1 ボイラー技術の系統化調査

Innovating Survey on the Boiler Technologies

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■ 要旨

本調査では、世界におけるボイラーの歴史を2つに分けた。1つは1700年から1950年までの産業革命の初頭から第二次世界大戦後の混乱終了時期までの2世紀半を「近代」とした。2つは1950年から2000年の20世紀後半の時期を「現代」とした。この期間は「近代」よりも、高度な工業技術をボイラーの安全設計に組み込むことができた。

初めの「近代」は長い期間であり、個人がボイラーの発明に大いに傾注し多数の発明があった。これらのボイラーには、発明者の名前がボイラーの呼称についている。例えばヤーローボイラー、スターリングボイラー、ベルヴィユボイラー、レフラーボイラー、スコッチボイラー、および池田ボイラーなどがその一部である。少数のボイラーは現代でも記憶に残っているが、ほとんどのボイラーはその名前も忘れられ市場から消えて行った。それは1900年代の米国・英国などの年間ボイラー事故件数が1,000件をこえる状況が現出したからである。これらの事故は、当時の本体の設計および工作技術並びに関連機器の技術が十分に揃っておらず、意にかなうボイラーを製作できないためであった。ボイラーの安全確保のため、安全規則、構造規格、並びに検査制度の早急な整備が要請された。20世紀前半は世界戦争が多発し、各国海軍の軍用面での進歩は多大であった。特に、石炭ストーカ焚きボイラーから重油専焼ボイラーへの切り替えが積極的に促進された。しかし、一般産業用ボイラーおよび発電事業用ボイラーまでは手がつけられなかった。

「現代」に入ると、米国ではボイラーの規格・大量生産設備・品質管理などの物量作戦が大きく発展し世界を独走している状態が、わが国視察団の調査により歴然となった。これは1880年に創立されたASME (American Society of Mechanical Engineers) が牽引役となって発展させたことによる。わが国は戦後、主として米国の技術導入に専心し、自らの勤勉性をもって世界に誇れる技術の確立に向かった。それはボイラー本体の安全を確保する基礎理論、設計・工作技術、品質管理および運転・保守のほかに、これらをサポートする各種の関連技術である材料・溶接・水処理・自動制御・環境対策などが、急速にその理論体系を整えることができたことが安定したボイラーの発展に結びついた。これらの自主技術の育成が、その効果を表し世界の第一線に並んだと自負できる状況になったといえる。

本書は、このように日本のボイラー技術の導入と発展を「近代」と「現代」として比較解析し、さらに今後のボイラーの方向性として推進すべき事項の要点を述べる。

■ Abstract

We have divided the history of the boiler into two eras: one of the boilers of the past and the other more recent designs. The former era spans the previous two and half centuries from 1700 to 1950, beginning during the industrial revolution and continuing to the end of World War II. The latter includes the second half of the 20th century from the years 1950 to 2000. During this time, modern engineering technologies were incorporated into boiler design and this led to boilers that were far safer than previous ones.

In the first era, many boilers displayed the names of their designers at the top of their structure. Some well known boilers from this period were the Yarrow boiler, the Stirling boiler, the Belleville boiler, the Loeffler boiler, the Scotch boiler and the Ikeda boiler. A few boiler designs may be remembered today, but most of these designs have ceased to be used because of their high rate of failure. There were over 1,000 failures during the 1900's throughout the U.S.A. and England. This high number can be attributed to the low level of engineering technology of the day. Design philosophy and manufacturing technologies were not highly developed. Then, the establishment of safety regulations, boiler design codes, and inspection systems addressed these problems. In the first half of 20th century,

the navies of most of the more powerful countries had converted the firing systems of marine boilers from coal stoker ones to oil firing ones. This research was limited to naval vessels, however.

At the beginning of the latter period, the U.S.A. was far ahead of other countries in the areas of boiler design codes, mass production systems and quality control. The American Society of Mechanical Engineers (ASME) started in 1880 and was to contributed to this development. Japanese engineers adopted some of their ideas and strove to establish and refine their own design methods, manufacturing networks, quality control, operation, maintenance and all related technologies, so that their boilers could compete with those of the advanced countries. We will compare boiler technologies of these two eras and look ahead to the future aspects for their further development.

■ Contents

2 飲料自動販売機技術発展の系統化調査

History of the Development of Beverage Vending Machine Technology in Japan

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■ 要旨

2006年末において物品やサービスを販売する自動販売機は427万台普及しており、それらの機械が販売する自販金額は7兆円の域に達している。そして、そのうち半数を超える266万台は飲料自動販売機が占めている現状から本調査の対象を飲料自販機とした。

自動販売機の歴史を辿ると紀元前215年に遡り、古代エジプトのアレキサンドリアにある寺院で、硬貨を使い聖水を販売する装置が使われていたといい、これが自動販売機の発祥であると伝えられている。現存する最古の自動販売機は1615年英国の居酒屋や旅館で使われていたタバコの自動販売機とされ、以降英国では多くの発明家たちが書籍や切手などいろいろな商品について自動販売機化を試みてきたが、販売の手段として本格的に実用に供されたものではなかったという。実用化し発展に寄与した自動販売機として米国のチュウインガムの自動販売機を挙げることができ、日本では戦後の高度成長期に出現したジュースの自動販売機である。

自動販売機は消費者の目から見ると無人で働く機械であるが、自動販売機メーカー、中身メーカー、オペレータ、整備事業者、ロケーションオーナーなど多くの事業者が自動販売機の健全な運営に係わり、レギュラーサービス、フルサービスといったルートサービスシステムによって運営されている。しかしながら、自動販売機の発展を振り返ると、消費者の信頼を勝ち得たことが主要因で、特に飲料自動販売機の場合は「飲料が最適飲用状態で販売する」「安全の確保」への努力が重要なポイントであった。

飲料は何らかの容器が使われている。飲料自動販売機はこの容器を基準に2種類の自動販売機に分けて考える必要がある。そのひとつは古い歴史を持つカップ式飲料自販機であり、他のひとつは容器入り飲料自販機である。同じ飲料自販機と称しながら技術的にみると両者は全く異なった分野にある。すなわち、前者は消費者に「おいしさ」「安全」を提供せねば相手にされなくなり、後者は「おいしさ」は既に中身メーカーが全国均一に保証してあり、この容器を効率よく収納し、おいしさを保つ最適温度で商品を販売することが課題なのである。

では課題に対してどのように取組んでいるのか、カップ式飲料自動販売機の場合は原料の保管、冷水や湯の管理、氷・炭酸水の製造、ミキシング方法、レギュラーコーヒー抽出装置、リーフティ抽出装置、カップ搬出装置など「おいしさを創り上げる基本的コンポーネント」の開発・改良の歴史があり、容器入り飲料の場合は容器の収納効率の良い、セールスマンの作業性の良い、ムラのない温度管理ができる「ラック（収納棚）」と容器を傷つけず、すばやく確実な搬出ができる「販売装置」の開発・改良の歴史がある。

飲料自販機の金銭処理装置は広く標準化して効率の良いメンテナンスに貢献している。コインメカは機械式検銭から電子式検銭に進歩して、主要トラブルである硬貨通路におけるジャミングが激減し扱う金種数も増えた。

金種数を見ると、検銭は10円専用から始まり現在4金種選別、つり銭装置も4金種払出しが可能になり、進歩するエレクトロニクスの活用により投入金額表示、売上金額表示、故障診断など多くの便利機能が付加された。

自販機の制御技術は、当初スイッチ・リレーによるシーケンス制御であったが、トランジスタ時代から部分的ではあるが電子化に取組み、IC化、さらにLSI化はコインメカの多機能化を実現し、現在のマイクロコンピュータ活用に結びついている。自販機業界は競ってこの進化に取組んでみたものの、スイッチ・リレーなど接点による制御とトランジスタ・ICなど無接点制御の混合時代、プログラムによるマイクロコンピュータ制御の黎明期は、各社とも多くの品質問題を解決するために時間を費やしている。

自動販売機は産業機械であり、製品・技術の開発はニーズオリエンテッド（needs　oriented）のウエイトが大きく、特有の技術ジャンルは金銭処理のみといえる。日本のコインメカ技術の流れをみると、クレードルなど基本的な機械式検銭技術や標準化思想などは技術提携による輸入技術からスタートし、電子式検銭においても基本特許を購入して国産化している。その間、各社技術者はこれを日本の社会、国土環境に整合させ改良を重ねていた。

ところが、エレクトロニクス時代を迎えてからは独自の技術により日本を自動販売機大国に発展させている。
この歴史は、シーズオリエンテッド（seeds　oriented）のウエイトを強化し、もっともっと多くの開発提案を続けていくならば、頭打ちになっている業界に新しい光がさすことを示唆している。

■ Abstract

Approximately 4.27 million vending machines were operating in Japan at the end of 2006, with annual sales in excess of 7 trillion yen. We have focused our research on beverage vending machines, because these account for over half of all the installed machines (at 2.60 million).

The first vending machine is thought to have been introduced at a temple in Alexandria in 215 BC. The machine dispensed holy water in return for a small coin. The oldest extant machines are cigarette-vending devices that were installed in English pubs and hostels as early as 1615. English inventors subsequently devised additional designs to sell books, postage stamps, and many other products as well, but the devices were not commercially practical. The first commercially viable vending machines were gum dispensers introduced in the United States. In Japan, the first viable machines were juice vending machines that appeared during the high-growth period following World War II. While vending machines appear to work without human intervention, an entire support network is active behind the scenes. Machine makers, product manufacturers, operators, service personnel, and location owners are just some of the individuals involved in marketing and management efforts. Other individuals are responsible for route systems that carry out collection, replenishment, and service. When we look back at the history, we see that success rests on gaining the consumer's trust. In the case of beverage machines, the crucial requirements are to maintain merchandise in optimal drinking condition and to ensure safety.

Beverage machines fall into two major categories: the original type that pours the beverage into a cup, and the more recently developed type that delivers prepackaged drinks. The technologies for these two approaches are quite different. With cuptype machines, the machine operator is responsible for both preparing a good-tasting drink and maintaining the safety necessary to attract the consumer. With the prepackaged approach, however, the beverage maker controls the taste, while the machine operator focuses on how best to load containers into the machine and maintain them at optimal temperature.

As the technologies differ, so do the issues that machine designers and operators have to face. Cup-type machines are backed by a long history of development and improvement of basic taste-related components-storing of the ingredients, control of the temperature of the water used in the mix, manufacture of ice and carbonated water for the mix, mixing methods, coffee and tea extraction, cup transport, and so on. With container-type machines, efforts have gone into issues such as effective loading of containers, ease of sales work, design of reliable temperature-control racks, and the design of fast, reliable, containerfriendly delivery systems.

Cash collection equipment for vending machines has been widely standardized, which in turn contributes to effective maintenance. Coin mechanisms have advanced from mechanical to electronic. Jamming problems have been greatly reduced. and the number of supported coins and bills has increased. Where early machines accepted 10-yen coins only, today's machines accept and dispense as change all four main denominations. Built-in electronics enable a wide range of convenient functions, such as display of the amount inserted, tracking and reporting of total sales, and diagnosis of machine errors.

Early coin mechanisms were driven by sequences of relays, but with the coming of the transistor age manufacturers began to incorporate various electronic components. The introduction of ICs and LSIs allowed for multiple functionality, and the subsequent introduction of microprocessors expanded functionality even further. Competition among machine makers spurred innovation, as machines advanced from full contact type (relays only) to hybrid types (with transistors and ICs) and finally to programmed control. The evolution took some time, however, as manufacturers faced numerous quality issues all along the way.

Because vending devices are industrial machines, development of products and technologies in this area has been strongly needs oriented, and has largely been limited to the concept of cash processing. Japanese makers entered the field through technical tie-ups through which they imported the technologies for coin cradles and other basic components and moved toward standardization. They purchased patents for basic electronic coin collection technologies, then implemented various improvements to adapt the technology to the needs of Japanese society and environment.

But now that we have fully entered the electronics age, Japan's innovative technologies have positioned the country as a major vending-machine producer. History suggests that increased emphasis on elemental research (a "seeds-oriented" approach) can spur a continuous stream of development proposals, making it possible to break through current barriers and find new ways forward.

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3 衣料用ポリエステル繊維技術の系統化調査

History of Polyester Fiber Technologies used for making Textiles

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■ 要旨

繊維産業は、わが国の基幹産業のひとつであった。合成繊維の中でも、ポリエステル繊維は性能とコストのバランスに優れ、世界的規模で急成長を遂げ、現在、天然繊維を含めた各種繊維の中で、最大の生産量を占めるに至っている。また、ポリエステルに限らず、繊維およびその技術は、単に衣料にとどまらず、交通・建設・情報・医療などの多くの産業分野に適用されている。

本稿では、衣料用ポリエステルフィラメントに焦点を絞って、わが国における技術発展の歴史を概観することとした。

合成繊維は、米国DuPont社のCarothersによるナイロンに端を発し、ポリエステルはやや遅れて英国で発明された。わが国では1957年、帝国人造絹絲㈱と東洋レーヨン㈱の2社が共同で技術を導入し、1958年からその生産が始められた。

わが国におけるポリエステル繊維、特に長繊維であるフィラメントは、繊維製造プロセスの合理化や革新にとどまらず、絹を頂点とする天然繊維の巧みな構造特性に学び、高機能繊維の製造技術に取り入れてきた。

プロセス革新の主な課題は、糸切れを生じないよう安定性を確保した上での、工程の連続と省略および高速化にあった。現在では新幹線の走行速度を越える時速400kmに達する速度で、ポリエステル繊維が連続的に巻き取られるに至っている。

高機能化にあっては、天然繊維の形態的模倣に始まり、ポリマ改質技術、複合紡糸技術、混繊技術、超極細繊維技術、仮撚加工技術などを駆使して、ついには合成繊維でありながら、1ランク上の「新合繊」と称されるまでに至った。

ここに適用されている技術は、精密な微細加工技術を含むものであり、各種の産業分野で広く活用されている。

■ Abstract

The textile industry has been one of the most important industries in Japan. Because of their excellent characteristics and low cost, various synthetic and polyester fibers rapidly become popular on all over the world. Nowadays, more polyester fiber is produced than any other natural and synthetic fiber.

Polyester and many other kinds of fiber and the technologies for producing them have been used not only in the apparel industry but also other industries, such as in vehicles, construction and civil engineering, IT and medical devices.

This report focuses on the history of polyester fiber technologies for making textiles in Japan.

The production of synthetic fiber started with nylon. It was discovered by Carothers, who worked for DuPont in the U.S.A. Polyester was invented later in the U.K. In Japan, two companies, Teijin and Toray, introduced polyester in 1957, and started production the next year.

In Japan, there have been several innovations in production technologies used to make polyester filament yarn. For example, there has been rationalization of the manufacturing process steps and also improvement in the production of high performance fibers. Some of these improvements have come from studying the excellent structures and mechanisms of natural fibers, such as silk.

The principal areas of process innovation have been the simplifying of processing steps and speeding up of production, while maintaining production stability without fiber breakage. The winding speed of high-speed spinning machines used to make polyester yarn is now about 400km/hr, which is faster than “Shin-Kansen”.

High-performance fiber technology started with the morphological imitation of natural fibers. Then, various kinds of key technologies, such as polymer modification, conjugate spinning, mixed filament, ultra fine fiber and false-twist texturing were developed. These technologies have been combined with each other and widely used. Finally, high performance polyester fabric is called “Shin-Gosen”. It means an enhanced status of synthetic fibers. This Japanese expression “Shin-Gosen” has become popular on all over the world.

These technologies include precise processing technologies, which are widely used in various industrial fields.

■ Contents

4 公衆移動通信システムの技術発展の系統化調査

Systematic Survey of Technological Development in Public Mobile Communication Systems

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■ 要旨

本報告書は、今日の「公衆移動通信システム」の基礎を作り出した約100年の歴史、技術とサービス発展の経緯、技術発達と社会・文化・経済・行政・海外の関わりを示す技術の系統化、課題と考察等の調査成果である。

*日本の初期の無線通信は自主技術開発中心で発展:　欧米の技術を輸入した有線電信電話とは異なり、国や軍主導の日本の無線技術は欧米諸国に劣らず、時にはしのぐものさえあった。1896 年、無線通信の研究が、逓信省の研究機関で開始された。1905年、国産の「36式無線電信機」が、日露戦争で大活躍した。1908年、逓信省は、我が国最初の無線による銚子無線電信局を開設し、「船舶との公衆無線電報」の取り扱いを開始した。1912年、携帯電話の祖先の「TYK式無線電話」が、発明された。1929年、対欧送信施設の「依佐美送信システム」の開設、1940年代、中波・短波帯の無線電話が、国産技術(真空管使用)で実用化された。

*世界初の自動車電話・第三世代携帯電話のサービス:　移動通信が一般に普及したのは、第二次世界大戦後で、超短波帯で初めてFM(周波数変調)技術を採用した「警察無線」が開発され、続いて「船舶電話」、「列車電話」、1967年、「自動交換接続による都市災害対策用可搬型無線電話システム」が開発された。1968年、「ポケットベル」の開始、1970年、大阪万国博覧会で日本電電公社が「日本初の携帯電話」を出展した。これらの技術が、携帯電話やコードレス電話へ応用された。1979年、世界初の800MHz帯を利用する「小ゾーン自動車電話」が、サービスされた。1980 年、1周波数方式のコードレス電話が、導入された。1985年に施行された通信自由化により、NTT以外の新規参入会社による自動車電話サービスが、開始された。1987年、日本初の「携帯電話」がサービスされた。1989年、日米貿易摩擦で米国方式電話も導入され世界に類のない複数方式で運用された。2001年、NTTドコモが第三世代の「携帯電話」を世界で初めて導入、2002年、auが米国方式を導入し複数方式で運用されている。

*独自のテレターミナル・第二世代デジタル・PHS(簡易型携帯電話システム):1989 年、世界初の無線パケットデータ専用の「テレターミナルサービス」や1993年、第二世代の世界トップ性能の「デジタル携帯電話」が導入された。1994年、端末の自由化で自由競争時代に入った。1995年、1.9GHz帯の日本独自技術のデジタルコードレス電話PHSがサービスされた。1999年、携帯電話のインターネット接続サービスが導入され、利用者が急増した。

*技術開発は周波数有効利用、伝送品質の向上、小型・軽量・経済化、多様化通信が推進されてきた。伝送方式の変遷は、モールス信号、アナログ方式、デジタル方式そしてインターネット、マルチメディア化へ、伝送メディアは音、データ、画像、映像へと進展している。第三世代携帯では世界のリーディング国になっている。

*移動通信発展の特徴は、社会や経済活動の複雑化、効率化、高度情報化にともなって多様なシステムがサービスされ、ケータイが「ライフパートナー」としての位置付けになった。携帯電話とインターネット・カメラ・放送・パソコンの融合が、「ユビキタス移動通信時代」を推進している。

*今後の開発課題は、第四世代移動通信システムのチャレンジングな開発、「フルIP(Internet　Protocol)方式」へのスムーズな移行、安全で安心な「ライフパートナー」としての移動通信システムの開発、認証・セキュリティ対策、オリジナルデバイスと擦り合わせ化技術による世界市場への挑戦、国際標準化の強力な推進等である。

誰でも使用できる制約のない、人間性重視の、使いやすく、安全で、安心なオンリーワンの「わがままなユビキタス通信システム」の官・民・学一体の開発推進が重要である。

■ Abstract

An investigation was conducted into the approximate 100-year history of public mobile communications technology. We looked at the development process, transitions in technology and services, and "technological systematization" and have shown the relationship between technological development and society, culture, economy, governmental radio wave administration, and foreign countries. Finally, we looked at the problems and factors that needed to be taken into consideration as the systems were developed and those that will need to be considered in the future.

*Wireless communications in Japan was initially developed independently from the rest of the world. The development history of Japanese radio technology differs from that of the wire communication which was imported from Europe and America. In fact, Japanese government-led wireless technology was, on occasion, superior to American and European technology. Research into wireless communication in Japan began in the research laboratories of the Communications Ministry in 1896. By the time of the Japanese-Russo War, the Japanese-developed 36-type radiotelegraph was playing an active part in the hostilities. The "TYK wireless telephone", the ancestor of the portable phone, was invented in 1912. In 1908, The Communications Ministry established the Choshi radio station which was the first radio communication station in Japan, and started a shore-to-ship public radio telegraph service. In 1929, the "Yosami Transmission Station" was established as the transmission station for Europe. In the 1940s, medium-wave and short-wave wireless telephone service were put into practical use using Japanese vacuum tube technology.

*The first car telephones and the third-generation portable systems in the world were developed in Japan. After World War II, mobile communications started dissemination. VHF-wave "police radios" using FM technology were developed for the first time, and maritime and train telephones were introduced. A portable telephone system using an automatic exchange connection was developed in 1967 for use during city disasters. The "pager" was introduced in 1968. Japan's first portable phone was exhibited at EXP01970 by Nippon Telegraph and Telephone Public Corpration in 1970. These technologies were then applied to portable and cordless phones. The first "cellular car telephone" in the world operated in the 800-MHz band was introduced in 1979. The single frequency cordless phone was introduced in 1980. Car telephone services by companies other than NTT began after the deregulation of communications, which began in 1985. The first "portable phone" service in Japan began in 1987. In 1989, the system using technology from the United States was introduced due to pressure applied by the U.S government in response to the trade imbalance between Japan and U.S. Then two systems of NTT and U.S. were operated anomalously. In 2001, the world's first "third-generation portable phone" was introduced by NTT DoCoMo. In 2002, au by KDDI introduced the a third-generation portable phone service that used a U.S. system. Since then, both Japanese and American systems have been used in Japan.

*Japanese original technology, TELETERMINAL, a second-generation digital and Personal Handy-phone System (PHS) : In 1989, "TELETERMINAL service" was introduced for the first service to send data as packet, and the world's most advanced second-generation "digital portable phone" was introduced in 1993. In 1994, with the deregulation for phone terminals, an age of free competition started. In 1995, PHS based on Japanese original technology operating in the 1.9GHz band entered the market place. Internet connection services for portable phones were introduced in 1999. The user increased rapidly.

*The technological development themes : Technological developments in mobile communications have been to use frequency resources more effectively, improve transmission quality, reduce the size, weight and cost of equipment, and diversify services. Over the years, signal transmission systems have evolved from simple Morse code to analog, to digital, and finally to Internet multimedia. What is actually being transmitted has advanced from sound only to data, to still images and finally to video. Japan is at the forefront of third-generation mobile phone technology in the world.

* Feature of development : The various systems are becoming more and more part of our everyday lives. A "Ubiquitous mobile communication age" is coming upon us as cellular phones can now access the Internet, incorporate cameras and broadcasting capabilities, and connect to personal computers.

*Future development subject : We are trying to develop the forth-generation mobile communication system. This will lead to "Full Internet Protocol (IP)" and the development of mobile communication systems such as "Life partner" that are safe, reliable and secure. We are challenging to supply the system to world market using original

devices and fitting technologies promote international standardization and so on.

What really matters is the promotion of co-development amongst nations, industries, and academia of ″fully flexible ubiquitous communications system″ that is usable by anyone without any restrictions, that is compatible with human nature, and is easy-touse, secure, and safe.

■ Contents

History of the Development of Beverage Vending Machine Technology in Japan

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Yoshihiro Higuchi

■ Abstract

Approximately 4.27 million vending machines were operating in Japan at the end of 2006, with annual sales in excess of 7 trillion yen. We have focused our research on beverage vending machines, because these account for over half of all the installed machines (at 2.60 million).

The first vending machine is thought to have been introduced at a temple in Alexandria in 215 BC. The machine dispensed holy water in return for a small coin. The oldest extant machines are cigarette-vending devices that were installed in English pubs and hostels as early as 1615. English inventors subsequently devised additional designs to sell books, postage stamps, and many other products as well, but the devices were not commercially practical. The first commercially viable vending machines were gum dispensers introduced in the United States. In Japan, the first viable machines were juice vending machines that appeared during the high-growth period following World War II.

While vending machines appear to work without human intervention, an entire support network is active behind the scenes. Machine makers, product manufacturers, operators, service personnel, and location owners are just some of the individuals involved in marketing and management efforts. Other individuals are responsible for route systems that carry out collection, replenishment, and service. When we look back at the history, we see that success rests on gaining the consumer's trust. In the case of beverage machines, the crucial requirements are to maintain merchandise in optimal drinking condition and to ensure safety.

Beverage machines fall into two major categories: the original type that pours the beverage into a cup, and the more recently developed type that delivers prepackaged drinks. The technologies for these two approaches are quite different. With cup-type machines, the machine operator is responsible for both preparing a good-tasting drink and maintaining the safety necessary to attract the consumer. With the prepackaged approach, however, the beverage maker controls the taste, while the machine operator focuses on how best to load containers into the machine and maintain them at optimal temperature.

As the technologies differ, so do the issues that machine designers and operators have to face. Cup-type machines are backed by a long history of development and improvement of basic taste-related components-storing of the ingredients, control of the temperature of the water used in the mix, manufacture of ice and carbonated water for the mix, mixing methods, coffee and tea extraction, cup transport, and so on. With container-type machines, efforts have gone into issues such as effective loading of containers, ease of sales work, design of reliable temperature-control racks, and the design of fast, reliable, container-friendly delivery systems.

Cash collection equipment for vending machines has been widely standardized, which in turn contributes to effective maintenance. Coin mechanisms have advanced from mechanical to electronic. Jamming in the coin channel, which was the biggest problem, has been greatly reduced and the number of supported coins has increased. Where early machines accepted 10-yen coins only, today's machines accept and dispense as change all four main denominations. Built-in electronics enable a wide range of convenient functions, such as display of the amount inserted, tracking and reporting of total sales, and diagnosis of machine errors.

Early coin mechanisms were driven by sequences of relays, but with the coming of the transistor age manufacturers began to incorporate various electronic components. The introduction of ICs and LSIs allowed for multiple functionality, and the subsequent introduction of microprocessors expanded functionality even further. Competition among machine makers spurred innovation, as machines advanced from full contact type (relays only) to hybrid types

(with transistors and ICs) and finally to programmed control. The evolution took some time, however, as manufacturers faced numerous quality issues all along the way.

Because vending devices are industrial machines, development of products and technologies in this area has been strongly needs oriented, and has largely been limited to the concept of cash processing. Japanese makers entered the field through technical tie-ups through which they imported the technologies for coin cradles and other basic components and moved toward standardization. They purchased patents for basic electronic coin collection technologies, then implemented various improvements to adapt the technology to the needs of Japanese society and environment.

But now that we have fully entered the electronics age, Japan's innovative technologies have positioned the country as a major vending-machine producer. History suggests that increased emphasis on elemental research (a "seeds-oriented" approach) can spur a continuous stream of development proposals, making it possible to break through current barriers and find new ways forward.

■ Profile

Yoshihiro Higuchi

Chief Survey Officer, Center of the History of Japanese Industrial Technology, National Museum of Nature and Science

March 1961:	Graduated from Meiji University Faculty of Engineering Department of Electrical Engineering
April 1961:	Started working for Sanyo Electric Co., Ltd. Involved in design and development of electronic refrigeration equipment and beverage vending machines for the planning, sales and quality assurance departments before being appointed the vice-director of the vending machine division.
March 1997:	Retired from Sanyo
April 1997:	Appointed as technical supervisor for the Japan Vending Machine Manufacturers Association
April 2006:	Appointed Chief Survey Officer of the Center of the History of Japanese Industrial Technology, National Museum of Nature and Science

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