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ИНОСТРАННЫЙ ЯЗЫК В ПРОФЕССИОНАЛЬНОЙ ДЕЯТЕЛЬНОСТИ

Методические указания к практическим занятиям

САМАРА
САМАРСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
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Иностранный язык в профессиональной деятельности: методические указания по английскому языку для студентов СПО / Сысуева И.Г.-Самара: Самарский государственный технический университет, 2024.

Методические указания предназначены для студентов, обучающихся по специальности среднего профессионального образования 08.02.13 Монтаж и эксплуатация внутренних сантехнических устройств кондиционирования воздуха и вентиляции.

Указания составлены в соответствии с программой курса Иностранный язык в профессиональной деятельности и предназначены для развития профессионально-коммуникативных умений и навыков у студентов энергетических специальностей

СОДЕРЖАНИЕ

ВВЕДЕНИЕ

Методические указания предназначены для студентов, обучающихся по специальности среднего профессионального образования 08.02.13 Монтаж и эксплуатация внутренних сантехнических устройств кондиционирования воздуха и вентиляции и осваивающих дисциплину Иностранный язык в профессиональной деятельности.

Целью методических указаний является подготовка обучающихся к применению английского языка в профессиональной сфере, что достигается при помощи соответствующих текстов и видео материалов со специально разработанной к ним системой упражнений. При этом используемые аутентичные материалы и упражнения направлены на работу над всеми видами речевой деятельности (чтение, письмо, аудирование и говорение) в объеме современных требований учебных программ для СПО по английскому языку.

Методические указания состоят из 8 разделов. Они включают тексты по специальности, обеспечены системой предтекстовых и послетекстовых упражнений; также содержат дополнительные тексты по темам, соответствующим профессиональным интересам студентов (Supplementary Reading).

UNIT 1
Polyethylene Pipes

1. Read and translate the text

HDPE (high –density polyethylene pipe) is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines. Made from the thermoplastic HDPE (high-density polyethylene), its high level of impermeability and strong molecular bond make it suitable for high pressure pipelines. HDPE pipe is used across the globe for applications such as water mains, gas mains, sewer mains, slurry transfer lines, rural irrigation, fire system supply lines, electrical and communication conduit, and storm water and drainage pipes.
Poly tubing, often referred to as PE tubing or polyethylene tubing is a flexible, lightweight, durable and corrosion resistant plastic that can be used for a wide range of liquid, gas and fluid transfer applications. Poly tubing is also FDA approved for use in food and beverage applications. Polyethylene tube is completely safe and is one of the most common PE tubing materials in the world. Freelin-Wade is one of the leading polyethylene tubing suppliers in the nation. With a wide range of size and color options, we can provide you with a polyethylene tubing product that meets your application requirement needs. **Contact Freelin-Wade** today for the high quality, long-lasting polyethylene tubes your application requires, or call us at **888-373-9233** and we will be happy to assist you with any poly tubing questions that you may have.

2. Answer the questions to the text.

1. What is HDPE?
2. How may a new pipe be classified?

3. What are the main characteristics of the pipe?
4. What kind of pipes do you know?
5. What can poly tubing be used for?

3. Choose the right variant

1. I am planning … (to visit/visiting) my granny next week. (Я планирую навестить бабулю на следующей неделе.)
2. When they finish … (to eat/eating) their lunch, they'll go to the office. (Когда они закончат обедать, они отправятся в офис.)
3. He suggested … (to buy/buying) some food. (Он предложил купить немного продуктов.)
4. Does Sally enjoy … (to go/going) to the gym? (Сэлли нравится ходить в тренажерный зал?)
5. Don't put off … (to write/writing) a report till the end of the month. (Не откладывай написание доклада до конца месяца.)
6. John refused … (to answer/answering) my question. (Джон отказался отвечать на мой вопрос.)
7. My brother intends … (to get/getting) married soon. (Мой брат намеревается скоро жениться.)

UNIT 2
Concrete. Types of Concrete

1. Read and translate the text

Concrete is considered to be a universal material for construction. Different kinds of concrete can be used practically for every building purpose. The raw materials for producing concrete can be found in every part of the world. The main property that makes concrete so popular is that it can be formed into strong monolithic slabs. Another good quality is its relatively low cost. Besides, concrete is known to be fire- and decay-resistant.

Concrete is produced by combining coarse and fine aggregates, Portland cement, and water. Coarse aggregate is generally gravel or crushed stone, and fine aggregate is sand. Cement, sand, gravel, and water are taken in proportional amounts and mixed. The quality of concrete depends mostly on the quality of the cement used. The process of production consists in pouring the mixed components into forms and holding them there until they harden. The process of hardening generally lasts for about 28 days.

There exist different ways of producing concrete. It can be produced by mixing the ingredients and pouring the mixture into position on the very site of building. Concrete can also be produced in a factory, and used as a material for manufacturing prefabricated blocks. Accordingly, there exist the so-called in-situ (cast-in-place) concrete and precast concrete.

Concrete, as any other building material, has not only advantages but also disadvantages. Its main disadvantage is that it has no form of its own. Also, it does not possess useful tensile strength. Because of these qualities, in modern times construction concrete is very frequently combined with different metals. Most common of them are iron and steel.

The introduction of metal into the structure of concrete is highly advantageous. It strengthens the material and helps to realize its limitless construction and architectural potential. It should be noted that the use of ferro-concrete started only in the nineteenth century and is still gaining popularity.

2. Translate the following sentences

1. What properties make concrete a highly used construction material?
2. What two types of aggregate are used for producing concrete?
3. Is sand a coarse or fine aggregate?
4. What ingredients does the quality of concrete depend upon?
5. How long does the process of hardening the mixed components last?
6. What is the difference between the so-called in-situ and precast concrete?
7. What quality is considered to be the main disadvantage of concrete?
8. For what reason is tensile strength considered to be an important quality?
9. For what purpose are metals introduced into the structure of concrete?
10. What metals is concrete frequently combined with?
11. When did the use of ferro-concrete start?
12. Would you like to live in a wooden or concrete building? Why?

3. Choose the right variant

1. Concrete as a building material possesses *(only advantages, both advantages and disadvantages)*.
2. Concrete is considered to be a *(universally used material, rarely used material)*.
3. One of the qualities of concrete is that *(it does not possess tensile strength, possesses tensile strength)*.
4. Ferro-concrete is *(rather popular, not popular)* in the modern construction.
5. Gravel is classified as *(coarse, fine)* aggregate.
6. One of the good qualities of concrete is its *(high, low)* cost.

7. Concrete *(decays and burns, does not decay and burn)*.

UNIT 3
The First Buildings

1. Read and translate the text

For many thousands of years people have lived in houses and 1iked comfortable and safe living, not so dependent on weather conditions. At first people began building houses of wood, stones or clay. Clay was mostly used in hot countries, as people had learnt that clay bricks dried in the sun became as hard as stones. Men learnt the use of these sun-dried
c1ay bricks especially in ancient Egypt. Some of buildings created at that time are still standing though several thousands of years passed. Hundreds of years later, the ancient Egyptians discovered that stone can be used as a building material. With it they built temples, palaces, tombs. .. The greatest tomb ever built was the stone pyramid of Khufu,
Pharaoh of Egypt. Another ancient civilization, the Greeks, also used stone, and their beautiful buildings remind us of their great culture. The Greeks decorated the houses with splendid carvings, they were very fond of using upright pillars for supporting and decoration. In Greece parts of many of these ancient buildings can still be seen today. The elements of ancient Greece architecture began to be used again during the period of the Renaissance in Europe. In our country the latest period when trends were followed was the period of „Stalin classicism‟. Greek culture was inherited by Roman one. The emperor August said that when he become emperor the Rome was made of clay and that he leaves Rome made of stone.
The Roman period left many architectural monuments, such as Colosseum, arch of Titus, Pantheon, and many other buildings and their relics. Ancient Rome embodied the tradition suppressed by time and followed to logical end. Many ancient cultures had their own architecture - ancient China, Burma, civilization of the American Indians. Archeologists find more and more p1aces 1eft by man for centuries - the legendary city Petra in Jordan which is hidden in the mountains, the city Machu-Picchu in Peru, 1eft for three centuries and found in 1911 by an American architect Hiram Bingham, a Buddhist temple Borobudur on Central Java (in Indonesia) forgot ten by everyone, bidden by thick forests. It was restored in the 1970s with the help of UNESCO.
Modem architecture is quite different from ancient buildings. In all epochs there are buildings that are designed to be beautiful and stand for centuries, and buildings which are built for practical purposes. In Soviet time buildings made from prefabricated Ьlocks were very popular and were erected very quickly. Their architectural style is very strict and devoid of any ornaments. The drawbacks of these buildings are: they conduct sound and give away heat, and nearly all of them exist longer than it was planned originally. This was the period when the idea of combination of architecture, technology and science was combined, and art gave way to constructivism.
Modem architecture is free to choose and combine all the experience accumulated during the centuries. There are hundreds and hundreds of buildings worth admiring in any country. New buildings that appear should match them in quality, longevity and beauty!

2. Study the words given below; make up sentences with these words.

1. accumulate - накапливать
2. admiration - восхищение
3. arch - арка
4. archaeologist - археолог
5. architectural - архитектурный
6. architecture - архитектура

7. art [a:t] искусство
8. block - блок, block of flats –многоквартирный дом
9. brick - кирпич
10. Buddhist - буддистский
11. carve - вырезать
12. civilization - цивилизация
13. classicism - классицизм
14. clay [kle1] глина
15. Colosseum - Колизей
16. combination - комбинация
17. combine - комбинировать, сочетать
18. concduct - проводить (физ.)
19. Construction - строительство
20. create - создавать
21. culture - культура
22. drawback - недостаток
23. dry - сушить
24. decoration - украшение
25. dependent - зависимый
26. devoid - лишенный
27. Egypt - Египет
28. Egyptian - *n* египтянин, египетский
29. Embody - воплощать
30. emperor - император
31. epoch - эпоха
32. erect [1"rekt] возводить
33. ever - когда-либо
34. everyone - каждый
35. follow - следовать
36. Indian - индиец, индеец; индийский, индейский
37. Indonesia - Индонезия
38. inherit - наследовать
39. Java - Ява (остров)
40. Jordan - Иордания
41. legendary - легендарный
42. live - жить
43. logical - логичный
44. longevity - долговечность
45. match - соответствовать
46. monument - монумент, памятник
47. originally - первоначально
48. ornament - орнамент
49. palace - дворец
50. Peru - Перу
51. pharaoh - фараон
52. pillar - столб, опора
53. plan - проектировать, планировать

54. prefabricated house - сборный дом
55. pyramid - пирамида
56. relics - останки
57. Renaissance - эпоха Возрождения
58. Roman - римский
59. safe - безопасный
60. sound - звук
61. splendid - великолепный, роскошный
62. stone - камень
63. strict - строгий
64. sun-dried - высушенный на солнце
65. suppress - подавлять, сдерживать
66. technology - технология
67. temple - храм
68. tomb [tu:m] могила, мавзолей
69. tradition - традиция
70. trend [trend] направление
71. wood [wud] дерево
72. worth стоящий

UNIT 4
Technology in construction

1. Read and translate the text

10 futuristic technologies that are changing construction

Technology in construction comes with devising innovative new ways of constructing and whilst the changing future of construction is largely unknown, there are some construction technology trends that are paving the way for certain futuristic construction technology.

1. Self-healing concrete

Millions of pounds are invested in maintaining, fixing and restoring roads, buildings, tunnels and bridges annually. This is because all concrete eventually cracks and needs to be restored. Self healing concrete would add years to a building‟s life and be an enormous help time-wise and financially.

The science behind this technological marvel shows itself when water enters a crack. This reactivates the bacteria that was mixed in during the mixing process. When the bacteria is activated, it excretes calcite which then heals the crack.

2. Transparent aluminium

Transparent aluminium is a bullet-proof new state of matter that is almost as strong as steel. Despite its herculean strength, it looks like glass which is four times weaker and shatters easily. Transparent aluminium is a new material and a see-through metal that is just breaking through the construction industry and adds a futuristic feel to buildings.

This new material is such advanced construction technology that it is made out of aluminium oxynitride (AION) and is created through the use of laser technology.

3. Aerogel insulation

Sometimes known as „frozen smoke‟, aerogel is semi-transparent and is produced by removing the liquid from a gel, leaving behind the silica structure which is 90% air. Despite being almost weightless, aerogel holds its shape and can be used to create thin sheets of aerogel fabric.

Aerogel fabric is beginning to be used within the construction industry, due to its incredible insulation properties. Aerogel insulation makes it extremely difficult for heat or cold to pass through and has up to four times the power of fibreglass or foam insulation.

4. Robotic swarm construction

Developed by researchers at Harvard, robotic swarm construction was designed based on how termites work. Termites work together like a „swarm‟ and construction robotics are programmed to work together in this manner.

Four-wheeled robots are programmed in each instance to build a certain design and come with sensors to detect the presence of other robots, so that they can work together.

5. 3D printed houses

3D printed houses are a glimpse into the future of construction. 3D printing homes will involve creating parts off-site and constructing the building on another occasion. It was pioneered by Apis Cor and based on San Francisco recently proved that they can 3D-print walls out of concrete in a relatively short space of time.

The „printer‟, which is similar in look to a small-scale crane, sets layers of concrete mixtures. 3D printed homes could be a great solution for quickly covering the housing needs of people who have been affected by physical disasters such as tsunamis, hurricanes and earthquakes or for those in poverty.

6. Smart roads

Also known as smart highways, smart roads are the future of transport and involve using sensors and IoT technology to make driving safer and greener. They give drivers real-time information regarding traffic information (congestion and parking availability for example) and weather conditions. This innovative technology can generate energy, charging electric vehicles on the move, as well as for street lights

7. Bamboo cities

Bamboo cities are cities made from innovative modular bamboo structures that interlock. It‟s a form of sustainable construction and a renewable resource that is stronger than steel and more resilient than concrete. The purpose is to hold a new community in the trees and as the number of inhabitants increases, the structure will extend to accommodate this.

As the structure extends to accommodate the number of people, it grows in strength. Modular structures are incredibly scalable and can grow in any direction, making it perfect for a city in the trees. Another added bonus – they can resist earthquake tremors due to bamboo‟s high flexibility.

8. Smart bricks

Smart bricks are modular connecting bricks and are similar to „Lego.‟ Made out of high strength concrete and developed by „Kite Bricks‟, smart bricks are versatile and come with substantial thermal energy control and a reduction in construction costs. As they are modularly designed, they are easy to connect and have space for insulation, electricity and plumbing.

9. Vertical cities

Vertical cities may soon become reality as the world‟s population grows and land increasingly becomes scarce. They are tetris-like buildings of towers for thousands of people to inhabit. Supporting an blooming population, vertical cities are a space-saving solution to preserve land for food, nature and production.

10. Pollution fighting buildings

Also known as „vertical forests‟, they are high-rise forest buildings designed to tackle air pollution. Pollution fighting buildings will be home to over 1,000 trees and 2,500 shrubs to absorb pollution in the air and to help filter it to make the air cleaner. Trees are highly productive in absorbing carbon dioxide, making this a cost-effective construction innovation.

2. Make 5 questions to the text

UNIT 5
Construction Design

1. Read and translate the text

In the industrialized world, construction usually involves the translation of designs into reality. A formal design team may be assembled to plan the physical proceedings, and to integrate those proceedings with the other parts. The design usually consists of drawings and specifications, usually prepared by a design team including architect, civil engineers, mechanical engineers, electrical engineers, structural engineers, fire protection engineers, planning consultants, architectural consultants, and archaeological consultants. The design team is most commonly employed by (i.e. in contract with) the property owner. Under this system, once the design is completed by the design team, a number of construction companies or construction management companies may then be asked to make a bid for the work, either based directly on the design, or on the basis of drawings and a bill of quantities provided by a quantity surveyor. Following evaluation of bids, the owner typically awards a contract to the most cost efficient bidder.

The best modern trend in design is toward integration of previously separated specialties, especially among large firms. In the past, architects, interior designers, engineers, developers, construction managers, and general contractors were more likely to be entirely separate companies, even in the larger firms. Presently, a firm that is nominally an "architecture" or "construction management" firm may have experts from all related fields as employees, or to have an associated company that provides each necessary skill. Thus, each such firm may offer itself as "one-stop shopping" for a construction project, from beginning to end. This is designated as a "design build" contract where the contractor is given a performance specification and must undertake the project from design to construction, while adhering to the performance specifications.

Several project structures can assist the owner in this integration, including design-build, partnering and construction management. In general, each of these project structures allows the owner to integrate the services of architects, interior designers, engineers and constructors throughout design and construction. In response, many companies are growing beyond traditional offerings of design or construction services alone and are placing more emphasis on establishing relationships with other necessary participants through the design-build process.

The increasing complexity of construction projects creates the need for design professionals trained in all phases of the project's life-cycle and develop an appreciation of the building as an advanced technological system requiring close integration of many sub-systems and their individual components, including sustainability. Building engineering is an emerging discipline that attempts to meet this new challenge.

2. Answer the questions to the text.

1. What does construction design involve?
2. What is the best modern trend in design?
3. What can you tell us about construction design?
4. Would you like to be a building designer or a building engineer

UNIT 6
Types of Houses

1. Read and translate the text

People used to live in caves. Later they lived in castles. We live in houses or blocks of flats. There a few different types of houses: detached, semi-detached, terraced and flats. I like socialising so my favourite one will be a flat in a huge block of flats.

England has many types of homes. In the large cities, people often live in apartments, which are called flats. In most towns, there are streets of houses joined together in long rows. They are several houses joined together and called terraced houses. Detached: it is a house, which is not joined to another house. Semi-detached: it is a house, which is joined to another house on one side; or two houses joined.

Flats: they are part of a bigger building where all the flats share a front door; they are called "apartments" in American English. Bungalow: it is a house, which is only on one floor, no stairs. It may be joined to another bungalow or might stand-alone. The most popular type of home in England is semi-detached (more than 27% of all homes), closely followed by detached then terraced.

My ideal house is a private big three rooms one and some land for kitchen garden and some fruit trees. There will not much furniture which is built in. In conclusion, I‟d like to say that it doesn‟t matter what house you live in, it matters how comfortable you made it, feel relaxed and safe.

2. Translate from Russian into English

1. бывало жили …
2. многоквартирный дом …
3. в длинных рядах …
4. мой идеальный дом …
5. в заключении …
6. не имеет значения …
7. встроенная мебель …
8. он может быть присоединен к другому …

UNIT 7
Houses in Different Countries

1. Read and translate the text

1. Flats:

These types of houses are most popular in more urban/city-like areas such as London and Birmingham. This is because they save a lot of space and provide accommodation for many people within a single building. A block of flats has multiple flats within it, depending on the height and overall size of the building. This type of property is ideal for a smaller family, single person or someone on a lower income.

2. 2-Level Flats:

A different type of flat that exists in the UK is the 2-level flat *(also known as a maisonette or duplex flat)*. These are types of flats which contain two floors within one household, meaning that they have a built-in staircase and their overall living space is split into two levels rather than just on the one, like in a typical flat.

3. Studio Flats:

Another property type is the studio flat. This sort of flat combines a kitchen, bedroom and living space in one large open space. A studio flat would be ideal for a single person or a couple as there is usually not enough room for a whole family and the space is not separated by any room.

4. Converted Flats:

This is not your typical „flat‟. It is characteristically an older, larger house which has been split into two houses – the top floor and ground floor (also known as a „period conversion‟). Converted flats aren‟t always split into two, depending on the initial size of the house, they can be divided into several households. Residing in this kind of property can be extremely noisy. This is because the house was originally built for a whole family and so is not made as soundproof like newer „blocks‟ of flats would be.

5. Detached Houses:

Also included in our list of the different types of houses is the detached house. Detached houses are single houses which are not connected to another house or building and consequently, these houses are viewed as more private. This type of house, more often than not, has both a large front and back garden as well as a driveway, as its space is not restricted by other buildings nearby. These properties are usually extremely expensive but are a common choice for those with larger families.

6. Semi-detached Houses:

Another house type that is similar to the popular „detached house, is the semi-detached. Semi-detached houses are simply coupled together via a wall on only one side. This saves more space on the given road. These types of houses are often much cheaper than the de

7. Terraced Houses:

This property type is attached, on both sides, to other houses. A terrace house is on a row of comparable houses attached to one another by their side walls. These are very popular type of houses in the UK and are especially prevalent in larger cities with denser populations making them a common source of accommodation for the working-class centuries ago. This particular property type saves a lot of space (not as much as a block of flats) and if you‟re looking to buy a house, a terraced house tends to be on the lower scale of the price range.

8. End of Terrace House:

It‟s easy to guess what type of house this is. Correct – the end of a line of terraced houses. This has very similar properties and features to a semi-detached house. This type of house only shares a wall on one side and not on the other.

9. Cottages:

These property types are often seen in more rural areas; on farms and in the countryside. A cottage is a small house, typically quite old-fashioned. These sorts of houses can have either one or two storeies, with the second level usually being smaller than the ground level. This type of property has very thick, strong walls which succeed in enduring the cold in the winter months. In addition, this type of house can often be used as a holiday/summer home for families who wish to spend time in a more rural, natural area – away from the busy cities.

10. Bungalows:

This type of home is quite unique. It is a single-storey house and is also detached from other houses. It is a shorter-looking house due to a lack of a second or third level. However, occasionally, bungalows have a room or two based in the „roof‟. The origin of the word „bungalow‟ comes from the word „baṅglā‟ which means „belonging to Bengal‟. This is because bungalows were first built for Europeans who settled in Bengal in the 17th century.

11. Mansions:

A mansion is the largest house of them all. This house is also the most expensive out of all the different types of houses in the UK. This is usually a place full of rich residents. The typical mansion consists of multiple large rooms, many floors and a huge garden, composed of many acres of land. If you‟re lucky enough to own a mansion, you will most probably have a pool, if not two (indoor and outdoor).
These are the main different types of houses found in the UK. Choosing the right property type can be a difficult process as there and pros and cons to all kinds of housing. However, it is important to be familiar

with all the different types of houses, so you can make a well-informed decision about what your next house should be. If you‟re looking to sell any of these types of houses, Fast Sale Homes buy any house!

2. Translate some expressions

1. экономит много пространства …
2. двухуровневая квартира …
3. совмещать …
4. разделенный на ….
5. не ограниченный …
6. намного дешевле …
7. таунхаусы . ..
8. свойства и особенности …

UNIT 8
Incredible Famous Buildings

1. Read and translate the text

The world's most famous buildings can be a great source of inspiration for designers and artists. Whether it's the structural shapes, unique design concept or decorative details, buildings can provide ample inspiration for design projects of all kinds. Tourists travel the globe to seek out unique or historical architecture, and often visiting a famous building is one of the most memorable parts of a trip abroad.
A country's most famous buildings can tell us a lot about its way of life and the culture during the period when it was built; a bit like looking at a historical photograph. But unlike a photo, buildings continue to change after construction is finished. The usual wear and tear demands renovation and the changing tastes of society have their own impact on the design and functionality of a building.
In this article, we've rounded up some most incredible famous buildings for you to marvel at – these structures are amongst the most Instagrammable places in the world. You might want to plan visiting a few of them on your next trip. If so, make sure you brush up on your photography skills before you go, or perhaps try some of our top sketching tips so you can bring your own version home with you.
The Notre Dame de Paris has long been one of the world's most celebrated cathedrals, and the spotlight has been firmly on this famous building since April 209, when a fire devastated the structure. We've included it on our list to remember it in its full glory. Construction began on this cathedral in 1160, and the building has since had a peppered history of destruction and reconstruction. Hopefully this next reconstruction will transform it to its past majesty, or perhaps take it in an exciting new direction.
The Heydar Aliyev Center is one of the most famous buildings designed by celebrated Iraqi-British architect Zaha Hadid. It's located in Baku, Azerbaijan, and is one of the newer designs on this list, having been completed in 2012. The design is noted for its distinctive, flowing lines and lack of sharp angles.

Zaha Hadid Architects was awarded the commission following a competition in 2007. On the practice's website, it explains the motivation behind the design: "The Center... breaks from the rigid and often monumental Soviet architecture that is so prevalent in Baku, aspiring instead to express the... optimism of a nation that looks to the future."
The Lotus Temple is a Bahá'í House of Worship in New Delhi consisting of 27 structures resembling petals of the lotus flower that open onto a central hall around 40m high. It has nine sides, nine doors, and can accommodate 2,500 people. Its surface is made of white marble from Mount Pentelicus in Greece, the same marble used to build the Parthenon.
Since its completion in 1986 it has become one of the most visited buildings in the world, attracting over 100 million people.

London's most iconic building, St Paul's Cathedral, was designed by English architect Sir Christopher Wren. Sitting at the top of Ludgate Hill, the highest point in the City of London, its famous dome is one of the world's largest, measuring nearly 112 metres high.
The original church on the site was founded in the year 604AD. Work on the present English Baroque church began in the 17th Century by Christopher Wren as part of a major rebuilding program after the Great Fire of London.
Wren started working on St Paul's in 1666, his designs for the cathedral taking nine years to complete and the actual construction taking a further 35 years. St Paul's has played an integral part of London life ever since – as a domineering element in the city's skyline, as a centre for tourism and religious worship, and most recently as a focal point for anticapitalist protests.

2. Answer the questions to the text.

1. What famous building do you know?
2. Where is it situated?
3. Who is the architect of this building?
4. What does it look like?
5. What does it impressed on you?

Supplementary Reading

COMPUTER PROGRAMMING LANGUAGES

The CPU of a computer – whether in a microcomputer or the largest mainframe – is programmed in binary code. It is almost impossible for humans to use binary code for programming. The nearest usable language to the binary code that the CPU needs is Assembly Language. Assembly Language instructions have a one-for-one correspondence to machine instructions: in other words, each Assembly Language instruction has an exact equivalent in binary code.

Assembly Language is not easy to learn, and it takes a long time to program a computer to do anything useful. An Assembly Language program to input two six-digit decimal numbers and divide one into the other, expressing the result as a decimal number, would take an experienced Assembly Language programmer a full week to write. Clearly there needs to be an easier way.

Assembly Language is known as a low-level language because it is close to machine language. Other computer languages are much nearer to English, and are consequently easier to learn. Such languages can make it much simpler to program a computer, and are used wherever possible. Such computer languages are called high-level languages. Programming languages are called "low level" when they are dose to machine language and don't look like English. They are called "high level" when they are nearer to English.

There are two classes of high-level language: compiled languages and interpreted languages. Both translate something closer to English into a code understood by the CPU, but they do it in different ways. We will start by looking at the most widely used computer language of all, BASIC. The name is an acronym for Beginners All-purpose Symbolic Instruction Code, and it was first used in the USA for teaching programming to university students, but has since been developed and extended until it can be used for a wide range of programming applications. BASIC is an interpreted language. A long and complex program (written in Assembly Language!) is kept in the ROM or RAM – this program is the BASIC Interpreter, and translates a program written in BASIC language into the binary code that CPU requires. One of the most popular compiled languages is still Pascal. The name is not an acronym this time, but is a tribute to Blaise Pascal, a seventeenth-century mathematician and philosopher. Pascal was designed at the outset to be a compiled language, and also to have a form such that its users are almost forced to write programs in an orderly, understandable way. Pascal compilers do not actually compile directly to machine code. Instead, they compile into an intermediate form called a Pcode; the P-code is itself then run as an interpreted "language", using a P-code interpreter! However, the "interpreter" is generally called a translator in this context, and the result is something that runs a lot faster than an interpreted language, because all the hard part of the translation (Pascal to P-code) is done before running the program.

The speed of a compiled language is a function of the quality of the compiler – all else being equal, the better the compiler, the faster the object code will run. The skill in writing a compiler is in getting it to produce a relatively economic code. There are, of course, many different high-level programming languages. They are easier to write than Assembly Language, and they all run more slowly, for no compiler or interpreter has yet been written that can equal well-written Assembly Language for efficiency. Programming computers is something people can still do better than computers!

One of the oldest programming languages (and still going strong!) is FORTRAN (FORmula TRANslator). It is an excellent language for science and mathematics, and bears a close similarity to BASIC, which was developed from it.

Another language that is still widely used is COBOL (Common Business Oriented Language) which is good for producing lots of long reports, inventory and stock control, but too "wordy" for scientific work, graphic programs or mathematics. Pascal itself is a good general-purpose language, but is not particularly good for control applications. For heavy-weight applications – defence networks, for example – languages like FORTH and Ada are used. For experiments in artificial intelligence (trying to make a computer behave like a person) a language called LISP is often used.

For applications programming where transportability (jargon for ease of translation for different makes of microprocessor and computer) is important, the programming language C, and its newer variants C+ and C++, are supreme. C++ is the language of choice for most commercial and scientific applications, because it is sufficiently low level to provide a very good speed of execution, it puts detailed control of the machine into the programmer's hands, and it is transportable.

LOVE AT FIRST BYTE

From opposite ends of the U.S., they carried on the computer industry's fiercest rivalry. Based outside New York City, International Business Machines has long looked down on Apple Computer, dismissing it as a ragtag bunch of rabble-rousers. Far away in California's Silicon Valley, Apple (1990 revenues: $5.6 billion) attacked IBM ($69 billion) as an impersonal bureaucracy, mocking the company in TV ads as Big Brother and depicting its customers as lemmings. The warring companies forced computer users to choose sides, sometimes dividing family members against one another. Those wanting easy-to-use software favored Apple, while others threw their lot behind IBM because its PCs were backed by a wider assortment of programs.

But in a rapidly changing industry, IBM and Apple have found much in common lately. After years of dominating their own spheres of influence, they now face similar woes: declining market share, relentless low-cost competitors and rapidly aging technology. While IBM and Apple remain the biggest players, with a combined market share of 38%, their rivalry has lost its potency, as brand loyalty has given way to price competition. Today IBM and Apple are more like a pair of aging prizefighters whose bout gets second billing.

The two companies decided last week to put away their boxing gloves. IBM and Apple plan to join forces and share technology in a potentially powerful partnership that could reshape the computer industry. The culmination of week of negotiations, the collaboration could help plug large gaps in their product lines and position both companies for the future. Among the elements:

- The two companies will form a joint venture to develop an advanced operating system, the basic controlling software of computers, which IBM and Apple will use in their machines and sell to other companies.
- Apple's user-friendly Macintosh system will be integrated into IBM's product line, including the large computers that serve as the heart of corporate systems.
- Apple will gain access to IBM's advanced, high-speed microprocessors, which will be incorporated into future editions of the Macintosh and other machines.
- The two computer makers will seek to develop a new generation of highpowered, multimedia hardware and software, which could be marketed under both brand names.

The deal represents a major realignment in the PC industry. "Who would have thought these two companies could possibly see eye to eye on anything? It's like a surfer girl marrying a banker," declared Richard Shaner, publisher of Computer-Letter. If the venture is successful, adds Shaffer, "it could create the most fearsome force in computing ever." Machines made by the two companies could become virtual look-alikes, which would not only eliminate the need for consumers to choose sides but also end much of the confusion prevalent in the industry over the lack of standards.

None of this would have been thinkable a decade ago. Apple founders Steven Jobs and Stephen Wozniak were riding high on the widespread acceptance of their best seller, the Apple He, when IBM launched its PC in 1981. While it was bulky, expensive ($2,600, vs. $1,395 for the Apple machine) and difficult to use, the PC was quickly adopted as the industry standard because IBM had a lock on the Big Business market. Apple eventually sold nearly 3 million of its He's, mainly for school and home use, but the company was largely shunned by corporations.

When Apple unveiled the revolutionary Macintosh in 1984, the rivalry with IBM reached full boil. Taking on Big Blue had become an obsession for the Silicon Valley boys, who called themselves "Bluebusters." Jobs launched Macintosh with an evangelistic zeal, exhorting an auditorium packed with dealers, customers and employees, "IBM wants it all end is aiming its guns on its last obstacle to industry control, Apple. Will Big Blue dominate the entire computer industry...? Was George Orwell right?" As the frenzied crowd shouted a chorus of "No!," Jobs cued a now notorious TV commercial known as "1984,"which was to run only once, during the Super Bowl football game.

The ad showed workers staring zombie-like at a Big Brother on a viewing screen, which a heroic female athlete smashed with a sledgehammer.

Offering stunning graphics and a stylish design, the Macintosh caught on well in the home and school markets, where Apple's machines now outsell IBM's by a two-to-one margin. Big Blue has always been frustrated in those markets. In the mid-80s, IBM offered the PCjr, a stripped-down version of its best seller, but the machine flopped because it couldn't operate many of the heavy-duty software programs designed for the PC. Yet IBM has virtually locked Apple out of the office market, mainly because IBM's operating software has been adopted for 90% of the PCs now in operation. Apple has never been able to match its rival's marketing clout either. The California Company's sales force is about a tenth the size of IBM's.

Lately, changes in industry taste have reduced the relevance of the IBM Apple rivalry. Rather than choose sides, customers now insist that computers work together in networks, regardless of the make or model. That has harmed Apple, since its operating software is not the most compatible. But it has been no blessing for IBM either, because its operating system is so common that customers often prefer to buy clone machines that work like IBM's but cost less. Customers have become more concerned about price than brand names or even high performance. That has turned things upside down for IBM and Apple, which find themselves struggling to make their products less distinctive and more compatible with their other rivals. Apple has developed desktop computers that not only run its Macintosh software system but also use the same disk operating system or DOS used by IBM models. And Big Blue has countered with desktop computers that are more user friendly, in the spirit of Macintosh.

Yet neither IBM nor Apple has been able to halt customer defections. IBM's market share in PCs has dropped by half, to 23%, while Apple's has declined to 15%, from 18%. The changing marketplace has forced both companies to make some painful adjustments. In the largest layoff in the company's history, Apple will now pare 1,500jobs from its payroll, a reduction of about 10%. The company is expected to post an earnings decline for the past quarter, largely because of price cutting. IBM, which during the January-March period reported the first quarterly loss in its 80-year history, plans to reduce its labor force by some 14,000 workers this year, a 4% cut.

Another problem that drove IBM and Apple into each other's arms is their growing friction with some powerful partners, most notably Microsoft, the software giant outside Seattle, which is ran by wunder-kind billionaire William Gates III. Microsoft was the creator of MS-DOS, the software that runs the IBM PC, but the two companies have had a falling out over the next generation, called OS/2, which runs IBM's line of PS/2 computers. Microsoft developed OS/2as well, but IBM believes the software company has undermined sales of that software by pushing a highly successful program called Windows 3.0, which enables old MS-DOS software to work much like a Macintosh. That has also alienated Apple, which contends that Microsoft stole elements of Windows from Macintosh programs. The new IBM-Apple venture, which will develop its own software, could spell the end of OS/2 and any remaining relationship with Microsoft. "We're flabbergasted," says Steven Ballmer, Microsoft's senior vice president. "This does not bode well for future cooperation between IBM and Microsoft."

The new alliance scorns another powerful company, Intel, which has supplied the microprocessors for IBM's machines and has commanded an almost monopoly position as a maker of IBM-compatible chips. Possibly to foster more competition, the new partnership says it will buy advanced processors from Illinois-based Motorola, whose chip business has been suffering lately because some of its big customers, including Unisys have been in decline. IBM has been busy lining up other partnerships as well. Only a day after announcing its deal with Apple, IBM said it would join forces with Germany's Siemens A.G.to produce a powerful new 16-mega-bit memory chip, which will hold four times as much data as current models. The collaboration could give IBM-Siemens a leg up in the race against Japanese companies to bring the new chip to market.

The IBM-Apple combination has its risks. Most PC joint ventures have foundered, and this one will have to stand the test of vastly differing corporate cultures. Consumers could be disillusioned with both companies at first, viewing Apple as selling out and IBM as consorting with free spirits from the West Coast. But if the collaboration works as well in practice as it is planned on paper, the biggest winners will be the customers. Consumers will no longer have to worry about divided loyalties and incompatible programs. They won't be in Apple's orbit or IBM's, but in the best of both computer worlds.

MICHAEL FARADAY

Michael Faraday (1791–1867), one of the greatest men of science, had little chance to get an education. His father was a blacksmith who made his living in the heat of his forge, and Faraday was born to work with his hands, too.

Being thirteen years of age, he went as apprentice to learn book-binding. He read many of the books he had to bind and made clear and careful notes from those books that interested him most. Once when binding an encyclopedia, he ran across an article on electricity. When Faraday turned to that page and began to read, he knew nothing of the subject, but it struck his imagination and aroused his interest. With the little money he could save, he bought a cheap and simple apparatus and set to make experiments. The farther he went along the road, the more interested lie became.

He attended the lectures of Humphry Davy, an outstanding scientist and the most popular lecturer in London at that time. It was Davy who helped Faraday to become an assistant at the laboratory of the Royal Institute and to get a profounder knowledge of the subject.

While still an assistant he helped Davy to create a safety lamp for miners. He learned chemistry, lectured to young people interested in science and wrote for a quarterly scientific journal.

In his spare moments Faraday was working on the problem of turning gases, into liquids. We know him to have heated hydrate of chlorine in a sealed tube and thus to have succeeded in liquefying chlorine. An important discovery of Faraday was that of benzol which he separated from condensed oil gas, and which since then found world-wide application.

For several years he is known to have been working at the problem of a perfect optical glass and to Lave made a glass that greatly improved the telescope.

Yet the problem of electricity and magnetism interested him above all. All scientific worlds had known by that time that if a current is run through a copper wire wound around a piece of iron, the iron becomes a magnet. If electricity magnetizes, why won't magnetism electrify? That was the question Faraday asked himself over and over. For a long time, he tried different experiments to solve the problem. At last, in 1831 he made his major discovery in the field of electricity – the electromagnetic induction.

But Faraday's work on electricity could not end at this point. He set about testing electricity from every known source and after a series of tests came to the conclusion that electricity, whatever the source may be, is identical in its nature.

Among a number of other discoveries, he is also known to have measured for the first time the electric current, and to have made several important observations on the conductivity of different materials. Although Faraday enjoyed world-wide popularity, he remained a modest man never wanting either to accept high titles or to get any money out of his numerous discoveries. He was one of those great men who made possible the age of electricity in which we live, all the marvels it brings us and all those it may bring to the future generations.

THE DISCOVERY OF ELECTO-MAGNETIC INDUCTION

It is at this important juncture in the history of electrical research 49 that we see the first, shy attempts to make the force of Nature do some work. Now we are concerned with the development of electricity for the transmission of energy.

One day in 1819 a Danish physicist Hans Christian Oersted, was lecturing at the University of Kiel, which was then a Danish town. Demonstrating a galvanic battery, he held up a wire leading from it when it suddenly slipped out of his hand and fell on the table across a marine's compass that happened to be there. As he picked up the wire again he noticed to his astonishment that the needle of the compass no longer pointed north, but had swung completely out of position. He switched the current off, and the needle pointed north again.

For a few months he thought over this incident, and eventually wrote a short report on it. No one could have been more surprised than Oersted at the extraordinary impact which his discovery made on Physicists all over Europe and America. At last the long sought connection between electricity and magnetism had been found! Yet neither Oersted nor his colleagues could for see the importance of this phenomenon, for it is the connection between electricity, and magnetism on which the entire, practical use of electricity in our time is founded!

What was it that Oersted had discovered? Nothing more than that an electrically charged conductor, such as the wire, leading from a battery, is the centre of a magnetic "field", and this has the effect of turning a magnetic needle at a right angle with the direction in which the current is flowing; not quite at a right angle, though, because the magnetism of the earth also influences the needle. Now the physicists had a reliable means of measuring the strength of a weak electric current flowing through a conductor; the galvanoscope, or galvanometer, such a simple instrument consisting of a few wire loops and a magnetic needle whose deflection indicates the strength of the current.

Prompted by the research work of Andre-Marie Ampere, the great French physicist whose name has become a household word as the unit of the electric current, the Englishman Sturgeon experimented with ordinary, non-magnetized iron. He found that any piece of soft iron could be turned into a temporary magnet by putting it in the centre of a coil of insulated wire and making an electric current flow through the coil. As soon and as long as the current was turned on the iron was magnetic, but it ceased to be a magnet when there was no 50 more current. Sturgeon built the first large electro-magnet, and with this achievement there began the development of the electrical telegraph and later the telephone.

But there was yet another, and perhaps even more important, development which began with the electro-magnet. Michael Faraday repeated the experiments of Oersted, Sturgeon, and Ampere. His brilliant mind conceived this idea: if electricity could produce magnetism, perhaps magnetism could produce electricity!

But how? For a long time he searched in vain for an answer. Every time he went for a walk in one of London's parks he carried a little coil and a piece of iron in his pocket, taking them out now and then to look at them. It was on such a walk that he found the solution. Suddenly, one day in 1830, in the midst of Green Park (so the story goes), he knew it: the way to produce electricity by magnetism was to produce it by motion.

He hurried to his laboratory and put his theory to the test. It was correct. A stationary magnet does not produce electricity. But when a magnet is pushed into a wire coil current begins to flow in the coil; when the magnet is pulled out again, the current flows in the opposite direction. This phenomenon, confirms the basic fact that the electric current cannot be produced out of nothing – some work must be done to produce it. Electricity is only a form of energy; it is not a "prime mover" in itself.

What Faraday had discovered was the technique of electromagnetic induction, on which the whole edifice of electrical engineering rests. He soon found that there were various ways of transforming motion into electric current. Instead of moving the magnet in and out of the wire coil you can move the coil towards and away from the magnet; or you can generate electricity by changing the strength of stationary magnet; or you can produce a current in one of two coils by moving them towards and away from each other while a current is flowing in the second.

Faraday then substituted a magnet for the second coil and observed the same effect. Using two coils wound on separate sections of a dosed iron ring, with one coil connected to a galvanometer and the other to a battery, he noticed that when the circuit of the second coil was closed the galvanometer needle pointed first in one direction and then returned to its zero position. When he interrupted the battery circuit, the galvanometer jerked into the opposite direction. Eventually, he made a 12-inch-wide copper disc which he rotated between the poles of strong horse-shoe magnet: the electric current which was generated in the copper disc could be obtained from springs or wire brushes touching the edge and axis of the disc.

Thus Faraday demonstrated quite a number of ways which motion could be translated into electricity. His fellow-scientists at the Royal Institution and in other countries were amazed and impressed – yet neither he nor they proceeded to make practical use of his discoveries, and nearly forty years went by before the first electric generator, or dynamo, was built.

Meanwhile, fundamental research into the manifold problems of electricity continued. In America, Joseph Henry, professor of mathematics and natural science, also starting from Oersted's and Sturgeon's observations, used the action of the electric current upon a magnet to build the first primitive electric motor in 1829. At about the same time, George Simon Ohm, a German school-teacher found the important law of electric resistance: that the amount of current in a wire circuit decreases with the length of the wire, which acts as resistance. Ohm's excellent research work remained almost unnoticed during his lifetime, and he died before his name was accepted as that of the unit of electrical resistance.

EDISON' LIGHTING SYSTEM

It was only in the last quarter of the nineteenth century that electricity began to play its part in modern civilization, and the man who achieved more in this field of practical engineering than any of his contemporaries was the American inventor, Thomas Alva Edison. His dramatic career is too well known, and has been described too often, to be told again; it may suffice to recall that he became interested in the problem of electric lighting in 1877, and began to tackle it with the systematic energy which distinguished him from so many other inventors of his time. Edison was no scientist and never bothered much about theories and fundamental laws of Nature; he was a technician pure and simple, and a very good business man as well.

He knew what had been done in the field of electric lighting before his time, and he had seen some appliances of his contemporaries, such as the arclamp illuminations which had been installed here and there. Two sticks of carbon, nearly touching, can be made to produce an electric arc which closes the circuit. Many scientists and inventors who tried to tackle the problem were therefore convinced that only incandescent electric light – produced by some substance glowing in a vacuum so that it cannot burn up – could ever replace gas lighting, then the universal system of illumination in Europe and America.

Edison put his entire laboratories at Menlo Park to the task of developing such a lamp. The most important question was that of a suitable material for the filament. He experimented with wires of various metals, bamboo fiber, human hair, paper; everything was carbonized and tried out in glass bulbs from which the air had been exhausted. In the end – it is said that a button hanging thread on his jacket gave him the idea – he found that ordinary sewing thread, carefully carbonized and inserted in the airless bulb, was the most suitable material. His first experimental lamp of 1879 shed, its soft, yellowish light for forty hours: the incandescent electric lamp was born.

It was, no doubt, one of the greatest achievements in the history of modern invention. Yet Edison was a practical man who knew well that the introduction of this revolutionary system of illumination must be properly prepared. He worked out methods for mass-producing electric bulbs at low cost, and devised circuits for feeding any number of bulbs with current. He found that 110/220 volts was the most suitable potential difference and would reduce transmission losses of current to a minimum – he could not have foreseen that the introduction of that voltage was to set the standard for n century of electric lighting. But most important of all "accessories" of the lamp was the generator that could produce the necessary high-tension current.

Since Faraday's ingenious discovery of the way in which movement could be transformed into electricity, only a small number of engineers had tried to build generators based on this principle. But none of these generators answered the particular requirements of Edison's electric light: so he had to design his own generator, which he did so well that his system – apart from minor improvements and of course the size of the machines – is still in general use today.

It is little known that the first application of Edison's lighting system was on board an arctic-expedition steamer, the "Jeanette", which the inventor himself equipped with lamps and a generator only a few weeks after his first lamp had lit up at Menlo Park. The installation worked quite satisfactorily until the ship was crushed in, the polar ice two years later.

Edison, a superb showman as well as a brilliant inventor, introduced his electric lamp to the world by illuminating his own laboratories at Menlo Park with 500 bulbs in 1880. It caused a sensation. From dusk to midnight, visitors trooped around the laboratories, which Edison had thrown open for the purpose, regarding the softly glowing lamps with boundless admiration. Extra trains were run from New York, and engineers crossed the Atlantic from Europe to see the new marvel. There was much talk about the end of gas-lighting, and gas shares slumped on the stock exchanges of the world. But a famous Berlin engineer – none other than Werner von Siemens, who later became Edison's great rival in central Europe – pronounced that electric light would never take the place of gas. When Edison showed his lamps for the first time in Europe, at the Paris Exhibition of 1881, a well-known French industrialist said that this would also be the last time.

Meanwhile, however, Edison staked his money and reputation on a largescale installation in the middle of New York. He bought a site on Pearl Street, moved into it with a small army of technicians, and built six large direct-current generators, altogether of 900 h.p., powered by steam-engines. Several miles of streets were dug up for the electric cables – also designed and manufactured by Edison – to be laid, and eighty-five buildings were wired for illumination. On 4 September 1881 New Yorkers had their first glimpse of the electric age when 2,300 incandescent lamps began to glow at the throwing of a switch in the Pearl Street power station. Electric lighting had come to stay. And what was most important: Edison had finally established a practical method of supplying electricity to the homes of the people.

Pearl Street was not the first generator station to be built. A 1 h.p. generator for the supply of current for Edison lamps was built in 1881. In Germany, Werner von Siemens did more than any other engineer for the introduction of electric lighting, in which he had first refused to believe, by perfecting his "dynamo", as he called the generator for continuous current.

Spectacular as the advent of electric lighting was, it represented only one aspect of the use of electricity, which was rapidly gaining in popularity among industrial engineers. For a century, the reciprocating steam-engine had been the only important man-made source of mechanical energy. Bui its power was limited to the place where it operated; there was no way of transmitting that power to some other place where it might have been required. For the first time, there was now an efficient means of distributing energy for lighting up homes and factories, and for supplying engines with power.

The engine which could convert electric energy into mechanical power was already in existence. As early as 1822, nearly a decade before he found the principle of the electric generator, Faraday outlined the way in which an electric motor could work: by placing a coil, or armature, between the poles of an electromagnet; when a current is made to flow through the coil the electromagnetic force causes it to rotate – the reverse principle, in fact, of the generator.

The Russian physicist, Jacobi built several electric motors during the middle decades of the 19th century.

Jacobi even succeeded in running a small, battery-powered electric boat on the Neva River in St. Petersburg. All of them, however, came to the conclusion that the electric motor was a rather uneconomical machine so long as galvanic batteries were the only source of electricity. It didn't occur to him that motors and generators could be made interchangeable.

In 1888, Professor Galileo Ferraris in Turin and Nikola Tesla – the pioneer of high-frequency engineering – in America invented independently and without knowing of each other's work, the induction motor. This machine, a most important but little recognized technical achievement, provides no less than two-thirds of all the motive power for the factories of the world, and much of modern industry could not do without it. Known under the name of "squirrel cage motor" – because it resembles the wire cage in which tame squirrels used to be kept – it has two robust circular rings made of copper or aluminum joined by a few dozen parallel bars of the same material, thus forming a cylindrical cage. It is built into an iron cylinder which is mounted on the shaft, and forms the rotor, the rotating part of the is exposed to a rotating magnetic field set up by the stator, the fixed part of the machine, consisting of many interconnected electrical conductors called the winding. The relative motion between the magnetic field and the rotor induces voltages and currents which exert the driving force, turning the "cage" round.

Although the induction motor has been improved a great deal and its power increased many times over since its invention, there has never been any change of the underlying principle. One of its drawbacks was that its speed was constant and unchangeable. Only in 1959 did a research team at the University of Bristol succeed in developing a squirrel-cage motor with two speeds – the most far-reaching innovation since the invention of the inductor motor. The speed-change is achieved by modulating the pole-amplitude of the machine.

From the day when Edison's lamps began to glow in New York, the entire world asked for electricity. Already a year earlier, Werner von Siemens had succeeded in coupling a steam-engine directly to a dynamo. But the engineers had their eves on another, cheaper source of mechanical power than the reciprocating steam-engine: that of falling water. We do not know which of them suggested the idea of a hydroelectric power station for the first time; it was probably very much "in the air". Back in 1827, a young Frenchman had won the first prize ill a competition for the most effective water turbine in which the water would act on the wheel inside a casing instead of from outside. It was one of the prototypes of the modern water turbine. In the 1880's, an American engineer designed a turbine wheel with enormous bucket-shaped blades along the rim, and a few American towns with waterfalls installed these turbines coupled to Edison generators. This type proved especially efficient where the fall of water was sleep but its quantity limited; for a low fall of water the turbine – with only four large blades proved better suited. However, the type which appeals most to the engineers is now the turbine for falls of water from 100 to 1000 feet, with a great number of curved blades.

The power-station which convincingly showed the enormous possibilities of hydro-generated electricity was the one at Niagara Falls, begun in 1891, and put into operation a few years later with an output of 5000 h.p. – it is 8 million h.p. today. The early power stations generated direct current at low voltage but they could distribute it only within a radius of a few hundred yards. The Niagara station was one of the first to use alternating current (although the skeptics prophesied that this would never work), generated a high voltage; this was transmitted by overhead cables to the communities where it was to be used, and here "stepped down" into lower voltages (110 or 220) for domestic and industrial use by means of transformers. High voltage transmission is much more economical than low-voltage; all other circumstances being equal, if the transmission voltage is increased tenfold the losses in electric energy during transmission arc reduced to one-hundredth. This means that alternating current at tens or even hundreds of thousands of volts, as it is transmitted today, can be sent over long distances without much loss.

These ideas must have had something frightening to the people at the end of the last century, when electricity was still a mysterious and alarming novelty. The engineers who built London's first power station, with a 10000-volt generator, in 1889, and their German colleagues who set up a 16000-volt dynamo driven by a waterfall in the river Neckar, to supply Frankfurt, 100 miles away, with electricity in 1891 – these men must have felt like true pioneers, derided, despised, and abused by the diehards. There were, of course, also some powerful commercial interests involved, for the gas industry feared for its monopoly in the realm of lighting – and with a good deal of justification as it turned out.

THE DEVELOPMENT OF ILLUMINATION

Perhaps we might in this connection give a brief sketch of the development of illumination. From his earliest times, Man has had an intense dislike of the dark. Besides, as soon as he had learnt how to use his brain the long winter nights with their enforced idleness must have bored him. Lightning, the fire from heaven, gave him the first "lamp" in the shape of a burning tree or bush. He prolonged the burning time of firewood by dipping it into animal fat, resin or pitch: thus the torch was invented. It was in use until well into the nineteenth century; many old town houses in England still have torch-holders outside their front doors, where the footmen put their torches as their masters and mistresses stepped out of the carriages.

Rough earthenware, oil lamps were in use in the earliest civilizations; these lamps, though much refined, were still quite common a hundred years ago. The Romans are usually credited with the invention of the candle, originally a length of twisted flax dipped in hot tallow or beeswax which later hardened as it cooled off. Candles were at first expensive, and only the rich and the church could afford them. As late as the 1820's steam candles – cheap and mass manufactured came into use, and still later they began to be made of paraffin wax.

By that time, however, a new kind of illumination had been introduced until all over the civilized countries: gaslight. In the l690's an English scientist Dr. John Clayton observed that the gases which developed in coal-pits and endangered the lives of the miners were combustible. He experimented with pieces of coal, which he "roasted" over a fire without allowing them to burn up, and found that the resulting gas gave a pleasant, bright flame. German and French chemists repeated his experiments, but a hundred years passed alter his discovery before gas became a practical form of illumination.

William Murdock, a Scotsman who started his career as a mechanic, took up Clayton's idea. He built an iron cauldron in his cottage garden and healed coal in it. This incomplete combustion produced a mixture of highly inflammable carbon monoxide and nitrogen. He piped the gas into his house and fixed taps in every room. Many a night the people of Redruth stood in silent awe around Murdock's cottage, gazing at the wonderful new lamps which shed a bright light throughout the house.

After two years of experimenting, he persuaded his employer, Watt, to let him illuminate the Soho factory by gaslight. The installation was completed just in time to celebrate the peace treaty of Amiens and the end of the Anglo-French war in 1802 with the first public exhibition of gas lighting in and around the factory.

A year later, gaslight came to London. The people of the capital saw for the first time a street bathed in light at night. But many people were against it.

"London is now to be lit during the winter months with the same coalsmoke that turns our winter days into nights," – complained Sir Walter Scott, and even such an eminent man as Sir Humphry

Davy exclaimed Mint he would never acquiesce in a plan to turn St. Paul's into a gasometer.

But the progress of gas lighting could not be stopped; the main argument for it was that it would increase public safety in the streets it took much longer to persuade the people that there was no danger to their homes if they had gas tubes laid into them.

The introduction of gaslight in the factories had an especially far-reaching effect it made the general adoption of night shifts possible. The first industry to do this was the Lancashire, textile industry, for the workers at their rooms were now able to watch the threads at any time of the day or night.

Murdock's assistant was responsible for many improvements; among other things he invented the gas meter, and put up gas lamps on Westminster Bridge in 1813. Three years later, most of London's West End was already gaslit, and by 1820 nearly all Paris. New York followed in 1823. In Germany there were many objections to be over-come until the advantages of gaslight were recognized.

William Murdock lived long enough to witness the beginning of another development whose importance few people recognized at the time: gas cooking. In 1839 the first gas-oven was installed at a hotel, and a dinner cooked for a hundred guests. For a long time, however, this idea did not catch on. But when towards the end of the century the electric light began to take over from the gas lamp, the industry was forced to make a new effort so as not to be squeezed out of existence. In 1885 the Austrian physicist Carl Auer introduced his incandescent gas mantle, which quickly superseded the open (and dangerous) gas flames which had until then been in use. He used the same principle as Edison in his electric lamp; his gas-mantle was a little hood of tulle impregnated with thorium or cerium oxide. For a while, incandescent gaslight gained ground, and many people who had already installed electric cables had them torn up again. But in the end electricity won because it was more effective and more economical.

Only then did gas cooking emerge as a new aid to the world's housewives. It has still its place in the kitchen; gas-operated refrigerators, gas stoves, and central-heating systems arc more recent developments. Gas has by no means outstayed its welcome in our civilization.

Auer himself was responsible for one of the decisive improvements in the electric bulb, the great rival of his gas lamp. Using his experience with rare earths he developed a more efficient filament than Edison's carbonized threadosmium. It was superseded in its turn by the tungsten "wolfram" filament, invented by two Viennes scientists in the early 1900s. Since about 1918, electric bulbs have been filled with gas; today, a mixture of argon and nitrogen is in general use. Is the incandescent lamp now also on its way out? In innumerable offices, factories, public buildings and vehicles, and a good many homes (especially in the kitchens) the fluorescent lamp has taken over from it. This is based on two scientific phenomena that have long been known: that certain materials can be excited to fluorescence by ultraviolet radiation, and that an electric discharge through mercury under low pressure produces a great deal of invisible ultraviolet radiation. Professor Becquerel, grandfather of the scientist whose work on uranium rays preceded the discovery of radium, attempted to construct fluorescent lamps as long ago as 1859 by using a discharge tube. American, German and other French physicists worked on the same lines, and eventually the new type of lamp found its first applications for advertising (neon light). The difficulty was the production of a daylight-type of light with sufficient blue in its spectrum.

The modern fluorescent lamp consists of a long, gas-filled glass tube, coated inside with some fluorescent powder; this lights up when excited by the invisible ultraviolet rays of an arc passing from the electrode at one end to that at the other. Strip lighting is extremely efficient and needs little current because it works "cold" i.e. very little electrical energy is turned into waste heat as in incandescent lamps. It is roughly fifty times more effective than Edison's first carbon-filament lamps.

The mercury or sodium vapour lamps which arc now used on the roads arc “discharge” lamps, invented in the early 1930s. They have a “conductor” in the form of gas or metallic vapour at low pressure; this is raised to incandescence by the electric current, and emits light of one characteristic colour, greenish-blue (mercury vapour) or yellow (sodium vapour). They are “monochrome” lamps, that is, they emit light of only one colour, which makes it easier for the motorist to distinguish objects on the roads; it is also less scattered by mist or fog. True, that light makes people look like ogres – but it makes our streets definitely safer by night.

THE STEAM TURBINE

It is most important to remember that electricity is only a means of distributing energy, of carrying it from the place where it is produced to the places where it is used. It is not a “prime mover” like the steam-engine or even the water mill. A generator is no use at all unless it is rotated by a prime mover. During the first few years of electric power there was no other way of moving the generators than either by the force of falling water or by ordinary steamengines.

Soon, however, there came a new and very efficient prime mover, the steam-turbine. The steam-turbine must be a much more efficient and powerful prime mover than the reciprocating engine because it must short-cut the complicated process of converting steam energy into rotary motion via reciprocating motion. But the problems involved in building such a machine seemed formidable, especially hint of high-precision engineering. It was only towards the end of the nineteenth century that engineering methods were developed highly enough for a successful attempt.

Two men undertook it almost simultaneously. The Swedish engineer, Gustaf Patrik de Laval, built his first model in 1883. He made the steam from the boiler emerge from four stationary nozzles arranged around the rim of a wheel with a great number of small inches, de Laval’s turbine wheel rotated at up to 10000 revolutions per minute. He supported the wheel on a flexible shaft so that it would adjust itself to the fluctuation of procure – which at Midi speeds, would have broken a rigid shaft in no time.

De Laval geared an electric generator to his turbine alter he had succeeded in reducing the speed of rotation to 300 r.p.m. His turbo generator worked, but its capacity was limited, and it was found unsuitable for large-scale power stations. Although the simplest form of a machine has often proved the most efficient one in the history of technology, this was not the ease with the teamturbine. Another inventor, and another system, proved much more successful.

In 1876 Charles Parsons began to work on the idea of a steam-turbine, for which he foresaw a wide range of applications. The reciprocating steam-engine, which was unable to convert more than 12 per cent of the latent energy of coal into mechanical power, was not nearly efficient enough for the economical generation of electricity – energy leaked out right and left from the cylinder, and the condenser. Besides, there were limits to the size in which it could be built, and therefore to the output: and Parsons saw that the time had come to build giant electric power stations.

As he studied the problem, he understood that the point where most would-be turbine inventors had been stumped was the excessive velocity of steam. Even steam at a comparatively low pressure escaping into the atmosphere may easily travel at speeds of more than twice the velocity of sound – and high-pressure steam may travel twice as fast again, at about 5000 feet per second. Unless the wheel of a turbine could be made to rotate at least at half the speed of the steam acting upon its blades, there could be no efficient use of its energy. But the centrifugal force alone, to say nothing of the other forces which de Laval tried to counter with his flexible shaft, would have destroyed such an engine.

Parsons had the idea of reducing the steam pressure and speed, without reducing efficiency and economy, by causing the whole expansion of the steam to take place in stages so that only moderate velocities would have to be reached by the turbine wheels. This principle still forms the basis of ail efficient steamturbines today. Parsons put it into practice for the first time in his model of 1884, a little turbine combined with an electric generator, both coupled without reducing gear and revolving at 18000 r.p.m. The turbine consisted of a cylindrical rotor enclosed in a casing, with many rings of small blades fixed alternately lo the casing and to the rotor. The steam entered the casing at one end and flowed parallel with the rotor ("axial flow"); in doing so it had to pass between the rings of blade – each acting virtually as a nozzle in which partial steam expansion could take place, and the jets thus formed gave up their energy in driving the rotor blades.

It was a more complicated solution of the problem than de Laval's, but it proved to be the right one. The speed of 18000 r.p.m. used the energy of the steam very well, and the generator developed 75 amperes output at 100 volts. The little machine, built in 1884, is now at the Science Museum.

Parsons expected, and experienced, a good deal of opposition after all, there, were enormous vested interests in the manufacture of reciprocating steam engines. He began to build some portable turbo generators, but there were no buyers. Strangely enough, a charity event created the necessary publicity for the turbine. In the winter of 1885–1886, a pond froze over, and a local hospital decided to raise funds by getting young people to skate on the ice and charging for admission. The Chief Constable had the idea of asking Mr. Parsons to illuminate the pond with electric lamps, powered by one of the portable 4-kW turbo-generators.

The event was a great success, and the newspapers wrote about it. The next step was that the organizers of the Newcastle Exhibition of 1887 asked Parsons to supply the current for its display of electric lighting. Parsons, who died in 1931 at the age of 76, lived long enough to see one of his turbines producing more than 200000 kW. He also succeeded in introducing his steam turbine as a new prime mover in ship propulsion.

Until this day, the steam-turbine has held its place as the great prime mover for the generation of electricity where no water power is available. The steam which drives them hi the power stations may be raised by coal, oil, natural gas, or atomic energy – but it is invariably the steam-turbine which drives the generators. Diesel-engines are the exceptions, and are only used where smaller or mobile stations are required and no fuel but heavy oil is available. Today's steam-turbines, large or small, run at much lower speeds than Parson's first model, usually at 1000–3000 r.p.m.

When, a quarter of a century after Charles Algernon Parsons's death, the first nuclear power station in the world started up, his steam-turbines were there to convert the heat from the reactor into mechanical energy for the generators. The atomic age cannot do without them – not yet.

ADVANCED TECHNOLOGIES AND LOADING SHOVEL DESIGN I.

The use of computer-aided design systems in shovel design has been in place for many years. However, recent advances in computer capability and improved software programs and graphics are making computers even more useful.

Loading shovels are at the heart of most surface mine production. As truck sizes have increased, shovel manufacturers have matched them with larger shoves. Further increases in shovel size may be in order if trucks in the 270-t (300-st) range find acceptance at the largest surface mines.

However, larger shovels are not currently the primary focus of shovel design engineers. Competition and user pressure are combining to keep their work directed toward improved shovel productivity and efficiency. Computer design technology and advanced electronics play an increasingly prominent role in this work.

"Improved diagnostic capability, system monitoring, vibration analysis and above all increased user friendliness in machine control systems are being pursued by most manufacturers working in our industry today," observes Stuart R. Cotterill, director of marketing for Harmschfeger Corp.

The use of computer-aided design (CAD) systems in shovel design has, been in place for many years. However, recent advances in computer capability and improved software programs and graphics are making computers even more useful.

Among other impacts, computers allow a company to bring a new shovel to the field much more quickly. Bob Griffiths, a Caterpillar design engineer, reports that "We started with the 5130 and had the machine in iron in one-a-half to two years. About halfway through that program, we started on the 5230, and a little over a year after that, that machine was in iron. It was introduced in the fall of 1994".

"In the past, these programs might have taken three years. The biggest gains have been in turn-around times, faster computers and working concurrently in the engineering and manufacturing process."

II. All shovel manufacturers emphasize easy access to machine service points. Walk-in access to engine and pump compartments is a design standard, as are automatic central lubrication systems. Cabs specifically designed for operator comfort and operating efficiency are also standard.

Most of the hydraulic loading shovels discussed in this article can be equipped for backhoe loading, or "mass excavation". Such use is gaining acceptance in some applications. "We are seeing that large contract miners may be more inclined toward the mass excavator (loading backhoe)," says Paul Ludwigsen, a Caterpillar design engineer.

"Especially the Australians, who are looking at these machines for work in the western gold fields when they have a fairly homogenous ore body. They can design their bench height to take advantage of the mass excavator's loading ability. They are also using them in the coal fields in the Bowen Basin and the Hunter Valley to chase rolling and dipping seams of coal to take away the partings. They have really worked at setting up a job to take advantage of the capability of an excavator where you can get your swing down from 20 to 25, while for shovels, swings are usually in the range of 40 to 90."

CAD and other more recently designed tools are contributing to the optimization of all major shovel components. "Forty years ago, mining shovels were designed by conventional means, which included generous overdesign and factors of safety to accommodate indeterminacy and unknowns," explains B-E design engineer, B. M. Lang. "In today's competitive world, excess "fat" has been taken out of designs."

"Designers now rely heavily on finite element analysis (FEA) as the primary design tool to determine stress and suitability, especially in more complex areas. FEA has also become a primary tool for analysis of field problem areas," Lang says. "Before-and-after computerized stress levels can be correlated to elapsed time when a problem occurs, to project increased component life".

"The way computers are used in the design of mining machinery has evolved markedly in the last four years. Where we previously ran CAD programs and FEA on mainframes, we are now on the third generation of engineering workstations. The new hardware and software permit finely meshed solid element FEA models to be solved quickly," says Lang. "Where previously a plate element model was used to recover stresses adjacent to critical welds, we now model the welds themselves with solid elements".

WHY JAPAN LOVES ROBOTS AND WE DON'T

Always looking to the future, Japanese businesses are pinning many of their industrial hopes on increasing use of factory robots.

So, what if robots don't pay back their investment right away?

They are a great bet for improving manufacturing quality and countering rising labor costs.

Andrew Tanzer and Ruth Simon in a factory where Matsushita Electric makes Panasonic VCRS, a robot winds wire a little thinner than a bum a hair 16 times through a pinhole in the video head, and then solders it. There are 530 of these robots in the factory and they wind, and then wind some more, 24 hours a day. They do it five times faster and much more reliably than the 3,000 housewives who, until recently, did the same job with microscopes on a subcontract basis in Japan's countryside. The robots even inspect their own work.

A U.S. company can't get this technology – even if there were an American consumer electronics industry to take advantage of it. Matsushita invented and custom-made all 530 wire-winders to gain a competitive edge.

Robots were invented here, and the U.S. still leads in advanced research, from robotic brain surgeons to classified undersea naval search-and-destroy robots. But when it comes to using robots to solve practical problems – on the factory floor and in everyday life – Japan has no equal.

What may sound like science fiction to most Americans is taken for granted by ordinary folk in Japan. The Japanese are now accustomed to having robots do everything from make sushi to perform Chopin. Ichiro Kato, a roboticist at Waseda University, designed Wabot, a famous piano-playing, music-reading robot. Says Kato: "There will be one or more robots in every house in the 21st century."

Wabot's creator expects to see robots in people's homes doing dishes and washing floors. He envisions a humanoid robot with movable arms and a synthesized voice that will provide mobility and companionship to lonely old people. Kato, 64, says: "I'd like to live to see that day." Advances in artificial intelligence will put all this in the realm of the probable.

You probably haven't heard much about robots lately in the U.S., and for good reason. Robots have been an embarrassing disappointment for many American manufacturers. But in Japan companies of all sizes have embraced robots. The robots make it easier to quickly alter a production line to make several different product models. Japanese suppliers are in the forefront of these "flexible manufacturing systems," in which robots play a crucial role.

Now the technology is moving beyond the factory into hospitals, concert halls and restaurants.

In 1988 Japan employed two-thirds of all robots in use in the world, and last year it installed about $2.5 billion worth of new ones. Compare this with the U.S., which added only about $400 million worth of robots last year. "The total population of robots in the U.S. is around 37000," says John O'Hara, president of the Robotic Industries Association. "The Japanese add that many robots in one year." To be sure, Japan has enough antiquated and small factories to leave its overall manufacturing productivity below that of the US. But robots will help narrow the lead. For example, U.S. carmakers are heavily robotized. However, the Japanese are installing new robots not simply to automate but also to make production lines more flexible. For example, Nissan's newer auto plants can produce hundreds of different variations on a given car model simply by reprogramming robots that paint auto bodies and install car seats, engines, batteries, windshields, tires and doors. In Japan, even small companies use robots in simple applications such as welding.

It is one more example of Japan's skill at grasping a new technology and putting it to work while others dither. It happened in consumer electronics, memory chip production and machine tools. Now it's happening in robotics.

As Japan's robot population grows explosively, the U.S. market for metal employees is inching up after falling sharply in the mid-1980s. In February Deere & Co. decided to can the robots it uses to paint tractor chassis and hire humans. The robots take too long to program for endless permutations of paint orders. Whirlpool's Clyde, Ohio washing machine plant has used articulated arms that resembled the human wrist, elbow and shoulder to remove washtubs from injection molding equipment. But the complex robots aren't up to running around-the-clock production. Whirlpool gave up on the idea of using robots for this job, opting for fixed automation -a technology the U.S. excels in.

"Robots give you a lot of flexibility, but there's also a lot of complication," says James Spicer, a director of engineering operations at Whirlpool. "To lift one cylinder at a time you don't have to duplicate the motion of a human arm."

So many other manufacturers have sent robots to the junkyard or slowed plans to add new ones that the U.S. robot industry is in shambles. Early robot producers like Westinghouse and General Electric abandoned robotics in the late Eighties because of disappointing sales. And one-time highfliers such as Unimation and Industrial Systems have disappeared into bigger companies, while Prab and Automata founder under heavy losses.

One of the few profitable U.S. robot companies is GMFanuc, a 50/50 joint venture between the carmaker and Fanuc, a leading Japanese robot maker. The venture last year earned a few million dollars on sales of $165 million. Japanese producers aren't making any real money in robots, either. But many Japanese firms design and make robots for their own use to boost competitiveness and quality, so profits are not the issue. They don't buy robots based on a spreadsheet showing payback periods.

Now U.S. companies, having invented industrial robots and licensed the technology to Japan back in the 1960s, are in the awkward position of licensing back new Japanese technology. Cincinnati Milacron, number three in the U.S. robot business, aided Matsushita Electric's push into robotics by licensing it technology. Last year Milacron became a U.S. distributor for small welding robots produced by none other than Matsushita.

Why is Japan so robot-happy? It has to do with a lot more than economics. Japanese managers and government officials consider robots a key tool in combating a severe labor shortage at home. The alternatives would be moving the labor-intensive operations abroad or letting immigrants into Japan. The first alternative would deprive Japan of its manufacturing skills. "If you can fully automate manufacturing, there's no reason you have to go to Southeast Asia," argues Tadaaki Chigusa, a director of McKinsey & Co., Inc. (Japan). The second alternative, immigration, is unacceptable in the homogeneous, somewhat racist Japanese society.

While Chinese, Filipino or Korean laborers would not be very welcome in Japan, no such prejudice exists against robots. The Japanese seem to have been primed for robots with positive images in their popular culture as far back as the 1950s – much earlier than in the U.S. Japanese toymakers have churned out millions of toy robots, and the country's cartoons and comic books are filled with robot heroes. The prototype is Astro Boy, developed in Japan in 19S3 and later exported to the U.S.

"Astro Boy is as well known in Japan as Mickey Mouse and Donald Duck are here," says Frederik Schodt, author of "Inside the Robot Kingdom" (Kodansha International, 1988), which argues the Japanese have been conditioned to feel comfortable with robots from a young age. "He's a very cute, friendly robot who's always fighting for peace."

Mostly, robots are portrayed favorably in Western popular culture nowadays, from Star Wars R2-D2 to the futuristic Jetsons cartoon family. However, in Western tradition, robots have frequently been stereotyped as soulless humanoid machines or evil characters in works such as Fritz bang's 1920s silent Him Metropolis and the 1920 Czech play R.U.K. by Karel Capek, in which the word "robot" was coined to describe man-created monsters that turned on their masters.

In Japan, friendly, peace-loving robots are seen as solving a growing bluecollar labor shortage. The number of Japanese high school graduates is stagnant, and fewer graduates are willing to get their hands dirty. “Young people would rather work at the Hotel Okura or McDonald’s than in the factory,” says Naohkie Kumagai, associate director of Kawasaki Heavy Industry’s robot division. Shirking factory work doesn’t carry a heavy penalty: Last year’s typical high school graduate had 2.5 job offers to choose from. Robots are more than a mere substitute for human labor. They can do some things better than humans. “Robots are becoming indispensable because they provide a precision, quality and cleanliness man can’t,” says Toshitsugu Inoue, senior engineer in Matsushita’s robot development department. Because robots work at a precise speed and don’t make mistakes, inventories are easier to control.

As electronic components are miniaturized, robots are becoming essential for quality and high yields in the production of everything from very large-scale integration chips (some of Japan’s “clean rooms” are already unmanned) to watches and VCRS. The inverse is also true: Because Japanese manufacturers have robots; they can further miniaturize the product. The process is redefining the product. Many consumers electronic products are designed from scratch to be efficiently assembled by robots.

The Victor Co. of Japan JVC Ltd.’s Yokohama camcorder factory is bathed in an eerie silence. Automated guided vehicles quietly deliver pallets of components to 64 robots, which perform 150 assembly and inspection tasks. Two workers operate the robots, which assemble eight models on the same production line. Before the robots were installed in 1987, LVC needed 150 workers to do the same job. Just as important, JVC has redesigned the camcorder and its components, some almost microscopic, to be more efficiently assembled by robots. The robots also provide flexibility: They’ll work around the clock – no overtime, sick leave or bonuses.

Japanese government industrial planners have since the 1970s provided a raft of incentives for robot research, development and use. The government allows accelerated depreciation for purchase of sophisticated robots and established its own leasing company to provide low-cost robots to the private sector. Japan’s Ministry of International Trade & Industry provides small and medium-size companies with interest-free loans to buy robots; it is also pouring $150 million into developing hazardous-duty robots for use in nuclear power plants or fighting fires at oil refineries. This would be unthinkable in the U.S., because it smacks of industrial policy. Politics and national differences aside, why has the U.S. lagged so far behind Japan in applying robots to manufacturing? “The companies selling robots plain lied about the capabilities of their equipment and the circumstances under which, they could perform,” says Roger Nagel, manager of automation technology for International Harvester (now Navistar Corp.) in the early 1980s and now a professor at Lehigh University. After struggling for two years to debug a robot brought in to load and unload stamped parts from a press, Nagel finally junked the robot. A Japanese customer would probably have worked more closely developing the robot with the supplier, incorporating ideas from the engineers and even from assembly workers on the customer’s own factory floor.

One reason for the overblown expectations is that U.S. robot engineers often came from the field of artificial intelligence and had little if any experience on the factory floor. They were enamored of the idea of a mechanical human, an idea readily embraced by corporate executives who hoped to replace workers in “lights out” factories.

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