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Reported are the performance characteristics of the Massachusetts Institute of Technology Technical Information Program (TIP) system based on a study involving three search strategies in retrieval of laser articles published in 1964. The TIP system provides access to (1) title, (2) author(s), (3) bibliographic references, and (4) literature citations of articles comprising a large part of the body of physics literature. The field of lasers was chosen for study because it is a relatively new field and would thus allow a complete view of the scope of its pertinent literature. Asburn's laser bibliography was used as a reference to which articles located in TIP were compared. There are 25 core journals in the field of physics which are stored by TIP. Programmed instructions are used to obtain a response from the system by (1) search, defining what literature is to be searched, (2) find, stating item to be found, and (3) output, describing requirements of computer output. Three different strategies were used to retrieve titles of the 1964 literature. Results of the project indicated that TIP was a reliable means of retrieval of laser articles within the TIP library. Similar research will continue in an effort to improve retrieval of scientific literature. (DH)

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RETRIEVAL OF THE 1964 LASER LITERATURE USING MIT's PROJECT TIP

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Articles on lasers published in 1964 were retrieved from the mechanized file of physics journals maintained by MIT's Project TIP. Three search strategies were used in this study and the results compared with the 1964 papers in Edward V. Ashburn's bibliography on lasers published in the Journal of the Optical Society of America. The performance characteristics of the TIP system are given in this report.

The Technical Information Program (TIP) at MIT, through the facilities of the MAC System,provides access to the title, author(s), bibliographic references and literature citations of articles published in a large volume of the journal literature of physics. By December 1965 the holdings of 25 physics journals, beginning with the first issues of 1963, were available on disc storage. AIP was anxious to encourage physicists to use the TIP system, and, through the cooperation of M.M. Kessler, director of TIP, and his staff, several studies were designed to explore the feasibility of employing TIP as a base for the retrieval and evaluation of the physics literature. It was also decided that AIP should record the purposes of its users, describe the search strategies employed to locate material in TIP, evaluate TIP performance, and recommend actions for TIP improvements. This report presents the results of the first AIP-sponsored project with TIP.

The field of lasers serves as an excellent area for a study of this nature, since the recency of the field allows for a complete view of the entire scope of the literature. Edward V. Ashburn edits a laser bibliography which is published periodically in the Journal of the Optical Society of America. Six parts of the bibliography have appeared to date:

Part I.	in Vol. 53, No. 5, p. 647 - 652
Part II.	in Vol. 54, No. 1, p. 135 - 142
Part III.	in Vol. 55, No. 6, p. 752 - 766
Part IV.	in Vol. 55, No. 8, p.1040 -1045
Part V.	in Vol. 56, No. 2, p. 263 - 267
Part VI.	in Vol. 57, No. 1, p. 119 - 148

Western Periodicals Company also published a machine-produced version of Ashburn's bibliography. Graph 1 shows the time distribution of laser papers as noted by Ashburn in this edition.

The TIP project undertook to compare ~~the~~ retrieval, by various search strategies, of this increasingly extensive literature. For the purpose of the TIP searches, it was decided to select from Ashburn's bibliography the papers which had been published in 1964 and to compare these with the number of 1964 papers which could be located in TIP. At the time of the search, the 1964 totals for laser materials included in Ashburn's bibliography were summarized as follows:

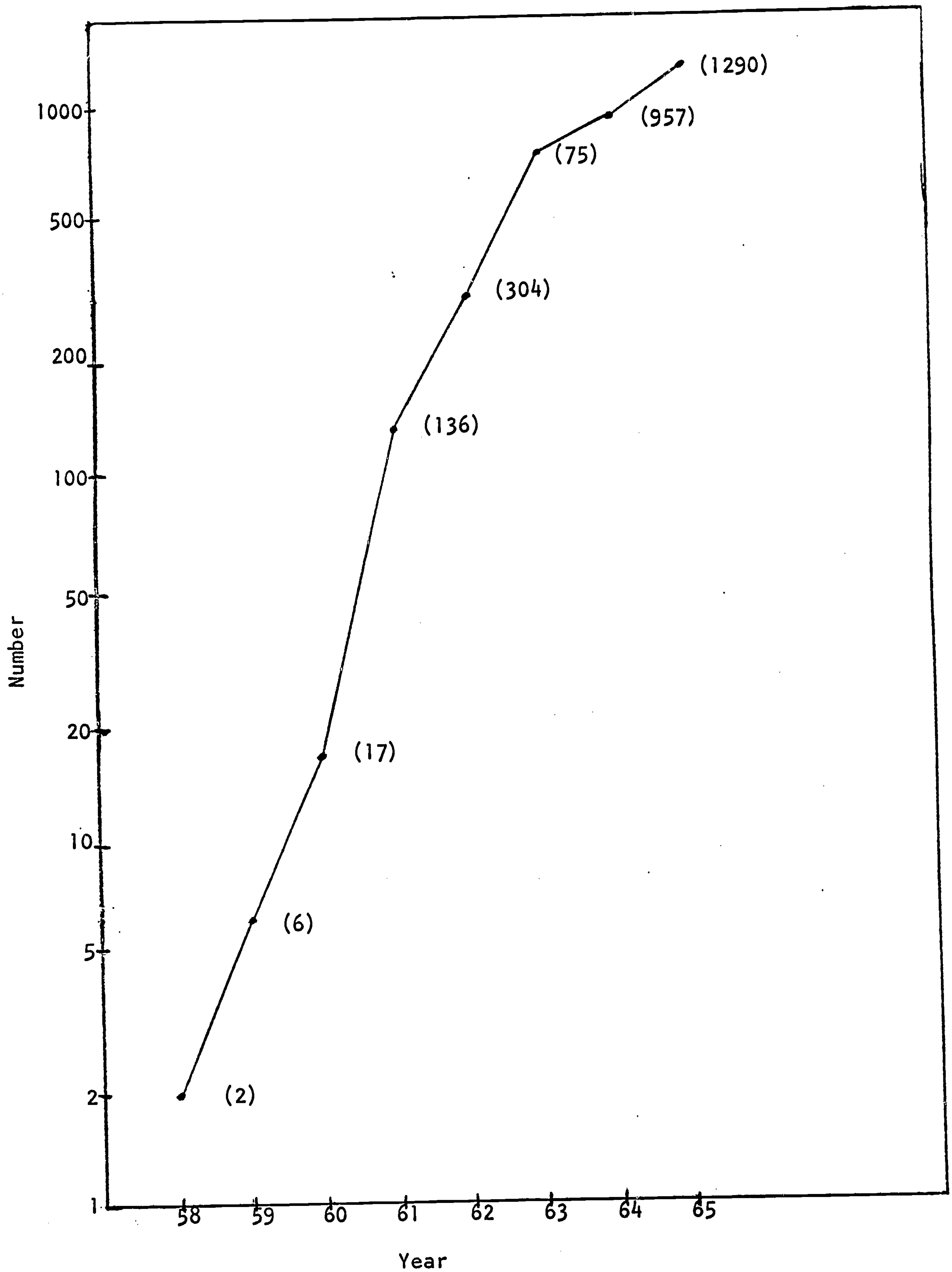
Articles in journals (See Appendix B)	768
Articles in books and other non-journal material	74
Total:	842

No. journals publishing laser articles in 1964: 134

It should be noted that this total corresponds only to those articles found up to the time of the TIP searches (April, 1966). The total in Graph I has been up-dated to include all additional materials found up to 1967. In fact, 47 additional articles can be accounted for as a result of the searches run by TIP. (See Appendix A)

Because the interest in lasers spans a wide range of fields, Ashburn scans the physics, electrical/electronic engineering, and medical literature for laser articles, as well as a number of journals devoted to science in general or miscellaneous specific fields (examples are

Graph 1



PUBLICATION PATTERN OF LASER PAPERS, 1958-1961

(Number of Papers Plotted Against Year of Publication)

Nature and J. Amer. Ceram. Soc.). The 25 journals stored in TIP comprise the core journals in the field of physics. Since the other types of materials are obviously out of TIP scope, the journals in Ashburn's list (Appendix B) were separated into several categories:

Table 1. Distribution of Articles in Laser Bibliography

	No. of Articles	No. of Journals
Journals in TIP	280	14
Physics journals not in TIP	224	58
Electrical/electronic engineering journals	166	31
Medical journals	29	17
Other journals	69	14
TOTAL:	768	134

The computer operates on the literature by means of programmed instructions or commands. To elicit a response from TIP, three such commands are used:

SEARCH -- defines what literature is to be searched
FIND -- states the items to be found
OUTPUT -- defines the nature and content of the computer output

A set of these commands which results in a list of papers matching the needs of the user constitutes a search strategy. Three search strategies were employed by Kessler in an attempt to retrieve the laser literature from the TIP store:

TIP Search 1

SEARCH -- the 1964 TIP library
FIND -- all titles containing one of the following words: laser, maser, Brillouin, stimulated emission, or coherence. (In a trial run of this search, Raman was also tested as a key word. This word generated a high recall of papers but a large percentage of these were judged to be irrelevant and the term was finally deleted from the search).
OUTPUT -- Print I.D. (journal, volume, page), author(s), and title of these papers.

The references which were cited by the relevant articles found in this search were saved as a separate file labeled file X. Before implementing Search 2, those cited references which had occurred two or more times were arranged by journal, volume and page in order of decreasing frequency.

TIP Search 2

SEARCH -- the 1964 TIP Library
FIND -- all papers that share common references with those in file X (cutting at a citation frequency of 5 in file X), less those that have laser, maser, Brillouin, stimulated emission, or coherence in the title.
OUTPUT -- print I.D. (journal, volume, page), author(s), and title of all relevant papers.

TIP Search 3

SEARCH -- the 1964 TIP library
FIND -- all papers that share common references with the remaining papers in file X (cutting at a citation frequency of 2 in file X), less those that have laser, maser, Brillouin, stimulated emission, or coherence in the title.
OUTPUT -- print I.D. (journal, volume, page), author(s), and title of all relevant papers.

The results of these searches are contained in Appendix A. It is readily seen that TIP was successful in the search for the 1964 laser literature in the TIP library. Ashburn's bibliograpny contained 280 articles from journals included in TIP. The TIP search located 323 articles, of which 64 were irrelevant. This gives a total of 259 relevant articles. Although Ashburn's bibliography had 68 papers that TIP failed to locate, TIP retrieved 47 relevant papers which were not listed by Ashburn.

Taking 342 as the total number of laser articles produced in 1964 (see footnote),* 212 or 62 per cent of these were found in common. Additional articles found by Ashburn but missed by TIP accounted for 20 per cent, while TIP located 14 per cent which were not in Ashburn's list. About 15 papers (4 per cent) were not retrieved by either method.

These findings are demonstrated clearly in Figure 1. The total number of laser articles found in TIP-covered journals was 327. If one assumes that the chances of a paper being missed by either searcher was independent of its being missed by the other, then the heavily shaded area would represent the possible material which may have been missed both by TIP and Ashburn.

If 342 is taken as the total number of relevant articles in the TIP-stored journals, then Ashburn's search found 280 of these. TIP retrieved 323 articles, 64 of which were judged irrelevant. Although Ashburn's bibliography had 68 papers that TIP failed to locate, TIP retrieved 47 relevant papers which were missed by Ashburn. It is also evident that the TIP performance in searches 1 and 2 retrieved the bulk of relevant material. Although 24 additional articles were found in search 3, 14 of these were judged to be irrelevant by Ashburn. It was

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* One can estimate the total number of laser papers in the TIP store by assuming that the search operations of TIP and of Ashburn are completely independent. This is a reasonable assumption since the only point of contact between the two was Ashburn's assessment of relevance of the material retrieved by TIP. To make the estimate let:

L = the total number of relevant laser papers produced
E_T = the search efficiency of TIP
E_A = the search efficiency of Ashburn

then: $259 = E_T L$ and $280 = E_A L$
also: $47 = E_T (L - 280)$ and $68 = E_A (L - 259)$
which gives: $L = (259)(280)/(212) \doteq 342$
and: $E_T = 0.76$ and $E_A = 0.82$

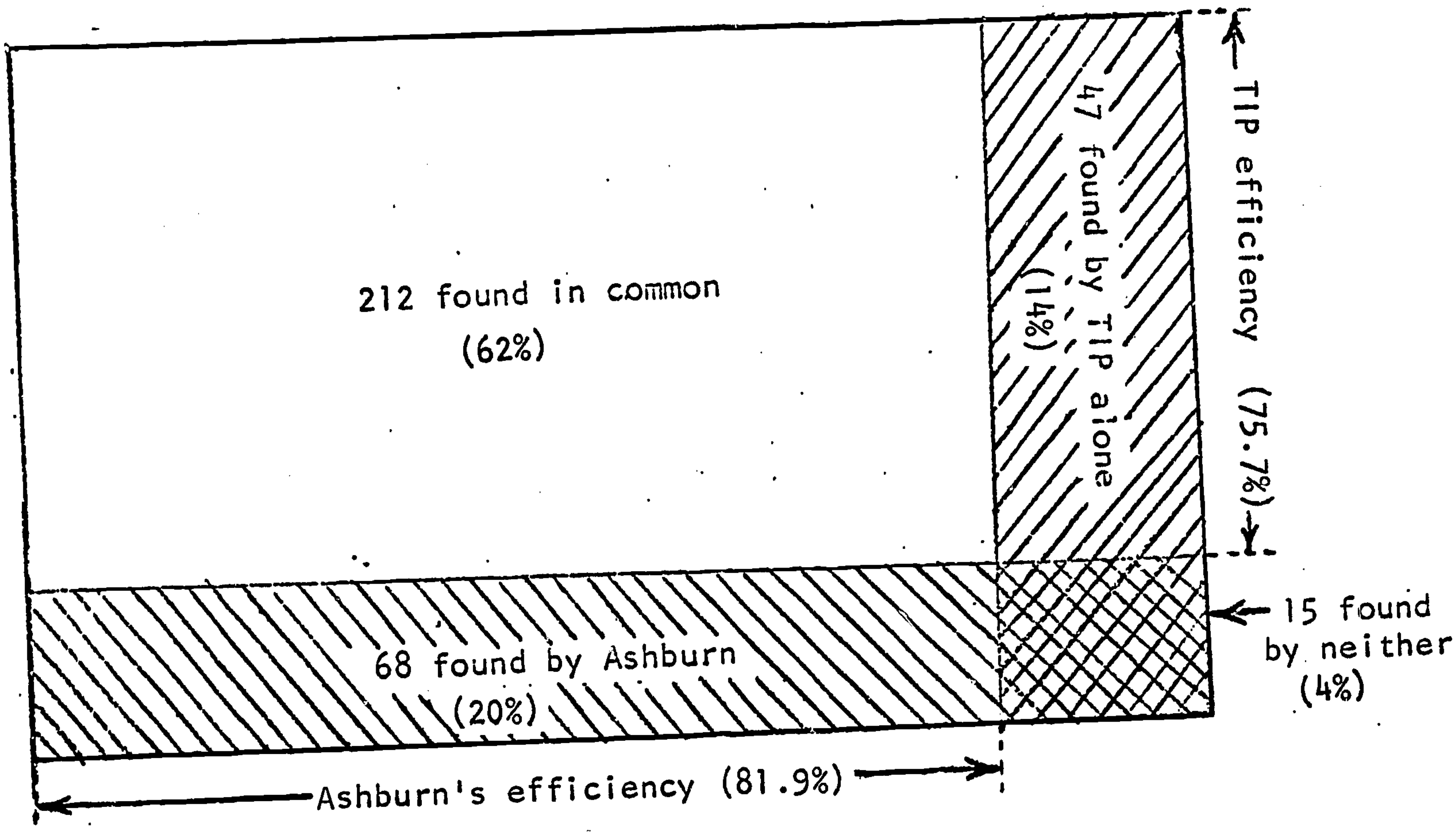
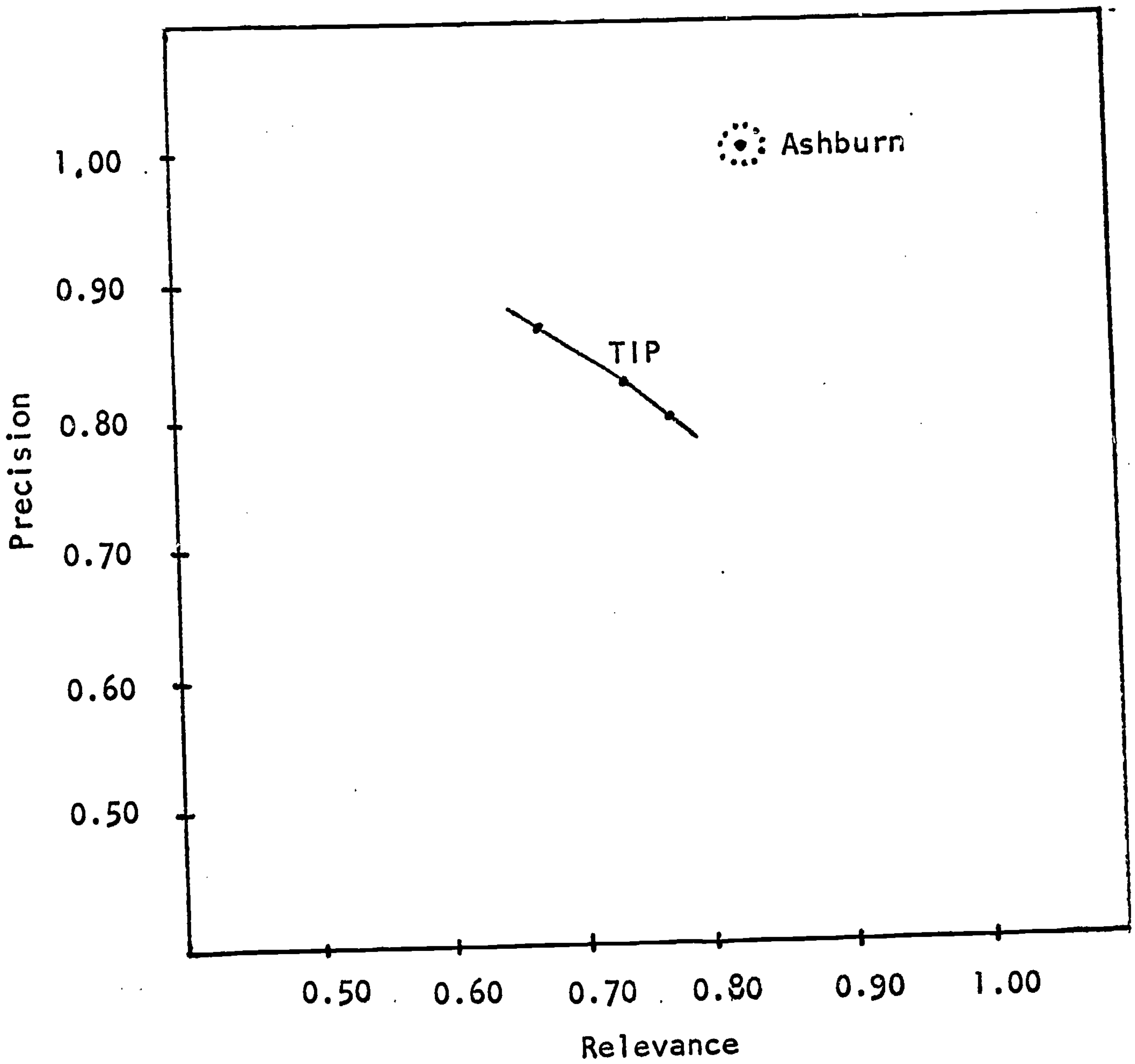


Figure 1



Graph 2

therefore suggested that this search be eliminated in future studies.

The performance characteristics of the three TIP searches are summarized below:

Table 2. TIP Performance Characteristics

Search	No. Relevant Articles Found	No. Irrelevant Articles Found	Total No. Relevant Articles	Recall	Precision
1	229	36	342	0.67	0.87
1+2	249	50	342	0.73	0.83
1+2+3	259	64	342	0.76	0.80
Ashburn	280	0 (by definition)	342	0.82	1.00

Ashburn's total recall was 0.82 as compared to 0.67 after TIP Search 1. The TIP recall was raised to 0.73 after Search 2 and to 0.76 at the completion of all three searches. The results of plotting the precision of each search against the recall ratios are shown in graph 2.

Of the physics material in Ashburn's bibliography, 280 articles came from the physics journals listed in TIP. The 58 additional physics journals searched by Ashburn produced only 224 additional articles (See Table 1). This means that the 14 productive journals in TIP were responsible for 56 per cent of the total articles retrieved from physics journals. Table 1 also shows that the journals from TIP produced 37 per cent of the total material listed by Ashburn in all categories (768 articles). The reason for this highly productive performance by the TIP journals lies in the criteria used for the selectivity of materials for TIP input.

As a result of the work with Ashburn, several changes were made in TIP. It became apparent during Search 2 that the year of publication was necessary for rapid identification of the 1964 papers. This data was subsequently added to the TIP bibliographic input.

In addition, an examination of the 58 physics journals producing laser papers which were not in TIP (Appendix B) showed that most of these generated 10 articles or less in 1964. The most productive journals not in TIP were Applied Optics which produced 68 articles, the Journal of the Optical Society of America which produced 15 articles, and the Soviet Journal Optika i Spektroskopiya which had 17. In January 1967, Journal of the Optical Society of America was added to the TIP store.

The results of the project seemed to indicate that TIP was a reliable means for locating laser articles within the TIP library, and a subsequent study of the 1966 laser literature was planned. A profile was also prepared for ASCA (Automatic Subject Citation Alert) for submission to the Institute for Scientific Information. This profile was set up to explore the effectiveness of retrieval by source author, cited author, and source reference. The ASCA profile was submitted so as to overlap the TIP retrieval of 1966 material. Reports of these studies will be issued separately.

Laser Searches on TIP Journals -- 1964

Journal Title	# in Ashburn's Laser Bibl.	TIP Search 1					TIP Search 2					TIP Search 3					Total TIP Performance				
		# found by TIP	# found in common	# irrelevant found by TIP	# missed by TIP	# missed by Ashburn	# found by TIP	# found in common	# irrelevant found by TIP	# missed by TIP	# missed by Ashburn	# found by TIP	# found in common	# irrelevant found by TIP	# missed by TIP	# missed by Ashburn	# found by TIP	# found in common	# irrelevant found by TIP	# missed by TIP	# missed by Ashburn
Ann. Phys. (USA)	0						1				1						1				1
Appl. Phys. Letters	95	78	76	1	19	1	2	2		17		1	1		16		81	79	1	16	1
Canad. J. Phys.	1	2		2	1					1					1		2		2	1	
Helv. Phys. Acta	0	2		2			1		1								3		3		
Indian J. Phys.	0	2		2													2		2		
Japan J. Appl. Phys.	11	2	1		10	1	1	1		9					9		3	2		9	1
J. Appl. Phys.	57	48	48		9					9		2	2		7		50	50		7	
J. Chem. Phys.	3	24	1	18	2	5	2		1	2	1	6		4	2	2	32	1	23	2	8
J. Phys. Soc. Japan	2	2		2	2		2		2	2		2		2	2		6		6	2	
Nuclear Phys.	0	1		1													1		1		
Nuovo Cimento	5	6	4	1	1	1				1					1		6	4	1	1	1
Phys. Rev.	25	21	16	2	9	3	16	4	6	5	6	10	1	7	4	2	47	21	15	4	11
Phys. Rev. Letters	15	20	12	1	3	7	2		1	3	1	1			3	1	23	12	2	3	9
Phys. Letters	36	37	32	2	4	3	4	1	3	3		1		1	3		42	33	6	3	3
Proc. Phys. Soc.	2	2		1	2	1	1	1		1					1		3	1	1	1	1
Soviet Physics--JETP	23	13	8		15	5	2	1		14	1				14		15	9		14	6
Soviet Physics--Solid State	4	4		1	4	3				4		1			4	1	5		1	4	4
Soviet Physics--Tech. Phys.	1	1			1	1				1					1		1			1	1
Total	280	265	198	36	82	31	34	10	14	72	10	24	4	14	68	6	323	212	64	68	47

APPENDIX B

JOURNALS IN WHICH LASER ARTICLES HAVE BEEN PUBLISHED IN 1964

Journal	Scope	No. Articles in 1964
Acta Dermato-Venereol. (Sweden)	Med	2
Acta Phys. Polon. (Poland)	Phys	2
Acta Phys. Sinica (China)	Phys	4
Advances in Phys. (G.B.)	Phys	1
AIAA Student J. (U.S.A.)	Phys	1
Akad. Nauk Armianskoi SSR, Dokl.	Phys	1
Alta Frequenza (Italy)	El Eng	4
Amer. Inst. Aeronaut. J.	Phys	1
Amer. J. Ophthal.	Med	2
Amer. J. Phys.	Phys	1
Amer. J. Surgery	Med	1
Ann. Oculist (France)	Med	1
Ann. Phys. (Germany)	Phys	1
Ann. Surg. (U.S.A.)	Med	1
APL Tech. Digest (U.S.A.)	Phys	1
Appl. Opt. (U.S.A.)	Phys	68
Appl. Phys. Letters (U.S.A.)	Phys	95 (TIP)
Arch. Dermatol. (U.S.A.)	Med	1
Arch. Ophthal (U.S.A.)	Med	3
Atti. Fond. Giorgio Contrib. Ist Nazl. Ottica (Italy)	Phys	1
Bell System Tech. J. (U.S.A.)	Phys	5
Brit. J. Appl. Phys.	Phys	2
Brit. J. Ophthal.	Med	2
Bull. Acad. Polon. Sci. Ser. Sci. Tech. (Poland)	Phys	1
Bull. Soc. Ophthal. France	Med	2
Bull. Univ. Osaka Prefecture (Japan)	Phys	1
Canad. Aeronaut. Space	Phys	1
Canad. J. Phys.	Phys	1 (TIP)
Canad. Med. Assoc. J.	Med	1
Cancer (U.S.A.)	Med	2
Chemie-Ingenieur-Tech. (Germany)	Phys	1
Compt. Rend. Acad. Sci. (France)	Misc	29
Contemp. Phys. (G.B.)	Phys	2
Current Sci. (India)	Phys	1
Czech. J. Phys.	Phys	2
Dokl. Akad. Nauk. (U.S.S.R.)	Phys	7
Electronics (U.S.A.)	El Eng	1
Electronics Progress (U.S.A.)	El Eng	1
Elektron Rundschau (Germany)	El Eng	1
Engineering (G.B.)	El Eng	1
Ergeb. Exakt. Natur. (Germany)	Phys	1
Exper. Tech. Phys. (Germany)	Phys	1
Federation Proc. (U.S.A.)	Misc	1
Fiz. Tverd. Tela (U.S.S.R.)	Phys	4 (TIP)
Frequenz (Germany)	El Eng	1
IBM J. Res. Develop. (U.S.A.)	Phys	8
IEEE Intern. Space Electronics Symposium Record (U.S.A.)	El Eng	1
IEEE Proc. Intern. Conv. Milit. Electronics (U.S.A.)	El Eng	7
IEEE Proc. Natl. Aerospace Electron. Conf. (U.S.A.)	El Eng	1
IEEE Proc. Natl. Electron. Conf. (U.S.A.)	El Eng	5

IEEE Trans. Electron. Devices (U.S.A.)	El Eng	2
IEEE Trans. Instr. Meas. (U.S.A.)	El Eng	1
IEEE Trans. Microwave Theory Tech.(U.S.A.)	El Eng	1
IEEE Trans. Milit. Electron (U.S.A.)	El Eng	1
IEEE Trans. Sonics and Ultrasonics (U.S.A.)	El Eng	1
Indian J. Pure and Appl. Phys.	Phys	1
Indust. Res. (U.S.A.)	Misc	1
Infrared Phys. (U.S.A.)	Phys	1
Instrum. Control Syst. (U.S.A.)	El Eng	1
Intern. Sci. Tech. (U.S.A.)	Misc	2
Japan. J. Appl. Phys.	Phys	11 (TIP)
J. Amer. Ceram. Soc.	Misc	1
J. Amer. Med. Assoc.	Med	3
J. Appl. Phys. (U.S.A.)	Phys	57 (TIP)
J. Chem. Phys. (U.S.A.)	Phys	3 (TIP)
J. Electronics Control (G.B.)	El Eng	1
J. Fac. Engng. Univ. Tokyo (Japan)	El Eng	1
J. Geophys. Res. (U.S.A.)	Phys	2
J. Inst. Elect. Commun. Engrs. (Japan)	El Eng	1
J. Inst. Navigation (G.B.)	El Eng	1
J. Invest. Dermatol. (U.S.A.)	Med	2
J. Math. Phys. (U.S.A.)	Phys	1
J. Opt. Soc. Amer.	Phys	15
J. Phys. (France)	Phys	2
J. Phys. Soc. Japan	Phys	2 (TIP)
J. Radio Res. Lab (Japan)	El Eng	1
J. Res. Natl. Bur. Stand. (U.S.A.)	El Eng	2
J. Res. Radio Sci. (U.S.A.)	El Eng	1
J. Sci. instrum (G.B.)	Phys	4
J. Surg. Res. (U.S.A.)	Med	1
Jemna Mechanika a Optika (Czechoslovakia)	Phys	2
Kristallografiya (U.S.S.R.)	Phys	1
Life Sci. (U.S.A.)	Misc	3
Mem Soc. Ingenieurs Civil de France	El Eng	1
Nachrichtentech. Z. (Germany)	Phys	1
Nature (G.B.)	Misc	24
Ned. Tijdschr. Natuurk (Netherlands)	Phys	1
Nucleonics (U.S.A.)	Phys	1
Nuovo Cimento (Italy)	Phys	5 (TIP)
Opt. i Spektroskopiya (U.S.S.R.)	Phys	17
Oral Surg., Oral Med., Oral Pathol. (U.S.A.)	Med	1
Ordnance (U.S.A.)	El Eng	1
Philips Res. Rep. (Netherlands)	Phys	2
Photographic Sci. and Engr. (U.S.A.)	Misc	1
Phys. Chem. Glasses (G.B.)	Phys	1
Phys. Fluids (U.S.A.)	Phys	1
Phys. Letters (Netherlands)	Phys	36 (TIP)
Phys. Rev. (U.S.A.)	Phys	25 (TIP)
Phys. Rev. Letters (U.S.A.)	Phys	15 (TIP)
Phys. Status Solidi (Germany)	Phys	4
Phys. Today (U.S.A.)	Phys	1
Proc. Golden Gate Materials Conf. (U.S.A.)	El Eng	1
Proc. IEEE (U.S.A.)	El Eng	110
Proc. Nat. Acad. Sci. (U.S.A.)	Misc	1

Proc. Phys. Soc. (G.B.)	Phys	2 (TIP)
Radiotekhnika i Elektronika (U.S.S.R)	El Eng	8
Radio Electronic Engr. (G.B.)	El Eng	1
Radiofizika (U.S.S.R.)	El Eng	2
Rep. Ionosphere Space Res. Japan	Phys	1
Rep. Progr. Phys. (G.B.)	Phys	1
Rev. Sci. Instrum. (U.S.A.)	Phys	10
School Sci. Rev. (G.B.)	Misc	1
Sci. American	Misc	1
Sci. Progr. (G.B.)	Misc	1
Sci. Tech. (U.S.A.)	Misc	1
Science (U.S.A.)	Misc	2
Semiconductor Prod. Solid State Technol. (U.S.A.)	Phys	2
Solid-State Communications (U.S.A.)	Phys	3
Solid-State Electronics (G.B.)	Phys	2
Space/Aeronaut. (U.S.A.)	Phys	1
Stud. Cercetari Fiz. (Rumania)	Phys	1
Surg. Forum (U.S.A.)	Med	3
Tekhn. i Matemat. Nauk (U.S.S.R.)	Phys	1
Trans Metall. Soc. AIME (U.S.A.)	El Eng	4
Trans Pacif. Coast Oto-ophthal Soc. (U.S.A.)	Med	1
Ukrayin Fiz. Zh. (U.S.S.R.)	Phys	3
Uspekhi Fiz. Nauk (U.S.S.R.)	Phys	2
Vacuum (G.B.)	Phys	1
VDI Z. (Germany)	Phys	1
Z. Angew. Phys. (Germany)	Phys	9
Z. Naturforsch. (Germany)	Phys	7
Z. Phys. (Germany)	Phys	6
Zh. Eksper. Teor. Fiz. (U.S.S.R.)	Phys	23 (TIP)
Zh. Tekh. Fiz. (U.S.S.R.)	Phys	1 (TIP)

Phys = Physics Journal
El Eng = Electrical and Electronic Engineering Journal
Med = Medical Journal
Misc = Miscellaneous Journal

Total # of Journals 134
Total # of Articles 768

		No. Articles
No. Physics Journals	72	504
No. Elect. & Electronic Journals	31	166
No. Medical Journals	17	29
No. Miscellaneous Journals	14	69
Total	134	768