INVESTIGATION OF CARBON NANOTUBES USING THE F-TERM CODE OF JAPANESE PATENT INFORMATION

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ABSTRACT

Patents contain much novel technological information. In this paper, the searching methods of the file index (FI) and F-term classification system developed by the Japan Patent Office (JPO) were employed to find patents containing information on carbon nanotube technology. All related patent data were searched for in the Intellectual Property Digital Library (IPDL). Moreover, using theme codes and term codes in the two-dimensional structure of the F-term list, we investigated and analyzed the technical features expressed by carbon nanotubes in related documents in Boolean operations.

Keywords: Japanese patent information, IPC, FI and F-term classification, Theme code, Term code, Carbon nanotube

1 INTRODUCTION

Patent classification has been expanded with a central, single technical viewpoint in the present International Patent Classification (IPC), which may be effectively concise but not precise enough to describe the nature of novel technology. For example, Schaller [1] indicated that only 70,000 items in the file index (FI) classification for IPC existed; however, in the Japan Patent Office (JPO) about 170,000 items existed. Hence, JPO could provide a wider scope of information in searching for topics of interest.

Schaller [2] also stated that FI and F-term classification systems developed by JPO [3] since 1980 provided a new quality control tool for analyzing literal and lingual information that is unique and effective in patent classification. The system was extended to classify more precisely the IPC from multiple technical viewpoints, such as purpose (object), use (usage), structure, function, material, manufacturing method, treatment means, solution means, etc. For example, FI classifications were expanded by the patent examiner of JPO for each field in the IPC and were expressed by subdivision symbols and file discrimination symbols. Further, F-term classification is subdivided into theme code (representing a technological field), viewpoint (material, operation, product, purpose, etc.), figure (subdividing the view point, expressed as term codes) in the way of F_S (single viewpoint expressed as singlet F-term), and F_M (multiple viewpoint as multiplet F-term) for FI.

IPC classification of the present edition cannot classify very well for novel technologies developed in the past ten years such as carbon nanotubes. However, JPO has published a publicly available patent map series report each fiscal year using keywords for the novel technologies [4]. For example, the eighth report in chemistry concerning carbon nanotubes was published in 2002, using carbon-nanotube related keywords to advantageous effect in searching the PATOLIS (Patent online information system) databank, which established a new F-term list of theme code 4G146 to keep pace with novel technology.

The purpose of this paper is to use carbon nanotubes as an example of how to use the Industrial Property Digital Library (IPDL) databank of the NCIPI (National Center for Industrial Property Information and Training), which is supported by JPO for FI and F-term classification systems developed by JPO to search for novel technologies and other information. Consequently, this paper aims to use FI classification and F-term classification to approach the technical nature of carbon nanotubes to more precisely analyze for technical features.

2 SEARCH METHOD

Figure 1 shows the flowchart for accessing the F-term list. The search steps are explained as follows.

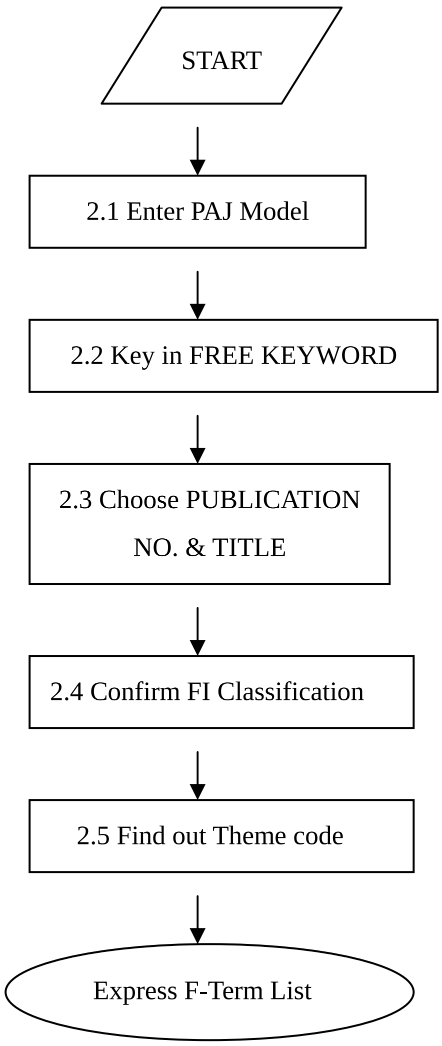

Figure 1. Flowchart for searching the F-term list

2.1 Enter PAJ Model

First, enter the English homepage of the Industrial Property Digital Library website (IPDL) [5], and click the PAJ (Patent Abstract of Japan) bar beneath Patent & Utility Model.

2.2 Key in free key word to obtain searching result

Key "carbon nanotube" (free keyword) in PAJ, and restrict the time period range (these papers are from 2000/01/01 to 2005/01/31), and then click the Search bar.

2.3 Choose the hit publication No. and Title

Click the "Index Indication" bar to show the Publication No. You can find the Title and Publication No. of what you want (for example, Publication No. 2004-299986, CARBON NANOTUBE AND ITS PRODUCTION METHOD, and IPC, CO1B 31/02.).

2.4 Confirm the FI classification of the chosen publication

Return to the English homepage of IPDL, and then click the Patent Map Guidance bar of the Patent & Utility Model.

2.5 Find theme code

Key CO1B 31/02 in the FI box, and then click the Search bar. The theme code 4G146 of the F-term list in the FI classification that corresponds to the subgroup CO1B 31/02 in IPC can be obtained. Even though we can find the IPC classification in the chosen Publication No. and Title and key in the IPC classification in the FI box of the Patent Map Guidance, the theme code of the F-term list can be found only in the expression of correspondence to further IPC-based subdivisions of FI expressed in 101 having A, B, F, or Z file discrimination symbols, for example F as "Fullerene; nanotubes". Then click the underlined theme code 4G146 to display the full content of the F-term list relating to multiple technological viewpoints of carbon nanotubes. Hence, we can use the combination of multiple viewpoints, such as AA11, AD29, BC15, etc., in the F-term list to search a specific technical feature, as opposed to the single viewpoint in IPC.

3 ANALYSIS OF TECHNICAL FEATURES FOR CARBON NANOTUBES

Carbon nanotubes were unexpectedly found by Prof. Sumio [6] of the NEC (Nihon Electric Corporation, Japan) laboratory in 1991 by using the arc discharge method to produce C_{60}. He found that there was some deposited residue, needle-shaped substances ranging from several nm to several tens nm, remaining on the surface of the cathode carbon rod infiltration. These needle-shaped substances were wound into an annular circle by 20~50 layers of graphite for a length of several micrometers as observed by a high resolution tunneling microscope. The new structure was a hollow tube comprised of carbon atoms, called multi-walled nanotubes. Then in 1993, uniform single-walled nanotubes of diameter 1 nm were synthesized by NEC and IBM laboratories by adding transitional elements onto the surface of anode carbon rods with an arc discharge method. The appearance of this single-walled nanotube is of dendritic and crooked shape, different from that of multi-walled nanotubes [7]. Carbon nanotubes do not exist in nature; their structure and characteristics are not the same as C_{60}. From then on, the preparation method, parameter study, and utility of carbon nanotubes were deeply developed.

Novel technology such as carbon nanotubes may not be well classified in IPC classification. Here, this work takes advantage of a newly established F-term list, emphasized by JPO's emphasis on novel technology. We find that by using the keyword "carbon nanotube" in searching PAJ in the several steps shown in the above flowchart, the theme code 4G146 of the F-term list can be found to correspond to the FI of carbon nanotubes.

This paper uses the term codes, such as AA00~QA10, of the F-term list of theme code 4G146 to proceed by using Boolean operations (using * 、＋、－ as operators) to find the preparation methods for carbon nanotubes. The technical matrix as shown in Table 1is expressed with preparation method as the Y-axis and parameter variation and utility (use) as the X-axis. The figures located at the intersection of the X-axis and Y-axis are the open publication cases in Japan. For instance, the open publication cases of carbon nanotubes manufactured by gas phase reaction processes which were used into electron beam emission elements number 70 for the time period from 2000/01/01 to 2005/01/31 (AD29*BC08).

Table 1. Technical matrix of carbon nanotubes

Parameter variation and utility / Preparation method	**Heat resistance (AD19)**	**Oxidation resistance (AD13)**	**Heat transmission and heat conductivity (AD20)**	**Conductive materials and conductivity (AD22)**	**Electrodes (AD23)**	**For lithium secondary battery (AD25)**	**Mechanical properties and uses (high density etc.) (AD26)**	**elements, emitters and displays**	**For semiconductors (AD30)**
Including catalysts in process (BC01)	0	0	0	2	1	0	1	5	2
Multi-stage heating (e.g. heating with different temperature conditions (BC07)	2	0	1	2	2	0	1	3	1
Gas phase reaction and thermal decomposition (BC08)	5	0	2	22	20	10	10	70	17
Chemical vapor deposition and plasma CVD (BC09)	0	0	0	10	16	5	2	55	8
By physical techniques and PVD (BC10)	1	0	0	0	1	1	1	4	1
Manufacturing under high temperature and pressure (BC11)	0	0	0	1	1	1	1	1	0

Using high energy sources (light, laser, etc.) (BC15)	11	0	9	8	17	4	6	37	9
Discharge and plasma (BC16)	10	0	9	7	15	2	6	30	7
Arc discharge (BC17)	8	0	7	6	15	1	4	20	11
Special environments (electric field, zero gravity, magnetic field, etc.) (BC18)	1	0	1	2	5	0	1	11	4

The technical features of the manufacturing method for carbon nanotubes can be exemplified by the technical matrix as follows.

(1) It shows that gas phase reaction process, thermal decomposition, chemical vapor deposition, and plasma CVD processes are the major technologies used in the preparation of carbon nanotubes, while energy sources such as light and laser, discharge and plasma, and arc discharge are also usually adopted to produce carbon nanotubes.

(2) Carbon nanotubes in electrical applications are most widely used as electronic emission elements, emitters, and displays to enhance the displaying characteristics. This is because the electronic emission element using carbon nanotubea has a high current intensity, a high luminance, and a good working ability at room temperature. In addition, when carbon nanotubes are fabricated into electrode and electrical conductive materials, their conductivity characteristics can be improved.

(3) Carbon nanotubes that were fabricated into cathode materials in lithium batteries can improve the capacitance of the cell. Carbon nanotubes can also be applied in semiconductor processing to produce compact semiconductors.

(4) It is worth mentioning that carbon nanotubes are relatively seldomly applied in the fields of heat transmission, heat conductivity, heat resistance, oxidation resistance, mechanical properties, and oxidation resistance. This information tells us that there are many areas yet to be developed for these applications.

4 CONCLUSION

In conclusion, foreigners who are not acquainted with Japanese can still search effectively in Japanese patents by making use of the file index (FI) and F-term classification system developed by JPO by using the theme code and term code of the F-term list found according to the above flowchart. They can analyze the technical features of every technical field, and then compare and analyze the prior art accumulated in the IPDL databank and sketch out the patent map into a technical matrix to identify the developing trends and designs to develop an improved invention. Furthermore, for more accurate searching, we can query with more restricted term codes by using Boolean operations to compare and analyze related subject matters.

5 REFERENCES

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