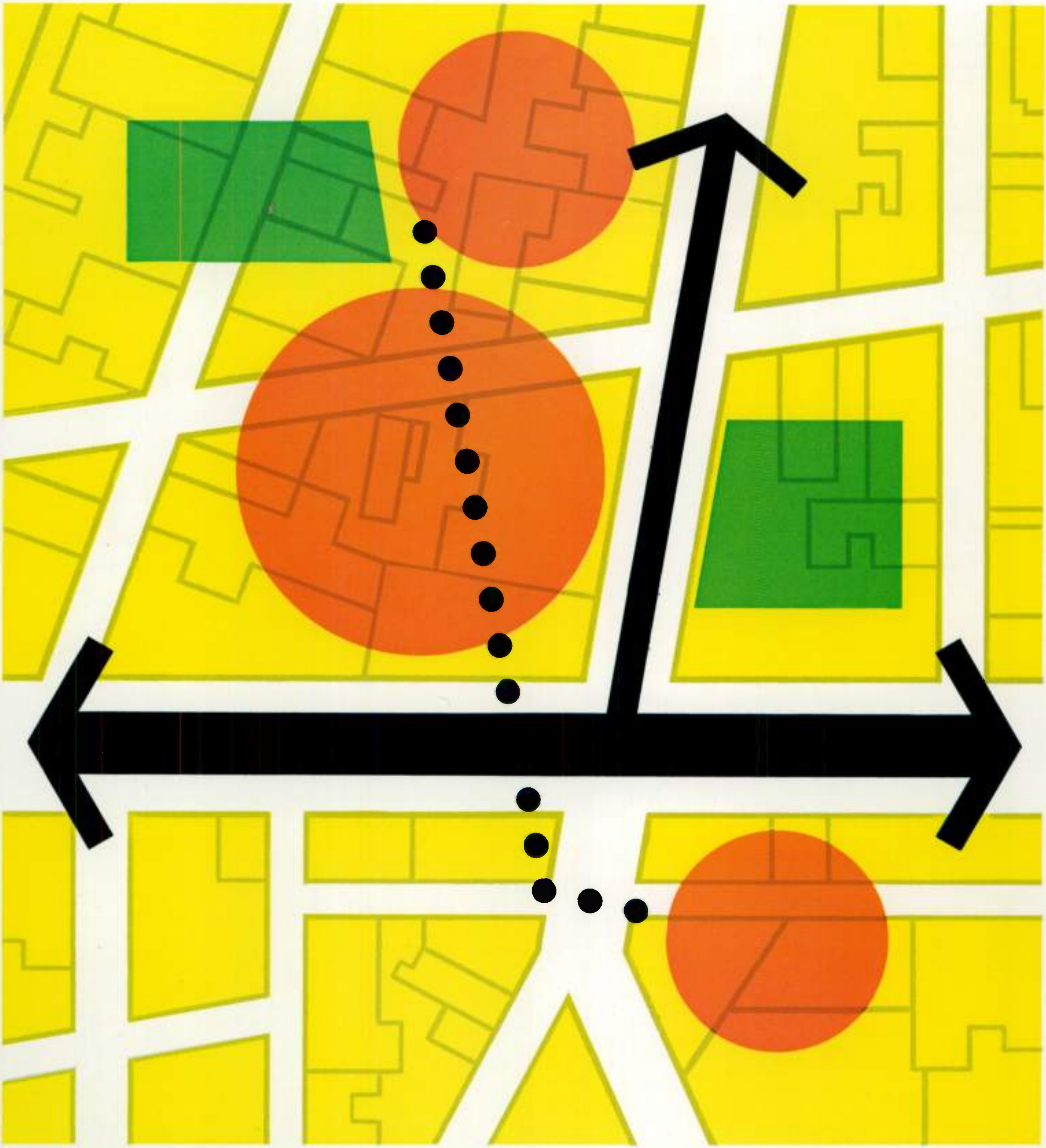
Westinghouse ENGINEER May 1972



Apparatus Service Expanded

Westinghouse apparatus service plants around the country are being expanded to provide more complete repair and modernization services for industrial and electric utility customers. An example is the plant at Richmond, Virginia, newly expanded from 8000 square feet of floor space to 19,000.

The plant has a crane with 30-ton capacity, a complete machine shop, electronic dynamic balancing machines with capacity up to 15 tons, and facilities for rebuilding power transformers and for rewinding, modernizing, and uprating all kinds of ac and dc rotating apparatus. It serves customers throughout Virginia and in the northern part of North Carolina. Like the other apparatus service plants, it repairs apparatus made by any manufacturer and, when necessary, works 24 hours a day and 7 days a week to get vital equipment back in action.

A typical day's activities are indicated by the accompanying photographs. In Fig. 1, the old winding is being stripped from the rotor of a 750-hp wound-rotor motor in preparation for rewinding. (In the background, workmen are rebuilding 115-kV condenser bushings for power circuit breakers and transformers.) The motor's stator also was rewound (Fig. 2). Since it was the main chipper motor for a paper mill, the men worked on it in shifts around the clock and finished the job in 7 days.

Another large motor in the shop at the same time was a 1500-hp synchronous drive motor for a Banbury mixer in a tire plant. It was rebuilt in 5 days. The motor's stator is shown in Fig. 3 as it was being swung into an oven to cure the varnish on its new windings. Its rotor was balanced (Fig. 4) and rewound. Fig. 4 also shows the balancing, after rewinding, of a rotor for a 200-hp 3600-r/min induction motor used by an electric utility for pump service.

A 20-MVA power transformer was being dismantled (Fig. 5). Its low-voltage coils were rewound, but its high-voltage coils (foreground) had not failed, so they were cleaned and reused. Fig. 6 shows a 10-MVA power transformer being rebuilt.

A worn feed screw from a high-speed pump unit in an electric utility generating station was built up by flame-spray metallizing (Fig. 7). It was then turned to the original dimensions.

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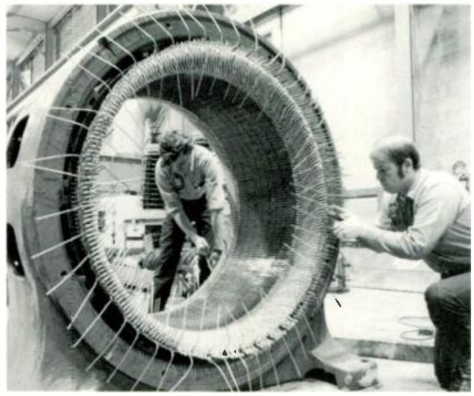

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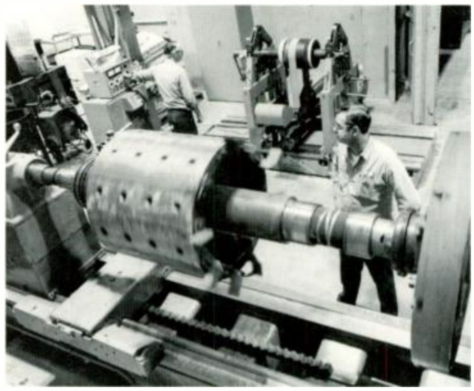

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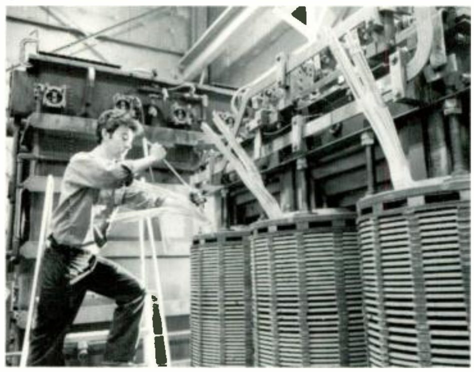

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Front Cover: Innovative urban planning requires a careful feasibility analysis of the total community situation. One element of the process is a study of existing and potential traffic flow patterns, depicted graphically by artist Tom Ruddy. The total planning process is described in this month's feature article, beginning on the following page.

Steps to Innovative Urban Planning

George T. Marcou
Jeremiah D. O'Leary, Jr.

Every urban development plan is eventually subjected to the crucial test: Can it be implemented? Effective implementation is feasible only if the plan satisfies human needs and thereby gains community consensus and support—and if it has a sound economic base that merits public-private support. This article discusses some of the considerations necessary to developing such a plan.

Government at all levels has long attacked urban problems with a variety of programs—public housing, urban renewal, area development assistance, and transportation loans and grants to name a few. Although these efforts have accomplished a great deal, they have fallen far short of need both qualitatively and quantitatively.

From a qualitative standpoint, the most serious criticism of the urban development effort is its emphasis on bricks and mortar and its corresponding inattention to human concerns. The growing awareness of this shortcoming is now resulting in much greater attention to human needs and their satisfaction as an integral phase of urban planning.

The quantitative shortcomings are primarily economic, and increased emphasis on the human aspects can make the economic problem even more severe. For example, innovations or improvements in educational systems, health care facilities, security systems, and all the other aspects of community development certainly have social value—but they also cost money.

The popularized solution to this social and economic problem is the public-private partnership. That concept is given much lip service but, in fact, actual partnership accomplishments in the area of urban renewal have been limited. To date, new towns and large-scale development projects have been approached mainly as real estate ventures. Such projects could offer much more: they could be excellent opportunities for packaging a vast array of goods and services to meet the needs of people, needs that are not presently provided by either public or private action separately. From a business standpoint, tapping this potential market could provide economic incentives that, in the long run, could well offset the initial costs of the real estate investment.

But effective public-private partnership will only result from innovations in urban planning that provide private enterprise with the opportunity and incentive to meet the wants and needs of people within an overall framework established by public action. This approach requires genuine creativity in urban planning, the participation of many diversified skills under effective management direction, and mobilization of resources commensurate with the task at hand.

Urban planning encompasses many aspects of city, county, and regional development, whether it be urban renewal of rundown areas, renovation of central business districts, preservation of communities of historic significance, or construction of completely new communities. Since each project is a localized case with its own specific set of problems, there is no "typical" plan that can serve as a universal blueprint for urban development. However, there are a number of key steps in the overall planning process that can help the planner arrive at a sound understanding of the problems of the project under consideration, both social and economic. Careful analysis of these problems provides the background necessary to developing an urban plan that satisfies the various needs and desires of the community and, at the same time, offers reasonable hope for economic survival of the urban plan.

Reconnaissance Analysis

The initial steps in an urban planning study are designed to provide the data and analytical base from which key problems, opportunities, and major issues related to the development can be identified. Factors examined include political, social, economic, and physical aspects of the development process.

Collect and Analyze Basic Data—Available information on the area to be developed and the surrounding neighborhoods is assembled to create a data file, which can be analyzed and mapped as appropriate. Data gaps requiring updating or reinterpretation are systematically identified.

Conduct Field Surveys—Field surveys of the site and its environs are conducted to supplement and detail basic data. Surveys for the study area surrounding the site are made as necessary. They may include existing land use, building conditions, streets and other transportation functions, and community facilities (schools, churches, parks, land and buildings in public and semi-public ownership, etc.). Natural features and scenic resources in the study area are evaluated. Impediments to development, natural and manmade, are also assessed.

Inventory Current Plans and Programs—Existing plans affecting the development of the site are inventoried. These include recently completed public plans and programs (especially scheduled highway improvements in the area), the programmed construction of schools and community facilities, existing zoning and impending changes, other regulatory controls, and existing utility service and scheduled extensions. Private development plans that may affect the development must be surveyed.

Interview Key People—A series of interviews are conducted with persons whose decisions could affect future development. They are designed to obtain an understanding of attitudes and underlying assumptions regarding the development of the site. Those interviewed include local community leaders and appropriate federal and local officials. Special effort is made to detect possible opposition to the development and to determine the underlying reasons for the opposition. Conscientious attempts are also made to contact all segments of the surrounding community.

Determine Market Potentials—Through market analysis, the site's potential for various types of residential and nonresidential development by time incre-

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ment is determined. Information from past market studies (if available) and existing regional studies on population, employment, transportation and land use are evaluated. The potential for local sources of employment is examined. The advantages and disadvantages of seeking public financial assistance of various kinds, and its effect on market potential, are included. Estimates of market demand and absorption rates provide the framework within which alternative development proposals can be formulated.

Define Minimum Facility Requirements— Projected minimum requirements for community and public facilities are forecast by development period. These include the need for educational and health facilities, churches, open space and recreational facilities, cultural buildings, utilities, public structures, and related construction.

Outline Possibilities for Technological Innovation—City-building technology, industrialized housing production, computer-based information systems, waste management and pollution control, transportation, energy transmission, and various management mechanisms should be investigated to determine their feasibility for use in site development.

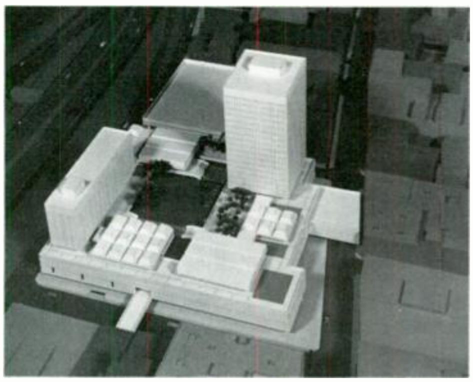
Define Preliminary Objectives—From the reconnaissance analysis outlined in the preceding steps and an evaluation of basic and secondary objectives, a preliminary summary of objectives and standards for the urban development plan is developed. Use of "basic" and "secondary" categories helps assign priorities to various components of the development program and serves as a reference point for measuring the desirability of modifications as work on the plan progresses.

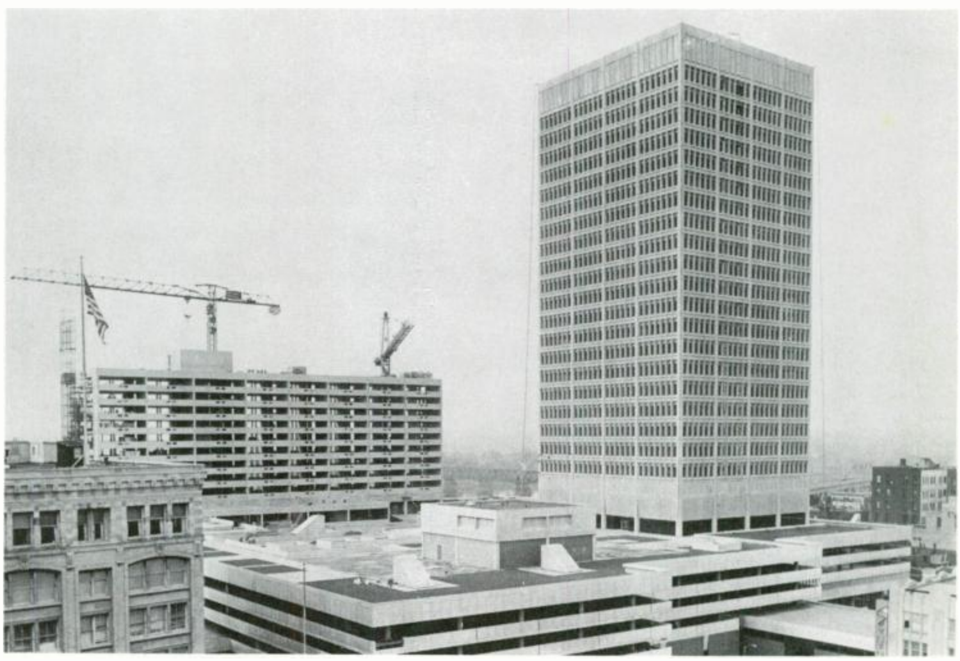
Baystate West Provides Nucleus for Redevelopment

When the businessmen of Springfield, Massachusetts, decided to improve the city's central business district, they retained Marcou, O'Leary and Associates along with economic and traffic consultants to prepare a comprehensive development plan for the downtown area. The plan identified key private investment opportunities, needed public actions, a schedule of costs, and specific implementing steps. A joint public-private improvement effort was recommended, agreed upon, and put into action.

The first step in the program was Baystate West, a commercial-office-hotel complex in the very center of downtown, undertaken by the local businessmen. The city is supporting the redevelopment effort with a new Sports and Convention Center adjacent to Baystate West.

The basic strategy was selection of a few downtown blocks that would exert maximum leverage throughout the entire area. Although it would have been easier and cheaper to clear the downtown's most dilapidated section for renewal, a fairly good block was selected for Baystate West because of its more desirable location. As predicted, Baystate West and the Convention Center have been significant enough to achieve the "critical mass" necessary to set off a chain reaction of rebuilding activity in nearby areas.





Feasibility Analysis—Individual Components
Next, selected components of the preliminary urban development program require extensive feasibility analyses. Those components may include any of the following: model school system, internal transit system, industrialized housing, consolidated underground utility systems, health care delivery systems, job training systems, security systems, environmental control systems, and computer applications for managing the development process.

Feasibility analysis of each program component selected from the above list (and any other potential components) includes the following tasks:

Describe Component Characteristics—The characteristics of each prospective component are described in terms of alternative manufacturers, alternative service groups, component specifications, staging requirements, personnel requirements, and historical experience in other development projects. In cases where the component is not yet operational, expert judgement on its potential capabilities must be obtained.

Identify Required Research and Development—If the component is not operational, or if more research and design are required to adapt the component to the project, the additional effort needed is determined, with estimates for timing and prospects for success.

Estimate Total Development Costs—The above analyses are used to estimate the total cost of each component under consideration as accurately as possible. Costs include research and development expenses, capital outlay, and annual operating costs.

Identify Patronage Prospects—For each component under consideration, mini-

Fort Lincoln—New Town in Town

The Fort Lincoln project, to be built on 335 acres of federal land in Washington, D.C., is designed to serve as a demonstration of social and physical innovation in new community development. The goal is a community of 20,000 people, representing a cross section of population, living in a variety of housing types, and served by a range of community and commercial facilities. The basic problem faced by Marcou, O'Leary and Associates, who led the planning team, was development of a community that would attract a cross section of population.

The need for low- and moderate-income housing in the Washington area is great, so there would be no problem in filling units of housing with people in those income categories. However, there has been ample experience in Washington and other American cities that large concentrations of lower-income housing cannot sustain the rising costs of service. All too often such projects deteriorate rapidly after completion. Therefore, a better approach is to build low- and moderate-income units within a framework of middle-income housing that will assure the needed economic stability and provide the economic support required for superior amenities and services. The basic problem in this approach is that although low- and moderate-income families can be attracted to and accommodated in an economically inclusive community that bears the image of being basically middle-income, the reverse is not true. Middle-income families, who have many housing options available to them, will not readily be attracted to an inclusive community that bears the image of being basically lower-income. Therefore, Fort Lincoln must have advantages that the public can identify as unusual for a new community of middle-class quality, available to all.

With this goal in mind, the planners have stressed quality and innovation in their proposed urban systems and design program. Visible and demonstrable superiority will be a key factor in marketing Fort Lincoln and achieving the goal of an inclusive community. Fort Lincoln has been planned to offer unusual value for the price, compared to what other communities can promise, so it will literally sell itself to many prospective residents. It will have an excellent school system and shopping center, a variety of housing types to choose from, a good security system, an abundance of recreation and entertainment facilities, and job opportunities.

Until now it has been virtually impossible to reconcile the need to build relatively high-density housing in an urban community with the natural desire of most families to own their own homes. It has been particularly difficult for low- and moderate-income families to afford the costs and meet the credit requirements of home ownership. The Fort Lincoln approach to these problems is to make ownership of townhouses and condominium garden apartments available to families of all income groups. The goal is for three-fourths of all dwellings to be owner-occupied—a proportion without precedent in a community of Fort Lincoln's income mix and location. Both conventional financing and federally assisted housing programs will be used to make that goal a reality.

Emphasis in the early phases on construction of middle-income units will help to establish a middle-income character and image for Fort Lincoln. Once that is accomplished, the capacity of the community to absorb moderate- and low-income housing without becoming labeled "a low-income project" will be substantially improved. Therefore, it has been proposed that for the first phase of a five-phase project, over half of the housing and at least 80 percent of the ownership housing be middle-income. After that, the proportion of moderate- and low-income family housing can be adjusted to maintain the desired balance of moderate- and low-income housing with middle-income housing.

Residents of Fort Lincoln will also be given a real voice in how their community is managed — and this should have a strong and positive impact on prospective buyers or renters. Through a nonprofit Fort Lincoln Community Corporation, residents will control many community facilities and decide for themselves how their needs and interests can be most effectively served.

These efforts to insure meaningful citizen involvement in community management and economy are without parallel in other Washington communities. They should be important inducements to many families who will compare Fort Lincoln with other housing opportunities.

mum and desirable levels of patronage for the performance standards specified are determined, and evaluated against estimated patronage levels. Other development requirements related to the component must also be identified and described. For example, if a model school system will be dependent on buses to bring students from the adjacent community, the bussing requirements must also be identified for feasibility analysis.

Estimate Revenues to Support Development—From patronage estimates, forecasts are made to estimate revenues over time.

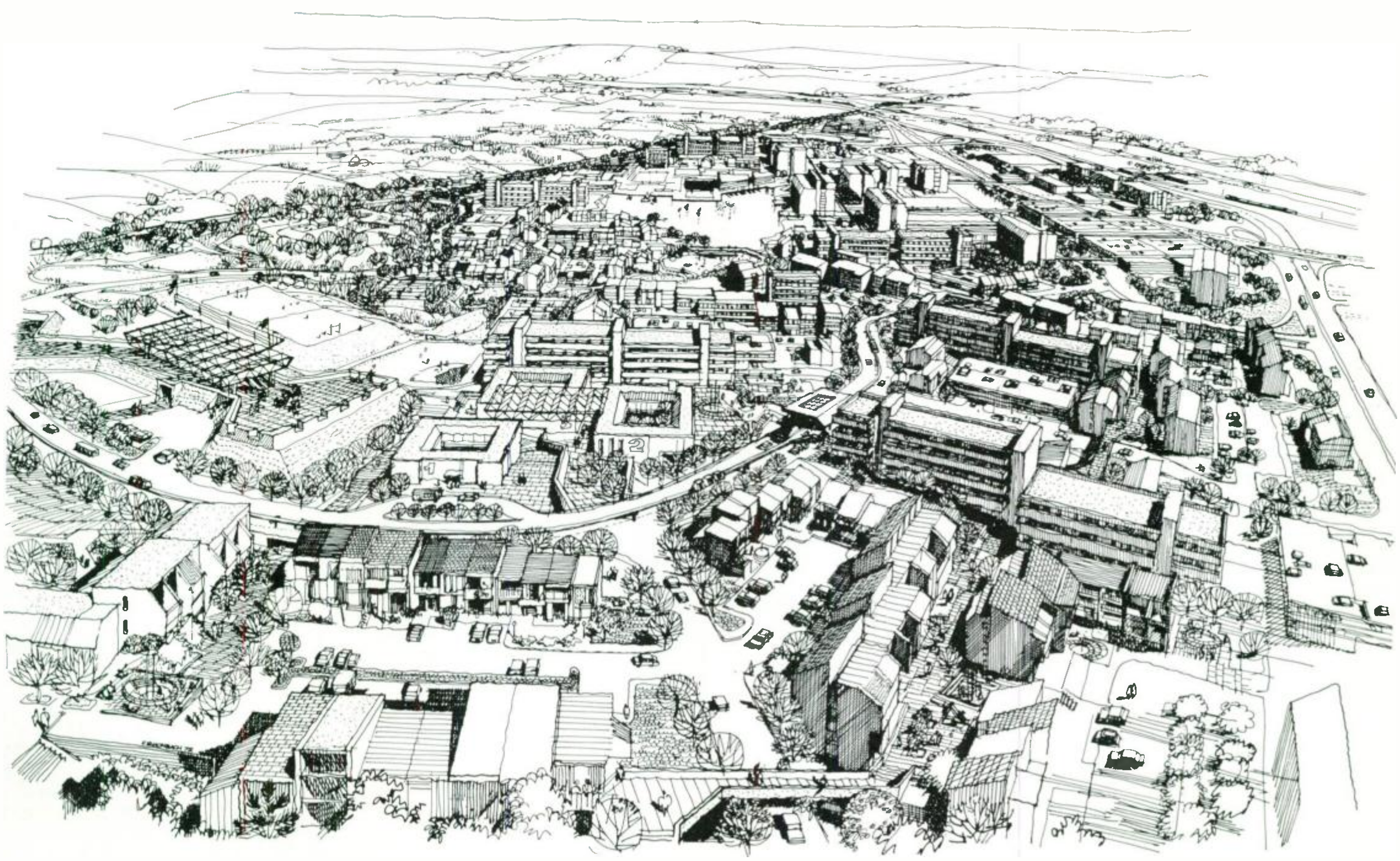
Identify Financial Subsidies—A survey is made of financial assistance programs potentially available to support the component. These are ranked by size, source, timing, and probability of attainment.

Estimate Net Development Costs—The cost information for the various components is compared with estimated revenues and potential financial subsidies. If a net cost results, additional means for gaining funds must be examined.

Evaluate Feasibility of Component Development—All the findings and conclusions established in the above tasks are reviewed to derive a preliminary assessment of the feasibility of using each prospective development component, *both* from an economic and a technological standpoint. Both economic and technological evaluations are considered in the development of the total plan or selected modifications.

Feasibility Analysis—Social and Physical

Often, potential obstacles not of a technological or financial nature must be analyzed as feasibility concerns. Some of



Lawndale Center—Prototype for a New City

The strategy and action plan for improving Lawndale, a black ghetto of 190,000 persons on Chicago's West Side, resulted from the Lawndale community organizing itself to tackle its own deep-seated problems. The approach demonstrates a unique and effective process for attempting to improve ghetto conditions.

The effort began in mid-1967 when two major Lawndale community organizations provided the leadership in raising funds from local businesses to create the Lawndale People's Planning Committee (LPPC). This committee engaged Marcou, O'Leary and Associates to act as advocate planners for the community in preparing a social and physical development strategy.

The plan that resulted contains four essential steps, now under way, for shaping and implementing urban renewal.

Organize for Action—It was apparent that many city agencies initially questioned the influence and power of LPPC. Officials were dealing with a variety of community groups, each claiming to represent the "people of Lawndale." Therefore, the first step was corporate merger of LPPC and three other strong community organizations into the Lawndale People's Planning and Action Conference (LPPAC). This organization now has the strong power base necessary, because it represents the majority of diverse factions within the community.

Define Tactics—A fundamental assumption is that significant improvements in Lawndale's physical environment can be more readily realized than improvements in its social and economic conditions. Therefore, early stress on physical improvements is seen as a way of proving to the community that local government is committed to alleviating ghetto conditions, and as a way of illustrating to city officials that their programs can be implemented in the ghetto in a way acceptable to local residents. And most important, physical improvements can provide an environment in which social and economic improvements can more readily occur.

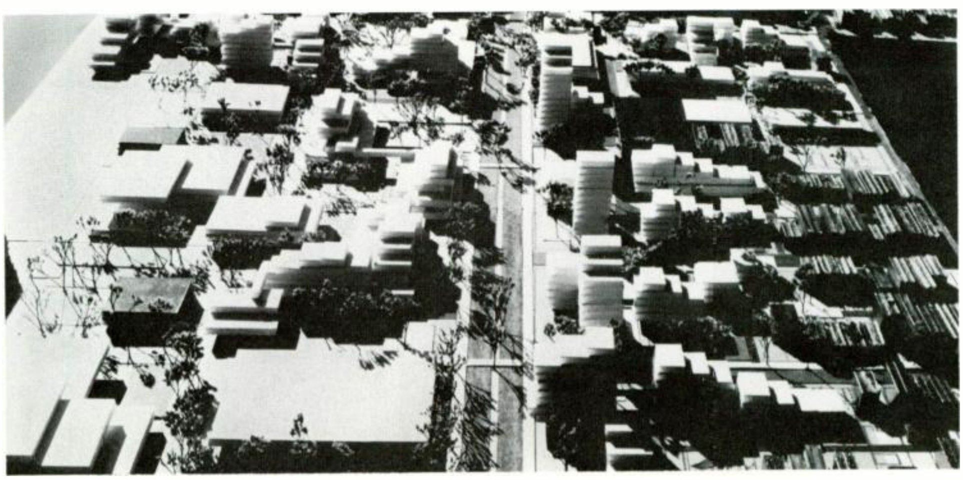
For example, insistent community demands that the school board improve the quality of teachers and curriculum in an old overcrowded high school, before spending money on a new physical plant, are probably doomed to failure. Problems of poor teaching facilities, overcrowding, and outmoded curriculum all reinforce each other in making it extremely difficult to attract high caliber teachers capable of implementing an improved curriculum. On the other hand, a new school with modern teaching facilities would help attract better teachers.

Organize for Economic Development—Another basic recommendation made by the consultants early in the study was formation of an economic development corporation, owned by Lawndale residents and capable of undertaking large-scale development projects. The recently formed North Lawndale Economic Development Corporation promises to be a model for development of black capitalism and community ownership. It operates with a profit-making structure and can undertake large housing and commercial ventures, with profits distributed to individual shareholders throughout the community. Democratic control and true distribution of profits are assured by the sale of voting stock to any Lawndale resident, but sales to any one person are limited to the extent necessary to insure wide distribution and avoid concentration of control in the hands of a few.

Start with Prototype Effort—The prototype approach to community development is a middle ground between long-range comprehensive planning (which often becomes an exercise in futility) and short-range coordination of current operations (which is usually inadequate). The prototype approach is simply development of some key portion of the community to demonstrate solutions to problems existing throughout the entire community. The development must be realistically accomplishable by coordinated action of the community and outside interests, guided by the LPPAC. The scale of the prototype development must be great enough to stimulate enthusiasm throughout the community, but small enough so that significant accomplishment will be evident in a short time span.

The prototype development began with special field surveys and community group discussions, individual leadership interviews, a household survey conducted within the community, and discussions with city officials and private developers. These efforts led to selection of the initial prototype area and action program—Lawndale Center.

Lawndale Center will encompass a 200-acre section that was once the commercial core of Lawndale but is presently a hollow shell surrounded by overcrowded and deteriorated housing. The development plan for the Center has three major components—a multifunction community shopping complex, a cultural-educational cluster including a much needed community high school, and new and rehabilitated housing of various types and costs. The goal is a new urban complex that will become the focus of community activity.



them result from establishing planning objectives, such as levels of racial and economic integration, which may not be achievable under the particular conditions. Other obstacles arise from the uncertainties of community reaction or of governmental commitment. Analysis must document such special conditions if the desired patterns of development are to be achieved. In addition, analysis must anticipate a process of development that can deal effectively with a political and administrative system normally resistant to bold action, a community demanding citizen participation, or local businesses concerned about federal renewal and community objectives.

Clearly, the realization of social development patterns (as well as new technological development of components, and their economic feasibility) is tied closely to the processes chosen for use during the development period. Moreover, feasibility in these cases may hinge greatly on the perceptions of issues by those involved and on their willingness to participate in trade-offs as part of an informal negotiating process.

The following issues can be thought of as problems of pattern or process, and must also be tested for feasibility.

Typical *patterns* of social and physical development are: racial and economic integration; high quality standards for public facilities and services; exemplary environmental quality.

Typical *processes* for achieving pattern development are: community participation in the development process; governmental roles and contributions; public-private partnerships.

The questions that must be answered and the strategies that are evaluated relate to the complex interrelationships surrounding those pattern and process issues. For example, the feasibility of racial integration depends on such factors as the type, size and cost of units, the amenities offered, the nature of community reaction to the project during its early stages, the manner in which units are marketed to the public, and the extent to which integration is desired within structures rather than on a structure-by-structure basis.

Preserving the *Tout Ensemble* of the Vieux Carré

A comprehensive study of the Vieux Carré, the historic French Quarter of New Orleans, was sponsored jointly by the city and the U.S. Department of Housing and Urban Development as a prototype to demonstrate ways of preserving historic areas in American cities. The study provided guidelines and controls that permit new development and historic preservation to work to each other's mutual advantage.

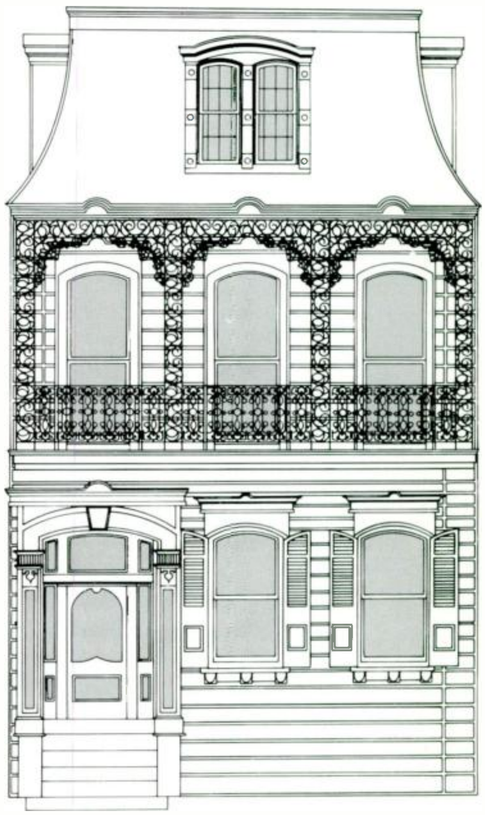
The French Quarter has become a major tourist and convention center. Preserving and improving it will therefore contribute significantly to the development of the whole New Orleans economy.

Preservation of the Vieux Carré lies not so much in saving or restoring individual buildings, most of which are neither architecturally distinguished nor historically significant, as in preserving its *tout ensemble*, the total effect of its buildings and environment.

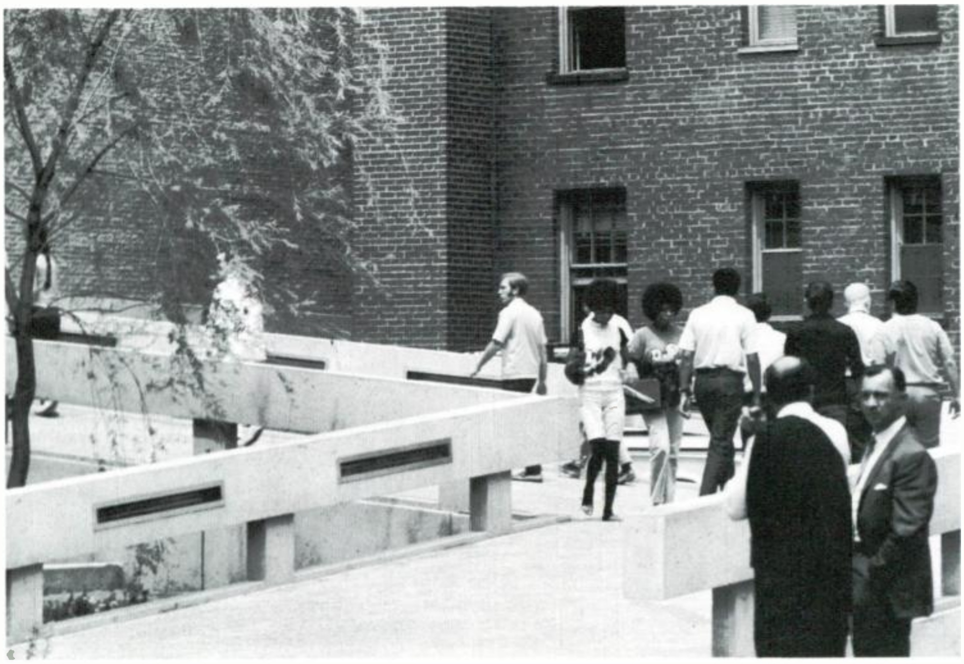
To preserve this total effect, the study team headed by Marcou, O'Leary developed an analytical method to determine what structures and activities in the area should be fixed and what could be changed without endangering the Quarter's essential character. The study team inventoried the Quarter's general characteristics, such as its major focal points, corridors of movement, landmarks, character areas, viewpoints and vistas, and facade combinations. It then surveyed and evaluated the specific characteristics of every building in the categories of architectural-historic significance, land use compatibility, and building condition.

Every building was scored in each category and placed in one of four groups determined by its total rating in all categories. These groups ranged from buildings of "irreplaceable architectural and historic value" which should not be replaced or changed under any circumstance to buildings which should be cleared for redevelopment. This rating technique produced a composite portrait of the entire Vieux Carré area and provided the guide for determining where change could be accommodated.

The action program that was proposed to carry out the Vieux Carré Plan makes no attempt to recreate the environment of a past era, but rather, to permit new development that will be compatible with the essential character of the area in scale, design, and land use. The program includes area-wide code enforcement, a revolving fund and other assistance to preserve buildings of major importance, comprehensive zoning changes, a private improvement corporation to supplement public preservation activities, and a redevelopment program covering the period to 1980.



A Campus Plan for The George Washington University

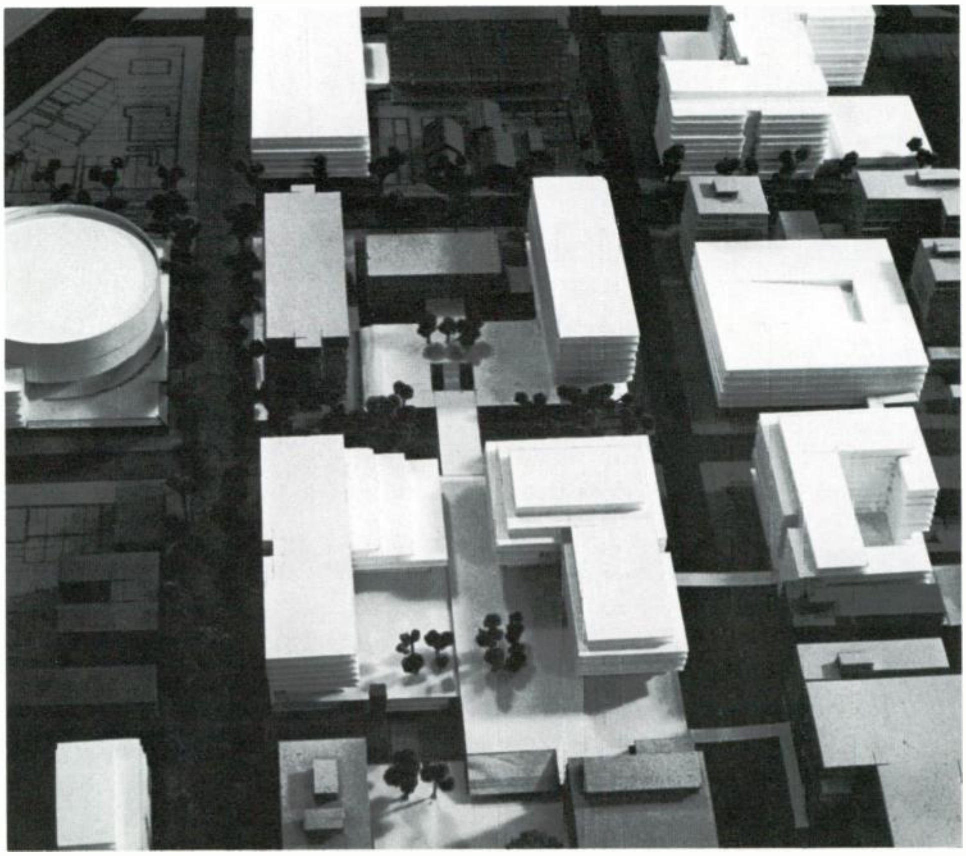


The goal of a revised campus master plan for The George Washington University is unification of many individual university buildings, now separated within a standard downtown street pattern, into a cohesive university campus. Since horizontal expansion is blocked on all sides by high-density development, new development must emphasize techniques that achieve more effective use of valuable land.

The Campus Master Plan prepared by Marcou, O'Leary can be divided into three basic components: a policy plan, a space program, and a development plan.

The *policy plan* provides a continuing and consistent guide to future development regardless of changing circumstances. Typical policies for university campus improvement include: relatively high-density buildings; a unified and distinctive open-space system with careful landscaping and pavement treatments, both on street frontage and in open spaces penetrating city blocks; separation of pedestrian from automobile traffic, including a network of upper-level walkways linking courts, squares, and interior open spaces in buildings; preservation where possible of buildings with architectural or historic interest; central location of facilities requiring the highest level of access, such as a new library; and location of buildings requiring less accessibility on the periphery of the campus.

The *space program* estimates future space requirements on the basis of specific assumptions derived from current trends in enrollment growth and in the university's enrollment policy.



The *development plan* inventories existing buildings and proposes new construction on a time scale and within the guidelines outlined by the policy plan and the space program. The development plan concentrates high-activity facilities such as classrooms, libraries, and faculty offices about a central open space to provide convenient pedestrian circulation throughout the campus. For example, the proposed new university library will be built on the most accessible site, whereas parking garages and administrative offices will be located around the periphery of the campus.

Although the development plan is presented in three specific time phases, it is primarily intended to be a general guide to future development of the campus. Because of the difficulty of anticipating the longer term physical needs of the university in such specific detail, the greatest planning emphasis is placed on the policy plan, within which space needs and physical development can be altered as required.

Washington's National Capital Planning Commission and Board of Zoning Adjustment have approved the plan.

The analysis of community participation alternatives provides another useful example of the feasibility assessments appropriate to these issues. The powerful desire for community self-expression and economic independence could be met, in part, by forming a publicly owned profit making economic development corporation that can own and manage many millions of dollars of residential and commercial property. Feasibility tests include such questions as: who initiates its formation; how will it relate to the developer, the local government, and other local community groups; and what impact will it have in promoting racial and economic integration?

Finally, feasibility questions on public-private involvement are of critical importance. What possibilities are there for launching a new type of public-private partnership for the development process? How can the obstacles that have thwarted full private participation in inner-city renewal efforts be overcome? By innovating and evaluating new techniques for bringing the public and private sectors together, a new way of using private means for public gain may be devised. In essence, the key to feasibility may be the way issues explored at this stage are resolved.

Formulation of The Plan

The comparative analyses listed above are used to develop a program that satisfies the various feasibility concerns.

The overall plan must be examined by a rigorous cost/benefit analysis geared to identifying *privately sponsored* and *publicly provided* services and facilities. It is important to group project elements into those two responsibility categories to establish the capacity of the designated developer to participate in the capital investment and yearly operating costs of publicly provided facilities. Conceptually, the excess cash flow potentially generated from private development, beyond the limits normally associated with a development of this character, should be committed to the construction and maintenance of publicly-provided facilities.

If subsequent cost/benefit analysis and other indicators of performance feasibility and overall project desirability indicate that the private facilities will not produce sufficient cash flow to ensure financial stability and adequate compensation for the investors, then modifications must be made to increase project productivity.

The development components that survive the feasibility analyses conducted to this point form the backbone of the total development program. But since feasibility analysis to this point has been done on an individual component or issue basis, the verdict as to how the complete development program will meet feasibility criteria must await the comprehensive analysis of the total program.

Feasibility Analysis—The Total Plan

Economic analysis of the overall urban development plan must begin by devising financial measures of (1) the capital outlay and annual operating costs for all the various program components, and (2) the cash flow accruing from the development itself and from assured governmental assistance programs made available to support the project. The results of this analysis determine total financial feasibility.

A considerable deficit between costs and available resources to meet these costs is likely for most urban development projects. The deficit can be reduced or closed fully by: (1) securing governmental subsidies; (2) making selected compromises in the quality level of the facilities, services, and environmental standards; or (3) changing the character of development to establish a greater net cash flow without compromising the primary objectives.

Dependence on the first approach is unwise because subsidies in sufficient magnitude have been unavailable to date and are uncertain for the future. The second approach is not desirable because it sacrifices too much too soon. Thus, the third approach of selectively changing the character of development to increase the net cash flow generated holds the greatest promise.

Further analysis should therefore be based on testing the plan for alternative modifications. In each instance, economic feasibility should be calculated by a cost/benefit study for individual components of the program, and their impact on the total program.

Two other secondary types of feasibility analysis can help assure that the development alternatives can, in fact, be achieved. Market studies are required to assess maximum market absorption rates for various land uses. Clearly, there are economic constraints to the range and intensity of incremental development possible on any site. In addition, the political feasibility of development alternatives should be evaluated. Concerns about development posed by the local community, regional government, Federal government, and other groups should be identified and alterations in the development alternatives made accordingly.

Finally, the preferred general development program (or programs) that results from the above analysis is selected and worked out in detail. But regardless of the merits of the plan that finally results, its chances for realization are very poor unless the usual development logjam can be broken by establishing two key criteria—reasonable latitude for the developer in the type and intensity of permissible development and a significant sharing in the development process and its financial rewards with local residents.

Selecting a Process Control Computer

Operator's console is the user's main link with his process, so it should be specified for easy and effective communication to and from the process. Such "human engineering" techniques as color coding should be considered.

The task of selecting a control computer is made easier, and more likely to succeed, if the prospective user concentrates on his area of expertise and allows the supplier to concentrate on his.

The task of writing a purchase specification for a process control computer and selecting the best system from all of those proposed can assume staggering proportions, even for users with some experience in applying and using computers. Users have admitted to spending as much as 1½ man-years of effort in writing a system purchase specification and another man-year in evaluating the proposals received.

A far better approach is for the user to summarize his hardware needs in terms of the control requirements of his process and submit them to the computer supplier, along with basic software specifications and any system constraints. The supplier can then propose a system that meets the requirements and employs his equipment to best advantage. That approach enables the user to concentrate on his process (the area in which *he* is expert) instead of on computer details (the area in which *the supplier* is expert).

Without detailed knowledge of each machine proposed, it is almost impossible for a user to evaluate all of the features of one machine against those of another. Even the most experienced computer designers frequently disagree on the merits of certain types of hardware and software.

For example, it is generally agreed that high-speed operation is desirable, as it allows any given function to be executed in a shorter period of time than a slower computer requires, and therefore allows the computer to perform more functions. However, speed expressed in terms of memory cycle time—as it usually is—can be very misleading. What is important is not cycle time but how efficiently the computer performs the functions required of it for the particular application. How fast any given machine can perform those functions depends to a larger extent on what time-saving hardware features are present and on how well the manufacturer's software takes advantage of the special characteristics of the machine.

Even system size may vary for the same application. The amount of memory required depends on word length, the ability of the machine to perform complex arithmetic operations on receipt of a single instruction, and the way in which the machine is programmed. In addition, it may well be worth a few extra dollars to obtain a machine that is easily and economically expandable if that becomes necessary. Ease of programming may also be important if the process being controlled is subject to change.

Since computer size is reflected directly in system cost, overcapacity cannot be economically justified. However, users of computer control systems frequently want to add functions once the system is successfully installed and operating. If the system was purchased with somewhat more capacity than is required immediately, such additions cost very little. If there is no extra capacity, later expansion to include additional functions will normally cost more than would have been required if the extra capacity had been included in the initial purchase. Therefore, it is advisable to include in the initial plan all of the tasks that will eventually be performed by the computer, even if not all of them are to be implemented at once.

However, modular purchase and installation may be justified in some cases (for example, if certain portions of the process require lengthy analysis before control logic can be developed). In that case, it may be wise to purchase computer control for that portion of the process where it can be put on line fast, because savings in materials or increased production effected by the computer will help offset the increased cost of expanding the system later.

Low-cost minicomputers are particularly useful in this type of planning. Many plants have installed dedicated minis—that is, small computers performing specific portions of the process—

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Scan Period (sec)	Analog Inputs (no. of points)	Scan Frequency (points/sec)
5	200	40
10	300	30
	500	70

Pulse Inputs (no. of points)	Input Rate (pulses/sec)
NONE	

Scan Period (sec)	Calculated Values (no. of points)	Scan Frequency (points/sec)
5	100	20
	100	20

Scan Period (sec)	Contact Inputs (no. of points)
5	100
	100

Output Period (sec)	Analog Outputs (no. of points)	Output Frequency (points/sec)
5	50	10
10	200	20
	250	30

Output Period (sec)	Pulse Outputs (no. of points)	Output Rate (pulses/sec)
	NONE	

Contact Outputs (no. of points)	Average Outputs/Sec
100	4
100	4

Scan Period (sec)	DDC Loops (no. of loops)	Loop Frequency (loops/sec)
5	100	20
10	200	20
	300	40

1—Use of a system summary form enables a prospective computer user to define system requirements in terms of the amount of control required. The form illustrated is for a direct digital control (DDC) system, with typical values entered.

and then added a larger supervisory computer when computer control became plant-wide.

Determining Minimum Hardware Requirements

It is probable, then, that the time-consuming effort required to specify and evaluate a computer according to the details of its internal construction would fail in the purpose for which it was undertaken—selection of the best and most economical computer for the application. Instead, the user should define system requirements in terms of the amount of control required. A system summary form, such as the one for a DDC system shown in Fig. 1, makes it easy for him to do so. [DDC (direct digital control) systems are assumed in the rest of this article, although the principles outlined are generally applicable to other process control systems.] With such a form, the user describes his process in terms of the number of analog inputs, pulse inputs, calculated values, contact inputs, and the frequency with which they are to be read; the number of analog, pulse, or contact outputs required for control; and the number of individual points or DDC loops to be controlled. Use of such forms assures that no part of the system is overlooked in the purchase specification.

In addition, the following requirements should be determined and specified:

1) The amount of additional core memory and mass memory required for programs to be written by the user's personnel and the amount required for storing data for his use.

2) The number and type of peripherals (line printer, card reader, card punch, tape reader, tape punch, and so on) required for communication between the computer and the operator.

3) The number of logging typewriters needed to record information about the process.

4) The type of console required to provide information about the process to the operator and to permit him to interrupt or change the operation of the control system. [A standard console supplied by the manufacturer may be the

least expensive, so it should be specified if it will meet the requirements of the process. However, additional items such as cathode-ray-tube displays (CRTs) and special indicators may be necessary.]

5) Existing instrumentation (if any) with which the computer must interface.

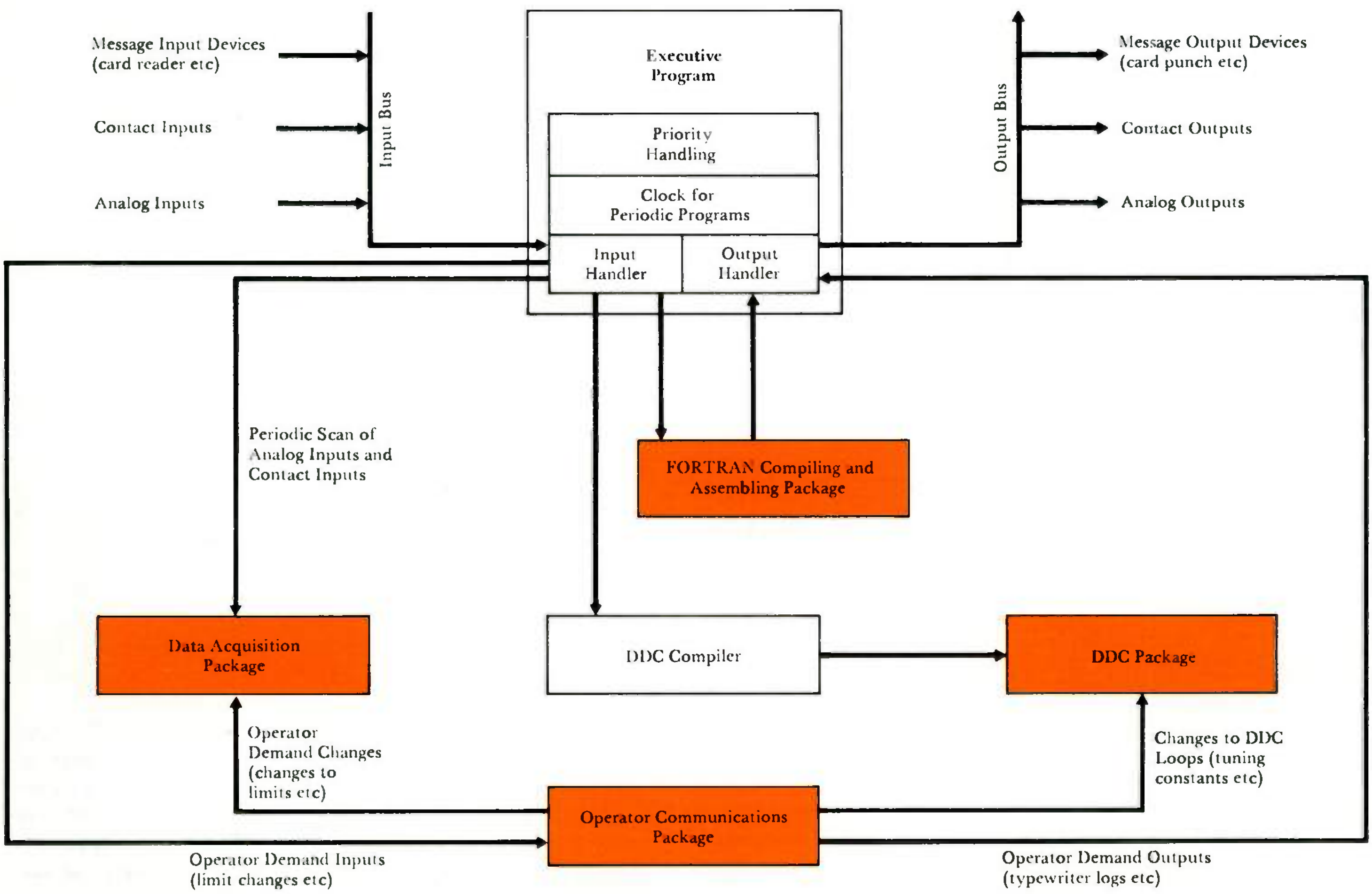
6) Accuracy requirements for analog conversion and loop evaluation. Accuracy beyond the instrument tolerance is meaningless (0.1 percent of full scale is usually more than sufficient), and unneeded accuracy is expensive. Consider, for example, a process that requires a valve to be positioned with an accuracy of ±2 percent of full scale. If the actuator responds to a signal with an error of ±1 percent of full scale, an error of ±1 percent of full scale is tolerable in converting the feedback signal to an output to the actuator. With a 10-bit analog output, the full-scale error is in the order of 1 bit in 10 or 1/1024, which is about 0.1 percent. The computational error is in the order of 1 bit in 15 or $\frac{1}{2}^{15}$, which is about 0.004 percent. Therefore, if it is assumed for purposes of this example that the computational and output error totals 0.1 percent of full scale, the input conversion error could be as large as 0.4 percent of full scale and still remain within acceptable limits.

Determining Minimum Software Requirements

Before a computer can control anything, it has to be programmed. The computer manufacturer supplies basic software—programs that run the machine and tell it how to operate. They include a real-time executive program that acts as a "traffic cop" for the many tasks to be run on the machine. An effective executive program is essential to DDC systems if the computer is to react promptly and efficiently to the demands of the process.

In addition, at least four software packages are needed for most DDC systems (Fig. 2). They should be specified. The packages and their main requirements are:

Data Acquisition Package—These programs supply information about the plant to the computer and store data about the process in computer memory. Data concerning analog points must be converted to engineering units acceptable to the digital computer. The result must be checked against the limits established for each point and stored in memory. Readings of analog instruments must be checked to determine that they are within the established range for operation.



Digital inputs must be scanned and any change in their status detected and reported.

The data acquisition package must also provide for calculation of derived variables (values that cannot be measured directly but must be calculated by the computer on the basis of other measured data for any particular time in the process). The computer must then determine that the variables are within established limits. The package should also provide for alarming the operator if established safe operating limits are exceeded at any point.

The computer must maintain a current value table showing the status of all analog and contact points in the process along with all calculated values. The data acquisition package should store this value table in computer memory and update it regularly for use by control programs.

DDC Package—The DDC system must have the ability to control plant variables by computing the difference between desired and measured values and sending a periodic correction instruction to the control elements. This computation is accomplished through standard algorithms that perform the functions (proportional, derivative, integral, etc.) of common analog hardware. The correction is then sent to automatic/manual stations through an analog output system or, if necessary, through a stepping-motor output system.

Most DDC systems also require that the DDC software package be able to accept additional control algorithms written by the user. A DDC compiler is needed, therefore, with the ability to create new control loops or to delete existing ones.

FORTRAN Compiling and Assembling Package—In addition to the DDC compiler, a FORTRAN compiler and assembler is needed to permit the computer to accept new programs written by the user and to accept deletions or changes in existing programs. The difference between it and the DDC compiler are shown at lower right.

Operator Communications Package—This package contains the programs that permit communication between the operator and the computer through the operator's console. It should provide for:

1) Printout of alarm messages on a typewriter.

2) Printout of changes and logs requested by the operator.

3) Verification of new entries through visual displays (digital or CRT) before the new instruction is entered in the computer.

4) Displaying and changing constants in a DDC loop for tuning purposes.

5) Turning a DDC loop output on or off (both cascade and output to the process).

6) Placing a variable on or off scan and limit-checking variables.

7) Changing the value of any given variable.

8) Changing alarm limits for any given variable.

9) Calling for logs and for user-generated functions.

Specifying System Constraints

Together, the hardware and software must provide a reliable system with sufficient computing capacity to meet the user's requirements. However, there are still other factors that should be spelled out clearly in the purchase specification.

One is maximum allowable downtime. Because of the high reliability of most present-day computers, downtime is usually considered for the individual loops rather than for the total process under control. Since not all the loops under control are critical to the process, a system is usually considered "up" when 98 percent of the loops are being controlled. For critical loops that cannot be lost at any time, duplication or analog backup is normally provided. All critical loops should be named in the purchase specification, as well as the percentage of total loops that must be maintained under control.

Another important specification is the minimum computer capacity that must be reserved for the user—capacity in addition to that required to control the process with the supplier's software. Great care must be taken to hold the duty cycle of the computer within limits that permit reliable control of the process under any conditions. Since the tasks to be performed at any given moment may be as much as 25 to 50 percent higher or lower than the average number of tasks performed, this is the area of greatest difficulty for the system designer.

Users who have experience with computer systems on their processes may be able to specify the duty cycle for a new system in percentages. For example, one customer recently stipulated that the duty cycle for the basic programs for his system be held at 40 to 50 percent to allow

2—Software requirements include the basic programs that run the computer and tell it how to operate. At least four additional software packages are needed for most DDC systems, as indicated here.

Two Types of Compiler

FORTRAN Compiler

Input: A source program on paper tape or punched cards, written in USASA FORTRAN IV.

Output: A set of computer instructions to be executed by the computer to perform the function specified in the source program.

Example: $I = J + K \bullet K2$ is a typical input statement. It generates an object code that loads the value of K in the accumulator, multiplies it by $K2$, adds J, and stores the result from the accumulator in location I.

DDC Compiler

Input: Source statements written in control language. The language depends on the system; there is no generally accepted standard language in use today. The prospective user should examine the features of each DDC control language proposed and decide for himself which offers the greatest convenience and utility for his needs.

Output: Data interpreted by the control system as a DDC function, which is then performed in real time. The data is linked by the DDC compiler to a particular analog function.

Checklist of Desirable Features

Software

1) Is special compensation required for some inputs? Flow, for example, sometimes requires compensation for temperature and pressure.
2) In addition to limit checking, do analog inputs have incremental limits? (Limits between normal alarm limits and instrument out of range.) Is it possible to set a special indicator when a given limit is crossed? Both can be important if special actions should be taken at various performance levels.
3) Are deadbands available on normal as well as incremental limits to permit ignoring low-level changes?
4) Can the scan frequency for an analog point or calculated value be changed on line? Experience with the operating control system frequently shows that for some loops many changes in the initially established frequencies are desirable before the best frequency is determined.
5) If scan frequency can be changed and if the point triggers a DDC loop, are all time-related DDC constants automatically adjusted? This is essential if on-line changes in frequency are to be permitted.
6) Is it possible to turn the whole system on or off DDC? This could be useful if there is a need to start up or shut down quickly.
7) Is the loop computation performed immediately after the input variable is scanned, so that phase error is minimized?
8) Is provision made for bumpless transfer? (This may not be important for inherently sluggish processes.)
9) Is on-line compiling possible? This is desirable on most systems; however, if the process is static and few changes are anticipated, off-line compiling may be satisfactory.
10) Does the compiler permit inclusion of FORTRAN or assembly language programs in a loop? This is particularly useful if a special arithmetic function is needed or if the function is too long to make an algorithm.
11) Is an on-line batch system available for compiling and assembling? (Again, this may not be important if the process is static and few changes expected.)
12) If a batch system is available, can it be interrupted by a control program (releasing the core it was using) and then completed when the control program terminates? This optimizes core usage and generally improves response time of the system.
13) Is hardware memory protect available? If a background on-line system exists and programs can be tested on line, it is important to protect control programs from being altered inadvertently.
14) Is a data file system available? If the user plans to store data for subsequent use, he may wish to be able to create, delete, and retrieve named data files.

Operator's Console

1) Does it accept a wide variety of data entry sequences?
2) Does it give a unique error signal for different types of data entry errors?
3) After a data entry error, can the operator re-enter merely the correction for the erroneous data, or must he repeat the complete entry?
4) Will it give the operator maximum information with minimum data entry?
5) Will it display the current value for any point on request?
6) Does it permit addition of customer-written functions?
7) Is operator information given in a form as close to English as possible?
8) Can the operator call for visual display of the value of any function that can be changed, as part of a change sequence?
9) Is the current value of any changeable function printed after it has been displayed?
10) Is a function always canceled before the operator gives an execute command?
11) Are executed functions automatically documented?
12) Can incremental alarm limits be changed by the operator?
13) Can the operator change the time and date?
14) Can points be trended on a digital display or CRT, an analog trend recorder, or a typewriter?
15) Can the status of groups of points be reviewed and additions or deletions be made to the group?
16) Is it possible to review points that have been removed from scan or limit checking?
17) Can points currently in alarm be reviewed?
18) Can all relevant parameters in a DDC loop be reviewed?
19) Is it possible to restore a failed device?

him enough capacity for his own programs. However, for the user who is purchasing his first DDC system, it is safer to give the supplier descriptions of the control loops (e.g., a three-mode controller, a deadband, and an output): the manufacturer then determines the hardware necessary to keep system duty cycle within safe operating limits.

Evaluating the Proposals

If each supplier being considered is required to meet the minimum hardware and software requirements specified, and to keep within the system constraints, evaluation and comparison are greatly simplified because they are then limited to those *extras* that each supplier is able to offer. There is almost no need to compare hardware, since most of the extras are in the software.

A representative list of desirable features, developed from long experience in system applications and console design, is given at left. The user may decide to add this list to his requirements. However, it should be kept separate from the minimum requirements, and separate prices should be requested for any item on the list that is not offered as part of the standard package. This way of pricing allows a more precise dollar comparison of the systems considered.

The list of features is presented in two parts: design of the general software system, which has little operator interface, and design of the operator's console. The latter is of prime importance to the user; what is easiest for the supplier's programmers is not necessarily easiest for the user of the system.

By limiting the comparison of proposed systems to the special features offered, meaningful analysis is made possible. The user is able to concentrate on the area in which he is expert and to assure himself a control system that is easy to use and responsive to his needs.

Respiratory Heat Loss Determined in Deep Diving Tests

J. E. Hudgens

New respiratory heat loss data have been obtained under a variety of conditions that simulate the actual deep diving environment.

A recent program for the Office of Naval Research has provided data on respiratory heat loss for deep diving. The program involved simulation of deep dives in the Westinghouse hyperbaric facility, shown in Fig. 1.

At sea level pressure, heat loss through respiration is relatively constant and is affected directly by the ventilatory (breathing) air-flow rate. Some investigators have estimated this heat loss to be about 24 percent of the total body heat generated. Many other studies have been conducted to determine the effect of breathing cold air down to —55 degrees C, but no known studies had been made on the effect of breathing cold helium mixtures at great depths.

At high rates of ventilation with relatively dense gas mixtures produced by high pressure, there is a very large heat loss affecting a limited area of the body—the upper respiratory tract. The possibility of physiological damage or disablement needed to be investigated. The investigation undertaken consisted of a series of saturation diving experiments performed during a simulated multilevel dive over a period of 22 days and 9 hours (Fig. 2). Simulated diving depths were 450, 650, 850, and 1000 feet, with inhaled gas temperatures of 55, 45, and 35 degrees F. As indicated in Fig. 2, initial compression and time at a simulated depth of 450 feet was about 1½ days; just under 2 days were provided for simulated runs at 650 feet. The remaining 9 days were at 850 feet, with two excursion dives to 1000 feet. The breathing mixture was 0.3 atmosphere absolute oxygen*, 1.2 atmospheres absolute nitrogen, and the balance helium.

All experiments were conducted with

*At a depth of 650 feet, assuming 33 feet of water produces one atmosphere of pressure, breathing pressure is equivalent to 20 atmospheres; thus the percentage of oxygen is $(0.3/20) \times 100 = 1.5$ percent.

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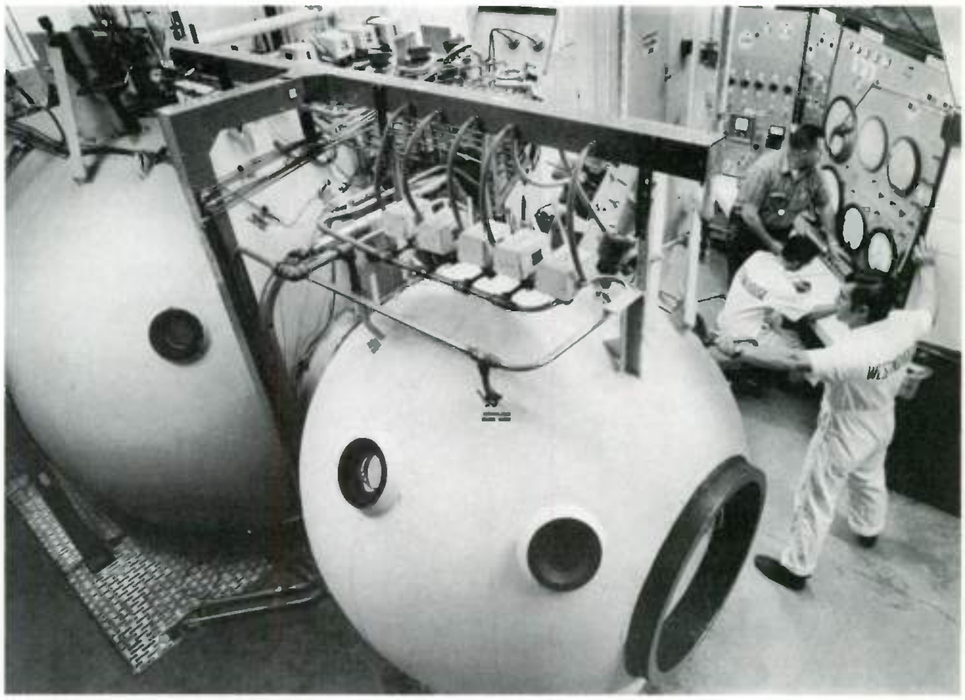

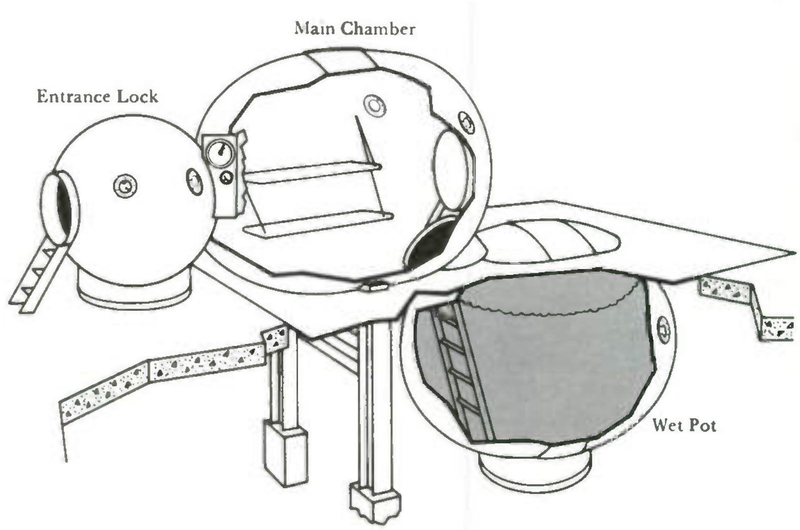

1—The Westinghouse hyperbaric facility consists of three interconnected chambers, all capable of pressurization equivalent to 1500 feet of sea water depth. The facility can accommodate four divers in the main chamber for short periods (less than eight hours), and three divers for longer simulated dives. An experienced operational staff monitors all aspects of a simulated dive from outside the chambers.

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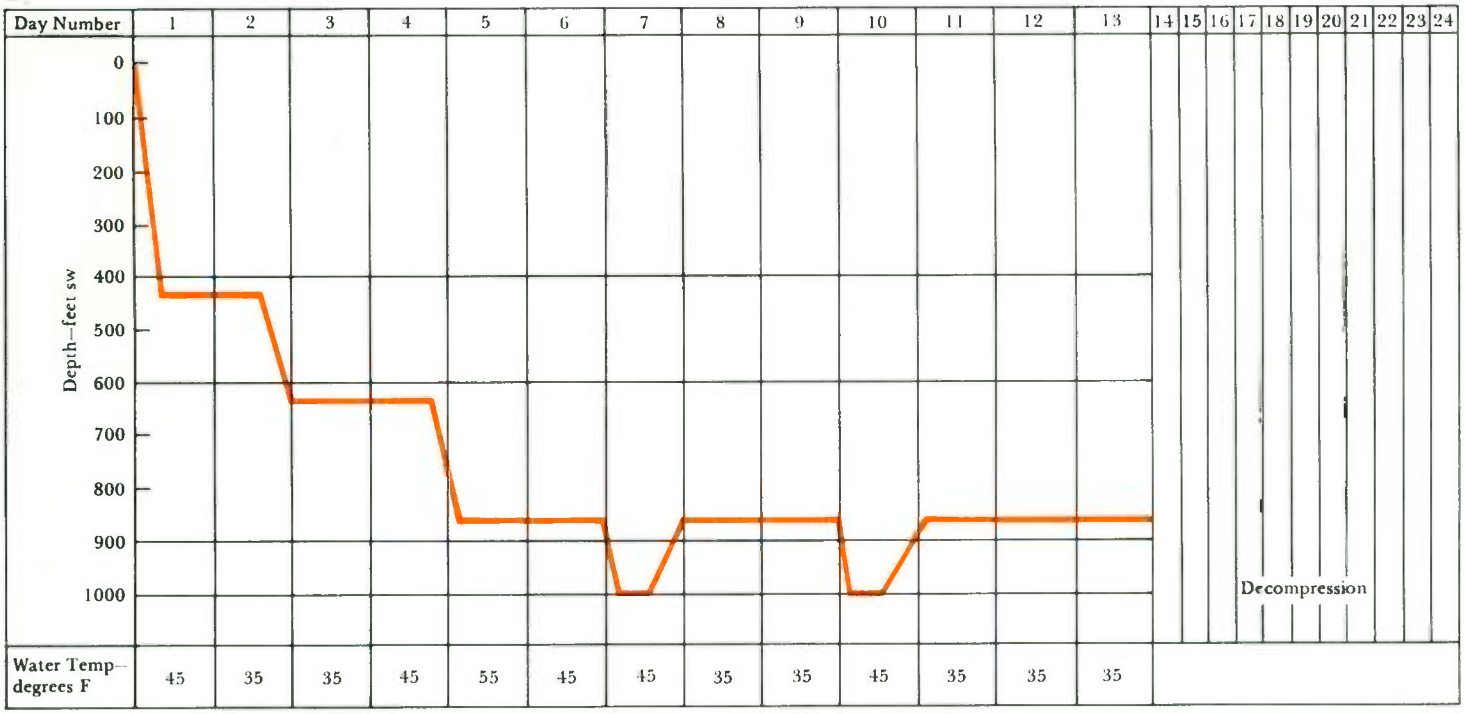

2—Dive profile and water temperatures are shown for the 23-day simulated deep-diving test.

3—Typical of the test results obtained are these respiratory heat loss data at the 850-foot depth.

4—The gas-flow system used during the deep-dive tests permitted measurement of exhaled gas temperature with a quick-responding thermistor mounted in the mouthpiece.

a three-man diving team, with each diver making at least one immersion run in the wet-pot chamber per full working day. Monitoring and surveillance were by direct observation through ports and by closed-circuit television. Temperatures over the body were measured by thermistors.

Since wet-pot water temperature controlled the temperature of the inhaled gas, all swims on a given day at a particular depth were at the same temperature. The divers were equipped with constant-flow hot-water-heated wet suits.

When fully dressed and checked out, the diver entered the wet-pot chamber by ladder and then rigged the ladder to function as an ergometer (a spring-and-weight trapeze deployed under water to provide a means of measuring work rate). Since breathing rates increase in response to applied effort, the diver swam against the ergometer at a rate to displace the ladder to precalibrated positions on the indicator.

The diver's pattern of work and rest was: dress and enter water, 30 minutes; rest and check equipment, 10 minutes; resting ventilation measurements, 15 minutes; light work, 20 minutes; rest, 10 minutes; moderate work, 20 minutes; rest, 10 minutes; heavy work, 20 minutes.

Test Measurements

The measured or derived parameters, referenced to the final portions of each of the four activity levels (rest and three work periods), were: inhaled gas temperature, exhaled gas temperature, respiratory minute volume (volume of gas moved in and out of the lungs in one minute), tidal volume (volume of gas moved in and out in a single normal respiratory cycle), respiratory frequency, inhalation and exhalation flow rate, exhalation pressure drop, mixed expired oxygen and carbon dioxide fraction, body core temperature, skin temperatures (arms, chest, legs, neck), water temperature, and equipment component temperatures. Respiratory heat loss was computed for each of 137 combinations of depth, work rate, and inhaled gas temperature for which ventilation and exhalation temperature were measured. A typical set of results, Fig. 3, shows the respiratory heat loss as a function of respiratory minute volume for the 850-foot depth and water temperatures of 35, 45, and 55 degrees F.

From the test, it was found that exhalation temperature does not vary appreciably with depth. Thus, probably the most important quantitative information acquired during the study was the temperature data for exhaled gas.

Reliable measurements of the temperature of the gas as it is exhaled are basic to accurate projections of heat loss through respiration. The gas-flow system used for the tests is shown in Fig. 4. A thermistor was used for measuring minimum and maximum inhaled and exhaled gas temperatures. The thermistor had

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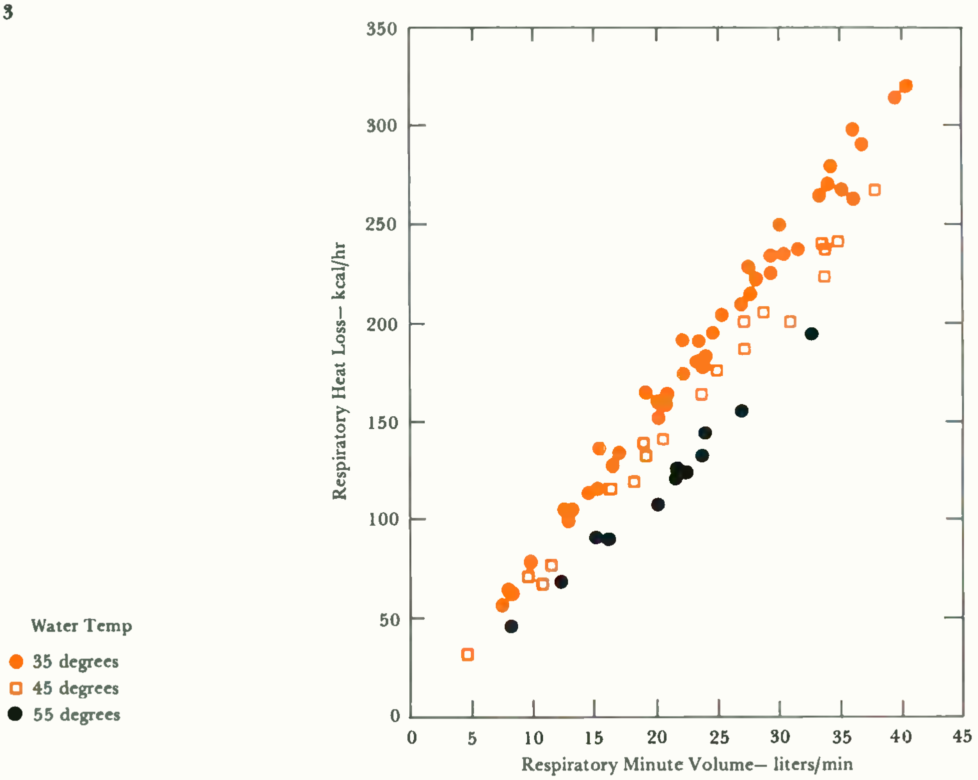

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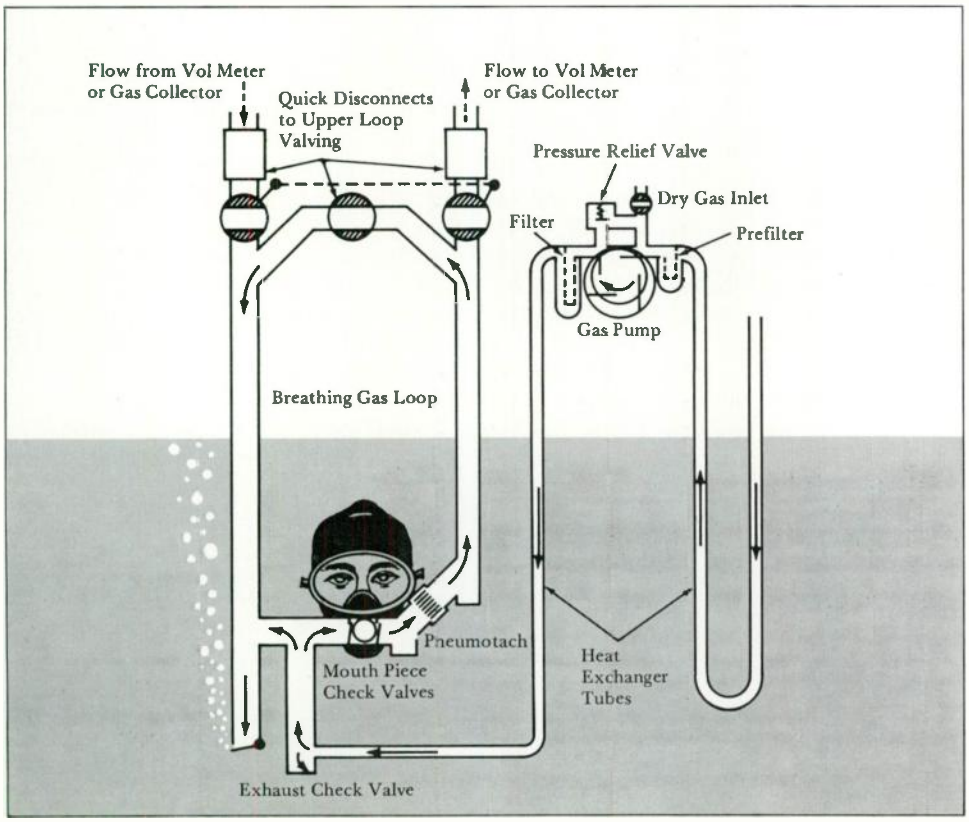


to have an accuracy of 0.5 degree F in 0.5 second for a range of 32 to 100 degrees F. A thermistor with a time constant in still air of 0.12 second was obtained and isolated thermally by mounting it by its lead wires (0.75 mil diameter) in a transistor type header in the mouthpiece.

Test Results

Exhalation gas temperature was always less than body core temperature, regardless of the inhalation gas temperature (55, 45, and 35 degrees F). The maximum rate of respiratory heat loss was observed with hard work (high ventilation rate) in 35-degree water at 850 feet; it was about 400 watts (345 kilogram calories per hour). Copious secretions, chest and back chilling and discomfort, and uncontrollable shaking and shivering were most severe under these conditions and, in fact, caused abandonment of three of the 140 trial combinations that were originally scheduled.

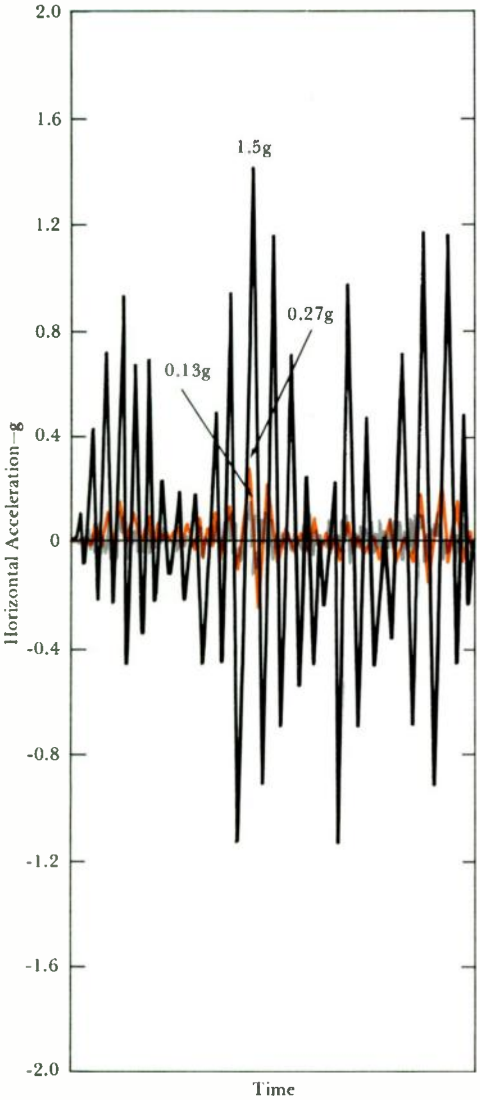
Two basic conclusions applicable to deep diving where supplemental heating of inhaled gas is not used were formulated from the computations of respiratory heat loss, observations of core temperatures, and the subjective responses:

1) Dives to 850 feet for periods greater than 90 minutes in water temperatures of 45 degrees F or colder are unacceptably hazardous;

2) Dives to 650 feet for periods greater than 90 minutes in water temperatures of 35 degrees F are likely to produce physically unacceptable stresses.

Sine-Beat Vibration Testing Verifies Earthquake Capability of Metal Clad Switchgear

Edward G. Fischer
August P. Colaiaco



1—Random horizontal building motion at ground level during a typical earthquake (gray curve) is filtered at a building natural frequency and magnified about two times to produce the floor motion shown by the colored curve. If equipment mounted on that floor has a five-percent damping factor and a natural frequency coincident with a building natural frequency (8 Hz in this example), then the horizontal acceleration is amplified about 5.5 times in the equipment (black curve). The peak accelerations of the building, floor, and equipment are 0.13g, 0.27g, and 1.5g respectively.

The sine-beat vibration testing method simulates the seismic effects of a building on equipment installed within it. The method is conservative because it amounts to simulation of the worst condition: resonance between the equipment and the building.

Switchgear for a nuclear generating station must be able to withstand forces resulting from earthquakes so that it can shut down the reactor, if necessary, and maintain the station in a safe condition during such an event. While there are currently no standards that state specifically how electrical control equipment should be verified for seismic applications, a recently released IEEE document* describes acceptable methods for qualifying such equipment. One method is sine-beat vibration testing, which was developed at Westinghouse and is described in several publications.[1,2,3]

During an earthquake, random motion at ground level is filtered and magnified by the building structure in amounts dependent on the building's natural frequencies and damping characteristics. The vibrational motion is further magnified in the installed equipment, with the greatest buildups occuring in components having natural frequencies coincident with those of the floor (Fig 1). The problem, then, is to determine whether equipment can function properly under the vibrational forces offered by a particular building floor during an earthquake.

The dynamic characteristics of a multistory building and its reactions to earthquake vibrations can be conveniently evaluated by computer-aided analysis of a mathematical model of the soil and structure system. Computer-aided analyses can also be used to qualify some types of equipment, provided an authentic mathematical model of the equipment can be defined (preferably based on test results). However, the vibrational responses of complex equipment such as switchgear are not so easily investigated with mathematical models because of the equipment's nonlinear and cross-coupled characteristics caused by friction, clearances, preloads, asymmetry, etc. In addition, the possibility of malfunction of shock-sensitive devices such as high-speed relays requires that a conservative test be performed to demonstrate operating reliability. For such types of equipment, vibrational responses can be determined through sine-beat vibration testing, which physically simulates the local floor's motion during an earthquake while recording the functional responses of the switchgear.

In this method, the input vibrations to the test bed on which the switchgear is mounted consist of five beats, each containing five sinewave cycles followed by a 2-second minimum pause (Fig. 2). The sinewave amplitude is selected to more than duplicate a floor's peak vibrational response to the most severe earthquakes, and the frequency is adjusted to coincide with natural frequencies of the equipment. This use of test-bed frequencies that coincide with equipment natural frequencies results in a quasi-resonance (less than steady-state resonance) that provides vibrational buildup in the equipment. The testing procedure is thus a conservative one since the equipment is rigorously tested at its most vulnerable frequencies. Un-

Guide for Qualification of Class I Electrical Equipment for Nuclear Power Generating Stations, IEEE Document No. 344-1971.

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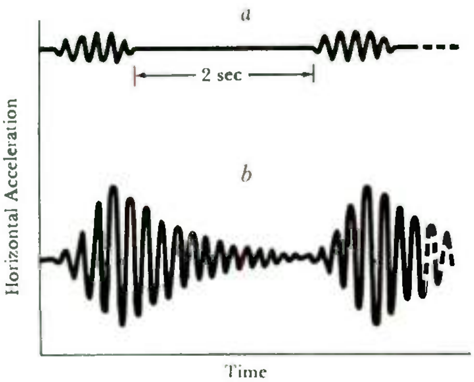
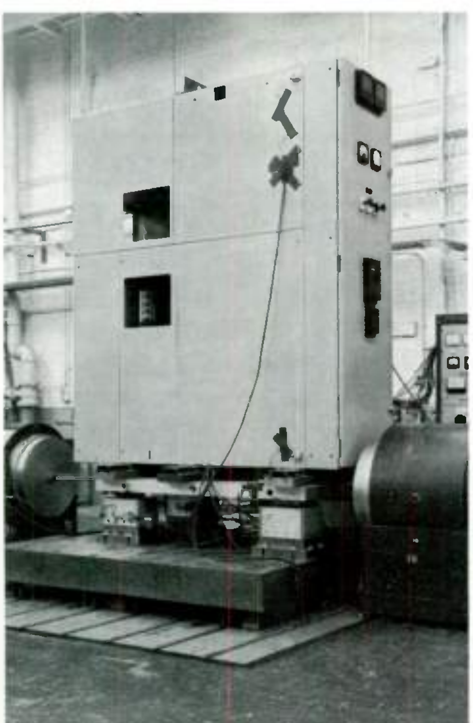
2—(*Above right*) The vibrational response of a building floor to earthquake motions is simulated in the test method by a standardized train of five beats (only two of which are shown here), with each beat followed by at least a 2-second pause (*a*). Each beat consists of five sinewaves. When subjected to sine beats that contain an equipment natural frequency, the equipment under test vibrates in a quasi-resonant manner (*b*).

3—(*Right*) Electromagnetic thrusters at either end of the test bed provide side-to-side sine-beat excitation to a 5-kV metal clad switchgear unit. Accelerometers are attached to the cabinet and other components to measure the amplified vibration during the tests. Tests are also made in the front-to-back and vertical directions.



realistic fatigue and destructive resonance effects in the equipment are avoided by limiting the cycles per beat to five and inserting the 2-second pauses between beats. (While a severe earthquake may have only one or two principal tremors, the sine-beat test is repeated at five cycles per beat to represent five separate tremors, thereby insuring a severe test). The number of cycles per beat and the peak amplitude of the beat for each test is chosen to reproduce the equipment response supplied by the architect-engineer in terms of floor or foundation response spectra.

Sine-beat tests are made on equipment in the side-to-side, front-to-back, and vertical directions at each experimentally determined natural frequency plus certain other frequencies to cover the frequency range of damaging seismic effects (Fig.3). (According to building floor and foundation response spectra that have been supplied by customers, the frequencies of conceivably damaging vibration buildup in installed equipment due to earthquake tremors are between 1 and 25 Hz.) The natural frequencies along each axis are found by vibrating the equipment with low-acceleration sinewaves of increasing frequency. Accelerometers attached to susceptible components such as door panels, cell structures, arc chutes, and potential transformers detect and feed to a recorder the vibrational buildups in those components when their natural frequencies are encountered.



During the testing phase, the accelerometers monitor the components' vibrational response to sine-beat excitations. In addition, observers are present for visual and audio recognition of possible resonant frequency buildup on non-critical components, such as side panels, which do not have accelerometer attachments. Various monitoring devices record the electrical performance of the relays and switches with the breakers opened, closed, and in the process of opening and closing during a sine beat.

In the past year and a half, sine-beat tests have been made on 600-volt metal enclosed, 5-kV metal clad, and 15-kV metal clad switchgear. All units were "off-the-line" production models and contained representative components including current transformers, trunnion-mounted potential transformers, zero sequence transformers, potheads, circuit breaker mechanisms and truck-operated switches, manual and remote operated instrument and control switches, and protective and auxiliary relays.

The test program has shown that switchgear of standard design can withstand the earthquake levels currently prevalent in nuclear generating station specifications without component failure or degradation of safe performance of principal functions. In addition, sine-beat testing has provided valuable information on component damping factors and natural frequencies that will help in developing authentic mathematical models of switchgear equipment to aid in future seismic designs.

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[2] E. G. Fischer, W. H. Ferguson, and A. P. Colaiaco, "Test Method to Demonstrate the Seismic Capabilities of Equipment," *IEEE Transactions*, Winter Meeting, New York, N.Y., Jan.-Feb. 1972.

[3] A. P. Colaiaco and W. S. Albert, "Seismic Testing of Metal Clad and Metal Enclosed Switchgear Using Sine-Beat Vibrations," *IEEE Transactions*, Winter Meeting, New York, N.Y., Jan.-Feb. 1972.

Largest Paper Machine Relies on Advanced Drive Systems

Improved regulators permit high operating speed and thereby provide high production rates. They control the speeds of drive motors in adjacent sections of the paper machine to keep the sheet tight without breaking it.

Weyerhaeuser Company's new linerboard paper machine, probably the largest paper machine in the United States, is now in full production at the company's mill in Valliant, Oklahoma. It makes a sheet 360 inches wide, is driven by a total of 15,000 hp supplied by motors rated from 10 to 1000 hp, operates at 2650 feet per minute at top speed, and can produce more than 1200 tons (about 5 square miles) of linerboard in each 24-hour work day.

Linerboard is the facing sheet that forms the two sides of the corrugated boxboard used for shipping cartons. Corrugating medium, the middle part of boxboard, is made at the Valliant mill on another paper machine that makes a sheet 260 inches wide. The two machines are designed to turn out a matching quantity of both types of paper.

The new mill is the major facility completed so far in Weyerhaeuser's billion-dollar four-year expansion program. It is part of a production complex in the Oklahoma-Arkansas area that also includes log processing facilities and timberland. Prime contractor for the mill was Brown & Root, Inc., and engineering was performed by Rust Engineering Company. The thyristor-powered adjustable-speed dc drives for both paper machines and for the processing equipment were supplied by the Westinghouse Industrial Systems Division and Large AC/DC Motor Division.

Wood chips, the raw material for the papermaking process, are brought to the mill by the trainload and stored in large rows by special cranes (Fig. 1). The same cranes reclaim chips as needed, moving them to conveyors that take them to the digesters seen at far left in the overall plant view (Fig. 2). There chemicals and steam dissolve the natural binders in wood to free the cellulose fibers, which

1—Wood chips are piled for storage.

2—The mill's two paper machines are housed in the long building in the background.

3—Paper production on the linerboard machine begins at the Fourdrinier section.

4—The forming sheet of paper is picked up by felts that carry it through presses to squeeze water out.

5—The next section, shown here on the drive side, consists of steam-heated drying drums.

6—The paper is wound up at the discharge end of the machine.

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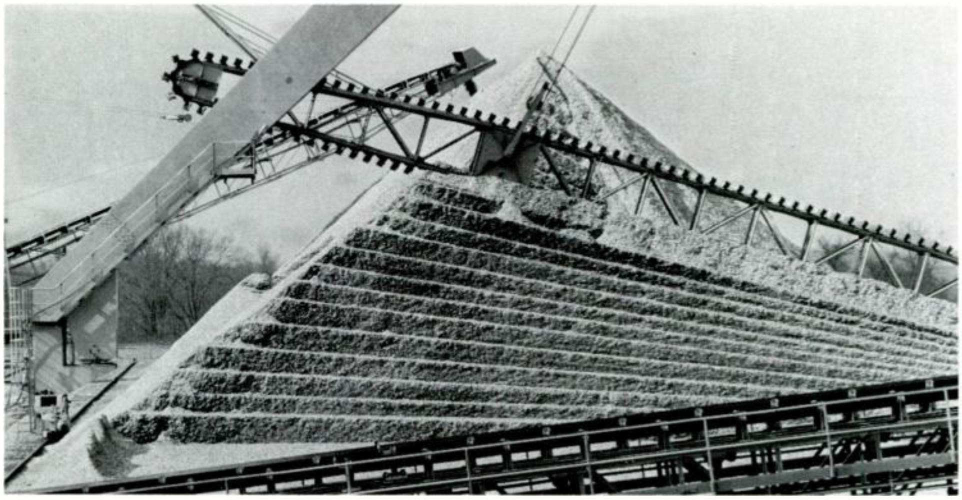

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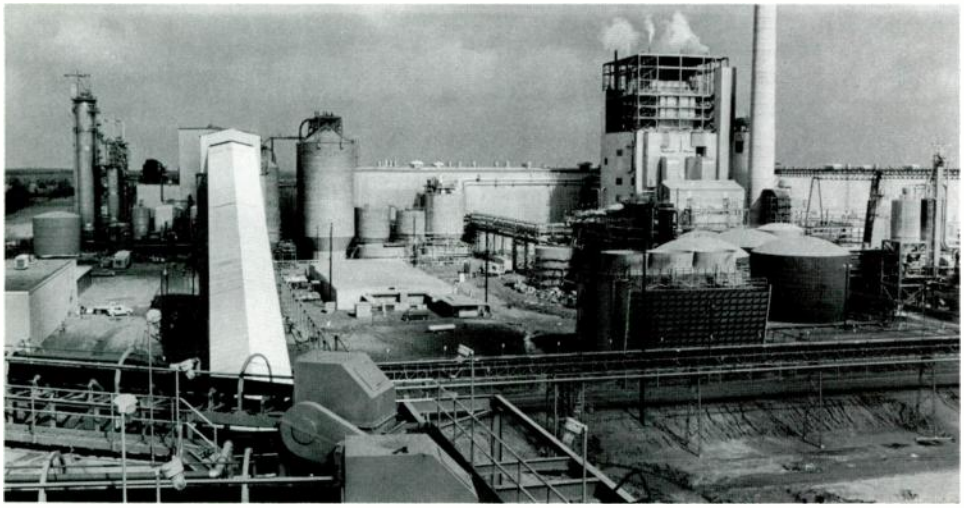

are then washed and mixed with water.

The remaining photographs illustrate the linerboard machine. The slurry of fibers and water is fed to the headbox and from there to the forming wire, called the Fourdrinier section, to form the sheet (Fig. 3). The Fourdrinier is an endless belt of bronze wire; enough of the water drains through it to give the fibers the integrity of a sheet of paper. The sheet is then picked up by the felts, a system of fabric belts that carry it through presses to squeeze out more of the water (Fig. 4). Once through the presses, the sheet has enough strength to span the gap between the presses and the dryers, which are steam-heated drums that complete the water removal (Fig. 5). In the dryer process, the paper is coated to give it a hard surface for printability. It is then run through calender rolls to give it a smooth finish.

The sheet comes off the machine too fast to be trimmed and slit to the customer's specifications, so it is wound onto a reel for temporary storage (Fig. 6).

Each section of the paper machine has a separate regulated drive system that includes the dc drive motors for that section (Fig. 7). The system also includes a thyristor static rectifier, which converts ac power to adjustable-voltage dc power (Fig. 8). The heart of each drive system is the high-precision T-100 regulator, which maintains exact synchronism between each machine section and the preceding section to keep the sheet tight at any speed.

Many innovations were incorporated in the drive system by a combination of Weyerhaeuser and Westinghouse engineering. New circuit combinations using the latest miniaturized components were designed to enhance regulator dependability, on-line test modules were included to allow operators to check critical parts of the regulators without shutting down the machine, and provision for computer control of the machine was incorporated.

Each section is regulated to keep the sheet under a set tension, which is especially important when slowing down or accelerating the machine. Too much tension would tear the sheet. Too little

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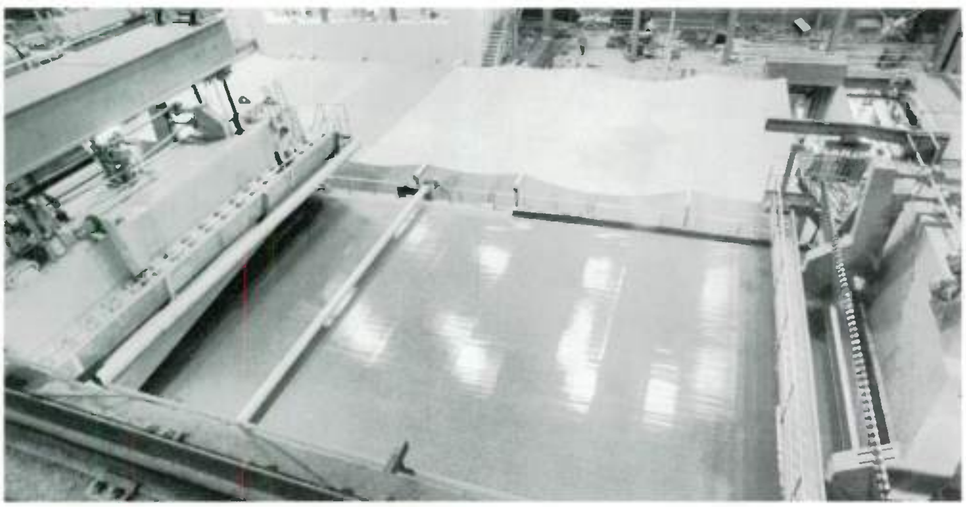

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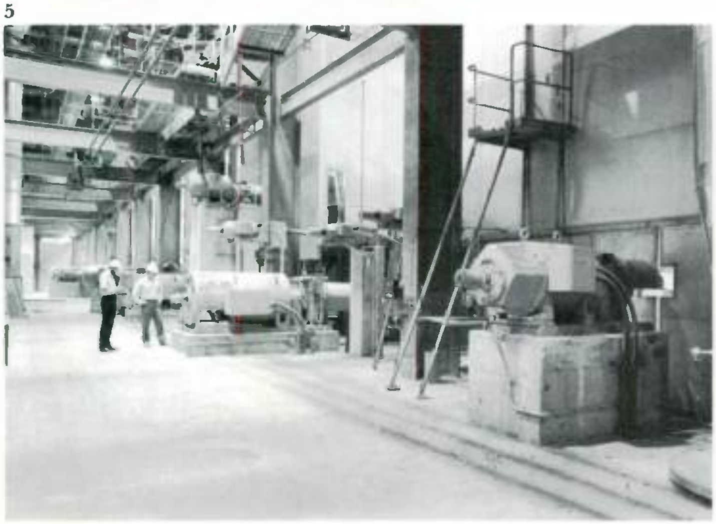

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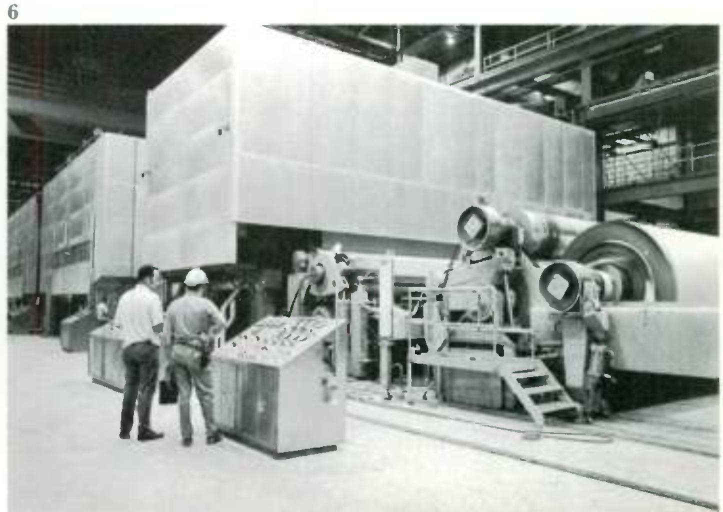

tension would allow the sheet to sag and possibly wrinkle; a wrinkle could mark the huge calender rolls, requiring that they be taken out and refinished. Downtime is expensive, so the mill must run continuously, shutting down only when necessary.

The Westinghouse T-100 regulator is an all-static device that constantly monitors motor load and speed and compares them against a master reference, which tells it how fast the overall machine should be going. The regulator is programmed to hold an exact tension on the sheet and not allow speed to vary more than 0.1 percent. It has to correct for changes in temperature and ac line voltage, so 360 times a second it makes a decision on whether to feed more or less power to its motor.

The T-100 regulator is also used in rewinding. As mentioned earlier, the paper is wound up, as it comes off the machine, into "mill rolls" that are about 9 feet in diameter. Then each mill roll has to be rewound under controlled conditions while being trimmed and slit to the desired widths. The mill roll is coupled to two 400-hp dc braking generators, and the free end of the paper is threaded through a row of slitters (Fig. 9). The paper is then rolled up into finished rolls on top of two steel rollers, each driven by an 800-hp dc motor.

The motors accelerate the paper smoothly to 90 miles an hour. Even tension is maintained by the two braking generators pulling at one end and the two motors pulling at the other end. With a full mill roll on the unwind, the generators run initially at 250 r/min; as the roll unwinds, they speed up to almost 1100 r/min before the roll is exhausted. The regulator is programmed to cause the braking generators to reduce tension as the finished rolls build up, thereby compensating for the changing diameter ratio and so keeping the density of the finished rolls uniform.

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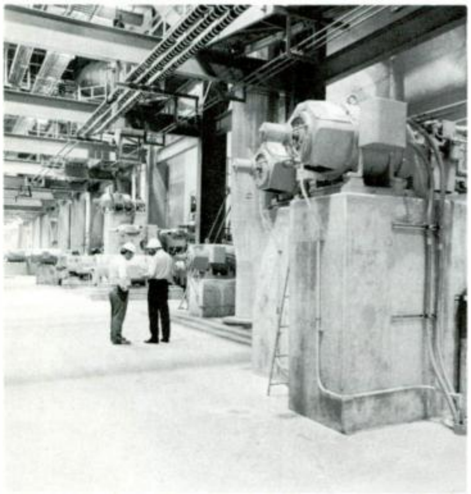

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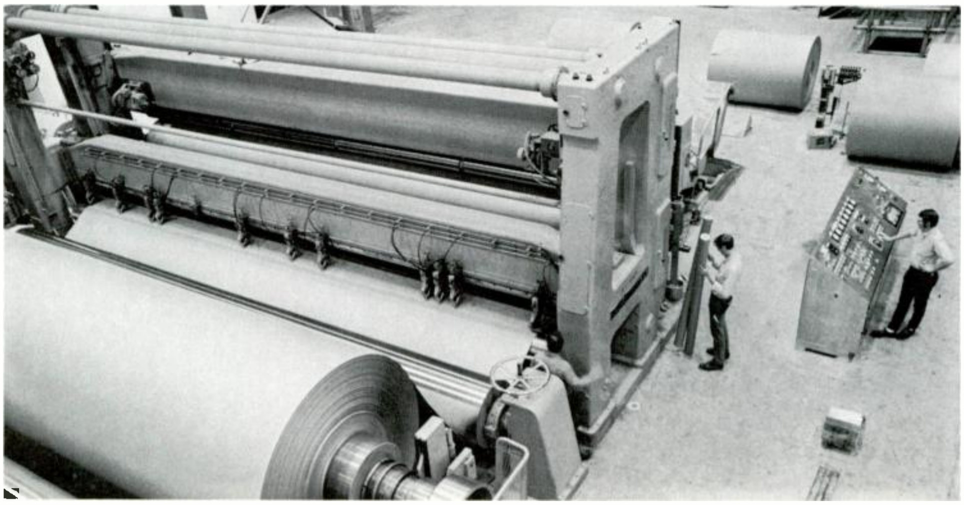


7—Machine sections are driven by dc motors.

8—Thyristor static rectifiers convert ac power to adjustable-voltage dc power to energize the drive motors.

9—Paper is rewound from the mill roll into finished rolls and, at the same time, is trimmed and slit to the desired widths.

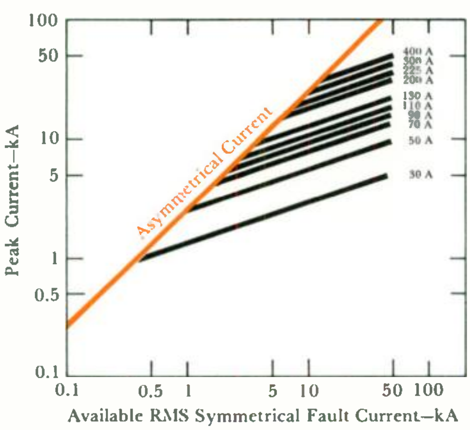
current-limiting fuse in limiting peak let-through current and the associated I^2t is illustrated in the example of Fig. 5.

Current Ratings

In most cases, expulsion and current-limiting fuses are applied with a higher current rating than that of the protected equipment to allow for permissible overloads and transient inrush currents. Equipment such as transformers and motor starters have overload capability because of their large thermal mass. While power fuses also have overload capability, their thermal mass is usually much smaller and so they require a higher current rating to prevent unnecessary blowing. Westinghouse publishes curves that show the overload capability of its expulsion and current-limiting power fuses and tables that list their minimum recommended sizes for application with single- and three-phase substation and distribution transformers.

Power fuses that protect transformers must not be damaged by the inrush of exciting current. The magnitude of the first peak of the exciting current and its exponential rate of decay are determined by the point of closing on the voltage wave, residual flux in the transformer core, core losses, supply circuit impedance, and transformer saturation characteristics. A general application guide has been that a fuse will not be damaged by inrush current if the fuse minimum melting curve lies above 0.1 second at 12 times transformer full-load current. That guide is based on the assumption that the heating effect of inrush current is equivalent to 12 times the full-load current flowing for 0.1 second. The assumption is still valid for expulsion fuses and distribution fuse links, but for current-limiting fuses, which generally have a more inverse time-current characteristic, the peak magnitude of the first loop of transformer exciting current must be considered in the application. Recent studies have shown that the first peak of inrush current in single-phase distribution transformers can be as high as 42 times the transformer full-load rms current. Although this upper bound corresponds to worst-case conditions, such conditions can exist.

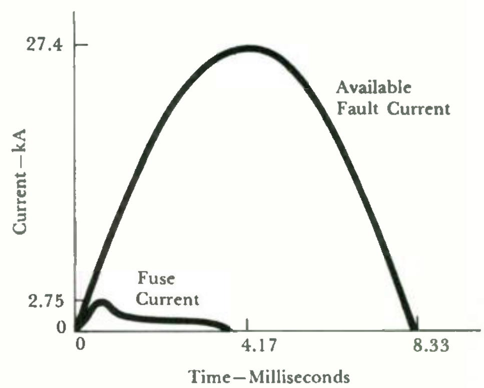
In a study to determine the smallest size current-limiting fuses that can be used with 7.2-kV single-phase distribution transformers, I^2t values of inrush current were computed at the first peak and at 0.1 second for the different kVA ratings. Those values were then compared with the minimum melting I^2t values of Westinghouse CLT and CLT-S current-limiting fuses to determine the minimum size fuse that could be used with each transformer. It was found that if the smallest current-limiting fuse that will not melt in 0.1 second at 12 times rated current is used to protect the transformer, the fuse may melt due to inrush currents. Therefore, Westinghouse publishes tables from such studies that list the minimum size CLT and CLT-S fuses that function properly with various size distribution transformers.



4—Current-limiting performance is illustrated for various size fuses. For a known available rms symmetrical fault current, the peak of the available fault current can be read off the ordinate scale at points where the available rms fault current intersects the colored diagonal line. Ordinate readings at points where the available rms currents intersect fuse curves (black lines) are the peak instantaneous let-through currents of those particular fuses. Thus, if there is an available rms symmetrical fault current of 5 kA, the peak value of asymmetrical current is about 13 kA. However, a 30-ampere fuse, for example, would let through only about 2.3 kA of peak instantaneous current to the protected circuit.

Voltage Ratings

The maximum design voltage of either an expulsion or current-limiting fuse should not be exceeded by the steady-state (normal frequency) recovery voltage that is across the fuse if it is blown. If the design voltage is exceeded, the fuse may continue arcing after the current-responsive element has melted and thereby permit equipment damage. In *Normal Frequency Recovery Voltages in Three-Phase Transformer Banks*, page 90, several types of secondary faults are considered



5—Interrupting ability of a 12-ampere 8.3-kV CLT current-limiting fuse is shown by tests made at the Westinghouse High Power Laboratory. The peak available symmetrical fault current was 27.4 kA with an associated I^2t for one half cycle of 3.12×10^6 amperes squared seconds. When the CLT fuse was inserted in the circuit, the peak instantaneous current was limited to 2.75 kA and the total clearing I^2t reduced to 5.25×10^3 amperes squared seconds.

to illustrate how to select minimum fuse voltage ratings on the basis of normal frequency recovery voltages.

Single-phase laterals and distribution transformers supplied from three-phase multigrounded neutral circuits in underground and overhead distribution systems are frequently protected with fuses. Those fuses do not need a voltage rating equal to full line-to-line voltage, assuming phase-to-neutral connections. As long as the fuse's maximum design voltage equals or exceeds the circuit maximum line-to-ground voltage, an adequately designed fuse will perform properly. In general, a fuse applied with single- or three-phase equipment so that its maximum design voltage equals or exceeds the maximum steady-state recovery voltage is applied properly from a voltage rating standpoint.

However, since a current-limiting fuse limits current by generating an arc voltage that exceeds the system supply voltage, a fuse with a too-high voltage rating could produce excessive arc voltage and cause sparkover of lightning arresters on the source side of the fuse. If that happens, part of the energy stored in the circuit inductances will be dissipated in the arrester and part will be dissipated in the fuse. The arrester may be damaged or destroyed, depending upon its characteristics and the division of energy stored in the circuit between the fuse and arrester. Arresters located on the load side of the fuse, however, will not spark over regardless of the magnitude of arc voltage generated by the fuse.

Normal Frequency Recovery Voltages in Three-Phase Transformer Banks

A delta wye-grounded transformer bank supplied from a radial system is shown in *a*. If a fault occurs from secondary terminal *X*1 to ground, the currents in primary phases *A* and *C* will be equal in magnitude if the effects of load current are neglected. If either fuse clears or if both fuses clear, the steady-state recovery voltage across the blown fuses will equal the primary line-to-line voltage. Therefore, the fuses' voltage rating should at least equal the system's maximum line-to-line operating voltage.

Many utilities use wye-grounded wye-grounded winding connections on pad-mounted distribution transformers to prevent high voltages caused by ferroresonance during single-phase switching (*b*). Those transformers are supplied from three-phase four-wire multigrounded neutral circuits. The steady-state recovery voltage across a blown primary fuse generally will not exceed the system line-to-ground voltage by more than ten percent for secondary three-phase-to-ground faults, or for single- or double-line-to-ground faults. That applies to wye-wye banks with either three-, four-, or five-legged cores or triplex type cores. Exact magnitudes of steady state recovery voltages depend on the sequence impedances of the supply circuit and transformer.

For an ungrounded line-to-line secondary fault (*c*), the recovery voltage across a blown fuse can approach full line-to-line voltage even though the neutral points of both wye-connected windings are grounded. With a line-to-line fault between secondary terminals *X*2 and *X*3, the magnitude of current in primary phases *B* and *C* will be equal if the load component of current is negligible. It is conceivable, though, that one fuse (for instance phase *B* fuse) would melt before the other melted because of load current, fuse tolerances, preloading, or different ambient temperatures. The fuse in phase *B* then is subjected to and must clear against a steady-state recovery voltage equal to full line-to-line voltage.

Even if both primary fuses open, either because of a line-to-line ungrounded secondary fault or a heavy secondary overload, the normal frequency recovery voltage across the open fuses can still approach full line-to-line voltage. This occurs if 100 percent of the secondary load on the transformer is connected from line to line. If part of the secondary load is connected from line to line and part is connected from line to neutral, the fuses' recovery voltage would lie somewhere between normal line-to-line and line-to-ground voltage, depending upon the ratio of line-to-line to line-to-neutral load.

On wye-grounded wye-grounded transformer banks, the primary fuses' voltage rating need only exceed the primary line-to-ground voltage, if the possibility of ungrounded line-to-line secondary faults can be discarded and if all secondary load is connected from line to neutral. If such faults are a possibility and not all the load is connected from line to neutral, the steady-state recovery voltage across an open primary fuse or fuses could equal full line-to-line voltage. Frequently, utilities install primary fuses rated less than line-to-line voltage inside the transformer tank. Less mounting space is required and the fuse and transformer costs are usually lower than if the fuses were rated at full line-to-line voltage. Economics may sometimes justify the risk of using such fuse ratings, but 100-percent correct fuse operation can be assured only by applying fuses rated for full line-to-line voltage.

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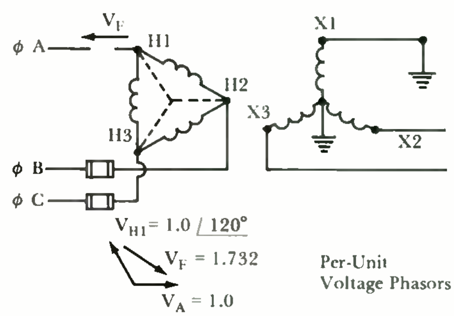

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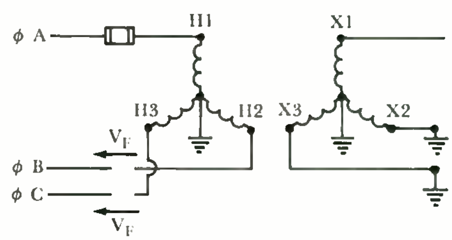

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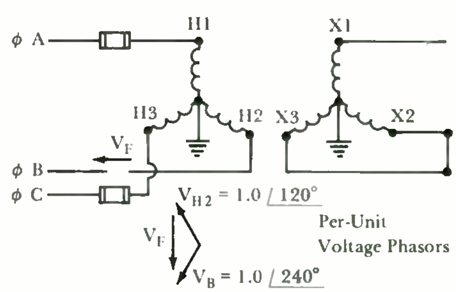

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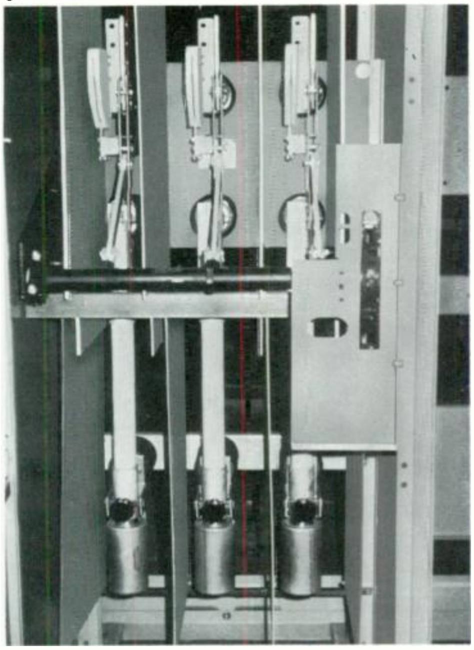

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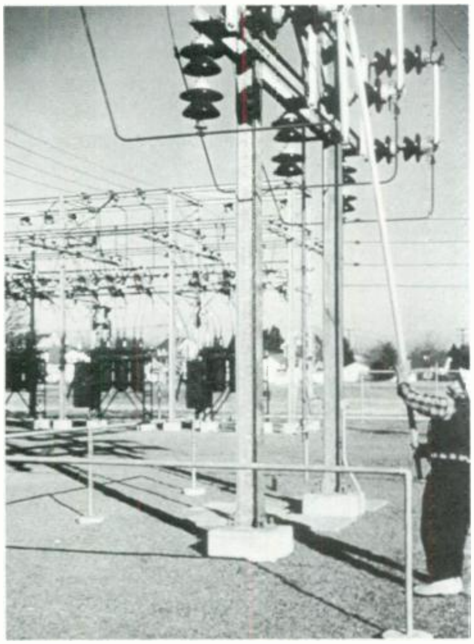

6—Type RBA-400 expulsion fuses are connected in series with a loadbreak LBF switch in 15-kV metal clad switchgear. Each fuse has an attached discharge filter and can interrupt 29.4 kA of symmetrical fault current.

7—Type DBA-2 expulsion fuses are being installed in the primary circuit of a 69-kV substation. The fuses have dropout action and an interrupting rating of 10 kA symmetrical.

When current-limiting fuses are used to protect single-phase devices such as distribution transformers or laterals supplied from three-phase four-wire multigrounded neutral circuits, the fuse nominal voltage rating usually is less than the arrester rating. For those conditions, the arc voltage generated by Westinghouse current-limiting fuses should not cause sparkover of distribution type arresters.

As an example, consider a three-phase four-wire multigrounded neutral circuit operated at 12.47 kV line-to-line. A single-phase 7200-volt distribution transformer supplied from that circuit frequently would be protected by a 9- or 10-kV arrester and 8.3-kV current-limiting fuse. The probability of fuse arc voltage initiating arrester sparkover is infinitesimal. In the rare event that the fuse arc voltage is sufficient to cause arrester sparkover, the arrester generally will not be damaged if it is a distribution type. However, station and intermediate type arresters, which have lower sparkover and discharge characteristics, may be damaged.

Interrupting Ratings

Fault currents in power systems essentially consist of a dc component, which decays exponentially with time, plus a steady-state ac component that varies sinusoidally with time. The magnitude of the dc component at the instant of fault inception is determined primarily by the point on the voltage wave where the fault begins, and the rate of exponential decay is determined by the circuit reactance-to-resistance (X/R) ratio. At any instant in time, the total rms asymmetric current is defined as the square root of the sum of the dc component squared plus the rms ac component squared. Because of the short interrupting time of power fuses (¼ cycle or less for current-limiting fuses and as little as ½ cycle for expulsion fuses), the fuse may have to interrupt the dc component as well as the ac component.

Power fuses of recent manufacture are rated in terms of symmetrical current but are designed to withstand full asymmetrical current based on a test circuit

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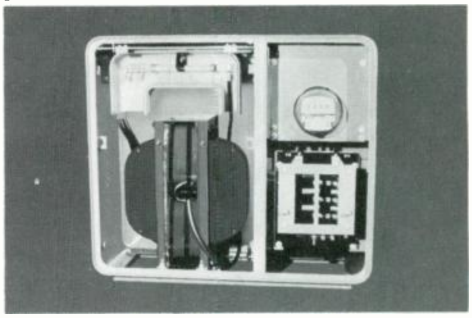

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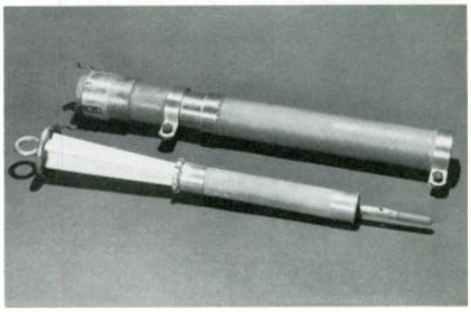

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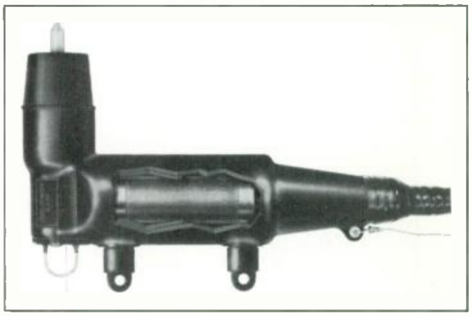

8—The unit residential transformer is protected with a current-limiting fuse.

9—This full-range draw-out current-limiting fuse protects a 50-kVA "Mini-Pak" distribution transformer of dead-front construction. The fuse has an interrupting rating of 40 kA symmetrical and is shown beside its holder, which mounts permanently inside the transformer tank.

10—A Westinghouse 8.3-kV current-limiting fuse is shown in this cutaway view of a separable elbow connector, manufactured by Burndy Corporation. The connector is for use with pad-mounted and submersible distribution transformers.

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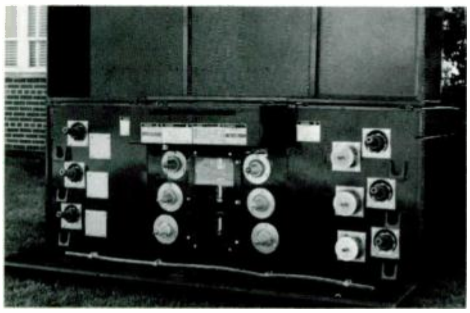

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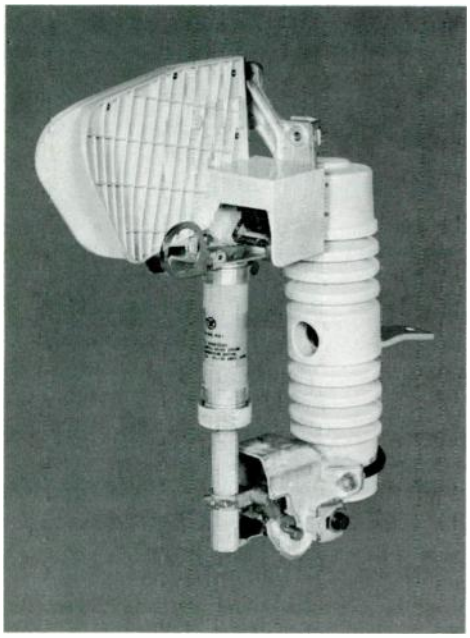


11—This pad-mounted "T-Tap" vacuum switch employs two three-phase gang-operated switches for incoming and outgoing portions of a 15-kV feeder, and it has three fusible single-phase tap-off points emanating from the central buswork. Current-limiting fuses for this application are available in ratings from 25 to 125 amperes in a single casing size to facilitate changeover as load fluctuation might dictate.

12—The fused distribution limiter is a new device that incorporates the less inverse time-current characteristic of the fused cutout type "K" link with a back-up current limiter to achieve easily coordinated characteristics and an energy-limiting capability to significantly limit damage during fault interruption. The device is presently available in 8.3-kV and 15-kV sizes for currents up to 40 amperes and will eventually be designed for even higher ratings.

X/R ratio of 15. Manufacturers publish tables that usually list the maximum symmetrical and asymmetrical rms interrupting ratings for the different types of fuses. When power fuses are applied in a distribution system, it is extremely important that the maximum available fault current not exceed the symmetrical or asymmetrical interrupting rating of the fuse. If the fuse is applied contrary to this principle, it may fail to perform its intended functions and thereby allow damage to other equipment.

Occasionally, the interrupting rating of the fuse is compared against the available three-phase fault current. In some parts of a system, however, the single-phase-to-ground fault current may be greater than the three-phase fault current. This situation could exist on a four-wire multigrounded neutral distribution feeder close to a substation that has delta-wye connected transformers with the neutral of the wye solidly grounded. Therefore, the adequacy of a fuse's interrupting rating should generally be determined by comparison with both the three-phase and the single-phase-to-ground fault current.

Application Areas for Power Fuses

With the addition of discharge filters, some types of expulsion fuses are suitable for cabinet installation (Fig. 6). Another application of expulsion fuses is in high-voltage installations, such as the 69-kV substation in Fig. 7.

Because of the unique capabilities of current-limiting fuses, they are used in an increasing variety of distribution equipment. A most successful application has been in preventing disruptive failure of distribution transformers.* Such a failure can result when fault current levels exceed the interrupting capability of the transformer's internal fuse link. The link is very effective within its own rating, but since it is an expulsion-type device, it would pass at least a half cycle of unattenuated current before isolating a faulted transformer from the distribution feeder. The available energy in that half cycle could destroy the transformer. Therefore a current-limiting fuse (mounted in the high-voltage bushing) is connected in series with the link; low-current faults are cleared by the link and high-current faults by the current-limiting fuse.

Fig. 8 shows a full-range current-limiting fuse installed at the high-voltage terminals of a 10-kVA 95-kV-BIL cast dry-type transformer. Typically, this type of transformer would be installed at the service entrance to a home as part of an underground distribution system. The drawout loadbreak current-limiting fuse shown in Fig. 9 is for protection of a "Mini-Pak" distribution transformer.

A new product is a current-limiting fuse mounted in a separable elbow connector for use with submersible or pad-mounted distribution transformers (Fig. 10). Such devices have been installed at the Florida Power and Light/Westinghouse Distribution Laboratory at Coral Springs, Florida.

Other new devices that employ current-limiting fuses are pad-mounted and submersible "T-Tap" vacuum switches (Fig. 11). The switches afford great flexibility for sectionalizing three-phase feeders, fusing tap-off points, providing alternate or preferred manual transfer schemes, and supplying load centers.

A new protection device called the fused distribution limiter (FDL) combines the high fault current interrupting ability and low energy let-through of the current-limiting fuse with the desirable low-current clearing ability and the less inverse time-current characteristics of the expulsion fuse (Fig. 12). Designed for use in the same fuse support assembly as a fuse cutout, the FDL provides interrupting ratings of 40,000 amperes, the same dropout action ordinarily associated with cutouts, the load-break feature where that is a part of the support assembly, and ready coordination with other devices in that it uses the same standard "T" or "K" cutout links that are widely used in the distribution field.

*H. W. Book, R. A. Ghirardini, and D. J. Ristuccia, "Cast Coils and Current-Limiting Bushings Improve Reliability of Distribution Transformers," *Westinghouse ENGINEER*, Jan. 1971, pp. 20-24.

Coal Gasification Process Being Developed for Power Generation

A major program has been launched to develop an economical process for turning coal into gas for use in generation of electricity. The objective is to have an advanced gasification system commercially available by 1980.

The development team consists of Westinghouse, Public Service Indiana, AMAX Coal Company, and Bechtel Corporation. Supporting the effort as associate members are Northern Indiana Public Service, Tennessee Valley Authority, and Consumers Power Company. The team is seeking financial support from the Federal government to help cover the costs of the necessary research and development. Their proposal includes testing of a full-size prototype.

The gasification process, when operated with a Westinghouse combined-cycle PACE power plant, should permit generation of electrical energy at significantly lower cost than is required with conventional coal-burning plants having stack-gas cleanup systems. Development of the process thus would permit economical use of the large reserves of high-sulfur coal in the United States.

In the advanced gasification process proposed, gas is cleaned of sulfur, tar, and particulate matter before it is burned in the gas turbine of the combined-cycle plant. The proposal differs significantly from other announced projects, which are aimed at making gas of pipeline grade from coal, in that it is aimed at making a cheaper gas of lower heat content.

The gasification process proposed is similar to the method that was used to make "city gas" before natural gas became generally available. In that process, coal was heated to drive off volatile materials, burned to form carbon monoxide, and reacted with steam to produce hydrogen. The resulting fuel gas consisted mainly of nitrogen, carbon monoxide, hydrogen, methane, and hydrogen sulfide. Operation was at atmospheric pressure.

The proposed plant would operate at elevated pressure to allow drastic reduction in the physical size of the equipment and, thus, in the capital investment. Coal would be burned in fluidized beds of inert particles supported by upward-flowing currents of air and steam. The fluidized beds would permit utilization of fine coal particles and would simplify ash removal by preventing formation of clinkers. Moreover, limestone particles included in the bed would trap sulfur molecules as they were released by the burning coal, thus making it unnecessary to scrub sulfur out of the product gas.

Training Center Teaches Use and Maintenance of Control Systems

The increased demand for training of control system operators, programmers, and maintenance personnel has made necessary a new and larger training center at the Westinghouse Computer and Instrumentation Division. The 9000-square-foot facility provides six classrooms, a student lounge and study area, and two laboratories. Its regular schedule includes 20 courses, and special courses can be arranged at a customer's plant.

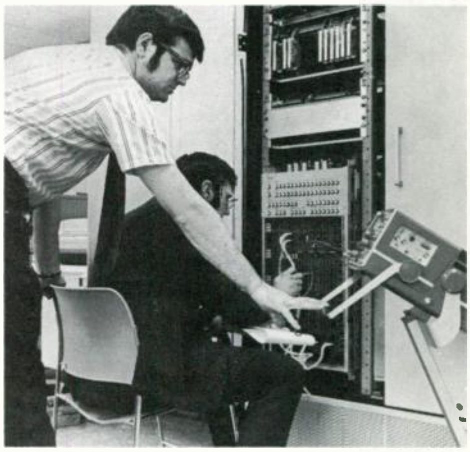
Many of the courses are systems oriented so that the student can learn the response of the entire plant to control actions. Such courses are especially helpful for systems where operating criteria are particularly stringent or where the system combines sophisticated analog and digital equipment.

Classes are kept small so the students can get all the personal help they need. Training includes not only classroom instruction but also considerable laboratory time to give the students opportunity to experiment, analyze, observe, and practice with the machines they are studying.

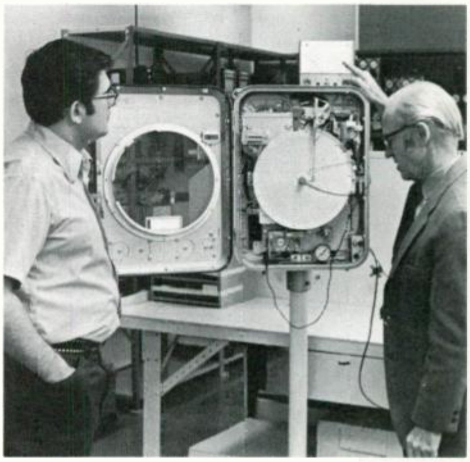
The digital training laboratory (Fig. 1) presently has four computer systems—a P-250, P-2000, W-2500, and P-50 computer, each with its own peripheral equipment. Training activities during a typical day include checking the printout from a student's work at the W-2500 system, helping a student in a maintenance class find a faulty component put into the P-50 machine (Fig. 2), operating a card reader, and helping a student check out the P-2000 main frame (Fig 3).

1—Digital laboratory at new training center.

2—Maintenance instruction with P-50 computer.



3—Diagnostic check on computer main frame.



4—Flow meter in analog laboratory.

An analog laboratory opens directly off the analog classroom so that students can easily move back and forth as demonstrations are needed. Fig. 4 shows an instructor explaining the operation of a Hagan ring balance meter for measuring gas flow.

FFTF Test Facility Nears Completion

Phases I and II of the High Temperature Sodium Facility (HTSF) are nearing completion at the Hanford Engineering Development Laboratory near Richland, Washington. The HTSF is part of the nation's Liquid-Metal Fast Breeder Reactor Program and is in direct support of the Fast Flux Test Facility (FFTF).

Phase I is a high-bay structure that will contain sodium and inert-gas systems for testing components before use in the FFTF. The test systems will be able to simulate most reactor operating conditions, except irradiation, for each component. Data from the tests will contribute to the design of future components for the fast breeder program.

The Phase II complex is a three-story building that will house laboratories and offices for approximately 400 personnel. It should be complete by December.

Management and operation of the FFTF, HTSF, and the Hanford Engineering Development Laboratory are by the Westinghouse Hanford Company, a subsidiary of Westinghouse Electric Corporation, under contract to the U.S. Atomic Energy Commission.

AWACS Radar Readied for Evaluation

Progress on the radar for an Air Force program to develop an improved radar screen for the United States passed a major milestone recently when the antenna (see back cover) and fuselage radar equipment were shipped to the Boeing Company, the program's prime contractor. The airborne warning and control systems (AWACS) will use very-long-range radars carried by large aircraft to detect and track multiple airborne targets flying at all altitudes. AWACS will augment and in part supplant present early warning systems. The major advantage of an airborne surveillance radar is that it covers a larger area than ground-based radar and can see low-flying aircraft.

The Westinghouse Defense and Electronic Systems Center is in competition to supply the radar for AWACS. The antenna shipped in December 1971 will be coupled with its radar equipment for a fly-off competition. An earlier antenna, a test unit shipped in mid-1971, was developed to demonstrate the compatibility of the Westinghouse antenna and the Boeing-designed radome.

Since an airborne radar looks down as well as out, special consideration must be given to the problem of signals reflected from the earth's surface, because this ground clutter can overwhelm radar reflections from low-flying aircraft. The new antenna — a key element to the successful performance of the AWACS system—suppresses ground clutter by reducing the sidelobe energy. (Sidelobes, an inherent antenna problem, are smaller beams propagated in addition to the main beam. Their reflections are responsible for much of the ground clutter.)

The low sidelobe characteristic of the antenna is achieved by very close control of the amplitude and phase of the voltage that is applied to the unit's hundreds of slot apertures, each of which is a miniature antenna and radiates its share of the microwave energy. Engineers used computer-aided design to find the best distribution of the apertures and to calculate the depth of cut and the angle of the slots. This antenna design provides a unit with no moving parts.

The radar's components are housed in easily accessible cabinets, making in-flight maintenance quick and easy. By employing the advantages of solid-state and digital circuitry, maintenance is reduced and reliability increased. The AWACS program is under the direction of the Air Force's Electronic Systems Division, Hanscom Field, Massachusetts.

Dual Air Conditioning System Provides Flexible Zone Control

The new Department of Transportation Building in Washington, D.C., covers a full city block, is ten stories high, has more than a million square feet of office area, and has two perimeters because it is built around a courtyard. In spite of its size and unusual construction, the build-

High-Temperature Sodium Facility will support FFTF development.

ing has flexible zone air conditioning, including control of conditions room by room around the perimeters.

The required flexibility was achieved by providing separate systems to handle core and perimeter conditioning requirements. All equipment was supplied by the Westinghouse Commercial/Industrial Air Conditioning Division.

The core area is served by chilled water from 40 packaged chillers located in a penthouse on the roof of the building. The air-cooled 50-ton chillers employ multiple compressors for efficient step control and service flexibility. They are allocated four to a floor, one for each of the four interior wings. Each chiller is operated completely independently of the others. The chillers supply cool water to air-handling units located above the corridor on each floor.

The building's internal and external perimeter areas have offices conditioned individually by through-the-wall units, each rated 9000 Btu. The units have electrical resistance coils for heating in winter. They have individual controls for ventilation and room air temperature, so units in unoccupied rooms can be turned off without affecting the heating or cooling of other rooms.

The entire system is computer controlled for different hours of operation. For unusual working hours, it can be manually controlled.

Tampa Airport Passenger Shuttle Completes First Year

An estimated 8,000,000 passengers rode the automated passenger shuttle system at Tampa International Airport in its first year of operation. The shuttle serves travelers 24 hours a day at the airport, which is operated by the Hillsborough County Aviation Authority. Eight rubber-tired vehicles on the shuttle system have traveled a combined total of more than 380,000 miles since the opening of the airport's new terminal in April 1971.

The system connects the airport's main Landside terminal with four satellite Airside terminals.* It eliminates much of the walking between car and boarding gate that air travelers are subjected to at many of today's sprawling airports. The longest walk from parking space to plane seat is about 700 feet.

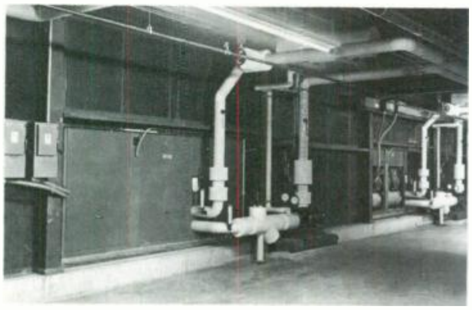
*E. E. Hogwood and R. B. Maguire, "Passenger Transfer System Will Take the Long Walk out of Air Travel," *Westinghouse ENGINEER*, January 1969, pp. 9-15.

Each of the lightweight electrically propelled cars on the system averages more than 1000 trips a day. The cars operate at speeds up to 30 miles an hour along eight concrete roadways, two on each leg of the system. Each car is locked to the roadway by an I-shaped center guidebeam.

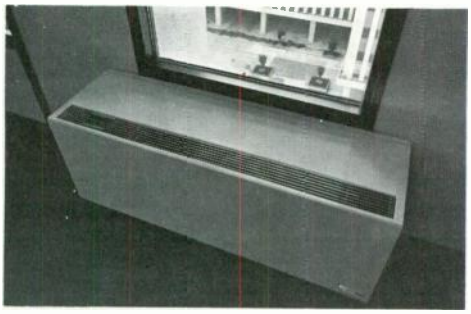
The system has proved to be reliable and safe; of those 8,000,000 passengers who rode during the first year, only two reported minor injuries from falling. Public acceptance of the system has been overwhelmingly favorable.

The entire system is under computer supervision, and the cars operate under automatic controls. Doors operate automatically. The cars can be operated continuously or, during off-peak hours, only on call. Each can carry 100 passengers.

Tampa International is the first airport in the world with a passenger shuttle designed as an integral feature. Its multilevel Landside building has baggage handling facilities, ticket counters, dining facilities, various concessions, and airport offices. Planes load and unload passengers at boarding areas in the four Airside buildings. The shuttle system was designed and installed by the Westinghouse Transportation Division, which



Air-cooled chillers cool the building's core area.



Each perimeter office has its own conditioning unit.

Cars on passenger shuttle system at Tampa International Airport.

is now installing a system using the same basic technology at the Seattle-Tacoma International Airport. That system is expected to be in operation later this year.

Products for Industry

Portable ac ammeters of the three-range transformer type have been upgraded from 3/4 to 1/2 percent accuracy as standard. High overload capacity protects against damage from momentary overloads without the inconvenience and errors associated with fuses. The mechanism is not damaged by instantaneous currents up to 35 times normal, depending on rating. Rating and ranges are related to common working levels so the instrument can be operated far up the dial to assure maximum reading accuracy. Composite scales are provided wherever a single scale necessitates reading a division as an odd fraction of a measurement unit. Scales are subdivided into units of 1, 2, 5, and their decimals. *Westinghouse Relay-Instrument Division, 95 Orange St., Newark, New Jersey 07101.*

Mini-Power Center is a self-contained transformer, primary breaker, and panelboard that eliminates the extra time and expense required when individual components are used. It is designed for use wherever 120- or 240-volt branch circuits need to be taken from a 480-volt line. The center is available in ratings of 3, 5, 7½, 10, 15, and 25 kVA. Either duplex 120-volt or regular 240-volt secondary breakers are available to match the load. The 25-kVA unit can provide up to 24 feeder circuits of 120 volts or 12 circuits of 240 volts, or any combination of 120- and 240-volt lines. The center consists essentially of a sealed Green Line potted dry-type distribution transformer, primary breaker, snap-in secondary breakers, and a panelboard, all factory prewired in a single box. Optional features include a safety pilot light to indicate an energized unit, padlocking capability for primary and secondary breakers, and special breakers with interruption capacity of 10,000 amperes instead of the standard 5000 amperes. *Westinghouse Specialty Transformer Division, Box 231, Greenville, Pennsylvania 16125.*

Three software systems are now available for use on the Westinghouse series 2500 minicomputer, each suited to a particular type of application.

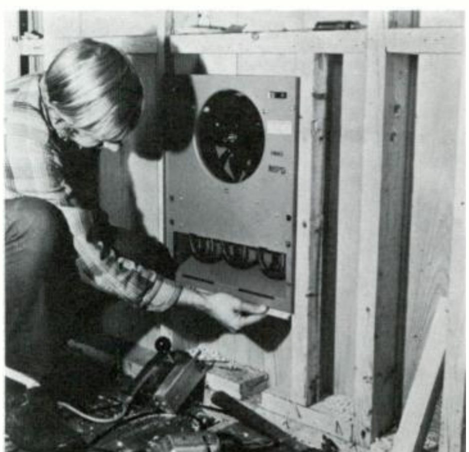
Monitor C is a communications monitor used to service telephone lines by changing parallel data to sequential data for transmission. It can tie W-2550 terminals to a variety of central computers. The system accepts special handlers and runs in approximately 2000 words of core memory. A terminal with Monitor C and a few additional peripheral devices can be used independently for batch and real-time process control, interfacing with the larger central computer only when needed data is stored there or for the most complex control tasks.

Monitor II is a small monitor for minimum core requirement and single-task processing in engineering, scientific, and general-purpose applications. It is an excellent batch operating system and a development tool for real-time task preparation. Learning it requires only about 4 hours of instruction time. The 1100-word system handles 9 conversational system commands and runs in about 4000 words of core memory. A file management system is optional.

Monitor V is a real-time multitask monitor that can be interfaced to a wide range of peripheral devices and process input-output equipment. A computer with as little as 20,000 words of memory can hold this 8000-word general-purpose monitor, handle core-resident and disc control programs in an additional 8000 words, and run FORTRAN background control programs in 4000 words. The system handles from 1 to 1024 tasks. Using the job control language, it can run tasks in the background during real-time operations. A file management system is standard with this monitor. *Westinghouse Computer and Instrumentation Division, 200 Beta Drive, O'Hara Township, Pittsburgh, Pennsylvania 15238.*

Electric wall heaters are self-contained units consisting of heating element, fan, controls, and thermostat. They are designed for easy built-in or surface mounting to provide supplemental or primary room heat. A fan delay prevents blowing of cold air when the heating element is first turned on; it also keeps the fan running, after the thermostat has turned the element off, until the element has cooled. A fan-only setting provides circulation without heating. The fan motor is permanently lubricated, and the grill comes off for cleaning. *Westinghouse Bryant Division, Bridgeport, Connecticut 06602.*

Portable AC Ammeter



Electric Wall Heater

About the Authors

George T. Marcou has been President of Marcou, O'Leary and Associates since its inception in 1963.

Upon graduation from M.I.T. (Bachelor of Architecture, 1953; Master in City Planning, 1955), Marcou joined the staff of the Nashville-Davidson County Planning Commission. From 1956 to 1960 he was Associate Professor of Community Planning at the University of Illinois, where he provided assistance to localities throughout the state in organizing urban planning programs. From 1961 to 1963, he was Director of the Washington office of Blair and Stein Associates, planning consultants.

Marcou has supervised and directed planning projects for cities, counties, metropolitan agencies, and private organizations in a dozen states. He has actively participated in the firm's work for the U.S. Department of Housing and Urban Development and the Department of Transportation. In addition to consulting, he has been active in university teaching and professional affairs.

Jeremiah D. O'Leary has major responsibility for the professional quality of the work of Marcou, O'Leary and Associates, and he has directed a wide range of urban planning and renewal projects.

O'Leary was formerly on the urban studies staff of the Office of Program Policy, U.S. Housing and Home Finance Agency. His responsibilities there included evaluation of existing federal urban programs and policy recommendations regarding needed legislation in the areas of housing, renewal, and urban planning. Before that, he was Principal Planner with the Greater Baltimore Committee. He worked there on studies of housing code enforcement, in-town renewal, and the planning of Charles Center, a major renewal project in the center of Baltimore.

O'Leary holds a Bachelor of Arts from Harvard College (1952) and a Master of City Planning from Harvard University (1957).

Vikram Pearce was born in India and educated at Manchester University, England, where he earned a BSEE degree. He worked with IBM World Trade Corporation in India from 1963 to 1966 as a systems engineer and as a data processing representative.

Pearce came to the United States in 1966 when he joined the Westinghouse Computer and Instrumentation Division. He has worked on transfer lines, BOF control, and direct digital control, and he is now a senior engineer with project responsibility in General Industries. He earned an MBA from the University of Pittsburgh last year.

James E. Hudgens graduated from Oklahoma State University with a BS in Chemistry in 1941. He worked at the Oak Ridge National Laboratories until 1948 and at the USAEC New Brunswick Laboratory until 1955. Hudgens joined Westinghouse in 1955 to work at the Bettis Atomic Power Laboratory as Manager of the Radiochemistry Laboratories there. He moved to the Ocean Research and Engineering Center in 1969 and is presently Manager of Life Support, responsible for deep dive systems, physiological testing, various breathing apparatus, and the engineering laboratories. Life Support developed the Mark 11 deep dive system, the only Navy certified system of its kind.

Edward G. Fischer graduated from the Cooper Union with a BSEE in 1936, attended Columbia University on a Westinghouse-Lamme Scholarship in 1941, and received his PhD (mathematics and engineering) in 1946 from the University of Pittsburgh. He joined the Westinghouse Research Laboratories in 1936 and has progressed in the Mechanics Department to Consulting Engineer.

Dr. Fischer is a pioneer in transient shock and vibration analysis. Starting in 1942, he has made studies of the structural dynamics of Navy propulsion equipment and, later, of the shock mounting and underwater launching of the Polaris missile. He is currently concerned with the resistance of power plant equipment to earthquake effects. From 1948 through 1958 he taught graduate courses in vibration and nonlinear mechanics theory at the University of Pittsburgh. In 1958 he was consultant to the Air Force on underground shockproof Titan missile bases. From 1963 to 1970 he was chairman of the Dynamics Panel of the Sentinel-Safeguard ABM system, National Academy of Sciences.

Dr. Fischer is author of two chapters in the Harris and Crede *Shock and Vibration Handbook* that cover both the theory and practice of equipment design under mechanical shock.

August P. Colaiaco graduated from Pennsylvania State University with a BSEE in 1942 and joined Westinghouse on the graduate student training program. One of his first assignments was to help develop the vacuum pumps used in the atomic project at Oak Ridge. In 1947, he was assigned to the Rectifier Development Section where he worked with ignitrons. When the semiconductor appeared suitable for power devices in 1952, Colaiaco's efforts were directed to this new field. He was made Manager, Semiconductor Rectifier Engineering, in 1956 and later Manager, Rectifier Engineering, which also included mercury arc rectifiers.

In 1963, he moved to the Transportation Division where, as Engineering Manager, he directed development of rapid transit propulsion equipment. Colaiaco came to the Switchgear Division in 1967, where he is currently Manager of the High-Voltage Metal Clad Switchgear Development Section.

Frank L. Cameron earned a BSEE from the University of Wisconsin in 1951 and joined Westinghouse on the graduate student training program. His first assignment was with the Switchgear Distribution Apparatus Department, where he worked on design and development of oil switches, reclosers, sectionalizers, and fuse cutouts. In 1958, he moved to the Assembled Switchgear and Devices Department to work on power fuses for motor starters and transformers.

Cameron assumed his current position of Manager, Fuse Development, Switchgear Division, in 1969. He is responsible for design and application of current-limiting and expulsion fuses and, most recently, the fused distribution limiter. Cameron holds 16 patents in his specialty.

David R. Smith received a BSEE in 1963 from Pennsylvania State University, and in 1968 he earned his Master's degree from the University of Pittsburgh. He joined Westinghouse in 1963 on the graduate student training program and later worked as a distribution engineer for the Electric Utility Headquarters Department (now the Distribution Systems Department). In 1965, Smith transferred to the advanced development section to work on utility short-circuit, load-flow, loss-formula, and stability studies. He returned to distribution engineering in 1967 to work on design and application of grid and spot networks and application of fuses.

Smith's current responsibilities as a distribution engineer include working with the distribution divisions and utility customers on system problems and equipment application. He helped develop the sequence sensor for the network protector test kit and has developed a computer program to simulate simultaneous shunt and series unbalance in three-phase systems.

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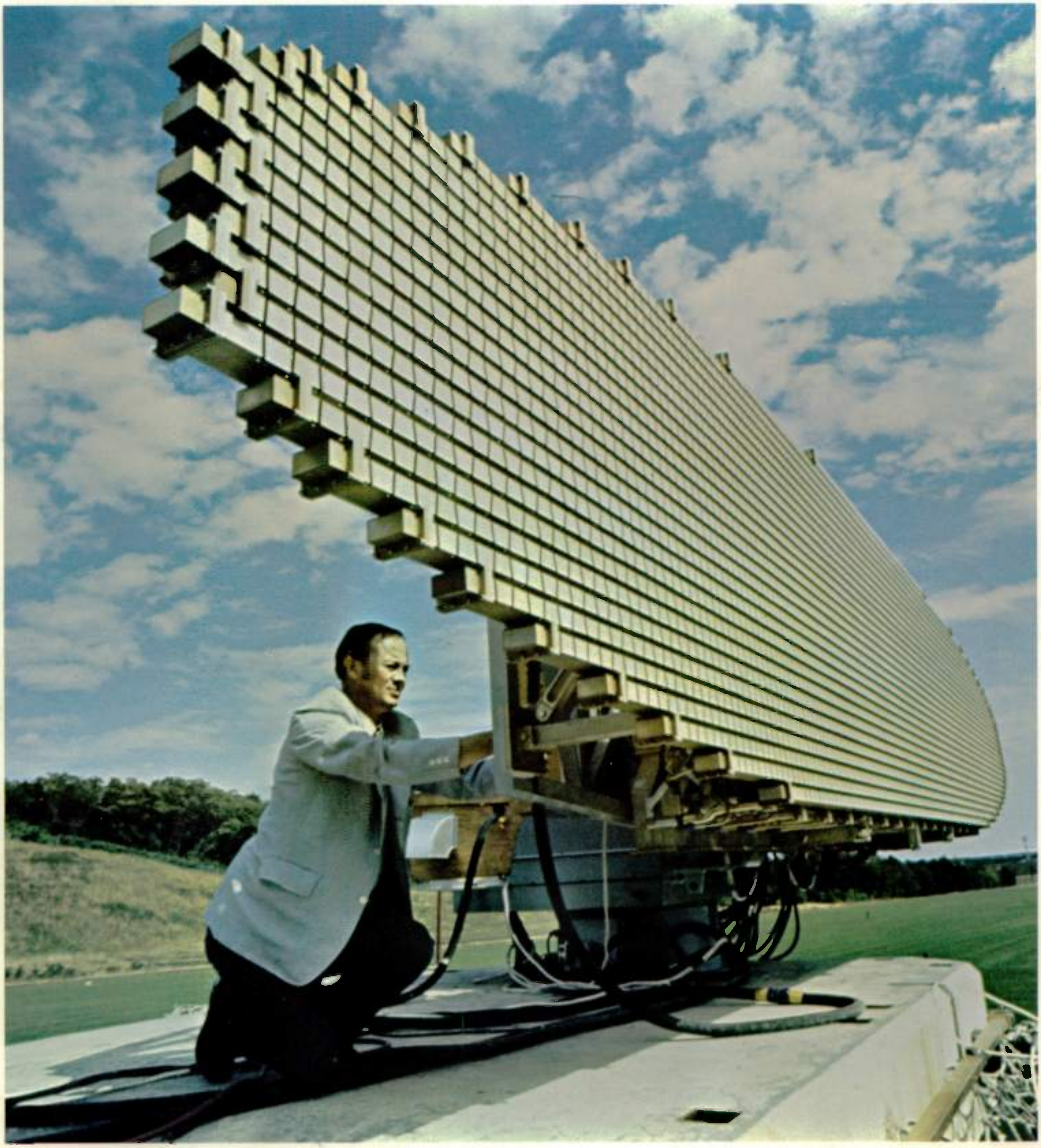

Antenna for AWACS airborne surveillance radar.
(More information on page 94.)