REFLECTIONS ON AUTOMOTIVE ADAPTIVE EQUIPMENT —
AN ESSAY

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Vannevar Bush’s “The Inscrutable Past” is a whimsical essay originally published in the Massachusetts Institute of Technology’s Technology Review in January, 1933. It was reprinted in 1946, with other essays by Dr. Bush. By implication this document purported to represent the views of a much younger author, writing in a generous yet patronizing style, presumably late in this century, but looking back toward the early 1930’s. He noted (with implied amazement) that in the thirties driving an automobile with a clutch pedal and a then-conventional manually-operated stick shift required fourteen separate yet carefully coordinated motions of the user’s hands and feet to steer the car while getting it under way from stop to full speed. A single false motion would spoil the whole affair, so the driver practically had to start the process anew! Even so, millions of normal people of all degrees and ages (literally from teenagers to grandparents) learned to perform this complex ritual so smoothly, so carefully timed, and so subconsciously, that they could drive cars of that quaint period. Indeed, they could carry on a conversation with a passenger simultaneously.

Those necessarily rapid, coordinated, and sometimes relatively forceful motions, though, posed severe problems (if not total barriers) for patients with major impairments of force, motion, coordination, or sensory feedback — paralysis, weakness, amputation, or arthritic joints. Fortunately there has been great progress since then in the development of automotive adaptive equipment. Often an improvement has been developed originally as a convenience (or even as a luxury) for masses of normal individuals, but (usually incidentally) it has proven a necessity for those people with impairments who, in-

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creasingly, are achieving more independent mobility. Usually — though not always—those with impairments are far fewer in number than the able-bodied persons who appreciate the feature as a convenience.

The technical possibilities for numerous improvements had indeed attracted attention long before Bush's essay. Automobile Trade Journal, established in 1896, published in its June 1, 1913 issue an editorial, "The Leverless Car," calling attention to "detailed refinements which make driving easier, less complicated, and more enjoyable." It noted the then-recent application of the engine starter, a new electric gear-shifting device, and the latest pneumatic gear-shift device, which "simplifies the operation to a point where women or even invalids are able to handle the largest cars." It cited automatic direction turn signals, doorstep lights operated by opening the door, tires inflated by power, and doing away with the spark advance lever. Then it questioned the time before air brakes would be controlled by a simple finger lever and noted the suggestion that the steering wheel might be replaced by pneumatic or other steering control. The editor, apparently aware of psychological factors, questioned the value of this last item, noting that "much of the exhilaration of personally operating the car is obtained from the actual handling of the wheel."

It is sometimes amusing, though sometimes frustrating, to study and to reflect on the factors influencing the pace of transition from idea through trials, failures, repeated redevelopments and reevaluations to production and widespread use—and then eventual obsolescence and replacement. Occasionally a phoenix-like rebirth occurs. In rehabilitative engineering there are occasional examples of relatively rapid transitions but more often of seemingly slow, erratic launching. Development of automobile features seems to show similar phenomena.

The Engineering Societies Library in New York not only has books and files of technical journals but many other items. A collection of photographs of very early steam cycles and cars, electric cars, and gasoline automobiles is fascinating. Lawrence J. White, in The Automobile Industry Since 1945 (his Harvard Business School thesis), suggests that in general an obvious improvement that can be sold at extra cost as an option is quickly adopted, whereas more basic, highly technical, but often hidden improvements come slowly.

A particularly fascinating document is a speech by Daniel C. Wilkerson, an engineer and patent attorney in the General Motors Transmission Development Group, "Why Didn't We Have Automatic Transmissions Sooner?" The speech was presented to the Armstrong

In tracing a great variety of attempts since 1897 in Europe and the United States to develop numerous types of automatic transmissions, Wilkerson was primarily interested in eliminating the need for voluntary actions by the driver; elimination of need to operate a clutch pedal (so crucial to many disabled persons) seemed secondary. He outlined many factors—technical, control, safety, economic (risk capital as well as production cost), reliability, and consumer demand—which, he believed, influenced the pace of development and introduction. He suggested a partnership enterprise of the public and the manufacturer in innovation. These same factors have similarly influenced development not only of other automotive adaptive equipment but of a wide variety of rehabilitative engineering devices and techniques. Clearly, rehabilitative engineering involves a partnership of disabled, developers, manufacturers, and often third-party payors for research and for devices.

The automobile itself is, in a sense, an adaptive aid for millions of normal human beings who cannot run at high speeds or travel hundreds of miles without fatigue—even though the automobile wheels cannot match the normal human legs in climbing or descending curbs, stairs, or especially mountains, or in traversing rough terrain. Civilization for several generations has made serious and expensive efforts to overcome barriers of terrain, weather, or architecture which would hamper motion or limit access or storage of its automobiles. Paved roads and even super-highways, sanding and plowing in bad weather, curbecuts and driveways, and parking lots and garages are examples of concern for one of civilization’s favorite devices. The Automobile Trade Journal in 1913 thought garage architecture was neglected. (The concern about architectural barriers to wheelchairs is more recent and far more limited in scope.)

The development of the electric starter to replace hand cranking seems to have been at least partially an attempt to overcome physical handicaps of potential drivers (thus broadening the market) and to remove known risks of serious accidents. Ralph Stein, in *The American Automobile*, noted that hand-cranking was impossible for women, who thus were typically limited to slow electric cars. [Though Stein did not comment, electric cars usually had relatively simpler controls than gasoline automobiles because the high torque of a direct-current motor at starting and at low speeds removed the necessity for a gear-shift.] Hand cranking was recognized as dangerous, so injuries during cranking were covered by automobile insurance policies. Stein com-
ments that many thousands of dollars were paid for such injuries. Hundreds of devices were tried. Springs, compressed air, exhaust gas under pressure, and compressed acetylene gas [at that period available because burned in the headlights] were examples. Battery-powered electric motors were attempted, but they were excessively big and clumsy because they were designed as if for continuous duty. Stein then traces the roles of Charles F. Kettering of Dayton Engineering Laboratories and of Henry Leland, head of Cadillac, in developing a practical electric starter.

Joseph B. Bidwell, Executive Director, General Motors Research Laboratory, has generously searched the Kettering archives and sent us "Keys" own account of the development of the electric starter. In 1910 Mr. Carter, head of the Carter Car Company, tried to assist a woman who had stalled her car in traffic. He attempted to crank the car, but she had neglected to retard the manually-adjustable spark. The engine kicked back and broke Mr. Carter's jaw. He later died of this injury. [The implications for bravery—or rashness—of the woman in driving an internal-combustion engine car, for density of traffic, for gallantry of Mr. Carter, and for level of medical care of maxillofacial injuries are not explored.]

Mr. Leland, a good friend of Mr. Carter, apparently thus became further conscious of the need for a starter. Kettering had been building small electric motors for National Cash Register in Dayton. Because of the intermittent use, they cooled rapidly, so they could be overloaded beyond usual design principles. When Kettering mentioned to Leland that he thought that he could crank a car electrically, Leland enthusiastically supported the effort. Motors were built at Dayton Engineering Laboratories (which later became Delco, a division of General Motors), but the rest of the starter was built in the Cadillac experimental shop, according to Stein. The 1912 Cadillac had an electric starter as standard equipment—an example of rapid transition to routine use.

Electric lights, made more feasible after a storage battery and a charging generator were required anyway in conjunction with the starting motor, replaced open-flame kerosene and acetylene lamps. The immunity of electric lamps to wind plus the ability to turn on lights from inside the car with a switch, instead of from outside with a match, further simplified for the entire population the problem of driving at night, especially in bad weather. Though the electric starter and electric lights as standard equipment won the Dewar Trophy for the 1912 Cadillac, they obviously broadened the market among able-bodied drivers. In addition, they were—and still are—far more
significant to prospective drivers with physical limitations or impairments.

Additional red rear lights to indicate application of the brakes became common in the 1920s and 1930s. Direction signals to indicate turns, without requiring the driver to project his forearm and hand for the conventional gestures, though mentioned in 1913, became widely used considerably later as semaphores in the door posts of some European cars. Then a lever mounted under the steering wheel (now on the left side), when moved in the plane of the steering wheel, controlled flashing lamps on front and rear of the car to indicate intended left or right turn. Thus the driver could leave the window closed and could keep his hand in the car on or near the steering wheel.

Various types of automotive adaptive equipment have been used for over 50 years to permit persons with major impairments to drive automobiles. The Disabled Drivers' Motor Club, for example, was organized in London in 1922. Undoubtedly many nominally “disabled” persons, e.g., unilateral below-knee amputees, have been able to drive conventional automobiles without modification. Others have used minor, locally produced devices.

Even before Franklin D. Roosevelt was elected Governor of New York State in 1928, he and at least one other polio patient with bilateral leg involvement at Warm Springs, Georgia, drove Model T Fords with planetary transmissions without using their paralyzed lower limbs to control the three pedals. Pressing handles (or pulling on rope-and-pulley systems) fastened to the left gear-shift and clutch pedal and the right brake pedal accomplished operating the two-speed planetary gear shift by hand (in place of using the left foot) or applying the brake (instead of using the right foot). Similarly, a cane could transmit manual pressure to the intermediate reverse pedal during the relatively rare occasions when reversal was needed. The spark advance and the throttle were manually adjusted, as was usual in those days, by levers just under the steering wheel, moving in a plane parallel with it, and adjusted when needed by a few fingers of the left and right hands respectively. Once set, these levers tended to remain in position.

Mr. Roosevelt and his friends therefore were disturbed when Ford Motor Company in 1928 replaced the classic Model T by a new Model A with conventional left-foot-operated clutch and a manually operated stick-shift transmission. (Ironically, perhaps, a few patients at Warm Springs already were close friends of the Ford family; the glass-enclosed patients' treatment pool dedicated in November, 1928,
was donated by Edsel Ford; yet later, by the early 1930s, the FDR "New Deal" administration in Washington and the Fords were bitter opponents.)

Nevertheless numerous designs of adaptive equipment were soon developed to allow operation of clutch, brake, and gear shift, and when necessary, of the then relatively new floor-mounted "accelerator" or throttle pedal. One mechanical example, on a 1938 Ford used by Mr. Roosevelt during the remainder of his presidency, is still on display at The Little White House at Warm Springs (Fig. 1). The driver's left hand causing forward motion of a lever at his left side first disengaged the clutch. Further motion also pressed on a projection from the brake pedal. The throttle was still controlled by a lever (moving over fine-tooth detents) salvaged from an older car and mounted under the steering wheel. This lever caused motion of the floor-mounted accelerator pedal. The button on the left side of the steering column, just under the wheel, appears to have been a supplemental starting switch, for convenience.

Starting in the late 1930s, millions of automobiles were built with automatically controlled vacuum powered clutch. The gear shift still had to be operated by hand.

Attempts to use a hand valve to control a vacuum cylinder to operate the brake pedal were not very successful, nor were such systems generally used. The development of vacuum-powered booster brakes grew out of such efforts.

Unless substantial vacuum reservoirs were provided, these vacuum systems had real risk of failure if the engine stalled. Descriptions of models illustrated in the magazine "Outwitting Handicaps" in 1945 mentioned the need for these reservoirs, but apparently some cars lacked adequate reserve, leading to an accident when the engine stalled.

Various solenoids and other electrical or pneumatic gear-shifting means and successive steps toward automatic transmissions had been proposed from the early part of this century, as noted above. They required at least one use of a clutch pedal when the car was initially put into motion, even if they successfully simplified later changing of speed or coping with hills. Conversely, the Chrysler "Fluid Drive" introduced in 1940 and some current semi-automatic transmissions, e.g., the Honda, avoid the need for a clutch pedal but require a manual shift when the speed is to exceed some value, such as 25 mph, or to reverse. Wilkerson cites scores of design attempts.

By 1937 a heavy-duty hydrodynamic transmission design simplified bus driving so much that a single employee could collect fares and drive simultaneously, thereby reducing delays at stops or eliminating
FIGURE 1. — Hand controls built by Georgia Warm Springs Foundation orthotics shop for President Franklin D. Roosevelt's 1938 Ford. He was still routinely driving this car independently during his last visit to Warm Springs in April, 1945. Lever at left sequentially disengages clutch and then, with further pressure, applies brake. A hand lever moving over fine-toothed detent under right side of steering wheel controls accelerator pedal. Button on left side of steering column apparently was an extra starting button, installed for convenience.

Photograph courtesy of Roosevelt-Warm Springs Rehabilitation Center and Little White House.
the need for a second employee as a conductor. During World War II
a rugged version was used to improve effectiveness of the crews of
military tanks.

The Oldsmobile Hydra-Matic transmission, introduced for pas-
senger cars in the fall of 1939 for the 1940 model year, was the first
widely available method for eliminating entirely the clutch pedal and
the need for frequent moves of a manually controlled shift lever
(whether on the floor or on the steering column), thus dramatically
reducing the frequent, complex, and elaborately coordinated pat-
terns of voluntary motions which Bush's imaginary commentator had
noted with amazement. The Hydra-Matic control system combined
inputs from speed and from throttle setting, thus allowing the driver
to change gear ratio automatically on hills or when accelerating to
pass another car.

A heavy-duty version of the Hydra-Matic likewise was used for
military and motor-coach applications. Wide experience with these
heavy-duty applications (viable for economic or at least for military
reasons) and mass-produced in large numbers provided far greater
assurance of reliability than is typically feasible for new devices
needed solely by the handicapped. These latter, as our readers know,
typically are produced in very small volume and tested on extremely
limited scales.

On June 22, 1944, late in World War II, the Governor of Michigan
addressed the American Association of Motor Vehicle Adminis-
trators. Himself a leg amputee from World War I, Governor Harry F.
Kelly asserted that a disabled veteran must be able to drive his own car
safely, either for business or for pleasure. He stated it would be
grossly unfair to exclude the disabled veterans from the highways if
there were any possible way of retraining them.

A systematic effort of many automobile manufacturers to develop
adaptive equipment then was coordinated through the Society of Au-
tomotive Engineers. Though initially most designs were for cars with
clutches (although some were vacuum powered), there was a rapid
shift shortly after World War II to various types of automatic trans-
mision, using gearing or fluid torque converters, available in func-
tionally equivalent form from many manufacturers. Obviously, any
form of automatic transmission greatly simplified driving by many
handicapped persons. This simplification occurred both directly and
also indirectly through increasing flexibility of design of other adap-
tive aids.

Unilateral loss or loss of use of the left leg became unimportant if
there were no clutch pedal (conventionally placed for pressure from
the left foot). The normal right leg, just as in the case of a normal
driver, could control the floor-mounted accelerator or could shift rapidly when needed to press the brake pedal.

Some individuals were still able to operate a floor-mounted button controlling transfer from “high” or “country” to “low,” “passing,” or “city” beams of the headlights, but for others such a switch was easily relocated, for example, to the steering wheel, its column, or the dashboard. (Very recently, in some European and American cars this control has been provided by lifting along the axis of the steering column the lever controlling the direction-indicator signal lights.) A photocell control to sense approaching headlights has been also available for years to switch automatically from high to low beams. It is limited because of inability to adjust automatically to reflectivity of road surfaces, road signs, etc.

The starter switch, sometimes located on the dashboard of early cars, later had migrated to the floor. A handle could be added. Later, fortunately for most people, designers moved it back to the dashboard or—now conventionally, as mandated by the government—to the ignition key switch mounted on the column of the steering wheel.

Individuals who had loss or loss of use of the right leg either could sit somewhat farther (or obliquely) toward the right in order to use the normal left leg alternately on brake or accelerator instead of the missing right leg, or could have the accelerator pedal, or both pedals, relocated for more convenient use of the left leg. An extra accelerator pedal can be located on the left but with linkage to the conventional pedal on the right. Indeed, many able-bodied persons, partly for safety through reduced reaction time but partly for convenience, now use the left leg on the brake pedal (often made wider than in past years) and the right foot on the accelerator while driving automobiles with automatic transmissions of various designs and manufacturers. Some might argue that there is a risk of pressing both pedals simultaneously in panic; nevertheless the small risk seems no worse than the risk of failing to move a single foot from accelerator to brake (with the inevitable delay) during an emergency. In New York State, at least, there is no legal restriction on use of separate feet for brake and accelerator.

The “cruise control” to maintain speed automatically at any desired value, regardless of changing grade and resistance, is a convenience used by many normal drivers on throughways. It also reduces fatigue from frequent readjustment of throttle by foot pedal or hand control for disabled drivers.

A bilateral loss or loss of use of the lower limbs could be compensated for by relatively simple lever arrangements plus an automatic transmission. By operating selectively the brake or accelerator pedals
(or both simultaneously if necessary, as in starting up a hill) with one hand while the other hand was used to control the steering wheel, the person with bilateral loss or impairments of the lower limbs could drive safely and adequately.

An automatic transmission also greatly simplified rehabilitation after loss or loss of use of only one arm because it was no longer necessary to shift the transmission as frequently, dexterously, and relatively forcibly as was suggested by Bush's essay. (The direction-indicator signals, as discussed above, also eliminated need on the usual American left-side-drive car to crank the left window down, regardless of weather, to project an arm—or prosthesis—to signal.) The steering wheel could be controlled with one hand, perhaps with the aid of a commercially available "spinner" knob easily gripped by a normal or even adapted to an arthritic hand. A rubber-lined ring, mounted on the steering wheel like a spinner, was designed by the Northrop Aircraft prosthetics project for convenient gripping by the split hook of a prosthesis. (Two bilateral arm amputees with appreciable stumps or residual limbs not only served as pilot wearers testing Northrop devices, but they also drove the project's car.) The British designed a cup-like receptacle on the wheel for a special tool "plugged" into their typical wrist disconnect in place of an artificial hand or hook.

Bush's essay notes that a motor-driven diaphragm could be activated to warn a pedestrian, though his commentator found it hard to imagine that an incautious pedestrian remained extant! The button for operating early examples of this horn was often in the center of the steering post, requiring the driver to release one hand from the rim. For many years the horn signal has been rearranged to allow operation by a thumb while the fingers of that hand continue to grip the rim of the steering wheel.

Even if only one usable arm (or prosthesis) were available, the steering wheel could be stabilized by pressure from the torso momentarily on those rare occasions, normally while the car was fully stopped anyway, for shifting the speed selector of an automatic transmission between "Park" and "Reverse," "Neutral," or "Drive" positions, in contrast to the very frequent shifts needed with a conventional transmission.

Persons severely handicapped by high or complete bilateral loss or loss of use of upper limbs but with reasonably normal lower extremities have been able to drive with the aid of major adaptations, even if they do not wear arm prostheses or orthoses. One version shown at the 1977 Congress of the International Society for Prosthetics and Orthotics, was designed by Franz with the assistance of Pro-
fessor Marquardt of Heidelberg. It can be fitted to the Volkswagen “Rabbit” with automatic transmission and to other small cars. Steering is controlled by forward and backward motion of the left foot controlling a crank-like mechanism, while the right foot controls the brake and accelerator. Various switches, signals, door latches, etc., are adapted for control by foot or knee. It is now available in the United States. Another design for steering, sometimes used, has a turntable with sandal or stirrup for the left foot rotating on the sloping floorboard.

In parallel with the greatly increased interest in driving by more profoundly impaired drivers which had been accelerated both by the concern for disabled veterans near the end of World War II and by prompt recognition of possibilities of the newly available forms of automatic transmissions, there was increased concern by manufacturers. As we have seen, this was demonstrated both individually and through the Society of Automotive Engineers.

A substantial part of the 1945 issue of the magazine “Outwitting Handicaps” was devoted to automobile insurance, the work of the SAE and individual manufacturers, and a variety of inventions and innovations by individuals. These latter included not only levers and knobs as driving aids but adjustable seating, a transfer board for sliding from wheelchair to car seat, and novel arrangements of mirrors.

Oldsmobile, for example, developed its so-called “Valiant” controls which permitted hand control in conjunction with the Hydra-Matic transmission. Originally Oldsmobile made cars equipped with these controls available on a priority basis to individual eligible disabled veterans, despite the great shortage of new automobiles in the immediate post-war era and the black or grey market in new automobiles.

Agencies at all levels showed concern. Various states, localities, and other jurisdictions authorized special license plates, parking privileges, or other concessions, and employers often reserved conveniently located parking areas for specific disabled employees. A law was passed under the stimulation of Mrs. Edith Nourse Rogers, the Chairman of the House Veterans Affairs Committee (as recalled in Notes and News, BPR 10-31, Spring 1979), authorizing a one-time allowance of $1,600 for an automobile for eligible veterans with loss or loss of use of one or both of the lower limbs. This concern was successively expanded to include other categories of disability.

These laws and ordinances were passed on the assumption that once a disabled veteran had regained the mobility permitted by an appropriately adapted automobile, had found adequate parking, and...
had received the appropriate vocational guidance, rehabilitation, and education offered by the Veterans Administration, he would then become self-supporting and would be able to purchase replacement vehicles as needed from his own resources. The original Federal law and thus the Veterans Administration's allowance was based on the price at that time of a two-door Oldsmobile sedan with automatic transmission.

The allowance remained fixed for many years, but it was subsequently modified by P.L. 93-538. This increased the allowance for the basic automobile to $3,300, still on a one-time basis, but provided indefinitely for provision and installation of necessary automotive adaptive equipment, not only for the original but for replacement autos.

It is sometimes mistakenly thought that hand controls were not feasible until power brakes, power steering, and perhaps other power options as well as automatic transmission became available. As mentioned in the earlier historical notes, there were indeed disabled drivers and various forms of hand control long before these power options became available.

Nevertheless numerous devices, whether they now are regarded as mandatory, current “standard equipment,” options routinely ordered as conveniences, or even luxuries for the general public, have been extremely valuable for appropriate disabled individuals. These range from the required seat and shoulder belts and customary direction indicator lights (required in some if not all states) through power-assisted steering, power booster brakes (particularly for large cars or for individuals with weak legs or arms), and power operation of the windows, to the photoelectric cell and circuit to switch the headlights automatically from high “country” to the lower “passing” beam, power driven adjustable seats to facilitate entry and exit, power doors, electric door locks, and other options. Air conditioning, as another example, has been medically prescribed for individuals whose high spinal cord injuries have damaged regulation of perspiration and control of body temperature and hence jeopardized their safety, whether as drivers or as passengers. Bucket seats for greater support, rear window defrosters and wipers, and remotely controlled mirrors are still more examples.

Thus many of the features which greatly assist handicapped individuals were originally developed, as White suggested, as conveniences for the normal population where there were large mass markets. It seems unlikely that most of them would ever have been developed or made nationally (or often internationally) available in high quality at reasonable prices just for the handicapped because of
the small markets involved. Availability of service and maintenance on a nation-wide basis likewise has depended on large-scale acceptance and use.

For generations “styling” has led to emphasis on lower floors, seats, and roofs. Initially the reduction in height from the lofty box-like sedans with high running boards of the early 1920s facilitated comfortable and dignified entrance and egress for ladies, elderly, and disabled. In very recent years, though, sedans have become so low that entering or emerging has again become difficult for substantial segments of the population. The rear seat of a two-door sedan offers a special challenge. Opening of the wide door of a two-door sedan in a congested parking lot is often limited, so entering or leaving the front seats may also be a problem. Special wide parking spaces are increasingly reserved for wheelchair users to allow full opening of the door (or use of power lift on the side or rear of a van) as well as for movement of a wheelchair. (Vans, in contrast, are so high and often so lacking in steps and handgrips as to suggest return to the old-fashioned carriage block!)

There may be danger that the additional increasing emphasis upon small, and indeed subcompact, cars in order to improve fuel economy will further complicate the problems of rehabilitating those with impairments, or even transporting the increasing number of senior citizens. Individuals with some disabilities, e.g., weakness of upper limbs, may find it increasingly difficult to transfer independently, or perhaps also with assistance, from a wheelchair or even from an ambulatory condition into and out of some smaller cars. Individuals with arthritis or other joint limitations, or even using devices with the conventionally acceptable but limited ranges of motion of orthotic and prosthetic joints, may find it difficult to move through low or narrow door openings or a narrow space between seat and door. The lack of sensation inherent with spinal cord injury or with amputation may impose further problems in avoiding injury or clothing damage. Such individuals may be willing to sacrifice “style” for function.

Maximum opportunity for a disabled person (whether driver or passenger) to escape from a damaged or wrecked vehicle, even with assistance, has received little attention. Low roofs or narrow door openings obviously offer complications. Wheelchair lifts on vans, for instance, should permit gravity descent at controlled speed without power, as long as the van is reasonably vertical. The power door operation should permit emergency manual release. Special crash-resistant gasoline tanks, like those used in stockcar racing, might be considered to reduce fire hazard.

The demand for progressively improved fuel economy on the
overall average of an automobile manufacturer’s product line understandably tends to stress sale of very small and fuel-efficient cars. Conversely, it minimizes the production of the somewhat larger cars (standard for many years) which permit ready accessibility and have those features like automatic transmission and power options which tend to use more fuel yet are essential for many of the disabled.

Public Law 94-581, now recodified as Title 38, U.S. Code, Section 1904, requires the Veterans Administration to conduct research and development on automotive adaptive equipment, including use of vans. Unfortunately implementation to bring the results to the disabled may require wisdom and tolerance not only in avoiding limitations from arbitrary rules on fuel economy but in encouraging availability of sedans and vans which are accessible alike to the ambulatory disabled, the elderly with impairments, and those persons using wheelchairs for various reasons.

Vans with automatic transmissions and power options, including wheelchair lifts, have been used increasingly by individuals in wheelchairs. Unfortunately, vans inherently tend to have higher fuel consumption. While vans have become very acceptable socially in recent years, there may be increasing pressure against making many of them because of their poorer fuel economy. The unintended risks to rehabilitation of the seriously disabled from these economic, regulatory, and legal pressures upon the manufacturers were noted by Mr. Harry Chesebrough, a retired Vice President of Chrysler, at a conference on automotive adaptive equipment co-sponsored by the Rehabilitation Services Administration and the Veterans Administration in June, 1977, at Washington.

An enlightened national policy may need to balance severe societal pressures against other societal goals. For example, suitably prescribed, installed, and maintained automotive adaptive aids in appropriate vehicles may overcome the special problems of limited numbers of persons with various physical handicaps in attaining productive, satisfying rehabilitation; nevertheless everyone recognizes other important societal goals such as fuel economy, balance of payment in foreign trade, etc. Consequently, legislators, regulators, rehabilitative engineering experts, and disabled persons all need generous imagination and broad perspective rather than selfish “realism” or narrow vision in seeking the judicious balance, true effectiveness, and long-range economy which are the hallmarks of sound government as well as good engineering.

Obviously the operator of any vehicle can control his total fuel consumption, over a wide range, not only by his initial choices of life
style and of vehicle but by judicious planning of trips, smooth driving, proper inflation of tires, etc. Each disabled driver thus may incur a personal responsibility for prudent, economical, and safe driving, not only for his individual protection but for public acceptance and for the long-range good of the rehabilitation cause.

Public Law 91-666, as amended by Public Law 93-538 and now codified as Chapter 39 of Title 38, United States Code, authorized the Administrator of Veterans Affairs not only to provide to eligible veterans the automotive adaptive equipment deemed necessary but to prescribe minimum standards of safety and quality. An interdepartmental Adaptive Equipment Committee was organized to oversee the entire program. Liaison was maintained with the Department of Transportation, the Department of Health, Education, and Welfare, the state licensing agencies, and numerous other concerned organizations and individuals.

A major effort by the Veterans Administration Prosthetics Center involved tests of available hand controls, promulgation of standards, and development of a VA Program Guide, M-2, Part IX, G-9, dated March 31, 1978. Later work at VAPC and at Texas A&M University has involved testing of wheelchair lifts for vans and development of tentative standards for them. All these efforts have been reported in previous issues of this Bulletin.

The Rehabilitative Engineering R&D program also has supported other efforts related to driving, adapted vans, and sophisticated controls, and to development of rugged wheelchairs and tie-down mechanisms designed to meet DOT standards for automotive seating. These studies, too, have been reported in the Bulletin.

There has been great technical progress, not only in automotive adaptive equipment but in systematic driver training programs. Each program should be specifically tailored to the disabled individual. Simulators with versatile adaptive equipment have also been developed to allow severely handicapped persons to begin learning confidently under safe conditions.

The Rehabilitation Engineering Education Program (REEP) at Wadsworth VAMC, Los Angeles, California, has been assigned responsibility for further specialized training of VA driver trainers at numerous VA Medical Centers throughout the country. These employees are therapists assigned to the Rehabilitation Medicine Service of a particular center. They work with amputees, spinal-cord-injured patients, and severely handicapped persons in many other categories requiring special adaptive equipment. Training is conducted in cooperation with Long Beach VAMC and California State University at
Long Beach. Both REEP and an increasing number of VA Medical Centers have simulators, an array of adaptive equipment, and adapted vehicles.

After developing and demonstrating reasonable skill and confidence on a simulator, the individual handicapped person can then move on to instruction in actual vehicles, first practicing in controlled locations or driving ranges before progressing to actual traffic. These simulators and controlled driving ranges may permit physicians and automotive adaptive equipment teams to allow marginal cases a cautious test. Some people with impairments may then decide for themselves that the stress of driving will be too great, yet they will not feel they have been arbitrarily rejected or that they have “failed.” Research and development efforts toward more objective criteria for selection, though, are generally regarded as needed. Psychological attitudes and motivation may be the hardest elements to assess, yet the most important for safety of the driver, his passengers, and the public.

Issuance of a driving license depends upon the particular state and the individual examiner. Typically various restrictions may be imposed. Categories or restrictions of licenses offer no novelty; when the Ford Model T was common, some states issued separate licenses for use of planetary and conventional stick-shift transmissions. Corrective lenses are often required. Some states have designated specific examiners to conduct road tests with disabled candidates, often for longer periods than usual, and to define any specific restrictions as to equipment or driving circumstances to be required on the license for a successful candidate.

State motor vehicle licensing examiners, in general, seem to have been fair, thorough, and objective, neither arbitrarily rejecting the physically impaired candidates nor demonstrating an overly sympathetic or emotional tolerance of marginal performance potentially hazardous to the candidate and to the general public alike.

Insurance against public liability is clearly desirable, and it is mandatory in many states. The editorial in the 1945 issue of “Outwitting Handicaps” is but one of many discussions of the problems of some disabled drivers in obtaining insurance at equitable rates. Insurance companies and their agents seem to have varied widely; some have issued policies at normal premiums, some have attempted to develop rational selection and rating methods, but others are alleged to have placed disabled drivers (regardless of their personal records) in the “assigned risk” pool with those normal individuals whose demonstrably poor records required that they pay abnormally high premiums.

As driving by persons with increasingly severe levels of physical
handicaps has become more feasible technically, there have been frequent expressions of concern not only about selection and licensing of drivers but about their long-term driving records. Professionals in rehabilitation have believed that the individual emotionally-stable disabled person, after careful selection, training, examination, and licensing, will be highly motivated to drive carefully. Also, as a mature, responsible person, he will refrain voluntarily from driving in unduly hazardous circumstances. Motivation, self-control, and self-confidence are considered at least as important as the physiological and technical factors.

There have been some surveys of opinions of knowledgeable officials about driving performance, and analyses of records of some specific groups. Typically, though with a few exceptions, the conclusion has been that “the disabled” drive as safely as the entire population—or perhaps even more safely. Comforting as this frequent conclusion may have been, unfortunately these studies typically reflect opinions, are based largely on anecdotes, or have experimental or statistical flaws. At a minimum, one may legitimately distinguish among various types and degrees of impairment, the corresponding appropriate or inappropriate adaptive equipment used, the amount of professional training received, the level of maintenance provided, the frequency of inspection of equipment, the type and amount of driving performed, and other factors.

As further technical development continues to broaden the field towards the Leverless Car foreseen in 1913, and as selection, training, licensing, and insuring processes improve, one may hope for more penetrating studies of accident records and driving performance of drivers in various categories of disabilities, with proper adaptive equipment, and due consideration of exposure. Then, as in Bush’s essay, future writers may imply surprise that so many thousands of physically impaired drivers managed to cope so well with the complex tasks of driving in traffic with the relatively primitive adaptive equipment of the 1970s!