SELECTION AND APPLICATION OF KNEE MECHANISMS

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FOREWORD

The Prosthetic and Sensory Aids Service assists clinicians in the prescription of prosthetic appliances by providing up-to-date, accurate, useful information. Prescription of prosthetic knee mechanisms is actually a complex task due to the large array of these devices. Many are quite similar in function, differing mainly with respect to size, kind of wood used in the setup, and other characteristics more associated with the assembly and installation process than with a prescription rationale.

Too often clinicians prescribe a limited number or only one type of knee mechanism because it has been found reliable or perhaps because specific information on the full range and variety of all available systems has not been at hand. The clinician rarely has the opportunity to see all the devices in a common perspective to compare the relative merits of one knee with another.

This Program Guide gives Veterans Administration and other prosthetics clinic teams a summary description of the knee mechanisms which have been evaluated by our VA Prosthetics Center. Orthopedic and Prosthetic Appliance Clinic Teams should study this information and the other factors important in prescription and fitting. This Program Guide should be used by the team to maximize benefits to the patient. In the future this document will constitute part of the specifications for the Veterans Administration's Centralized Artificial Limb Contract.

ROBERT E. STEWART, D.D.S.
Director, Prosthetic and Sensory Aids Service

DEDICATION

The basic inspiration and the stimulus for this document have come from the patient and persistent urgings of the late William H. Talley
Selection and Application of Knee Mechanisms

This Program Guide presents specific guidelines for the prescription of knee mechanisms for above-knee amputees in relation to such important factors as stump length, alignment, socket, suspension, and foot-ankle assemblies. The heart of this document, Section 5, should be studied carefully by those participating in the prescription process.

To provide a basis for understanding knee designs and the extent to which they simulate normal gait, a description of normal knee function is offered at the beginning. Fundamental similarities and differences among knee mechanisms are then presented in a classification system, whose digital designations are now used in the VA Prosthetics Center's data recording processes. The classification of prosthetic knees is based primarily on the type of swing-phase function provided, with the stance-phase controls and other features considered supplemental functions.

Section 6 of this document is a catalog of prosthetic knee units which have been evaluated by the VA Prosthetics Center. Many of those listed are presently on the centralized VA Artificial Limb contract and these are so indicated. We have chosen, nevertheless, to include units not now on contract in order to provide a complete description of the whole range of knee mechanisms.

We should like to note the significant contributions made to this publication by many people in the VA Prosthetics Center: the photographers, the illustrators, and the typists. Dr. Edward Peizer, Assistant Director, and Mr. Henry F. Gardner, Technical Assistant to the Director, were the primary authors.

ANTHONY STAROS
Director
VA Prosthetics Center

1. KNEE FUNCTION

a. Normal

In level walking the normal human knee rotates cyclically through a range of approximately 70 deg., going from a position of full extension in early and mid-stance phase to 70 deg. of flexion shortly after toe-off. The center of rotation of the normal knee joint is located within the condyle of the femur (Fig. 1). As the tibia rotates about the femur in flexion, the eccentric curvature of the distal portion of the femoral condyle causes the center of rotation to displace distally and posteriorly during the first 20 deg. of flexion. The center of rotation displaces proximally and anteriorly as the knee rotates from flexion to full extension. The human knee is therefore a polycentric joint whose locus
displaces approximately 1/2 in. during the flexion-extension cycle. There is a group of polycentric prosthetic knee mechanisms whose centers of rotation also displace to permit adequate knee swing as well as stability in early stance phase.

Level walking is divided into two phases—a stance, or weight-bearing phase and a swing, or non-weight-bearing phase. Stance phase begins (Fig. 2) with contact between the heel and the ground at a time when a large proportion of the body weight is still on the other leg and well
behind the knee center. There is therefore during early stance phase a bending moment about the knee tending to collapse it or drive it into flexion. This is prevented by action of the quadriceps whose eccentric contraction allows the knee to yield approximately 20 deg., and then by isometric contraction to prevent further flexion. After the foot is flat on the ground, the quadriceps contract to bring the knee back to a position of full extension at the time of mid-stance. Knee stability in this position is maintained by the changing direction of the bending moment about the knee: after mid-stance, the body weight is forward of the extended knee joint and the foot, creating an extension moment which stabilizes the knee. Knee stability in late stance therefore depends on the alignment of the hip (extended), knee (extended), and ankle (resisting dorsiflexion) behind the vertical projection of the weight line.

Knee flexion is initiated late in stance phase when the heel is off the ground and the vertical projection of the body weight is well forward of the foot, producing an increasing bending moment about the knee in the direction of flexion. As the toe clears the ground, the shank tends to remain in the position of flexion it attained in late stance. However, as the toe clears the ground, the hip flexors rotate the femur forward into hip flexion. The forward movement of the distal end of the thigh causes the shank to rotate rearwards (knee flexion). The speed of knee flexion and the total rotation (noted as heel rise) is controlled by the quadriceps muscles which absorb the rotational force. The quadriceps act to dampen and control both the range and velocity of knee flexion. After the knee has reached the position of full flexion, the effect of gravity tends to swing it down in the direction of extension. This is accompanied by contraction of the quadriceps which accelerate rotation of the knee into extension. As the knee nears the position of full extension, the hamstring muscles absorb the energy of the swinging shank and act to reduce its velocity and control its terminal impact as stance phase begins.

b. Prosthetic

The controlled absorption of knee motion in a prosthesis is the function of the knee mechanism. Some devices perform this function by mechanical friction, others by resistance to fluid flow. The swing-control component of a knee mechanism therefore is the mechanical analogue of the quadriceps and hamstring muscles acting to dampen the swing of the knee at the extremes of flexion and extension.

“Alignment stability” is a key element in prosthetic fitting. By
reference to "TKA," i.e., a vertical line in the sagittal plane through the trochanter, knee, and ankle (static), the prosthetist strategically shifts the position of the socket with respect to the knee center to maintain stability in late stance and to take advantage of certain special features of particular knee mechanisms (Fig. 3). For example, with a single-axis mechanical friction knee (Bock 3P4) he aligns the socket forward of the knee to assure that the body weight will be transmitted through the prosthesis along a line falling anterior to the knee center in late stance. However, this is done at the expense of impeding, to some extent, the initiation of swing. With the special stance-phase control features of the Mauch S-N-S he aligns the socket so that body weight is transmitted through the prosthesis along a line falling posterior to the knee center in order to take advantage of the high resistance to knee flexion in stance, making it unnecessary to use alignment stability to prevent knee buckling and, at the same time, to facilitate initiation of swing phase.

Understanding these relationships and taking advantage of the special features of knee mechanisms for the benefit of the patient is the highest form of the prosthetist's art and science. The highest level of prosthetic treatment the clinic team can provide the patient rests on the selection from the widest possible range of devices, the specific knee mechanism whose features are most closely matched to the individual patient's needs.

Figure 3.—Prosthetic knee center (left to right) anterior, through, and posterior to the lateral reference (TKA) line.
Selection and Application of Knee Mechanisms

Knee mechanisms for above-knee prostheses include a large number of devices ranging from very simple single-axis knees to increasingly complex components which control the character of knee rotation in various ways. The simpler devices permit a range of motion about the knee to meet the minimal requirements of swing phase, sitting, and kneeling, but furnish no other functions or controls. Other more sophisticated mechanisms control the character and timing of swing and of stance-phase stability. Despite the variety of functions and features afforded by these mechanisms, it is possible to classify them on the basis of certain primary functions: 1. knee rotation, 2. resistance to knee rotation in swing phase and/or in stance phase, and 3. extension aid. All other functions are considered accessory features.

2. DEFINITIONS

a. To describe the variety of knee functions in a meaningful way, terms of reference to knee functions have been standardized:

1. **Knee Rotation.** The angular motion about the knee joint or relative motion between knee block and shank. Flexion or positive rotation is that portion of knee rotation in which the angle inside the joint formed by the knee block and the shank is diminishing. Extension or negative rotation refer to motion in which the angle is increasing.

2. **Swing Phase.** The portion of the gait cycle in which the reference leg is not in contact with the ground.

3. **Swing-Phase Controls.** Devices which provide resistance in order to control angular velocity and/or acceleration of knee rotation. Included are mechanical and fluid resistance mechanisms.

4. **Extension Aids.** Devices which provide a force to facilitate active negative rotation of the knee (extension). They may be internal, that is, integral components of the knee mechanism, or externally applied devices.

5. **Adjustable Resistance.** The capacity for presetting the magnitude of knee rotation at one of many prescribed levels.

6. **Constant Resistance.** The characteristic resistance pattern provided by a swing-control mechanism in which its magnitude remains relatively constant throughout the swing phase independently of angular velocity or time.

7. **Variable Resistance.** Variation at any preset level of the resistance to knee rotation as a function of angular position of knee rotation.

8. **Cadence Response.** Variation in resistance to knee rotation at any preset resistance level as a function of angular velocity.

9. **Independent Adjustment of Resistance to Flexion/Extension.** The capacity for altering the ratio of the resistance to positive or negative rotation.
10. **Stance Phase.** The portion of the gait cycle in which any part of the reference leg is in contact with the ground.

11. **Knee Moment.** The product of the force tending to produce knee rotation, and the perpendicular distance from the line of action of that force to the center of knee rotation.

12. **Knee Lock.** A mechanism which prevents rotation at the joint in stance phase. Automatic knee locks operate cyclically under the control of applied loads, inertia, or other forces to prevent positive knee rotation (flexion). Manual knee locks are non-cyclical in that, once engaged, they prevent knee rotation until disengaged manually.

13. **Yielding Resistance in Stance Phase.** A higher degree of resistance to positive knee rotation than normally available, designed to reduce the rate of knee rotation under load.

14. **Polycentric Joint.** A mechanism whose instantaneous center of rotation displaces posteriorly to decrease positive knee moment (flexion) during stance phase; or which displaces proximally to decrease the hip extension moment required to prevent knee flexion.

15. **Correlated Knee and Ankle.** A mechanism in which knee and ankle motion are coupled: motion of one is accompanied by motion of the other.

16. **Alignment.** Proper utilization of the major components of an above-knee prosthesis—socket, knee, foot-ankle assembly—requires that they be joined in a particular relationship. The foot must remain flat on the floor when standing or during mid-stance. The body weight carried by the socket must project slightly anterior to the knee joint so that standing can be effected without excessive hip extension. Knee flexion must be initiated smoothly. This basic relationship is commonly referred to as TKA (trochanter-knee-ankle) alignment, which is the preliminary alignment step in the fabrication of all above-knee prostheses. Prescribed variations from basic TKA alignment are made in relation to anatomical anomalies and the special functions of various knee mechanisms.

17. **Locus.** The path of a point or curve moving according to some law, i.e., the path followed by the instantaneous axis of rotation of a polycentric knee through the cycle from full extension to full flexion.

### 3. classification

Since knee mechanisms may provide control over either swing phase or stance phase, or over both, it is simple to classify those that control either swing or stance on the basis of the type of control they offer. Classification of units providing both swing- and stance-phase control is difficult because a particular unit may embody highly sophisticated swing controls and very simple stance controls, or the reverse. The other function—extension aid—must also be considered. The following
Selection and Application of Knee Mechanisms

Classification has been developed to include all the major classes and types of knee mechanisms (Fig. 4).

**CLASS 1**

*Type 0:* Free Knee, Non-Adjustable
- Bock 3P4
- Polymatic Knee

**CLASS 2**

*Type 1:* Swing-Phase Control, Constant, Adjustable
- Wagner 320
- Bock 3P25
- Wagner 319
- Wagner 98B
- Standard Wood Knee
- Vari-Gait V300A
- Standard Metal Knee

*Type 2:* Swing-Phase Control, Variable, Adjustable
- Vari-Gait Vl00

*Type 3:* Swing-Phase Control, Variable, Adjustable, Cadence Responsive
- Mauch S-N-S

**CLASS 3**

*Type 1:* Swing- and Stance-Phase Control, Constant, Adjustable
- Bock 3P24
- Bock 3P23
- Wagner 205
- Wagner 200
- Teufel Secura
- Blatchford BSK
- Polycadence

*Type 2:* Swing- and Stance-Phase Control, Variable, Adjustable
- Vari-Gait V100

*Type 3:* Swing- and Stance-Phase Control, Variable, Adjustable, Cadence Responsive
- Mauch S-N-S

**CLASS 4**

This class includes a new “hybrid” system consisting of 2 components, each of which may be used alone to control swing and/or stance.

Class 1

This category includes knee mechanisms which provide “free knee rotation”; i.e., knee rotation is resisted solely by the friction inherent in the bolt and bushing assembly. They do not permit adjustment of the magnitude or phase (time pattern) of resistance (Fig. 5). Accessory features include (internal) or permit inclusion (external) of an extension to full flexion.

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The numerical descriptions of classes and types are based on the ADP coding system employed in the VA Prosthetics Center.

Formerly known as the Hydra Knee.
### CLASS 1

**"FREE KNEE" CONSTANT RESISTANCE**

<table>
<thead>
<tr>
<th>Swing-Phase Control</th>
<th>Stance Phase Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Classification</td>
</tr>
<tr>
<td>Constant Resist</td>
<td>Variable Resist</td>
</tr>
<tr>
<td>Non-Adjustable</td>
<td>Adjustable</td>
</tr>
</tbody>
</table>

#### FUNCTIONAL FEATURES OF KNEE MECHANISMS

**Figure 4**

#### MOMENT IN EXTENDING TO RESIST EXTENSION OR FLEXION

<table>
<thead>
<tr>
<th>Moment (in-lb-ft)</th>
<th>Percent of Knee Flexion-Extension Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>30</td>
<td>20%</td>
</tr>
<tr>
<td>60</td>
<td>40%</td>
</tr>
<tr>
<td>90</td>
<td>60%</td>
</tr>
<tr>
<td>120</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Figure 5**
sion aid whose force is adjustable (Fig. 6). The extension aid produces moments of different magnitudes in flexion and extension as shown in Figure 5. Other accessories such as stability controls consisting of manual knee locks or polycentric joints may be featured. Two units fall into this category: the Otto Bock 3P4 knee with manual lock and the Polymatic with a polycentric knee joint, to control stance phase (Fig. 4).

Extension Aids

Extension aids are of the internal or external type. The stick control usually pivots at its proximal end about an axis 1 in. posterior and slightly below the level of the knee axis. The stick is made of fiber or wood and is approximately 7–8 in. long. The distal end inserts into a horsehide pocket suspended from the back of the upper shank by means of elastic straps or springs. Both the shank and knee are padded in the area of contact with the stick to provide damping and an extension stop as the stick is forced against the posterior wall of the shank by the knee moving into maximum extension. The stick control being suspended in elastic also acts as an extension aid. The elastic straps are placed under increasing tension as the knee is flexed toward 90 deg. From full extension through 90 deg. of knee flexion, the tension on the elastic strap increases, causing a higher extension moment. Beyond 90 deg. of knee flexion, the upper pivot of the stick passes forward of the knee axis and the shank is drawn into full flexion by the elastic straps. This permits sitting with the knee fully flexed.

There are two basic types of external extension aids: 1. an adjustable anterior elastic webbing strap attached to the upper anterior wall of the shank, passing anterior to the knee and attached on the socket, and 2. an elastic strap passing through the roller portion of a knee extension stop through the socket wall anteriorly, and fixed to the anterior socket wall or pelvic belt (Fig. 6). This strap acts as an extension aid (kick strap), similar in function to that of the stick control. However, when flexed 90 deg. or more, the anterior elastic strap does not produce flexion force as does the stick type.

Extension Stops

The metal knee stop is fixed about the knee axis and attached posteriorly at the top of the shank. The extension control extends anterior to the knee axis and stops the motion of the knee at full extension. The knee area of contact with the metal stop is padded with rubber or felt to dampen the impact.
The bilateral above-knee amputee and the unilateral amputee with an extremely short stump occasionally require more stability than that provided by the knee unit and the alignment of the prosthesis. New amputees learning to stand on their first prosthesis, and elderly, enfeebled patients may require manual knee locks. They are usually designed as a bar or rod which passes through the knee anteriorly from above the axis to a point below the axis. When the rod is manually elevated or depressed, it engages a slot or hole located in the shank, thereby locking the knee. The most advanced locks are spring-loaded to lock automatically after one rises from a seated to a standing position.

Class 2

Included in Class 2 are knees whose rotation is controlled by special mechanical or fluid resistance mechanisms which permit adjustment of resistance to knee rotation. All such units include a knee extension aid which is adjustable. They may include other accessory features. This class consists of three different types of knee mechanisms:

Type 1. These units permit adjustment of the magnitude of resistance to knee rotation. They provide constant resistance at any setting; i.e., their resistances at any setting do not change significantly during the
Selection and Application of Knee Mechanisms

CLASS 2 TYPE 1
ADJUSTABLE RESISTANCE (CONSTANT) THREE SETTINGS

![Graph showing adjustable resistance settings](image)

PERCENT OF KNEE FLEXION—EXTENSION CYCLE

Figure 7

The unilateral amputee with quire more stability than that present of the prosthesis. Newer prostheses, and elderly, en-nee locks. They are usually notched to control the knee anteriorly from i. When the rod is manually or hole located in the shank, need locks are spring-loaded to seated to a standing posi-

1. Swing-phase control in these single-axis mechanical knees is usually achieved by means of friction devices acting on the knee bolt. Typical of these devices are dual screw arrangements which wedge or compress a section of fiber or other material against the surface of the knee bolt (Fig. 8). This type of friction is called constant adjustable friction.

2. These units permit adjustment of the magnitude of resistance to knee rotation. They also provide variable resistance; i.e., the magnitude of resistance varies with angular position of knee rotation at any given resistance setting (Fig. 9). They do not provide cadence response.

Units in this category are: Northwestern University Disc Friction Unit and the Vari-Gait V 200. Variable resistance in these units may be controlled by increments or decrements in frictional force. This is accomplished in some units by concentrically mounted friction discs or by eccentric bearing surfaces whose functional resistance varies during swing phase.

3. These knees permit adjustment of the magnitude of resistance, provide variable resistance, and are also cadence responsive, that
CLASS 2 TYPE 2
ADJUSTABLE RESISTANCE (VARIABLE) THREE SETTINGS

Figure 8

Figure 9
Selection and Application of Knee Mechanisms

is, resistance at any setting varies with walking cadence or knee angular velocity (Fig. 10). Devices in this category provide the most sophisticated control of swing phase in their class. All these devices are fluid piston/cylinder arrangements; some are pneumatic and others hydraulic.

Fluid Knee Control. The major advantages of fluid knee mechanisms are better gait, quiet and smooth operation, versatility in adapting to different speeds of walking, and in some cases, better performance on inclines and stairs. Since resistance to turbulent fluid flow is proportional to the square of the fluid velocity, all such systems are inherently cadence responsive. Units depending on mechanical friction are not inherently cadence responsive because frictional force depends on the coefficients of friction of the two mating surfaces and the force clamping the two surfaces together. With both these values fixed in a particular design, frictional forces are not closely correlated with flexion-extension velocities. However, mechanical resistance knee controls can be designed to preprogram a particular resistance pattern, but they are not as versatile as fluid systems.

A common fallacy is the notion that fluid units are inherently more energy consuming than mechanical frictional devices. Actually, the amount of energy required for starting, swinging, and stopping the
motion of the shank depends on the resistance to be overcome. A mechanical friction knee and a fluid resistance device will require exactly the same amount of energy provided that their mass moments of inertia and resistance settings are equal. The idea that fluid resistance units require more energy is probably based on the fact that they are capable of operating at higher resistance settings than most mechanical friction units, a distinct advantage for many cases, particularly vigorous patients with long stumps. Two other advantages characterize the fluid resistance systems. Under ordinary circumstances, resistance levels, once set, need not be frequently readjusted, while mechanical friction units are constantly subject to wear of the surfaces in contact and need more frequent adjustments. Fluid resistance mechanisms are also inherently more stable, that is, they do not collapse (a form of very rapid knee flexion) since resistance is increased with the velocity of fluid flow. This enables prosthetists to align hydraulic units with the vertical projection of the body weight passing closer to the knee center, a procedure which improves the initiation of flexion in walking.

Class 3

Class 3 includes mechanisms which control knee rotation by mechanical friction, or by shifting the effective center of knee rotation, or by fluid resistance devices during both swing phase and stance phase. Three specific types are identified:

a. Type 1. These units permit adjustment of the magnitude of resistance to knee rotation, but they do not provide variable resistance or cadence response.

b. Type 2. These units permit adjustment of the magnitude of resistance to knee rotation and provide variable resistance, but they are not cadence responsive.

c. Type 3. These units permit adjustment of the magnitude of resistance to knee rotation, provide variable resistance, and are also cadence responsive.

SWING PHASE IN TYPES 1, 2, AND 3 IN ALL THESE CLASS 3 UNITS IS CONTROLLED IN THE SAME WAY AS IN CLASS 2 UNITS, TYPES 1, 2, AND 3, RESPECTIVELY. HOWEVER, STANCE PHASE IS CONTROLLED IN A VARIETY OF WAYS.

Stance-Control Methods

The different methods employed to control stance phase have created a certain amount of confusion due to basic similarities and differences among them. Stance-control devices include manual locks, hydraulic
Selection and Application of Knee Mechanisms

Resistances of the knee to be overcome. A resistance device will require provided that their mass moments of inertia be based on the fact that they resistance settings than most antage for many cases, particularly. Two other advantages of cylinder ordinary circumstances, are frequently readjusted, while subject to wear of the surfaces adjustments. Fluid resistance, that is, they do not collapse resistance is increased with the resistance units operating on the friction principle depend on the body weight applied during stance phase either to compress a spring and bring bearing surfaces in contact (Bock 3P24, 23), or to tighten a belt about a drum (Blatchford BSK). A bi-axial arrangement is often used where the proximal axis, which is the center of rotation during swing phase, is linked to another point of rotation on the shank. As weight is applied, the link rotates a few degrees about its lower center of rotation, causing the upper center of rotation to descend, placing the bearing surfaces in contact, and increasing the resistance to rotation in stance phase (Fig. 11).

These stance controls might be considered polycentric devices since their effective center of rotation in swing phase is displaced downward in order to bring into play the stance-phase friction mechanism. However, defining them in these terms serves no useful purpose since the “polycentricity” is incidental to the function.

b. Shifting Locus

A second group of stance-phase controls depends on displacing the center of rotation to a more proximal and posterior position in stance phase than it occupies in swing phase. This may have two significant effects: 1. with the center of rotation moved backward, an extension moment about the knee is generated during most of stance phase; 2. if the device is properly aligned, the hip extension force required to stabilize the knee is reduced when the knee center is raised.

This is commonly accomplished by means of four (or more) bar linkages whose instantaneous centers of rotation are shifted strategically (Fig. 12). In some, an extension moment is generated about the knee
when it is extended or even when it is flexed several degrees. In another
approach, the instantaneous center ascends in stance phase enabling
a patient to maintain knee stability with less forcible extension of the
hip. All of these units depend on the angular position of the knee to
displace the center of rotation and are therefore not weight-controlled
as are the friction devices. They are properly called polycentric devices
because their function depends on the shifting center of rotation.

c. Fluid Resistance

A third group of stance-control units depends on relatively high
resistance to fluid flow to stabilize the knee in stance phase. They are
designed with valves which increase the velocity of fluid flow and
increase resistance to piston displacement. One such mechanism is con-
trolled by application of the patient’s weight to block the flow of fluid
completely and effectively lock the knee. The heel of the foot contains
a wobble plate connected by a rod to the valve which ordinarily con-
trols swing phase. When weight is applied to the heel, the valve is
closed and acts as a hydraulic lock in stance phase. It unlocks when
weight is taken off the heel and controls swing phase as adjusted.

Another type is controlled by gravity which causes a pendulum to
rotate depending upon the angle of the unit with respect to the hori-
Selection and Application of Knee Mechanisms

Horizontal plane. The pendulum is released when a hyperextension moment about the knee is generated. When the leg is advanced and placed on the ground at an angle in the beginning of stance phase, the pendulum rotates and closes orifices through which the fluid normally flows in swing phase, sharply increasing resistance to knee rotation. In this unit, however, the flow is not completely blocked and a certain amount is permitted to “leak” past the valve, providing a high, though yielding, resistance. The leak rate and hence the rate of yielding under various loads can be adjusted. As the patient proceeds from heel-contact to mid-stance and begins to generate a hyperextension moment about the knee, the pendulum rotates in the opposite direction, opening the valve to its swing-phase setting, permitting the desired transition into swing phase, and exercising the required control over knee flexion/extension.

The several types of Class 3 swing- and stance-control units are described below:

a. Type 1. In addition to adjustment of resistance magnitudes in these units, stance phase is controlled by friction generated under weight bearing. Examples of knees which fall into this category are: Bock 3P24, Wagner 200, and the Teufel Secura Knee.

Except for one or two infrequently seen “physiological” knees which are not designed with conventional knee bolts, all of these systems rotate about a single axis during swing phase. Body weight, applied as stance phase begins, causes the spring-mounted knee block to descend, engaging two friction surfaces to increase resistance to flexion during stance phase. However, knee flexion before sufficient weight is born to engage the braking may result in buckling. The knee must be stably aligned posterior to the TKA line to support the portion of body weight applied before the braking occurs. Also included in this type are units which provide adjustment of resistance in swing phase but which depend on a shifting center of rotation for stability in stance phase.

b. Type 2. These units permit adjustment of the magnitude of resistance to rotation and provide variable resistance but they are not cadence responsive. Some units of this type are also designed to control stance phase by increasing friction between mating knee surfaces under weight-bearing. In other units of this type, stance-phase control is accomplished by means of displacement of the center of knee rotation to produce an extension rather than a flexion moment in stance phase. These polycentric devices consist of four (or more) bar linkages; the precise lengths of the links and positions of the centers of rotation control the displacement path of the loci during the swing and stance cycle.
c. **Type 3.** Units of this type: 1. permit adjustment of the resistance to knee rotation, 2. provide variable resistance, and 3. are cadence responsive. Stance-phase control is also effected by means of fluid resistance. Both the Regnell Hydraulic Knee (non-contract) and the Henschke-Mauch S-N-S control systems are of this type.

The Regnell unit is a single orifice hydraulic swing-control system in which stance phase is controlled by means of an automatic hydraulic “positive lock” which prevents positive knee rotation (flexion). The locking effect is achieved in stance phase during the period when the heel is on the ground. Body weight on the heel actuates a lever and rod which block fluid flow and effectively prevent knee flexion. For stair descent a manually operated unlocking switch is provided (stair valve) which disables the locking mechanism and allows the knee to yield slowly.

The Mauch S-N-S hydraulic system is a multi-orifice swing-control mechanism which offers the amputee a high degree of control. It provides independent adjustment of flexion/extension resistance. In stance phase, resistance to flexion is increased when the device is not perpendicular to the ground in early stance phase, stabilizing the knee against flexion during this period. Shortly after mid-stance, after a hyperextension moment has been generated about the knee, the resistance control valve is opened and the unit is free to flex. Although the stance-phase control stabilizes the knee, it is not of the “locking type”; the knee actually yields at a slow rate under high moments. This is particularly effective in stair and hill descent. This unit also features a manual locking device which locks the knee against flexion but permits extension.

**Class 4 (Hybrids)**

Included in this class are “hybrid” knee systems which consist of two separate components—one to control swing phase and another one to control stance phase. They usually combine mechanical friction stance controls with fluid swing controls. Either of the two components may be used alone. Two such systems have been demonstrated and are in use on a small scale at the present time.

1. One system is the combination of the BSK, described in Class 3 Type 1 and the Blatchford Pneumatic knee, described in Class 2 Type 3, mechanisms. In this system the patient depends on the BSK for stance control as described previously, and the Blatchford Pneumatic knee controls swing phase.

2. The Kolman knee, described in Class 3 Type 1, has been combined with the Dyna-Plex (Class 2, Type 3) to provide both swing and stance control.
4. GENERAL REQUIREMENTS

Regardless of class or type, all knee mechanisms should meet the following general requirements:

1. The knee-shank assembly should readily be attached to above-knee sockets and should receive prosthetic feet conveniently.

2. The knee must be durable, safe, relatively lightweight, and of good workmanship.

3. A range of sizes should be available.

4. All knee mechanisms should provide smooth rotation through a range of not less than 120 deg. measured from a position in which the long axes of the knee block and shank are aligned vertically through the knee center (180 deg.)

5. Extension aids should provide a force of sufficient magnitude to measurably decrease the resistance to negative knee rotation. The peak moment should occur in the last 20 deg. of negative knee rotation. The magnitude of the extension moment should be readily adjustable.

6. The lower limit of the range of resistance to knee rotation should be not less than 25 in.-lb. of moment at a peak point during swing phase. Class 2 and Class 3 knee mechanisms should provide resistance to rotation which is adjustable through a range of not less than 30 percent above the minimum setting for each unit.

7. The magnitude of resistance to knee rotation should vary with angular knee velocity or cadence in Class 2 Type 3 and Class 3 Type 3 units.

5. PRESCRIPTION OF PROSTHETIC KNEE MECHANISMS

The ultimate purpose of an above-knee prosthesis is to restore the capacity to walk in a reasonably normal manner. The knee-control mechanism must be considered the functional heart of the above-knee prosthesis. No knee mechanism can restore any semblance of normal walking in the absence of other components, nor can it function effectively without a well-fitted, comfortable socket, proper alignment, and a properly selected foot/ankle mechanism. However, the functions of the socket are to provide comfortable, non-tissue-damaging weight-bearing; a mechanical link to and suspension for the knee and foot; and sensory feedback to the stump about the behavior of the knee and foot. The foot/ankle/shank assembly also provides support and contributes to the normality of walking. Nevertheless, the major element in simulating normal gait is control of the flexion-extension cycle and stability in early stance. These are the principal functions of knee mechanisms.
Prescription Rationale

Clinicians prescribing a prosthesis for a new amputee and particularly re-prescribing for an experienced amputee are frequently told that the patient prefers a particular knee mechanism. The preference may be based on experience with the knee mechanism or, in the case of the new amputee, on hearsay about its virtues. Simply acceding to the patient’s request may indeed satisfy him, particularly if the prescribing clinic team’s rationale is based on the question: “How can we satisfy the patient”? or “Which set of components—socket, knee, foot/ankle assembly—will satisfy the patient”? Although a strong patient preference is a dominating factor, the information contained in this Program Guide provides a more effective rationale which takes the form of the following question: “What is best for the patient”? “What is best for the patient” usually turns out to be adherence to the following guidelines:

1. Basic Prescription Considerations

   a. Alignment. All above-knee patients should be fitted with the least stable alignment consistent with required security in order to provide maximum control over the prosthesis by minimizing the effort required to initiate swing phase. Alignment stability must be thought of as a component of the prosthesis just as though it were a piece of hardware. The more alignment stability built into the prosthesis the more gait is compromised although security may be increased. The first step in prescription is to consider the selection of the most appropriate knee mechanism, which is to say, the one which will require the least alignment stability. The degree of alignment stability required in any case is determined by two factors: a. the length and strength of the stump, and b. the type of knee mechanism to be used.

   In general, stump length and strength are highly correlated: short stumps are usually weaker than medium length stumps, which in turn are weaker than long stumps. Due to more residual muscle masses, longer stumps are stronger. The effective strength of long stumps is increased due to their advantage in mechanical leverage; i.e., with exactly the same muscular forces available a longer stump will exert a greater extension moment than a shorter stump. Moreover, long stumps have greater surface areas in contact with the socket, resulting in more positive control and better feedback.

   As shown in Figure 13 it may be too much to expect that patients with short above-knee stumps can be fitted with a “trigger” alignment, i.e., least alignment stability. All the units listed in Figure 4 as Class 3 Type 1, Class 3 Type 2, and all the Class 4 knee mechanisms will
Selection and Application of Knee Mechanisms

PERMISSION RELATED TO STUMP AND ACTIVITY LEVEL

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>HIGH-VERSATILE</th>
<th>FAIRLY ACTIVE</th>
<th>RELATIVELY IN ACTIVE</th>
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<tbody>
<tr>
<td>S T U M P</td>
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</tr>
<tr>
<td></td>
<td>1. FAST WALKER</td>
<td>2. MOSTLY LEVEL GROUND</td>
<td>3. SLOW MOVEMENT</td>
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<tr>
<td></td>
<td>2. WALKS LONG DISTANCES</td>
<td>3. MOSTLY LEVEL GROUND</td>
<td>4. SLOW MOVEMENT</td>
</tr>
<tr>
<td></td>
<td>3. WALKS ON HILLS AND UNEVEN GROUND</td>
<td>4. MOSTLY LEVEL GROUND</td>
<td>5. SLOW MOVEMENT</td>
</tr>
<tr>
<td></td>
<td>4. ALIGNMENT STABILITY IS INADEQUATE FOR UNEVEN TERRAIN AND OTHER ACTIVITIES</td>
<td>5. MOSTLY LEVEL GROUND</td>
<td>6. SLOW MOVEMENT</td>
</tr>
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LONG OVER 50% OF FEMUR REMAINING

<table>
<thead>
<tr>
<th></th>
<th>RX NO. 1</th>
<th>RX NO. 2</th>
<th>RX NO. 3</th>
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<tbody>
<tr>
<td>Exhibits the maximum walking endurance.</td>
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<tr>
<td>Exhibits a moderate walking endurance.</td>
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<tr>
<td>Exhibits a minimum walking endurance.</td>
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MEDIUM BETWEEN 50% AND 50% OF FEMUR REMAINING

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<td>Exhibits a minimum walking endurance.</td>
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LESS THAN 50% OF FEMUR REMAINING

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<tr>
<td>Exhibits a moderate walking endurance.</td>
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<tr>
<td>Exhibits a minimum walking endurance.</td>
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BILATERAL AND/OR OTHER INVOVEMENTS AFFECTING BALANCE

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<tr>
<td>Exhibits a minimum walking endurance.</td>
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ADVANTAGES OF EACH RX

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PERMISSION RELATED TO STUMP AND ACTIVITY LEVEL

COXSWING CONTROL WITH ADJUSTABLE VARIABLE CADENCE RESPONSE AND EXTENSION AID

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<th>RX NO. 1</th>
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<tbody>
<tr>
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<tr>
<td>Exhibits a minimum walking endurance.</td>
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b. STANCE CONTROL. Is it preferable to control stance phase by weight-bearing or by shifting the locus of the knee to a more stable position when the knee is extended? Polycentric knee mechanisms are more dependable stance-phase controls but in general are somewhat heavier than the weight-control types; on the other hand, their swing characteristics may be inferior. In general more positive stance control is provided by the polycentrics. The choice, then, lies in balancing the stability needs against the mobility needs.

c. EXTENSION AID. Certain units in these categories have internal extension aids while others require external elastic band-type extension aids (Fig. 14). In general, internal extension aids of the spring type, although adjustable, do not provide high extension-aid forces. The external extension aids of the elastic-band type are uncosmetic, wear...
rapidly, and may interfere with clothing. But they are adjustable by
the patient and provide higher forces than are available from springs.
The order of preference, therefore, should be: a. external elastic
extension aids where high extension forces are necessary as, for example,
in the patient with a short stump whose activity pattern requires
him to take very short steps for lengthy periods, and who still tolerates
the cosmetic compromise; b. internal adjustable spring extension aids
where high forces are not required as, for example, patients with
medium and long stumps who do not work in confined areas and for
whom external straps are not desirable. The last choice in almost any
case is for the non-adjustable internal spring type.

d. Sockets and Suspensions. Optimally, every above-knee amputee
should be prescribed a total-contact suction quadrilateral socket. The
reasons are simple: total contact minimizes the possibility of tissue
damage; leads to more uniform pressure distributions and hence im-
proved comfort; provides better control over the prosthesis by the
stump due to reduction in the relative motion between stump and
socket; and permits the optimal employment of suction suspension.
Suction suspension has the advantage of eliminating external belts
and straps, although putting on and taking off the prosthesis may be
more difficult, especially for old or infirm patients (see following discus-
sion on Variations).
Use of the total-contact suction socket reinforces the principle of
fitting with the least alignment stability possible. Minimum alignment
Selection and Application of Knee Mechanisms

Stability requires greater control over the prosthesis, an advantage of total-contact sockets. The more sophisticated knee mechanisms, including highly functional stance controls, also require finer control by the stump. To prescribe a Mauch S-N-S, for example, with an open-end plug-fit socket and pelvic belt is to deny the patient the kind of control he needs to take advantage of the features of this unit. There is no recorded basis whatsoever for prescribing anything but total-contact above-knee sockets. There may be several reasons for prescribing nonsuction suspension in the form of Silesian bandages or even a pelvic belt, but total-contact sockets are still indicated.

If, for reasons such as patient preference, etc., the clinic prescribes an open-end, plug-fit-type socket, it makes little sense to couple this component with the sophisticated knee mechanisms in Class 2 Type 3, or Class 3 Type 3, or Class 4.

Control of a prosthesis depends upon contact between the stump and the socket during all phases of walking. It is essential that the greatest possible stump surface area is firmly in contact with the socket at all times. Accurately fitted total-contact sockets are required for best results. Regardless of the sophistication of the knee mechanism, its value is not available to the patient UNLESS IT IS USED WITH A SOCKET THAT PERMITS THE PATIENT TO EMPLOY ALL THE FEATURES IT OFFERS.

e. Foot/Ankle Assemblies. Foot and ankle systems are designed to absorb impact upon heel-contact and permit plantar flexion, improving knee stability during the early stance phase. The ankle is usually blocked against dorsiflexion to improve knee stability during the later portions of the stance phase and to prevent drop-off at the end of the stance phase. Lateral motion, transverse rotation, and toe pick-up are provided in some foot/ankle systems. Although their use is not widespread, these functions are desirable for special activities.

Multi-axis foot/ankle assemblies should be carefully considered for extremely active patients or those who engage in special activities such as dancing, sports, etc. These types of foot/ankle assemblies can offer no more function than either the SACH or the properly “tuned” single-axis foot in ordinary activities or as far as knee stability is concerned.

The effects of a well-selected socket and knee mechanism aligned with the least possible alignment stability can be lost by improper selection of a foot. The more the prosthesis is “triggered” the more necessary it is to have a dependable and sophisticated stance-control knee mechanism; it is also necessary to provide low plantar-flexion resistance. Unnecessarily high resistance to plantar flexion will reduce knee stability in early stance phase.

At the present time the choice of foot/ankle assemblies lies between
feet with single-axis ankles and the multi-axis foot/ankle assemblies including the SACH foot. For the patient without complications regardless of stump length, the SACH foot is an obvious choice because it permits selection of a sufficiently soft plantar-flexion resistance, it is available in the full range of sizes, and it is readily attached to the shank. The molded SACH foot has no open sections and the combination of keel length and the resilient toe provide adequate control of roll-over in late stance. In fact, stability in late stance phase is principally a function of the roll-over characteristics of the foot and has little to do with the function of the knee.

However, patients who have been prescribed any of the Class 2 knees (without stance-phase control features) may require finer adjustment of the resistance and ranges of motion in the foot/ankle assembly than is readily achievable in the SACH type. In the absence of integral stance-control features in the knee, the patient must depend on alignment stability and the plantar-flexion function of the foot/ankle. Cases of this type might be more adequately served by a single-axis foot which the prosthetist "customarizes" for the patient by appropriate variations in the selection of plantar-flexion bumpers and in the adjustment of the permissible dorsiflexion range. Accurate alignment and adjustment of the foot can permit a more triggered overall alignment even in the absence of a knee mechanism with stance-control features.

2. Variations from Basic Prescriptions

a. Short Stumps. If for any reason the best knee mechanism (Class 3 Type 1, Class 3 Type 2, or Class 4) for the patient with a short stump cannot be prescribed, the clinic must recognize that the next most appropriate knee mechanisms for this patient, Class 2 Types 1, 2, or 3, can only be fitted at a cost of increasing alignment stability. This means that the selection of Class 2 units without integral stance-phase control components will require that the prosthesis be aligned in a relatively stable position to reduce the effort required of the patient to stabilize his knee in early stance. Moreover, the secondary consequence of stable alignment is increasing difficulty in initiating swing phase.

b. Medium Length Stumps. It is generally quite possible to align the prosthesis for a patient with a medium length stump with minimal alignment stability by prescribing knee mechanisms of Class 3 Types 2 and 3 or Class 4. The other factors mentioned above in relation to the patient with the short stump (type of stance-phase control, type of extension aid, etc.) deserve the same consideration for the patient with the medium stump. If for any reason, such as patient preference, prejudice, cost, etc., it becomes necessary to prescribe other units, it must be recognized that the second choice group, consisting of Class 2 Types
Selection and Application of Knee Mechanisms

2 and 3 and Class 4, can only be fitted with increased alignment stability. In addition, patients with uncomplicated medium length/strength stumps can use more sophisticated swing controls to better advantage. Class 3 Type 1 and Class 2 Type 1 units do not provide as much functional versatility.

c. Long Stumps. Patients with long stumps might be considered to have the least need for stance-phase control because their long, strong stumps can readily generate muscular forces to stabilize the knee in early stance, even in the absence of mechanical stance controls. These patients, however, are likely to be more vigorous walkers than the others and can benefit most from the sophisticated swing-control systems. In addition they are more likely to be users of stairs and to walk on uneven terrain and down hills, activities in which stance-phase control mechanisms would be most advantageous. The prescription choice for these patients lies in Class 3 Types 2 and 3 and Class 4 to obtain all the advantages of: 1. the most versatile swing-phase pattern, 2. stance control to reduce the hazard of walking on non-level surfaces, and 3. minimum alignment stability. Apart from all secondary criteria mentioned above in relation to patients with short and medium length stumps, an additional criterion must be considered for the patient with the long stump. The knee center to floor dimension must be considered to determine which of the available Class 3 and Class 4 units can be fitted—excessively long stumps may not permit fitting of certain units.

d. Stump Condition. Stump surface conditions may cause difficulties in fitting. Conditions which cause pain or sensitivity must be considered in prescription. Painful scars, neuromata, or other skin conditions on the posterior aspect of the stump, for example, may make it difficult or impossible for the patient to extend his hip with sufficient force to stabilize the knee in early stance. Apart from medical/surgical solutions, the most obvious and least effective method of dealing with this problem is to increase alignment stability in the hope of reducing the hip extension force the patient is required to apply. A better solution is to prescribe a knee mechanism which provides stance control and a foot/ankle assembly which provides minimal resistance to plantar flexion to reduce any tendency toward knee instability.

A more severe problem is pain in the area of the ischial tuberosity. An intimately fitted total-contact socket will do much to relieve the pressure in the painful area. A common site of pain is the lateral distal aspect of the stump due to impingement of the sharp end of the femur against soft tissue. In this case a well-fitted total-contact socket and proper medial-lateral alignment can often relieve the problem. A sound skin without blemishes and with non-adherent scar is considered most desirable for prosthetic fitting.
e. Other Physical Impairments. In the presence of other physical impairments, prescription criteria often change radically. The use of braces, additional amputations of either the upper or lower limbs, and blindness are factors which require serious consideration.

Patients in a clinic for prescription of an above-knee prosthesis who also have upper-extremity amputations cannot be prescribed a suction socket because of difficulty in donning. A non-suction socket will require either a Silesian or pelvic band, a fact which need not influence the choice of knee mechanism. Obtaining the full function available in a Class 3, 4, or Class 2 Type 2 or 3 knee mechanism depends on the control afforded by intimate stump/socket contact and not on the type of suspension.

If a patient wears a brace on one side and is being prescribed an above-knee prosthesis, the clinic's concern should be more for stability and reduced energy consumption than for esthetic swing characteristics. For these patients, Class 3 Types 1 and 2 knee mechanisms should be combined with total-contact suction sockets.

The blind above-knee patient has no visual feedback to cue him about the behavior of his limb. He depends on noise and proprioceptive feedback to control his prosthesis. He should be prescribed one of the polycentric units.

f. Level of Activity. A patient's anticipated or actual level of activity is a critical factor influencing the prescription of knee-control systems. Many patients are content only to stand and walk sufficiently to care for their personal needs while others compete with non-amputees in all daily activities including sports. The demands made upon the prosthesis may vary from sedentary wearers with poor strength to very active wearers with excellent strength. The more active wearers usually require the highest degree of knee swing control while the more sedentary-type wearers may not. Stance-control features can be of benefit to both.

g. Maintenance. Prosthetic knee systems are designed to withstand long periods of use with minimal wear or malfunction. However, the more complex mechanisms, due partly to the numbers of components and moving parts, tend to require more care and periodic preventive maintenance than the simpler systems. This care must be given by a competent, qualified technician. Thus, the cost and convenience of maintenance must be reckoned with. Also to be considered in this respect is the distance the patient lives from the nearest qualified limb facility or the patient in a heavy-duty occupation. For patients living in remote areas with long travel times involved, the clinic should consider a compromise in favor of low maintenance components.

h. Cost. The cost of the unit should not be a consideration except
Selection and Application of Knee Mechanisms
in situations where two or more devices of absolutely equal function are being considered.

i. Cosmesis. Cosmesis does not consist of appearance features alone. Weight, texture, noise-free function, as well as color and shape, are important. Until recently, cosmetic requirements were being met by the generally anthropomorphic shape of socket, shank and foot, and by reasonably homogeneous coloration. Demands for improved cosmesis have led to the development of new unitized cosmetic leg covers which:
1. cover the entire limb, including the knee, without impairing its function,
2. are shaped to approximate the contours of the sound leg,
3. are soft, resilient foam, reducing noise and impact,
4. feel more lifelike.

6. CATALOG OF KNEE MECHANISMS

This section contains standardized descriptions of individual prosthetic knee mechanisms grouped by the Classes and Types defined in Section 3. Separate pages are used for each different device regardless of the extent of difference. Significant data for prescription and installation in a prosthesis are given. The information provided is in abbreviated form to facilitate ready reference.

All units previously examined or presently under evaluation by the VA Prosthetics Center are included here. The units now on VA contract are so designated. The others for various reasons are still being evaluated.
Class 1

Type 0 (Fig. 15 and 16): These knees do not control the swing characteristics of walking by means of mechanical friction or fluid resistance. The only control over swing phase is provided by extension aids which resist flexion ineffectively and help initiate extension. Without other swing controls these are essentially one-cadence knee mechanisms. They will tend to swing at some natural speed related to their mass moments of inertia which are determined by their mass (weight) and the distance from the center of rotation to the center of gravity of the shank and foot/ankle assembly. If an amputee walks faster than the natural frequency of the limb, he will display excessive terminal impact and excessive heel rise and will have to "wait" for the limb to swing through the cycle thus limiting his cadence.

Of the two units in this Class, one features a mechanical lock which might warrant classifying it as a stance-control unit. However, since a mechanical lock is an extreme form of control, in effect, analogous to a "peg leg" during gait, it is classed according to its swing characteristics.

The other unit also classed according to its swing characteristics features a stance control in the form of a four-bar polycentric knee mechanism.

Although not recommended, the best potential use of these devices may be for patients who walk very little.
Selection and Application of Knee Mechanisms

BOCK 3P4 SINGLE-AXIS KNEE
CLASS 1 TYPE O

1. MATERIALS
A. Knee: Laminated poplar, semi-shaped, open front
B. Shank: Laminated poplar, semi-shaped
C. Finishing: Laminated exterior
D. Alignment device attachment: Wood screws

2. DIMENSIONS
A. Knee width: 3-1/2 inches in rights and lefts
B. Calf circumference: 11-1/2 through 15-3/4 inches, in 3/4 inch increments in rights and lefts
C. Stump length accommodated: Within 3 inches of knee axis

3. SWING CONTROLS
A. Flexion resistance: None
B. Extension resistance: None
C. Extension aid: None
D. Extension stop: Mechanical

4. STANCE CONTROLS
A. Mechanical lock: Automatic locking, manual unlocking
B. Frictional brake: None
C. Hydraulic lock: None
D. Changing knee locus: None
E. Yielding lock: None
F. Static alignment: Knee axis posterior to TKA

(On VA contract)
POLYMATIC KNEE
CLASS 1 TYPE 0

1. MATERIALS
A. Knee: Laminated willow, Semi-shaped
B. Shank: Laminated willow (two piece), Semi-shaped
C. Finishing: Laminated exterior knee and shank
D. Alignment device attachment: Wood screws

2. DIMENSIONS
A. Knee width: 3-3/4 inches in rights and lefts
B. Calf circumference: 14-1/2 through 16 inches, in rights and lefts
C. Stump length accommodated: Within 3 inches of knee axis

3. SWING CONTROLS
A. Flexion resistance: None
B. Extension resistance: None
C. Extension aid: External elastic straps
D. Extension stop: Mechanical

4. STANCE CONTROLS
A. Mechanical lock: None
B. Frictional brake: None
C. Hydraulic lock: None
D. Changing knee locus: Four-bar linkage
E. Yielding lock: None
F. Static alignment: Knee axis on TKA

(On VA contract)
Selection and Application of Knee Mechanisms

Class 2

Type 1 (Fig. 17–24): (Adjustable mechanical constant friction swing-phase control.) Constant friction knees are low in initial cost and their repair and maintenance are relatively simple and inexpensive. However, the mechanical friction settings wear rapidly and must be frequently readjusted. Stability of the constant friction knee is obtained by alignment of the knee axis posterior to the vertical weight reference line drawn to the ankle from the trochanter. In spite of their simplicity these knees are not a good choice for older patients in a generally weakened condition because of their relatively poor stance-phase control.
STANDARD WOOD KNEE  
CLASS 2 TYPE 1

1. MATERIALS
   A. Knee: Poplar wood, semi-finished, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: All sizes
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: \text{Constant, Adjustable, Mechanical}
   B. Extension resistance: Mechanical
   C. Extension aid: Stick control or elastic strap
   D. Extension stop: mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
VARI-GAIT V 300A KNEE
CLASS 2 TYPE 1

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 10 through 17 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)

Figure 18
BOCK 3P25 KNEE
CLASS 2 TYPE 1

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: (Constant, Adjustable)
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
Selection and Application of Knee Mechanisms

WAGNER 320 KNEE
CLASS 2 TYPE 1

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inch rights and lefts
   B. Calf circumference: 11-3/4 through 15 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

   (On VA contract)
STANDARD METAL KNEE
CLASS 2 TYPE 1

1. MATERIALS
   A. Knee: Aluminum, preformed, step front
   B. Shank: Aluminum, preformed
   C. Finishing: Paint
   D. Alignment device attachment: None

2. DIMENSIONS
   A. Knee width: 3-1/2 through 4-1/2 inches in 1/2 inch increments
   B. Calf circumference: Made to order
   C. Stump length accommodated: Within 1-1/2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Stick control or elastic strap
   D. Extension stop: Check cord

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
VARI-GAIT V 300 KNEE
CLASS 2 TYPE I

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 10 through 17 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROL
   A. Flexion resistance: Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: None
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
WAGNER 988 KNEE
CLASS 2 TYPE 1

1. MATERIALS
A. Knee: Balsa wood, semi-shaped, closed front and rear
B. Shank: Balsa wood, semi-shaped
C. Finishing: Plastic laminated exterior knee and shank
D. Alignment device attachment: Wood screws

2. DIMENSIONS
A. Knee width: 3-1/2 inches in rights and lefts
B. Calf circumference: 11-3/4 through 15-3/4 inches in 3/4 inch increments in rights and lefts
C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
A. Flexion resistance: Constant, Adjustable
B. Extension resistance: Mechanical
C. Extension aid: None
D. Extension stop: Mechanical

4. STANCE CONTROLS
A. Mechanical lock: None
B. Frictional brake: None
C. Hydraulic lock: None
D. Changing knee locus: None
E. Yielding lock: None
F. Static alignment: Knee axis posterior to TKA

(On VA contract)
Selection and Application of Knee Mechanisms

WAGNER 319 KNEE
CLASS 2 TYPE 1

1. MATERIALS
A. Knee: Laminated poplar wood, semi-shaped, closed front
B. Shank: Laminated poplar wood, semi-shaped
C. Finishing: Plastic laminated exterior knee and shank
D. Alignment device attachment: Wood screws

2. DIMENSIONS
A. Knee width: 3-1/2 inches in rights and lefts
B. Calf circumference: 11-3/4 through 15-3/4 inches in 3/4 inch increments in rights and lefts
C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
A. Flexion resistance: (Constant, adjustable
B. Extension resistance: Mechanical
C. Extension aid: None
D. Extension stop: Mechanical

4. STANCE CONTROLS
A. Mechanical lock: None
B. Frictional brake: None
C. Hydraulic lock: None
D. Changing knee locus: None
E. Yielding lock: None
F. Static alignment: Knee axis posterior to TRA

(On VA contract)
Type 2 (Fig. 25 and 26): (Adjustable, variable, swing-phase control.) Although the adjustable, variable, mechanical friction knee is not cadence responsive, it does provide varying degrees of resistance in swing phase. Increasing resistance at the time of heel rise during flexion and again just prior to full extension minimizes terminal impact and produces a more natural gait.
Selection and Application of Knee Mechanisms

NORTHWESTERN DISC FRICTION KNEE
CLASS 2 TYPE 2

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, closed front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Plastic laminated over exterior
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3 through 4 inches in 1/4 inch increments in rights and lefts
   B. Calf circumference: 11-1/2 through 16-1/2 inches in rights and lefts
   C. Stump length accommodated: Within 3 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Variable, Sequential
   B. Extension resistance: Adjustable, Mechanical
   C. Extension aid: None
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated over knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 10 through 17 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Variable, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROL
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
Type 3 (Fig. 27-31): (Adjustable, variable cadence responsive swing control.) Hydraulic knee systems employing fluid resistance for control of the swing phase have as an integral part of the hydraulic system an extension bias spring which preloads the unit in the direction of extension. Although the spring action is mild and non-adjustable, its effects are noticeable in assisting the return of the knee into extension from a flexed position. Pneumatic systems differ in that the fluid (air) used for control is compressible and forms an air spring to control extension; the pneumatic systems provide lower resistance than hydraulic systems.

The active patient for whom these devices should be prescribed should be fitted with minimal alignment stability. These devices must be initially fitted on an alignment device for trial walking during which time the knee is “triggered,” i.e., aligned in the minimal posterior placement with respect to TKA.
DUPACO HYDRAULIC KNEE
CLASS 2 TYPE 3

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches, 3-3/4 inches, and 4 inches in rights and lefts
   B. Calf circumference: Matched to knee
   C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Independent, Adjustable, Variable, Cadence responsive
   B. Extension resistance: Independent
   C. Extension aid: Spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior but near TKA

(On VA contract)
Selection and Application of Knee Mechanisms

HYDRA CADENCE HYDRAULIC KNEE
CLASS 2 TYPE 3

1. MATERIALS
   A. Knee: Cast aluminum frame and knee cap
   B. Shank: Aluminum alloy tubing
   C. Finishing: Prefabricated polyurethane cover
   D. Alignment device attachment: Tapped holes for coupling

2. SIZING
   A. Knee width: Neuter 3-3/4 inches wide
   B. Calf circumference: Shank frames 16-1/2 through 21-1/2 inches in 1 inch increments
   C. Stump length accommodated: Within 2-1/2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Adjustable
   B. Extension resistance: Cadence responsive
   C. Extension aid: Spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis trigger on TKA

(On VA contract)
DYNA-PLEX HYDRAULIC
CLASS 2 TYPE 3

1. MATERIALS
   A. Knee: Poplar or willow wood, semi-shaped, open front
   B. Shank: Willow wood, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment and device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3 through 4 inches in 1/4 inch increments in rights and lefts
   B. Calf circumference: 11-1/2 through 16-1/2 inches in rights and lefts
   C. Stump length accommodated: Within 4 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Hydraulic, adjustable
   B. Extension resistance: Cadence responsive
   C. Extension aid: Spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior but near TKA

(On VA contract)
HOSMER PNEUMATIC KNEE
CLASS 2 TYPE 3

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches, 3-3/4 inches, and 4 inches in rights and lefts
   B. Calf circumference: Made to order
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Pneumatic, Independent, Adjustable
   B. Extension resistance: Cadence responsive
   C. Extension aid: Air spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)

FIGURE 30
BLATCHFORD PNEUMATIC KNEE
CLASS 2 TYPE 3

1. MATERIALS
   A. Knee: Shaped metal, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated exterior shank
   D. Alignment device attachment: Tapped holes for coupling

2. DIMENSIONS
   A. Knee width: 3 through 4 inches in 1/4 inch increments (neuter)
   B. Calf circumference: 11-1/2 through 14-7/8 inches in rights and lefts
   C. Stump length accommodated: Within 4 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Independent, Adjustable
   B. Extension resistance: Cadence responsive
   C. Extension aid: Air spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to TKA

(On VA contract)
Selection and Application of Knee Mechanisms

Class 3

Type I (Fig. 32–39): (Adjustable, constant, swing control with stance control.) Stance control is achieved by means of a "floating" knee axis which is suspended by springs whose range of compression is adjustable. The springs or spring-loaded bars allow the knee to descend under weight-bearing to engage or rub against a mating surface in the shank. The amount of friction is proportional to the surface area in contact and the type of surfaces. Although they are considered stance-control knees, moderate to maximum alignment stability may be required to avoid buckling before sufficient weight is borne on the knee in early stance.

Weight-bearing stance control has a serious disadvantage. It prevents the patient from voluntarily flexing the knee when bearing weight. This feature prevents use of the "jackknifing" technique on descending stairs and creates difficulty in negotiating declines. The use of these knees should be restricted to those patients for whom stability is a problem.

These knee units have either an internal extension control such as the stick type described under the swing-control units, or the external extension bias strap. They also use the same type of friction swing controls described for the single-axis mechanical knees.
TEUFEL-SECURA KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped knee and shank
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
   A. Flexion resistance: {Constant, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating surfaces of knee and shank under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)

FIGURE 32
WAGNER 205 KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, closed front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-3/4 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating knee and shank surfaces under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
BOCK 3P23 KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Semi-shaped poplar wood
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant
   B. Extension resistance: Adjustable
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating knee and shank surfaces under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
BOCK 3P24 KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, closed front
   B. Shank: Semi-shaped, poplar wood
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 1-1/2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Adjustable
   B. Extension resistance: Mechanical spring
   C. Extension aid: Adjustable spring
   D. Extension stop: Mating section of knee and shank

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating (flat) knee and shank surfaces under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
BLATCHFORD STABILIZED KNEE (BSK)
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Preformed aluminum, closed front
   B. Shank: Pre-shaped willow
   C. Finishing: Painted knee, laminated shank
   D. Alignment device attachment: Tapped holes for coupling

2. DIMENSIONS
   A. Knee width: 3-3/4 inches open front in rights and lefts
   B. Calf circumference: 11-1/2 through 14-7/8 inches in rights and lefts
   C. Stump length accommodated: Within 3-1/2 inches of knee axis

3. SWING CONTROLS

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Weight activated drum and band
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
Selection and Application of Knee Mechanisms

KOLMAN SAFETY KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3 through 4 inches in 1/4 inch increments, neuter
   B. Calf circumference: 11-1/2 through 16-1/2 inches in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Spring assist, adjustable
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Weight activated drum and band
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
WAGNER 200 SAFETY KNEE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, closed front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 11-1/2 through 15-3/4 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodated: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: (Constant, Adjustable)
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating knee and shank surfaces under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)

FIGURE 38
Selection and Application of Knee Mechanisms

POLYCADENCE
CLASS 3 TYPE 1

1. MATERIALS
   A. Knee: Cast aluminum
   B. Shank: Cast aluminum fittings with aluminum tubes
   C. Finishing: Prefabricated polyurethane shank cover
   D. Alignment device attachment: Tapped for coupling

2. DIMENSIONS
   A. Knee width: 3-1/2 inch neuter
   B. Calf circumference: Made to order
   C. Stump length accommodated: Within 1 inch of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Constant
   B. Extension resistance: Mechanical
   C. Extension aid: Spring, non-adjustable
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: Four-bar linkage
   E. Yielding lock: None
   F. Static alignment: Knee axis on TKA

(On VA contract)
Type 2 (Fig. 40–42): (Adjustable, variable, swing control with stance control.) Two of these variable swing- and stance-control knees feature eccentric surfaces which are driven into contact with concentric shank surfaces. The contact areas at different points of the swing-phase cycle vary due to the eccentricity. The third device, the Laurence polycentric knee, provides variable sequential, mechanical friction applied by brake rings to achieve swing control.

These stance features have essentially the same disadvantages as those discussed in Class 3 Type 3, constant, adjustable swing- and stance-control knees.
VARI-GAIT V 100 DELUXE KNEE
CLASS 3 TYPE 2

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped, open front
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches in rights and lefts
   B. Calf circumference: 10 through 17 inches in 3/4 inch increments in rights and lefts
   C. Stump length accommodations: Within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Variable, Adjustable
   B. Extension resistance: Mechanical
   C. Extension aid: Adjustable spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating (flat) knee and shank surfaces under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

(On VA contract)
LANG POLYCENTRIC KNEE
CLASS 3 TYPE 2

1. MATERIALS
   A. Knee: Poplar wood, semi-shaped
   B. Shank: Poplar wood, semi-shaped
   C. Finishing: Plastic laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: Standard 3-1/2 inch axis
   B. Calf circumference: 12-1/2 through 15-3/4 inches in rights and lefts
   C. Stump length accommodation: To level of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Variable, Adjustable,
   B. Extension resistance: Mechanical
   C. Extension aid: External elastic strap
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mating knee and shank surfaces under weight-bearing
   C. Changing knee locus: None
   D. Yielding lock: None
   E. Static alignment: Knee axis posterior to but near TKA

   (Not on VA contract)

FIGURE 41
LAURENCE POLYCENTRIC KNEE
CLASS 3 TYPE 2

1. MATERIALS
   A. Knee: Cast aluminum
   B. Shank: Aluminum tube
   C. Finishing: Plastic knee cap and foam shank cover
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2 inches
   B. Calf circumference: Custom-foamed to any size and shape
   C. Stump length accommodation: Within 1 inch of knee center

3. SWING CONTROLS
   A. Flexion resistance: (Variable, Adjustable, Mechanical)
   B. Extension resistance: None
   C. Extension bias: None
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: Four-bar linkage
   E. Yielding lock: None
   F. Static alignment: Knee axis on TKA

(Not on VA contract)
Type 3 (Fig. 43-45): (Adjustable, variable, cadence-responsive swing and stance control.) These fluid swing-control knee systems provide stance control in different ways. In the Regnell hydraulic system, a higher resistance than that required for swing control is triggered upon weight-bearing by a mechanical linkage in the ankle to activate a hydraulic lock. A manually activated lever called a “stair valve” provides a slowly yielding resistance for use on stairs. The rate of yield is adjustable.

A four-bar linkage polycentric system is used to control the stance phase of the Orthopedic Hospital, Copenhagen (OHC) pneumatic. Although the linkage arrangement was designed originally to elevate the functional center of the knee for use in knee-disarticulation prostheses, its function as a stance control is also useful for other above-knee amputees.

Two types of stance controls are provided in the Mauch hydraulic unit. During level walking or on descending stairs and slopes, phasic, yielding, adjustable resistance is provided until the patient creates a hyperextension moment about the knee to release a pendulum which changes resistance. The pendulum is gravity dependent. A second mode of stance control is provided by means of a manually operated lever at the top of the piston rod, creating a positive lock against flexion. The sophisticated stance-phase control of this unit makes it a choice prescription for patients with multiple amputations.

Prostheses incorporating hydraulic systems must be aligned with an adjustable coupling device because of the vast difference in function between this type of device and an adjustable leg. The most satisfactory alignment is obtained when the knee is set in a position of less stability than is typical of mechanical friction knee mechanisms.
Selection and Application of Knee Mechanisms

ORTHOPEDIC HOSPITAL, COPENHAGEN (OHC)
PNEUMATIC SWING-CONTROLLED POLYCENTRIC
CLASS 3 TYPE 3

1. MATERIALS
   A. Knee: Cast aluminum
   B. Shank: Aluminum tube
   C. Finishing: Foam shank cover over skeletal structure
   D. Alignment device attachment: None

2. DIMENSIONS
   A. Knee width: 1-3/4 inches custom-made to any width
   B. Calf circumference: Custom-foamed to any size and shape
   C. Stump length accommodation: Knee-disarticulation level

3. SWING CONTROLS
   A. Flexion resistance: Independent, Adjustable, Cadence-responsive
   B. Extension resistance: Mechanical
   C. Extension aid: Air spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: None
   D. Changing knee locus: Four-bar linkage
   E. Yielding lock: None
   F. Static alignment: Knee axis on TKA

(Not on VA contract)

Figure 43
REGNELL HYDRAULIC KNEE
CLASS 3 TYPE 3

1. MATERIALS
   A. Knee: Metal or plastic shell
   B. Shank: Metal or plastic shell
   C. Finishing: Paint
   D. Alignment device attachment: None

2. DIMENSIONS
   A. Knee width: 3-3/4 inches
   B. Calf circumference: 16-1/2 through 21-1/2 inches in 1 inch increments in rights and lefts
   C. Stump length accommodation: Within 1-1/2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Hydraulic, Adjustable, Cadence
   B. Extension resistance: responsive
   C. Extension aid: None
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: Weight control knee lock
   D. Changing knee locus: None
   E. Yielding lock: "Stair valve," manual control
   F. Static alignment: Knee axis on TKA

(Not on VA contract)
MAUCH S-N-S KNEE
CLASS 3 TYPE 3

1. MATERIALS
   A. Knee: Laminated willow, semi-shaped
   B. Shank: Laminated willow, semi-shaped
   C. Finishing: Laminated external knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3-1/2, 3-3/4 and 4 inches in rights and lefts
   B. Calf circumference: Matched to knees in right or left
   C. Stump length accommodation: Within 1-1/2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: (Hydraulic, Independent, Adjustable, Variable, Cadence responsive)
   B. Extension resistance: (hydraulic)
   C. Extension aid: Spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: None
   C. Hydraulic lock: Unidirectional (flexion), manually activated (hydraulic)
   D. Changing knee locus: None
   E. Yielding lock: Adjustable rate
   F. Static alignment: Knee axis on or anterior to TKA

(On VA contract)
Class 4—Hybrid Units

Type 3 (Fig. 46 and 47): (Adjustable, variable, cadence responsive, swing-phase control with stance control.) The addition of a fluid swing-phase control to a mechanical stance-phase control knee permits additional functions to be added following prescription in the event of a demonstrated need. This procedure seems expensive because it employs two otherwise independently used components. However, this may be balanced in cases where the initial prescription is primarily aimed at providing effective stance control. Later, as the patient becomes more active, more adequate swing control may be added without making a completely new unit. Mass production and standardization may reduce the cost of a hybrid system to a practical level.

GENERAL REFERENCES

Blatchford Modular Prosthesis Guide Book: Charles A. Blatchford & Sons Ltd., Lister Road, Basingstoke, Hants, England.

Fillauer Catalog: Fillauer Surgical Supplies, Inc., 956 East Third Street, Chattanooga, Tennessee.


Suggestions for Fitting and Aligning the SACH Foot (Chart): VA Prosthetics Center, 242 Seventh Ave., New York City, May 1962.


Wagner Catalog: Wagner's Orthopedic Supply Company, 875 West Fourth South, P.O. Box 1585, Salt Lake City, Utah, April 1969.
Selection and Application of Knee Mechanisms

BLATCHFORD STABILIZED KNEE WITH PNEUMATIC SWING CONTROL
CLASS 4 TYPE 3

1. MATERIALS
A. Knee: Preformed aluminum, closed front
B. Shank: Preshaped willow
C. Finishing: Painted knee, laminated shank
D. Alignment device attachment: Tapped holes for couplings

2. DIMENSIONS
A. Knee width: 3-3/4 inches open-front design, neuter
B. Calf circumference: 14-1/4 inches in rights and lefts
C. Stump length accommodated: To within 3-1/2 inches of knee axis

3. SWING CONTROLS
A. Flexion resistance: Pneumatic, Independent, Adjustable, Cadence responsive
B. Extension resistance: Cadence responsive
C. Extension aid: Air spring
D. Extension stop: Mechanical

4. STANCE CONTROLS
A. Mechanical lock: None
B. Frictional brake: Band and drum under weight-bearing
C. Hydraulic lock: None
D. Changing knee locus: None
E. Yielding lock: None
F. Static alignment: Knee axis on or posterior to TKA

(Not on VA contract)

REFERENCES
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Foot (Chart): VA Prosthetics Center,
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KOLMAN SAFETY KNEE WITH DYNAPLEX SWING CONTROL
CLASS 4 TYPE 3

1. MATERIALS
   A. Knee: Laminated poplar, semi-shaped, open front
   B. Shank: Laminated poplar, semi-shaped
   C. Finishing: Laminated exterior knee and shank
   D. Alignment device attachment: Wood screws

2. DIMENSIONS
   A. Knee width: 3 through 4 inches in 1/4 inch increments
   B. Calf circumference: 11-1/2 through 16-1/2 inches in rights and lefts
   C. Stump length accommodation: To within 2 inches of knee axis

3. SWING CONTROLS
   A. Flexion resistance: Adjustable, Cadence
   B. Extension resistance: Responsive
   C. Extension aid: Spring
   D. Extension stop: Mechanical

4. STANCE CONTROLS
   A. Mechanical lock: None
   B. Frictional brake: Mechanical lever brake and drum under weight-bearing
   C. Hydraulic lock: None
   D. Changing knee locus: None
   E. Yielding lock: None
   F. Static alignment: Knee axis posterior to but near TKA

   (Not on VA contract)