22 letters or less. The original name list contained 8207 names, and included 23 duplicates.

III. DISCUSSION

A. Initial Letter Usage for Text Material and Subject Words

Table I describes five different rankings by usage of initial letters. Three different studies of continuous text material show relatively good correlation among themselves, with complete agreement that T, A, and O are the three most popular characters for initial letters. Two different studies of subject words also show relatively good correlation between each other, with complete agreement that S, P, and C are the three most popular characters for initial letters. Taken as a group, the rankings for subject words are different than the rankings for continuous

TABLE I

Comparative Ranking by Frequency of Occurrence of Initial Letters in English Words

Subject words (Bourne-Ford)	Subject words (Ohlman, p. 92)	Continuous text (Pratt, p. 258)	Continuous text (Ohaver, p. 27)	Continuous text (Smith, p. 153)
S	C	T	T	T
P	S	A	A	O
C	P	O	O	A
T	A	S	S	W
A	B	W	H	B
D	M	I	I	C
M	T	H	W	D
R	R	C	C	S
B	E	B	B	F
I	F	F	P	M
E	D	P	F	R
F	G	M	D	H
H	H	R	M	I
L	I	E	R	Y
G	L	L	E	E
W	N	N	Y	G
N	W	D	N	L
O	O	U	L	N
V	V	G	U	P
J	U	Y	G	U
U	J	J	V	J
K	K	V	K	K
Q	Q	Q	J	
Y	Y	K	Q	
Z	Z	X	Z	
X	X	Z	X	

text, with the degree of difference noted in the Table. It should be intuitively obvious that there would be a difference, primarily because of the relatively large number of prepositions and other small words (e.g., a, and, in, is, the, to, with, etc.) which appear in continuous text.

B. Initial Letter Usage for Proper Names

It was of interest to study the distribution of initial letters in proper names because of the help that this information can be in setting up

TABLE II

Comparative Ranking by Frequency of Occurrence of Initial Letters in Proper Names

(Bourne-Ford[a])	(Bourne-Ford[b])	(Ohlman, p. 93)	(Cox *et al.*, p. 69)
B	S	S	S
S	B	B	B
M	M	M	M
H	H	H	H
C	C	C	C
W	W	D	W
R	R	G	R
L	G	K	P
P	L	L	L
G	P	R	G
D	D	P	D
K	F	W	F
F	K	A	K
T	T	F	T
A	A	T	A
J	J	E	E
E	E	N	J
N	N	V	N
O	O	J	V
V	V	O	O
Y	I	I	Y
I	Y	Z	I
Z	Z	U	Z
U	U	Y	U
Q	Q	Q	Q
X	X	X	X

Note:

[a] Based on a detailed study of 8207 names.

[b] Based on an independent, but less-detailed study of approximately 63,000 names.

many types of administrative procedures (e.g., allocating filing space, code design, establishment of equal quantities of names for registration or accounting purposes, etc.). Table II shows that four different studies were in relatively good agreement, with complete agreement that B, S, M, H, and C are the most popular characters for initial letters.

C. Terminal Letter Usage for Text Material and Subject Words

Table III describes four different studies of terminal letter usage in English words. The three studies which examined continuous text had complete agreement that E, S, D, T, and N were the most popular characters for terminal letters, and had relatively good agreement for

TABLE III

Comparative Ranking by Frequency of Occurrence of Terminal Letters in English Words

Subject words (Bourne-Ford)	Continuous text (Pratt, p. 258)	Continuous text (Ohaver, p. 28)	Continuous text (Smith, p. 153)
E	E	E	E
N	S	S	S
R	D	T	T
S	T	D	D
T	N	N	N
L	Y	R	R
Y	F	O	Y
D	R	Y	F
C	O	F	L
G	H	L	O
M	G	G	G
H	A	H	H
A	L	M	A
K	M	W	K
P	K	K	M
O	P	P	P
X	C	A	U
Y	W	C	W
B	U	X	
F	X	B	
I	I	U	
V	B	I	
Z	J	J	
Q	Q	Q	
J	V	V	
U	Z	Z	

TABLE IV

COMPARATIVE RANKING BY COMPOSITE[a] FREQUENCY OF OCCURRENCE OF LETTERS IN ENGLISH WORDS AND PROPER NAMES

Subject words (Bourne-Ford)	Continuous text (Pratt, p. 252)	Continuous text (Ohaver, p. 25)	Continuous text (Griffith, p. 426)	Continuous text (Smith, p. 153)	Proper names (Bourne-Ford)
E	E	E	E	E	E
I	T	T	T	T	A
R	A	A	A	O	R
O	O	O	O	A	N
A	N	N	N	N	L
T	R	I	I	I	O
N	I	S	S	R	I
S	S	R	R	S	S
L	H	H	H	H	T
C	D	L	L	D	H
P	L	D	D	L	D
M	F	C	C	C	M
D	C	U	U	W	C
U	M	P	M	U	B
H	U	F	F	M	G
G	G	M	Y	F	U
Y	Y	W	W	Y	W
B	P	Y	G	G	Y
F	W	B	P	P	J
V	B	G	B	B	K
K	V	V	V	V	P
W	K	K	K	K	F
X	X	Q	X	X	V
Z	J	X	J	Q	Z
J	Q	J	Q	J	X
Q	Z	Z	Z	Z	Q

[a] These are all composite samples which did not consider the position of the letters within the words.

the remainder of the characters. The rankings for the study of subject words was distinctly, but not radically, different from the other three rankings. All the studies agreed that E was the most common terminal letter.

D. Composite Letter Usage for Text Material, Subject Words, and Proper Names

Table IV describes six different studies of the composite rankings of letter usage, that is, rankings which describe the relative frequency

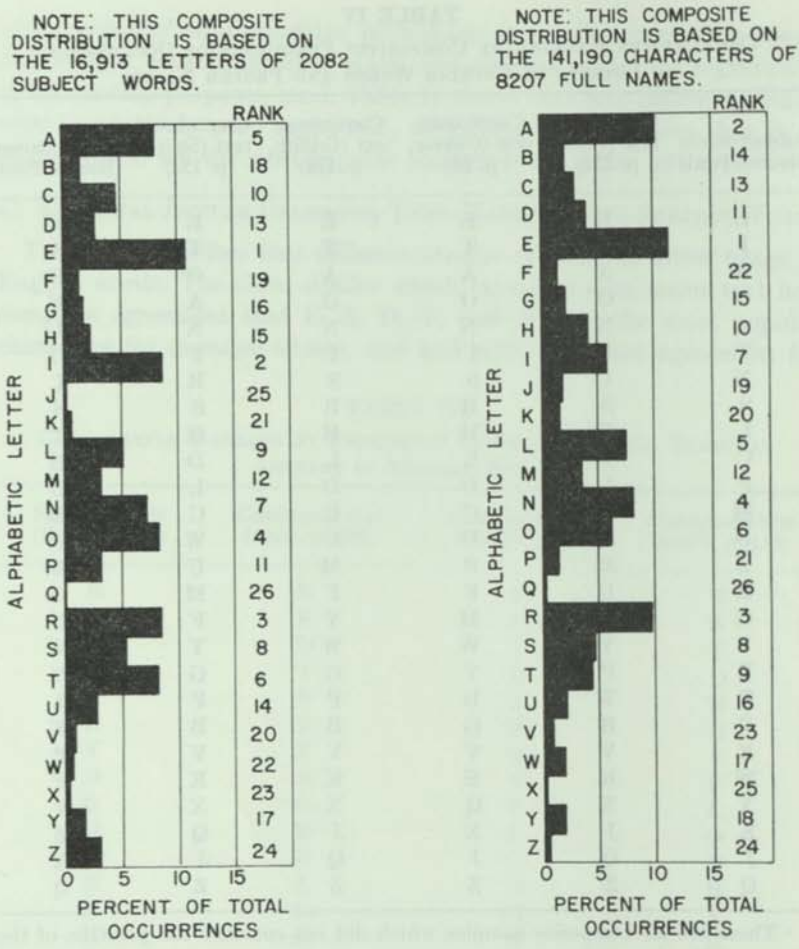

FIG. 1. Composite distributions and rankings for the alphabetic letters in subject words and people's names.

of occurrence of the *total* collection of letters, regardless of their particular letter positions. The four studies of continuous text material show remarkably good agreement, and unanimously conclude that E, T, A, O, and N are the most popular letters. The studies of the subject words and the proper names differ from each other and from the rankings for continuous text material. The only point of complete agree-

ment by all six studies was the fact that E was the most popular letter. A more graphic comparison of the composite distributions for subject words and proper names is given in Fig. 1, which shows the actual frequencies of usage as well as the rankings.

E. Character Usage by Letter Position for Subject Words

Figure 2 illustrates the rankings and frequency distributions for the characters of subject words within a particular letter position (i.e., the frequency distribution for the initial letter of the word, the second letter of the word, etc.). The study was continued out to the 22nd letter position, but was not plotted beyond the 10th letter position since the validity of the data decreased as the sample size decreased. However, it should be noted that the distributions after the 10th letter position looked very similar to the seven distributions which immediately preceded them. Figure 2 shows some very interesting patterns. It should be noted that the distributions of the first, second, and possibly the third letter positions have relatively unique patterns, and that the remaining letter positions generally have the same pattern. In the second letter position, the vowels are the most common characters (ranked E, O, A, I, R, U). Excluding the R, this group of five characters accounts for over 61 percent of the letter usage of that position.

F. Character Usage by Letter Position for Proper Names

Figure 3 illustrates the rankings and frequency distributions for the characters of proper names within a particular letter position. In the same manner as the subject words, the distributions of the first and second letter positions have relatively unique patterns, while the remainder of the letter positions have much the same pattern of distribution. The vowels dominate the second letter position of proper names, as they did with subject words. In this case, the vowels (A, O, E, I, U) account for over 70 percent of the character usage of the second letter position. There is general agreement between the patterns for corresponding letter positions of subject words and proper names.

G. Composite Bigram Rankings for Text Material, Subject Words, and Proper Names

Table V describes a portion of seven different studies and rankings of bigram occurrences. The five different studies of continuous text and

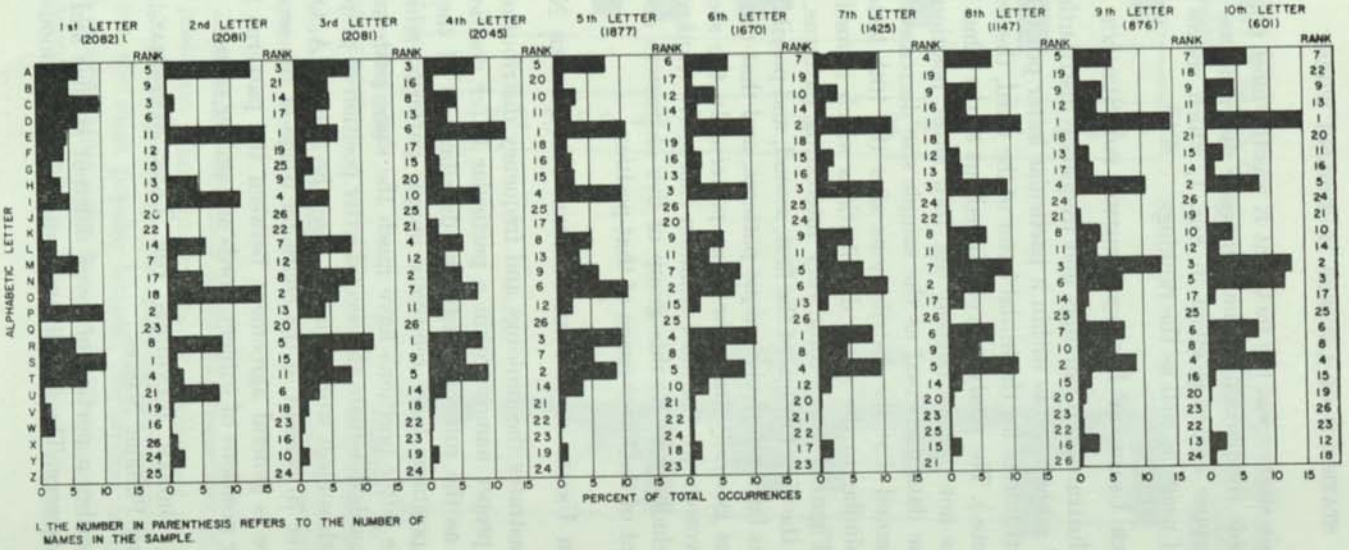

FIG. 2. Frequency of occurrence and rankings for the letters of subject words by letter position

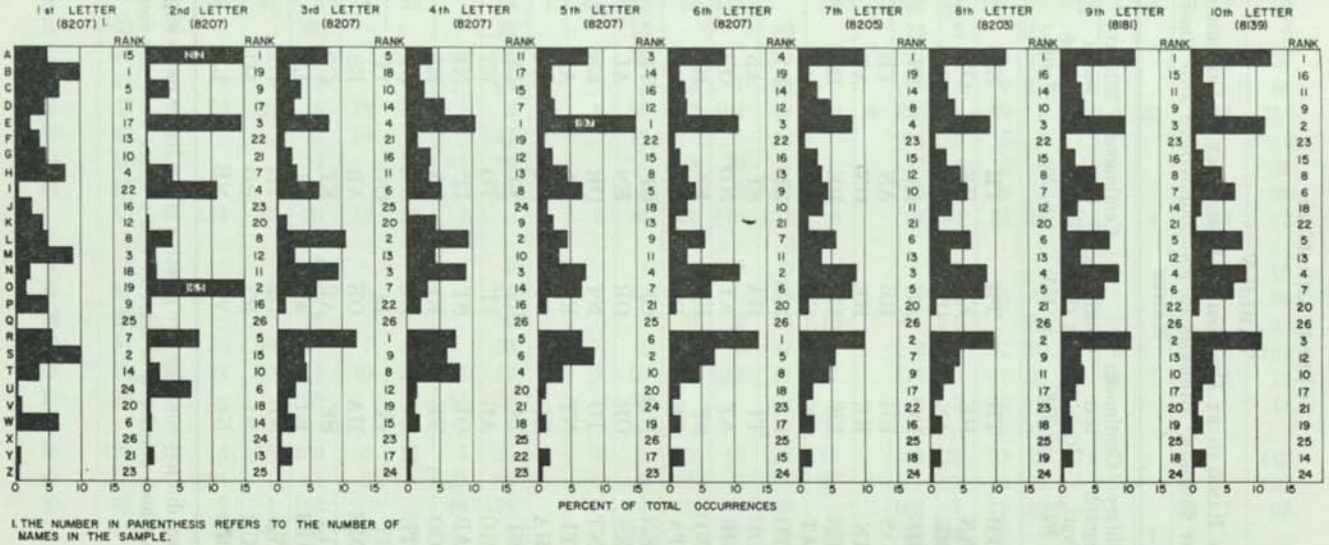

FIG. 3. Frequency of occurrence and rankings for the letters of proper names by letter position

TABLE V

COMPARATIVE RANKING BY COMPOSITE[a] FREQUENCY OF OCCURRENCE OF THE MOST COMMON[b] BIGRAMS IN ENGLISH WORDS AND PROPER NAMES

Continuous text (Pratt, p. 260)	Military telegraph (Pratt, p. 260)	Continuous text (Gaines, p. 218)	Continuous text (Smith, p. 153)	Continuous text (Ohaver, p. 26)	Subject words (Bourne-Ford)	Proper names (Bourne-Ford)
TH	TH	TH	TH	TH	ER	ER
HE	AN	HE	ER	HE	ON	AR
AN	RE	AN	ON	ER	TI	AN
RE	HE	IN	AN	IN	IN	ON
ER	ON	ER	RE	AN	TE	LE
IN	IN	RE	HE	ON	AT	EN
ON	ER	ES	IN	RE	RA	LL
AT	AT	ON	ED	AT	RO	HA
ND	TO	EA	ND	ED	IO	EL
ST	OU	TI	HA	ST	AN	NE
ES	OR	AT	AT	ND	OR	RO
EN	ND	ST	EN	ES	IC	AL
OF	TA	EN	ES	HA	RE	IN
TE	EN	ND	OF	OF	TR	MA
ED	ES	OR	OR	EN	AL	RI
OR	NT	TO	NT	OR	EN	CH
TI	TI	NT	EA	AS	AR	LI
HI	HA	ED	TI	NT	NT	RE
AS	ST	IS	TO	TI	LE	TH
TO	RO	AR	IT	TO	ET	BE
AR	AR	OU	ST	IT	NE	AM
OU	CO	TE	IO	EA	RI	ES
IS	TE	OF	LE	NG	ST	IL
IT	IT	IT	IS	OU	IT	RT
LE	ME	HA	ON	AR	ES	RD
NT	TT	SE	AR	ET	CO	RA
RI	OM	ET	AS	HI	LA	LA
SE	VE	AL	DE	TE	DE	OR
HA	UR	RI	RT	RO	ME	IC
AL	ED	NG	VE	NE	LI	TE

[a] These rankings did not consider the position of the letter pairs within a word.

[b] The bigrams which consisted of a letter and a space were not considered for these rankings.

TABLE VI

FREQUENCY OF OCCURRENCE[a] OF BIGRAMS FOR A COMPOSITE[b] SAMPLE[c] OF SUBJECT WORDS

Letters of the first position	Letters of the second position																								Space
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
A		13	46	30	3	8	24	1	25	1	10	105	35	119		29		101	44	137	7	13	5	4	9	7	23
B	23	2			20				25			13			20			14	5		17						5
C	57		5		52			44	21		15	14			83			24	7	56	18				8	1	57
D	17	1	1	4	78		4		54			2	2	1	18			17	6	1	15		1		5		58
E	35	5	56	33	15	12	14	2	6		1	68	22	104	12	19	5	223	84	89	5	9	4	20	3	1	213
F	12				17	10			27			19			17			14	1	5	7						2
G	17				34		2	11	10			11	2	10	7			27	4	1	7				8		55
H	33				53				24			3	1	2	47			13		8	5				26		24
I	35	13	111	36	23	18	22	2			2	43	24	174	121	13		27	54	85	18	17		1		11	2
J	1				5										2						5						
K	2				17				9			1		2	2				2						4		18
L	81	1	2	8	89	3	1		76		4	42	3		55	2			11	24	23	2			17		85
M	50	7			76				50				9	2	45	18			1		20				1		43
N	51		39	40	88	7	66		53	1	7	1	1	6	37	1		2	40	91	10	7	2		5	1	162
O	10	13	24	25	5	10	26	3	17	1	2	69	68	213	11	47		111	43	41	28	7	14	7	5	1	12
P	29				60			54	24			28			49	4		28	5	12	9				7		14
Q																					13						
R	128	12	14	15	109	5	13	5	86		5	4	32	15	128	13		18	26	21	18	7	2		23		142
S	11		24		47	2		25	65		6	9	7	3	36	27	1		27	86	26		2		8		122
T	69		3	1	143			46	178			4	2		69			108	7	17	23		1		26	1	92
U	11	11	12	8	8	2	5		8			41	33	31	5	17		39	28	24				1			
V	18				40				17						7						1						1
W	18				9			3	8		1	1		2	8			1	1								7
X	1		2		3				4						2	2				5					3		8
Y	3	2	6	10	2		1					16	2	12	2	10		9	13	1							72
Z	6				8				4						6										1		1

[a] Expressed as the number of occurrences per 10,000 bigrams. Frequencies of less than 1 part in 10,000 are not shown in this Table.

[b] These tallies did not consider the position of the letter pairs within the word.

[c] This sample consisted of 2082 subject words with a total of 16,918 bigrams.

TABLE VII

FREQUENCY OF OCCURRENCE[a] OF BIGRAMS IN A COMPOSITE[b] SAMPLE[c] OF PROPER NAMES

Letters of the first position	Letters of the second position																								Space
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
A	8	15	25	17	18	5	10	11	19	8	9	107	91	216		5		248	39	30	27	30	12	2	29	2	17
B	34	3			91				8	1		6			13			28	3		11				4		3
C	35		5	2	33		2	99	14		34	16			29			10		2	5				7		6
D	57	5	6	10	59	5	9	5	21	13	2	12	9	5	40	4		20	15	4	7	1	27		5		49
E	42	10	14	51	40	7	12	9	21	16	4	119	22	132	22	21		255	90	59	8	13	24	2	40	1	89
F	5				8	12			9	1		3	1		13			35		1	3						3
G	27	1	1	2	62		4	13	13	3		14	2	2	14			19	5	2	6		2				7
H	121	2	3	1	64		1	2	28	6	1	8	7	44	49	1		12	4	5	21		3		5		25
I	58	3	73	28	37	5	12		9	1	4	89	10	105	7	9		19	61	33		5		1		9	8
J	49				17				2						68			27			10						2
K	20	1	1	1	42		1	2	14	5		8	3	2	6			6	7		3		3		1		12
L	85	11	5	45	139	9	4	4	97	8	5	126	12	2	41	7		4	18	17	6	6	4		22		35
M	105	6	16	1	58	1	1	2	40	4	1	2	7		28	7		3	7	1	10		2		2		16
N	56	13	42	65	118	8	44	11	27	30	19	19	17	65	21	9		32	43	31	2	2	14		6	3	108
O	8	43	8	16	9	6	7	44	2	2	4	48	27	146	18	7		81	28	17	30	5	26	2	12		7
P	28	1			27			31	5	1	1	3	1		5	4		7	5		1						3
Q																					3						
R	86	16	12	87	95	4	33	5	102	16	16	43	17	23	112	6		45	28	87	20	7	8		40	1	60
S	34	7	24	8	54	4	7	32	12	16	8	13	17	4	52	10		12	23	61	12	1	14		2		47
T	26	3	9	4	71	3	3	93	22	9	2	10	6	2	39	2		22	11	36	7		5		3	6	28
U	5	3	11	11	11	2	20	1	12		1	22	6	18		2		35	28	10					1	1	2
V	12				22				41						3												1
W	54			1	22	1		5	60	1		2	4	5	9			8	4	1					1		5
X	2																			1							1
Y	13	3	6	11	11	2	3	3	1	12	2	15	9	21	4	3		11	6	4	1	1	4				36
Z	12				4				3	1			1		1												

[a] Expressed as the number of occurrences per 10,000 bigrams. Frequencies of less than 1 part per 10,000 are not shown in this table.

[b] These tallies did not consider the position of the letter pairs within the name.

[c] This sample consisted of 8207 proper names with a total of 141,190 bigrams.

TABLE VIII

BIGRAM RANKINGS[a] FOR A COMPOSITE[b] SAMPLE[c] OF SUBJECT WORDS

Letters of the first position	Letters of the second position																									
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Space
A	385	177	66	94	295	230	118	347	113	365	207	19	87	14		96	417	21	70	9	246	187	265	287	220	251	127
B	128	320		392	135			401	114	406		181	410		136			175	274		161	432			437		267
C	47		260		58			69	133		166	172			32		418	122	237	50	145				228	382	48
D	151	343	345	288	34		281		54	407		326	311	372	149			156	258	353	168	433	354		266		46
E	85	259	49	91	169	192	171	323	254	408	368	41	132	20	194	140	273	1	31	25	277	219	286	138	303	358	2
F	189	386			158	204			104			139		411	160			176	375	276	247						317
G	152	387			88		309	200	206			201	327	208	236			102	291	377	239	434			233		51
H	89		390		56				119			300	370	330	63		419	186		227	264		436		107		115
I	86	178	16	83	125	148	131	310			324	72	121	5	13	182	420	105	55	30	150	162		356		197	318
J	341				268				404						312						278						
K	319			393	153		399		214			349		331	334	415		423	314	426	428				292		141
L	33	344	306	222	24	297	346		36		289	74	301	412	52	336		424	203	123	129	315			163		29
M	60	242			35	397			61				216	332	68	143			352		137				380		71
N	59	388	81	77	26	235	43	402	57	366	243	350	371	256	82	373	421	338	78	23	210	248	339		279	359	6
O	211	179	116	111	269	205	109	298	159	367	325	40	42	3	202	65		15	73	75	98	240	173	249	280	383	188
P	95			394	45			53	120			99		413	62	285		97	275	195	218				250		170
Q																					184						384
R	10	190	174	165	17	270	180	272	027		261	290	92	167	11	185		144	106	134	146	241	340		126		8
S	198	389	117	395	64	322		112	44	409	255	215	244	302	84	101	374		103	28	110	435	316		229		12
T	38		294	363	7	398	400	67	4			284	328	414	39	416		18	238	157	130		355		108	360	22
U	199	196	191	223	224	308	271		231			76	90	93	262	155		80	100	124	429			357		439	
V	142		391		79				154						245				425		379				438		361
W	147			396	213			299	226		348	369		333	232			351	376	427							234
X	342		307		296				282						335	337				263					304		221
Y	293	305	253	212	321		364	403	405			164	329	193	313	209	422	217	183	378	430						37
Z	252				225				283						257						431				381	440	362

[a] The most frequent bigram is given a rank of one.

[b] These tallies did not consider the position of the letter pairs within the words.

[c] This sample consisted of 2082 subject words with a total of 16,918 bigrams.

TABLE IX

BIGRAM RANKINGS[a] FOR A COMPOSITE[b] SAMPLE[c] OF PROPER NAMES

Letters of the first position	Letters of the second position																									
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Space
A	243	169	118	157	147	318	216	209	143	255	235	13	22	3	463	316	544	2	76	94	109	96	200	391	99	412	156
B	85	346	536	508	21	567	525	540	247	455	569	276	557	558	180	598		101	369	475	204		581		339	611	352
C	80	507	307	404	87	518	409	17	171	501	84	165	502	492	98	572	464	224	487	374	300	579	609		268	535	286
D	46	304	282	218	43	309	232	313	135	186	381	198	238	303	73	330	600	141	168	324	262	457	110		315	583	53
E	65	217	176	51	74	266	192	239	136	160	322	9	123	6	131	132		1	23	42	245	184	120	379	72	415	25
F	301	552	515	467	249	195	538	553	229	459	556	360	414	520	178	599		82	465	423	370	607	547				345
G	114	453	421	393	37	468	341	181	183	347	483	173	395	384	175	486	601	145	320	378	277	546	406		488	612	270
H	8	385	357	422	36	469	419	401	107	275	447	248	267	60	54	420		199	323	305	134	522	349		306	613	117
I	45	361	31	103	77	311	197	482	231	427	336	24	221	14	273	236	574	142	39	89	471	314	534	429	472	237	241
J	52		566	587	154				405	592	593		595	597	33			112			215		582		610		403
K	139	432	438	444	67	509	454	375	174	319	484	251	368	382	284	470		291	256	532	362	561	372		430		202
L	29	207	297	57	5	230	342	343	18	244	295	7	196	402	69	265	602	333	150	153	278	285	322		126	466	81
M	15	281	167	417	44	434	425	380	70	338	440	389	264	530	102	260		354	261	418	219	562	407		399	584	166
N	47	182	66	35	10	254	59	206	113	95	146	144	155	34	137	233		91	62	93	396	397	172		279	355	12
O	240	63	253	159	234	289	271	61	386	410	325	55	111	4	149	257	575	30	105	158	97	296	115	398	193	476	263
P	104	416	473	498	108	490	539	92	298	451	441	348	436	521	294	344		272	308	503	448	563	506		565		356
Q																					371						
R	28	162	191	27	19	340	88	302	16	161	164	64	152	122	11	290	545	58	106	26	138	274	246		71	449	40
S	86	259	119	242	48	321	269	90	203	163	250	185	151	337	50	223	603	189	121	38	201	413	177		408	477	56
T	116	358	227	331	32	364	366	20	130	225	383	220	280	376	75	377		125	210	79	258	512	312		359	288	100
U	317	363	212	205	211	390	140	435	188	528	428	129	283	148	479	411	576	83	128	222	578	494	564	495	443	424	400
V	187			588	127		590	591	68	555	594	529	596	571	365			493	560	605	606				549		452
W	49	496	481	433	124	458	526	293	41	445	462	387	329	299	228	559		252	334	446	504		548		431	614	310
X	392	586	537	524	499	589	568	554	500	478		542	570		480	573		531	577	461		608	523				450
Y	179	351	287	213	208	388	350	353	426	194	394	170	226	133	326	373	604	214	292	328	456	437	327		550	585	78
Z	190	497	516	517	335	519	491	527	367	439	541	485	460	543	442	510		474	511	533	505	580	513		551	489	514

[a] The most frequent bigram is given a rank of one.

[b] These tallies did not consider the position of letter pairs within the names.

[c] This sample consisted of 8207 proper names with a total of 141,190 bigrams.

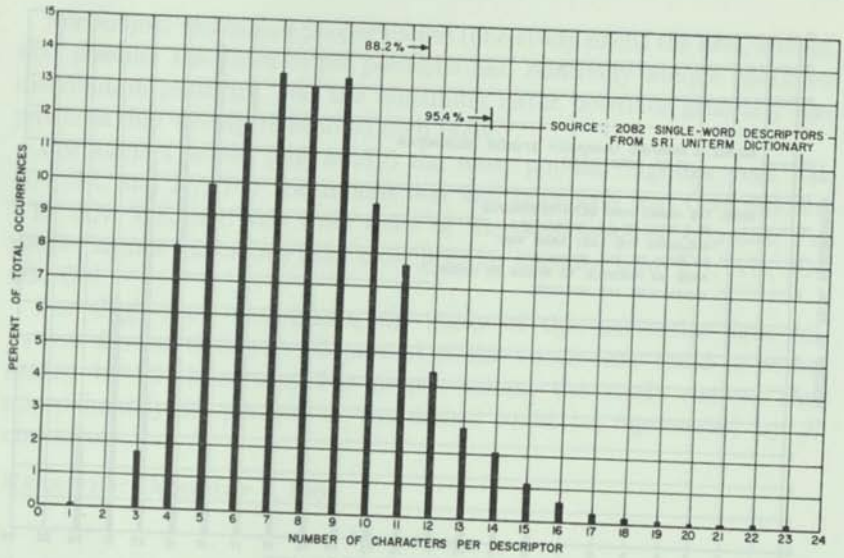

FIG. 4. Distribution of subject word lengths

telegraph text were similar in many respects (e.g., complete agreement that TH was the most common bigram). The bigram rankings for subject words and proper names were different from each other (except for agreement that ER was the most common bigram) and somewhat different from any of the other five rankings. However, it is more difficult to make a quantitative judgment of the degree of similarity between bigram rankings than it is for the ranking of single alphabetic characters. Complete descriptions of the bigram frequencies of occurrence for subject words and proper names are given in Tables VI and VII, respectively. Complete descriptions of the bigram rankings for subject words and proper names are given in Tables VIII and IX, respectively.

H. Distribution of Subject Word Lengths and Proper Name Lengths

The distribution of subject word lengths and the proper-name word lengths are illustrated in Figs. 4 and 5, respectively. This information is useful for code design, and for the planning of some mechanized data handling operations.

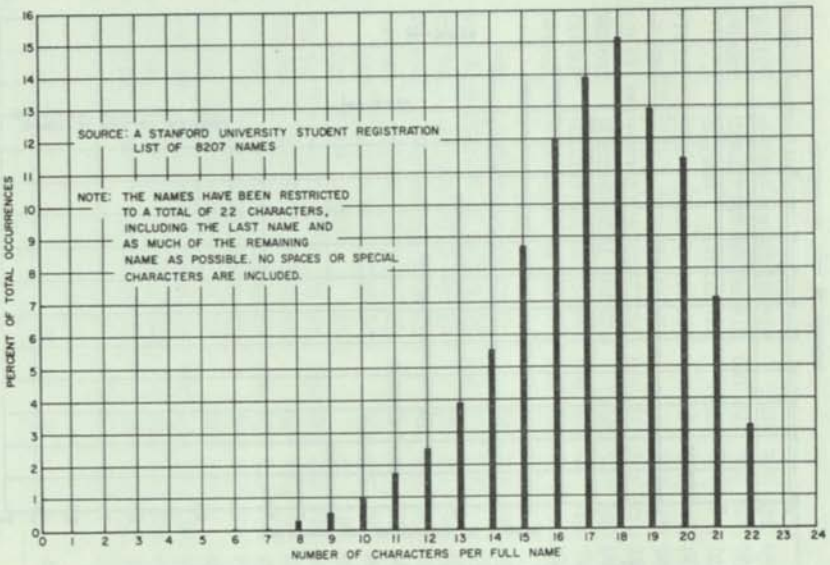

FIG. 5. Distribution of proper name lengths

IV. SUMMARY

In general, the usages or statistical characteristics of the alphabetic letters is markedly different for the three different applications of English words considered here (continuous text material, proper names, and subject words). Several independent studies of continuous text material show good agreement for a number of characteristics, and suggest that the reported data is a good representation of the nature of continuous text material.

For subject words (two studies) S, P, and C were the three most popular initial letters. For continuous text (three studies) T, A, and O were the three most popular initial letters. For proper names (four studies) B, S, M, H, and C were the most popular initial letters.

For subject words (one study) E, N, R, and S were the most popular terminal letters. For continuous text (three studies) E, S, T, and D were the most popular terminal letters.

For subject words (one study) E, I, R, and O were the most popular letters. For continuous text (four studies) E, T, A, O, and N were the most popular letters. For proper names (one study) E, A, R, and N were the most popular letters.

For subject words and proper names (one study each) the first, second, and possibly the third letter positions had relatively unique character distribution patterns, and the remaining letter positions generally had patterns that closely resembled each other.

For subject words (one study) the most popular bigrams were ER, ON, TI, and IN. For continuous text and telegraph text (five studies) TH, AN, HE, and RE were some of the most popular bigrams. For proper names (one study) the most popular bigrams were ER, AR, AN, and ON.

For single-word descriptors, the study of this particular data collection showed that over 95 percent of the vocabulary could be represented by 13 characters. For proper names, the study showed that approximately 95 percent of the names could be represented by 25 characters.

RECEIVED: December 1, 1960.

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Statistics of English Letters

- Whitby
- Dillon
- Kantz
- Tukey
- Ohlman
- Howerton
- Claire Schultz
- Lauren Doyle
- Hal Borko
- NSF – Helen Brownson – M. Harkenson, George Rothwell
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INFORMATION AND CONTROL

An International Scientific Journal

December 20, 1960

Mr. Charles P. Bourne, Research Engineer
Division of Engineering Research
Stanford Research Institute
Menlo Park, California

Dear Mr. Bourne:

Thank you for sending me the new title and running title for your paper. This has been sent to the publisher and I expect it should appear in the March 1961 issue of INFORMATION AND CONTROL.

The original drawings have also been received and sent to the publisher.

Sincerely yours,

Peter Elias

Peter Elias, Editor

PE:nm

INFORMATION AND CONTROL

An International Scientific Journal

December 2, 1960

Mr. Charles P. Bourne
Research Engineer
Division of Engineering Research
Stanford Research Institute
Menlo Park, California

Dear Mr. Bourne:

A referee has read your paper "A Study of the Statistical Nature of English Words" and has suggested that the title be changed to something like "A Study of the Statistics of Letters in English Words." This will prevent people from expecting a paper on something like Zipf's law on relative frequency of words in English.

Otherwise the paper is acceptable for publication, and if you will send the original drawings and a reviewed title and running title, I will be happy to forward it to the publishers.

Very truly yours,

Peter Elias

Peter Elias
Editor

PE:nm

December 13, 1960

Dr. Peter Elias
Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Dr. Elias:

Thank you for your letter of acceptance of our paper for Information & Control. I understand the reviewer's comments, and I agree that it would be better to change the title. The new title and running title should read:

TITLE: A Study of the Statistics of Letters in English Words
RUNNING TITLE: Statistics of Letters in English Words

All of the original drawings are enclosed with this letter.

Could you give me an estimate of when this paper will be published? I would like to use it as a reference for some related studies that we are currently working on. Thank you.

Sincerely,

Charles P. Bourne
Research Engineer

CPB/scj
Enc.

CORNELL AERONAUTICAL LABORATORY, INC.
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6 July 1961

Mr. Charles Bourne
Research Engineer
Stanford Research Institute
Menlo Park, California

Dear Mr. Bourne:

Thank you very much for your note of June 27th and the reprint. I am pleased to have your list of subject words, which I am returning after having a copy made.

I will look forward to meeting you when I reach Stanford.

Sincerely,

Edith Crowell Trager
dek

Edith Crowell Trager, Ph.D.

ECT/dek

Encl.

1960-61

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A. B. Novikoff, G. H. Ball, C. P. Bourne

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AUTHOR A. E. Brain, A.Macovski, C. O. Childress,
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- NETWORK
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- PHOTOGRAPHS
- SIMULATION

try multi-aperture [illegible]

BOURNE, CHARLES P. (see also Project 3101)

0	1	2	3	4	5	6	7	8	9
4900	5121			5834	6875	7036		6858	7029
8140	5221			6294					7199
	5961			7424					7852
	7021								9219

S. R. I.

DATA PROCESSING, DATA RECORDING, DATA REDUCTION, DATA HANDLING

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260	301	262	253	284	2975	366	287	308	189
510	361	2252	283	2564	3155	2756	- 477	438	519
1240	2511	3342	343	2714	3225	3506	3727	3198	2719
2510	3021	4382	493	2734 -	3285	3666		3318	3519
2730	3161	4452	1073	3074	4445	3706		4228	3839
3020	3831	5002	2023	3164	4925	4246		4368	5249
4370	4371	5122	2693	3344	5125			5288	6129
5460	4431	[illegible]	3343	4524	5695			5478	
5590	5121	6302	4373	5024	5865			5808	
6540	5221	6322	5123	5124	5985				
	5931		[illegible]	5834	6305				
	6401		5533	5954	6495				
			6323	6224					
				(6294)					

S.R.I.

CORE

0	1	2	3	4	5	6	7	8	9
3850		4822	5673	1224	575	746	147	148	2459
		6202		(6294)	1405		1407	4848	4579
					2665				
					2685				
					4815				
					6395				

S.R.I.

· ELECTRIC, ELECTRICAL, ELECTRICITY

0	1	2 242	3	4	5	6	7	8	9
430	11	302	153	284	65	356	357	328	619
860	391	432	383	434	425	426	1257	558	859
2050	861	492	473	594	435	776	2357	2478	1369
2400	1361	862	863	3614	465	1656	2657	2628	1779
2920	2201	1612	1613	4344	1635	2186	3187	3058	1969
2970	3161	1812	2923	4764	2245	2816	3437	3238	1989
3150	3641	1932	3143	4924	2755	3016	3627	3938	2179
3440	3991	2392	3283	5934		3326	3847	4888	2239
3710	4081	2842	3573	6094		4746		4958	2599
3830	5001	2942	5053	6294		4786			2689
4540	5021	3142	5113	6344		5226			2849
5000	5431	3822		6694		5416			3099
5380	6171	4292				6706			4059
5660	6531	5632							4999
5910	6581	6202							5549
									5909

S. R. I.

INTEGRAL GEOMETRY

0	1	2	3	4	5	6	7	8	9
				6294					

S. R. I.

MAGNETIC, MAGNETIZATION

0	1	2	3	4	5	6	7	8	9
1000	391	102	13	254	255	26	287	168	189
1310	1001	432	153	1224	575	256	1307	1818	599
4870	1221	1002	423	1304	585	746	1347	2448	1309
5240	1311	1312	1073	1654	1055	1056	1777	3758	1369
5310	2401	1652	2353	1864	1305	2026	1917	4038	2719
5610	2581	2492	2493	2284	1655	2156	2277	4208	2759
	4251	2942	2703	2734	1865	5166	2847	4848	2859
	4291	2972	2783	3204	2025	5286	4587	5018	4179
	4531	3392	3243	4004	2685	5806	5167	5928	4579
	4911	3832	4303	4391	5165	6556	6457	6198	
	5581	4842	5673	4584	5285			6458	
	5611	5702	6383	6294	5485			6598	
		6202	6533		5625				
		6312			6125				
		6482			6555				

S.R.I.

MULTI-APERTURE, MULTI-APERTURE-DEVICES

0	1	2	3	4	5	6	7	8	9
	4251	2492		5294	4605	5806	6017	4848	4579
	4891	2972		6294	6555	6556		5018	
	5611	6202							
		6362							

S.R.I.

NETWORK

0	1	2	3	4	5	6	7	8	9
	4721	82	4773	84	6385	436	4577	5658	2589
	5081	4772	5853	1634		6036	4587	5908	2799
	6201	6202	6223	4254		6736	6057		6129
	6501	6492	6493	5064					
				6164					
				6294					
S. R. I.									

NEUTRAL

0	1	2	3	4	5	6	7	8	9
	6201	6202		6294					
S. R. I.									

PHOTOGRAPH, PHOTOGRAPHY, PHOTOGRAPHIC

0	1	2	3	4	5	6	7	8	9
2680	4741	2452	1493	2734	125	5306	1327	368	239
5090	5551	3102	2803	4584	205	5326	2347	648	369
5930	6201	4832	4073	6294	1895		4307	978	5929
		6042		6624	4625			1328	5949
					5215			1348	6219
								3128	
								6038	
								6638	

S.R.I.

PATTERN RECOGNITION

0	1	2	3	4	5	6	7	8	9
				6294					

S.R.I.

SIMULATOR, SIMULATION

0	1	2	3	4	5	6	7	8	9
4370	4371	3002	2683	134	2585	5596	4577	4368	1829
	6201	5082	3243	2584	2915	6616	4627		5009
		5442	5643	4904	5635		5257		6069
		6202		4954	6635				
				5614					
				6294					

S.R.I.

DETACHMENT NO. 1
AERONAUTICAL CHART AND INFORMATION CENTER
~~AIR PHOTOGRAPHIC AND CHARTING SERVICE (MATS)~~
UNITED STATES AIR FORCE
WASHINGTON 25, D. C.

REPLY TO
ATTN OF: ACRPL-32 (60F102)

SUBJECT: Request for Photography - 16 Jun 60

JUL 8 - 1960

TO: Mr. Charles P. Bourne
Research Engineer
Computer Techniques Laboratory
Stanford Research Institute
Menlo Park, Calif

1. The Standard Indexing System is used for indexing the film coming into this library. This system is used for the aerial cartographic and mapping photography. Only a small percentage of this film is represented by prints in our library. The prints maintained for reference are selected by an established requirements criteria. These are filed by an arbitrary code number in units of flight lines or missions.

2. We also maintain a subjective print file which is arranged by countries, degree squares, and place names. Various subjects such as you mentioned may be found in this collection.

3. We do not have sample photographs available. Each individual order must be reproduced from the film.

4. There is attached for your information an Index to Aerial & Ground Photographic Illustrations of Geological & Topographic Features Throughout the World. This collection is the exception to the rule of our filing system.

Robert M. Caserta

ROBERT M. CASERTA
Lt. Colonel, USAF
Chief, Photographic Records and Services Division

1 Atch
Index

INDEX

to

AERIAL & GROUND PHOTOGRAPHIC ILLUSTRATIONS

of

GEOLOGICAL & TOPOGRAPHIC

FEATURES

THROUGHOUT THE WORLD

PHOTOGRAPHIC RECORDS AND SERVICES DIVISION

OFFICE OF RESEARCH AND LIAISON

DETACHMENT NO. 1

AERONAUTICAL CHART AND INFORMATION CENTER

WASHINGTON 25, D. C.

REPRINTED - 7 March 1955

DETACHMENT Nr. 1
AERONAUTICAL CHART AND INFORMATION CENTER (MATS)
PHOTOGRAPHIC RECORDS AND SERVICES DIVISION
UNITED STATES AIR FORCE
WASHINGTON 25, D. C.

The Photographic Records and Services Division maintains the still Photographic Records of the USAF. It operates the Central Print and Index Library containing aerial photographic coverage at the Midway Building. It also operates the Pictorial Record Library located in the Pentagon Building.

Copies of unclassified photography are made available to the Public for a nominal charge to cover the cost of service and production. Since military requirements are given priority, requests will be filled as research and reproduction capabilities permit. For aerial photography the requester should define the special area of interest by means of a detailed geographic description or sketch. The subject or description of subject should be defined for pictorial or historical photography.

U. S. Air Force aerial photography will not be furnished in areas of the United States, its territories and possessions when compatible coverage is held by any commercial organization or Federal Agency. The Map Information Office, Geological Survey, U. S. Department of the Interior, Washington 25, D. C. should be contacted for specific data for coverage held by other agencies.

INSTRUCTIONS FOR PURCHASE OF PRINTS FROM DEPARTMENT OF THE AIR FORCE NEGATIVES

1. The requester can only obtain unclassified photography. Release of aerial photography of foreign countries is subject to agreement with the country concerned. All such requests must be authorized by the country concerned prior to release of information or photography. Therefore, application for photographic coverage should first be made to the Embassy of the country concerned as many countries now have their own aerial photography and can furnish information on availability.

2. Payment for Air Force Photography must be made by Postal Money Order or a Certified Check made payable to the Treasurer of the United States and must accompany the print order. Monies in excess of one dollar ($1.00) will be refunded for any part of an order not filled. No refund will be made for less than $1.00. Since prints are not stocked but are custom processed for each order, they cannot be returned for credit or refund.

3. Print enlargements or reductions are not furnished. Prints are produced at the same size of the negative (contact print). Prints of selected parts of negatives are not available for purchase.

4. No more than three (3) prints of any single negative may be sold to an individual. If more than three (3) prints are desired, it is recommended that a single glossy print be obtained, from which any commercial photographer can obtain a copy negative, and the desired number of prints made. This procedure can also be followed to obtain enlargements or reductions.

5. Prints are sold only with the distinct understanding that the purchaser shall not use them to show, by implication or otherwise, that the Department of the Air Forces indorses any product or project, nor does the furnishing of documentary type prints waive the privacy rights of individuals shown in official photographs. No exclusive rights to any official photographs may be claimed by any organization or individual.

6. Shipment by parcel post up to four (4) pounds is prepaid. Orders shipped by express, air mail, special delivery, or exceeding four (4) pounds must be paid by the purchaser. Such shipments will be forwarded by express collect.

7. The following price list is to be used when ordering prints from U.S.A.F. photography.

a. Pictorial and Documentary Photography (includes prints of U.S.A.F. aircraft, guided missiles, ground equipment, personnel, and historical photography of U.S.A.F. installations, record-establishing flights or projects. etc.)

(1) Photography is only available in print size indicated.

(2) Color photography can only be furnished when available.

(3) Glossy prints will normally be furnished unless otherwise specified. (Add $0.05 on to the price of a print for a double weight, matte finish print).

Black & White	8" x 10"	$0.55
Color Print (Printon)	8" x 10"	4.00
Color Transparency	4" x 5"	5.00
Color Transparency	8" x 10"	10.00
Ektacolor Negative	4" x 5"	5.00
Ektacolor Negative	8" x 10"	10.00

Ektacolor negatives may be used for ektacolor paper printing or for dye transfer processing.

(4) Photostat copies of records (8½" x 10") pertaining to documentary or historical events - $0.20 each

b. Aerial Photography (includes verticals and obliques of ground areas of subjects.

(1) Print size is determined by the size of the original negative and, as such, the purchaser cannot exercise a choice.

(2) All photography available for sale is black and white.

(3) Glossy prints will be furnished unless otherwise specified. No additional charge is made for double weight, semi-matte finish.

SIZE	NO. OF SEPARATE PHOTOGRAPHS	PRICE (each)
5" x 7", 7" x 9"	1 to 100	$0.70
9" x 9"	101 to 1,000	0.55
"	over 1,000	0.50
9" x 18"	1 to 100	1.40
"	101 to 1,000	1.10
"	over 1,000	1.00

c. Mosaics or Photographic Indexes

(1) Mosaics or photographic indexes are not prepared for all areas of U. S. Air Force photographic coverage. Each area of interest will be reviewed and the purchaser advised accordingly.

(2) Mosaics and indexes vary in size, but are generally 20" x 24".

(3) The price per mosaic or index print is $1.20.

d. Aerial Photographic Information Material (including individual plot maps, coverage diagrams, and composite plots, etc.) when available, will be charged for according to the labor and time involved in production. Hand drawn plots and sketches will be charged for at the rate of $2.00 each or per hour of labor.

8. Prices listed above are subject to change without notification.

AFRICA

Item No.	Subject	Location	No. Photos Available	Type	Negative Numbers
1	Basin, Small Sharp	N13°45' E12°00'	2	V**	1803.632 1803.633
2	Cap Rocks	N10°10' W12°45'	2	V**	1803.634 1803.635
3	Craters & Lava Flows	N15°20' E26°20'	4	O*	1803.636 thru 1803.639
			4	V**	1803.640 thru 1803.643
4	Dike	N15°40' W11°00'	3	V**	1803.644 thru 1803.646
5	Dike	N20°35' E12°20'	1	O	1803.647
6	Domes	N32°25' W04°55'	3	O	1803.648 thru 1803.650
7	Dome, Planed-Off & Intermittent Drainage	N21°15' W11°30'	3	O*	1803.651 thru 1803.653
8	Dome (Eroded), Basin, Playa, Eroded Beds of Anticlinal Folds		3	V**	1803.654 thru 1803.656
9	Drainage, Dendritic	N14°10' W23°30'	2	O**	1803.657 1803.658
10	Drainage, Near Circular	N11°30' W10°35'	2	O*	1803.659 1803.660

AFRICA (Cont'd)

11	Dunes	N29°15' W01°15'	2	V**	1803.661-662 1803.663-664
12	Dunes	N29°23'15" W03°15'32"	2	0*	1803.665 thru 1803.666
13	Dunes, Patch-Like Pattern	N13°45' E29°50'	2	0*	1803.668 1803.669
13Aa b	Dunes, Long Dune Ridges of highly complex structure on sand-covered plain. (Raoui Dunes)	Algeria N28°45' W01°35'	2	V**	1807.960 thru 1807.961
13Ac d e f	Dunes, Long Dune Ridges of highly complex structure on sand-covered plain. (Raoui Dunes)	"	4	0*	1807.962 thru 1807.965
13Ag h i	Dunes, Long Dune Ridges of highly complex structure on sand-covered plain. (Sebka el Melah)	Algeria N29°10' W01°20'	3	V**	1807.966 thru 1807.968
13Aj	" " "	"	1	0	1807.969
13Ak l m n o p	Dunes - Great mass of longitudinal sand dunes adjoining desert plateau. Various types of dunes are shown. (Makteir Sand Dunes)	Mauretania N21°40' W11°10'	6	V**	1807.970 thru 1807.975

13Ba b c	Erosion of Folded Beds standing on edge, resistant beds remaining. Old Drainage	N32°27' W03°25'	3	V**	1805.034 thru 1805.036
14	Falls & Gorge. River Damming up Against Low Dripping Resistant Stratum	N14°20' W11°20'	2	V**	1803.670 1803.671
15	Folds	N31°35' W02°10'	1	0	1803.672
16	Folds, Plunging	N28°20' W09°35'	5	0*	1803.673 thru 1803.677
16Aa b c d e	Folds, Plunging	N28°24' W09°38'	5	0**	1805.043 thru 1805.047
17	Folds, Plunging	N29°55' W02°05'	2	0*	1803.678 1803.679
18	Folds, Plunging	N29°25' W08°15'	2	V**	1803.680 1803.681
19	Folds, Plunging	N30°40' W06°05'	1	0	1803.682
20	Folds, Plunging	N31°35' W07°35'	2	V**	1803.683 1803.684
21	Folds, Plunging	N31°15' W09°10'	1	0	1803.685
22	Folds, Rock	N24°35' E03°45'	7	V**	1803.686 thru 1803.692
23	Folded Rock	N25°25' E01°35'	7	0*	1803.693 thru 1303.699

AFRICA (Cont'd)

24	Folded Structure	N25°35' E02°45'	2	V**	1803.700 1803.701
25	Grand Canyon	N13°15' E38°10'	5	O*	1803.702 thru 1803.706
26	Hogback Ridges	N29°35' W07°35'	8	V**	1803.707 thru 1803.714
27	Hogback Ridges	N32°30' W03°35'	1	O	1803.715
28	Ignious Rock, High Isolated Remnants of, Forming Small, Steep-Sided Butte	N15°00' W02°20'	2	V**	1803.716 1803.717
29	Jointing, Columnar	N25°40' E10°15'	3	V**	1803.718 thru 1803.720
30	Lava, New Flows	N17°40' E08°45'	2	V**	1803.721 1803.722
30Aa b c d e f	Mountains - Steep-dipping and folded beds. Youthful erosion	N31°47' W05°56' to N31°45' W06°08'	6	V**	1805.037 thru 1805.042
31	Offset Faults	N23°35' E32°05'	3	V**	1803.723 thru 1803.725
32	Offset Faults	N24°30' E31°05'	2	V**	1803.726 1803.727
33	Outcropping Rock Strata	N26°45' E00°50'	3	V**	1803.728 thru 1803.730

AFRICA (Cont'd)

34	Piracy, Stream	N24°50' E32°25'	1	0	1803.731
35	Plateau-Cap Rock	N09°35' W12°35'	1	0	1803.732
36	Plateau & Scarp	N13°15' E38°30'	2	0*	1803.733 1803.734
37	Playa and Coalescing Fans	N14°15' E40°05'	2	0	1803.735 1803.736
38	Playa, Old Drainage	N30°30' W11°25'	3	0	1803.737 thru 1803.739
39	Ridges, low, & Stream Pattern	N27°45' W12°05'	1	0	1803.740
40	Sculpture (Stream) of Horizontal Sedmentary Beds	N31°33' E25°11'	2	0	1803.741 1803.742
41	Sinkholes in Plateau Having Underground Drainage	N33°13'33" W01°38'06"	2	V**	1803.743 1803.744
42	Volcanic Crater & Cone Containing Deriba Lake. Extensive Erosion By Streams.	N13°00' W24°10'	3	0*	1803.745 thru 1803.747
43	Volcanic Crater, Extinct (300 ft. deep, 1 mile in diameter)	N15°35' W28°41'	1	0	1803.748
44	Wadi, Dry	N27°00' E32°00'	1	0	1803.749
45	Waterfalls, Cascading	N10°05' W12°10'	2	V**	1803.750 1803.751

ALASKA

45Aa b	Braids in Tanana River		2	V**	1808.621 thru 1808.622
46	Cape Puget	N59°59' W148°26'	1	V	1803.752
47	Chisek Island	N60°08' W152°36'	1	0	1803.753

ALASKA (Cont'd)

48	Cinder Cone, extinct, Surrounded by its own Erosion Materials	N59°15' W153°30'	1	0	1803.754
49	Drainage, Connecting	N64°30' W160°30'	2	0	1803.755 1803.756
50	Drainage, Connecting	N60°55' W149°10'	4	0*	1803.757 thru 1803.760
51	Drainage, Connecting	N65°30' W146°30'	1	0	1803.761
51Aa	Dunes - Barchane Dunes	Northway	2	V**	1808.609 thru 1808.610
52	Glacier, Columbia	N61°01' W147°02'	2	0	1803.762 1803.763
53	Glacier, Davidson, on Lynn Canal between Skagway and Juneau		1	0	1803.764
54	Glacier, Ellsworth	N60°06' W149°01'	1	0	1803.765
54Aa b	Glacier, Eldridge Glacier	N63°05' W150°05'	2	0**	1805.048 thru 1805.049
55	Glacier, Excelsior	N80°01' W148°45'	2	0	1803.766 1803.767
55Aa b c	Glacier - Kahiltna. (Tri-metrogon - vertical and two obliques showing entire glacier and smaller feeder glaciers.)	N61°45' W151°20'	1 2	V 0	1805.051 1805.050 1805.056
55Ad	The above photos pieced together in form of a mosaic, showing entire glacier from origin to terminus	"	1	Compo-site	1807.976

ALASK (Cont'd)

56	Glacier, Malaspina	N59°57' W140°33'	2	O	1803.768 1803.769
57	Glacier, Tiger, Icy Bay	N59°55' W141°35'	2	O	1803.770 1803.771
58	Glacier, Muldrow	N63°15' W151°	2	O	1803.772 1803.773
			10	V**	1803.774 thru 1803.783
58Aa	Glacier - Ruth Glacier (Tokichitna in background)	N64°45' W150°50'	2	O*	1805.055 1805.052
59	Glacier, Terminus of	N61°25' W145°10'	3	V**	1803.784 thru 1803.786
59Aa	Glacier - Tokichitna Glacier	N64°45' W150°50'	2	O*	1805.053 thru 1805.054
60	Glacier Showing Ice Cave at Bottom from which is emitted a Torrential Stream of filt-Laden Water		1	O	1803.787
61	Glacier - Main Glacier and Smaller Feeder Glaciers	N62°45' W151°20'	1	O	1803.788
61Aa	Ice - Icebergs		1	G	1805.098
b	Arctic Ice showing cracks and Pressure Ridges		1	O	1808.627
c	Arctic Ice showing cracks and Pressure Ridges		1	V	1808.628
d	" " "		1	O	1808.629
62	Kettle Holes, Depression-Like	N60°37' W150°28'	1	O	1803.789
63	Kettle Holes, Malaspina Glacier	N59°45' W140°50'	3	V**	1803.790 thru 1803.792

ALASKA (Cont'd)

63Aa	Glaciated Valley	Alaskan Range	1	0	1808.624
64	Lakes, Flat Shore Line, Low Ridges	N59°40' W155°	5	0*	1803.793 thru 1803.797
65	Lakes - Scattered Lakes & Ridges	N62°20' W163°45'	1	0	1803.798
66	Lakes - Scattered Lakes & Connecting Drainage	N61°20' W163°35'	3	0	1803.799 1803.802 1803.800
67	Lakes - Scattered Lakes and Connecting Drainage	N61°05' W164°00'	1	0	1803.801
67Aa b	Lava Flow over Lava Lake area. Small cinder cone visible.	Seward Peninsula	2	V**	1808.615 thru 1808.616
68	Meanders & Cut-Offs	N65°55' W156°30'	2	0*	1803.803 1803.804
69	Meanders - Coalescing Meanders	N68°00' W150°50'	2	V**	1803.805 1803.806
70	Moraine - Medial Moraine	N59°55' W139°	1	0	1803.807
70Aa	Monadnoc		1	0	1808.623
71	Mountains - High Mountains, Deep Valley, Killik River	N68°25' W154°15'	1	0	1803.808
72	Mt. Deborrah and Susitina Glacier	N61°28' W150°44'	2	0	1803.809 1803.810
73	Mt. McKinley	N63°04' W151°05'	3	0	1803.811 thru 1803.813
73Aa b	Mt. McKinley	N63°10' W151°00'	2	0	1805.099 1807.977
73Ba	Oxbows		1	V	1808.625

ALASKA (Cont'd)

74	Outwash - Glacial Outwash and "U" Trough	N67°05' W156°40'	2	O*	1803.814 1803.815
74Aa	Polygons - Immature				
b	Polygons - note formation of streams	North of Fairbanks	2	V**	1808.611 thru 1808.612
c	Soil Polygons	"	1	O	1808.613
d	Polygon (cross section) View of ice wedge in polygon trench exposed by thawing. Also cross-section of niggerhead plant.		1	G	1808.614
e	Ice Polygons and Elliptical Lakes		2	V**	1808.617 thru 1808.618
75	River Junction (Yukon and Tanana Rivers)	N65°20' W152°15'	1	O	1803.816
76	Snow - Unstable Snow Masses above Ice Fields	N59°55' W139°	1	O	1803.817
77	Syncline	N69°05' W160°37'	3	V**	1803.818 thru 1803.820
			1	O	1803.821
78	Tundra and Icepack	(Wainwright)	1	O	1803.822
78Aa b	"Tailings" from gold mines. Pipelines are seen on hillsides.		2	V**	1808.619 thru 1808.620
78Ac	Valley of Alpine Glacier (with annotations)		1	O	1808.626
79	Volcano, Iliamna	N60°01' W153°05'	3	O	1803.823 thru 1803.825

ALEUTIANS

80	Herbert Island		1	0	1803.826
81	Kaganul Island		1	0	1803.827
82	Onnekotan Island		4	0	1803.828 thru 1803.831
83	Terrain - Adak Island	N51°38' W176°42'	2	0*	1803.832 1803.833
84	Terrain - Kiska Island	N52°40' W177°25'	2	V**	1803.834 1803.835
85	Terrain, Coast, Umnak Island	N52°53' W169°03'	1	0	1803.836

ARABIA

85Aa	Dendritic Drainage Patterns	N15°25' E49°58' (near Quaiti Highlands)	1	0	1805.100
86	Dunes -Sand Dune Patterns after Variable Winds on a Peneplain Surface in an Arid Climate	N18°45' E52°50	2	0*	1803.837 1803.838
87	Dunes - Active Sand Dunes on an old Peneplain Surface	N21°E43°05'	2	V**	1803.839 1803.840
88	Mountains - Buried Mountains (All except Peaks & Ridges) in their own Debris.	N22°50' E44°35'	3	0*	1803.841 thru 1803.843
			3	V**	1803.848 thru 1803.850
89	Mountains - Old Mountains Nearly Buried in their own Debris. Structural Lines show Fault and Joint Plains and Dykes in Old Rock Formations Chiefly Igneous		4	0*	1803.844 thru 1803.847

16 June 1960

Photographic Records and Services Division
Office of Research and Liaison
Detachment No. 1
Aeronautical Chart and Information Center
Washington 25, D. C.

Gentlemen:

I am currently working on a Signal Corps project, Contract DA-36-039-SC-78343, concerned primarily with the research and development of graphical processing techniques. We are studying such things as techniques for automatic pattern recognition of aerial photographs, as well as methods for the storage and retrieval of this information.

My reason for writing this letter is to find out whether your organization uses any scheme of indexing aerial photographs by other than its geographical coordinates. I would be interested in knowing whether or not you have a system to index the photos by categories such as; geography and topography (shore-lines, water bodies, swamp, etc.), general appearance (predominantly urban, rural, or virgin area), and man-made content (airfields, bridges, storage facilities, roads, etc.). That is, do you have an indexing scheme which permits you to locate photos in response to requests, for example, of pictures of all Asian airfields or all Chinese railroads? I would appreciate any information or references which you could give me on this matter. My only reference is your report, "Standard Indexing System for Aerial and Radar Photography", ACIC Tech. Report No. 65, January 1955.

Would it also be possible to obtain a representative sample of 9 by 9 prints from your organization for use as reference and study material? Is there some regular channel or procedure that we could use for obtaining sample prints in the future?

If you need any further information, please let me know. Thank you.

Sincerely,

Charles P. Bourne
Research Engineer
Computer Techniques Laboratory

CPB:js

90	Mountains - Old Mountains of Two Different Rocks Partially Buried in own Debris	N21°50' E43°55'	2	V**	1803.851 1803.852
90Aa b c d e f	Intermediate and advanced stages of Erosion cyple in a peneplain (arid climate)	N16°40' E49°35'	6	V**	1805.057 thru 1805.062
91	Peneplain - Shallow Dissection of a Peneplain in an Arid Climate too dry to Support Vegetation. Some farming in Narrow Valley floors.	N25°10' E46°20'	2	O*	1803.853 1803.854
92	Peneplain - Upturned Edges of Sedimentary Formation Planed off by Erosion to a Sand-Covered Peneplain	N22°35' E44°30'	2	O*	1803.855 1803.856
93	Peneplain - Upturned Edges of Sedimentary Formations Exposed by Peneplanation in an Arid Climate	N21°30' E43°30'	3	O*	1803.857 thru 1803.859
94	Peneplain - Two Stages in Shallow Dissection of a Peneplain in Arid Climate. Effect of Secondary Base Level is shown in Active Advance of Erosional Scarps. Drainage Capture in Progress.	N25°45' E46°00'	2 2	O* V**	1803.860 1803.861 1803.862 1803.863
95	Peneplain - Drainage Pattern in Dissection of a Peneplain without Effect of Vegetation	N16°10 E48°50'	3	V**	1803.864 thru 1803.866
96	Peneplain - Advanced Stage of Dissection and Peneplanation in an Arid Climate.	N22°35' E44°30'	2	O*	1803.867 1803.868

ARABIA (Cont'd)

97	Peneplain - Advanced Dissection of a Peneplain. Level of the New Peneplain being Established in Broad Valley Flows.	N15°50' E48°30'	3	O*	1803.869 thru 1803.871
98	Peneplain - Vast Peneplain Dissected by a Complex of Drainage Channels	N16°15' E49°10'	1	O	1803.872
99	Peneplain - Advanced Stage of Peneplanation in an Arid Climate.	N17°15' E50°30'	1	O	1803.873
100	Peneplain - Valley Floor in Advanced Stages of Dissection of an Old Peneplain.	N15°50' E48°30'	2	V**	1803.874 1803.875
			3	V**	1803.876 thru 1803.878
101	Peneplain - Advanced Stages in Dissection of a Peneplain and Beginnings of a New Peneplain with Reference to a New Base Level.	N17°40' E51°10'	4	V**	1803.879 thru 1803.882
102	Planation - Advanced Stage of Peneplanation.	N22°10' E44°05'	3	V**	1803.883 thru 1803.885
103	Planation - Advanced Stages in Planation of Old Mountain in an Arid Climate.	N23°40' E45°00'	3	O*	1803.886 thru 1803.888
104	Scarps - Detail of Moving Erosion Scarps Advancing up Drainage	N24°45' E46°00'	2	V**	1803.889 1803.890
105	Submergence - Shoreline of Submergence.	N12°50' E45°02'	1	O	1803.891

AUSTRALIA

106	Bluffs	S15°15' E129°40'	1	O	1803.892
107	Bluffs - Very Sharp Bluff area and folds	S16°10' E129°40'	2	O*	1803.893 1803.894
108	Bluffs - Very sharp Bluff area and folds	S16°05' E130°25'	3	V**	1803.895 thru 1803.897
109	Caves, Buchan Caves	S38°00' E147°00'	1	G	1803.898
110	Cliffs - Undercut Sea Cliffs	S12°15' E136°05'	1	O	1803.899
111	Cliffs - Coastline	S38°36' E142°54'	1	G	1803.901
112	Coast of South Adelaide	S37°07' E140°20'	1	G	1803.900
113	Coastline	S15°10' E141°35'	1	O	1803.902
114	Dike with Stream Cutting through	S20°40' E118°45'	2	V**	1803.903 1803.904
115	Drywash - Flat	S15°10' E142°15'	5	O*	1803.905 thru 1803.909
116	Escarpment	S15°20' E130°10'	1	O	1803.910
116Aa b	Falls, Karanda Falls	N16°30' E145°15'	2	O*	1805.063 thru 1805.064
117	Fault Lines	S21°15' E116°05'	2	V**	1803.911 1803.912
			2	O*	1803.913 1803.914
118	Folds - Anticlinal Fold Eroded with Cross-Flowing Stream.	S14°25' E132°25'	5	V**	1803.915 thru 1803.919
119	Folds - Excellent Folding	S16°20' E123°58'	2	O*	1803.920 1803.921

AUSTRALIA (cont'd)

120	Folds - Fold Exposed at Surface	S21°05' E117°55'	2	O*	1803.922 1803.923
			2	V**	1803.924 1803.925
121	Islands - Bay of Islands	S38°36' E142°54'	1	G	1803.926
122	Jointing - Cross-Jointing	S17°55' E138°15'	2	V**	1803.927 1803.928
123	Jointing - Cross-Jointing	S17°35' E138°15'	2	O*	1803.929 1803.930
124	Mesa	S13°10' E131°00'	1	O	1803.931
125	Syncline - Pitching Syncline	S14°20' E127°35'	1	O	1803.932
126	Waterfall - Waterfall in Intermittent Stream Bed.		2	V**	1803.933 1803.934

CANADA

127	Braided Stream, High Ridges	N56°05' W130°30'	2	V**	1803.935 1803.936
127 Aa	Eroded Anticline	N78°25' W102°00'	1	O	1808.632
b	Typical Fiord coastline of northern islands		1	O	1808.630
128	Glacier and Snowfield	N58°50' W134°25'	1	O	1803.937
129	Lake - Cirque Lake	N57°00' W131°40'	1	O	1803.938
130	Lake - Possible Dry Lake, Flat Wooded Country	N54°10' W116°40'	3	V**	1803.939 thru 1803.941
131	Moraines - Multiple Medial, Lateral & Terminal Moraines and Talus Slopes.	N56°W129°30'	1	O	1803.942

CANADA & CANADIAN ISLANDS

131Aa	Flood Plain - highly intricate meanders	Peace River N58°50' W111°45'	1 1	O V	1807.978 1808.631
b	Ice and Polygons	Banks Island	2	V**	1808.633 thru
c	Polygons				1808.634
d					

CHINA

132	Craters - Eroded Craters	N30°20' E117°15'	2	V**	1803.943 1803.944
133	Drainage thru Low Mountains	N29°15' E110°45'	4	O	1803.945 thru 1803.948
134	Drainage	N22°40' E111°45'	2	V**	1803.949 1803.950
135	Dunes - Lunar-Shaped Sand Dunes	N22°55' E116°05'	2	V**	1803.951 1803.952
135Aa	Erosion - accelerated stages of	Near Ching Ho River			1807.979 thru
b	erosion in recent times.	N34°55' E108°00'	3	V**	1807.981
c					
d		Near Chien-chun-chen			
e					
f					
g		N34°40' E108°05'	5	O**	1807.982 thru
h					1807.986
i	Junction of mountains with	Mts. so. of Wei Ho			
j	Loessial Plateau	River			1807.987 thru
		N34°00' E108°00'	2	V**	1807.988
k	" " " "	" "	2	O**	1807.989 thru
l					1807.990
m	" " " "	" "	1	O	1807.991
136	Syncline	N29°30' E110°30'	1	O	1803.953
136Aa	Columnar Jointing in a "plug" or outcrop	(St. Flour) N45°02 E03°06'	1	G	1805.065

FRENCH INDO-CHINA

137	Ganges River		4	0	1803.954 thru 1803.957
137Aa	Glacial terminals, ice floes, snowbergs				
b					
c					
d					
e					
f					
g					
h					
i					
j					
k					
l					
m					
n					
o					
p					
q		N78°50' W76°15'	17	V**	1805.067 thru 1805.083
r	Glacial split. Smaller feeder glacier	N77°28' W78°40'	1	0	1805.101

GREENLAND

s t	Tongues of ice-cap descending toward fjord. Lateral moraines suggest recent retreat.	N66°20' W52°45'	2	0**	1807.994 thru 1807.995

GREENLAND (Cont'd)

137Au	Tongues descending from ice-cap into U-shaped valley at head of fjord.	N66°10' W50°58'	1	0	1807.996
v	Plateau cut across steeply dipping strata with broad incised alluvial valley.	N67°10' W51°35'	1	0	1807.993
w	Weathering, mechanical	N60°10' W43°59'	1	G	1805.066

HAWAII, T. H.

138	Alia Point - Terrain	N19°51' W155°05'	1	0	1803.958
139	Coastline, Cliffs - Oahu	N21°18' W157°39'	1	0	1803.959
139Aa	Mauna Loa Crater	N19°30' W155°40'	1	0	1808.001
b	" " "	" "	1	V	1808.002
140	Terrain - Kahoolawe Is.	N20°31' W156°40'	1	0	1803.960
141	Terrain - Lanai Island	N20°48' W156°48'	1	0	1803.961
141Aa	Chain of Lava Jets.	N19°30' W155°40'			
b	Mokuaweoweo Crater, Mauna Loa volcano		2	0	1808.003 thru 1808.004
c d e f	Eruption and lava flows of Mauna Loa (Nov. 21, 1935)	" "	4	0	1807.997 thru 1807.999 and 1808.005
g	Lava flow within Mokuaweoweo Crater, Mauna Loa Volcano.	" "	1	0	1808.000

INDIA

h	Flood plains - broad plains traversed by many winding channels and abandoned sloughs. Densely cultivated.	N23°45' E89°55'	1	0	1808.006

		IRAN			
142	"Caspian Gates" - Spur of Badlands Defile	N35°13' E52°00'	1	O	1803.962
		ITALY			
142Aa b	Mt. Etna Volcano	N37°45' E15°00'	2	V**	1805.102 thru 1805.103
		JAPAN			
143	Coastline - Hokkaido	N33°50' E136°05'	5	V**	1803.963 thru 1803.967
144	Drainage - Dendritic (Hokkaido - China Peninsula)	N35°25' E140°10'	2	V**	1803.968 1803.969
145	Mountains	N33°45' E138°50'	6	V**	1803.970 thru 1803.975
146	Oxbows, Meandering River	N42°30' E140°50'	3	V**	1803.976 thru 1803.978
147	Volcano - Sakura - Jina	N31°35' E130°40'	3	V**	1803.979 thru 1803.981
148	Volcano - Numerous Simple-Cone volcanoes	N33°18' E126°15'	2	O*	1803.982 1803.983
149	Volcano - Numerous Simple-Cone Volcanoes	N33°46' E126°30'	2	V**	1803.984 1803.985
150	Volcano, Caldera, Crater Lake	Hokkaido	3	V**	1803.986 thru 1803.988
151	Volcano, Caldera, Crater Lake	Hokkaido	3	V**	1803.989 thru 1803.991
152	Volcano, Caldera, Crater Lake	Hokkaido	3	V**	1803.992 thru 1803.994

152Aa	Volcanic Crater appears thus in a tri-metrogon composite photo. Crater is water-filled with snowy peak rising in center. Both east and west coasts of island show at top and bottom of picture.	Onnekotan Island	1	Composite	1808.008
b	Volcano (Minami-Dake)	N31°40' E130°39'	1	O	1808.007
		NETHERLANDS EAST INDIES			
153	Coastline, Mouth of Golgal River	New Guinea	2	V**	1803.995 1803.996
154	Delta	S02°42' E136°09'	2	V**	1803.997 1803.998
155	Mountain, Kintamani (Bali Island)	S08° E115°	1	O	1803.999
156	River - Golgal River and Vicinity	New Guinea	2	O*	1804.000 1804.001
157	Volcano - Batoer Volcano (Bali Island)	S08 °16' E115 °10'	1	G	1804.002
		NEW ZEALAND			
158	Glacier - Franz Joseph (South Island)	S43 °25' E170 °11'	1	O	1804.003
159	Mitre Peak	S44 °35' E167 °48'	1	O	1804.004
		PALESTINE			
160	Rugged Terrain	N31 °30' E35 °30'	1	O	1804.005
160Aa	Dissected Edge of Mountain adjoining	Wadi Ithnelk Area			1808.009 thru
b	desert basin. Fans, dunes and dry	N30 °00' E35 °05'	3	V**	1808.011
c	washes.				
d	Maturely dissected arid				1808.012 thru
e	landscape.	N30 °00' E34 °57'	2	V**	1808.013

		PALESTINE (Cont'd)			
161	Wadi	N31°06' E35°34'	1	0	1804.006
		SOUTH AMERICA			
162	Beach - Old Beach Line, Sand, Lagoons	N31°05' W52°00'	1	0	1804.007
162Aa b	Angel Falls (Venezuela)	N05°58' W62°32'	2	0*	1805.084 thru 1805.085
163	Reef Island (Arenas Cays)	N22°07' W91°24'	2	0	1804.008 1804.009
163Aa	Mount Chimborazo (Ecuador)	S01°29' W78°45'	1	0	1807.992
b c d	Plateau - Large high plateau remnant, underlain by flat-lying rocks. (Auyantepui Mts.)	N05°34' W62°30'	3	0**	1808.017 thru 1808.019
164	Ridge - Overhanging Ridge	N11°W74°05'	2	0*	1804.010 1804.011
165	Volcan de Misti (Miati)	S16°23' W71°25'	2	0*	1804.012 1804.013
		SOUTHWEST PACIFIC			
165Aa b c d	Limestone Cave - Underground river. (Shangri-la, Baliem, New Guinea)	S03°55' E138°28'	4	0	1805.086 thru 1805.089
166	Chasms - Very Deep	S05°40' E144°10'	2	V**	1804.014 1804.015
166Aa	Atoll - Ailuk	Marshall Is.	1	Mosaic	1808.020
167	Cinder Cone - Smoking	S06°05' E155°10'	1	0	1804.016
168	Cinder Cone with Deep Crater	S05°25' E151°05'	2	0*	1804.017 1804.018

SOUTHWEST PACIFIC (Cont'd)

169	Crater Lake	S15°25' E167°55'	2	V**	1804.019 1804.020
170	Lava - New Lava Flow	S05°35' E150°25'	3	V**	1804.021 thru 1804.023
171	Lava - Recent Lava Flow thru Jungle	S04°55' E151°10'	2	V**	1804.024 1804.025
172	Mining (Dredge)	S07°30' E146°35'	1	0	1804.026
173	Terraces - Coral	Aguijan Island	3	0*	1804.027 thru 1804.029
			9	0	1804.030 thru 1804.038
174	Volcanic Rock - Waterfalls	Lanao, Mindanao, P. I.	1	0	1804.156
175	Volcanic Rock - Waterfalls (Stimson Falls)	N. E. Coast of Luzon, P. I.	1	0	1804.157
176	Volcano - Active	S16°10' E168°05'	1	0	1804.039
177	Volcano - Live Volcano & Craters	S06°25' E155°10'	2	V**	1804.040 1804.041
	Volcano - Live Volcano and Craters	S06°25' E155°10'	3	V**	1804.042 thru 1804.044

UNITED STATES

178	Basaltic Intrusion in Flat-Lying Beds - Dalles. (Mount Hood in Background)	Oregon	1	0	1804.134
179	Basaltic Intrusion in Flat-Lying Beds - Dalles	Oregon	4	0	1804.135 thru 1804.138

UNITED STATES (Cont'd)

180	Bays - Carolina "Bays"	Myrtle Beach, S. Carolina	2	V**	1804.045 1804.046
180Aa b c d e f	Carolina "Bays"	Myrtle Beach, So. Carolina	6	V**	1805.090 thru 1805.095
181	Crater - Meteor Crater (600' deep - 400' in diameter)	20 miles west of Winslow, Ariz.	4	O	1804.139 thru 1804.142
181Aa b c d e f	Dendritic Drainage Pattern Dendritic Drainage. Flat-lying stratified rocks maturely dissected. Contour outcrop pattern of different strata clearly shown.	Del Rio Vicinity, Texas N30° W101°30' New Mexico - Dark Canyon River Area. N32°15' W104°25'	3 3	V** V**	1805.104 thru 1805.106 1808.014 thru 1808.016
182	Dissection - Stream Dissection of Flat-Lying Beds of Plateau.	Deschutes River Oregon	1	O	1804.152
183	Erosion - Soil Erosion in Soft Formations.	Near Lumpkin Georgia	2	O	1804.144 1804.145
183Aa	Pemplain, dissected. Table tops, small glaciers, glacial lakes and talus slopes.	Bear Tooth Mts., Montana N47°40' W115°43'	1	O	1805.096
184	Lakes formed by Glacial Action and Underground Solution. (Nature's Freaks - "The Penguin", "The Horse's Head", "Profile of Smiling Satan". "The Ellipse".	Northern Michigan	1	V	1804.153

UNITED STATES (CONT'D)

185	Mountain - Granite Mountain Rounded by Exfoliation and Natural Weathering	Stone Mountain Georgia	1	O	1804.154
186	Mountain - Close-up of Stone Mountain Monument, Sculpture in Progress.	Stone Mountain, Georgia	1	O	1804.155
186A	Stream Evolution	Texas			
a b c d e f g		N29°33' W102°50' to N29°35' W102°50'	7	V**	1805.107 thru 1805.113
187	Volcanic Cone - Secondary Volcanic Cone in Crater (Wizard Island)	Crater Lake, Oregon	2	O	1804.146 1804.147
188	Volcanic Cone Lake With Secondary Cone	Crater Lake, Oregon	4	O	1804.148 thru 1804.151