IENG 450
INDUSTRIAL MANAGEMENT

CHAPTER 2

HISTORICAL DEVELOPMENT OF ENGINEERING MANAGEMENT

17.03.2021

Introduction:

The story of the development of management thought and of our ability to organize and control complex activities has already been documented. In this chapter, only a small part of this history is introduced, concentrating on people and situations of the most significance and interest to the engineer in management.

First, the great construction projects of ancient civilizations are considered, and then the medieval production facility that was the Arsenal of Venice is discussed.

Introduction (Cont.):

- The Industrial Revolution changed not only manufacturing, but society as well, first in England, and then in America.
- As the nineteenth century ended and the twentieth century began, the United States led the world in finding better, more efficient ways to do things, in a movement that became known as **scientific management**, while Europeans such as Max Weber and Henri Fayol were developing philosophies of management at the top level.
- Around 1930, a series of experiments at the Hawthorne Works near Chicago led to studies on the impact of individual and group behavior on the effectiveness of managing.
- Engineering management continues to evolve, with the development in the second half of the twentieth century of methods for managing large projects such as the Apollo program, the customer-centered organizations, globalization, and the revolution in our lives that computer technology is creating.

Ancient Civilizations

- Even the earliest civilizations required management skills wherever groups of people shared a common purpose: tribal activities, estates of the rich, military ventures, governments, or organized religion.

- In ancient Mesopotamia,lying just north and west Babylon, the temples were developed an early concept of a corporation or a group of temples under a common body of management.

- For example; High priest was responsible for ceremonial and religious activities, while administrative high priest coordinated the secular activities of the organization.

- Records were kept on clay tablets (kil plaka), plans made, labor divided and work supervised by a hierarchy of officials.

Ancient Civilizations

- Many ancient civilizations left behind great stone structures that leave us wondering how they could have been created with the few tools then available.

- Examples include the Great Wall of China, the monoliths on Easter Island, Mayan temples in South America, and Stonehenge in England. Especially impressive are the pyramids of Egypt.

Ancient Civilizations

- Egyptian Pyramids

- The great pyramid of Cheops, built about 4500 years ago, covers 13 acres(hektar) and contains 2300.000 stone blocks weighing an average of 5000 pounds a piece.
- Estimates are that it took 100,000 men and 20 to 30 years to complete the pyramid—about the same effort in worker-years as it later took the United States to put a man on the moon.
- The only construction tools available were levers, rollers, and immense earthen ramps. Yet the difference in height of opposite corners of the base is only half inch!

Ancient Civilizations

- China – Great Wall

- Perhaps the most recognizable symbol of China and its long and vivid history, the Great Wall was originally conceived by **Emperor Qin Shi Huang** in the third century B.C. as a means of preventing incursions from barbarian nomads.

- The Great Wall was built over many years. It is believed the original Great Wall was built over a period of approximately 20 years. The Great Wall which is mainly in evidence today was actually built during the Ming dynasty, over a period of around 200 years.

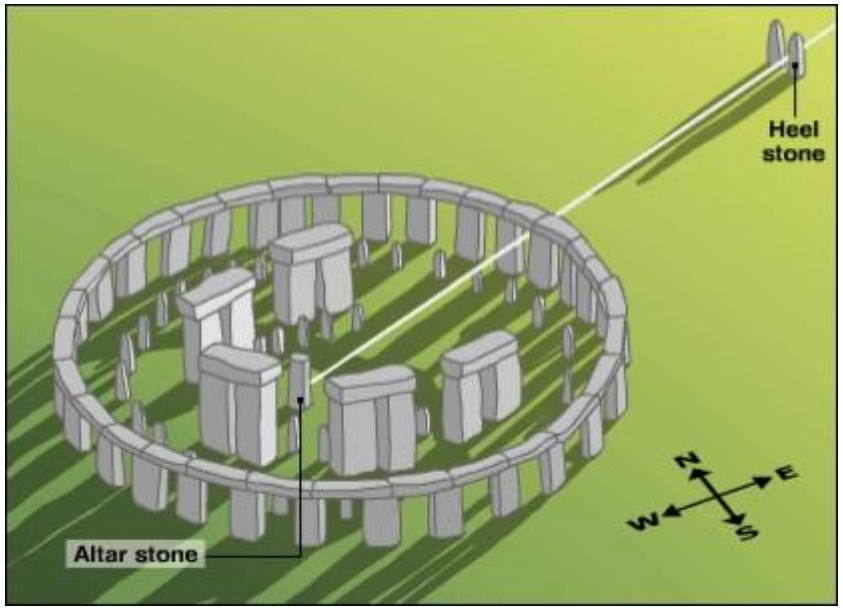
Ancient Civilizations

- Mayan Temples
  - Guatemala

- Civilizations like the Olmec, **Maya**, Aztec and Inca all built pyramids to house their deities, as well as to bury their kings. In many of their great city-states, **temple**-pyramids formed the center of public life and **were** the site of holy rituals, including human sacrifice.
- Tikal is a complex of Mayan ruins deep in the rainforests of northern Guatemala. Historians believe that the more than 3,000 structures on the site are the remains of a Mayan city called Yax Mutal, which was the capital of one of the most powerful kingdoms of the ancient empire.

Ancient Civilizations

- England – Stonehenge (another engineering miracle)

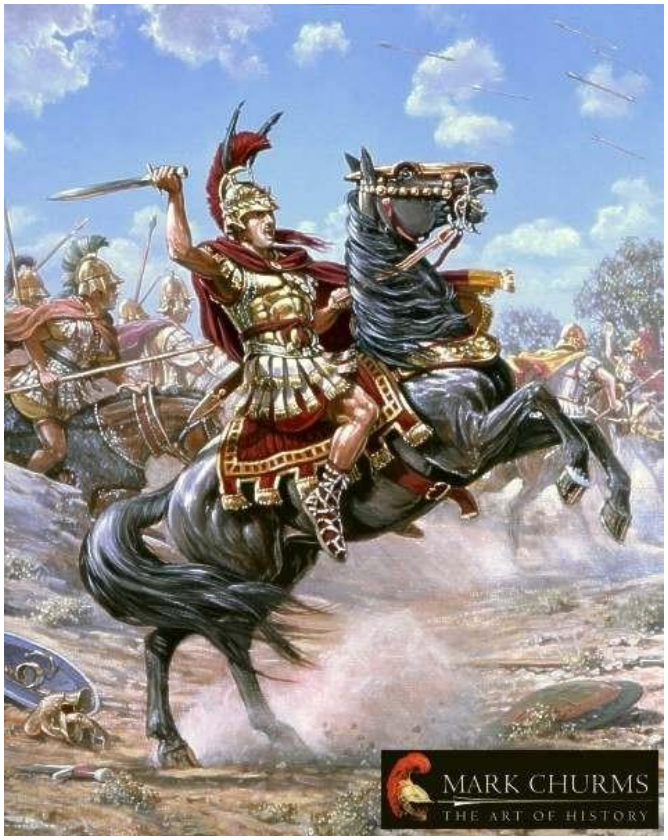


Ancient Civilizations

- Problems of controlling military operations and dispersed empires have made necessary the development of new management methods since ancient times. Alexander the Great is generally credited with the first documented use of staff system.

Ancient Civilizations

- Alexander the Great – staffing system



He developed an informal council whose members were each entrusted with a specific function;

- Supply,(malumat)
- Provost marshall, (inzibat amiri)
- Engineer

Ancient Civilizations

- Romans – roads and aqueducts

- The great Roman roads that made it possible to move messages and Roman legions (ordu) quickly from place to place were an impressive engineering achievement that helped the empire survive as long as it did

The Arsenal of Venice (Renaissance)

Largest industrial plant of the medieval world.

As Venice's maritime power grew the city needed an armed fleet (donanma)to protect her trade and by 1436 it was operating its own government shipyard, the Arsenal.

The Arsenal of Venice (Renaissance)

The Arsenal had a threefold task;

- The manufacture of galleys(buyuk kayik), arms (silah) and equipment,
- The storage of the equipment until needed,
- The assembly and refitting of the ships on reserve.

Other industrial management practices of the Arsenal;

- Systematic warehousing and inventory control,
- Well-developed personnel policies (wage payment),
- Standardization (manufacturing of ships in the same way),
- Accounting and auditing,
- Cost control.

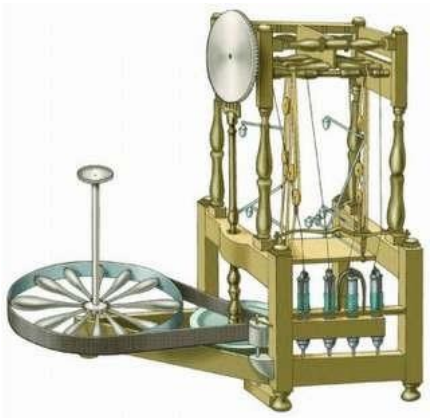
An important innovation developed in Venice during this period was double-entry bookkeeping.

The Industrial Revolution

Before the late eighteenth century farm families would spin cotton, wool to yarn or on a spinning wheel, wet the goods with mild alkali and spread them on the ground for months to beach in the sun before selling at a local fairs for whatever price they could get

- End of Cottage Industry

1. The spinning jenny
   - Invented by James Hargreaves (1764),
   - Could spin 8 threads of yarn(iplik) at once



2. The water frame
   - Patented by Samuel Crompton (1779),
   - Spinning machine driven by water power

The Industrial Revolution

3. The mule (cark)
   - Invented by Samuel Crompton (1779),
   - A combination of the spinning jenny and water frame.

4. The power loom (dokuma tezgahi)
   - Patented by Edmund Cartwright (1785),
   - A weaving machine of making cloth

The Industrial Revolution

5. Chlorine bleach (beyazlatici)
   - Discovered by French chemist Claude Louis Berthollet (1785),
   - Provided quick bleaching without the need for large open areas or constant sunlight.

6. The steam engine
   - Patented by James Watt (1769),
   - Used in place of water power in factories.

The Industrial Revolution

7. The screw-cutting lathe (vida-torna tezgahi)
   - Developed by Henry Maudslay (1797),
   - Made possible more durable metal machines.

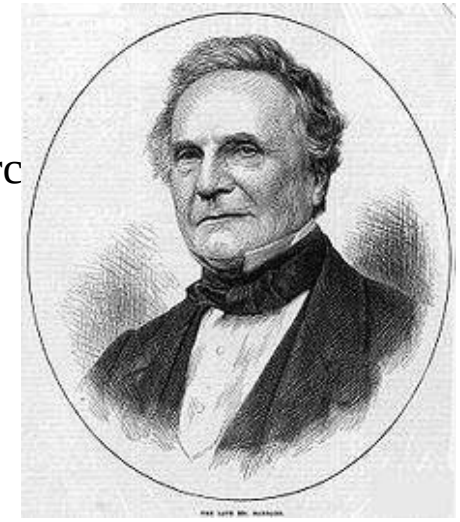
8. Interchangeable manufacture
   - Attributed to Eli Whitney (1798),
   - Developed to carry out a contract for 10,000 muskets (rifle).(tufek namlusu)

   Note: it consists in the making of every part of them so exactly alike that what belongs to any one, may be used for every other musket.

Management Philosophies

- The different management philosophies have been numerous. All have had, as their goal, to obtain optimal organizational performance, with the overall business environment guiding the selection of a particular style of management.
- Some theories have been fads that have not influenced a company's performance in the long term, while others have enhanced quality and productivity. Each theory has had its merits and drawbacks.
- These philosophies may be grouped into general categories of scientific, administrative, and behavioral.

Scientific Management



- Charles Babbage (1792 – 1871) Patron saint of operations researc management science.
  - Inventor of
    - difference engine, *financial support from the state*
    - analytical engine, *no financial support*
      - *memory*
      - *arithmetical unit*
      - *punch card input system*
      - *conditional transfer (***if s***tatement)*

  - Babbage's inventions never became a commercial reality, largely because of the difficulty of producing parts to the necessary precision(hassas) and reliability And he then had to visit many factories. His experiences were published in *On the Economy of Machinery and Manufactures,* 1832. E.g. how to measure the *daily performance of a worker.* The notion *a fair day's work* is introduced.

  - **(Not to engineering management but important to know)** The most important collaborator of Babbage was **Lady Ada Byron** the daughter of the poet Lord Byron**.**
    - Very gifted young lady interested in natural sciences.
    - ***The first computer scientist of the world!***
    - Not obtaining money from husband for scientific books.
    - ADA programming language was named after her.

Scientific Management

- **Henry Towne and the ASME (American Society of Mechanical Engineers) 1886.**
  - *Henry R. Towne* (co-founder and president of Yale Lock Company) emphasized the importance of money in the work of engineers by presenting his famous paper "The Engineer as Economist".

Scientific Management

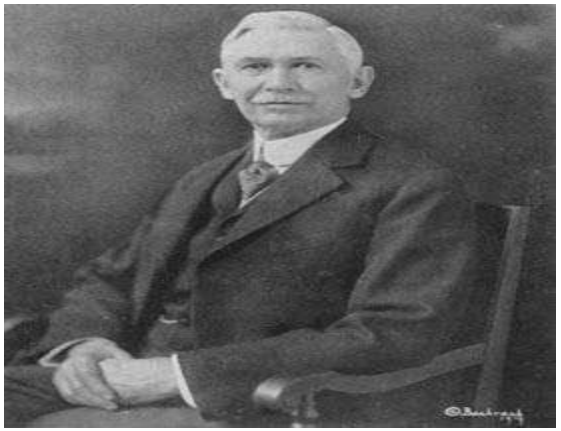
- Frederick Winslow Taylor (1856 – 1915)
  - Called “father of scientific management”,
  - Presented his work at Midvale Steel Company to ASME his famous papers;
    - “A Piece Rate System” (1895)
      - break a job into elementary motions
      - discard unnecessary motions
      - find an efficient method to connect the remaining elementary motions
      - train the workers for the new method
    - “Shop Management” (1903)

Scientific Management

- The Gilbreths
  - Frank Bunker Gilbreth (1868 – 1924)
    - Analyzed each job to eliminate unnecesary motions,
    - Devised a system of classifying hand motions into 17 basic divisions (*therbligs*);
      - Search, select, transport loaded, position, hold, etc…

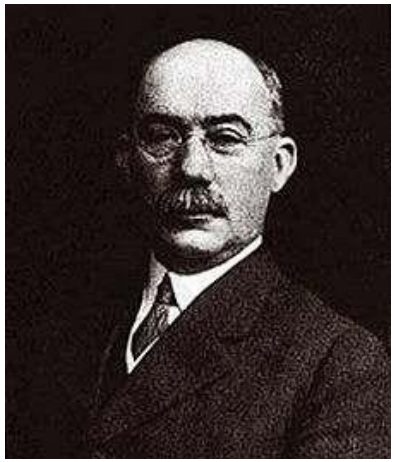
  - Lillian Moller Gilbreth (1878 – 1972)
    - Worked on understanding the human factor in industry, got Ph.D. in Psychology.
    - Continued on her own, advancing the concept of work simplification especially for the physically handicapped.

Scientific Management



- Harrington Emerson (1853 – 1931)
  - Applied scientific methods to work on the Santa Fe Railroad and wrote a book, 'Twelve Principles of Efficiency,' in which he made an effort to inform management of procedures for efficient operation.
  - Reorganized the company, integrated its shop procedures, installed standard costs and a bonus plan.
  - His effort, resulted in excess of $1.5 mililion.
  - His effort was recognized as the term 'Efficiency Engineering.'

Scientific Management



- Henry Laurence Gantt (1861 – 1919)
  - Developed simple graphs that would measure performance while visually showing projected schedules.
  - Invented a Wage Payment sytem that rewarded workers for above-standard performance, eliminated any penalty for failure, and offered the boss a bonus for every worker who performed above standard.
  - Emphasized Human Relations and promoted Scientific Managemet as more than an in human ‘Speed up’ of labor.

GANTT CHART

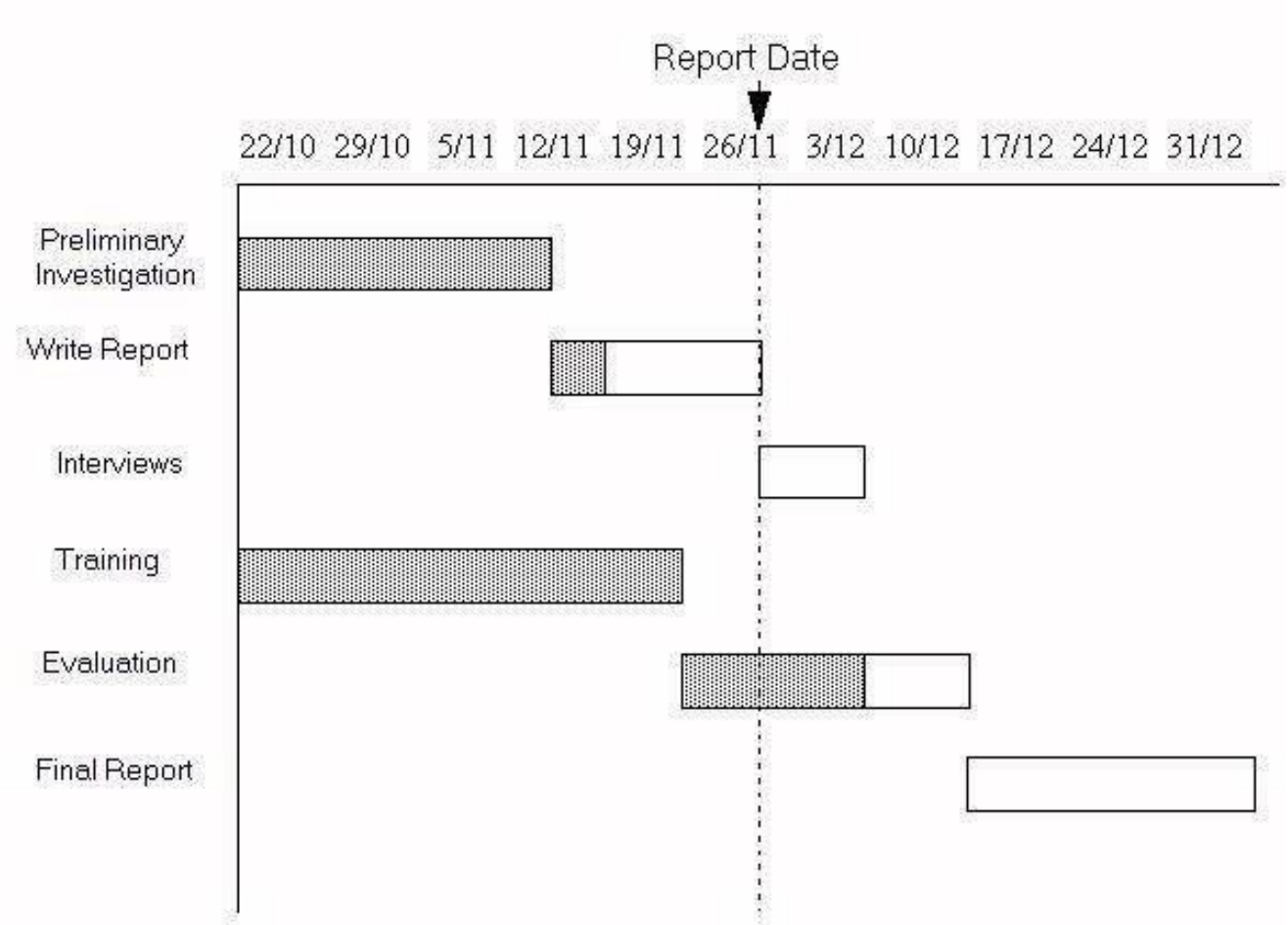


Figure 1: Gantt Chart

Administrative Management

- Henri Fayol (1841 – 1925)
  - He believed that the activities of industrial undertakings could be divided into six groups:
    - Technical (production),
    - Commercial (marketing),
    - Financial,
    - Security,
    - Accounting, and
    - Administrative activities.
      - Planning / Forecasting,
      - Organizarion,
      - Command,
      - Coordination, and
      - Control

Well known…

Administrative Management

- Henri Fayol developed a set of 14 "*General Principles of Administration*", most of which have meaning today.

1. **Division of work:** Division of work and specialization produces more and better work with the same effort.
2. **Authority and responsibility:** Authority is the right to give orders and the power to exact obedience. A manager has official authority because of her position, as well as personal authority based on individual personality, intelligence, and experience. Authority creates responsibility.
3. **Discipline:** Obedience and respect within an organization are absolutely essential. Good discipline requires managers to apply sanctions whenever violations become apparent.
4. **Unity of command:** An employee should receive orders from only one superior.
5. **Unity of direction:** Organizational activities must have one central authority and one plan of action.
6. **Subordination of individual interest to general interest:** The interests of one employee or group of employees are subordinate to the interests and goals of the organization. This is necessary to maintain unity and to avoid friction among the employees

Administrative Management

Henri Fayol's "*General Principles of Administration*" continued…

7. **Remuneration of personnel:** Salaries - the price of services rendered by employees - should be fair and provide satisfaction both to the employee and employer.
8. **Centralization:** The objective of centralization is the best utilization of personnel. The degree of centralization varies according to the dynamics of each organization.
9. **Scalar chain:** A chain of authority exists from the highest organizational authority to the lowest ranks.
10. **Order:** Organizational order for materials and personnel is essential. The right materials and the right employees are necessary for each organizational function and activity.
11. **Equity:** In organizations, equity is a combination of kindliness and justice. Both equity and equality of treatment should be considered when dealing with employees.
12. **Stability of tenure of personnel:** To attain the maximum productivity of personnel, a stable work force is needed.
13. **Initiative:** Thinking out a plan and ensuring its success is an extremely strong motivator. Zeal, energy, and initiative are desired at all levels of the organizational ladder.
14. **Esprit de corps:** Teamwork is fundamentally important to an organization. Work teams and extensive face-to-face verbal communication encourages teamwork.

Administrative Management

- Max Weber (1864-1920) and Bureaucracy
  - Weber developed a model for rational and efficient large organization, which he termed as “bureaucracy”.
  - He described any kind of bureaucracy incl. that of industrial organizations:
    - basic organizational unit is the office/position,
    - loyalty to the office not to individuals,
    - candidates must be appointed, and not elected,
    - clearly defined hierarchy of offices,
    - officials are subject systematic discipline and control, subordinates may appeal,
    - every act must be documented in written form,
    - incumbent has fixed salary, office is the primary occupation,
    - promotion depends on superiors,
    - officials are not the owners of the organization.

Behavioral Management

- **Hawthorne Studies**
  - As part of the Scientific Management regime, companies routinely studied the effects of the physical environment on their workers.
  - For example, they varied the lighting to find the optimum level of light for maximum productivity. They piped in music, varied the temperature, tried different compensation schemes, adjusted the number of working hours in a day, etc.
  - The Hawthorne studies were carried out by the Western Electric company (now AT&T) at their Hawthorne plant near Cicero, Đllinois) in the 1920's. Initially, the study focused on lighting.
  - Two things emerged from the initial studies:
    1) the experimenter effect – making changes was interpreted by workers as a sign that management cared, and more generally, it was just provided some mental stimulation that was good for morale and productivity.
    2) a social effect – it seemed that by being separated from the rest and being given special treatment, the experimentees developed a certain bond and camaraderie that also increased productivity.

Behavioral Management

- Abilene Paradox
  - is the situation that results when group take an action that contradicts what the members of the group silently agree they want or need to.
  - It is the inability of a group to agree to disagree.

Behavioral Management – Abilene Paradox (1/2)

Four adults are sitting on a porch in 40-degree heat in the small town of Coleman, Texas, some 53 miles from Abilene. They are engaging in as little motion as possible, drinking lemonade, watching the fan spin, and occasionally playing dominoes. The characters are a married couple and the wife's parents. At some point, the wife's father suggests they frive to Abilene to eat at a cafeteria there. The son-in-law, despite having reservations because the drive is long and hot, thinks that his preferences must be out-of-step with the group and says, "Sounds good to me. I just hope your mother wants to go." The mother-in-law then says, "Of course I want to go. I haven't been to Abilene in a long time.". They get in their Buick with no air-conditioning and drive through a dust storm to Abilene. When they arrive at the cafeteria, the food is as bad as the drive.

Behavioral Management – Abilene Paradox (2/2)

They arrive back home four hours later, exhausted, hot, and generally unhappy with the experience. One of them dishonestly says, "It was a great trip, wasn't it?" The mother-in-law says that, actually, she would rather have stayed home, but went along since the other three were so enthusiastic. The husband says, "I wasn't delighted to be doing what we were doing. I only went to satisfy the rest of you." The wife says, "I just went along to keep you happy. I would have had to be crazy to want to go out in the heat like that." The father-in-law then says that he only suggested it because he thought the others might be bored. It is revelaed that none of them really wanted too go Abilene – they were just going along because they thought the others were eager to go.